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CARP CULTURE

PACKAGE OF PRACTICES FOR INCREASING PRODUCTION

CENTRAL INLAND FISHERIES RESEARCH INSTITUTE
(INDIAN COUNCIL OF AGRICULTURAL RESEARCH)
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FOREWORD

The Central Inland Fisheries Research Institute has been working on various aspects of carp culture for nearly three decades. During 1960's the Institute evolved a production system around the six species combination made of Indian major carps and exotic carps which showed promises of high yield. This has since been improved and tested at all India level under diverse eco-climatic conditions through the All India Coordinated Research Project on Composite Fish Culture and Fish Seed Production. The results have been uniformly good and an average production of 4 t / ha / yr has been achieved. The present manual synthesises all the available information on carp polyculture experiments and sets forth the package of practices that would help practising farmers/fishery operatives to achieve a high fish production from undrainable ponds. The present manual has been prepared keeping in view the diverse requirement of the extension workers, entrepreneurs, bank officials and progressive fish farmers.

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CONTENTS

PACKAGE OF PRACTICES FOR INCREASING PRODUCTION IN CARP CULTURE PONDS

1. INTRODUCTION

The country had a traditional system of carp culture which depended on naturally occuring fish spawn/early fry of major carps mixed with undesirable species and was largely practiced in Bengal and, to some extent, in adjoining states. Without any basis of scientific management in the traditional system of culture, the yield varied in the range 60-600 kg/ha/yr. It is against this scenario, the Central Inland Fisheries Research Institute (CIFRI) addressed itself initially with gradual development of a technology ultimately leading to a package of practices of carp culture with an average production potential of 4000 kg/ha/yr. The technology is applicable to the existing available pond resources throughout the country without any zonal restrictions.

Ponds in India are generally dug-out units, rainfed and non-drainable with stagnant waters. These belong to the categories namely perennial and seasonal and find multipurpose uses including drinking purposes, livestock washing, bathing, minor irrigation, cleaning of clothes, washing of utensils and fish culture etc.

The fertility status of pond soil in India varies widely in the country depending upon soil types such as alluvial, laterite, red black cotton etc. Of these, alluvial soil is more productive from aquaculture point of view than the others. The chemical reactions of these soil types are either acidic, alkaline or neutral.

Acid soils generally show wide variation in pH ranging from 3.5-6.5 with low calcium and magnesium content and pronounced deficiency in nitrogen, phosphorus, organic carbon etc., resulting in low fertility. Such soils of hilly and forest region are, however, rich in organic matter and nitrogen. Vast stretches of acid soil exist in north-eastern States of Arunachal, Nagaland, Meghalaya, Manipur, Mizoram, Assam, Tripura and some stretches of West Bengal, Bihar and Orissa. This soil type is also encountered in certain areas of northern States of Jammu and Kashmir, Himachal Pradesh, Punjab, Uttar Pradesh, southern States of Andhra Pradesh, Tamil Nadu, Karnataka and in the western State of Maharashtra.

The alkaline soil may be slightly alkaline (pH 7.5-8.0), moderately alkaline (pH 8.0-8.5) or highly alkaline (pH above 8.5). Highly alkaline soil is also known as sodic soil. Low organic matter and poor nitrogen content coupled with unfavourable soil reaction makes it unproductive. Alkaline soil is extensively encountered in semi-arid regions of northern States like Punjab, Haryana, Madhya Pradesh, Uttar Pradesh, Bihar and arid regions of Rajasthan. Western States of Maharashtra and Gujarat, southern States of Andhra Pradesh, Tamil Nadu and Karnataka also have some stretches of this type.

The pH of neutral soils vary around 6.5-7.5 with better nutrients and thus impart a productive status. The country's major portion of pond soil falls under this category providing excellent opportunity for aquaculture.

The production of fish in traditional culture system is solely based on the inherent natural productivity of ponds. There is no effort of removing fish enemies from the ponds or monitoring the fertility status of soil and water for enhancing the carrying capacity. Their effort is generally limited to stocking assorted carp seed of any size with no post-stocking management, ultimately resulting in miserably poor fish yields.

Modern carp culture technology in India which has come to be known as composite fish culture aims at fuller utilization of pond productivity at different ecological niches by culturing together fast growing six compatible species of complementary feeding habits (Fig. 1). The ratio and number of different species is suitably regulated in an environment free of weeds and harmful fishes under hygienic condition with health monitoring, as an when required. The soil and water conditions are also monitored. The carrying capacity of the pond is enhanced by using manures and fertilizers in addition to providing nutritive supplementary feed.

The package of practices developed at CIFRI is described chronologically in the succeeding sections mainly as guideline for the extension personnel.

2. POND REQUIREMENTS

The fingerlings are raised to table size in stock ponds which are also known as grow out ponds. For operational convenience such pond may be rectangular, 0.1 to 2.0 hectare in size with depth varying from 2.0-3.0 m. Perennial ponds are preferable than the seasonal ones.

However, ponds with little low depths, in absence of ones with above desirable depths, can also be used as indicated in recent studies.

Analysis of variance performed to test the yield in relation to depth of pond ranging from 0.5 - 1.5 m in experiments carried out in different parts of the country, indicated that the average depth ranging from 1.0 - 1.5 m yielded better than the lower depths (Table - 1).

T A B L E - 1 Analysis of variance of depth in relation to yield

Source of variation	*Degress of freedom*	*Sum of squares*	*Mean square*	*F*
Between depths	2	134643.72	67321.86	4.147 *
Within depth	6	97398.38	16233.06	
Total	8			

* Singificant at 10% level ($P<0.10$)

However, the above investigations did not take higher depths into consideration.

The pond soil and water should contain desirable properties. The productive soil status include loamy or clay loamy bottom free from excessive decomposing matter, pH 6.5-7.5, available nitrogen (N) 30-50 mg/100 g, available phosphorus (P_2O_5) 6.0-16.0 mg/100 g, organic carbon 1.0-2.0%. The productive water conditions include turbidity below 20 ppm, pH 7.0-8.0, total alkalinity 75-150 ppm, nitrate (NO_3) and phosphate $(PO)_4$ 0.2-0.5 ppm each and dissolved oxygen 5.0-10.0 ppm.

Ponds with abovesaid desirable properties as well as with slightly alkaline (pH 7.5-8.0) or moderately alkaline (pH 8.0-8.5) soil can straight way be used for fish culture. But ponds with acid soil (pH below 6.5), sodic soil (pH above 8.5), sandy soil and soil with heavy load of organic matter are unproductive and thus, need corrective measures for their profitable utilization in fish culture. The corrective measures recommended for such ponds are as follows.

Correction of acid soil : Lime corrects the acidity of soil, For this purpose, pH of soil need be tested and quick lime may be applied as per the schedule below.

Total quantity of lime may be divided into 3-4 instalments and applied at 2-3 days interval. Stocking of fish can only be done after about a fortnight of the last application.

Soil pH range	*Soil type*	*Dose of lime kg/ha*
4.0 - 5.0	Highly acidic	2000
5.0 - 6.0	Moderately acidic	1200
6.0 - 6.5	Slightly acidic	1000
* 6.5 - 7.5	Near neutral	400

* Though this group of soil falls under the category of near neutral soil yet, liming is required for better utilization of fertilizers and prophylactic measure.

Correction of sodic soil : Sodic or highly alkaline soil (pH above 8.5) may be corrected to favourable pH range by applying cowdung at a high dose of 20 - 30 t/ha and gypsum ($CaSO_4$) at the rate of of 5 - 6 t/ha.

Correction of sandy bottom : The fertility status and water retention of ponds with sandy bottom are poor. Application of organic manures *viz.* cowdung, biogas slurry etc. at 20 - 30 t/ha helps to improve the conditions.

Correction of heavy load of organic matter on the bottom : Presence of heavy load of organic matter on the pond bottom generate many noxious gases. The fertility status of such ponds is also generally poor. Corrective measures include removal of excess muck, ploughing, liming @ 1 t/ha and exposing the pond bottom to sun for about a fortnight. If dewatering and desilting are not feasible, the bottom may be raked occassionally during culture period, followed by application of lime @ 1 t/ha/yr in split up doses.

3. AQUATIC WEED CONTROL

Aquatic weeds are of common occurrence in fishery waters and are generally undesirable. Besides consuming the nutrients from the water body, excessive growth of aquatic vegetation poses serious problems by upsetting the oxygen balance, creating obstruction in movement of fishes and in netting operations etc. The weeds are, thus, completely removed as a first step in fish culture. The common aquatic weeds may be broadly grouped into undermentioned five categories.

(i) **Free floating surface weeds :** The most common weeds under this category are :—*Eichhornia crassipes* (water hyacinth) *Salvinia* sp., *Pistia stratiotes* and *Lemna minor*.

(ii) **Submerged weeds :** *Hydrilla*, *Ceratophyllum*, *Vallisneria*, *Ottelia*, *Najas* are some of the common weeds of this category.

(iii) **Rooted emergent weeds** : Lotus, lilies, *Nymphoides*, *Euryale* sp. and *Trapa* sp. are the important types of this category.

(iv) **Marginal shallow water weeds :** Aquatic grasses (e. g. *Panicum* sp.,) sedges and rushes (e. g. *Cyperus*, *Scirpus*, *Typha* etc.), creepers and bushes (*Ipomoea aquatica*, *I. carnea* respectively) are the notable examples of this category.

(v) **Algae :** The noxious algae which cause serious problem in fish ponds may be planktonic (*Microcystis*, *Anabaena*, *Euglena* etc.) or filamentous (*Spirogyra*, *Pithophora*).

Control measures : The aquatic weed control methods may be broadly grouped under four different categories, *viz*. (1) Manual, (2) Mechanical (3) Chemical and (4) Biological. In some cases an integrated approach with more than one method may be necessary.

(1) **Manual method :** It is the simplest one which involves physical removal of weeds by manual labour. This is convenient and economical particularly in small ponds.

(2) **Mechanical method :** This method has the advantage of requiring only manual labour and some sickle and barbed wire which are readily available in rural areas. This mtehod is also convenient for small water bodies.

For clearance of large areas by mechanical method, several types of machines have also been evolved but their efficacies and economics have to be carefully assessed before making investment for such machines.

(3) **Chemical method :** This method is effictive and long lasting in largerwater bodies. The weeds killed by chemicals are allowed to settle at the bottom and ultimately recycled to become manure for enhancing fertility of fishery waters. Sometimes, however, the sudden death and decomposition of large masses of vegetation may deplete dissolved oxygen in water causing even fish mortality. Hence, technical guidance is essential in regard to choice of the herbicide and methods of application etc.

The common herbicides, the weeds on which these have been found effective, their doses and the methods of application are outlined in Table - 2.

(4) **Biological method :** Grass carp (*Ctenopharyngodon idella*) is a very useful fish for biological control of some species of aquatic vegetation. Many species of submerged vegetation *viz. Hydrilla, Najas, Ceratophyllum* etc. can be effectively controlled by stocking the weed infested waters with grass carps of 200 mm and above in size. The surface floating duck weeds *viz. Wolffiia, Lemna, Azolla, Spirodela* are also fed upon by grass carp. *Puntius gonionotus* is also reported to be a good subsititute for grass carp. Yamuna turtle, *Kachuga tectum*, has been reported to be a consumer of water hyacinth. The larva of *Erastroides curvifasciata* is reported to consume *Pistia.*

Biological method of weed control has great advantage as the undesirable weeds get directly converted into fish flesh. Moreover, this method is most natural and acceptable from environmental and social point of view. The inputs of manual labour and materials are also reduced to minimum. But the selective feeding preferences of these biological control agents limit their usefulness to some extent in aquatic weed control.

TABLE-2 Common herbicides for Chemical control of weeds

Weeds	*Herbicide*	*Usual dose*	*Method of application*
Water hyacinth	2, 4 - D	8 - 10 kg/ha	Foliar spraying (X_1)
Ipomoea spp.	,,	2 - 4 ,,	,,
Sedges and rushes	,,	5 - 10 ,,	Foliar spraying/Root zone treatment (X_2).
Lotuses and lilies	,,	5 - 10 ,,	Root zone treatment
Ottelia, Vallisneria	,,	10-20 ,,	,,
Aquatic grasses (in young stages)	Dalapon	5 - 10 ,,	Foliar spraying
Aquatic grasses	Paraquat	2 ,,	,,
Aquatic grasses	Diuron	4 ,,	Root zone treatment

Microcystis, other planktonic and filamentous algae.	Diuron	0.1-0.3 ppm	Root zone treatment. Dispersal in water column.
All submerged weeds	Ammonia	10-15 ppm	,,
Pistia	,,	1% aqueous solution with 0.25% wet-ing agent.	Foliar spraying
Pistia	Paraquat	0.2 kg/ha	,,
Salvinia	Ammonia	2% aqueous solution with 0.25% wett-ing agent.	,,
Salvinia	Paraquat	0.4 kg/ha	,,

(X_4) Foliar spraying : Herbicide should be taken in required dose in sufficient water volume and sprayed over the foliage uniformly by means of sprayer.

(X_2) Root zone treatment : Brick pellets should be soaked in a solution of required quantity of herbicide in water. The herbicide soaked brick pellets are applied in the root zone of the weeds of the bottom.

4. ERADICATION OF UNWANTED FISHES

Predatory fishes directly prey upon the young ones besides competing with them for space and oxygen. The weed fishes compete with the cultured species for their demand of food, space and oxygen. In view of the harm caused by these undesirable fishes, their complete eradication from the pond before sotcking is of utmost importance in scientific management.

The commonly encountered species of predatory fishes are : *Channa* spp., *Clarias batrachus*, *Heteropneustes fossilis*, *Pangasius pangasius*, *Mystus* sp., *Ompok* spp., *Wallago attu*, *Glossogobius giuris*, etc.

The common weed fishes are : *Puntius* sp., *Oxygaster* sp., *Ambassis* sp., *Amblypharyngodon mola*, *Colisa* sp., *Rasbora* sp., *Aplocheilus* sp., *Laubuca* sp., *Esomus danricus*, etc.

Repeated netting of the pond is a common method for eradication of fishes. But many fishes escape the net, particularly in deeper waters. Another efficient method of eradication is the draining of the pond. But this method can only be applied in small water bodies and that too where additional water source, to refill the pond, is available. Hence, to ensure complete removal of existing fish population use of fish toxicants is necessary. This may be done during premonsoon season, from economic point of view, when the water level is minimum. The date may be adjusted about 5 weeks earlier to the anticipated time of seed availability.

However, seasonal ponds which dry up during summer months are generally devoid of such unwanted fishes and thus no treatment is required.

The suitability of fish toxicant is judged on its properties like effective minimum dose, its cost, consumability of the killed fish, least adverse effect on the pond biota, short duration of the toxicity, non-cumulative residual effect in the pond, commercial availability and simplicity of application etc.

Efficient fish toxicants can be (a) mahua oil cake, tea seed cake or any other plant derivative (b) Ammonia and (c) Bleaching power. Depending on availability and convenience, one may choose fish toxicant of any of the following.

a. (i) **Mahua oilcake :** The most extensively used fish toxicant in the country is oilcake of Mahua (*Basia latifolia*) containing 4-6% saponin. It kills fishes at 200-250 ppm in 6-10 hours. The fishes, thus, killed are fit for human consumption. The toxicity lasts for 15-20 days in water. Subsequently, it serves as organic manure in the pond.

The quantity required is calculated on the basis of pond area and average water depth. At the above mentioned dosage Mahua oilcake required is 2000-2500 kg per hectare for every metre of average depth. The required quantity of mahua oil cake is powdered, soaked in water and broadcast over water surface. The pond is then netted repeatedly by dragging for its proper mixing in water and for taking out the affected fishes.

(ii) **Tea seed cake :** Seed cake of tea (*Camellia sinensis*) may prove to be a substitute for Mahua oilcake as fish toxicant. A dose of 75-100 ppm is su-

fficient to obtain a complete kill in the pond with toxicity lasting for 10-12 days. It also ultimately acts as fertilizer in the pond. The treated fishes are fit for human consumption. Method of application is same as in Mahua oilcake.

(iii) **Other plant derivatives :** Other fish toxicants of plant origin like stem bark (20 ppm), seed (15 ppm) and root bark (10-15 ppm) powder of *Barringtonia acutangula*, seed powder of *Croton tiglium* (3-5 ppm) and *Milletia piscidia* (4-5 ppm), root powder of *Milletia pachycarps* (3-6 ppm), unripe fruit powder of *Randia dumetorum* (15 ppm) and *Cassaria arevaolaus* (25-30 ppm), seed husk of *Tamarindus indica* (5-10 ppm) bark powder of *Walsura piscidia* (5 ppm) and whole plant of *Euphorbia thirucalli* have been found to be effective as fish toxicant under laboratoty conditions. However, these toxicants are not yet commercially available.

b. **Ammonia :** Anhydrous ammonia @ 20-25 ppm has been found to be an effective fish toxicant.The cost of ammonia as a fish toxicant is off-set to some extent by its fertilizer value which has been estimated to be about 36% of the cost of ammonia applied. Ammonia acts as herbicide also. Toxicity of ammonia in water lasts for 4-6 weeks.

Anhydrous ammonia from a cylinder is introduced under water through a hose and a 1.2 m long G. I. pipe applicator with delivery holes. The applicator is suspended from a boat or held in position by long ropes by two people standing on opposite banks. The cylinder is partly immersed in water near the shore to prevent excessive cooling and condensation of ice. Ammonia being lighter than water, the applicator is kept as far below the water level as necessary to effect the bottom dwellers. However, the applicator should be kept well above the bottom soil to prevent loss of gas from abosrption by the soil. Its efficacy also depends on the pH of water, effect being quicker with increasing pH.

c. **Bleaching powder :** Bleaching powder, calcium hypochlorite, as fish toxicant has been found to be effective in 3-4 hours at 25-30 ppm. Its toxicity lasts for about 7-8 days in the pond. It has got disinfecting effect besides oxidising the decomposing matter on the pond bottom. In view of limited supply of Mahua oilcake, bleaching powder is an effective substitute with easy availability and lower cost etc.

The powder is dissolved in water and the solution is sprayed on the water surface immediately. Distressed or killed fish is then removed by repeated netting.

5. POND FERTILIZATION

Soil and water management is an essential step for optimising fish production. Natural productivity of a pond can be greatly enhanced by the use of manures and fertilizers which provide essential nutrients for aquatic biota serving either directly or indirectly, through involved ecosystem, as food of fishes.

5.1 **Liming**

Aiming at fast mineralisation of organic matter and for prophylactic reasons, use of quick lime (a) 400 kg/ha is recommended also for slightly alkaline soil. Initial dose @ 100 kg/ha may be applied one week earlier to stocking the pond and the rest in equal monthly instalments. Qiuck lime need be dissolved in water, allowed to cool down and broadcast uniformly over the pond surface during morning hours.

Besides, use of lime @ 150-200 kg/ha in one dose may be necessary when fishes show distressed conditions.

5.2 **Manuring**

A combination of roganic manures and inorganic fertilizers is considered more effective than either of these alone. The fertilization schedule is prepared on the basis of fertility status of soil which is ascertained by chemical analysis. Based on soil fertility status, fertilization schedule to be followed is given in Table 3.

Initial manuring with orgaic manure @ 20% of the total requirement is done 15 days prior to stocking. If mahua oil cake is applied earlier as pisticide, the intitial manuring may be dispensed with. The remaining 80% of the organic manure may be applied in split up 11 equal monthly doses during the rearing period.

The total quantity of inorganic fertilizers is applied in 11 equal monthly instalments during the culture period. While organic manures may be dumped in water at corners/sides, inorganic fertilizers may be mixed together and broadcast all over the pond. The organic manure and inorganic fertilizers are alternately applied with a gap of about a fortnight. Manuring/fertilization need be suspended in adverse ecological conditions.

Nitrogenous fertilizers may be selected on the bais of soil reaction : calcium ammonium nitrate in acid soil (pH 5.5—6.5) urea in neutral soil (pH 6.5—7.5) and ammonium sulphate in alkaline soil of pH above 7.5.

Inorganic fertilizer application need be discontinued temporarily when the nitrate and phosphate contents of water show a level of 0.5 ppm or above at any stage during the periodic soil and water tests. Similarly, organic manuring may also be temporarily discontinued if organic carbon level of soil goes beyond 2%. Such measures prevent excessive use of fertilizers and algal bloom etc. Application may be resumed when the nutrient level goes below the indicated values.

In absence of soil testing facilities the generally recommended fertilizer schedule as below may, however, be adopted with expectation of moderate results.

Item	*Quantity kg/ha*	*Remarks*
Cowdung	2000	Initial dose.
Cowdung	1000	Monthly.
Urea	25	Monthly.
or		
Ammonium sulphate	30	Monthly.
or		
Calcium ammonium nitrate	30	Monthly.
Single super phosphate	20	Monthly.
or		
Triple super phosphate	8	Monthly.

The various fertilizers and their doses as applicable in fish ponds according to the soil nutrient status of the pond is given in table—3.

TABLE—3 Fertilization schedule based on soil nutrient status

POND TYPES	SOIL CONDITION pH	Organic carbon %	Avl. Nutrients mg/100g	NUTRIENT REQUIREMENTS (kg/ha)	TOTAL QUANTITY OF FERTILISERS/ MANURES FOR PONDS (kg/ha/year)	
Low productive	Below 5.5 (Moderate to highacid	Below 0.5	N-Below 25 P_2O_5 Below 3	N-200-250 P_2O_5-100-125 Crg. C-600-720	Calcium ammonium nitrate or Urea Single super phosphate or Triple superphosphate Rock phosphate Cow-dung or Gobar gas slurry	500-650 225-290 315-405 110-145 300-400 10,000-12,000 20,000-30,000
Medium productive	5.5-6.5 (Slightly acid)	0.5-1.5	N-25-50 P_2O_5-3-6	N-150-200 P_2O_5-75-100 Org. C-480-600	Calcium ammon. nitrate or Urea Single superphhsphate or Triple superphasphate Cow-dung or Gobar gas slurry	350-500 156-225 219-315 75-110 8,000-10,000 16,000-20,000
High productive	6.5-7.5 (Neutral)	1.5-2.0	N Above 50 P_2O_5 ,, 6	N-100-150 P_2O_5 50-75 Org. C-300-480	Urea or Ammonium sulphate Single superphosphate or Triple superphosphate Cow-dung or Gobar gas slurry	112-156 225-330 156-219 54-76 5,000-8,000 10,000-16,000

6. SPECIES MIX AND RATIO :

6.1 **Species mix :**

Judicious selection of compatible fast growing economic species is of vital importance in maximising fish production. A combination of six species, *viz.* catla (*Catla catla*), Silver carp (*Hypophthalmichthys molitrix*), rohu (*Labeo rohita*) grass carp (*Ctenopharyngodon idella*), mrigal (*Cirrhinus mrigala*) and common carp (*Cyprinus carpio*) fulfills the criteria of species selection and has proven to be the ideal combination for freshwater carp culture in India. Of these, catla and silver carp are surface feeders, rohu is a column feeder, grass carp is a macro-vegetation feeder and mrigal and common carp are bottom feeders (Fig. 2). Six as well as the four species (catla, rohu, mrigal and common carp) combinations have been found to yield maximum production and are generally preferable. The statistical analysis of data collected from carp culture experiments with different species combinations conducted in different parts of the country showed that mean production of both 6 species as well as the 4 species combinations were significantly superior than the others. No significant difference in mean production was, however, observed between the 6 species and 4 species combinations. The results are summarised in Tables 4 & 5.

TABLE - 4 Analysis of variance of 6 species

Source of variation	*Degrees of freedom*	*Sum of square*	*Mean square*	*F*
Between species combinations	3	315887.18	105295.73	4.27*
Within species combinations	192	4730697.45	24639.05	
Total	195	5046584.63		

* Significant = ($P < 0.01$)

TABLB - 5 Summary Table

Difference of means from 6 species combinations	*Standard Error of difference*	*Critical difference*	*Significance*
5 species combination 82.01	29.35	57.53	$P<0.05$
4 species combination 71.01	38.63	75.71	Not significant.
3 species combination 100.94	44.22	86.67	$P<0.05$

Thus, it can be recommended that if seed of all the six species are available one may go for such a combination. But 4 species culture can also be taken up and is expected to yield equivalent production. The four species culture may be more profitable in view of the fact that market price of Indian major carps is comparatively high than that of silver and grass carp. However, the result of the above analysis does not recommend five species (catla, rohu, mrigal silver carp, common carp) culture. The tradiional three species culture (catla, rohu, mrigal) can also be profitably adopted in absence of seed of exotic species.

6.2 **Species ratio**

Selection of species ratio generally depends on local conditions of seed availability, nutrient status of pond etc. Certain general guidelines, thus, can only be given which are as under :

6 species culture : It should be so adjusted that surface feeders form 30-40% (catla 10-15%, silver carp 20-30%), column feeder (rohu) forms 15-20% in moderately deep ponds (above 2.0 m average water depth) and 10% in shallow ponds (below 2.0 m average water depth), bottom feeders (mrigal and common carp) form 40-45% (mrigal 15-20% and common carp 20-25%) and macro-vegetation feeder (grass carp) forms 5-15%, depending upon the availability of a dependable source of weed supply.

4 species culture : Catla 30-40%, Rohu 20-30% in deeper ponds and 10-15% in shallower ponds, Mrigal 15-20% and comomon carp 20-25%.

3 species culture : Catla 40%, Rohu 30%, and Mrigal 30%.

7. FINGERLING STOCKING

7.1 **Stocking rate**

Rate of stocking generally depends on the fertility of the pond and the measures adopted to increase its biological productivity by fertilization and artificial feeding etc. Stocking rate is generally decided in relation to area of the pond at the time of stocking. A pond having average water depth of 2.0—3.0 m may be stocked at the rate of 5000 fingerlings/ha. Stockings need be done about 3 weeks later to piscicide application after ascertaining complete detoxification. The toxicity may be tested by releasing few fingerlings in a hapa fixed in the pond. Their comfotable behaviour for about 24 hours indicates complete detoxification.

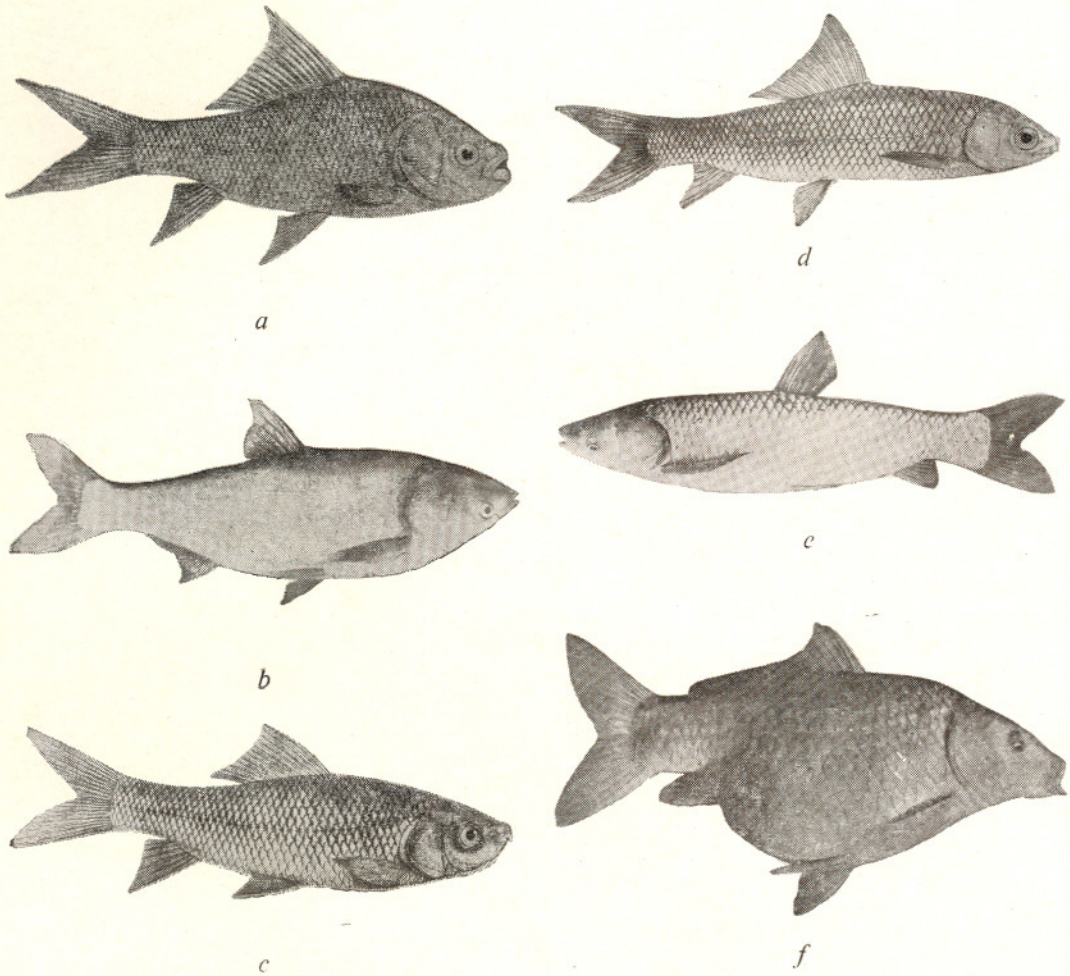

FIG. 1.—**The six compatible carp species under composite fish culture.**

a Catla	*b* Silver carp	*c* Rohu
d Grass carp	*e* Mrigal	*f* Common carp

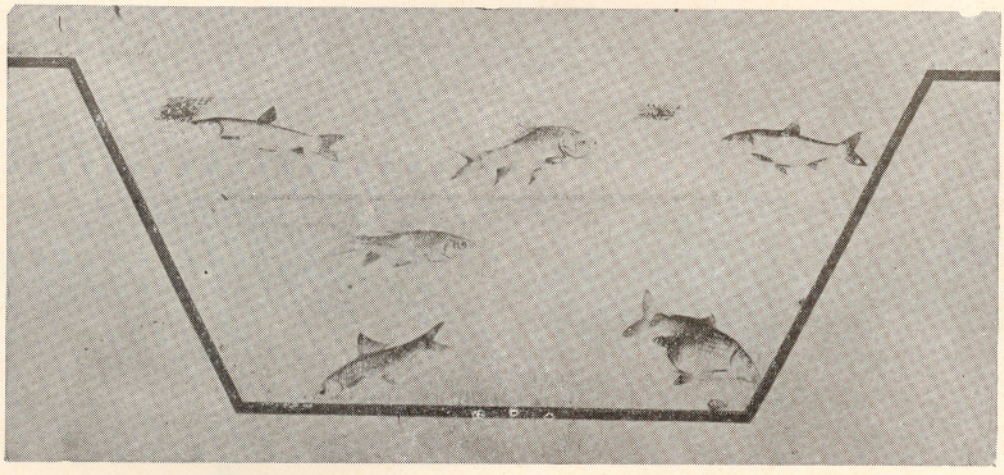

FIG. 2. **Association of carps in composite fish culture.**

FIG. 3. **Feed trays being fixed in a pond.**

Generally all the fish species are stocked simultaneously. But it has been observed that due to interspecific competion for food between catla and silver carp to some extent, the former suffers in growth. As such it is advisable to stock silver carp two or three months later than catla, the time by which catla generally picks up its growth. Silver carp with its faster growth rate is able to compensate the loss in its culture period and attains over 1 kg size in the remaining 9-10 months itself.

7.2 **Stocking size**

It is generally advisable to stock the ponds with fingerlings of 100-150 mm size for better survival. Recent experiments have, however, indicated the possibility of high survival and production rates even with stocking of advanced fry (25-40 mm) and early fingerlings (40-80 mm) in predator free ponds.

7.3 **Time of stocking**

While water temperatures ranging from 25-30 °C is conducive to fish growth, low temperatures below 18 °C adversely effect the growth and as such in areas of severe winter the stocking time may be so manipulated that low temperature month (winter months) are not included in the culture period.

Mild winter zones : Coastal and north-eastern states of the country have comparatively mild winter. In such states, June to September is the best period of stocking to take advantage of the high temperature and large water volume expanse in the monsoon season with culture period continued for full year.

Severe winter areas : North and north-western states experience severe winter. These areas of the country call for limiting the culture period to 8-9 months with a view to fully utilizing the growth period during warmer months. Stocking time in such areas is suggested during February-March with harvesting of fish stock during November or so. The fallow winter season may be utilized for pond preparation.

8. SUPPLEMENTARY FEEDING

The level of natural food organisms in the fish culture ponds can not be maintained to the required extent even after manuring. Hence, supplementary feeding with diets rich in protein and carbohydrates etc. is essential for high rate of fish growth.

Criteria of food : Protein requirement of about 30-35% have been found to be essential for optimum growth in carps. However, to economise on the cost of feed, a reasonably nutritive mixture of supplementary feed may contain 25-30% protein, 30-40% carbohydrate with dietary energy content at 3.5-4 K cal/g of feed. Acceptability, digestibility, assimilation and conversion efficiencies are other criteria for selection of an efficient feed.

Feed items : Various items of vegetable and animal origin are used as feed of carps. The vegetable items include leaves, grasses, tubers, roots, starches, oilcakes, grain fooders and other agricultural by-products, while the items of animal origin include chironomids, housefly maggots, fish meal, prawn meal, silkworm pupae etc. Commercial fish feed under different trade names are also now available in the country.

Common feed and the schedule : The most commonly used mixture of oilcake of groundnut or mustard and rice polish or rice bran in 1:1 ratio by weight with conversion ratio of 2.5 : 1 is an efficient supplementary feed for major carps (except for grass carps.) Other oilcakes like til and coconut can also be used. Extent of intensive feeding is an economic question which depends on the cost and conversion ratio. A feeding rate at 2-3% of body weight of fish per day commencing from seocnd day of stocking is generally recommended.

A monthly sampling of fishes by drag netting is essential for estimating the average weight of fishes, and thus the standing crop, for calculation of feed quantity required. However, the quantity may be regulated according to consumption etc.

A generalised feed schedule with oilcake and rice bran mixture (1 : 1 ratio) at stocking density of 5000 fingerlings/ha is given below :

Period	*Approx. quantity in kg/day*
First month	4
Second month	5
Third month	6
Fourth month	8
Fifth month	10
Sixth month	12
Seventh month	14
Eighth month	16
Ninth month	18
Tenth month	20
Eleventh month	22
Twefith month	24

Fishes are daily fed during morning hours with doughs prepared by the feed mixture and placed in trays hung from a bamboo fulcrum at different depths of the pond (Fig. 3). In case of appearance of algal bloom or oxygen depletion due to any other reason, feeding need be suspended till revival of normal conditions.

Feed for grass carp : Grass carp is fed with *Hydrilla*, *Najas*, *Caratophyllum*, *Wolffia*, *Lemna*, *Azolla* and *Spirodella* according to their consumption. Cut bits of marginal vegetation, soft fodder grasses like napier grass, berseem and soft vegetable wastes etc. can also be fed. Weeds may be dumped in corners of the pond or placed on an elevated platform made of coconut rope tied in bamboo frame and kept floating.

If the choiced weeds are naturally not available in the vicinity of the pond, *Wolffia arrhiza* can be easily cultured in cement cisterns/plastic pools/ditches with application of cowdung @ 20 t/ha or in primary treated sewage water, if available, and fed to grass carp.

9. WATER MANAGEMENT

The average water depth in a pond is an important factor in fish culture. This, generally, depends on various factors like rainfall, lifting of water for irrigation etc. If necessary, water may be let in from nearby available sources during summer or drained out during monsoon to maintain desirable water depth in the pond. With intensive fish culture, heavy accumulation of metabolites takes place at the bottom of such ponds and may deplete oxygen in the medium during low water depths, adversely affecting fish growth. However, such problem generally does not occur in seasonal ponds.

Various measures can be taken for warding off the ill effects of metabolites. If stand by source of water is available, change of pond water or refilling/replenishment has been found to add to productivity. It can also be achieved by reconditioning of water by use of biological filters and aeration, as practiced in some countries.

10. HARVESTING AND YIELD

10.1 Harvesting

The ultimate aim of fish culture is to grow fish to a marketable size in shortest possible time. It may be very difficult to specify the marketable size (in weight) of fish in view of the fact that in India, by and large, fish is marketable at any size. But generally, a fish of 750 g and above is of good market value. However, an individual weight of 1.0 kg or above is highly attractive.

It has been observed that carps attain weight of atleast one kilogram in a culture period of about one year in scientific fish culture. If management measures are followed, under favourable conditions the marketable size can even be attained in 6 to 8 months of culture period when the fishes may be harvested.

10.2 Yield

The production potential and economic viability of carp polyculture on an all India basis have already undergone rigorous tests and thus, stand on a sound footing.

While high productions of over 10 t/ha/yr have been achieved at the Institute's experimental farms, fish farmers, under this package of practices, have been obtaining an average production of over 4 t/ha/yr in their ponds.

The statistical analysis of performance of six species culture in 4 geographical zones of India. *Viz.* East, West, North and South showed that the mean productions in different zones did not differ significantly. The result of the anlysis of experiments is given in Table - 6.

TABLE - 6 Analysis of variance of zone-wise yield

Sources of variation	*Degrees of freedom*	*Sum of squares*	*Mean square*	*F*
Between zones	3	176481.96	58827.32	2.19 †
Within zones	92	2471370.37	26862.72	
Total	95	2647852.33		

† Not significant($P>0.05$)

Thus, a modest average target production of 4 t/ha/yr is achievable in any part of the country.

11. DISEASE CONTROL

Health monitoring of the cultured fishes is an important aspect of management which can be done at the time of monthly sampling. Maintenance of sanitary conditions in the pond generally avoids occurence of fish diseases. The pathogens, however, get congenial environment for multiplication causing disease manifestations when the fishes constantly suffer from stress due to adverse conditions in the pond ecosystem like higher temperature, less oxygen and heavy organic load etc. The fishes also become vulnerable to infection of disease when they are physically weak for reason like malnutrition, pollution etc.

Common diseases encountered in carps can be caused by bacteria, fungi, protozoa, helminth and crustacea. Such diseases of carps, their causative organisms, symptom, predisposing factors and their prophylactic, and therapeutic measures are given in Table - 7.

TABLE-7 Common fish diseases, causative organisms, symptoms, predisposing factors and their remedial measures

Name of disease	*Host*	*Causative organisms*	*Incidence*	*Symptoms of disease*	*Clinical signs*	*Predisposing factors*	*Remedial measures*
1	2	3	4	5	6	7	8
Bacterial Diseases :							
Tail & fin rot (Fig. 4)	Indian major carps.	Myxobacters and *Aeromonas* sp.	Frequent in summer months, mostly in young ones.	Whitish margin in fins.	Putrefaction of fins	High organic load at pond bottom.	Fishes are fed for 7 days with fish feed mixed with either the antibiotic Terramycin @ 100 mg per kg of feed or Sulphadiazine @100mg/kg of feed.
Dropsy (Fig 5)	-do-	*Aeromonas* sp.	Frequent in summer months.	Accumulation of water in body cavity or scale pockets.	Disfucnention of kidney	-do-	
Ulcer	-do-	Unidentified bacteria.	-do-	Small pimple to conspicuous sores on the body.	Degeneration of cells.	-do-	
Reddish blotches.	Silver carp	-do-	Frequent in post-winter months.	Posterior part of the body exhibiting reddish bruises	Oozing of blood and formation of clots.	-do- and higher stocking density.	

1	2	3	4	5	6	7	8
Fungal diseases :							
Branchi omyces.	-do-	*Branchio-myces*	—	Rotting of gills.	Obstruction of blood vessels.	High decaying organic matter in the pond.	Addition of lime in the pond @ 150 kg/ha and bath to infected fishes in 3-5% Sodium Chloride for 3-5 minutes.
Saprolegniases	-do-	*Saprolegnia* sp.	Mostly young ones	Whitish tufts on eggs or injured part of fishes.	Ulceration, tail and fin rot.	High, decaying organic matter in the pond.	Bath to infected fishes in solution of 3% Sodium Chloride or 0.5 g of Copper Sulphate per litre of water or 1 g of Pottassium permangnate per litre of water. Pond treatment is done with Malachite Green @ 0.1 mg per litre.
Protozoan diseases (*Myxozoan*)							
Myxosporidioses							
Gill spot disease.	*C. catla*	*Thelohanellus catlae.*	Post monsoon & winter months mostly in young ones.	White cysts encroaching gill surface surfacing & retarded growth of fish.	Excessive mucus secretion from gills & irregular growth of gill epithelium.	Presence of spores in ecosystem, high stocking density, general weakness loss of appetite in winter	Dip treatment for infected fishes in 2 to 3% Sodium Chloride for 3-5 minutes. Pond treatment may be done with a mixture of Malachite
Scale and body spot disease (Fig. 6).	*C. mrigala* & *L. rohita*	*Myxobolus mrigalae* & *M. rohitae*	Pre/post monsoon and winter months, mostly	White cysts embedded in scales & body	Emaciation, degeranation of scales, ulcers.	-do-	

1	2	3	4	5	6	7	8
			in young ones	surface, falling of scales, retarded growth, secondary infection			Green @ 0.1 mg per litre of water and Formaldehyde @ 25 mg per litre of water. Liming for pond sanitation also need be done. Malnutrition of fish stock need be taken care of.
(Ciliate) Trichodinosis.	Indian major carps & exotic carps.	*Trichodina* sp.	Post monsoon & winter months.	Frayed fins, excessive secretion of mucus from gills & body.	Pale gills, asphyxiation, clubbed gills or worn out gill filament	Higher organic loaded pond resulting in excessive mucus secretion from fishes.	
Helminth Diseases Dactylogyrosis and Gyrodactylosis.	Indian & Exotic carps.	*Dactylogyrus* sp. and *Gyrodactylus* sp.	Post monsoon and winter months.	Fading of normal colour, droping & folding of fins, feebleness & surfacing.	Excessive secretion of mucus & damage of gill epithelium.	Higher stocking density, general weakness, loss of appetite in winter.	Dip treatment of the infected fishes for 3-5 minutes in Formalin @ 200-250 mg / litre of water or in 2-3 % Sodium Chloride solution.
Blackspot	Indian carps.	*Diplostomum* spp. *Diplostomulum* spp.	Post winter months.	Blackcyts over the body.	Cysts harbouring metacercarial stage of the trematode.	Fish eating bird population inhabiting pond vicinity	Dip treatment of infected fishes in Picric acid solution @ 30 mg/litre of water for one hour. Removal of infected fishes.

1	2	3	4	5	6	7	8
Crustacean diseases :							
Argulosis (Fig. 7)	Indian & Exotic carps	*Argulus* sp.	Summer & premonsoon months.	Rubbing behaviour	Emaciation & pigmentation.	High decaying organic load.	
Lernaeosis	Indian carps.	*Lernae* sp.	Summer months.	Pin like white bodies on entire fish surface and gills.	Excessive secretion of mucus and damage of gills.	High organic loaded pond	Pond treatment with gammaxene @ 0.2 mg/litre of water or 3 % Sodium Chloride bath to infected fishes for 3-5 minutes.
Ergasilosis	Indian & Exotic carps.	*Ergasilus* sp.	Summer & winter months.	Listless, surfacing, fading of normal colour	Excessive secretion of mucus, paleing of gills.	High organic loaded pond.	

12. COMMON HAZARDS AND REMEDIES

During carp culture operations several types of incidental hazards may be encountered, the nature and remedies of which are as under :

Incidence of fish diseases : As in section- 11.

Incidence of algal bloom : Pond fertilization may some times result in the development of excess microscopic plants which are less desirable or may even become undesirable when they form bloom. Depending on the intensity of such blooms, Diuron @ 0.1 to 0.3 ppm (1 to 3 kg per hectare-meter of water) may be used to control the bloom. The required quantity of herbicide may be mixed with water and spread uniformly over the pond surface. However, blooms in small ponds are most conveniently controlled by thickly covering the surface with duck weeds for about a week. The duck weeds may afterwards be removed from the pond. If grass carp exists in the pond, duck weeds will serve as their food and thus need not be removed.

Oxygen problem : Not only the fish stock but also the plants and organic matter present in the pond alter the oxygen availability. Imbalance in oxygen content due to various reasons may cause distress or even fish mortality. Surfacing of fishes with snout protruding for gulping air especially during the early morning hours is a symptom of oxygen defficiency in the pond.

The remedial measures include letting in some freshwater, beating of water surface by bamboo poles, recirculation of water through a pump, addition of potassium permanganate and application of lime @ 200 kg/ha.

If the depletion of oxygen is due to heavy deposition and putrefaction of organic matter at the bottom, bottom raking followed by liming need be resorted to.

Population imbalance : Common carp, owing to its early maturity and pond breeding habit, may upset the species ratio in the pond thereby resulting in poor growth of bottom feeders.

Certain weeds like *Hydrilla* or water hyacinth may be provided in the pond. The weed with eggs attached to them may be collected for hatching under control conditions thereby preventing population imbalance.

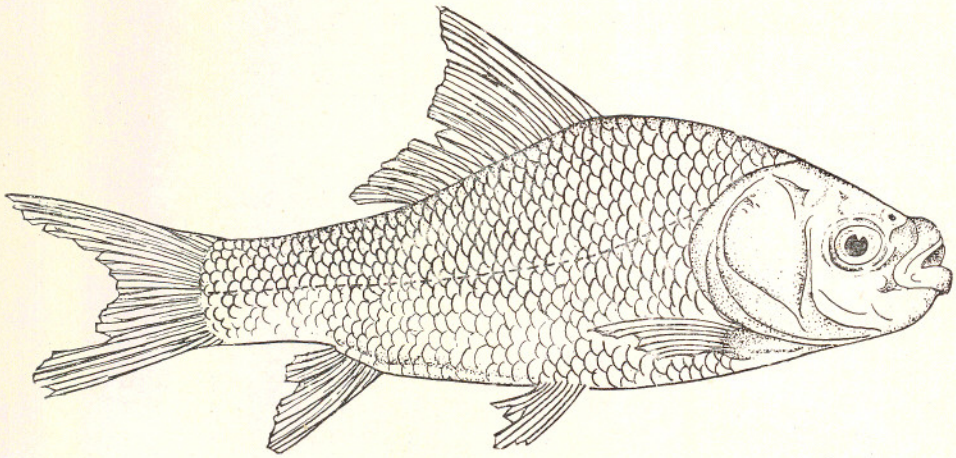

FIG. 4. **Fish affected with tail & fin rot.**

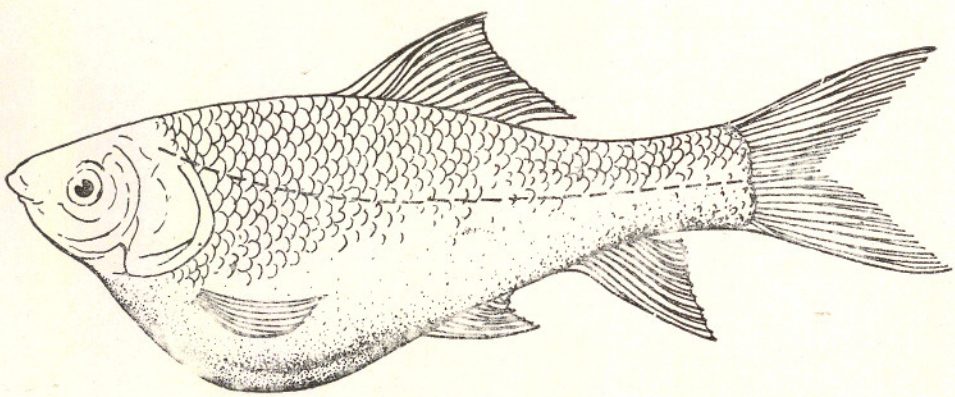

FIG. 5. **A fish showing dropsy.**

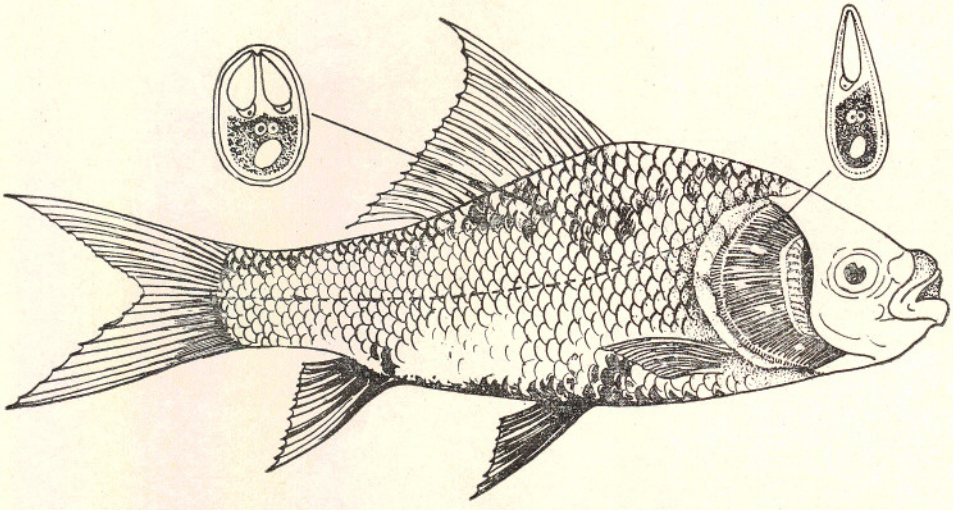

FIG. 6. **Myxosporidiasis in a fish.**

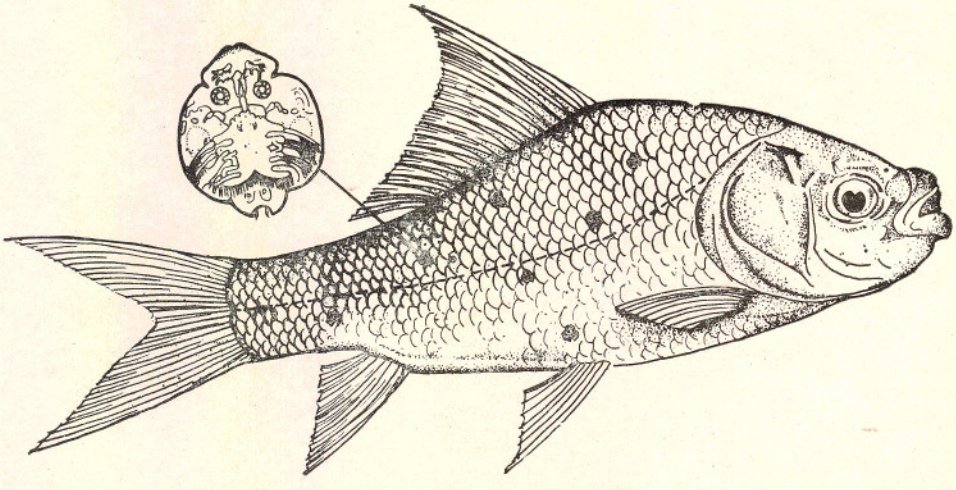

FIG. 7. **Argulus infected fish.**

Unwanted fishes and weeds : Care need be taken to stop entry of predatory and weed fishes which are highly undesirable as stated earlier. The reappearance of weed be checked by periodic deweeding.

Harvesting in large deep ponds : Netting with usual drag nets ensures catching of all species except the bottom dwellers who usually escape. For catching bottom feeders effectivly, drag nets with pockets may be used.

13. INVESTMENT AND RETURN

Producers of fish have seldom faced a phenomenon of sagging market unlike other agricultral commodities. Favourable output prices have proved to be a potent production incentive for fish production. Table - 8 gives details of cost and return in carp production at current prices. However, it may vary with time and location.

TABLE - 8 Cost and return of table size fish production

FACTOR SERVICES :	*Per/ha/yr.* Rs.
Rent of water body	3000
Labourers 730 man-days @ Rs. 10/day (watch & ward, weed collection and feeding etc.)	7300
Netting charges	600
Maintenance and repair	500
Contingent	500

MATERIAL INPUTS :

Items	*Quantity (kg)*	*Rate/(kg)*	*Expenditure Rs.*
Mahua oilcake	2500	0.80	2000
Lime	400	1.00	400
Fingerling	5000	100.00/1000	500
Organic manure (cowdung)	13000 kg	50.00/t	650

Urea	180	2.50	450
Triple superphosphate	96	2.00	192
Mustard oilcake	2700	2.00	5400
Rice bran	2700	0.70	1890
Total variable cost			23382
Interest on working capital @ 15% per nnum			3507.30
A. Grand total			26,884.30
		Say	26,900.00
B. RETURN			
Sale of 4000 kg fish @ Rs. 10/kg.			40,000.00
C. NET PROFIT B-A			13,100.00
% of return on varible cost			48.7
Cost of production per kg			6.72
Percentage of profit to turnover			32.7

14. CONSTRAINTS

As evident from the preceeding chapters the scientific carp culture technologies have high production potential with economic return. However, there are certain constraints hindering the desired spread of the technologies in the country which may be broadly categorised as input supply, financial, extension gap, legal and social. These need be tackled on priority basis for effecting extensive fish culture.

Input : Fish seed, a major input in fish culture, is still in short supply in many parts of India. Seed of Chinese Silver and Grass carps are particularly still scarce. Efforts like popularisation of induced breeding technique and bundh breeding in areas of favourable ecological conditions are steps which need be given due emphasis to overcome this constraint.

Timely and easy availability of other critical inputs, like fertilizers and feed in rural areas for fish culture poses problem in the development. Streamlining of a system of availability of these inputs is called for.

Financial : In order to meet the increased capital requirement of new technologies, selective liberalisation in lending procedure is essential. In case of ownership ponds banks may accept water bodies as adequate securities, while in lease hold ponds the fish crop may be accepted for hypothecation to meet the short term requirement of funds.

Extension : Lack of knowledge regarding scientific fish culture and its economic viability on the part of the farmers is another constraint. A cencerted effort by different concerned organisations with trained man power, equipments and other facilities to gear up the fishery extension machinery is essential to overcome this constraint.

Legal : States particularly in eastern region abound in natural endowments, human skills and conventional wisdom in respect of culture fisheries but adequate legislative support was often lacking for the development of inland fisheries. The ownership/control of water areas belonging to the Government in several States vested with departments other than fisheries. Further, community ownership through agency of Panchayats or local self bodies did not aid development of fisheries. In respect of private waters structural rigidities namely multiple ownership, public easement rights etc. impeded the development process. The leasing arrangements have generally been devoid of development bias mainly because of the short term lease period. Vast majority of water bodies particularly in eastern India are privately owned where leasing agreements are a bipartite affair depending on market forces. There is an imperative need for framing tenancy legistalion similar to agricultural lands.

Social : Poisoning with agriculture insecticides or weedicides out of sheer vendetta and illegal removal of fish crop (poaching) are serious production disincentives in fish culture. This probably can be tackled by creating a social awareness on the matter and also by making the law of the land more stringent.

15. SUMMARY

The fingerling of Indian and exotic carps are raised to table size fish in about a year in enemy free stock ponds under favourable conditions with enough of food.

- The ponds may be rectangular, 0.1-2.0 ha in size and 2.0-3.0 m deep. Ponds with depth ranging from 1.0 to 1.5 m can also be used in absence of above desirable depth range.

- The productive soil status of a fish pond include loamy or clay loamy bottom free of excessive decomposing organic matter, pH 6.5-7.5, available nitrogen (N) 30-50 mg/100 g, available phosphorus (P_2O_5) 6.0-16.0 mg/100 g and organic carbon 1.0-2.0%.

- The acid and sodic soil types are less productive and are initially corrected. While acid soil is corrected by liming at different doses (500-2000 kg/ha) according to pH of soil, sodic soil is corrected by application of cowdung @ 20-30 t/ha and gypsum @ 5-6 t/ha.

- Sandy bottom is corrected with organic manure @ 20-30 t/ha. Pond bottom with heavy organic matter is corrected by removing excess mud, ploughing, liming @ 1 t/ha and exposing the bottom to sun. If dewatering is not possible, bottom may be raked occasionally followed by liming @ 1 t/ha/yr in split up doses.

- Weeds are undesirable in fish ponds and can be controlled by manual, mechanical, chemical or biological methods.

- Manual method involving only physical labour and the mechanical method requiring sickles, barbed wire etc, operated by manual labour, are easy to operate and are convenient for small ponds.

- Chemical method includes use of different harbicides like 2, 4-D, ammonia etc. at different doses for various weeds. This method may be used with proper technical guidance.

- Biological control agents include grass carp for submerged weeds like *Hydrilla*, *Najas*, *Ceratophyllum* etc. and floating duck weesds like *Wolfiia*, *Lemna*, *Azolla*, *Spirodela* etc. *Puntius gonionotus* is also useful with similar feeding habits. Yamuna turtle (*Kachuga tectum*) consumes water hyacinth. Larvae of *Erastoides curvifasciata* is a consumer of *Pistia*.

- Predatory and weed fishes are eradicated by application of mahua oilcake @ 2000-2500 kg/hectare-metre or tea seed cake @ 750-1000 kg/hectare-metre or ammonia @ 20-25 ppm, or bleaching powder @ 25-30 ppm.

- Quick lime @ 200-250 kg/ha is generally recommended for application as prophylactic measure even in slightly alkaline soil, a week prior to stocking.

- Both organic manures and inorganic fertilizers are used on monthly instalment basis, during the culture period, the quantity of each item determined on the basis of soil nutrients. Organic manures and inorganic fertilizers are applied alternately at an interval of a fortnight. The initial dose of cowdung, if mahua coilcake is not applied as piscicide, may be applied 15 days prior to stocking.

- In absence of soil testing facilities, the generalised recommendation of fertilizer schedule include cowdung @ 200 kg/ha as initial dose and @ 100 kg/ha as monthly dose. Inrganic fertilizers *viz.* Urea @ 15 kg/ha/month or ammonium sulphate @ 30 kg/ha/month or calcium ammonium nitrate @ 30 kg/ha/month and single super phosphate @ 20 kg/ha/month or triple super phosphate @ 8 kg/ha/month.

- 6 species combination of catla, rohu, mrigai, grass carp, silver carp, common carp and the 4 species combination of catla, rohu, mrigal and common carp perform equally well on an all India baisis.

- The ratio of different secies in 6 species culture may be catla 10-15%, silver carp 20-30%, rohu 15-20% in moderately deep ponds and 10% in shallow ponds, mrigal 15-20%, common carp 20-25% and grass carp 5-15% depending on the availability of weeds. The 4 species culture may include catla 30-40%, rohu 20-30% or 10-15% depending on water depth, mrigal 15-20%, common carp 20-25%. The 3 species culture may include catla 40%, rohu 30% and mrigal 30% in general.

- The general recommended stocking rate is 5000 fingerlings of100-150 mm size per hectare. In well prepared ponds, early fingerlings or even advanced fry can also be stocked. Stocking need be done 3 weeks later to piscicide application after ascertaining complete detoxification.

- Water temperatures ranging from 25-30°C is conducive to fish growth and lower temperatures below 18°C adversely effect growth. The stocking period may thus be so manipulated that low temperature months are not included in the culture period.

- The mild winter zones of coastal and north eastern states provide scope for a 12 month culture with stocking operation between June and September.

- Severe winter areas of north and north western states experience low temperatures during winter, limiting growing priod to 8-9 warmers months. Stocking time in such places may be in February—March with harvesting operations in November or so. The fallow winter periods may be utilized for pond preparation.

- A supplementary feed item need contain 25-30% protein, 30-40% carohydrate with dietary energy content at 3.5-4 Kcal/g of feed. Various feed combinations including commercial feed are now available in the country.

- The most commonly used feed mixture of groundnut/mustard oilcake and rice polish/bran at 1 : 1 by weight is generally fed @ 2-3% of body weight of fishes daily in morning hours, commencing from second day of stocking, as doughs placed in trays. A generalised quantity recommended is @ 4 kg/day during first month, @ 5 kg/day during second month, @ 6 kg/day during the third month and thereafter, increasing the quantity by 2kg during every subsequent month to be coninued upto 12th month.

- Grass carp is fed with aquatic weeds like *Hydrila*, *Najas*, *Ceratopyllum*, *Wolffia*, *Lemna*, *Azolla* and *Spirodella*. In absence of these, berseem, napier grass, soft land grass, vegetable wastes etc can also be fed. Feeding is done as per their consumption.

- If alternaive water source exists nearby, water replenishment or refilling can be done which will help removal of adverse affects due to metabolites. Reconditioning of water by biological filters and aerators are done in some countries.

- Fishes over 750g are regarded as marketable and can be harvested. Generally the fishes attain individual weight of atleast 1 kg in 12 months when they are harvested.

- An average production of 4 t/ha/yr is obtained by the farmer through this technology and the same is achievable in any part of the country against the production range of 60-600 kg/ha/yr under traditional system.

- Well fed fishes grown in ponds under hygienic conditions are less vulnerable to diseases. In incidence of diseases, prophylactic and therepeutic measures are adopted according to requirement of the specific disease.

- Common hazards that need care, time to time, include incidence of diseases, algal bloom, population imbalance, undesirable weeds and fishes, harvesting in large deep ponds.

- With an investment of Rs. 26,900/-, net profit of Rs. 13,100/- per hectare per year with cost of fish production at Rs.6.72 showing 48.7 percent of return on variable cost is obtained at current prices.

- The constraints that need be tackeed on priority basis for effecting extensive fish culture in the country can be categorised as input supply, financial, extension gap, legal and social.