STUDIES ON THE BREEDING AND REARING OF *CYRINUS CARPIO COMMUNIS* L. AND *LABEO ROHITA* (Ham.) IN THE ALTITUDINAL SITUATIONS OF MEGHALAYA ALONG WITH AN EXPERIMENT ON COMPOSITE FISH CULTURE

By

DONBOR ROY THANGKHIEW, M.Sc.
DEPARTMENT OF ZOOLOGY,
SCHOOL OF LIFE SCIENCES

SUBMITTED IN FULFILMENT OF THE REQUIREMENT
OF THE
DEGREE OF DOCTOR OF PHILOSOPHY
TO

THE NORTH-EASTERN HILL UNIVERSITY
SHILLONG
January, 1981

ABSTRACT

The present investigations were focussed on the various breeding and culture aspects of the Common Carp, Cyprinus carpio communis L. and the Indian major carps, Labeo rohita carried out at different altitudinal situations in Meghalaya State during the years of 1977, 1978 and 1979. These experiments included breeding, suitability of different egg collectors, rearing of spawn to fry, fry to fingerlings and fingerlings to table size fish along with an year round experiment on composite fish culture.

The most efficient of the egg collectors proved to be the Coconut fibre raft which was five times more efficient than the Aluminium wire frame nylon net, 3.5 times than the Wooden frame nylon flap and twice efficient than the aquatic weed.

Based on the breeding experiments conducted during the 3-year period, the percentage of hatching in the different years were 62.2% in 1977, 64.2% and 53.7% in 1978 for the two experiments and 76.14%, 61.9% and 81.8% in 1979. The loss of most of the fertilized eggs and their hatchability were due to a fungal infection caused by Saprolegnia which were seen to bloom in the rotting weed even from the very first day of egg incubation and spreads to the unfertilized eggs specially at low temperatures. However, in 1978 in addition to the fungal infection the low hatching was also attributed to rain and hailstorm and the prevailing cold temperature (14.5 to 19.5°C).

The rearing experiments on Common Carp were carried out for the three year period (1977-1979) in various combinations

of habitats and feeding regimes. Further, these experiments relatu to the rearing of the spawn to fry, fry to fingerlings and fingerlings to table size.

It is very clear at the present altitude in spite of thu species differences the growth rate in the Common Carp fry is certainly retarded about 3 to 5 times lesser since what is obtained in 15 days at the plains is reached only in a mean period of 75 days. Thus the faster growth achieved in the tropics is due to much warmer temperature and whereas at Fish Dale farm at Shillong the slow growth rate was mainly due to the prevailing low water temperature in addition to the water having an acidic pH range, low alkalinity and low plankton production. It may be added that despite these somewhat adverse environmental conditions along with low plankton production, the frys probably survived subsisting mostly on the supplementary feed of rice bran and mustard oil cake fed every alternate day, augmented by weekly addition of nutrients manuring with cowdung.

The major advantages of rearing spawn in closed and fixed nurseries (hapas) are that these are primarily predator free in addition to the maintenance of a fair degree of constancy and free from the influence of some of the physical factors such as heavy rains and hailstorms which do not normally affect such hapas as these are covered at the top. Nevertheless, the meshes of the hapa always facilitated the entry of phytoplankton and zooplankton and encouraged the growth of periphyton which also form added nutrition as these organisms are known to be a primary fish food. The other benefits of such confined rearing of spawn are that the hapas serve to be hygienic since the wasto matters are unused food or faecal matter are easily seeped down through the meshes and also reduces the elaborate manual labour which are otherwise needed in nursery ponds. Such closed rearing reduces the strain and injury to the fry while netting which could not be avoided in nursery ponds.

The gross growth increment in the plastic pools is almost similar to that achieved in the nylon hapas as well as the rate of growth is retarded as was also seen in hapa. These results once again confirm the altitudinal effects of the physicochemical and biological factors in the present study, as compared to the findings in the plains. However, the mortality rates in the plastic pools (28.4%, 39.6%, 21.4%, 16.6%) are on the higher side when compared with the nylon hapas. While it is not possible to pinpoint the causes precisely, it may be suggested that the total isolation and confined nature of the plastic pool habitat with no physical contact with the surrounding water medium probably led to accumulation of toxic metabolites in addition to lack of inflow of any food material from the surrounding environment as was the case in the immersed nylon hapas.

The rearing experiments were designed with a primary purpose of finding out the growth and survival of Carp fry to fingerling size by employing not only different foed combinations but also during the off season of the annual cycle, in contrast to the conventional practice of fry rearing from May-July, soon after the breeding season in March and April. Normally, in these Hill Regions these frys are reared to fingerlings of about 3-6 cm length and 5.0 gm weight for a 3 month period (May-July) before they are distributed for stocking.

A comparison of the growth and production in the different plastic pools, reveals that the optimal yield was obtained in Pool 1, followed by those of Pools 2, 3, 4 and 5 in that order. This could be undoubtedly due to the differences in the nutritive value of diets offered in the pools, which enabled the fry in Pool No. 1 and 4 to grow better, probably by efficient conversion. The present results have further shown that while addition of organic manure certainly oncouraged better growth as seen between Pools 1 and 2, oil cake alone could probably enhance growth as seen in Pool 4, since the growth in this system was even more than in Pool 2 with rice bran and mustard oil cake. The growth in Pool 3 with rice bran alone did not yield good results. It may therefore be suggested that even oil cake alone or when supplemented by cowdung would probably yield optimal growth rate at this altitude.

The third and final phase of the present series of experiments on the Common Carp was the rearing of fingerlings to table size as conducted in a pucca nursery pond at an altitude of 1,550 m at the Fish Dale farm, Shillong for one year during 1977-78. The size range of fingerlings used were between 6.0-16.0 cm and 5.0-50.0 gm. As a result of this experiment, the mean weight attained by these fingerlings was between 65-585 gm, with the individual maximum of 585 gm. Based on this rate of growth the total production worked out to 4,240 kg/ha/yr. The monthly record maintained on growth increment showed that most fish attained their maximum growth during the first fivo months of the rearing. This period extended from November to April which included the months with rising temperature soon after winter. An interesting sidelight of this experiment is the attainment of sexual maturity and subsequent spawning of a few of the larger females as clearly evidenced by the presence of newly recruited fry of 3.0-3.5 cm long and 0.6-1.0 gm in weight in the population.

While relating the groups of plankton to the growth of fish it was seen very clearly that among the phytoplankton, it was Euglenophyceae and among zooplankton it was Protozoa which showed positive correlation with the growth rate of the fish. It is known however, that very high production of fish are noted from waters with blue-green algae specially the plankton food-urs in the lowest trophic levels grew well and high yield (Sreenivasan, 1966) though occassional mortality due to oxygen depletion simultaneously have been recorded (Sreenivasan, 1964). However, in our case it is an omnivorous feeder and has proved that it is the disturbance created by these fishes on the sides and bottom of the ponds releasing the necessary protozoans and flagellates like Euglena which has definitely improved in their growth rate.

An outcome of the rearing experiments from fingerling to table size fish is an attempt to calculate the overall economics of the monoculture of Common Carp in Shillong area in terms of expenditure incurred and the total return of fish from the experiment. Tho results of the present experiment at Fish Dale, Shillong, indicate that on the basis of a total input of Rs.408/-, the cost of production of a kilogram of fish worked out to Rs.3.85 as compared to the cost price range of Rs.2.38 to Rs.2.93 kg reported earlier from the composite fish culturo experiments conducted by the Central Inland Fisheries Research Institute in different regions of the country (Jhingran, 1978). This production cost of under Rs.4/- in the present study is to be compared with the prevailing market rate of fish price at Rs.16/- kg. Thus, the cost of production is just one fourth of the current selling price, in spite of the fairly high cost of supplementary feeds in the hill regions used in the present study.

The present series of predatory experiments on one vertebrate and the three invertebrate predators have shown that the overall predatory propensities on 100 carps spawn in terms of percentage are 31% and 56% for the dragonfly nymphs, while 22.4% and 18% for the notonectids and frogs respectively. Thus it may be concluded that the most important predatory pressure at these altitudinal ponds are due to the dragonfly nymphs followed by the notonectids and the frogs in that order of descending magnitude.

Further the breeding, spawning and rearing experiments on the Indian Major Carps, Labeo rohita at this altitude, may be concluded that this naturally acclimated tropical species from the plains of India could be bred and reared at intermediate altitude, though with limited success. The present concensus based on available information points to the fact that breeding and growth of major carps, perhaps, cannot be attributed to any one single factor as a combination of several abiotic and biotic factors of the environment is involved. The present experiments conducted only reveal that induced breeding and subsequent rearing of Rohu (*Labeo rohita*) are possible at the lower altitudes of these hill regions and the environmental factors are not totally unsuitable.

The composite fish culture experiment tried for the first time in the State of Meghalaya at a relatively warmer altitude of 850 m with fingerlings of Silver Carp, Common Carp, rohu and mrigal showed that rohu had the least growth reaching a maximum of 240.0 gm, mrigal fingerlings obtaining a maximum of 305.0 gm, Common Carp growing to 655.0 gm and the Silver Carp showing the best growth of 715.0 gm at the end of the growing period.

These different experiments discussed above have given some baseline information on the culture potential of water systems in the State of Meghalaya in North Eastern India. It is admitted that various constraints beset such field oriented researches, particularly in countries like ours. These studies had to be undertaken in collaboration with the local State Fisheries Department who offered their field facilities. Since this Department itself is in a state of infancy, not much help could be obtained. Nevertheless, the present studies have opened up some problem areas for further intensive work. It is hoped that a combination of the available technology in the country and the few techniques evolved in the present study will ultimately help in establishing sound aquacultural practices in this part of our country.

STUDIES ON THE BREEDING AND REARING OF *CYRINUS CARPIO COMMUNIS* L. AND *LABEO ROHITA* (Ham.) IN THE ALTITUDINAL SITUATIONS OF MEGHALAYA ALONG WITH AN EXPERIMENT ON COMPOSITE FISH CULTURE

By

DONBOR ROY THANGKHIEW, M.Sc.
DEPARTMENT OF ZOOLOGY,
SCHOOL OF LIFE SCIENCES

SUBMITTED IN FULFILMENT OF THE REQUIREMENT
OF THE
DEGREE OF DOCTOR OF PHILOSOPHY
TO

THE NORTH-EASTERN HILL UNIVERSITY
SHILLONG
January, 1981

Thesis

Grams : NEHU

Phone : { Office : 3390
Res. : 6620

North-Eastern Hill University

Dr. R. George Michael
Professor ~~& Head~~

DEPARTMENT OF ZOOLOGY
SCHOOL OF LIFE SCIENCES
NONGTHYMMAI
SHILLONG - 793 014

I certify that the Thesis entitled "Studies on the breeding and rearing of _Cyprinus carpio communis_ L. and _Labeo rohita_ (Ham.) in the altitudinal situations of Meghalaya along with an experiment on Composite fish culture" submitted by Shri Donbor Roy Thangkhiew for the Degree of Doctor of Philosophy of the North-Eastern Hill University, Shillong, embodies the record of original investigation carried out by him under my supervision. He has been duly registered and the Thesis presented is worthy of being considered for the award of Ph.D Degree. This work has not been submitted for any degree of any other University.

Date 18/12/80

Place - Shillong

R George Michael
(R. George Michael)
Signature of the Supervisor

ACKNOWLEDGEMENTS

I wish to express my indebtedness to Professor R.George Michael, Department of Zoology, North-Eastern Hill University and also gratefully acknowledge him for the encouraging and unfailing guidance, the critical comments and kind scrutiny throughout the course of the work and in the final analysis as it is presented now.

My deep sense of gratitude to Dr. J.R.B. Alfred, Reader, Department of Zoology, North-Eastern Hill University, for his kind help, valuable suggestions and interest in the work throughout.

I would be failing in my duty if I miss to specially acknowledge Mr. Madhap Prasad Thapa and Md.Rashad ul-Islam my colleagues, for their unfailing and constant help during each stage in the development and outcome of this thesis. Thanks are also due to Mr. A.Bhattacharya, Mr. H.Dkhar and Mr. W.Diengdoh and all friends for their kind help for processing of this thesis.

I am also grateful to Mr. M.S. Lyngdoh, Deputy Director, State Fishery Department, Meghalaya, for his interest and in rendering every possible help to me.My thanks are also due to all the Fishery Officers and Fisherman of the State Fishery Department for their kind cooperation during the course of my work.

I also wish to express my sincere thanks to Mr. Khambor Tariang for typing the manuscript, Mr. S. Roy Choudhury, Artist and Mr. B. Das for helping with photographic plates.

Last but not the least, my thanks are also due to the North-Eastern Council for the award of a Fellowship under the "Hydrobiological conditions for Fishery Development in the North-Eastern Region" during the tenure of which the present investigations were carried out.

Lastly, I wish to record my sincerest gratitude to my Parents, Grandmother and family members for not only rendering me every possible help during the course of my work, but encouraging me to forge ahead in moments of deep frustations.

(Donbor Roy Thangkhiew)

C O N T E N T S

-:o0Oo:-

LIST OF PLATES

LIST OF FIGURES

between pages

LIST OF TABLES

INTRODUCTION

INTRODUCTION

Meghalaya meaning the 'abode of the clouds' is the twenty-first State in the Union of India. It is bounded by Nowgong, Kamrup and Goalpara Districts of Assam on the North, Mikir Hills and North Cachar Hill Districts of Assam on the East and Bangladesh in the South and West. The total area of the State as of date is 22,549 sq km. It lies between the latitudes of 25°47'N and 26°10'N and the longitudes 89°45'E and 92°47'E. The main land of Khasi and Jaintia Hills Districts has a salubrious climate while the third District of Garo Hills is relatively warmer being situated at a lower altitude than the others. The average minimum temperature in the Khasi and Jaintia Hills is 4°C, while it is 12°C in Garo Hills. The average maximum temperature is 24°C and 34°C for these two areas (Meghalaya Year Book 1975). The State of Meghalaya is endowed with immense water resources comprising of about 5303.24 ha of ponds, tanks, lakes, reservoirs and beels and innumerable stretches of rivers, streams and rivulets (Annual Plan Report of Meghalaya State Fishery Department, 1980). In addition to this ideally suited agro-climatic conditions characterised by the early onset of monsoon and high rainfall exist in this region. In spite of these immense natural resources in terms of aquacultural production potential, fish production is far from development in this region,as only empirical means and methods of fish culture are still in vogue. In order to augment the fish production, considerable attention is being paid by the State Fishery

Department for intensive exploitation of smaller water areas and as such extensive breeding experiments on the Common Carp (Cyprinus carpio communis L.) for the production of fish seeds are given priority.

Fish culture in ponds has been practised in India, especially in Northeast region since very long time. The traditional method used to be to stock the ponds with available species of fish fry without adopting any rational scientific method and as such the production remained very low with about 600 kg/ha/yr on an average (Sukumaran, 1978). In comparison to this, fish production ranging from 3863-4815 kg/ha/yr was obtained by culturing together Silver carp, Grass carp, Black carp (Mylopharyngodon piceus) and Mud carp (Cirrhina moliterella) in Chinese waters (Lin, 1954). Production in Japan by using different culture techniques were esimated at about 4.1-8.2 tons/ha in small ponds and irrigation tanks, 112-338 tons/ha in recirculating and filtering ponds, 616-1950 tons/ha in running water ponds and 414 tons/ha in impounding nets (Brown, 1969).

In the Indian scene, Inland fish culture practices have made tremendous strides in the last two decades. The introduction of exotic fish like Silver carp and Grass carp into India (Alikunhi & Sukumaran, 1964) and the initial success in inducing them to breed in captivity (Alikunhi et al 1963) along with the then already established induced breeding technique of Indian major carps (Choudhuri & Alikunhi, 1957) assured the supply of quality fish seeds.

This in turn paved the way for multi-species culture, otherwise termed as composite fish culture. It is now known that this attempt initially yielded a production of 1,000-4,900 kg/ha/yr (Alikunhi *et al* 1971) and the same results further confirmed by reaching a production of 2,229-4,210 kg/ha/yr (Lakshmanan *et al* 1971). The highest production so far achieved with a combination of six species of carps is 9,397 kg/ha/yr (Chaudhuri *et al* 1974).

In contrast to these national achievements of maximum fish production there are still areas in our country lagging far behind in such endeavours. The conditions prevalent in the hill states of the North eastern region could be cited as typical examples of the above state of affairs. For instance in the State of Meghalaya, inspite of the existing adequate water resources and agroclimatic conditions, still the production figures are considerably low. Even the attempts of the State Fishery Department were restricted mostly to the method of control breeding and hence the supply of limited amount of seeds of Common Carp, although recently attempts are being made towards composite culture. With this low fish production and to provide a quantity of fish protein (20 kg/capita) at least to 50% of the population, it is estimated that about 10,000 tons of fish would be required per annum as against the present total production of 1,390 tons. It has been suggested that by implementing modern techniques and also by bringing in additional water area under fish culture, even at the rate of 2,000/kg/ha/yr, 1,980 tons of fish could be added to make a total of 2,250 tons of fish from culture fishery alone (Jhingran, 1974).

Seized with these problems of inadequate fish production and lack of proper infrastructure for fish culture, the North Eastern Council, Shillong sanctioned a scheme to collect as much base line information as possible which will be of help in implementing sound modern techniques for fish culture. This was all the more necessary since the altitude, range of temperature, nature of soil and water and even the biotic communities are somewhat unique as compared to those conditions obtained in the plains of India. Consequently these hill aquatic ecosystems are to be thoroughly investigated as to their suitability for fish culture. With this in mind the present investigations have been attempted to gather fundamental information on as many aspects as possible on the environment, breeding, rearing and culture of Common Carp, a widely used species in fish culture in these hill regions.

Records on the introduction of exotic varieties of carp into Meghalaya State shows that the first consignments of the Prussian strain of Common Carp was brought in 1954 from Ootacamund and released in one of the systems in Shillong called Ward lake. The second consignment of Common Carp seems to have found its entry from the Gauhati Fish farm in Assam during 1964 which itself was earlier brought from Cuttack, Orissa. Since then the State Fishery Department had started controlled breeding of the fish with a view to supply seeds and to propagate this species. Since this is the only major cultivable species so far attempted for culture, the present investigations are largely confined to the problems concerning this species.

Based on an initial survey and identification of the problems related to fish culture in this State, two main areas were chosen for detailed study, viz., (i) study of high mortality of fish seeds and (ii) the retarded growth of fish in the local water bodies.

Naturally these two problems are closely interlined with pond management, breeding techniques, rearing practices, feeding regimes and understanding of the habitats. It was thought that if these problems are worked out under actual field conditions, the results achieved will be of direct value for immediate implementation, hence all the experiments were conducted in the fish farms belonging to the State Fishery Department. Thus, three fish farms were chosen representative of different altitudes. These are, the Fishdale in Shillong at 1,550 m, the Mawpun Fish farm in Barapani at 1,100 m and the Fish Farm in Kyrdemkulai at 850 m. Since these farms are also the seed producing centres of the State, they offered an opportunity to compare our results with those of the existing methods as practised by the State Fishery Department.

Thus the present thesis embodies the results achieved on the breeding experiments, rearing of the spawn to fry, fingerlings and table size fish, causes of mortality and predation in the Common Carp, *Cyprinus carpio communis* L. from the highest altitude of Meghalaya. In the middle altitude, induced breeding, hatching and rearing experiments were conducted on *Labeo rohita* and the result gathered are presented. At the lower altitude, a round the year study of Composite culture employing four species of carps (Rohu, Mrigal, Common Carp and Silver carp) was attempted and the results discussed. The thesis also includes data on the present status on fish and fishery as obtained through proformas circulated within the State.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Fish culture owes its inception to the Chinese, since the earliest clear record in Chinese literature is said to be "The Classic of Fish culture", believed to have been written by Fan Lai in 475 B.C. With the experience gained through generations, the Chinese have brought fish culture to a very high level of development even to adjacent countries like Malaya, Formosa, Indonesia and Thailand. The origin of fish culture in India is largely unknown, though Kautilya's - Arthasastra', written sometime between 321-300 B.C. indicates that fish were probably cultured in reservoirs at that time. Eastern India, particularly Bengal is an area where fish culture is conducted on a large scale.

Fish culture in the modern sense is known to have become established in England in the 1400 and 1500 A.D. using carp; this must have been introduced from Europe at about that time. Taverner (1600) gives an idea of certain experiments on the study and practice concerning fish culture. He further gives carp not only a frequent mention but pride of place as a cultivated fish. Markham (1613) also writes and suggests that the best soil for fish culture is those which are either marshy, boggy or full of spring and indeed most unfit either for grazing or for any other use. The common carp, which is probably a native of China, has been exported to several countries all over the World and its culture has achieved a very high degree of perfection. The association of the species with a view to utilizing all available food resources in a pond, appear to have been first developed in China (Gunther, 1868). The general conditions under which carp culture is carried out in Bengal have been briefly mentioned by Prashad (1919), according to whom the large majority of the tiny fry stocked in ponds are either preyed upon by predators or die owing to lack of food, the latter also causing stunted growth of the very few that survive. Birthwhistle (1931) states that in Singapore, the sandy soil gives the sweetest fish. Schaperclaus (1933) also supports the idea and refers to the culture of common carp as early as in 475 B.C. in China. He also suggested that the large and important fish farming industry of Lusiata is situated on the poorest soil from the point of view of agriculture and forestry and that waters which need 0.1 to 0.5 cc of HCl are not very productive, whereas a productive water is that which titrates 2-5 cc; and also gives the following as a desirable ratio between the areas of the successive ponds : Breeding pond - 0.25%, Nursery pond - 2.75%, Fingerling pond - 10.00%, Rearing pond - 23.00% of the area. Hoffman (1934) describes that in China a fish pond is of varying size and is drained every 2-3 years. At this time, surplus soft mud may be scraped off and used as fertilizers in field and garden. Buschkiel (1937) pointed out that in Java, the pond may be very small indeed for only a few square metre to 50 X 30 m. The carp fry are bought from dealers and are mainly bred in rice fields. Lin (1940) also studied Hoffman's work and suggested that fish pond should be drained partly or wholly to dryness once every one or two years, so that the bottom is exposed to full rays of the sun for sometime. An average mortality of 50-60% is generally experienced in rearing of fry of the large mouth black bass (Huro solmoides) to fingerling stages as reported by Smith and Swingle (1943). In the cultivation of milk fish (Chanos chanos) in the Phillippines an estimated mortality of 70% from the fry stage to marketable size and 10 to 40% mortality of fry during the first 4 or 5 weeks in nursery ponds have been reported by Carbine (1948). Rather heavy mortality of fish fry in the early stages of rearing has been reported from various countries. Krumholz (1949), reported that not more than 40% of the Bluegill yolk fry stocked in the spring survived the first summer, while by the end of the second summer as few as 1% and not more than 20% of the original stocked remained. Lin (1949) in his account of the fish fry industry of China does not give exact figures of the percentage of survival of carp fry but states that if only 5% of the fry collected could survive and grow to attain a reasonable increment in weight, this could give a clear idea that the fish grew. Wunder (1949) states that a newly constructed pond built on soil which has not previously been flooded gives a high yield of fish. He also pointed out that the yield of a pond has been doubled by liming. Lin (1950) has however, stated that the newly hatched fry of common Chinese carps released in half hectare nursery ponds at the rate of about 4 million survive only to the extent of 12-30% during a period of two weeks to a month. Probst (1950) observed that the yield of carp pond is positively correlated with average temperature during the growing period of May to September. Alikunhi et al (1951) observed that high dissolve oxygen generally accompanied with high pH and vice versa. In ponds which had dense algal blooms the dissolved oxygen was over 20 ppm, resulting in supersaturation exceeding 300% and such conditions are fatal to the fry owing to gas accumulation in the stomach, gut and subcutaneous spaces. It has been shown that the main food of the tender carp fry in the first few days from the commencement of their feeding in the environment is zooplankton and that the planktonic algae are consumed only as emergency food which is hardly digested and on which the fry do not thrive (Alikunhi, 1952). Removal of all minnows and other fish from the nursery ponds is of utmost significance as they usually feed heavily on the tender carp fry released in them (Alikunhi et al 1952). With given ideal conditions like abundance of desired food and absence of all enemies, even a 100% survival of fry has been obtained in aquaria during the first week of rearing (Alikunhi, 1952). In Indonesia, the average survival of Chanos fry in the tambaks is not more than 30%, though some expert Chinese fish growers obtain a survival of 60-80% by adopting special methods of rearing (Schuster, 1952). Whereas Hofstede et. al. (1953) state that in the culture of common carp (*Cyprinus carpio* L.) in Indonesia a mortality of about 60% of the fry stocked has been estimated. Mortimer (1954) observed that the water supplying a pond will usually contain some useful nutrient salts such as nitrate, ammonium, phosphate and potash and at times these salts are present in the water in such quantities that added fertilizers will be ineffective.

Depasse (1956) found that water shows great variation as to acidity and alkalinity reserves. More acidic the water, the biogenic capacity is slight or nil with low faunal variety and more alkaline the water it supports rich and varied plant and animal life. Wurtz (1956) showed that lime is used mainly to correct the acidity in the soil and water. Swingle (1957) considered that productive waters are those with a pH ranging from 6.5-9.0, and pH below 4.0 and above 11.0 proves generally lethal for fish. In India water on acidic soils is generally less productive of fish than that on alkaline soil (Alikunhi, 1957). Shimadata et al (1957) observed that in Japan, proper management with liming, fertilizing and feeding with silkworm pupae gave a crop of carp equivalent to 3,350 kg/ha. The production figure is still higher in the tropics where there is usually little seasonal variation of temperature and as a result fish growth may proceed the year round without any check. Swingle (1957) supported the idea and pointed out that fish are variable in their tolerance of cold. Kawamato et al (1957) found that carp grown at different stocking densities grew better when more sparely than when densely stocked even though given the same amount of food per fish. Yashouv (1958) observed that carp raised in waters in which other carps had been crowded show retarded growth and the harmful effect was greater with greater concentration of carp waste products. Rose (1959) records that water in which tadpoles or fish have been grown inhibits the growth of their own kind or other species because of the secretion of harmful byproducts in the water in greater quantities.

Schaperclaus (1959) observed that the fish production in pond in East Germany could be much increased by restoring them to their original depth. Investigations on various cultural aspects of the scale carp have been carried out at the Pond culture division of Central Inland Fisheries Research Institute at Cuttack, India and some important contributions on the bionomics of common carp (Cyprinus carpio L.) are from Alikunhi and Chaudhuri (1959). Various views have been advocated as regard to the origin and distribution of common carp (Gunther, 1868; Schaperclaus, 1933; Okada, 1960; Jenkin, 1961). Hora and Pillay (1962) have presented valuable information on common carp of the Indo-Pacific region and at present, the common carp is known to enjoy global distribution occurring in tropical as well as temperate regions acclimatised to a variety of habitats and extremes of environment (Alikunhi, 1966). Sarig (1966) has produced biological data on common carp in the Near East and Europe and stated that in East European countries in fertilized ponds with artificial feeding, this fish attains 30-100 gm at the end of the first summer, 250-700 gm at the second summer and a marketable size of 1,000-2,000 gm at the end of the third summer, with the stocking densities varying from 500-1,200 fish/ha; and in Israel about 500-700 gm was harvested in 90-120 days when ponds are heavily manured and fishes artificially fed. The diverse breeding techniques employed on common carp have been described in detail by several workers (Schaperclaus, 1933; Hofstede and Ardiwinata, 1952; Sahin, 1955; Hora and Pillay, 1962; Alikunhi, 1966 and Sarig, 1966). Detailed investigations on various cultural aspects of scale carp of India is mostly through the works of Alikunhi (1966). It was observed that the eggs in the prespawning stage can remain dormant for many months and yet respond at once to a suitable spawning stimulus or trigger such as by the rising water temperature of spring and autumn or the seasonal changes of day light or a combination of both (Wee and Chung, 1964; Lake, 1967). The common carp can be made to breed any time during the year, yet there are two seasons when optimum results are achieved, one during July and August and the other in mid January and March (Singh, 1968). But **currently** most of the Indian and Chinese carps and even the Russian and Rumanian Sturgeon are no longer relied upon for their natural spawning but are increasingly bred artificially by pituitary inducement (Tang, 1964; Yashouv, 1969; Manea, 1969). The procurement of pure seed of cultivated fishes from dependable sources posed a problem in India until the technique of hypophysation was successfully applied to Indian major carps. The history of hypophysation of fishes has been reviewed by Pickford and Atz (1957), while those of Indian carps by several workers (Alikunhi et al 1960, Chaudhuri, 1960; 1963; Das and Khan, 1962; Bhimachar and Tripathi, 1967; Jhingran, 1969; Chondar, 1970; Shehadeh, 1970; Tripathi and Bhimachar, 1972 and Khan and Jhingran, 1975). The various cultural aspects of fishes in nursery, rearing and stocking ponds along with the stocking rate, growth, mortality, feeding regimes and the production rate have been reviewed by most earlier investigators (Schaperclaus, 1933; Alikunhi et al 1952; Alikunhi, 1956, 1957; Ibrahim, 1957; Yashouv, 1959;

Chaudhuri, 1960; Hickling, 1962 and 1971; Hora and Pillay, 1962; Lakshmanan *et al* 1967, 1968; Ling, 1967; Shell, 1967; Huet,1970; Khan, 1971; Sneed *et al* 1972; Singh *et al* 1972 and Jhingran, 1975). On the other hand, the destructive effects of predatory insects upon carp spawn, fry and fingerlings causing low survival rate have been reviewed by various authors (Khan and Hussain, 1947; Pakrasi, 1954; Alikunhi *et al* 1955; Alikunhi, 1957; Chaudhuri, 1960; Ganguli and Mitra, 1961; Gorai and Roychaudhuri, 1961; Julka, 1965, 1969 and Jhingran, 1975). Vaas and Sachlan, 1957; Kuronuma, 1968; Gribanov *et al* 1968;
Bardach et al (1972) and Suzuki (1976) showed the high potential of culturing fishes in floating cages which has assumed the dimension of a full scale enterprise in Japan and Thailand where both marine and freshwater habitats are utilized. According to them the most suitable among the freshwater fishes are the common carp, Bass, Bluegill, *Tilapia*, White channel Cat fish and *Pangasius* cat fishes which are used in large scale for cage culture. In India cage culture was attempted for the first time with air breathing fishes in swamps with successful results and among the Indian carps *Catla catla* and *Cirrhinus reba* appear to be well suited for cage culture in reservoirs and other lentic waters (Dehadrai *et al* 1974 and Natarajan, 1976).

Introduction of Silver and Grass carps into India (Alikunhi *et al* 1957) and the first success in inducing them to breed in captivity (Alikunhi *et al* 1963) along with the then already established induced breeding technique of Indian major carps (Chaudhuri and Alikunhi, 1957) assured the supply of quality fish seed in this country. This paved the way for multispecies culture as composite fish culture which yielded high production of 1,000-4,900 kg/ha/yr, hitherto not reported from India before 1971 (Alikunhi *et al* 1971). However, it should be added that equally high production of 2,229-4,210 kg/ha/yr was obtained from the experiments during 1965-1968 though reported only later (Lakshmanan *et al* 1971). Subsequently by employing exotic carps alone the production figure of 2,896 to 3,281 kg/ha/yr was obtained (Singh *et al* 1972). The highest record production of 9,397 kg/ha/yr was achieved in 1974 amounting to a net production of 9,056 kg/ha/yr (Chaudhuri *et al* 1974; Jhingran, 1975, 1977). Another exotic species of fish of appreciable significance for developing aquaculture in uplands of India was the introduction of the German strains of common carp, *Cyprinus carpio* in the year 1939 at the Fish Dale farm at Ootacamund in Nilgiris was established in 1946 for breeding and culture of the three phenotypes of common carp (Jhingran and Sehgal, 1978). In the global context, the detailed accounts of the history of transplantation of common carp have been given by Howell (1916), Mitchell (1918), Molesworth and Bryant (1921), Mackay (1945), Jones and Sarojini (1952), MacCrinon (1971), Sehgal (1974), Jhingran and Sehgal (1978). A note on the breeding care and management of common carp, *Cyprinus carpio* L. was again reviewed by Jhingran and Sehgal (1978).

Pedro Noriega (1979) has studied the various parameters associated with the productivity of a fish pond and concluded that manuring of fish pond may not only be an exercise in fertilization but also a means of promoting the growth of fish through other alternative trophic pathways. It was also reported that by using supplemented artificial food and different fertilizers, the growth rate of Mrigal capito fry was increased in Egypt (Bishara, 1979).

The growth kinetics of Anabas testudineus showed that there existed inverse relationship between the growth curve and the variations of conductivity, bicarbonate, alkalinity and phosphate content of water but pH, free carbon-dioxide and dissolved oxygen showed no linkage. However, growth increment and nitrate level were directly related (Jana and Das, 1980). Joshi (1980) while working on the induced breeding of Labeo rohita from Nainital revealed that continuous rainy weather is essential for successful induced spawning with a water temperature range between 27°-30°C and turbidity 72.5-135 ppm for 80% fertilization and hatching of eggs respectively with a optimum pH range of 7.2-8.5. Joshi and Khanna (1980) observed that the fecundity of Labeo gonius per kg body weight was 2,86,111.

MATERIAL AND METHODS

MATERIAL AND METHODS

For all the experiments during the present investigations, the experimental ponds in three fish farms of the Meghalaya State Fishery Department were used. These were the Fishdale at an altitude of 1,550m at Shillong, Mawpun fish farm at 1,100m and in Kyrdemkulai fish farm at 850m. In addition to this, a few sets of experiments on predation were conducted under laboratory conditions and on mortality rates of fry and fingerlings under seminatural conditions in plastic pools within the premises of the University.

Most of the breeding experiments were conducted with the Common Carp, Cyprinus carpio communis L. in the farm ponds at Fishdale, Shillong; during the breeding seasons (March-May) of 1977, 1978 and 1979. Every year, prior to the experiments, brooders were netted out from the stocking ponds during the month of February. Males and females were segregated and reared in separate nursery ponds of 0.01 ha size with a depth of 1.5m. A mixture of rice bran and mustard oil cake in the ratio of 1:1 was fed at intervals of alternate days at a rate of 2-3% of the total body weight of the fish. The temperature was monitored continously during these months of breeding as it was known that the common carp at this latitude normally spawns at a temperature range of 17°-22°C (Annual Report of Meghalaya State Fishery Department, 1977). When the optimal temperature was reached, the broeders from the conditioned ponds were netted out usually in the morning and evening hours and transferred into the nylon hapas of 2.5 X 1.0 X 1.0m size.

PLATE - I

Showing map of the State of Meghalaya, indicating the rivers, reservoirs and State Fishery Department Ponds.

Name of rivers

1) Hari	22) Umiew
2) Umngot	24) Umsohryngkew
5) Lubha	26) Umkrem
7) Kopli	29) Someswari (Simsang)
8) Umkhen	30) Dareng
10) Umiam	36) Dudnai
12) Umsen	37) Krishnai
13) Khri	40) Jinjiram
14) Umngi	42) Rongai
15) Umsyntai	44) Ganol
20) Kynchiang	47) Umtrew

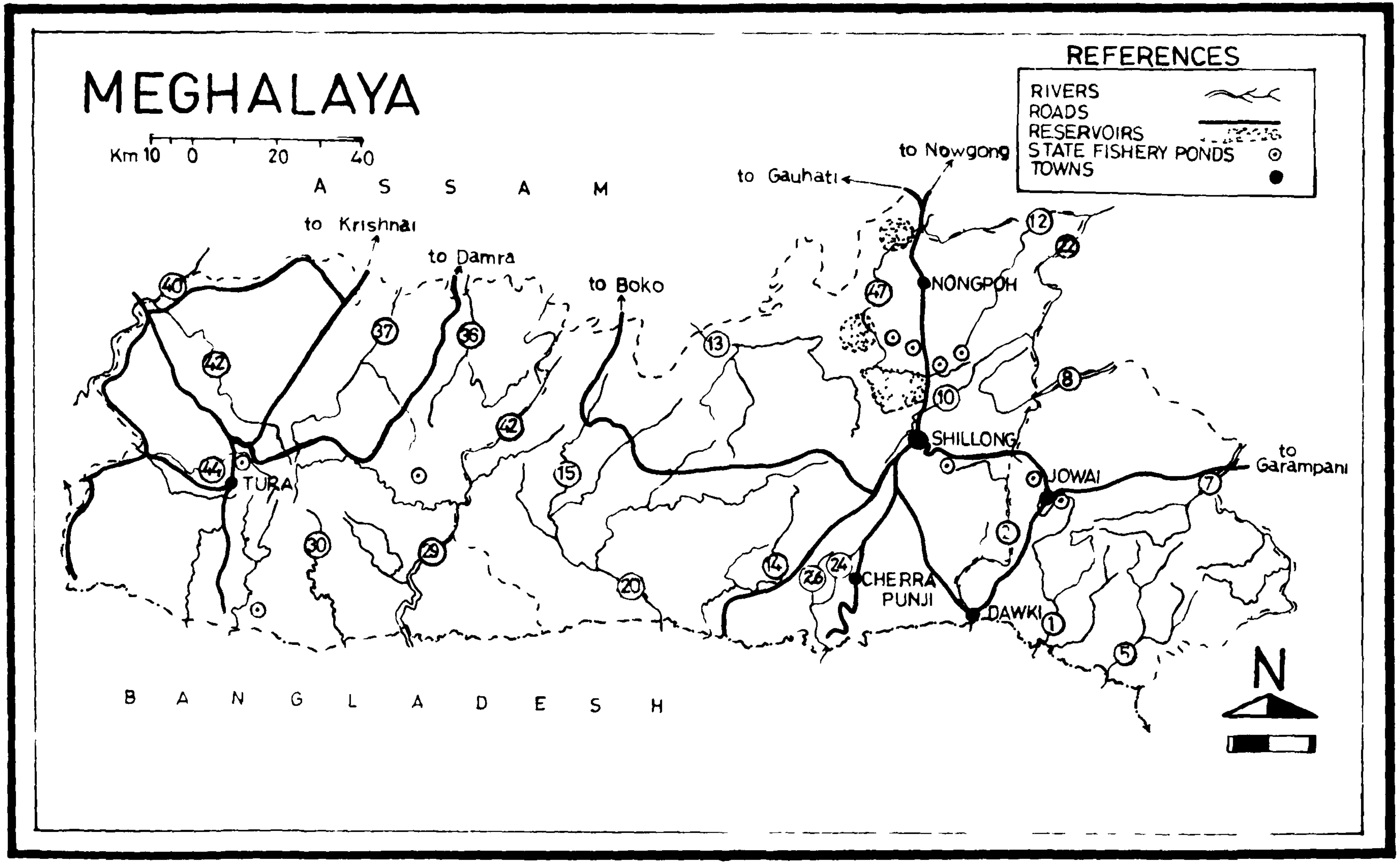

MEGHALAYA
Km 10 0 20 40
A S S A M
B A N G L A D E S H
REFERENCES
RIVERS
ROADS
RESERVOIRS
STATE FISHERY PONDS
TOWNS
to Krishnai
to Damra
to Boko
to Gauhati
to Nowgong
to Garampani
NONGPOH
SHILLONG
JOWAI
DAWKI
CHERRA PUNJI
TURA
N
40
42
37
36
42
44
30
29
15
20
13
47
10
14
26
24
12
22
8
7
1
5

PLATE I

While choosing the brooders, care was taken always to select the fully matured females characterised by an almost rounded, soft and bulging abdomen and vent slightly projecting like a small papilla with a narrow median slit. Similarly, males were chosen on the basis of characteristics such as very rough pectoral fins, rough scales with the vent not projecting but deep and pit like. Further, males were easily distinguished by the free release of milt with gentle pressure on the abdomen. The individual brooders were weighed using a Monopan spring balance (Yamato make) graduated to 5 gm divisions. Brooders were stocked in a ratio of 1:3 by weight (one female: three males). In the present study, two types of breeding experiments were conducted; (a) Control breeding (b) Induced breeding. Again experiments on control breeding were performed using both the hapa and the plastic pool. Each of the plastic pools measured 2m broad and 1m deep and water was filled only upto 2/3 of its height. Pools were always kept covered by a net to prevent escape and jumping of the brooders. Since the eggs of common carp are known to be of an adhesive type, the conventional method was by providing artificial substratum. The present practices as employed by the State Fishery Department is the use of the aquatic weed, Rotalla rotundifolia, Hydrilla and pine needles. For reasons to be discussed in detail later, in addition to the aquatic weed Rotalla, improvised Coconut fibre rafts and Nylon net frames were also tried in the present studies in order to estimate the relative efficiencies of different substrata. Generally the weed Rotalla used in the present experiments were collected from near the banks of streams and ponds at Umkhen (Happy Valley); Mawpun Fish Farm (Barapani), Umsning farm (Umsning), Kyrdemkulai farm (Kyrdemkulai) and Umran stream and brought to Fish Dale at Shillong and kept in one of the nursery ponds for the breeding experiments. These plants were well sorted out and thoroughly washed before introducing the same in breeding hapas for egg collection. Normally 2 kg of the weed was used for a 1 kg female fish (Jhingran & Sehgal, 1978). The Coconut fibre raft was made of wooden frame of 45 x 30 cm, rectangular in shape in which five hanging rows of Coconut fibre were arranged longitudinally with 5 cm spacing in between (Plate IV). The Nylon net frame were also made of a wooden frame rectangular in shape of 45 x 30 cm with five rows of nylon flaps fixed longitudinally with 5 cm spacing (Plate IV). These nylon flaps are made to hang like curtains with their free ends extending upto 15 cm in height. Both the Coconut fibre raft and wooden nylon net frame were made to float by fixing thermocool to the top four corners of the frame. These artificial egg collectors were always thoroughly washed in water before the introduction into the hapa or plastic pools. Whenever these artificial substrata were experimented upon, only two of each and 0.5 kg of aquatic weed (Rotalla) were used for each hapa or plastic pool. After spawning, the egg collectors were carefully examined as the fertilized eggs of common carp are less conspicuous than the unfertilized eggs which are whitish and opaque. The diameter and weight of each individual egg was measured with the help of a reading scale calibrated to mm readings and a Balmer electric monopan balanco sensitive to 0.001 gm. The

PLATE - II

(a) Showing the overall view of the Fish Dale Farm, Shillong.

(b) Showing the breeding hapa.

(c) Showing the Plastic Pool for breeding experiments.

PLATE II

a

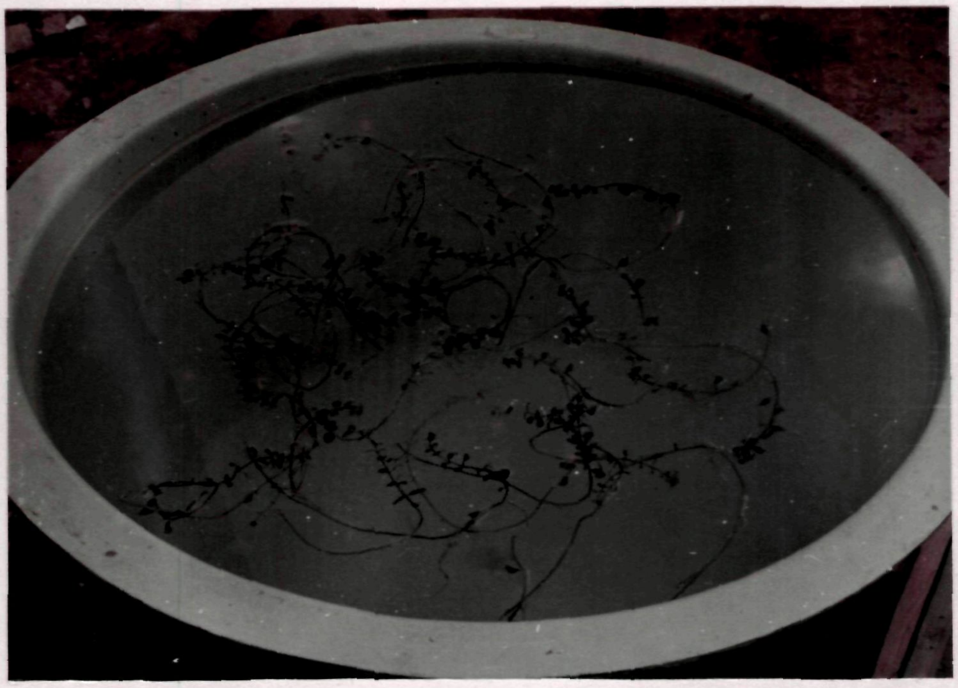
b

c

PLATE - III

Plastic Pool showing the aquatic weed,
Rotalla rotundifolia used as egg collector.

PLATE III



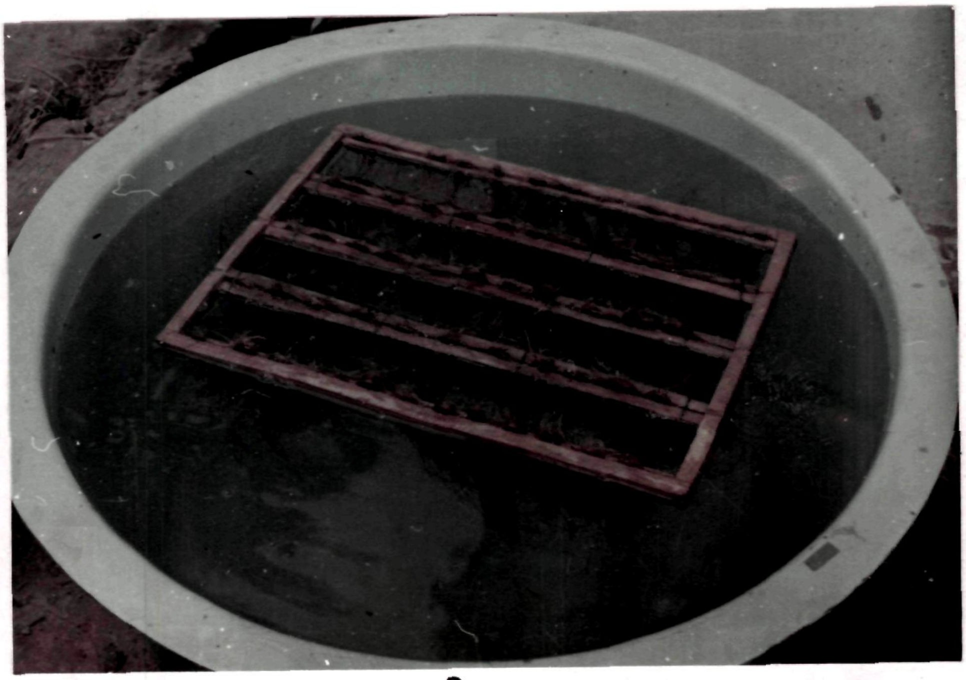
a

PLATE .. VI

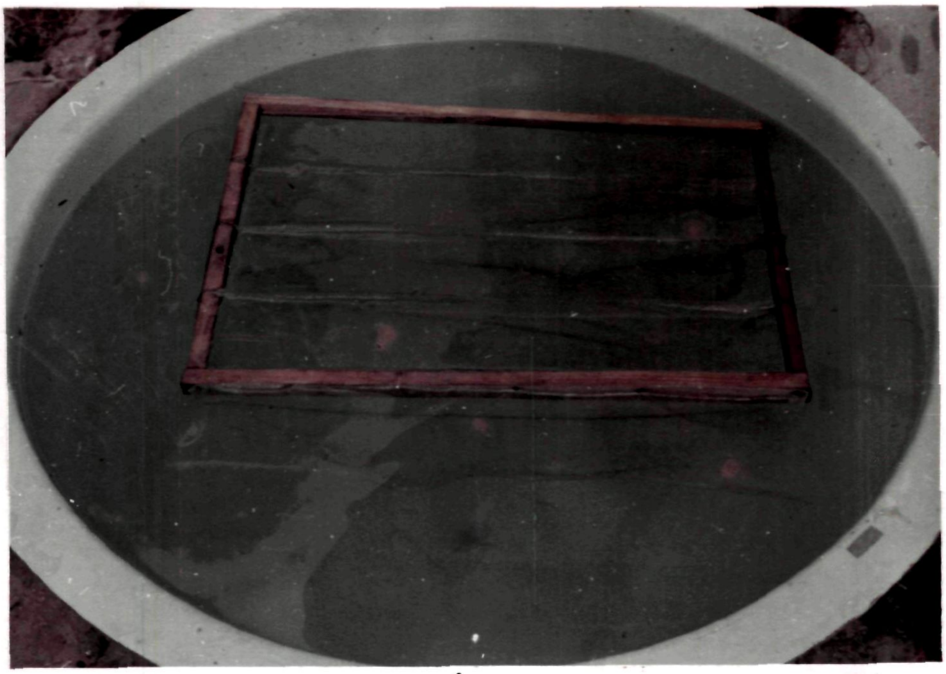
(a) Showing the unfertilized eggs attacked by *Saprolegnia* sp.

(b) Heavily infected eggs with *Saprolegnia*.

PLATE IV



a



b

difference in weight between the gravid and the spent female, multiplied by the weight of each egg, gave approximate fecundity of the fish in terms of total number of eggs per female (Alikunhi, 1960; Jhingran & Sehgal, 1978).

The egg collectors with the attached eggs were removed from the breeding hapa and were uniformly distributed in a doubled wall hatching hapa of 2.0 X 1.0 X 1.0 m (outer hapa) and 1.75 X 0.75 X 0.50 m (inner hapa). It is known that a hapa of the above size can accomodate 40,000 - 60,000 eggs. Subsequently these hapas were fixed in the nursery ponds or in stocking ponds for hatching. After hatching the egg collectors were kept for a day or two in the hapa in order to provide shade to the young hatchlings. On the third day both the egg collector and the inner hapa were removed and the hatchlings left in the outer hapa till the absorption of yolksac. The actively swimming baby fish with yolksac completely absorbed having the mouth opened and feeding voraciously is known as the spawn. While collecting the spawn, all the corner ropes of the hapa are first untied from the poles and spawn brought to the centre by lifting it slowly, two persons holding either ends. The spawn which get stuck to the cloth on the inner wall of the hapa are washed down the centre by splashing water from outside. Water was allowed to drain off and the spawn are measured in a small perforated cup of known volume (200 number of spawn/cup). At the time of measurement, the dead spawn are removed as far as possible. Three samples of spawn are taken for counting the number of live and dead spawn in each sample cup. The total number of spawn obtained can be worked out approximately by multiplying the total number of spawn produced in each sample cup by the total number of cups. Following this, the spawn are stocked in nursery ponds, nylon net hapas or in plastic pools. Most of the above procedures are already available in literature (Chonder, 1970; Jhingran & Sehgal, 1978), though were slightly modified to suit the altitudinal conditions of this hill region.

In a three tier fish culture system, the first step begins with the rearing of the 3-4 days old spawn of common carp to fry size in nursery ponds. In the present study the size of spawn used were between 5-6 mm (Plate XIIc). The nursery ponds used for rearing experiments at Fish Dale, Shillong were of the pucca type, two in number of 100 sq m and 200 sq m with a maximum depth of 1.5 m. The source of water was from a small stream named 'Ka Wah Dienglieng'. The ponds being small in size were easily manageable as water can be refilled and drained off at will. Hence the initial problems of eradication of aquatic weeds, predatory fishes and aquatic insects do not arise. The only major problem to be taken care of were the acidic nature of the water and the low plankton content. In order to rectify the acidity of water, liming was resorted to by adding quicklime at the rate of 1,000 kg/ha/yr since the water was too much on the acidic range. The pond management was done twice a year, the first during the month of March for the rearing of spawn to fry and the second during October for the rearing of fingerlings to table size fish. During each period the pond was completely cleaned and sundried for seven days and on the eight day half of the required amount of quick lime was sprayed all over the pond bottom and sides and left as such for four days. On the twelfth day water was added upto 1 m depth when the pH of water was usually about 9.5. Gradually the pH decreases day by day and remained close to 8.0. On the sixteenth day the remaining amount of lime was sprayed all over the water surface. The pH of the water was further noted and around the twentysixth day it stabilised at 7.5. To obviate the low plankton production, manuring of fish ponds were necessary and organic manure in the form of dry cowdung was administered at the rate of 15,000 kg/ha/yr. Normally, one-fourth of the total amount was broadcast all over the pond, fifteen days before stocking and the rest was given as instalments at weekly intervals.

The spawn of 6-10 mm size were reared in such well prepared and managed nursery ponds at a very low stocking rate of 10^6 spawn/ha as compared to 10^7 spawn/ha suggested by the CIFRI (Sen, 1978). The spawn were fed with finely powdered rice bran for the first few days. Later on with a mixture of finely powered rice bran and mustard oil cake in the ratio of 1:1 fed on alternate days by broadcasting all over the pond surface in the morning hours. The feeding schedule was as follows :-

1st-3rd day of stocking - No supplementary feed. The spawn thrive with the abundant planktonic organisms present in the pond.

4th-10th day of stocking - Fed only with finely powdered rice bran, 3 times the initial weight of the total spawn stocked.

11th-20th day of stocking - Fed with a mixture of rice bran and mustard oil cake, 4-5 times the initial weight of the total fish stocked.

20th day onwards - Fed with a mixture of rice bran and mustard oil cake, 6-8 times the initial weight of fish stocked.

The duration of rearing of spawn to fry and early fingerlings stages ranged between 60-90 days in the above systems. After each set of exptt. the frys and fingerlings were completely netted out and the growth and mortality rates were noted.

The rearing of fingerlings to table size was conducted in a well managed pucca pond of 300 sq m size with 1.5 m of water in the same fish farm at Shillong. This experiment lasted for one year during November, 1977 to November, 1978. The fingerlings stocked and roared were of the 1976 brood, ranging between the initial length of 6.0 cm to 15.0 cm and 5.0 to 50.0 gm in weight. Supplementary feeding with a mixture of finely powdered rice bran and mustard oil cake in the ratio of 1:1 was given every alternate day at 4% of the total body weight of the fish. Along with this, the pond was also manured with cowdung at weekly intervals. A weekly analysis and record of the physicochemical and biological factors were made and as well as a monthly sampling of fish to note the growth rate, both in length and weight.

In another series of experiments spawn were also roared in fine meshed nylon hapas of 2 X 1 X 1 m size fixed to bamboo poles in a well managed nursery pond. In each hapa 10,000 spawn were reared ranging between 6.0-10.0 mm size and 5.0-12.0 mg weight. The duration of rearing was between 60-75 days with feeding at every alternate day with a mixture of rice bran and mustard oil cake in the ratio of 1:1. Weekly manuring with cowdung was also done by broadcasting all over the pond surface.

In a third series of experiments, plastic pool of 2 m broad and 1 m depth were used for the spawn rearing experiments. These pools were kept near the managed nursery pond and the same water was used. Each pool was stocked with 500 spawn of 6.0-10.0 mm and 6.0-12.0 mg weight and the same reared for a period of 60 days. Supplementary food of a mixture of rice bran and mustard oil cake was given every alternate day, although no cowdung was added. Each pool was drained half of its water at every 20 days interval and the same was replaced by fresh water from the adjacent nursery ponds.

A few experiments using plastic pools of varying sizes were also attempted for the rearing of fry to fingerlings in the University campus. These experiments were done mostly with different feed combinations to note the growth and mortality of fish. The plastic pools used were of 2.5, 1.5, 0.8, 0.5, 0.5 m broad and 1 m deep and were filled with tap water of pH 5.8. In order to attain the desired pH, suitable liming was done according to the sizes of the pools at the rate of 1,000 kg/ha. The pools were stocked with frys ranging between 5,500-1,500 mg weight and 3.5-4.0 cm size and reared for a period of

6 months (September, 1978 - March, 1979). The feeding regime in these pools were followed as under :-

Pool No. 1 - Rice bran, mustard oil cake and cowdung.
Pool No. 2 - Rice bran and mustard oil cake.
Pool No. 3 - Rice bran.
Pool No. 4 - Mustard oil cake.
Pool No. 5 - Control (no supplementary food).

In all the different systems along with these rearing experiments, environmental data such as temperature, pH, conductivity, oxygen, carbondioxide, alkalinity and plankton were collected and analysed at weekly intervals, with a monthly sampling of the stocked fish to note the growth rate.

A few predation experiments using the dragonfly nymphs, notonectids and the frog species, *Rana limnocharis* on the spawn of common carp were conducted at the laboratory during 1977. The following were the materials used for the experiments.

a) *Aeshna* (dragonfly nymph) - Size 5.0-6.0 cm
b) *Cordulia* (dragonfly nymph) - Size 2.0-3.5 cm
c) *Anisops* (notonectids) - Size 7.0-10.0 mm
d) *Rana limnocharis* (Frog) - Size 1.5 cm
e) Spawn of common carp - Size 5.0-6.0 mm
f) Rectangular glass jars of different sizes - 24 X 11 X 25 cm, 14 X 10 X 35 cm and 14 X 10 X 20 cm.

The jars and trays were thoroughly washed and filled with tap water. The predatory animals were brought fresh from Fish Dale and were reared in a glass aquarium containing pond water. Prior to the experiments these animals were netted out of the aquarium, their length were noted and were kept without food for 2 days in a glass jar containing tap water. For each set of experiments, 5 jars as replicates were used for each of the dragonfly nymphs, 2 trays for the notonectids and 4 jars for the frogs. Each set of experiment lasted for 24 hours. A total of 5 such series of experiments were conducted. The number of predators and spawn of common carp released in each jars/trays are given below :

Name of the Predator		Number of predators used per jar/tray		Number of spawn used per jar/tray
Aeshna	...	1	...	20
Cordulia	...	4	...	20
Anisops	...	10	...	50
Rana limnocharis	...	1	...	25

During the present series of investigations though the major thrust was on several culture aspects of common carp, a few studies were also attempted to work out the feasibility of the breeding and rearing of one of the Indian major Carps at the middle altitude of 1,100 m having a fairly low water temperature with the pH value mostly in the acidic range. For this purpose two sets of induced breeding experiments of the Rohu, *Labeo rohita* were conducted for the first time at Mawpun fish farm near Barapani during July, 1979.

The two-year old matured brooders for the above experiments were procured from the State Fisheries Department, Government of Assam at Gauhati in July, 1979. The weight of females used ranged between 450 to 460 gm, while the males were of 350 to 500 gm. These fish were stocked in one of the breeding ponds of 0.02 ha at Mawpun fish farm for acclimatization. The brooders were daily fed with a mixture of rice bran and mustard oil cake in 1:2 ratio given at 4% of the body weight.

Prior to the proposed hypophysation experiment the brooders were chosen on the criteria of, the female fish having a soft bulging abdomen with a pinkish and slightly protruding vent, while the males had rough pectoral fins and with milt oozing freely when the abdomen was gently pressed. Such male and female fish of somewhat comparable size comprising of one female and two males were weighed prior to the pituitary injection.

These induced breeding experiments on Rohu (*Labeo rohita*) were performed by the injection of fish pituitary hormone into the brooder fish. In addition the fish pituitary glands (rohu) were also brought from Gauhati and were stored in a 50 cc phial containing absolute alcohol. The glands are individually weighed in a Balmer monopan electric balance and are stored separately in a phial containing absolute alcohol with the weight noted therein. An extract was prepared from the pituitary gland and the quantity of the gland required for injection was at first calculated from the weights of the broodors. The required quantity of the gland was taken out of the phials and kept on a piece of filter paper for 1-2 minutes to allow the alcohol to evaporate. The glands were taken into a tissue homogenizer with little quantity of distilled water and 0.3% sodium chloride solution. The homogenized glands are then diluted by adding the required quantity of the same media in which maceration was done. The dilution depends upon the quantity of the gland to be injected and suspension was usually done at the rate of 4 mg of pituitary gland in 0.1 ml of the media, i.e. at the rate of 40 mg of the gland in 1.0 ml of the media. The gland suspension was then poured into a centrifuge tube and the homogenizer was shaken well so that the settled down gland particles mixes with the solution. Now the extract in the tube was centrifuged by a hand centrifuge machine (PlateXVIII) so as to separate minute suspended particles of crushed tissues and fat bodies from the liquid part containing the hormones. The solid particles settle down at the bottom of the centrifuge tube as sediment. The clear fluid containing the hormone was then decanted into a small beaker to be taken into a hypodermic syringe for injection. A preliminary dose at the rate of 4 mg of pituitary gland per kilogram body weight of fish was administered to the female brooder only. After 6 hours a second dose of 8 mg of gland per kg body weight was given to the female, while the males received only one dose this time at 4 mg/kg body weight. Intramuscular injection is usually administered on the caudal peduncle. The needle was inserted under the scale, first parallel to the body of the fish and then pierced into the muscle at an angle. A 2 ml hypodermic syringe was always used for the purpose having graduation to 0.1 ml division. The size of the needles used were BDH needle Number 22 and 24. The brooders in the hand net are then brought one by one for injection and placed on a small field table provided with a foam cushion just by the side of the water where the experiment was carried on. Two persons were required at the time of injection, one of them holds the head of the fish pressed gently against the cushion, while the second presses the tail with one hand and with the other gives the injection on the caudal peduncle through the meshes of the hand net (Plate XIX). The breeders after injection are released immediately inside the breeding hapa (Plate XVIII). Usually, a set comprising of one female and two males were kept in a breeding hapa for spawning, fixed in a nursery pond near the inlet having a gentle flow of water into the pond (Plate XVIII). The salient features which were maintained for the spawning are summarised hereunder :-

(i) Prior to the induced breeding experiment one of the nursery ponds was sundried for 10 days and refilled with water to a 1.5 m depth.

(ii) A constant flow or circulation of water was maintained through a nullah feeding the pond.

Soon after spawning the brooders were slowly brought to one side of the hapa leaving the eggs on the other an then removed without much disturbing the eggs. The female fish was weighed again and the loss in weight indicated the amount of egg released.

The eggs were collected from the breeding hapa when the embryos exhibited the twitching movement. For collection of eggs, the bottom corners of the hapa were first untied from the bamboo poles and then slowly lifted in order to bring all the eggs towards the open end and scooped out with a plastic mug and poured into a bucket containing water. Subsequently, the eggs were transferred into a rectangular close-meshed nylon net held in water. This net was then lifted slowly out so as to allow the water to drain off and the eggs to accumulate at one corner. The density of eggs were then quantified with a perforated and calibrated cup with a capacity of ca 150 eggs/cup.

After recording the quantity of eggs laid and the percentage of fertilization, the eggs were spread uniformly as a monolayer in the inner hatching hapa fixed to the shallow margin of a stocking pond to enhance aeration and easy handling. After most of the eggs hatch out, the inner hapa along with the unfertilized eggs and the cast egg membranes were carefully lifted and removed. The hatchlings in the outer hapa were allowed to remain there undisturbed for 10 days following which they were finally transferred into the Nylon hapa and nursery ponds for rearing.

Prior to the release of Rohu (Labeo rohita) spawns, the nursery pond was managed by drying, liming and manuring with cowdung following the same programmes as discussed earlier for rearing of Common carp spawn. The first phase of rearing was in a nylon hapa (2 X 1 X 1 m) by releasing 1,048 spawn of 6.5 to 8.5 mm in length. These were fed daily with finely powdered rice bran at the rate of 200 gm/day broadcast all over the surface of the water in the hapa and the feeding regime lasted for a period of 15 days. Subsequently for the second fortnight of rearing a mixture of finely powdered rice bran and mustard oil cake in 1:1 ratio at 400 gm/day was used.

The composite fish culture experiments attempted for the first time in Meghalaya was conducted in one of the farm ponds of the State Fishery Department, in a comparatively low altitude at Kyrdem Kulai for a duration of one year, from February, 1979 to February, 1980. The pond was of a katcha type, spring fed of 1,000 sq m area and having a depth ranging between 0.8 to 1.5 m. Prior to the stocking of fish, the pond was prepared and managed as described earlier. The seeds for these experiments as fry and fingerlings were procured from the Ulubari fish farm, Gauhati and Kyrdem Kulai fish farm in East Khasi Hills, Meghalaya. A four species combination was tried with two indigenous and two exotic carps with Rohu, Mrigal, Common carp and Silver carp. The fish were fed with a mixture of rice bran and mustard oil cake in 1:1 ratio every alternate day at 5% body weight, and a weekly manuring with cowdung at 15,000 kg/ha/yr on an instalment basis. Along with this a fortnightly study of the major parameters of the physical, chemical and biological factors of the pond were made, and a monthly sampling of fish was also conducted to note the growth rate. The length of fish was recorded with the help of a 'fish measuring board' calibrated in cm scale and a monopan balance of 5 gm sensitivity for measuring the weight. On each sampling date, two or three nettings were done to obtain a random sample of different species of fish for the record of length and weight. After measurements fish were always released back into the pond for further growth and development.

A fortnightly collection of plankton and water samples were made from the fish pond at Kyrdem Kulai fish farm, Kyrdem Kulai throughout the period of investigation from February, 1979 to February, 1980. Among the physicochemical factors, rainfall, atmosphere and surface temperature, conductivity, hydrogen ion concentration, dissolved oxygen, free carbon dioxide, total alkalinity, phosphate, nitrate and silicate were recorded. The water samples and plankton hauls were generally made in the morning between 9.00 to 10.00 A.M.

The rainfall data for the entire period of the present investigations from May, 1977 to March, 1980 were obtained from the Meteorological Observatory, Shillong, Meghalaya. The temperature readings were obtained using an ordinary thermometer graduated from 0-50°C. Samples of water were collected separately, one for dissolved oxygen determination and another for the rest of the chemical analysis in 250 and 500 ml glass stoppered bottles respectively. The Hydrogen ion concentration was estimated colorimetrically in the laboratory by means of an electric pH meter and in the field with a BDH pH comparator. The indicators used were Phenol Red (pH 6.8-8.4 & BDH Universal 4.0-11.0). Before employing the electric pH meter it was standardised by means of standard buffer solution (usually at 4.0-7.0 pH). Determination of dissolved oxygen, free carbon dioxide, total alkalinity, nitrate, phosphate and silicate were done by employing standard procedures (APHA Standard Method - 1955). For the estimation of dissolved oxygen, carbon dioxide and total alkalinity titrimetric methods and for the nutrients Colorimetric methods were followed. A Spectronic-20 Colorimeter (Bausch and Lomb Model) was used for this purpose. For the estimation of nitrate one additional technique, Nitrophenol disulphonic acid method as cited by Jackson (1964) was also adopted. Similarly, an alternative technique of Dienert and Wandenbulcke described by Vogel (1961) was followed for the estimation of the silicate content.

As indicated earlier, the plankton samples were collected along with the water samples at weekly and fortnightly intervals taken between 7.30 to 8.30 A.M. and 9.00 to 10.00 A.M. at Fish Dale, Shillong and Kyrdem Kulai fish farm respectively. The plankton was collected by filtering 50 l of pond water through a net of No. 25 bolting silk. A standard plastic bucket of 5 l capacity was used to draw water. On each occasion a bucket full of water was taken from each of the ten different points on the pond surface. Care was taken to disturb the water as little as possible while making the collections. Each sample was then made to 50 ml by addition of water and preserved by adding formalin to make a final 5% concentration. It was then thoroughly stirred, a sub-sample of 1 ml was quickly drawn with a wide mouthed pipette and poured into a modified Sedgwick rafter plankton counting cell of 1 ml capacity. This cell has 1,000 equal sized squares etched on its floor. Usually all the individual organisms in the subsample were completely counted. However, when blooms were present random squares were selected and the organisms present in such areas were enumerated. From this the total count per litre could be calculated. For the purpose of enumeration, a compound microscope with 10 X 10 magnification was used. All organisms were represented numerically as units of organisms per litre of water. The different taxa of plankton were grouped into major Categories and presented for discussion.

GENERAL SURVEY OF EXISTING FISHERY ACTIVITIES AND ASSOCIATED PROBLEMS IN THE STATE OF MEGHALAYA.

General Survey of existing fishery activities and associated problems in the State of Meghalaya.

Meghalaya is one of the youngest states within the Union of India. In view of its location among the hilly terrains of the Eastern Himalayan ranges, the State has several swift flowing rivers offering possibilities for not only generating hydroelectric power for industrial purposes but as well for fishery development and production. In view of these rich potentialities present, the present project was undertaken to survey and assess the total water areas, the water quality, the available fish species and also the existing practices of fishery management. The present data though primarily gathered as to the available water areas within the State, special attention was focussed on aquatic systems managed by the fishery department. The method adopted for this purpose was through proformas which were distributed at all levels, right from the individual fisherman and the private fish farm owner to the State Fishery units and personnel, Meghalaya State Electricity Board, Public Health Engineers and also to the three District Councils. In total 5,000 such proformas were distributed to individual fisherman alone of which only 2,553 were recovered. In the same way, out of the 2,000 proformas issued out to private fish farmers, 618 were returned. The rest of the results were gathered from governmental departments enumerated above by giving them modified proformas particularly suited for each of them. However, the hydrobiological data presented in this section include the proforma information from the Fishery Department, and additional data gathered by actual survey and analysis of water samples done as part of the present thesis work. The account given below therefore embodies the results and findings based on cumulative data thus gathered during a period of four years from 1977 to 1980.

Methods followed in data collection.

Three types of proforma (A, B, C) were prepared so that each compliments the other and thereby comprehensive data could be collected. The first relates to the individual fisherman and his catches, the second to the private fish pond owner, while the third pertains to the various departments of the State dealing with fish and the water systems.

The first category of proforma was distributed to as many individual fisherman as possible covering all the 5 districts of the State in order to gather maximum information on the fish catches, their quality, mode of fishing and frequency of fishing trips. The second proforma involved the collection of statistical information of the pond areas available in Meghalaya, as well as the fishes cultured and the problems arising during fish culture by private fish farmers. The third deals with data collection from the various governmental agencies concerning their programmes with reference to water area, fishery management and the current status in the field of fishery development in the State of Meghalaya.

Results

The data obtained through the recovery of different proforma were summarised and are presented below. The

PROFORMA-A : STATISTIC ON INDIVIDUAL FISHERMAN

1) Name :

2) Village and constituency :

3) Monthly income :

4) Sex - Male/Female :

5) Is fishing your whole time occupation or just a hobby? :

6) How frequently you go for fishing. :

7) Fishes generally caught :

8) Do you sell the fish caught? If so, :
   (i) How much of it you use for home consumption? :
   (ii) If sold, how much per kg.? :

9) In your opinion, are the fish population decreasing over the years? :

10) If so, do you think any of the following are the causes : overfishing/more poople are fishing/many kinds of poison used/more easy and quick transport available to reach the fishing sites/damming/trapping/or any other reasons. :

11) Any information about the most important sport fish of the State (Mahaseer group) :
    (i) How frequently do you catch these, their size and in which seasons and what will be their number in relation to the total catch. :

PROFORMA-B : PONDS AND THEIR PRIVATE USE FOR FISH CULTURE

1. Do you own a fish pond? If so, what is the size. :

2. What fish do you grow? :

3. How do you obtain the fish seed?:

4. What is your experience with regard to their growth: growing well/stunted/fast. :

5. Did you face the problem of seepage in your pond? :

6. In your opinion, do you think the seepage will pose a big problem in fish culture. :

7. Did you make any attempts to rectify the same. :

8. How much did you spend on the construction of your pond. :

9. Did you get any subsidy from the Government. :

10. Do you think any other species you know of could be cultured successfully in ponds? If so, why and what are their names. :

11. What is your opinion on fish culture? Do you think it will be an economic proposition? If not, why do you think so? :

12. In your constituencies, have people tried fish culture at all? If so, what information can you give? Are there any published record of fish cultural practices in the past, like gazetters, etc. :

PROFORMA-C : WATER AREAS, FISH AND FISH PRODUCTION IN MEGHALAYA

1. Names of the principal rivers of Meghalaya (Khasi Hills, Jaintia Hills & Garo Hills) :
2. Length of rivers or streams (Khasi Hills, Jaintia Hills & Garo Hills) :
3. Origin, length and confluence of these rivers/streams. :
4. Total water areas :
5. Water area presently used for fish culture :
6. Nos. of Ponds/lakes/Beels (In numbers and total area in hectare) :
7. Whether these ponds/lakes/beels are natural or man-made. :
8. Source of water :
9. Do they retain water in dry season :
10. Any problem of seepage/evaporation encountored. :
11. Local names of the fish species found :
12. What species predominate and in which environment :
13. Do any swampy areas available in the State. If so, where ? :
    (i) What is their approximate size in hectare
    (ii) What endemic fish species are available
    (iii) What is the annual production
14. Considering the different kinds of fresh water systems available which is more productive at present? If so, Why? :
15. In your opinion what are the factors responsible for their productivity (i.e. Physical, Chemical and Biological factors) :
16. Total annual fish production - :
    (i) Percentage of capture fisheries
    (ii) Percentage of culture fisherios
17. Have you introduce the technique of composite fish culture. If so, :
    (i) Name the fish species introduced and source of fish seed.
    (ii) Is this system proving successful?
18. What is the annual production of fingerlings of Common Carp in Meghalaya? :
19. What is the per capita consumption of fish in the State? :
20. What is the average landing of fish in the State with special reference to Shillong market. :
    (i) Where do fish come from
    (ii) What are the species? Gives names.
21. What are the fishing crafts and gears employed:
22. What are the methods of processing and preservation commonly practised in the State. :

information gathered on the fishing activities and catches of the individual fisherman are compiled and given in Table - A & B.

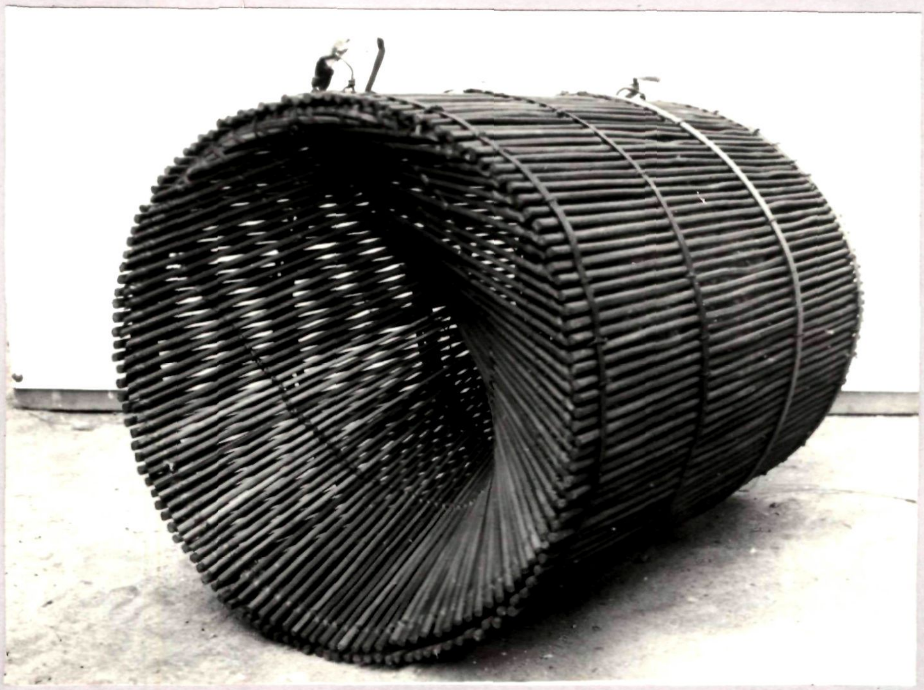
As mentioned earlier, that out of the 5,000 proformas distributed to fishermen, only 2,553 were received back from the 48 out of a total of 60 constituencies present in the State. The analysis of data further revealed that of the total fishermen almost 90% of them are engaged in fishing as a hobby and include people from all walks of life right from children attending schools to professional fishermen of all age groups. It is also of interest to note from the results that about 35% of the fishing community constituted of women, especially in Khasi Hills District, Generally, the fishes caught appear to be of only in small quantities with a mean catch of 800 gm/ head/trip. The fishes thus caught comprises mostly of the Common carp (*Cyprinus carpio communis*) Mahaseers (*Tor* spp and *Acrossocheilus hexagonolepis*), *Garra* spp and loaches in the hilly regions, while a mixture of both the Indian major and minor Carps and the Mahaseers in the plain areas. The present surveys show that fishes caught by those who fish for sports are mainly for home consumption, while some of the professional fishermen do sell their fishes at the rate of Rs.15/- kg for Common carp and Rs.18/- to Rs.20/- kg for the Mahaseer. The general consensus of most of the individual fisherman is that the fish population is on the decline in most streams, especially the Mahaseers, *Garras*, Loaches and *Glyptothorax*. The various causative factors attributed for the dwindling of the fish population are, such as damming and trapping in streams, the use of toxic plants, chemical poisons and dynamiting, resulting in overfishing. Regarding the methods of fishing, the most common technique as practiced in this hill region is by damming the stream water at the upper end with stone chips and by placing a basket made of bamboo kept submerged in water at the lower end (Plate V) Thus as the flow of water decreases both in terms of speed and quantity, the fish move downstream where they are finally trapped in the bamboo baskets. The next common technique of trapping employed in streams is by a method of partial damming with stones commencing from either banks till only a narrow middle zone is left open where a bamboo basket with both ends open is fixed (Plate V) This method is more efficient since it prevents the movement of fish both up and downstream which results in their final trapping. Such a method appears to be more in vogue during April and May and also in October and November during the breeding and spawning seasons of fishes. The technique employed for trapping in large bodies of water like the reservoirs was by the use of a bamboo cage fitted across the mouth on the outpushing of the lake. The mouth of the cage is provided with a sliding door which in turn is fixed to one main string with three side strings. The intensity of the movement of the string seem to indicate the presence and abundance of fish. The door is then pulled to close down and act as a trap closing the mouth of the bamboo cage. Normally this method of fishing is resorted to during the monsoon season when the rising water level naturally floods the outpushings and in turn these fencing cages. Various baits such as maize, gram, rye, rice bran and potatoes are used in this mode of fishing.

PLATE - V

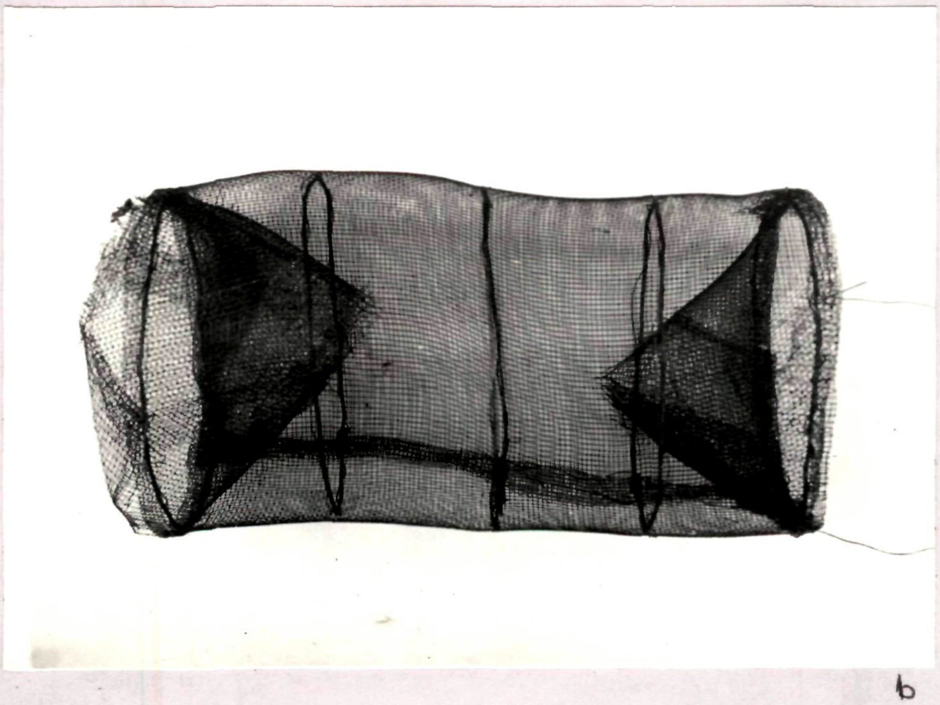
(a) Showing a fish trap (basket made of bamboo) with one end opening.

(b) Showing a fish trap (wire mesh basket) with both ends opening.

PLATE V



a



b

One of the most important factors for the decreasing fish population as revealed from the study of proformas is the indiscriminate killing by the use of crude extracts of different parts like roots, stem, fruits, leaf and even bark of certain plants that are toxic to fish which is an ancient custom among the tribal people of this State. At times, this method of poisoning is practiced either singly or by groups of people and at times even by the whole village community, performed as an annual ritual. In recent years, destruction of fish through the use of chemicals and dynamites appears to be on the increase.

One another specific problem pointed out in most of the proformas is the diminishing catches of the Chocolate Mahaseer, Acrossocheilus hexagonolepis, from the Umiam stream and reservoir in comparison to the rising number of the exotic Common carp. The Mahaseer group of fishes appear to be present throughout the State with their maximum catches reported during April to October in the colder hilly regions and from October to May in the warmer plain areas. As per the proforma, the maximum size recorded in angling of the catch of Acrossocheilus hexagonolepis was 80 cm long of 14.5 kg weight from the Umiam stream in July, 1977 and that of Tor putitora of 120 cm and 42 kg from the Kopli river in Jaintia Hills during December,1975.

Proforma B dealt with the data on ponds and their use for fish culture by private fish farmers as presented in Table - C. Out of a total of 2,000 handouts, 618 were returned and compiled and form the basis of the analysis. It is seen that there are about 1,131 ponds under private use covering an area of 590 ha. These water bodies appear to vary in size and range from 0.05 to 8.0 ha and distributed all through the State. The maximum number of ponds and those of large size were always reported from the plain areas. However, most of these ponds, specially those located in the hilly terrain have problems of seepage and consequently the water level drops to a minimum and in extreme cases totally dries up in late winter and spring season.

With reference to the querries based on fish culture technique and pond management, it is seen that the prevalent fish culture techniques are still mostly empirical and the method employed in stocking the ponds is mainly dependent upon natural seeds available from rivers or bought from private fish seed suppliers sold in markets. At times a meagre supply of Common carp seeds are being procured from the Fishery Department Farm at subsidised rates. It was also noticed from some of the replies in the proforma that the State Fishery Department is encouraging some interested fish farmers by offering grants for construction and rectification of their ponds. The most common practice employed in these ponds seems to be a form of mixed fish culture comprising of major and minor Indian carps, catfishes, murrels and Common carp. However, no further details of these practices are available for any evaluation in terms of management or production.

Proforma C relates to the various governmental departments in Meghalaya concerning their programmes with reference

TABLE-A : Presents the itemwise compiled data on the fishing activities and catches of individual fisherman as obtained through Proforma-A :

1.

2. <u>People engaged in fishing</u> -

   48 out of the 60 constituencies do fishing.

3. <u>Categories</u> -

   Non-earning children, to high income groups of Government officials and businessmen.

   <u>Income</u> -

   (i) Non-earning children; (ii) Daily wages labour (Rs.10/-day)
   (iii) Government and private firm employees (Rs.2500/-month)
   (iv) Businessmen (more than Rs. 1000/- day).

4. <u>Sex ratio</u> -

   Male 65% and Female 35%.

5. <u>Fishing</u> -

   As hobby 90% and as a profession 10%.

6. <u>Fishing trips</u> -

   A mean of 20 trips per annum.

7. <u>Hilly areas</u> -

   Mahaseer, <u>Garras</u>, Loaches, <u>Glyptothorax</u> sp, Cat fishes, <u>Channa</u> spp., Minnows and Common Carp.

   <u>Plain areas</u> -

   Mahaseer, Indian carps, Cat fishes, <u>Channa</u> sp. and Minnows.

8. <u>Use of fish</u> -

   (i) Mostly for home consumption.
   (ii) Rs. 15/-kg for Common Carp and Rs.18/-kg for Mahaseer.
   (iii) Rs. 12/-to Rs.16/-kg for Garra, Loaches, Minnows.

9. <u>Views on decline of fish populations</u> -

   No decline 10%; Causes unknown 30% and Positive decline-60%.

10. <u>Methods of fishing</u> -

    (1) Damming (2) Trapping (3) Toxic plants and chemicals
    (4) Dynamiting and (5) Rise of Common Carp population in the Umiam river and reservoir with corresponding decline of <u>Acrossocheilus hexagonolepis</u>.

11. <u>Information on Mahaseer</u> -

    Present in almost all the streams of the State of Meghalaya.
    (i) April to October, in the hilly and cold regions.
    (ii) October to May in the plains and warmer climate.

TABLE-8 : Presents the itemwise compiled data on the fishery activities and catches of Individual fisherman as obtained through Proforma-A :

1. Average Nos. of fishing trips annually.	:	20
2. Fishes generally caught	:	Mahaseer, Common Carp, *Labeo gonius*, *Labeo rohita*, *Cirrhinus mrigala*, *Puntius sarana*, *Notopterus* sp. *wallago attu*, *Rita rita*, *Bagarius* sp., *Channa* sp., *Mastacembalus* sp., *Anguilla* sp., Cat fishes, loaches, *Garra* sp., *Glyptosternum*.
3. Average weight of fishes caught per trip.	:	800 gm.
4. Total amount of fishes caught annually per man.	:	16,000 or 16 kg.
5. Uses of the fishes	:	Home consumption.

TABLE-C : Present itemwise compilation and summary of the data gathered on private owned fish ponds and the existing pond management practices therein as obtained through Proforma-B :

1. Pond size range -

   0.05 to 8.0 ha.

2. Species used -

   Mixed species culture :- Rohu (*Labeo rohita*), Catla (*Catla catla*), Mrigal (*Cirrhinus mrigala*), Calbasu (*Labeo calbasu*), Gonius (*Labeo gonius*), Puntius (*Puntius serana*), *Wallago atu*, *Channa* spp., Magur (*Clarias batrachus*), Singi (*Heteropneustes fossilis*), Common Carp (*Cyprinus carpio*).

3. Source of fish seed -

   (i) Rivers (ii) Private fish seed seller brought in hundies in village market (iii) State Fishery Department with Common Carp seeds only.

4. Growth -

   Mostly stunted. Reason not known.

5. Seepage -

   Only in Hilly terrains seepage is greatest, though a few systems in the Plain areas also.

6. Problem posed by Seepage -

   Yes, by (i) Low level of water available in December to May.
   (ii) And water drying up in spring season.

7. Remedial for Seepage -if any -

   Not attempted.

8. Cost of pond construction -

   Ranges from a minimum of Rs.400/- to a maximum of Rs.5,500/-.

9. Subsidy -

   Only few fish farmers are receiving. The amount received ranges from 25% to 40% of the total cost of the construction.

10. Aternative choice of fish species -

    No response.

11. Fish as an enterprise -

    Most people think it to be profitable.

12. Information of existing fish culture -

    No information on this aspect.

TABLE-D : Represent the Hydrobiological investigation of Pond water in Meghalaya (1977-1980).

RANGE OF THE PHYSICO-CHEMICAL FACTOR

Temperature (°C)	pH	Dissolved oxygen (mg/l)	Free carbon dioxide (mg/l)	Total Alkalinity (mg/l)	Phosphate (mg/l)	Nitrate (mg/l)	Silicate (mg/l)
7.0 to 33.0	5.2 to 7.5	6.0 to 16.2	2.0 to 8.0	12.0 to 80.0	0.003 to 1.25	0.01 to 0.35	.025 to 1.6

TABLE-E : Represent the fish seed produced, farm wise of the State Fishery Department, Government of Meghalaya during the 5th Five Year Plan.

Name of the Farm	SPAWN PRODUCED (units in millions)				
	1974-75	1975-76	1976-77	1977-78	1978-79
1) Fish Dale Farm, Shillong.	0.20	0.30	0.40	0.20	0.50
2) Mawpun Research Centre, Mawpun.	-	-	-	0.02	0.05
3) Nayabunglow Fish Farm, Umsning.	-	-	-	0.20	0.50
4) Kyrdem Kulai Fish Farm, Kyrdem Kulai	-	-	-	0.50	0.08
5) Thadlaskein Fish Farm,	-	-	-	0.04	0.50
6) Ladthalaboh Fish Farm, Jowai,	-	-	-	-	-
7) Tasek Fish Farm.	-	-	-	0.0115	-
8) Gangdubi Fish Farm.	-	-	-	-	0.03
9) Digrishiring Fish Farm.	-	-	-	0.176	0.1048
10) Dalu Fish Farm.	-	-	-	-	-

P. T. O.

TABLE-E : Represent the fish seed produced, farm wise of the State Fishery Department, Government of Meghalaya during the 5th Five Year Plan.

Name of the Farm	FRY PRODUCED				
	1974-75	1975-76	1976-77	1977-78	1978-79
1) Fish Dale Farm,	0.12	0.20	0.07	0.10	0.07
2) Mawpun Research Centre, Mawpun.	-	-	-	0.02	0.015
3) Nayabunglow Fish Farm, Umsening.	-	-	-	0.0213434	0.50
4) Kyrdem Kulai Fish Farm, Kyrdem Kulai	-	-	-	0.0085	0.08
5) Thadlaskoin Fish Farm.	-	-	-	0.0031	0.0055
6) Ladthalaboh Fish Farm.	-	-	-	-	-
7) Tasek Fish Farm	0.07	-	-	0.003	0.021
8) Gangdubi Fish Farm	-	-	-	-	0.009
9) Digrichiring Fish Farm.	-	-	-	0.03	0.022065
10) Dalu Fish Farm.	-	-	-	-	-

TABLE-E : Represent the fish seed distributed to private fish farmers (Assistant to Pisciculturist) by the State Fishery Department, Government of Meghalaya during the 5th Five Year Plan.

Name of the Farm.	FRY DISTRIBUTED/SOLD				
	1974-75	1975-76	1976-77	1977-78	1978-79
1) Fish Dale Farm.	0.04031620	0.078855	0.481150	0.86160	0.38021
2) Mawpun Research Centre	-	-	-	0.013	0.016
3) Nayabunglow Fish Farm.	-	-	-	0.020	0.031
4) Kyrdem Kulai Fish Farm.	-	-	-	0.008	0.0055
5) Thadlaskein	-	-	-	0.0031	0.0055
6) Ladthalaboh Fish Farm.	-	-	-	-	-
7) Tasek Fish Farm	-	-	-	-	-
8) Gangdubi F.Farm	-	-	-	-	-
9) Digrichiring Fish Farm.	-	-	-	-	0.01065
10) Dalu Fish Farm	-	-	-	-	-

TABLE-F : Represent the average daily landing of Fish at Shillong market for a period of six month collected during April 1978 to October 1978.

Name of the Fishes	Local Name (Khasi)	Average landing per day (kg.)	Landing from Meghalaya (kg.)	Landing from Other States (kg.)
1. Labeo gonius	Kha Ski	70	10	60
2. Labeo calbasu	Kha Iong	80	10	70
3. Labeo rohita	Kha Bah	100	-	100
4. Catla catla	Kha Baw	75	-	75
5. Cirrhinus mrigala	Kha Mrika	45	-	45
6. Hilsa ilisha	Kha Ilisa	25	-	25
7. Wallago attu	Kha Buwa	20	5	15
8. Notopterus chitala	Kha shitor	30	7	23
9. Notopterus notopterus	Kha Blang	20	5	15
10. Eutropiichthysvacha	Kha Basa	15	-	15
11. Clupisoma garua	-	8	-	8
12. Clarias batrachus	Kha Mukur	15	5	10
13. Heteropneustes fossilis	Kha Hingki	15	5	10
14. Channa sp.	Kha Thli	30	10	20
15. Mastacembalus	Kha Bsien	7	2	5
16. Mystus sp.	Kha Kot/Kha Tyngkra	3	-	3
17. Bagarius bagarius	Kha Khla	10	-	10
18. Ompok sp.	Kha Babia	5	-	5
19. Rita rita	Kha Rita	15	-	15
20. Labeo nandina	Kha Nanin	10	5	5
21. Puntius sarana	Kha Puthia	60	10	50
22. Acrossocheilus hexagonolepis	Kha Saw	8	8	-
23. Cyprinus carpio	Kha Dkhar	20	20	-
24. Garra sp.	Doh Jei/Doh Lynkdon/Doh Thang,Byrtum	3.5	3.5	-
25. Neomacheilus	Doh Sher	1.5	1.5	-
26. Minnows	Kha Shalynnai	0.5	0.5	-

TABLE-G : Represent the Departmental Farm wise water area in Meghalaya during 1978 - 1979.

Names of the District Farms	Total water area (ha.)	Stocking Pond area (ha.)	Rearing Pond area (ha.)	Nursery Pond area (ha.)	Potentiality of fry production from the available Nursery area (anticipated fry production in lakhs)
1. EAST KHASI HILLS					
a) Fish Dale Farm, Shillong	0.80	0.30	0.20	0.30	1.00
b) Mawpun Research Centre, Mawpun	1.67	0.88	0.34	0.47	2.00
c) Umktieh Fish Seed Farm, Barapani.	0.26	0.25	-	0.01	0.04
d) Nayabunglow Fish Farm, Umsning	0.75	0.55	0.10	0.20	1.00
e) Kyrdem Kulai Fish Farm, Kyrdem Kulai.	2.25	0.85	0.20	1.00	4.00
2. JAINTIA HILLS					
a) Ladthalaboh Fish Farm, Jowai	0.25	0.15	0.09	0.01	0.04
b) Thadlaskein Fish Farm.	0.24	0.11	0.05	0.09	0.32
3. EAST GARO HILLS					
a) Tasek Fish Farm.	13.48	13.40	0.04	0.04	0.16
b) Gangdubi Fish Farm.	0.79	0.34	0.34	0.11	0.50
4. WEST GARO HILLS					
a) Digrichiring FFish Farm.	0.84	0.40	0.34	0.10	0.40
b) Dalu Fish Farm	0.36	0.34	-	0.02	0.08

TABLE-G : Present the culturable water area in Meghalaya upto 1980

	Total water area for fish culture (ha.)	Present water area used (ha.)	Source
TOTAL CULTURABLE WATER AREA IN MEGHALAYA	5303.24		Annual Plan Report, 1980 - State Fishery Deptt., Govt. of Meghalaya.
1) State Fishery Farm, (Meghalaya).	21.60	21.60	"
2) Assistant to Pisci-culturist.	1121.84	1121.84	"
3) Applied Nutrition Programme.	10.00	10.00	"
4) Border Area Development Programme.	32.00	32.00	"
5) Reservoirs - 3 Nos :-			
(a) Umian (Barapani)	1036.00	-	ME.S.E.B. 1979
(b) Kyrdom Kulai (Kyrdem Kulai)	44.00	-	Annual Plan Report, 1980 Fishery Deptt.
(c) Umtrew (Byrnihat)	88.00	-	"
6) Beels and lakes.	213.00	-	North-Eastern Council Publication No.12
7) Private owned Ponds of local people.	590.00	590.00	Present Study (as obtained through Profoma-D)

to water area and fishery management. Data were gathered from these respective agencies and the results are summarised and presented herewith.

Since the major thrust of the present thesis was to evolve remedial measures with reference to fish production, the proper identification and recognition of the causes underlying low fish yield in this hill State is an essential prerequisite. With this in view, the proforma C was framed accordingly to obtain as much data as possible for eventual study and research. Hence the summarised information presented here forms an important prelude to the actual carrying out of the present investigations.

Water areas

Principal rivers of Meghalaya :-

In Meghalaya, rivers, rivulets and streams hold excellent possibilities for fishery development especially those fish which could be acclimated for the higher altitudes. These major lotic systems available in the three districts of Meghalaya are described below.

Khasi Hills District :

(1) Umiam (2) Umran (3) Umsen (4) Khri (5) Umngi (6) Umsyntai (7) Umterseng (8) Umbara (9) Gigang (10) Tidek (11) Kynchiang (Jadukata, Wahblei, Umtiniang, Kynshi, Umkrem) (12) Mukai (13) Umiew/Umiam/Bagara (14) Khasimara (15) Umiuh (16) Umkrem, etc.

Jaintia Hills District :

(1) Hari river (Myntdu, Lynriang, Prang) (2) Umngot

(Umkrem, Umsong, Umsot, Wahrashi, Umsaw, Umlane, Umtangphar, Umiew, Umngot) (3) Umtyrngai (Umsniang, Umkhlaw) (4) Umryngka (5) Lubha river (Umlunar, Jmsngat) (6) Lukha river (Wahmaneng, Khongpan, Umsnat) (7) Kopli (Umkyrpong, Kharkor, Myntang (8) Umken (9) Umiew, etc.

Garo Hills District :

(1) Moheskali (2) Mahedeo (3) Someswari (4) Darang (Nitai) (5) Bogai (6) Tulong (7) Marsi (8) Sasai (9) Tidek (10) Dudnai (11) Krishnai/Damring (12) Tinari (13) Didak (14) Jingiram (15) Ditti (16) Ronggai/Ringge (17) Kolongkini/ Galwang (18) Kalu (19) Daru (20) Ronkai.

Origin, length and confluence of these rivers :-

District and name of rivers	Origin	Length in km.	Confluence
(1)	(2)	(3)	(4)
KHASI HILLS :			
1. Umiam	Shillong peak	-	Via Mikir Hills into the Brahmaputra.
2. Umran	Syngku/Mawrong village	-	Digru river (Assam)
3. Umsen	Sakhirbam	-	
4. Khri	Jirang/Mariong/ Sohiong/Mairang	-	Umkiam bill (Goalpara) Assam.
5. Umngi	Lawbyrsad/Mariaw	-	Umkiam bill
6. Umsyntai	Nongstoin	-	Boko
7. Umtyrseng	Lawbyrsad (Nongstoin)	-	Atiabari (Assam).
8. Umbara	Lymryngkew	-	Atiabari (Assam).
9. Gigang	Nongkhongkhil	-	Hamka (Goalpara)
10. Tidek	Moranga (Garo Hills)	-	Dubangalpara

(1)	(2)	(3)	(4)
11. Kynchiang or	Pendengra/Mobenggithin, Nongpathar, Lummawkhlam, Nongstoin, Nongspung	.	Lengar Bazar, Bangladesh
12. Mukai	Maharam, Mawiang, Nongspung	-	Dhammalia nadi, Bangladesh
13. Umiew/Umiam	Shillong peak, Mawphlang, Mawsmai fall	-	Shella Bazar
14. Khasimara	Mawsynram, Nonglah	-	Nawagang River of Bangladesh
15. Umsohryngkew	Cherra, Dympep, Laitlyngkot	-	Bairang Bazar, Bangladesh
16. Umniuh	Mawjah	-	Barpuji Bazar
17. Umkrem	Thanginath (Cherra)	-	Hatlakading.
JAINTIA HILLS :			
1. Hari River	Jowai, Rymbai, Nongthymmai	-	Lalakhal (Bangladesh)
2. Umngot	Mawngap, Padu, Pamtadong, Thangsiri/ Mawkhlam, Mawblang/ Khliehhasem, Mawiang, Dohkharang, Dienglieng, Smit, Mawlyndep, Thynroit	-	Khyrim Syiemship (Dawki) Bangladesh
3. Umtyrngai	Thangsar	-	Jaintiapur (Bangladesh)
4. Umryngka	Torangblang	-	Jaintiapur (Bangladesh)
5. Lubha	Mawbyntur, Lumkharoh	-	Dewkergul (Bangladesh)
6. Lukha	Lumpdeng, Maryngksih, Dedaship Siapong forest	-	Bangladesh
7. Kopli	Saipung reserve forest, Shangpung, Pamra, Tuber, Lamarsiang, Nongkynrih, Mynso	-	Mikir Hills (Assam)
8. Umkhen	Mawryngkneng, Shillong peak	-	
9. Umiew	Mawlyntha	-	Umkhen

(1)	(2)	(3)	(4)
GARO HILLS :			
1. Moheskali	Balphakram	165	Sylhet District
2. Mahadeo	Balphakram	142	Mymensing District
3. Someswari	Nokrek Peak	205	Mymensing District
4. Dareng	Eastern Nokrek	197	Via Silkigiri, Bangladesh
5. Bogai	Eastern Nokrek	148	Via Dalu Village, Bangladesh
6. Tulong	Balori Peak	133	Bangladesh
7. Marsi	Balori Peak near Tura, Darengiri	127	Bangladesh
8. Sarai/Rokai	Balori Peak	130	These two rivers originate from the Baroli peak and join together just two miles before the Garo Hills border.
9. Tidek	Papia Peak	144	Goalpara District (Assam) (Brahmaputra)
10. Budnai	Jomge	108	Via Koknal and Danal flow to Checkra river
11. Krishnai or Damring	Albella Peak	174	Via Mendipathar-Jira river, Goalpara
12. Jinari	Dolonggiri village	154	Via Bajendoba into Goalpara District
13. Didak	Anogiri village	196	Goalpara District
14. Jinjiram	Upto hill near Darek village of Goalpara	297	Gagua river
15. Ditti	Wategiri village	173	Didak river
16. Rongai	Albella Hills	201	Via Ringigiri village to Jinjiram
17. Kalongkini (Galwang)	Rangigiri hills	106	Via Rajaballa village to Goalpara

(1)	(2)	(3)	(4)
18. Kalu (Ganal)	Tura Peak (Duragiri)	95	Via Mankachar into Rongram and Dilni river.
19. Daru	Balori peak	101	Western Goalpara District.
20. Rongkai	Rongkaigiri peak	85	Via Kodalchar Village to Brahmaputra.

Pond Fisheries :-

As per proforma data gathered, in Meghalaya about 1775.44 ha of ponds are known to exist which offer excellent resources for intensive fish culture of both indigeneous and exotic fishes. The State Fishery Department maintains a few ponds that are used mostly for seed production and caters to the need of parties owing private fish ponds.

Reservoir Fisheries :-

The State at present has about five reservoirs and about ten or more of the flexible sausage dams. The latter are nothing but temporary impoundments by employing stone-filled wire bags across the river course to stem the flow though allowing a spill over. The present existing reservoirs are the Umiam, Umtham, Kyrdem Kulai, Umtru, Myntdu and those under construction are the Kopli Project in Jaintia Hills, Umiew Dam for Greater Shillong Water Supply Scheme and Syntuksiar Dam for Jowai Water Supply Scheme. It is of interest to note that so far none of these water bodies are used scientificially for fishery development programmes. But recently the State of Meghalaya has urgently urged the taking up of the

Umiam reservoir for fishery development programme. This system also known as the Barapani reservoir, has about 4 sq mile or 1,036 ha of water surface .Secretary, ME.S.E.B. Personal Communication) and will prove suitable for fishery development since till now it remains underexploited.

Beel Fisheries :-

The proforma data reveal that there are about 213 ha of beels in Meghalaya (N.E.C. Publication No.12), which are mostly located in the Garo Hills Districts bordering Goalpara District of Assam and Bangladesh. A few beels are also found in Khasi and Jaintia Hills Districts, bordering the plain areas of Assam and Bangladesh. Surveys of these water spreads are needed and the fish species therein are yet to be assessed and hence our knowledge of fish production from these water areas are totally wanting at present.

Water area used for fish culture :-

Though the State of Meghalaya has extensive riverine systems but no detailed survey of these systems has yet been carried out. The State at present is estimated to have about 5303.24 hectare or more of culturable ponds, lakes, reservoirs, beels etc. of which the water used at present for fish culture is estimated to be about 1775.44 ha (33.48%). But of this, only 21.60 ha are under proper management. This constitutes a mere 0.41% of the available water sources and the remaining 99.59% amounting to 5281.64 ha need to be reclaimed for proper fishery utilization.

Hydrobiological investigations :-

The State has a land area of 22,549 sq km and lies between the latitudes of 25°47'N and 26°10'N and longitude of 89°45'E and 92°47'E. The average temperature ranges from 4-34°C and the altitude ranges from 300 to 1960 m. The range of variation in the physicochemical factor recorded in the State are given in Table - D.

List of fishes :-

Of over a thousand species of fish which occur in India, eightythree species are found in Meghalaya (Parthasarathi and Alfred, 1980), of which thirtyeight are commercially important. The following are the list of the commercially important fishes of the State.

Family : Notopteridae

1) *Notopterus notopterus* (Pallas)
2) *Notopterus chitala* (Ham.)

Family : Cyprinidae

1) *Labeo pangusia* (Ham.)
2) *Labeo rohita* (Ham.)
3) *Labeo gonius* (Ham.)
4) *Catla catla* (Ham.)
5) *Cirrhinus mrigala* (Ham.)
6) *Puntius sarana sarana* (Ham.)
7) *Danio (Danio) acquipinnatus* (McCl.)
* 8) *Barilius bola* (Ham.)
* 9) *Puntius shalynius* Yazdani & Talukdar
*10) *Acrossocheilus hexagonolepis* (McCl.)
*11) *Tor putitora* (Ham.)
*12) *Tor tor* (Ham.)
*13) *Garra gotyla gotyla* (Grey)
*14) *Garra lamta* (Ham.)
*15) *Garra lissorhynchus* (McCl.)
*16) *Garra nasuta* (McCl.)

Family : Bagridae

1) *Mystus vittatus* (Bloch)
2) *Aorichthys seenghala* (Sykes)

Family : Siluridae

1) *Ompok pabo* (Ham)
2) *Ompok pabda* (Ham)

Family : Schilbeidae

1) *Clupeosoma garua* (Ham)
2) *Eutropiichthys vacha* (Ham)
3) *Silonia silondia* (Ham)

Family : Pangasiidae

1) *Pangasius pangasius* (Ham)

Family : Sisoridae

1) *Bagarius bagarius* (Ham)
*2) *Glyptothorax cavia* (Ham)
*3) *Glyptothorax striatus* (McCl.)

Family : Clariidae

1) *Clarias batrachus* (Linn.)

Family : Heteropneustidae

1) *Heteropneustes fossilis* (Bloch)

Family : Channidae

1) *Channa marulius* (Ham)
2) *Channa punctata* (Bloch)
3) *Channa striatus* (Bloch)
4) *Channa orientalis* Schneider

Family : Anabantidae

1) *Anabas testudineus* (Bloch)
2) *Colisa fasciata*

Family : Mastacembelidae

1) *Mastacembelus armatus* (Lacepede)
2) *Mastacembelus pancalus* (Ham)

* Hill stream species.

Fish production :-

The data available for fish production in Meghalaya as revealed through the proforma information seem to be inadequate and far from satisfactory as no proper record have been maintained. Such lack of production figures may be attributed to the following factors.

(i) Fish production are mostly from the riverine systems and reservoirs and no landing centres as such exist for collection of data.

(ii) Fishing habits of the people in Meghalaya is primarily meant as a hobby and

(iii) Hence most of the fish caught go for home consumption.

However, whatever information was gleaned from the proformas and other sources are categorised as :-

(i) Fish production data of the State Fishery Department (Table - E).

(ii) Market landings (Table - F).

(iii) Questionaire data from local fisherman (Table -B).

Problems of fish culture in Meghalaya State :

In view of the presently available knowhow within the country and proven technology in regard to various aspects of fishery development, plans and projects are being considered for Meghalaya to enhance fish production. For the present study out of the many problems involved, two specific aspects have been taken up for detailed survey and investigation in terms of priorities with a view to strengthen the local fishery establishments along sound scientific lines. Prior to actual investigations a survey of the causes is needed on :

(i) high mortality of fish seeds;
(ii) the retarded growth of fish in the water bodies.

The present survey was undertaken especially because of the complete lack of any such data available for this hill State. Further, because of the unique nature of the terrain, climate and altitude as reflected in the water bodies, it was programmed to obtain first hand knowledge on these problems, though relevant works, specially for the tropical plains of India are available as obtained by the Central Inland Fishery Research Institute and other State Fishery Departments.

Thus the present survey is the first of its kind for Meghalaya to identify the causes of mortality of fish seeds and stunted growth. It was felt that the best way would be to go right into the field and work with the help of officials of fishery departments and to gather data. For this purpose we have taken up three farms, Fish Dale at Shillong, Mawpun fish farm near Umroi and Kyrdem Kulai fish farm at Kyrdem Kulai. These three centres were at different altitudes with Fish Dale at 1,550 m, Mawpun 1,100 m and Kyrdem Kulai 850 m. Moreover, these farms are chosen because they are the seed producing centres for the State and supply the same to private fish farmers. The present existing practice is the induced and controlled breeding of only Common carp and thus the study on high mortality and stunted growth was confined only to this species. Along with the above study, a general survey of all the ponds owned by the State Fishery Department was made during 1978, such as the Trout farm at Shillong, Umsning fish farm at

Umsning in the Khasi Hills, Thadlaskein and Ladthalaboh fish farm in Jaintia Hills and Digrishiring, Tasek, Simsangiri, Dalu and Gangdobi in Garo hills.

Based on the present survey the problems so far identified relate to pond management programmes, breeding, hatching, rearing and feeding techniques, the abiotic and biotic parameters of the habitats, the system of supply of seeds and lack of training and basic scientific knowhow of private fish culturists. Apart from this, other related aspects which emerged from the survey are the site location of the farms in hilly terrains with problems of seepage, cold climate, acidic nature of the water and low amount of available nutrients, all contributing to the mortality and stunted growth of fish.

In the following account the problems enumerated above are individually dealt with in detail. As mentioned before, Meghalaya with a total water area of 5303.24 ha is estimated to have about 5303.24 ha of culturable water. Of these only 1175.44 ha are utilized for fish culture and even out of this, hardly 21.60 ha are under proper management. The rest of the 5281.64 ha of uncultivated waters are yet to be brought under proper management and utilisation.

(i) Problems of pond management :

The existing practice of fishery department with regard to pond management commences in early January till late February every year. The present survey conducted on this aspect further revealed that under pond management programme no proper drying, liming or manuring are being done in preparing the ponds.

The drying period in most of the fishery ponds in Meghalaya ranges between 3-5 days only, and it so happens that most ponds have not even fully dried when water is filled again. It is well known that drying of ponds should atleast last for 12-15 days, when all the harmful organisms present will be completely killed, thus facilitating healthy and hygienic conditions (Report of CIFRI 1978). The liming of pond under the present conditions was always found to be minimal as till date no proscribed dosage has been formulated for Meghalaya, although in the tropical plains of India the amount is 250 kg/ha. It is seen that in the fish ponds only a mere minimum and random amount is being sprayed all over the pond surface. For example, in Fish Dale, Shillong alone which has a total water area of 0.832 ha, only about 80 kg of lime were used annually which is inadequate. The aspect of liming*/in most waters and especially for the waters of Meghalaya which have a very low pH and thus liming should form an essential part of the maintenance of ponds. It is needless to emphasise the rate of liming as correction of water conditions for increasing the pH and alkalinity, liberation of bases and buffering action, acceleration of decomposition of the mud and reduction of the spread of parasitic and bacterial diseases, enhances the overall biological activity.

One another important aspect of pond management is fertilization which provides the best means of increasing fish production. The present survey showed that in this State, organic manure in the form of cowdung is the only source of fertilization. It has been seen though that in almost every

*/is very important

farm, a truck load of cowdung is usually kept in stock, only occasional broadcasting of twice or thrice a year was done. The total amount thus used when computed in terms of dosage it worked out to hardly 800-1,000 kg/ha/yr, while the current prescribed amount under Indian conditions is around 25,000 kg/ha/yr. Further, the stored cowdung is always for multiple use since a good part of the same goes to the maintenance of flower gardens within the precincts of the fish farms. Moreever, it was also seen that the cowdung supplied had a high percentage of plant fibres and also of an inferior variety and of possible low nutrient content, evidently contributing very little to the total fertilising effects expected of such manures. The consoquent effect of such minimal dose of manuring combined with low grade cowdung need not be elaborated.

(ii) Problems associated with breeding and hatching techniques as practised in the State :-

The brooders are generally collected either by netting out from the stocking ponds at the fish farms or by angling from lakes maintained by the fishery department for this purpose. The brooders thus collected are either immediately released and stocked in nursery ponds or temporarily kept in large metal drums covered with hapa cloth and subsequently transferred to ponds in the evening hours. All such brooders collected from different sources were stocked together without segregation of males and females and maintained at a daily feeding routine of a mixture of rice bran and mustard oil cake in a ratio of 1:1 broadcast over the pond surface.

Three methods are followed in the breeding of Common carp viz., wild breeding, control breeding and induced breeding. The wild breeding refers to the natural spawning of the brooders in the nursery, breeding, stocking ponds and lakes when the optimal conditions are obtained. Breeding hapa are usually employed for conducting the control breeding experiments, where one female and two to three males were kept together. The induced breeding is through the well known pituitary hormone technique. The initial dose of injection is at the dosage level of 2 mg/kg body weight to both sexes and subsequently a second dose is given at the rate of 4 mg/kg to the female fish only.

In order to collect eggs, aquatic weeds like Rotalla, Hydrilla, Nymphaea and Eicchornia and even pine needles are provided artificially at the bank or corner of the aquatic systems. Routine checking in the morning and evening hours is being practised to note the presence of eggs for subsequent transfer to initiate hatching.

Closer observations on the practice of the techniques enumerated above point out certain drawbacks. For example, the segregation of brooders was always done only an hour or two before conducting the breeding experiments, although these fishes were always kept in the same pond for months together. As a result what really obtained is that in spite of optimal conditions of the water and temperature having reached, breeding does not effect immediately but often takes even weeks.

Secondly, it was noticed that the male:female ratio normally suggested for successful breeding is not strickly adhered to, resulting in variable ratios of 3:1, 2:1, 1:1. Further the weight of male:femalo fish which ought to bo 3:1, seldom this is observed. For these reasons, the maximum percentage fertilization never went higher beyond 50-60%.

The conditions and maintenance of the weed used for egg collection are far from satisfactory, since these are simply kept in stock in one of the natural open ponds. When used during the breeding experiments, the weeds wore not even rinsed and cleaned of the adhering debris and some of them have already started rotting. When such egg collectors are used, it naturally encourages attack of eggs by several pathogenic microbes and parasitic organisms, which take their toll by infecting the eggs, hatchlings and spawn, causing heavy damage and mortality of the frys.

Whenever the brooders were kept together and for long hours there is always a heavy spoilage and loss of eggs by the movement of the fish within the hapa, at times further aggravated by cannibalism.

With regard to incubation and subsequent hatching of the eggs, these were to be kept in a double walled hatching hapa, where the inner wall is of a mosquito net and the outer hapa made of a fine mesh muslin cloth. However, it was noticed that often overcrowding of ponds takes place with the hatchings hapas being kept in stocking ponds which results in poor aeration and spoilage of eggs caused by the pulling and tugging movement from fishes outside the hapa. One another critical factor which results in loss of eggs and low percentage of hatching, in spite of about 60% fertilization, is the infection due to *Saprolegnia*, caused both by the rotting weedy substrata used and through the fluctuating external temperature. Both fertilized and unfertilized eggs are affected and the spread of infection goes unabated during the period of incubation.

(iii) Rearing of spawn and associated problems :

Under the present existing method of fish rearing, the hatchlings are usually kept in the hapa for at least a week to ten days till the yolk sacs are totally completely absorbed. These active baby fish at this stage termed as spawn were transferred into the nursery ponds of 0.01 ha size. The rearing period normally extends upto 4-5 months until the fry and fingerlings are netted out for supply to private fish farmers.

The present survey has clearly indicated that these nursery ponds are just filled with water and are practically unmanaged. As a result, heavy bloom of aquatic weeds (*Hydrilla*, *Rotalla*) and many other harmful aquatic organisms such as the Notonectids, Gerrids, Water beetles, Water scorpions, nymphs of dragon flies, murrels, tadpoles and frogs abound in these habitats. When the delicate spawn are introduced into such an environment, the predatory and other adverse effects of the coexisting fauna and flora heavily tell upon the subsequent survival of fry and fingerlings. Further, it was also seen that the nursery ponds were always heavily stocked thus leading to heavy mortality and stunted growth in view of the competition and demand for food, space and other favourable environmental parameters. Although such heavy stocking is justified for convenience in feeding, netting and harvesting the fish as and when need arises, the disadvantages outweigh those of the advantages.

(iv) Defects in feeding techniques :

The normal practice followed at present is to feed the spawn and fry either with rice bran only or with a mixture of rice bran and mustard oil cake in a ratio of 1:1 made into a paste with water. It was found that the feed is broadcast on the pond surface twice or thrice weekly which is undoubtedly inadequate in terms of the stocking densities and body weight of fish. As pointed out earlier with low or no manuring of cowdung and with such poor feeding schedules the growth of fry and fingerlings are adversely affected. Such effects are both direct and indirect since even the natural plankton fail to grow under such low nutrient conditions.

(v) Lack of studies on the abiotic and biotic variables of the fish ponds:

Apart from measurement of temperature, that too only during the breeding season of Common carp, no detailed round the year records of physicochemical factors are maintained of the ponds. So, one is at a loss to identify and pinpoint one or more of the target factors responsible for the well being of the fish. Similarly none of the biotic factors are being analysed as to the seasonality of different plankton, bottom fauna and periphyton or any of the predatory organisms. Life history studies and seasonality on the latter groups, will enable to time the stocking programmes, minimise their harmful effects and encourage successful growth.

(vi) Mortality effects during transport and supply of fry:

Every year during late June and July, the State Fishery Department is engaged in the supply of seed to private fish farmers. It is seen that the seeds supplied were early frys of 2.0-4.0 cm in length and 2.5-4.0 gm in weight. It is quite obvious that the size of fry is too small as they are still delicate for transport to long distances. Moreover these fry are densely packed in polythene bags, thus causing depletion of oxygen leading to 20-30% or more mortality even before the fry reached the pond sites of the respective fish farmers. The argument put forth by the fishery officials for the supply of such early fry stage is that more seeds could be given to each farmer and also longer retaining period of fry in ponds will involve additional cost of fish food and more labour. The sum total effect, however, is the higher rate of mortality, in certain cases even exceeding 50-60% (Wankhar, 1977, personal communication).

(vii) Lack of training facilities to fish farmers on pond management and fish production :

The foregoing results of the survey clearly demonstrate the empirical mode of fish culture as practised by the private fish farmers in the State. This state of affairs needs to be rectified by proper training and demonstration in pond management and fish culture to individual fish culturists which is unavailable at present. It is felt that the dissemination of such knowledge is all the more necessary in view of the uniqueness of the hilly terrain, altitude and water quality.

It will be ideal if a suitable technology is evolved through the study and understanding of these hill areas with reference to the above parameters, which in turn will be of value to the people of the region.

RESULTS

BREEDING, HATCHING AND REARING EXPERIMENTS ON THE COMMON CARP *CYPRINUS CARPIO COMMUNIS* L.

RESULTS

Results of investigations on the various aspects of culture and breeding of Common carp carried out at Fish Dale farm, Shillong during the years 1977, 1978 and 1979 are presented below. These experiments were on the breeding, suitability of different egg collectors, rearing of spawn to fry, fry to fingerling and fingerling to table size fish.

I. BREEDING, HATCHING AND REARING EXPERIMENTS ON THE COMMON CARP, CYPRINUS CARPIO COMMUNIS L.

A. Breeding Experiments :-

(i) Breeding experiment conducted on the Common carp, *Cyprinus carpio communis* L. in Hapas :

In April, 1977 one set of breeding experiment was conducted with the Common carp using a breeding hapa in a breeding pond. The ratio was 1:3 with the female brooder weighing 650 gm and males of 625, 650 and 765 gm size (Table - I). On the same day of the experiment the fish spawned during the night at an ambient temperature of 20°C. The aquatic weed *Rotalla rotundifolia* was used as the egg collector. Subsequent to spawning the female brooder lost 100 gm of woight of which 90% is thought to be the weight of the eggs and the rest due to the faecal matter and other waste products. The individual fertilised egg size varies from 1.4 to 1.8 mm in diameter with an average weight of 0.0020 gm, about 500 number of eggs per gram. The total number of eggs spawned was estimated to be ca 45,000 (i.e. 500 Nos/gm X 90 = 45,000). Based on 80% fertilization estimated, the number of fertilised eggs were 36,000. However, the total number of hatchling and spawn harvested

TABLE I : Showing the breeding experiment of the Common Carp, *Cyprinus carpio communis* L. conducted in Breeding Hapa at Fish Dale Farm, Shillong during 1977

Temperature (°C)	Time of spawning (hr.)	Weight of Female fish (gm.)	Weight of Male fish (gm.)	Egg collector used (kg.)	Loss in weight after spawning (gm.)	Expected weight of eggs (gm.)	Expected weight of waste matter (gm.)
1	2	3	4	5	6	7	8
20	7.30 P.M. (21/4/79)	650	625 765 650	*Rotalla rotundifolia*	100	90	10

Size of egg in diameter (mm.)	Average weight of egg (gm.)	Approximate number of egg per gm.	Approximate number of eggs (Nos.)	Percentage of fertilization (%)	Fertilized eggs expected to hatch (Nos.)	Total number of hatchling/spawn produced	Percentage of hatchling (%)
9	10	11	12	13	14	15	16
1.4 to 1.8	0.0020	500	45,000	80	36,000	22,400	62.2

were 22,400 indicative of a hatching rate of 62.2%. The percentage of fertilisation was visually estimated by counts of 500 eggs randomly selected from the different sections of the weed provided (Table-V).

In 1978, two sets of breeding experiments were conducted, one in March and the other in the month of May. During March, 1978, one set of brooders with a female of 520 gm and males of 525, 450, 350 gm were used (Table-IIa). During this year, the fish bred partially and spawned at night at the ambient temperature of 18.5°C, and breeding continued till next morning when the temperature was lower with 16.5°C. For these experiments 1.5 kg of Rotalla rotundifolia was used for egg collection. After spawning the female showed a loss of 85 gm in weight and the egg size ranging between 1.2-2.0 mm in diameter and weighing 0.0024 gm. The estimated number of eggs/gm was 415 with the total number of eggs to bo 31,747. Table-II(a)show the percentage of fertilization for the breeding experiments in 1978. It has beon calculated that the percentage fertilization was 55%, with the total number of fertilised eggs to be 17,460. But based on actual estimates the total number of hatchlings and spawn procured were 13,160, working out to a hatching percentage of 64.2%.

In the second experiment conducted in May 1978, small sized brooders were used with the female of 250 gm and males of 220, 265 and 300 gm (Table-IIb). One kg of aquatic weed Rotalla rotundifolia was used as egg collectors in this set of experiment. Tho loss in weight by the female brooder after

TABLE II (a) : Showing the breeding experiment of the Common Carp *Cyprinus carpio communis* L. conducted in Breeding Hapa at Fish Dale farm, Shillong during 1978.

Temperature (°C)	Time of spawning (hr.)	Weight of Female fish (gm.)	Weight of Male fish (gm.)	Egg collector used (kg.)	Loss in weight after spawning (gm.)	Expected weight of eggs (gm.)	Expected weight of waste matter (gm.)
1	2	3	4	5	6	7	8
18.5	6.55 P.M. (20/3/78)	520	525 450	*Rotalla rotundifolia* 1½ kg.	85	76.5	8.5
16.5	5.45 A.M. (21/3/78)		350				

Size of egg in diameter (mm.)	Average weight of egg (gm.)	Approximate number of egg per gm.	Approximate number of eggs (Nos.)	Percentage of fertilization (%)	Fertilized eggs expected to hatch (Nos.)	Total number of hatchling/spawn produced.	Percentage of hatchling (%)
9	10	11	12	13	14	15	16
1.2 to 2.0	0.0024	415	31,747	55	17,460	11,220	64.2

TABLE II (b) : Showing the breeding experiment of the Common Carp *Cyprinus carpio communis* L. conducted in Breeding Hapa at Fish Dale farm, Shillong during 1978.

Temperature (°C)	Time of spawning (hr.)	Weight of Female fish (gm.)	Weight of Male fish (gm.)	Egg collector used (kg.)	Loss in weight after spawning (gm.)	Expected weight of eggs (gm.)	Expected weight of waste matter (gm.)
1	2	3	4	5	6	7	8
17.5	4.45 to 8.30 P.M. (3/5/78)	250	220 300 265	*Rotalla rotundifolia* 1 kg.	50	45	5

Size of egg in diameter (mm.)	Average weight of egg (gm.)	Approximate number of egg per gm.	Approximate number of eggs (Nos.)	Percentage of fertilization (%)	Fertilised eggs expected to hatch (Nos.)	Total number of hatchling/spawn produced.	Percentage of hatchling (%)
9	10	11	12	13	14	15	16
1.3 to 1.7	0.0020	500	22,500	75	16,875	9,055	53.7

spawning was 50 gm. The egg sizes were ranging from 1.3 to 1.7 mm and weighed 0.0020 gm forming 500 numbers per gram of egg. Thus the total estimated number of eggs spawned were 22,500. The percentage fertilization was found to be 75% and based on this, the expected number of fertilized eggs were 16,875 (Table-II(b). The total number of spawn harvested however was 9,055 representing a 53.7% hatching rate.

In 1979, three sets of breeding expe-riments were (Table-III(a) in breeding hapas and in plastic pool, using different substrates for egg collections, viz., the aquatic weed (Rotalla rotundifolina), coconut fibre raft, wooden frame with nylon flaps and Aluminium wire frame nylon net.

Of the above, for the first breeding experiment conducted in hapa the brooders used were females of 310 gm and males of 340, 350 and 465 gm. The breeding took place at the temperature range of 19° to 20°C. In this experiment the post-spawning weight was 61 gm, of which 55 gm was estimated to be the loss due to the liberation of eggs and the rest, of waste products. The percentage of fertilization was calculated to be 85% with the eggs measuring 1.2 to 1.8 mm and 0.0018 gm in weight. On this basis it was seen that there would have been 555 number of eggs per gram. Thus the total number of eggs was estimated to be 27,500 and with 85% fertilization, the total fertilized eggs could have been 23,375. However, the actual number of the total spawn collected from the hapa were 17,875 indicating 76.4% hatching rate. As mentioned above, in addition to these breeding experiments the relative efficiency of different egg collectors was also worked out for the four different types. It was seen that the most efficient among them appear to be the coconut fibre raft with the maximum attachment rate of 50%, compared to Rotalla (25%), Wooden frame nylon flap (15%) and Aluminium wire frame nylon net with 10% (Table-VI(1)). These percentages were computed based on 5 random counts in an area of 8 X 5 cm for each of the type of egg collectors and such counts in each of the two hapas and the plastic pools (Table-V).). The results show that Coconut fibre was five times more efficient than the Aluminium wire frame nylon net, 3.5 times than that of the Wooden frame and twice efficient than the aquatic weed. Similarly, when the percentage attachment of fertilized eggs were calculated, the values ranged between 85% in Coconut fibre raft, 90% in Wooden frame, 95% in Aluminium frame and 75% in Rotalla.

The second set of experiments in this series during 1979 was also conducted in breeding hapa on 12/4/79 using the same four types of egg collectors. The female brooder was 425 gm and the males of 310, 410 and 500 gm. This fish spawned in the morning hours at the temperature range between 19° and 20°C. The loss in weight of the female after spawning was 88 gm, where 80 gm and 8 gm were estimated to be the amount of eggs and waste products of the fish respectively. The eggs ranged between 1.5 to 1.8 mm in size with an average weight of 0.0022 gm amounting to 455 numbers/gm. The total number of eggs spawned at 80 gm loss in weight were 36,400 and with 70% fertilization, the total number of fertilized eggs were estimated to be 25,480. Nevertheless, the total number of actual

TABLE III (a) : Showing the breeding experiments of the Common carp, <u>Cyprinus carpio communis</u> L. conducted in Breeding Hapa at Fish Dale farm, Shillong during 1979.

Temperature (°C)	Time of spawning (hr.)	Weight of Female fish (gm.)	Weight of Male fish (gm.)	Egg collector used (kg/Nos.)	Loss in weight after spawning (gm.)	Expected weight of eggs (gm.)	Expected weight of waste matter (gm.)
1	2	3	4	5	6	7	8
19.0 to 20.0	6.30 to 8.30 A.M. (7/4/79)	310	340 350 465	1. <u>Rotalla</u> -½ 2. <u>Coconut fibre raft</u> -2 3. <u>Wooden frame</u> with nylon like flap -2 4. <u>Aluminium</u> wire frame with nylon net -2	61	55	6

Size of egg in diameter (mm.)	Average weight of egg (gm.)	Approximate number of egg per gm.	Approximate number of eggs (Nos.)	Percentage of fertilization (%)	Fertilised eggs expected to hatch (Nos.)	Total number of hatchling/spawn produced.	Percentage of hatchling (%)
9	10	11	12	13	14	15	16
1.2 to 1.8	0.0018	555	27,500	85	23,375	17,875	76.4

TABLE III (b) : Showing the breeding experiments of the Common Carp, Cyprinus carpio communis L. conducted in Breeding Hapa at Fish Dale farm, Shillong during 1979.

Temperature (°C)	Time of spawning (hrs.)	Weight of Female fish (gm.)	Weight of Male fish (gm.)	Egg collector used (kg./Nos.)	Loss in weight after spawning (gm.)	Expected weight of eggs (gm.)	Expected weight of waste matter (gm.)
1	2	3	4	5	6	7	8
18.0 to 20.0	5.30 to 7.30 A.M. (12/4/79)	425	500 410 310	1. Rotalla - ½ 2. Coconut fibre raft - 2 3. Wooden frame with nylon like flap - 2 4. Aluminium wire frame with nylon net - 2	88	80	8

Size of egg in diameter (mm.)	Average weight of egg (gm.)	Approximate number of egg per gm.	Approximate number of egg (Nos.)	Percentage of fertilization (%)	Fertilised eggs expected to hatch (Nos.)	Total number of hatchling/spawn produced.	Percentage of hatchling (%)
9	10	11	12	13	14	15	16
1.5 to 1.8	0.0022	455	36,400	70	25,480	15,380	61.9

hatchling and spawn harvested were 15,380 working out a hatching rate of 61.9%. In this experiment too the Coconut fibre raft showed the maximum percentage of egg attachment with 55% followed by *Rotalla* 20%, Wooden frame 20% and Aluminium wire frame 5% in that order. In terms of efficiency, the Coconut fibre therefore was 11 times more efficient than Aluminium frame, 2.5 times more of each of the aquatic weed and Wooden frame. The percentage of fertilized eggs attached to the different egg collectors were 93% in the Coconut fibre, 92% in Wooden frame, 96% in Aluminium frame and 70% in *Rotalla*.

(ii) Breeding experiment conducted on the Common carp, *Cyprinus carpio communis* L. in plastic pool :

Similar breeding experiments were repeated for the third time during 1979, although they were conducted in a Plastic pool. The brooders used were a female of 510 gm weight and 410, 520 and 620 gm males. The fish bred at the temperature ranging between 18.5 and 19.0°C in the evening hours between 6.00 to 7.15 P.M. The percentage of fertilization was 75% with the female losing 125 gm of weight after spawning of which 110 gm and 15 gm respectively were estimated to be the amounts of eggs and waste products of the fish. The egg size ranges between 1.4 to 2.0 mm and of 0.0024 gm in weight amounting to 415 eggs per gram. The estimated total number of eggs spawned were 46,650 of which 34,235 numbers alone were the fertilized eggs. However, the total number of spawn produced was 28,010 at the hatching rate of 81.8%. The attachment of eggs in Coconut fibre was 60% with 90% fertilized ogg. On the other hand the aquatic weed has 20% of attachment with 75% fertilization. The Wooden

TABLE IV : Showing the breeding experiment of the Common Carp, *Cyprinus carpio communis* L. conducted in Plastic Pool at Fish Dale farm, Shillong during 1979.

Temperature (°C)	Time of spawning (gm.)	Weight of Female fish (gm.)	Weight of Male fish (gm.)	Egg collector used (kg./Nos.)	Loss in weight after spawning (gm.)	Expected weight of eggs (gm.)	Expected weight of waste matter (gm.)
1	2	3	4	5	6	7	8
19.0 to 18.5	6.00 to 7.15 P.M. (18/4/79)	510	620 520 410	1. Rotalla - ½ 2. Coconut fibre raft - 2 3. Wooden frame with nylon like flap - 2 4. Aluminium wire frame with nylon net - 2	125	110	15

Size of egg in diameter (mm.)	Average weight of egg (gm.)	Approximate number of egg per gm.	Approximate number of egg (Nos.)	Percentage of fertilization (%)	Fertilised eggs expected to hatch (Nos.)	Total number of hatchling/spawn produced.	Percentage of hatchling (%)
9	10	11	12	13	14	15	16
1.4 to 2.0	0.0024	415	45,650	75	34,235	28,010	81.8

frame had the attachment capacity of 15% with the fertilized eggs forming 95%. The Aluminium frame showed the attachment value of 5% having 98% fertilized eggs. Once again, it has been shown that the Coconut fibre raft had the maximum efficiency of attachment with 12 times more than that of the Aluminium wire frame, 4 times of the Wooden frame and 3 fold increase as compared to the aquatic weed Rotalla rotundifolia.(Table IV-VI).

B. HATCHING EXPERIMENTS :-

(i) Incubation and Hatching of the eggs of Cyprinus carpio communis L. in Nylon Hapas :

Of the various breeding experiments on Common carp, conducted during the three years of investigations, only Rotalla rotundifolia was used for egg collection in the first two years (1977 and 1978). Whereas in 1979, four different types of egg collectors were experimented upon as shown earlier. In this section, data on the hatching rate along with the efficiencies and the associated problems of different substrata used are presented. Thus it will be seen from Table-I to IV, the percentage of hatching of eggs in the production of hatchling and spawn were 62.2% in 1977, 64.2 and 53.7% in 1978 and 76.4%, 61.9% and 81.8% in 1979. As mentioned above during 1977, only the aquatic weed Rotalla rotundifolia was used for egg collection and as a result, 62.2% of hatchlings were obtained as net production. It has been observed that the loss of most of the fertilized eggs in these experiments was due to fungal infection, the main causative agent being the phycomycetous species, Saprolegnia spp (Mishra, 1979 personal communication). These fungi were seen to bloom in the rotting weed even from the

PLATE .. VI

(a) Showing the unfertilized eggs attacked by *Saprolegnia* sp.

(b) Heavily infected eggs with *Saprolegnia*.

PLATE VI

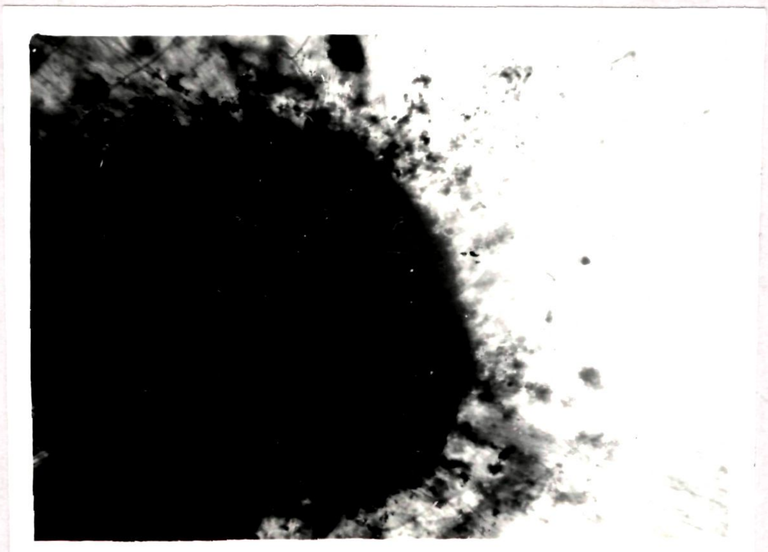


PLATE - VII

(a) Third day embryo being attacked by *Saprolegnia*.

(b) Fifth day embryo (just before hatching) being attacked by *Saprolegnia*.

PLATE VII

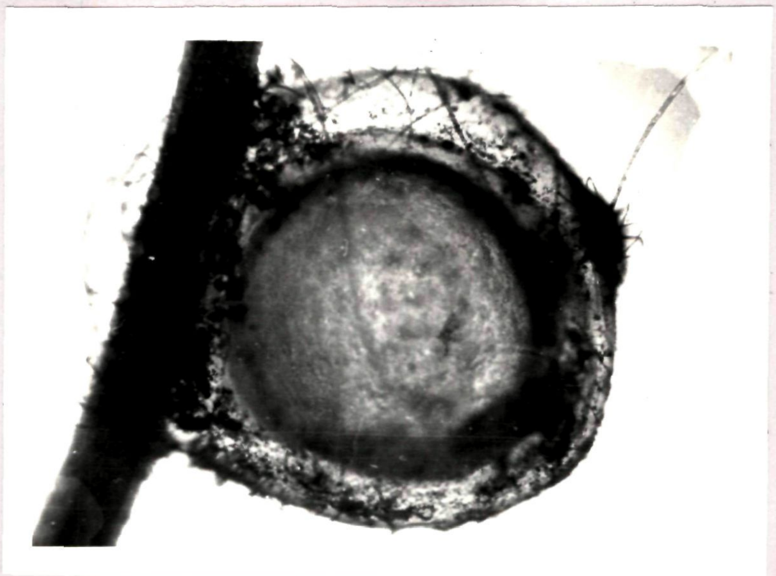


TABLE V : Showing the estimation of the percentage of fertized eggs of *Cyprinus carpio communis* L. attached to egg collectors conducted in Hapas and Plastic Pools.

Experiment Nos.	Month and Year	Nos. of ramdom sets taken for counting the eggs in each of the experiment	Total eggs counted	Nos. of fertilized egg	Mean percentage of fertilization
I	April 1977	1	100	65	80%
		2	100	82	
		3	100	75	
		4	100	90	
		5	100	88	
II(a)	March 1978	1	100	41	55%
		2	100	66	
		3	100	38	
		4	100	43	
		5	100	87	
II(b)	May 1978	1	100	85	75%
		2	100	61	
		3	100	93	
		4	100	64	
		5	100	72	
III(a)	April 1979	1	100	86	85%
		2	100	80	
		3	100	95	
		4	100	75	
		5	100	89	
III(b)	April 1979	1	100	77	70%
		2	100	63	
		3	100	71	
		4	100	74	
		5	100	65	
IV	April 1979	1	100	71	75%
		2	100	86	
		3	100	73	
		4	100	70	
		5	100	75	

TABLE VI : Showing the percentage efficiences of different egg collectors conducted in Hapas and Plastic Pools during 1979.

Experiment conducted	Coconut fibre raft Size-18"x12"		Wooden frame with nylon curtain flap Size-18"x12"		Aluminium wire frame with nylon net Size-18"x12"		*Rotalla rotundifolia* ½ kg.		Total attachment (%)
	Attachment (%)	Fertilized eggs (%)	Attachment (%)	Fertilized eggs (%)	Attachment (%)	Fertilized eggs (%)	Attachment (%)	Fertilized eggs (%)	
Hapa I	50	85	15	90	10	95	25	75	100
Hapa II	55	93	20	92	5	96	20	70	100
Plastic Pool	60	90	15	95	5	98	20	75	100

very first day of egg incubation and by the second day it spreads to the unfertilized eggs especially when the temperature of water was low and below 16°C. It was also seen that on the third day of incubation the fungus further spreads and infects the fertilized eggs, considerably interferring with the hatching rate. Thus from the initial percentage fertilization of 80% obtained soon after spawning, the day to day increase of fungal infection ultimately brought down the hatching rate to 62.2% with a loss of 27.8% or 3,600 of the spawn.

Similarly in the two experiments in 1978 while the percentage of hatching was 64.2% and 53.7%, the loss during hatching in the first experiment was mainly due to the prevailing cold temperature ranging between 14.5 to 19.5° during the incubation period, causing the bloom of Saprolegnia spp which again infected both the fertilized and unfertilized eggs thus limiting the hatching rate with a loss of 35.8% or 6,240 spawn.

In the second experiment in addition to the low temperature and attack by Saprolegnia spp further damage to fertilised eggs was caused by rain and hailstorm during the incubation period thereby bring down the percentage of hatching to a very low level with a loss of 46.3% or 7,820 of spawn.

Once again, in the three sets of experiments conducted in 1979, first experiment showed the production of 76.4% of hatchlings and spawn. The fungal infection was low during this period and was restricted mostly to the aquatic weed Rotalla that too with much less severity. No Saprolegnia infection was noticed at any time on the rest of the egg collectors viz., Coconut fibre, Wooden frame or Aluminium net frame during these experiments. In the second series of experiments the percentage of hatching was 61.9%. Saprolegnia infection spread among the unfertilized eggs attached to Rotalla as well as to the Coconut fibre raft, although no infection occurred in the Wooden frame, Nylon flap or the Aluminium wire net frame.

(ii) Incubation and Hatching of Cyprinus carpio communis eggs in Plastic pool :

In the third experiment conducted in the Plastic pool the percentage of hatching was recorded to be 81.8% and probably due to the confined nature of the environment all the different type of egg collectors were free of fungal infection.

C. REARING EXPERIMENTS :-

(i) Rearing of spawn to fry of the Common carp, Cyprinus carpio communis L. in Nursery Ponds :

In the month of May 1977, and April 1978 roaring experiments were commenced with the spawn of Common carp in a pucca nursery pond and these experiments extended for a duration of two to three months with continous daily observations. Data on the proportion, quantity and intervals of feeding regimes using the feed of finely powdered rice bran and mustard oil cake along with manuring with cowdung were done.

In the first experiment 8,000 spawn of Common carp ranging between 4.0 to 6.0 mm in length and 5.0 to 8.0 mg in weight were stocked in the 100 sq m pond (Table-VII). During the period of rearing, from this initial size the spawn had grown to a fry stage of 20.0 to 50.0 mm len gth with a weight range of 3000.0 to 8000.0 mg. Out of the 8,000 numbers stocked 5,805 were finally harvested indicating a 72.5% survival rate. The rate of growth from stocking to harvest was thus estimated to be 7 times of initial length while weight had increased 1,000-fold. While computing the mortality rate with a loss of 2,195 spawn, it worked out to 27.5%.

In the second set of experiments 15,000 numbers of spawn of Common carp ranging in size from 4.0 to 6.0 mm in length and 5.0 to 8.0 mg in weight were reared in a 200 sq m pucca nursery pond. The duration of rearing was three months to the fry stage ranging between 60.0 to 90.0 mm in length and 8000.0 to 15,000 mg in weight. The average growth rate attained during the rearing period was 15 times of initial length and 1,643 times the growth in weight. The total number of fry harvested was 9,124 giving a 60% survivality. The mortality rate was 40% taking into account the actual loss of 5,876 numbers of fry.

During the second year, in the first experiment of April 1978 the pucca nursery pond was stocked with 10,000 spawn of Common carp, ranging between 8.0 to 10.0 mm in length and 10.0 to 12.0 mg in weight and reared for a period of two and half months (Table-VII). The fry grew to 40.0 to 80.0 mm in length and 5,000 to 15,000 mg in weight. The growth increase from stocking to harvest was estimated at 6.5 times more in length and 909 times in weight. The final number of fry harvested were 7,659 reflecting a survival rate of 76.5%. The mortality figure was 2,341 which worked out to 23.5%.

TABLE VII : Showing the rearing of Spawn to Fry of Common Carp, *Cyprinus carpio communis* L. in a Pucca Nursery Pond at Fish Dale farm, Shillong during the year 1977-78

Expt. No. & Date of stocking.	Pond Size sq.m.	Stocking size		Spawn stocked (Nos.)	Rearing period (days)	Fry harvested (Nos.)	Fry harvested size		Mortality		Percentage of survival
		Length mm.	Weight mg.				Length mm.	Weight mg.	Nos.	%	
No.1 2/5/77	100	4.0 to 6.0	5.0 to 8.0	8,000	60	5,805	20.0 to 50.0	3,000 to 8,000	2,195	27.5	72.5
No.2 2/5/77	200	4.0 to 6.0	5.0 to 8.0	15,000	90	9,124	60.0 to 90.0	8,000 to 15,000	5,876	40.0	60.0
No.1 5/4/78	100	8.0 to 10.0	10.0 to 12.0	1,000	75	7,659	40.0 to 80.0	5,000 to 15,000	2,341	23.5	76.5
No.2 5/4/78	100	8.0 to 10.0	10.0 to 12.0	8,000	75	4,460	60.0 to 100.0	7,500 to 18,000	3,540	44.3	55.7

In the second set of experiments conducted in the same year in another pond, the total number of spawn stocked was 8,000, ranging in size between 8.0 to 10.0 mm in length and 10.0 to 12.0 mg in weight (Table-VII). In the two and half month rearing period, the fish grow to a size, ranging between 60 to 100 mm in length and 7,500 to 18,000 mg in weight. The growth rate estimated from stocking to harvest works out to 9 times the growth in length and 1,160 times the growth in weight. The total number of fry harvested were 4,460 with a survival rate of 55.7%. The total loss of fry was 3,540 in number resulting in a mortality rate of 44.3%.

(ii) Rearing of spawn to fry of the Common carp, *Cyprinus carpio communis* L. in Nylon Hapas.:

In the year 1978 and 1979, spawn of Common carp were reared in a 2 X 1 X 1 m nylon hapa placed within in a well managed nursery pond. Finely powdered rice bran and mustard oil cake at 1:1 ratio were given as feed every alternate day and the pond itself was manured with cowdung at weekly intervals.

In April and May 1978 four series of rearing experiments were conducted.

In the first experiment in April, 1978 (Table-VIII) 1,000 spawn of Common carp of sizes ranging from 8.0 to 10.0 mm in length and 10.0 to 12.0 mg in weight were reared. The rearing period lasted for 75 days at the end of which 724 fry were harvested. Their sizes ranged in length and weight from 50.0 to 80.0 mm and 4,500 to 8,000 mg respectively. Thus the growth

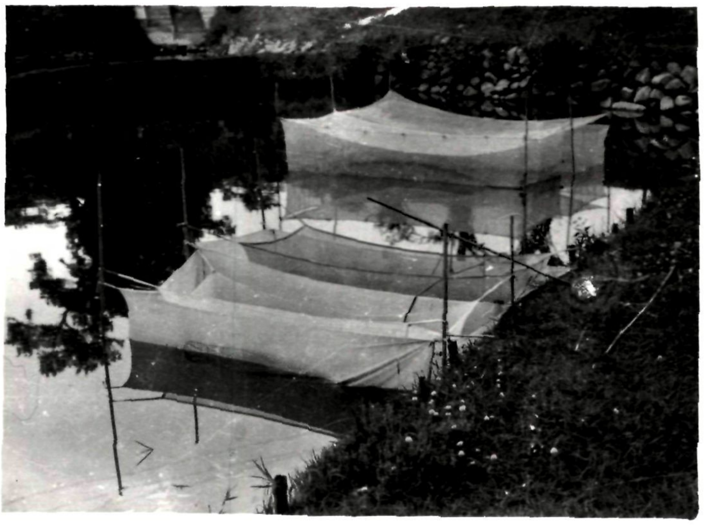
PLATE - VIII

(a) Showing the nylon hapas for rearing of spawn to fry at Fish Dale Farm, Shillong.

(b) Showing the hatching hapa.

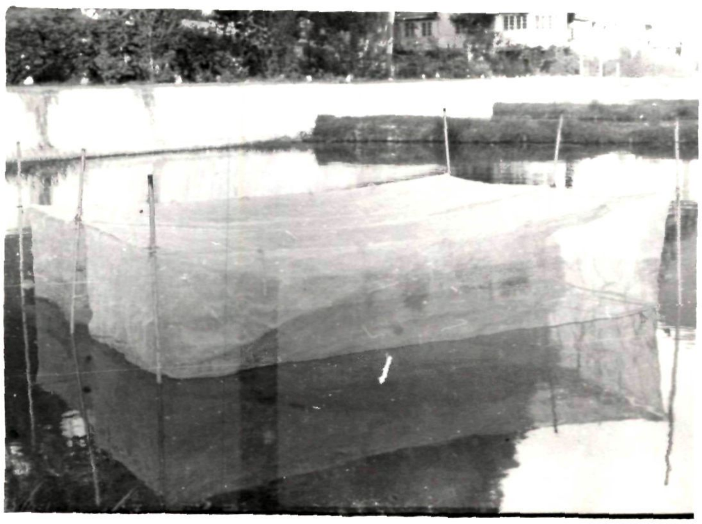
(c) Showing the nylon hapas in nursery ponds for the rearing of spawn to fry.

PLATE VIII



a

b



c

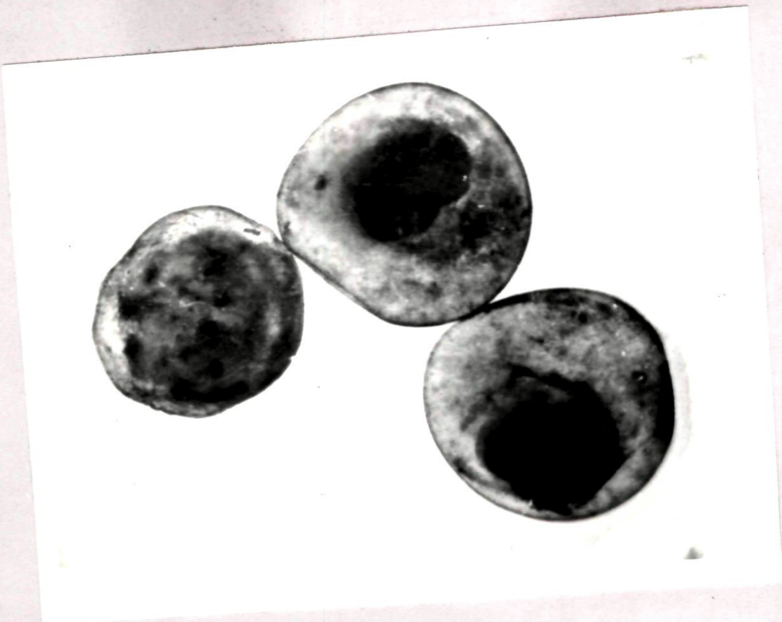
PLATE - IX

(a) Showing freshly stripped eggs before fertilization.

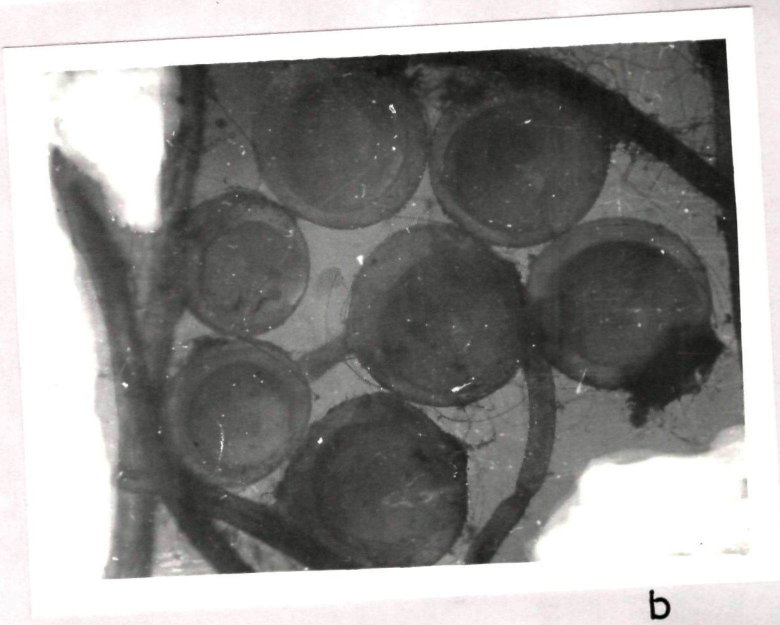
(b) First day fertilized eggs.

(c) Second day embryo.

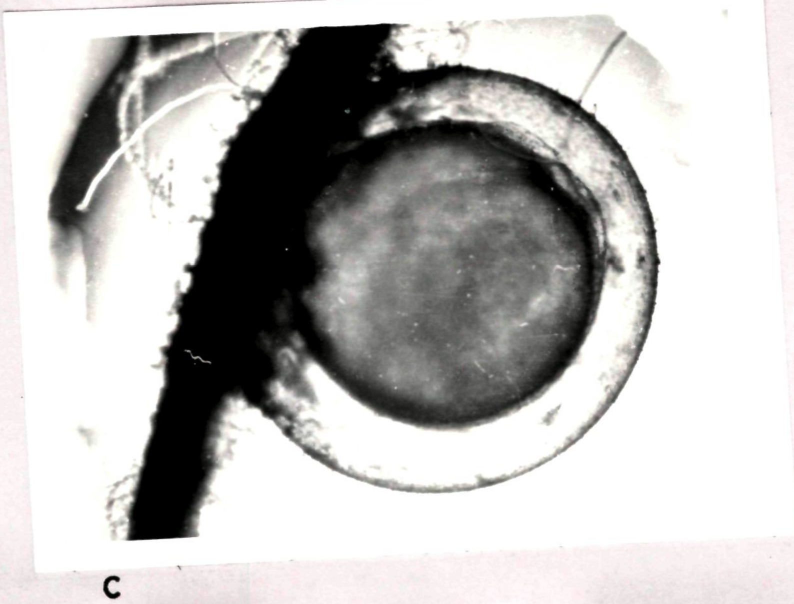
PLATE IX



a



b



c

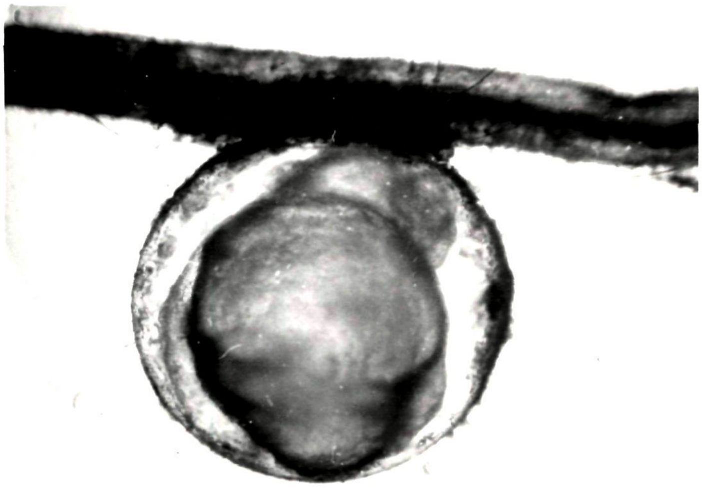
PLATE - X

(a) Showing the third day embryo.

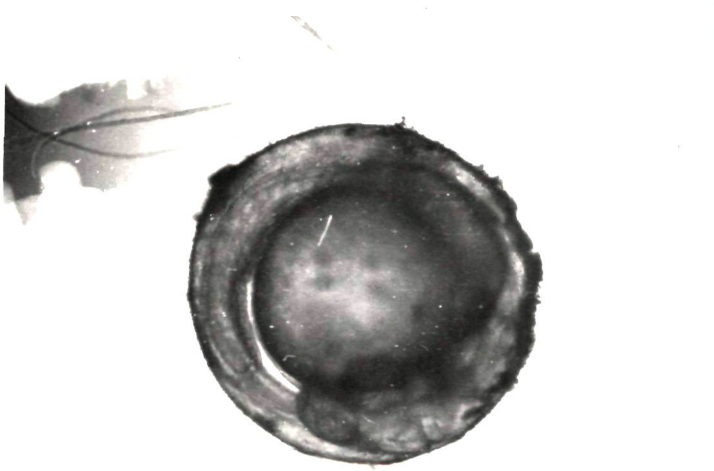
(b) Showing the fourth day embryo (morning hours).

(c) Showing the fourthhday embryo (evening hours).

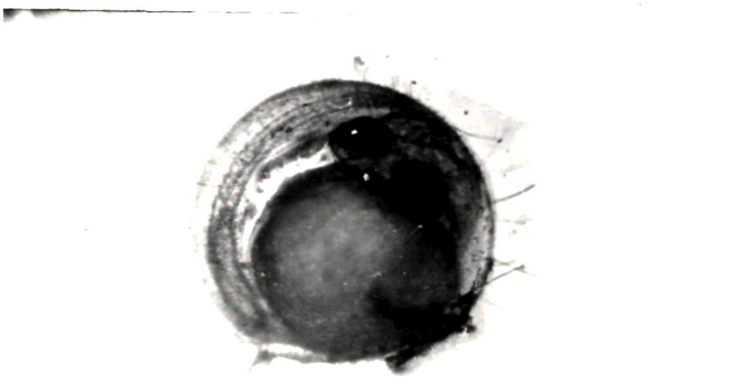
PLATE X



a



b



c

PLATE - XI

(a) Showing the fifth day embryo before hatching (morning hours).

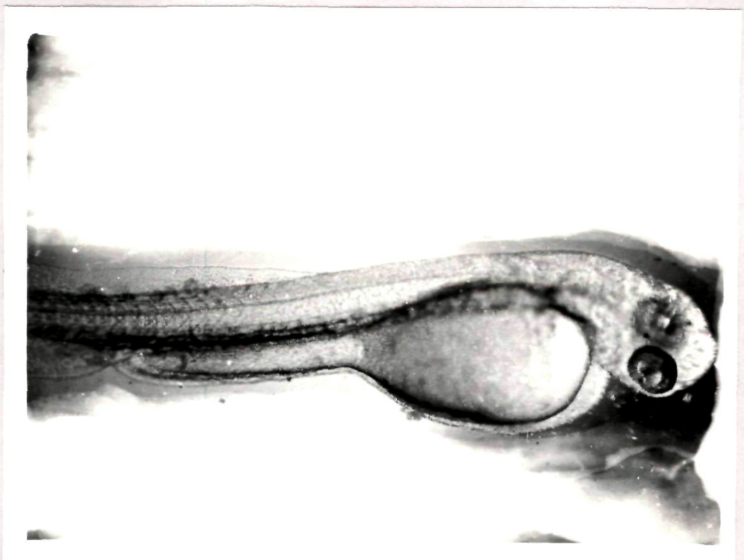
(b) Showing the fifth day embryo before hatching (evening hours).

(c) Showing the early hatchling.

PLATE XI

a

b



c

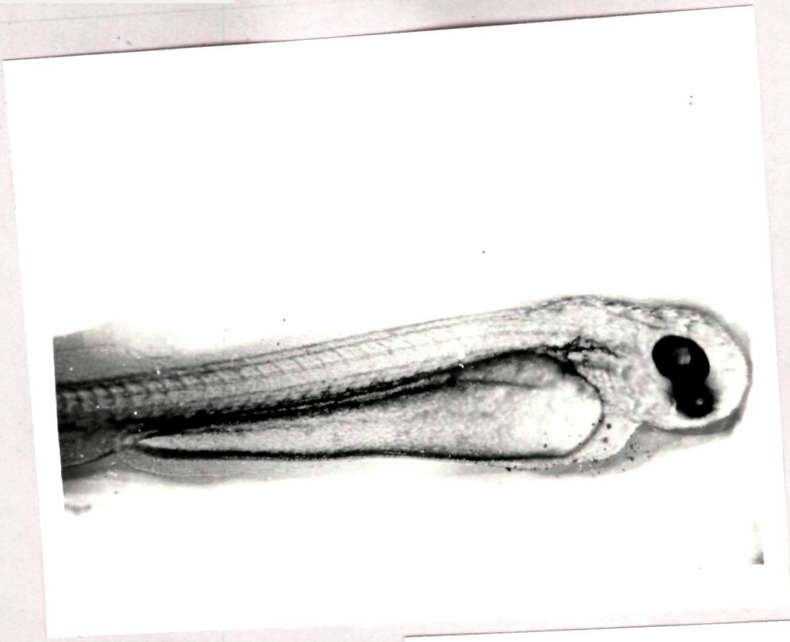
PLATE · XII

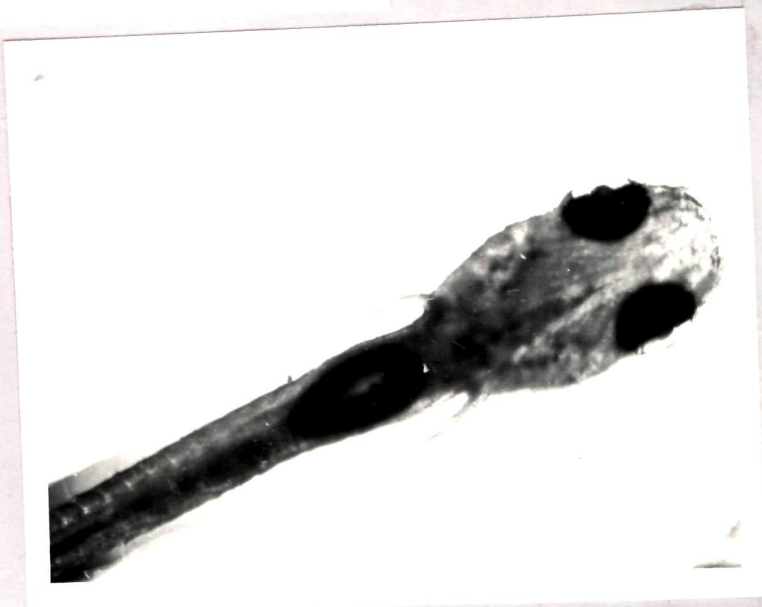
(a) Showing hatchling in the second day.

(b) Showing hatchling in the third day.

(c) Showing an early spawn (sixth day).

PLATE XII





from stocking to final harvest was estimated to be 7 fold in length and 1,136 times in weight. The survival rate was computed to be 72.4% and the actual loss due to mortality was 276 numbers forming a rate of 27.6%.

In the second experiment in April, 1,000 spawn were again reared in the hapa (Table-VIII). The initial stocking size was 8.0 to 10.0 mm and 10.0 to 12.0 mg. During 75 days rearing period, the fry grew to 40.0 to 80.0 mm and 3,500 to 6,500 mg in length and weight respectively with the rate of growth of 6.6 times in length and 45.5 times in weight. The total number of fry harvested from this experiment was 752 working out to 75.2% of growth and survival. The mortality loss was 248 frys with a rate of 24.8%.

In the third experiment conducted in May 1978, 1,000 spawn ranging in size from 8.0 to 10.0 mm in length and 10.0 to 12.0 mg in weight were reared. In the 60 days of rearing, the spawn grew to a fry stage ranging from 40.0 to 70.0 mm and 3,500 to 6,000 mg in length and weight. Thus the growth rate in length and weight was estimated at 6.1 and 432 times the initial sizes. The total numbers of fry harvested were 856 with the growth and survival rate of 85.6%. The mortality rate was 14.4% with a loss of 144 frys.

In the fourth experiment performed in May 1978, 1,000 spawn of 8.0 to 10.0 mm and 10.0 to 12.0 mg had grown to a fry size ranging between 30.0 to 60.0 mm and 2,500 to 6,000 mg in a period of 60 days. The growth rate estimated was 5 times and

384 times from initial length and weight. The final number of fry harvested was 813 with a survival rate of 81.3%. A total of 187 fry were lost during this experiment with a mortality rate of 18.7% (Table-VIII).

In the year 1979 for purposes of replication, four sets of rearing experiments were once again planned and executed in the month of April. 1,000 spawn of 6.0 to 10.0 mm and 5.0 to 10.0 mg were reared in a nylon hapa (2 X 1 X 1 m) for a total duration of 75 days. The fish fry finally harvested ranged in size from 40.0 to 65.0 mm and 4,000 to 6,000 mg with the growth rate estimated to be 6.5 and 1,066 times in length and weight respectively. The actual number of fry taken out finally was 891 implying a survival rate of 89.1%. The mortality rate was 10.9% since 109 of the originally stocked fry were lost during the experiment (Table- VIII).

In the second set of experiments, 1,000 spawn of 6.0 to 10.0 mm and 5.0 to 10.0 mg, grew to fry stage in the 75 days rearing period. Their final sizes ranged between 30.0 to 70.0 mm and 3,000 to 6,500 mg. As a result their growth in length and weight was estimated to be 6.2 and 766 times from that of the initial measurements. The total number of fry survived was 847 amounting to a survival rate of 84.7%. In this experiment the mortality figure was 153 which worked out to a mortality rate of 15.3%.

During the third experiment conducted in the same month, 1,000 spawn of 8.0 to 10.0 mm and 10.0 to 12.0 mg, grew to a

TABLE VIII: Showing the rearing of Spawn to Fry of Common Carp, *Cyprinus carpio communis* L. in Nylon Hapa at Fish Dale farm, Shillong during the year 1978 and 1979.

Expt. No. & Date of stocking.	Hapa size sq.m.	Stocking size		Spawn stocked (Nos.)	Rearing period (days)	Fry harvested (Nos.)	Fry harvested size		Mortality		Percentage of survival
		Length mm.	Weight mg.				Length mm.	Weight mg.	Nos.	%	
No.1 (5/4/78)	2	8.0 to 10.0	10.0 to 12.0	1,000	75	724	50.0 to 80.0	4,500 to 8,000	276	27.6	72.4
No.2 (5/4/78)	2	8.0 to 10.0	10.0 to 12.0	1,000	75	752	40.0 to 80.0	3,500 to 6,500	248	24.8	75.2
No.3 (20/5/78)	2	8.0 to 10.0	10.0 to 12.0	1,000	60	856	40.0 to 70.0	3,500 to 6,000	144	14.4	85.6
No.4 (20/5/78)	2	8.0 to 10.0	10.0 to 12.0	1,000	60	813	30.0 to 60.0	2,500 to 6,000	187	18.7	81.3
No.1 (22/4/79)	2	6.0 to 10.0	5.0 to 10.0	1,000	75	891	40.0 to 65.0	4,000 to 6,000	109	10.9	89.1
No.2 (22/4/79)	2	6.0 to 10.0	5.0 to 10.0	1,000	75	847	30.0 to 70.0	3,000 to 6,500	153	15.3	84.7
No.3 (30/4/79)	2	8.0 to 10.0	10.0 to 12.0	1,000	60	855	50.0 to 75.0	6,000 to 9,000	145	14.5	85.5
No.4 (30/4/79)	2	8.0 to 10.0	10.0 to 12.0	1,000	60	873	45.0 to 65.0	4,000 to 7,500	127	12.7	87.3

fry size ranging between 50.0 to 75.0 mm and 6,000 to 9,000 mg in the 60 days interval. The growth rate estimated in both length and weight was 7 and 682 times initial sizes. The total number of fry harvested was 855 with a growth and survivality rate of 85.5% with the mortality number and rate forming 145 and 14.5% respectively.

In the fourth experiment, 1,000 spawn of the sizes ranging between 8.0 to 10.0 mm and 10.0 to 12.0 mg, had grown to fry stage in a period of 60 days rearing. The fry ultimatoly harvested were of 45.0 to 65.0 mm and 4,000 to 7,500 mg size. The growth rate estimated was 6.1 and 545 times in length and weight respectively. The total number of fry harvested out was 873 obtaining a survival rate of 87.3%. The mortality figure was 127 with a rate at 12.7%.

(iii) Roaring of spawn to fry of the Common Carp, *Cyprinus carpio communis* L. in Plastic Pools.:

In another series of roaring experiments aimed at obtaining results on the comparative efficiencies of the fry habitat during 1978 and 1979, the Common carp spawn were reared in Plastic pools. The feed comprises of a mixture of finely powdered rice bran and mustard oil cake in a 1:1 ratio. No manuring was done as the pools were filled with pond wator taken from the nursery pond which had been manured at weekly intervals prior to these experiments.

In the first rearing experiment done in May 1978, the pools were stocked with 500 spawn of size range between 8.0 to 10.0 mm and 10.0 to 12.0 mg (Table-IX). In the 60 days of rearing the spawn had grown to fry stage of 35.0 to 50.0 mm and 3,000 to 5,000 mg. The growth rate recorded was 4.7 and 364 times in terms of length and weight increment. The total fry harvested was 358 with a survival rate of 71.6%. The actual loss due to mortality was 142 fry which worked out to 28.4%.

In the second series of rearing experiment conducted in the same month of 1978, the pool stocked with 500 spawn of 8.0 to 10.0 mm and 10.0 to 12.0 mg had shown the fry to have grown to 45.0 to 60.0 mm and 5,000 to 7,000 mg in length and weight. Thus the growth rate from stocking to harvesting was estimated to be 6 times and 545 times in terms of length and weight. The total number of fry harvested was 302 with the survival rato of 60.4%. The mortality of fry was estimated to be 198 with a mortality rate of 39.6%.

As before, two sets of experiments were conducted in 1979. In the first experiment during April 1979, 500 spawn ranging between 6.0 to 8.0 mm and 6.0 to 8.0 mg were reared for a poriod of 60 days. The growth noted after harvesting was found to be ranging between 45.0 to 65.0 mm and 4,000 to 6,000 mg, working out to 8 and 714 times in length and weight. The total number of fry netted out was 393 with a survival rate of 78.6%. The mortality was 107 at the rate of 21.4%.

In the second experiment conducted during the month of May 1979, 500 spawn of 6.0 to 10.0 mm and 7.0 to 11.0 mg reared for a period of 60 days, had grown to a size ranging between 40.0 to 60.0 mm and 3,500 to 5,500 mg. The final growth revealed

TABLEIX : Showing the rearing of Spawn to Fry of Common Carp, *Cyprinus carpio communis* L. in Plastic Pools at Fish Dale farm, Shillong during the year 1978 and 1979.

Expt.No. and Date of stocking	Stocking size		Spawn stocked (Nos.)	Rearing period (days)	Fry harvested (Nos.)	Fry harvested size		Mortality		Percentage of survival
	Length mm.	Weight mg.				Length mm.	Weight mg.	Nos.	%	
No.1 (20/5/78)	8.0 to 10.0	10.0 to 12.0	500	60	358	35.0 to 50.0	3,000 to 5,000	142	28.4	71.6
No.2 (20/5/78)	8.0 to 10.0	10.0 to 12.0	500	60	302	45.0 to 60.0	5,000 to 7,000	198	39.6	60.4
No.1 (28/4/79)	6.0 to 8.0	6.0 to 8.0	500	60	393	40.0 to 65.0	4,000 to 6,000	107	21.4	78.6
No.2 (5/5/79)	6.0 to 10.0	7.0 to 11.0	500	60	417	40.0 to 60.0	3,500 to 5,500	83	16.6	83.4

a 6-fold and 500-fold increment in terms of length and weight. The total number of fry harvested was 417 which accounts for 83.4% of survival resulting in a loss of 83 fry, yielding a mortality rate of 16.6%.

(iv) Rearing of fry to fingerling of the Common carp *Cyprinus carpio communis* L. in Plastic Pools at different feed combinations :

The rearing of Common carp fry to fingerling stages was conducted in Plastic Pools of varying sizes for a period of 6 months and with different feeding combinations as detailed in Table- X . These experiments were carried out in the premises of the University Campus. The rate of feeding was at 4% of the body weight of the fish stocked and fed every alternate day. The amount of feed was doubled after every 15 days to compensate the corresponding growth of fish (Table- XI, XII & Fig: 1)

In these Plastic Pools experiments most of the factors were kept under control. The pools are rain free as these were kept in a net house covered with plastic sheet and predator free as well. The pH of water was maintained at an optimum around 7.0. The data gathered from these experiments in different pools are compiled and presented in Table-XIII .It will be seen from the Table that pool 1 stocked with 100 fry and fed with rice bran, oil cake and cowdung showed the highest growth. From an initial weight ranging from 0.5 to 1.0 gm these fry grew to a maximum size ranging from 35.0 to 51.0 gm in a 6 month rearing period. This works out to an average growth rate of 6.8 gm per month. The total number of fingerlings finally harvested was 84, accounting for a survival rate of 84% and amounted to a total production of 3,600 gm in 6 months. The actual loss of fingerlings due to mortality was 16 numbers with a mortality rate of 16%.

Similarly, Pool 2 with a feed combination of rice bran and oil cake and stocked with 75 fry showed a growth from an initial stocking weight of 0.5 to 1.0 gm to a maximum of 22.0 to 35.0 gm with an average monthly growth rate of 4.85 gm with a total production of 1,815 gm for the 6 months. The final number of fingerlings harvested was 66 accounting for 88% survival. The loss due to mortality was estimated at 12%.

In Pool 3, stocked with 25 fry with initial weight range of 0.5 to 1.0 gm growth recorded ranged from 18.0 to 26.5 gm in 6 months with an average monthly growth rate of 3.50 gm. The feed given for these experiments comprised only of finely powdered rice bran. 20 fingerlings were finally harvested accounting to 80% survival, with the total production of 462 gm in 6 months. The mortality rate was 20%.

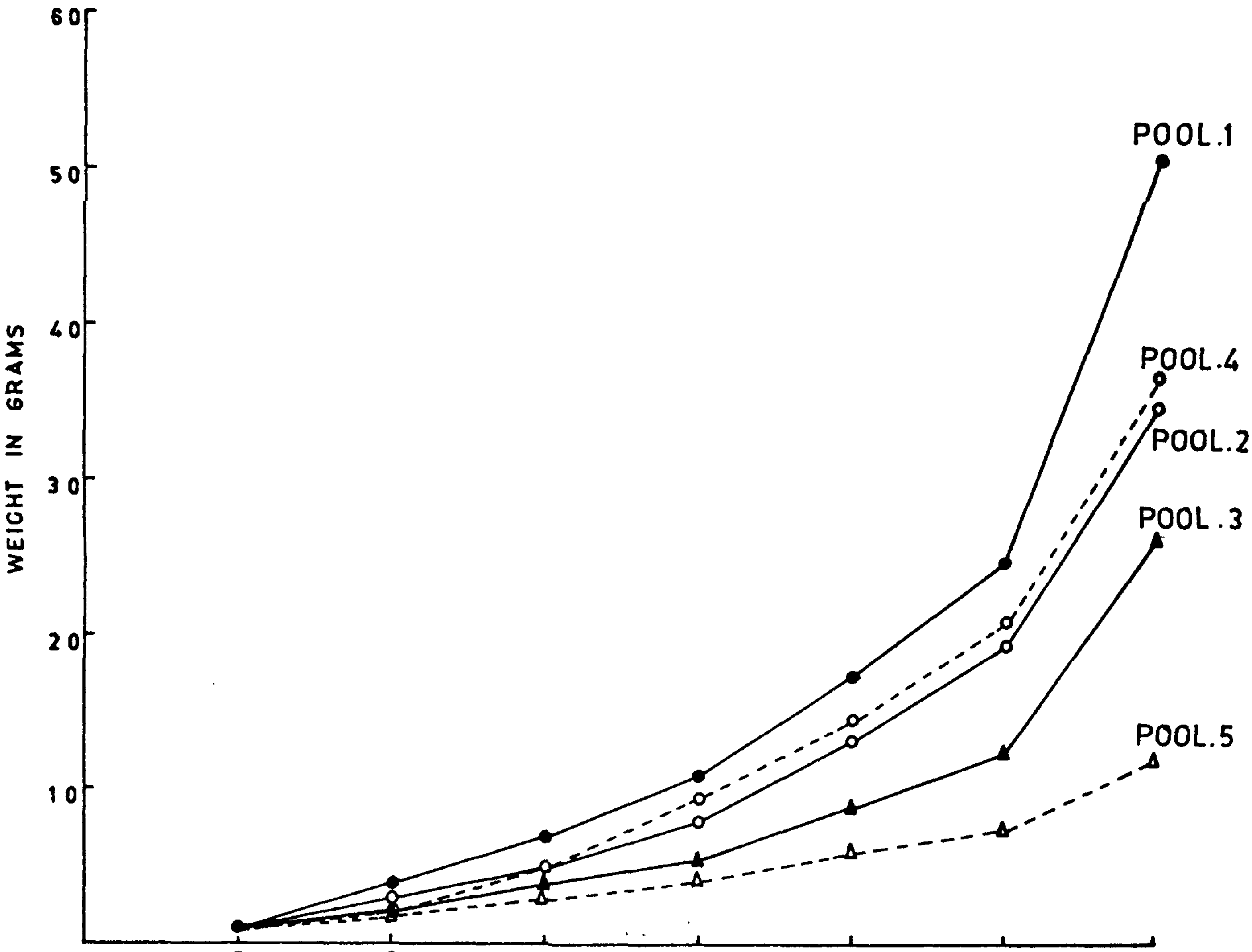
Pool 4, stocked with 25 fry with an initial stocking weight of 0.5 to 1.0 gm grew to sizes ranging between 25.0 to 38.0 gm. The growth rate on an average was found to be 5.3 gm per month. The fingerlings harvested were 18 numbers accounting to a survival rate of 72%, with the total production of 590 gm in six months. The mortality rate was 28%. The feed in this pool comprised of mustard oil cake only.

The Pool 5 with 55 fry showed the least growth rate, since this was the control with no supplementary food at all.

FIG. 1

Graph showing the growth rate and weight of Common Carp, Cyprinus carpio communis L. in five different experimental Plastic Pools.

FIG.1



60
50
40
30
20
10
WEIGHT IN GRAMS
POOL.1
POOL.4
POOL.2
POOL.3
POOL.5
S
O
N
D
J
F
M
1978
1979

TABLE X : Showing the different feeding combination given during the rearing of Fry to Fingerling stages of the Common Carp, <u>Cyprinus carpio communis</u> L. in different Plastic Pools for the six month period i.e. from September 1978 to March 1979.

Pool No.		Feed combinations
1	....	Rice bran, Mustard oil cake and cowdung
2	....	Rice bran and Oil cake.
3	....	Rice bran.
4	....	Oil cake.
5	....	Control (no feed).

TABLE XI : Showing the total amount of food given per month on two instalment basis, for the six months period i.e. September 1978 to March 1979 during the rearing experiment of Fry to Fingerling of <u>Cyprinus carpio communis</u> L. in Plastic Pools at different feed combinations.

POOL NO. 1			POOL NO 2			POOL NO. 3			POOL NO. 4		
1-15 days (gm)	16-30 days (gm)	TOTAL (gm)	1-15 days (gm)	16-30 days (gm)	TOTAL (gm)	1-15 days (gm)	16-30 days (gm)	TOTAL (gm)	1-15 days (gm)	16-30 days (gm)	TOTAL (gm)
56	128	184	35	80	115	14	32	46	14	32	46
140	320	460	105	240	345	35	80	115	35	80	115
280	480	760	210	360	570	70	120	190	70	120	190
560	960	1520	420	720	1140	140	240	380	140	240	380
840	1280	2120	630	960	1590	210	320	530	210	320	530
1020	1600	2620	840	1200	2040	280	400	680	280	400	680
1750	2000	3750	260	1440	2700	420	480	900	420	480	900

POOL NO. 5 - No supplementary food

TABLE XIV: Showing the Monthly Sampling of Fish during the rearing experiments of Fry to Fingerlings of the Common carp, *Cyprinus carpio communis* L. in Plastic Pools using different feed combinations for six months period i.e. September 1978–March 1979.

Months & Year	Pool Nos.	MINIMUM		MAXIMUM	
		Length (cm.)	Weight (mg.)	Length (cm.)	Weight (mg.)
September '78	1	3.0	500	4.4	1,000
	2	3.0	500	4.4	1,000
	3	3.0	500	4.4	1,000
	4	3.0	500	4.4	1,000
	5	3.0	500	4.4	1,000
October '78	1	5.0	1,800	6.0	4,000
	2	4.2	1,500	5.5	3,000
	3	4.5	1,500	5.5	2,500
	4	4.5	1,500	5.0	2,100
	5	4.5	1,500	5.0	2,000
November '78	1	5.2	2,200	7.0	7,000
	2	5.0	1,800	6.5	5,000
	3	5.0	2,000	6.5	4,000
	4	5.5	2,500	6.5	5,000
	5	5.0	1,800	5.0	3,000
December '78	1	6.0	4,000	8.5	11,000
	2	5.5	3,000	7.5	8,000
	3	5.0	2,600	6.5	5,500
	4	5.0	3,800	7.0	9,500
	5	5.5	2,300	6.0	4,200
January '79	1	8.0	11,000	9.5	17,500
	2	7.0	8,000	8.5	13,500
	3	6.5	6,500	7.5	9,000
	4	7.0	9,000	8.5	14,500
	5	6.0	5,000	6.5	6,000
February '79	1	9.5	19,000	10.5	25,000
	2	8.5	14,500	9.5	19,500
	3	7.5	10,000	8.5	13,000
	4	9.0	16,000	9.5	21,000
	5	6.5	6,500	7.0	7,500
March '79	1	12.0	33,000	14.5	51,000
	2	11.0	27,000	13.5	35,000
	3	10.0	18,000	12.5	26,500
	4	11.0	28,000	13.0	38,000
	5	8.0	9,500	9.0	12,000

TABLE XIII : Showing the overall data on the experiment of growth, survival and mortality rate alongwith the different feeding regimes employed on the Common Carp, <u>Cyprinus carpio communis</u> L. conducted in Plastic Pools of varying sizes in the premises of the University Campus during September 1978 to March 1979.

Pool Nos.	Size of the Pool in diameter (m)	Numbers of fishes stocked	Feeding combinations	Amount of food given for 6 months (gm.)
1	2	3	4	5
1	2.5	100	Rice bran, Mustard Oil Cake (Cowdung).	11,400 (1,500)
2	1.5	75	Rice bran and Mustard Oil Cake.	8,500
3	1.0	25	Rice bran only.	2,740
4	0.5	25	Mustard Oil Cake only.	2,740
5	0.5	55	Control.	Nil

Initial weight before stocking (gm)	Final weight after harvesting (gm.)	Average monthly growth rate (gm)	Total production in 6 months (gm.)	Survival		Mortality	
				Nos.	%	Nos.	%
6	7	8	9	10	11	12	13
0.5-1.0	35.0-51.0	6.80	3600	84	84	16	16
0.5-1.0	22.0-35.0	4.85	1815	66	88	9	12
0.5-1.0	18.0-26.5	3.50	462	20	80	5	20
0.5-1.0	25.0-38.0	5.30	590	18	72	7	28
0.5-1.0	9.0-12.0	1.57	126	12	22	43	78

These fry from an initial stocking size of 0.5 to 1.0 gm, grew to a maximum weight of 9.0 to 12.0 gm, with an average monthly growth rate of 1.59 gm yielding a total production of 126 gm in 6 months. The fingerlings finally harvested were 12 numbers accounting for the lowest survival rate of 22%. The loss due to mortality was very high with 43 out of 55, working out a mortality rate of 78%.

(v) Physico-chemical and biological factors of the Plastic Pools :

Temperature :

One of the important factors as could naturally be expected to influence the growth of fry is temperature. Therefore, this factor has been measured and the data presented. The surface temperature recorded from the above pools under study are shown in Fig. 1, and it will be seen that the range was between 10 to 21°C in all of them. The maximum value was attained during September and October, 1978 ranging between 20-21°C. From November 1978 till February 1979 a trend of decrease in water temperature was observed from an initial 18 to 10°C, whereas in March, the temperature rose again to 16°C.

pH :

The pH of water was found to be in the alkaline range and varied between 7.0 to 8.6 in Pool 1, 7.0 to 9.2 in Pool 2, 7.0 to 8.3 in Pool 3, 7.0 to 8.8 in Pool 4 and 6.6 to 10.0 in Pool 5. These values along with the attendant fluctuations for the 6 months period are shown in Fig. 2. In Pool 1, the pH of 7.0 was recorded in January 1979 and the high value of 8.6 in November 1978, whereas for the rest of the study period it ranged between 7.2 to 7.4. Similarly, in Pool 2, a pH of 7.0 was recorded in September 1978 which tended to rise to 7.3 in October, 9.2 in November, only to drop to 8.3 in December and remained stable at 8.2 for the rest of the period of study. The pH of 7.1 recorded in September in Pool 3, showed a steady rise to 7.3 in October, thereafter the value more or less stabilised between 8.0 to 8.3 for the other months. In Pool 4, the initial pH of 7.0 in September rose to 8.8 in November. It again dropped to 8.6 during the next month and become steady at 8.1 for the rest of the period of investigation. In Pool 5, the initial pH of 6.8 was recorded in September which rose to 10.1 in November. It will be seen that the value drops to 7.5 in January and reached constant at 7.8 for the rest of the months.

Conductivity :

The conductivity values recorded in the five Plastic pools ranged between 58.80 to 63.00, 78.75 to 98.70, 105.00 to 168.50, 115.00 to 168.50 and 42.00 to 52.50 umhos/cm for the five pools respectively (Fig. 2). From the observations, it was noted that in Pool 1, from an initial reading of 68.00 recorded in September 1978 there was a drop to 58.80 by January 1979, where again a steady rise was observed to 63.00 by March 1979. Similarly in Pool 2, from the maximum level of 98.70 in September a steady decline to 78.75 in January was seen. The value again rises to 84.00 by March 1979. In Pool 3, from an initial reading of 105.00 there was a rise to 168.50 in December, which ultimately dropped to 147.00 in January. February witnessed a rise in value to 157.00 which once again dropped to 126.00 in March. Pool 4, showed a steady rise of conductivity values from

115.00 to 168.50 during the month of November, December and February. It was noted that in January and March decrease in values was recorded reaching 147.00 umhos/cm. In Pool 5, the conductivity initially recorded was 50.40 which gradually decreased to 42.00 in October, but rose again in December to 49.90 only to drop in February to 44.10. There was once again an increase to 52.50 in March 1979.

Dissolved oxygen :

During the present experimental period, the amount of dissolved oxygen in these Plastic pools showed a marked fluctuations. Thus in Pool 1, the oxygen content ranged between 8.0 to 12.4; in Pool 2 from 6.4 to 11.6; in Pool 3, 4.0 to 11.6; in Pool 4, 4.0 to 10.8 and in Pool 5, 2.0 to 12.8 mg/l (Fig.2). In Pool 1, the low level was observed in October whereas high values were recorded in January with a steady range of 11.2 to 11.6 mg/l throughout the rest of the period of study. Pool 2, showed a steady rise from 6.6 to 11.6 all through the period of investigation except a few lowering values in December, February and March to 10.4 and 9.6 mg/l. Pool 3, too showed a rise from an initial of 4.0 mg/l to a maximum of 11.6 mg/l in January with a decrease to 4.8 in December. Again the values were 10.8 and 10.4 during February and March 1979. Similarly in Pool 4, the value rose up to a maximum of 10.8 in January when it began to drop in February and March to 10.4 and 10.0 mg/l respectively. Pool 5, always showed a rise from a minimum of 2.0 to a maximum of 12.8 mg/l throughout the six-month period of investigation.

FIG. 2

Graph showing the fluctuation of physico-chemical parameters (Air and water temperature, conductivity, dissolved oxygen and pH) in five different experimental Plastic Pools.

FIG. 2

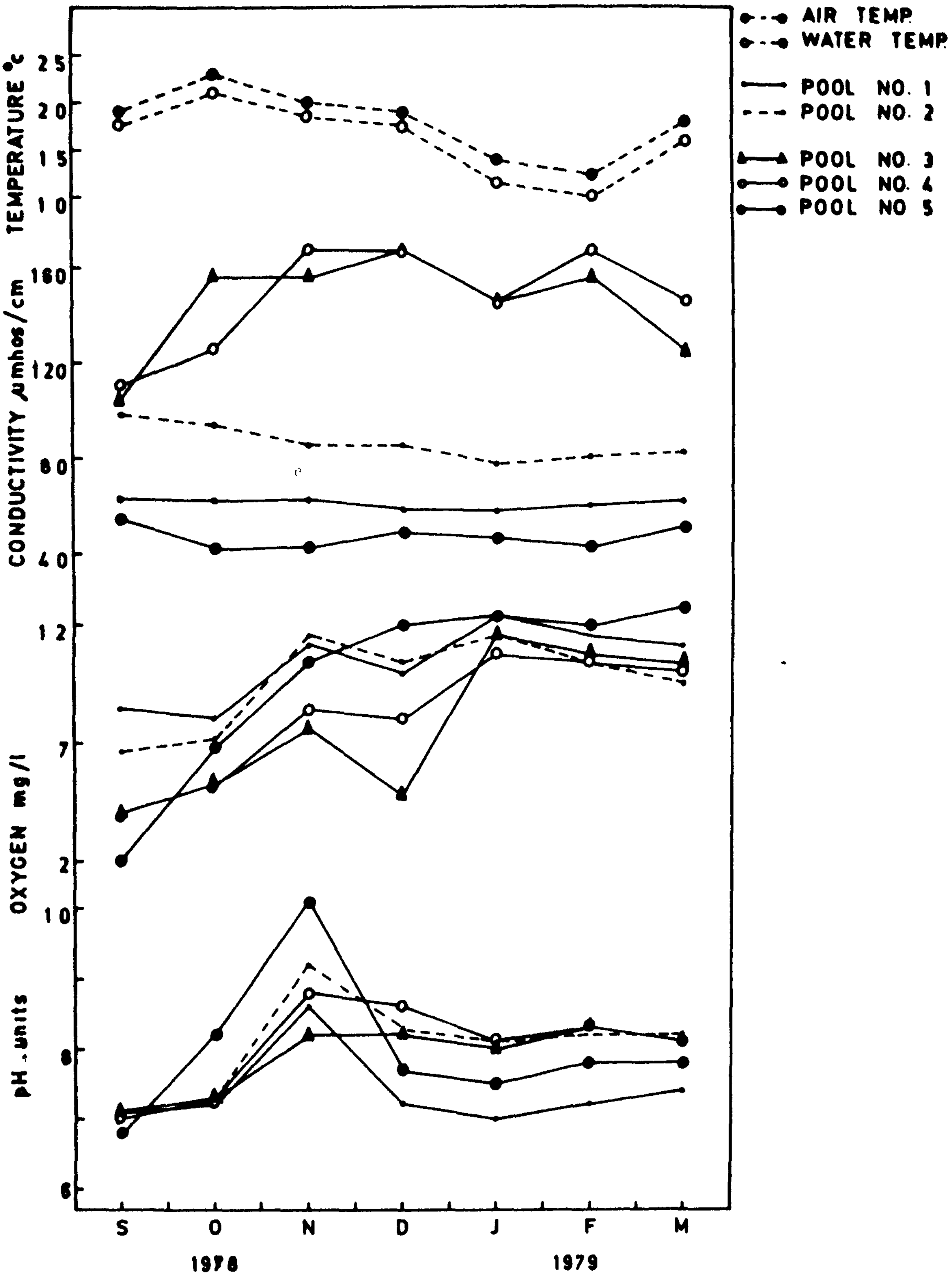

AIR TEMP.
WATER TEMP.
POOL NO. 1
POOL NO. 2
POOL NO. 3
POOL NO. 4
POOL NO 5
TEMPERATURE °c
25
20
15
10
CONDUCTIVITY µmhos/cm
160
120
80
40
OXYGEN mg/l
12
7
2
pH . units
10
8
6
S
O
N
D
J
F
M
1978
1979

TABLE XIV Showing the Physico-chemical parameters analysed during the rearing of Fry to Fingerlings of the Common carp, Cyprinus carpio communis L. in Plastic Pools using different feed combinations for six months period i.e. September 1978-March 1979.

Months & Year	Pool Nos.	Temperature Air (°C)	Temperature Water (°C)	pH	Oxygen	Conductivity
September '78	1	19.0	17.5	7.1	8.4	63.00
	2			7.0	6.6	98.70
	3			7.1	4.0	105.00
	4			7.0	4.0	115.00
	5			6.8	2.0	50.40
October '78	1	23.0	21.0	7.2	8.0	61.95
	2			7.3	7.2	94.50
	3			7.3	5.2	157.50
	4			7.4	5.2	126.00
	5			8.2	6.8	42.00
November '78	1	20.0	18.5	8.6	11.2	63.00
	2			9.2	11.6	86.10
	3			8.2	7.6	157.00
	4			8.8	8.4	168.00
	5			10.1	10.4	43.05
December '78	1	19.0	17.5	7.2	10.0	58.80
	2			8.3	0.4	86.10
	3			8.2	4.8	168.50
	4			8.6	8.0	168.50
	5			7.7	12.0	49.90
January '79	1	14.0	11.5	7.0	12.4	58.80
	2			8.1	11.6	78.75
	3			8.0	11.6	147.00
	4			8.1	10.8	147.00
	5			7.5	12.4	47.25
February '79	1	12.5	10.0	7.2	11.6	60.90
	2			8.2	10.4	81.90
	3			8.3	10.8	157.50
	4			8.3	10.4	168.00
	5			7.8	12.0	44.10
March '79	1	18.0	16.0	7.4	11.2	63.00
	2			8.2	9.6	84.00
	3			8.1	10.4	126.00
	4			8.1	10.0	147.00
	5			7.8	12.8	52.50

POOL 1

Phytoplankton (Fig. 3; Table-XV) :-

(i) Scenedesmus :

This algae was found to be present throughout the period of investigations, from September 1978 to March 1979. The maximum occurrence of this species was seen in the month of September 1978 and minimum in March 1979. From September onwards the number steadily dropped till March, but the relative percentage of abundance revealed a drop from September till December with fluctuations around that value thereafter.

(ii) Haematococcus :

This species ranged from 17.18 to 64.47% of the total plankton throughout the study period. In this species, the actual counts and their relative percentage did not tally. The maximum number was recorded in December with 81,450 cells/litre comprising of 61.52%, whereas the relative percentage of abundance as seen in March was 64.47% with a count of 78,120 cells/litre. The minimum was recorded in September with 25,120 cells/litre marking 17.18% of the total plankton. An increase in number was noticed from October till December with a drop in January to further rise in February and March. The relative percentage of this group revealed an exponential phase throughout the period of investigation.

(iii) Staurastrum :

This species ranged from 310 cells/litre (0.22%) to 3,150 cells/litre (2.43%) throughout the period of investigation. The maximum was recorded in November and minimum in September. It was noticed that there was a steady rise from October till it reached a peak in November, and from December onwards a drop was noticed for the remaining period of investigation.

(iv) Pandorina :

This species was found throughout the period of investigation with the minimum in September and maximum in January comprising of 15 and 460 cells/litre respectively. September onwards, a trend towards the increase in numbers was noticed till a peak was obtained in January, with a drop in February to rise again in March.

(v) Anabaena :

Anabaena reached a peak in November with 1,300 cells/litre but only 1.00% of the total plankton, while the minimum was in September with 185 cells/litre making a percentage of 0.13%. As in Pandorina here too a rise was observed from September till a peak was formed in November. From December a drop was noticed till February to rise significantly in March.

(vi) Aphanocapsa :

This species was found to be present only from September to December 1978 and was absent throughout the rest of the study period. The maximum was reached in November with 80 cells/litre and the minimum in September with 15 cells/litre. This species too showed an increase from September to reached a peak in November, dropped in December and disappeared thereafter.

(vii) Nitzchia :

This species was found during September, October and December 1978 and January and February of 1979. The peak was obtained in October with 40 cells/litre making 0.02% of the total plankton. In November it was absent to again reappear in December with a rise in January, to drop in February with a minimum of only 5 cells/litre and totally absent in the month of March.

Zooplankton :- POOL 1

(i) Protozoa (*Difflugia* sp.)

This species was found to be present throughout the period of investigation, maximum being recorded in November with 8,510 cells/litre and 6.57% while the minimum was in January with 2,175 cells/litre and 1.91%. From September onwards there was an increase in the population till it reached a peak in November. A drop was seen in December which reached the minimum in January, February and March revealed a trend towards the increase.

(ii) Rotifera (*Asplanchna* sp.)

This species ranged from 25 cells/litre to 160 cells/litre, with a maximum in November. The minimum was recorded in September, January and February. From September onwards an increase in the trend was seen, till a peak was obtained in November, but abruptly dropped in December reaching the minimum in January and February. March revealed an increasing trend.

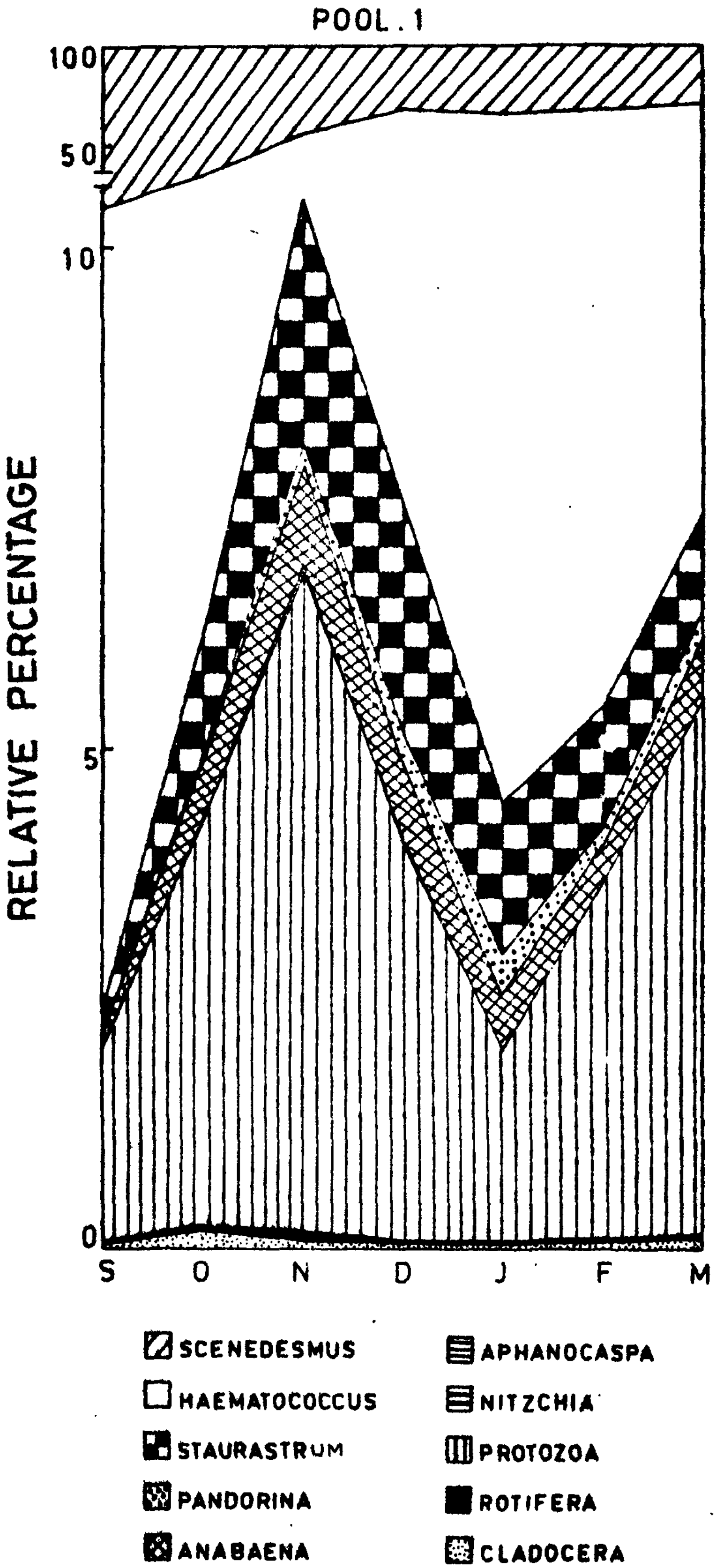
(iii) Cladocera (*Moina* sp.)

This species were maximum in October with 240 cells/litre and the minimum in January with 60 cells/litre. Though found from September, yet it reached its peak only in October. From November onwards a steady drop was noticed till the minimum was recorded in January. An increasing trend was again noticed during the subsequent months.

FIG. 3

Graph showing the relative percentage abundance of different groups of Phytoplankton and Zoopl-ankton in experimental Plastic Pool No. 1.

FIG.3



POOL.1
RELATIVE PERCENTAGE
100
50
10
5
0
S
O
N
D
J
F
M
SCENEDESMUS
HAEMATOCOCCUS
STAURASTRUM
PANDORINA
ANABAENA
APHANOCASPA
NITZCHIA
PROTOZOA
ROTIFERA
CLADOCERA

TABLE XV : Showing the groupwise seasonal abundance of different Phytoplankton and Zooplankton in the rearing experiment of Fry to Fingerling of *Cyprinus carpio communis* L. in Plastic Pools with different feed combinations from September, 1978 to March, 1979.

POOL 1

Name of the Species	SEP	OCT	NOV	DEC	JAN	FEB	MAR
SCENEDESMUS	117600 80.45%	85200 63.95%	55350 42.75%	41200 31.10%	38400 33.66%	35200 30.99%	34150 28.18%
HAEMATOCOCCUS	25120 17.18%	39840 29.90%	60550 46.77%	81480 61.52%	70600 61.88%	72300 63.61%	78120 64.47%
STAURASTRUM	310 00.22%	1600 1.20%	3150 2.43%	3000 2.26%	1750 1.53%	1400 1.23%	1200 0.99%
PANDORINA	15 .01%	60 .05%	280 .22%	400 .30%	460 .40%	200 .18%	350 .29%
ANABAENA	185 .13%	800 .60%	1300 1.00%	1000 .75%	600 .53%	450 .39%	720 .59%
APHANOCAPSA	15 .01%	20 .01%	80 .06%	30 .02%	- -	- -	- -
NITZCHIA	25 .02%	40 .02%	- -	10 .01%	25 .02%	5 .004%	- -
PROTOZOA (*Diffugia* sp)	2800 1.9%	5350 4.02%	8510 6.57%	5230 3.95%	2175 1.91%	3990 3.51%	6470 5.34%
ROTIFERA (*Asplanchna* sp)	25 .02%	87 .06%	160 .	40 .04%	25 .02%	25 .02%	40 .03%
CLADOCERA (*Moina* sp)	80 .05%	240 .18%	85 .07%	65 .05%	60 .05%	90 .08%	130 .11%

POOL 2

Phytoplankton (Fig. 4 and Table-XVI) :-

(i) Scenedesmus :

This species ranged from 74.60% to 33.80% throughout the period of investigation. The maximum was recorded in September with 99,280 cells/litre amounting to 74.60% and the minimum in March with 40,500 cells/litre comprising of 33.80%. From September onwards the number decreased steadily till March, while the relative percentage of abundance dropped from September till December with a rise in January to again drop in February and March.

(ii) Haematococcus :

This species was found to be present throughout the study period forming a peak in March with 62.90% and the least in September with 21.88%. It was noticed that the numbers of abundance among this species increased month after month till December with a drop being observed only in January to again rise in February and March. The relative percentage of abundance showed an increasing trend from September onwards till it reached a peak in March.

(iii) Staurastrum :

This species was found to present from September to February only and was absent in March. The maximum was recorded in November with 7,700 cells/litre and the minimum in February, 1979 with 325 cells/litre. This species showed an increasing trend from September to November but revealed a drop from December onwards according to the minimum in February.

(iv) Tetrallantos :

This species was limited only in the two months of the study period i.e. during October and November. The maximum was recorded in October, with 1,360 cells/litre and the minimum of 890 cells/litre in November.

(v) Anabaena :

Anabaena was seen to be present from September to January and absent in February and March. Maximum was reached in November and the minimum in September. From September to November an increasing pattern was noticed, when a drop was seen in the subsequent two months.

(vi) Euglena :

Euglena was seen to be present from September to January only and absent during the rest of the study period. This species showed an increasing trend from September onwards to reach a peak in December, with a fall in January and absent completely in February and March.

Zooplankton :- POOL 2

(i) Protozoa (Ascomorpha)

This species was seen to be present throughout the period of investigation. The maximum was recorded in November with 8,090 cells/litre forming 5.59% and the minimum in September with 1,250 cells/litre of 0.94%. An increasing trend was noticed from September to November when it dropped in December and January. In the month of February, a rise was noticed whitch continued till March.

(ii) Rotifera (Polyarthra sp.)

This species occurred only during October and November but was absent throughout the rest of the study period. The maximum

FIG. 4

Graph showing the relative percent abundance of different groups of Phytoplankton and Zooplankton in experimental Plastic Pool No. 2.

FIG. 4

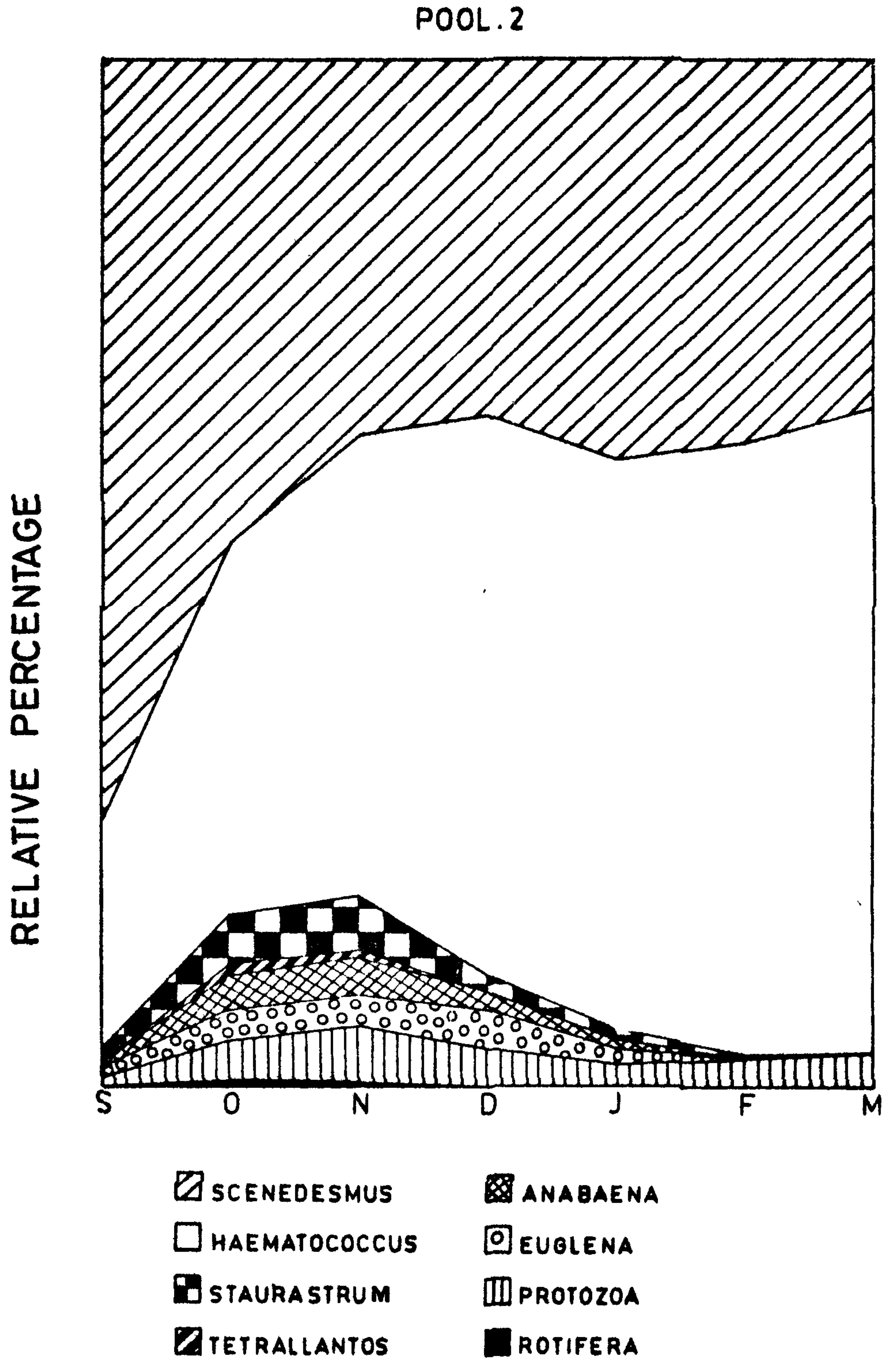

POOL. 2
RELATIVE PERCENTAGE
S
O
N
D
J
F
M
SCENEDESMUS
HAEMATOCOCCUS
STAURASTRUM
TETRALLANTOS
ANABAENA
EUGLENA
PROTOZOA
ROTIFERA

TABLE XVI : Showing the groupwise seasonal abundance of different Phytoplankton and Zooplankton in the rearing experiment of Fry to Fingerling of *Cyprinus carpio communis* L. in Plastic Pools with different food combinations from September, 1978 to March, 1979.

POOL - 2

Name of the Species	SEP	OCT	NOV	DEC	JAN	FEB	MAR
SCENEDESMUS	99280 74.60%	60000 46.85%	52750 36.42%	50800 34.52%	48200 38.69%	44540 37.07%	40500 33.80%
HAEMATOCOCCUS	29120 21.88%	46800 36.54%	65130 44.97%	80240 54.53%	69500 55.79%	72000 59.92%	75360 62.90%
STAURASTRUM	1740 1.31%	5920 4.62%	7700 5.32%	2410 1.64%	1100 .88%	325 .27%	- -
TETRALLANTOS	- -	1360 1.06%	890 .62%	- -	- -	- -	- -
ANABAENA	500 .37%	3200 2.50%	5130 3.54%	2650 1.80%	1140 .92%	- -	- -
EUGLENA	1200 .90%	400 3.12%	4500 3.11%	5510 3.74%	1930 1.55%	- -	- -
PROTOZOA (*Ascomorpha* sp)	1250 .94%	6000 4.70%	8090 5.59%	5550 3.77%	2700 2.17%	3300 2.75%	3950 3.30%
ROTIFERA (*Polyarthra*)	- -	800 .62%	640 .44%	- -	- -	- -	- -

was recorded in Octobor with 800 cells/litre forming 0.62% and the minimum in November with 640 cells/litre (0.44%).

POOL 3

Phytoplankton (Fig. 5 and Table XVII) :-

(i) Scenedesmus :

The relative percentage of abundance of this species showed a decreasing trend from the month of September to November and a rise from December to March. The maximum was recorded in March with 10,210 cells/litre forming 71.45%. The minimum relative percentage was observed in November with 37.73% for 8,140 cells/litre, though the minimum number among the group was observed in September with 7,780 cells/litre making 45.60%.

(ii) Haematococcus :

The maximum recorded in this species was 9,280 cells/litre amounting to 54.40% in the month of September and the minimum was recorded in March with 4,080 cells/litre of 28.55% relative abundance. It was noticed that the relative percentage of abundance decreased steadily from the month of September till December, when it shot up in January to again fall in the subsequent months.

(iii) Staurastrum :

This species was found to be present only from October to January and was absent in September 1978 and February and March 1979. The maximum was recorded in the month of December with 5,900 cells/litre and the minimum in January with 1,340 cells/litre. From October onwards an increasing trend was noticed till it reached a peak in December, but subsequently dropped in January to the minimum when it completely disappeared for tho rest of the study period.

Zooplankton :- POOL 3

Rotifera (Polyarthra) :

Polyarthra was seen to be present only in the month of October and November and were absent throughout the rest of the study period. The maximum recorded was 1,120 cells/litre in November and the minimum of 800 cells/litre in October.

POOL 4

Phytoplankton (Fig. 6; Table-XVII) :-

(i) Scenedesmus :

This species was observed throughout the period of investigation, with the maximum of 85:15%, in the month of March and with the minimum of 30.35% in September. It was seen that from September onwards an increasing trend was noticed till it reached the peak in March with 5,03,500 cells/litre.

(ii) Haematococcus :

The maximum relative percentage of abundance of this species was observed in September with 69.65% and the minimum in March with 9.65%. From September onwards the relative percentage of abundance dropped month after month till it reached the minimum in March. It was noticed in the month of October that this species showed the maximum number of 2,86,400 cells/litre though forming only 44.97% as compared to that of the month of September with 2,52,800 cells/litre of 69.65%.

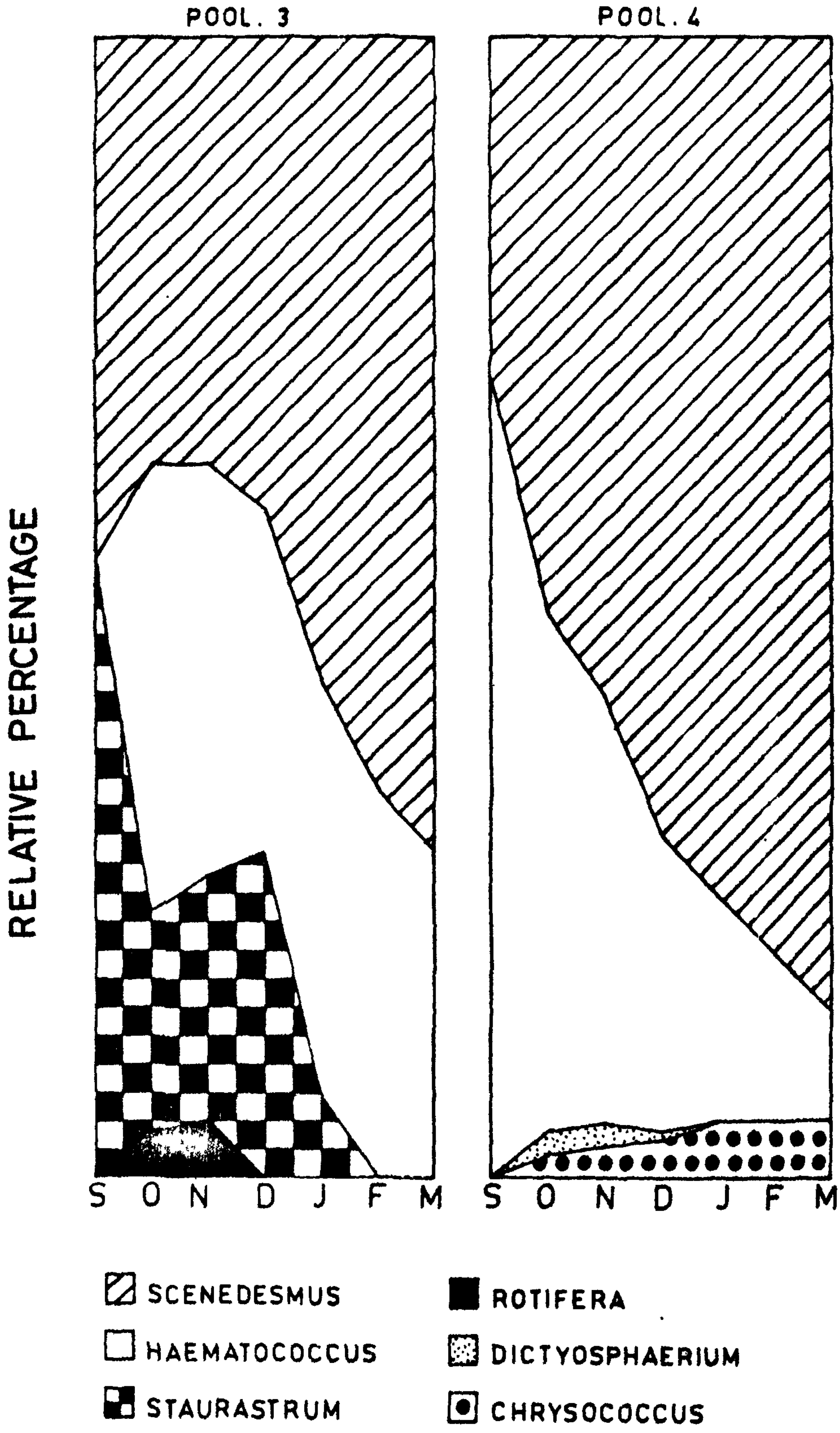
(iii) Dictyosphaerium :

Dictyosphaerium occurred in the plankton sample only during October, November and December. The maximum was recorded in October with 12,800 cells/litre and the minimum in November with 3,620 cells/litre. This species showed a decreasing trend from October onwards till it reached the minimum in November.

FIG. 5 and 6

Graph showing the relative percent abundance of different groups of Phytoplankton and Zooplankton in experimental Plastic Pool Nos. 3 and 4.

Fig. 5 Fig. 6


POOL. 3
POOL. 4
RELATIVE PERCENTAGE
S O N D J F M
S O N D J F M
SCENEDESMUS
HAEMATOCOCCUS
STAURASTRUM
ROTIFERA
DICTYOSPHAERIUM
CHRYSOCOCCUS

(iv) Chrysococcus :

This species was found to be present from October 1978 to March 1979 and was absent in September. The maximum was recorded in March with 30,770 cells/litre forming 5.20% whereas the minimum was observed in October with 13,600 cells/litre of 2.14%. This species showed an increasing trend every month beginning October 1978 and reaching a peak in March 1979.

POOL 5

Phytoplankton (Fig. 7 and Table XVII) :-

(i) Scenedesmus :

The maximum occurrence of this species was recorded in October with 8,56,080 cells/litre and the relative minimum percentage of abundance was seen in November with 4.24% for 3,55,000 cells/litre; whereas, September month showed the least numbers of occurrence, with only 1,68,000 cells/litre forming 29.01%. Though a peak was reached in October, yet in November it dropped to a minimum. Again in December a steady rise was observed for the remaining period of study.

(ii) Haematococcus :

This species ranged from a minimum of 56.14% as observed in October to a maximum of 96.76% in November. The actual counts and their relative percentage did not tally. The maximum number, recorded in March was 99,24,000 cells/litre amounting to only 92.67%, whereas the maximum relative percentage of abundance with 95.76% for 80,25,100 cells/litre. Similarly the minimum number recorded in September with 4,11,200 cells/litre of 70.99%, was actually observed as minimum relative percentage of abundance in October with 56.14%. A fluctuating trend in the relative percentage of occurrence, when 70.99% recorded in September dropped to 56.14% in October, to rise in November and drop in the subsequent months.

FIG. 7

Graph showing the relative percent abundance of planktonic organisms, Scenedesmus and Haematococcus in experimental Plastic Pool No.5.

FIG.7

POOL.5

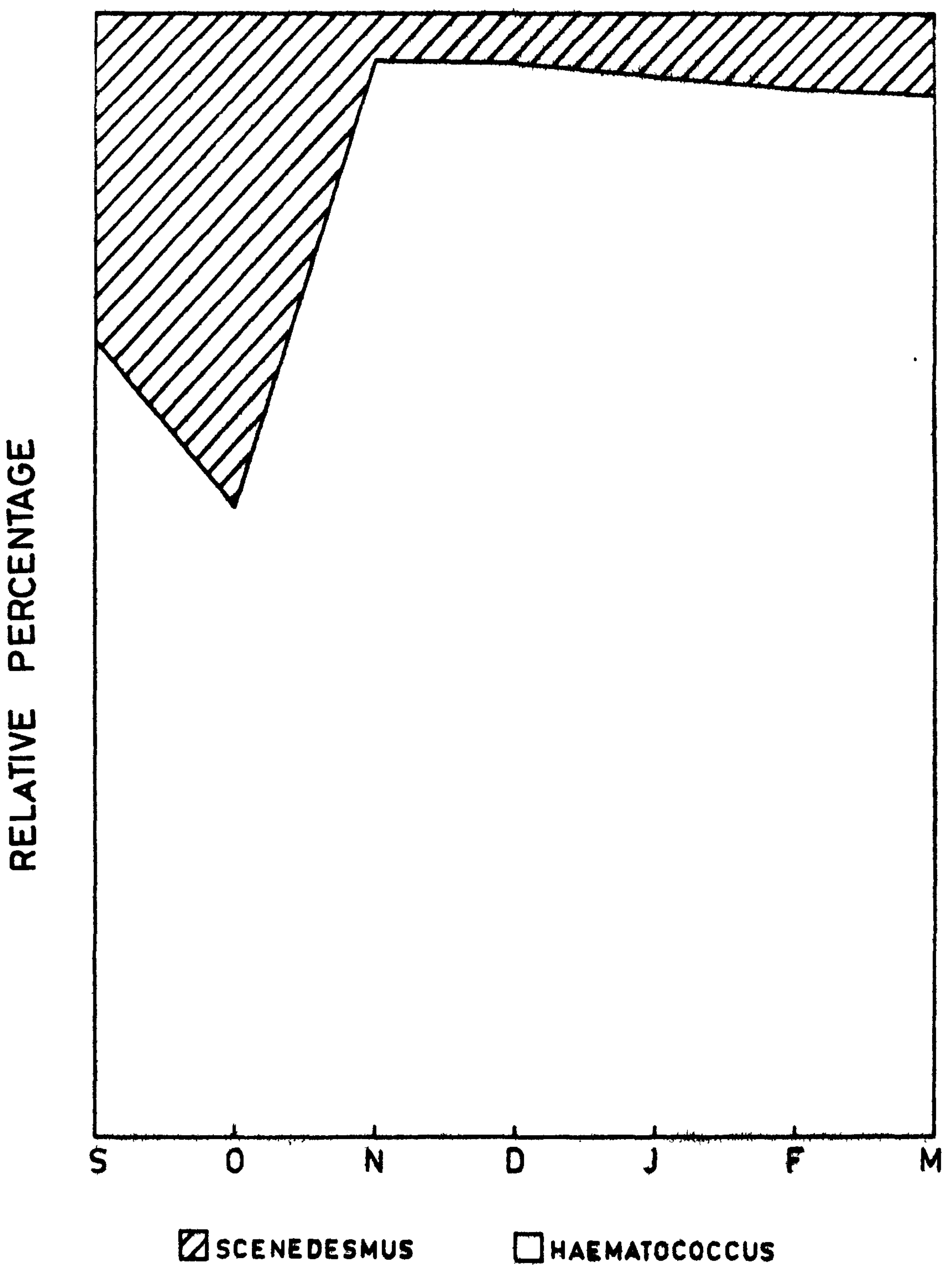


TABLE XVII : Showing the groupwise seasonal abundance of different Phytoplankton and Zooplankton in the rearing experiment of Fry to Fingerling of *Cyprinus carpio communis* L. in Plastic Pools with different feed combinations from September, 1978 to March, 1979.

POOL - 3

Name of the Species	SEP	OCT	NOV	DEC	JAN	FEB	MAR
SCENEDESMUS	7780 45.60%	7920 37.79%	8140 37.72%	8560 41.41%	9240 56.58%	9580 66.21%	10210 71.45%
HAEMATOCOCCUS	9280 54.40%	8240 39.31%	7800 36.14%	6210 30.05%	5750 35.21%	4890 33.79%	4080 28.55%
STAURASTRUM	- -	4000 19.08%	4520 20.95%	5900 28.54%	1340 8.21%	- -	- -
ROTIFERA (*Polyarthra*)	- -	800 3.82%	1120 5.19%	- -	- -	- -	- -

POOL 4

SCENEDESMUS	110160 30.35%	324000 50.88%	299680 58.07%	378000 69.89%	401570 75.23%	422050 80.39%	503500 85.12%
HAEMATOCOCCUS	252800 69.65%	286400 44.97%	192000 37.20%	140000 25.88%	105000 19.67%	75950 14.46%	57000 9.65%
DICTYOSPHAERIUM	- -	12800 2.01%	9400 1.82%	3620 .67%	- -	- -	- -
CHRYSOCOCCUS	- -	13600 2.14%	15000 2.91%	19250 3.56%	27200 5.10%	27000 5.15%	30770 5.20%

POOL 5

SCENEDESMUS	168000 29.01%	856080 43.86%	355000 4.24%	428000 4.47%	553500 5.66%	662000 6.69%	785000 7.33%
HAEMATOCOCCUS	411200 70.99%	1095600 56.14%	8025100 95.76%	9152000 95.53%	9230000 94.34%	9510500 93.31%	9924000 92.67%

(vi) Rearing of fingerlings of the Common carp, *Cyprinus carpio communis* L. to Table size fish in Pucca Nursery Ponds :

This experiment was conducted during November 1977 to November 1978 in one of the pucca nursery ponds of 0.025 ha and 1.5 m depth located at the Fish Dale, Shillong. The purpose of this experiment was to note the growth rate of Common carp and compute per hectare production per annum at the altitude of 1,550 m of Shillong. The fingerlings used for this experiment belonged to the 1976 brood and ranged betwenn 6.0 to 16.0 cm in length and 5.0 to 50.0 gm in weight. The feed for these fish comprised of a mixture of rice bran and mustard oil cake fed every alternate day along with cowdung manure provided at weekly intervals on an instalment basis (Table-XVII and Fig.8).

The results of this experiment revealed that the maximum weight attained by these fingerlings was 585.0 gm (Table-XIX), while the total production of fish was recorded to be 106 kg in a 0.025 ha pond for one year duration or 4,240 kg/ha/yr (Table-XIX, XX and Fig. 9).

Apart from this, month to month measurements of growth in terms of length and weight during this 12-months experimental duration showed that most of the fish attained their maximum growth by April 1978, five months time after stocking. At the end of these five month period the maximum length and weight recorded for the fish were 29.0 cm and between 390.0 to 405.0 gm. Subsequently it was also noticed that a sudden fall of mean weight occurs in the population in May 1978 when the weight ranged from 330.0 to 345.0 gm. This decrease in mean weight

PLATE - XIII

(a) Showing an overall view of the Pucca Nursery Ponds at Fish Dale Farm, Shillong for the rearing of fingerlings to Table Size fish of *Cyprinus carpio communis* L.

(b) Showing the source of water for the Pucca Nursery Ponds.

(c) Showing the water passing through different nurseries before reaching the Pucca Nursery Ponds.

PLATE XIII

PLATE - XIV

(a) Showing the netting of fish from the Pucca Nursery Pond.

(b) Showing the initial size (length) before stocking.

(c) Showing the intial size (weight) before stocking.

PLATE XIV

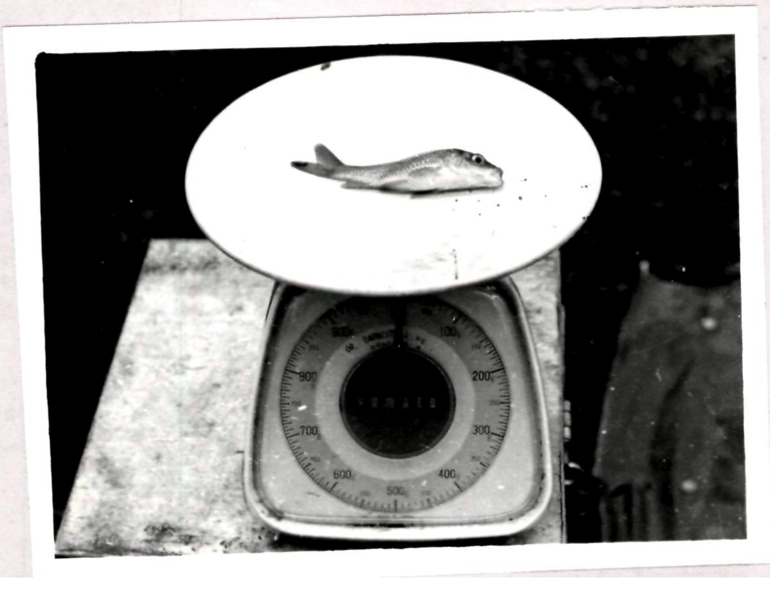


PLATE - XV

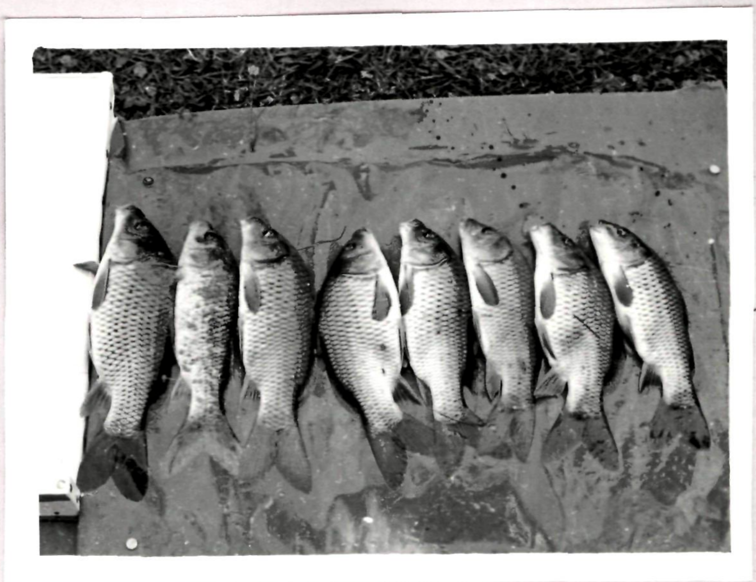
(a) Showing a haul during the harvest of fish from the Pucca Nursery Pond.

(b) Showing the length of the Common Carp, *Cyprinus carpio communis* L. after six months of stocking.

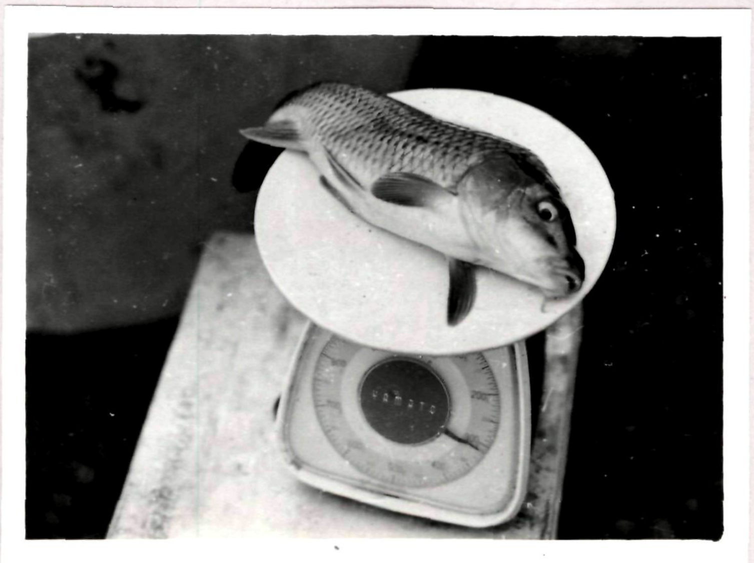
(c) Showing the weight of the Common Carp, *Cyprinus carpio communis* L. after six months of stocking.

PLATE XV

a



b



c

PLATE - XVI

Showing the maximum size attained after one year of rearing experiment in Pucca Nursery Pond.

PLATE XVI

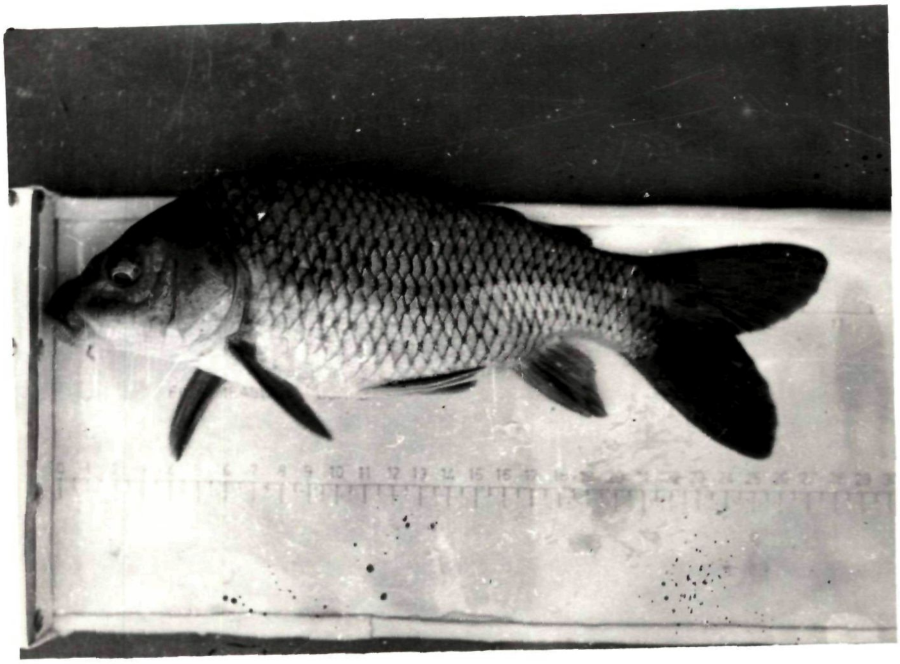
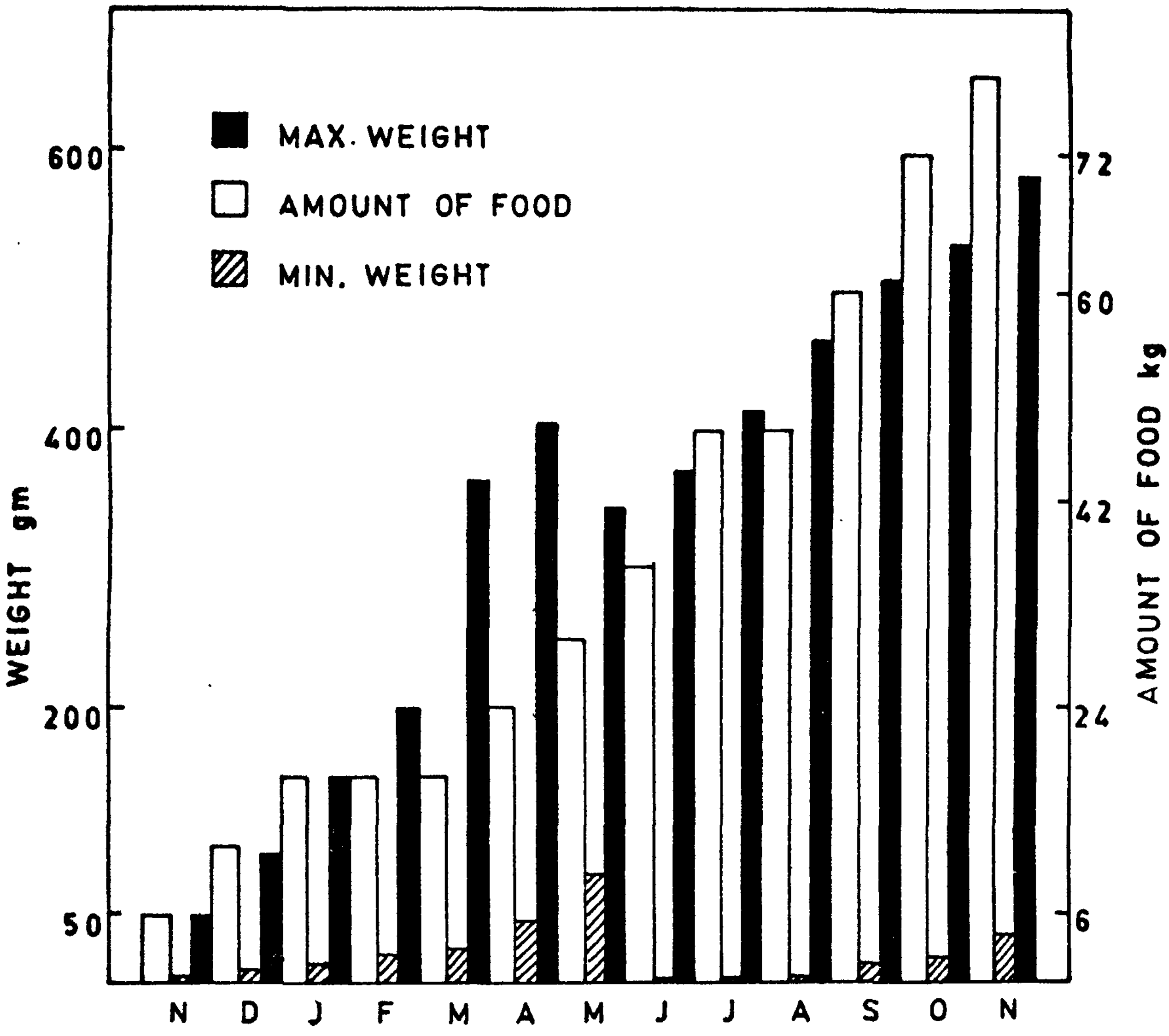


FIG. 8

Histogram showing the maximum and minimum weight of the fish along with the amount of supplementary food given per month during the rearing of Fingerlings to Table size fish of Common carp, Cyprinus carpio communis L.

FIG.8

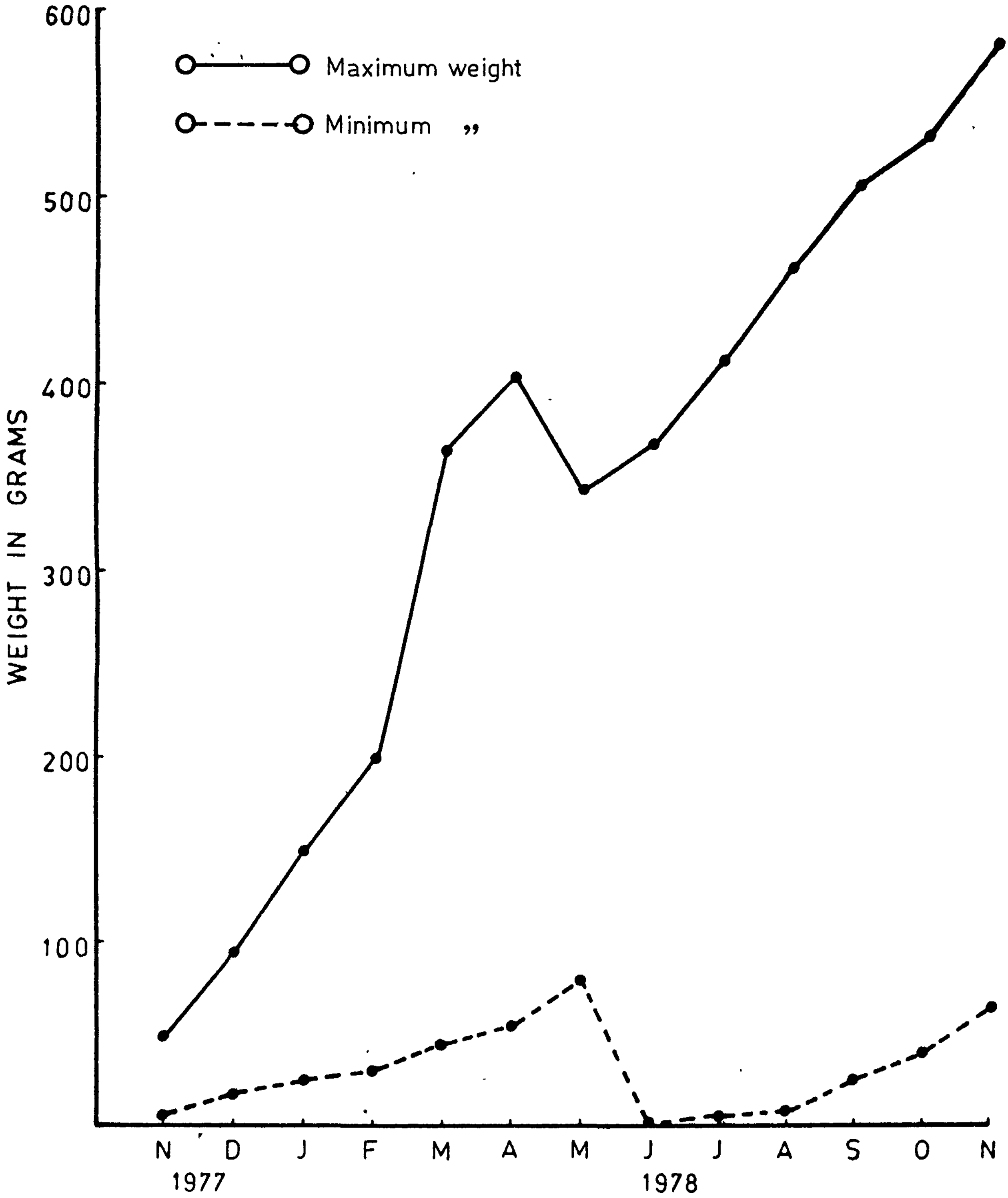


MAX. WEIGHT
AMOUNT OF FOOD
MIN. WEIGHT
WEIGHT gm
AMOUNT OF FOOD kg
600
400
200
50
72
60
42
24
6
N D J F M A M J J A S O N

FIG. 9

Graph showing the maximum and minimum weight of Common Carp, *Cyprinus carpio communis* L. during the rearing of Fingerlings to Table size fish at Fish Dale Farm, Shillong.

FIG.9



600
500
400
300
200
100
WEIGHT IN GRAMS
Maximum weight
Minimum ,,
N
D
J
F
M
A
M
J
J
A
S
O
N
1977
1978

TABLE-XVIII: Showing the details of the amount of Supplementary Feed given per month during the rearing of Fingerlings to Table size fish of the Common carp, *Cyprinus carpio communis* L. at Fish Dale farm, Shillong during the year 1977 - 1978.

Month	Amount of Food/Month Rice Bran (gm.)	Oil Cake (gm.)	Total Amount (Rice bran and Oil Cake) (gm.)
December	3,000	3,000	6,000
January	6,000	6,000	12,000
February	9,000	9,000	18,000
March	9,000	9,000	18,000
April	12,000	12,000	24,000
May	15,000	15,000	30,000
June	18,000	18,000	36,000
July	24,000	24,000	48,000
August	24,000	24,000	48,000
September	30,000	30,000	60,000
October	36,000	36,000	72,000
November	40,000	40,000	80,000
T O T A L	2,26,000	2,26,000	4,52,000

= 4,52,000 gm or 452 kg.

TABLE-XIX: Showing the Monthly sampling of Fish, *Cyprinus carpio communis* L. conducted at Fish Dale farm, Shillong during the year 1977 - 1978.

Month and Year	Minimum Size		Maximum Size	
	Length (cm)	Weight (gm)	Length (cm)	Weight (gm)
NOV. 1977	6.0	5.0	16.0	50.0
DEC. 1977	8.5	18.0	17.5	85.0-95.0
JAN. 1978	10.0	24.0	18.5	105.0-150.0
FEB. 1978	12.0	30.0	20.0	165.0-200.0
MAR. 1978	10.5	35.0-40.0	28.0	350.0-365.0
APR. 1978	13.0	45.0-55.0	29.5	390.0-405.0
MAY 1978	14.5	50.0-80.0	30.0	330.0-345.0
JUN. 1978	4.0	1.0	30.0	340.0-370.0
JUL. 1978	5.0	4.0	31.5	400.0-415.0
AUG. 1978	6.5	8.0	32.5	400.0-465.0
SEP. 1978	9.5	25.0	34.0	490.0-510.0
OCT. 1978	13.0	30.0-40.0	36.0	525.0-535.0
NOV. 1978	15.0	65.0	37.0	565.0-585.0

could be attributed to the loss of weight in May due to the breeding and spawning of the fish following the tremendous development of the gonads in April, since some of them reached maturity. Again it was seen that at the farm pond at Fish Dale, Shillong, the average annual water temperature ranging between 11.0 to 24.5°C probably provided the necessary conditions for the fingerlings to mature in the second year as these belonged to the previous year brood of 1976. It was further confirmed that in June 1978, a recruitment of small carp fry ranging between 3.0 to 3.5 cm in length and 0.6 to 1.0 gm in weight were also recorded along with the regular monthly sampling of fish. It is thus seen that the voluntary breeding of the stocked fish with the resultant fry have also contributed towards the fish biomass and in turn to the total production.

(vii) Physical factors of the Pucca Nursery Pond :-

Temperature :

The temperature recorded in this pond for the period November 1977 to November 1978 ranged between 10-24.5°C as shown in Fig. 10. Low temperatures were noted in December, January, February and March which ranged between 10-16°C and the lowest observed in January and February with 11 and 10°C. The highest temperature was seen in September with 24.5°C. The trend of temperature fluctuation in this pond shpwed that from April to June there was a steady rise in water temperature for the rest of the study period till November 1978 when it dropped to 16°C.

(viii) Chemical factors of the Pucca Nursery pond :-

pH :

In this pond the pH was always in the acidic range and varied between the minimum of 6.3 to the maximum of 6.9 throughout the annual cycle. Even the trend of fluctuation of pH values were not significant as most of the year it ranged between 6.4 to 6.6 during the experimental period (Fig. 10).

Conductivity :

The conductivity values recorded during the 12-month period of the present growth experiment ranged between 33.60-66.15 umhos/cm (Fig. 10). The lowest values were observed in November 1977 with 33.60 umhos/cm while the highest value was in December with 66.15 umhos/cm. From January to November 1978, the conductivity values were almost constant around 57.75 umhos/cm though slight fluctuations were observed in April and August 1978 with 53.55 and 54.60 umhos/cm respectively.

Dissolved oxygen :

The amount of dissolved oxygen varied between 8.4 to 14.0 mg/l during the 12-months study period. As seen in Fig. 11, the oxygen values usually ranged between 8.8 to 10.4 mg/l for a greater part of the year, though the maximum values were recorded in November 1977 while the minimum was in December 1977 and January 1978.

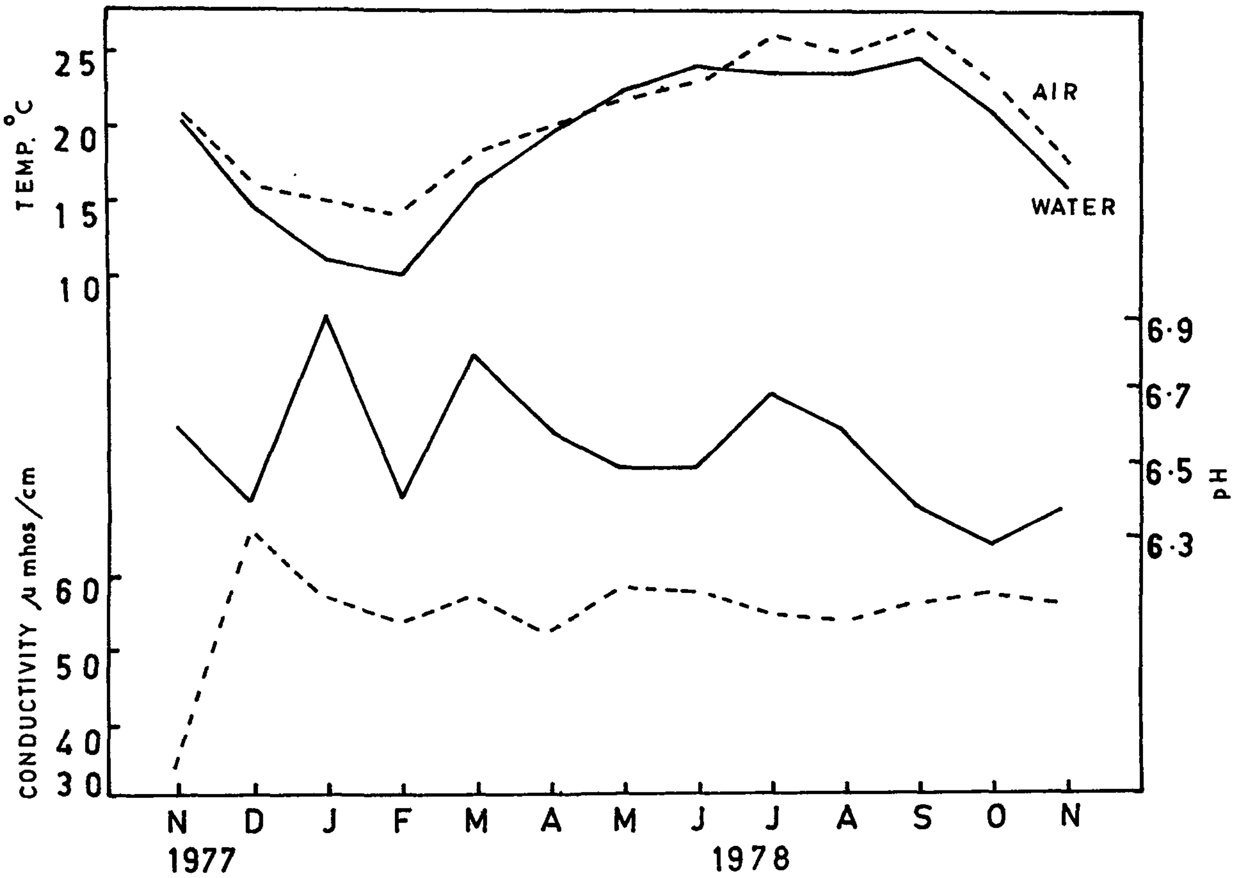
Free Carbon-dioxide :

The free carbondioxide was observed to be present throughout the period of study (Fig. 11). and fluctuated between 2.0 to 6.0 mg/l. The minimum value was recorded in December, January and February whereas the maxima were in July, August and September, the values during the rest of the months being 4.0 mg/l.

FIG. 10

Graph showing the suasonal fluctuation of physical parameters (air and water temperature, pH and conductivity) during the rearing of Fingerlings to Table size fish of Common Carp, *Cyprinus carpio communis* L. at Fish Dale Farm, Shillong.

FIG. 10

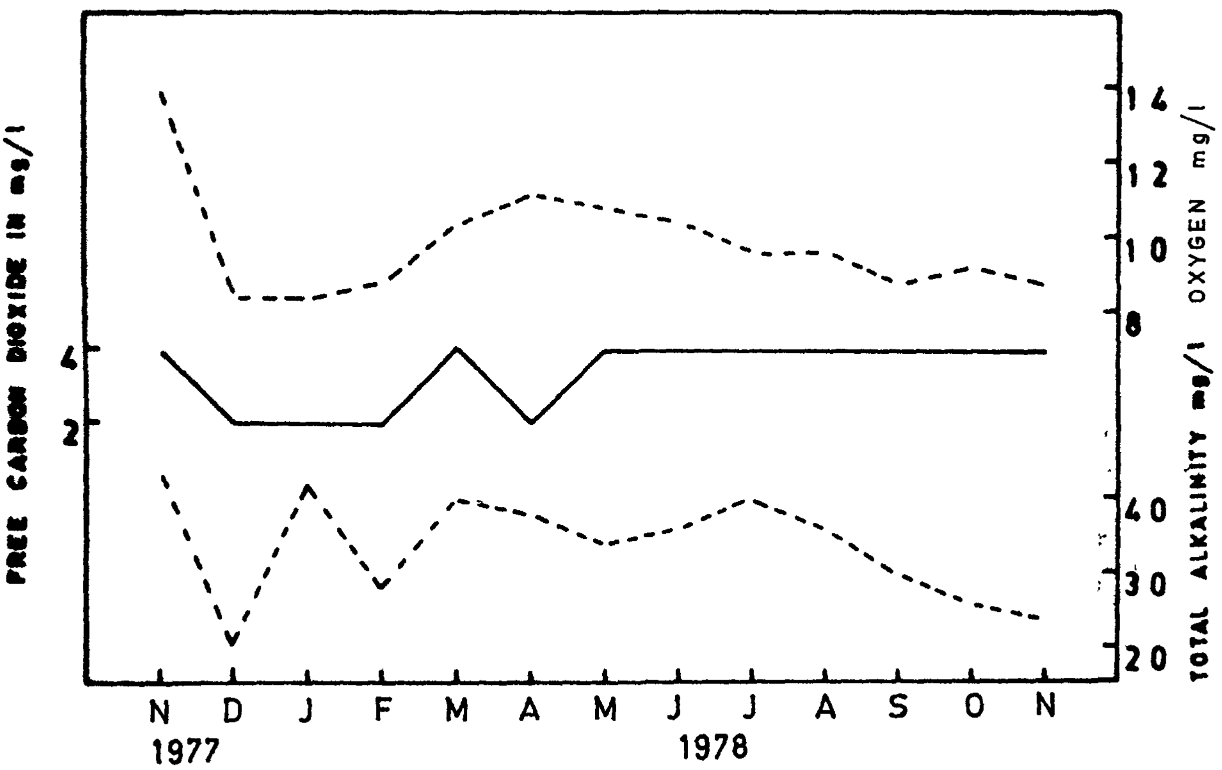


TEMP. °C
25
20
15
10
AIR
WATER
CONDUCTIVITY µ mhos/cm
60
50
40
30
6·9
6·7
6·5
6·3
pH
N D J F M A M J J A S O N
1977
1978

FIG. 11

Graph showing the seasonal fluctuation of physicochemical parameters (free carbon-dioxide, dissolved oxygen and total alkalinity) during the rearing of Fingerlings to Table size fish of Common Carp, *Cyprinus carpio communis* L. at Fish Dale Farm, Shillong.

FIG.11



FREE CARBON DIOXIDE IN mg/l
4
2
14
12
10
8
OXYGEN mg/l
40
30
20
TOTAL ALKALINITY mg/l
N D J F M A M J J A S O N
1977
1978

Total Alkalinity :

The total alkalinity recorded in the present study ranged between 20.0 to 44.0 mg/l with the maximum value observed in November and the lowest in December 1977 (Fig. 11). Again in January 1978 the value rose to 42.0 mg/l only to drop in February to 28.0. From March onwards till August the values narrowly fluctuated ranging between 36.0 to 40.0 mg/l. However there was a drop in September to 30.0 mg/l and finally to 24.0 mg/l in November 1978.

Phosphate :

The inorganic phosphate content and its annual fluctuation in the pond are shown in Fig. 12 . As will be seen the pond water contained very low amount of this macronutrient, the maximum being only 0.14 mg/l and the minimum 0.01 mg/l. The highest values were recorded in November 1977 till February 1978. During April a drop occurred to reach a minimum of 0.01 mg/l, while from May onwards till November the phosphato content ranged between 0.04 to 0.08 mg/l with slight fluctuations between them.

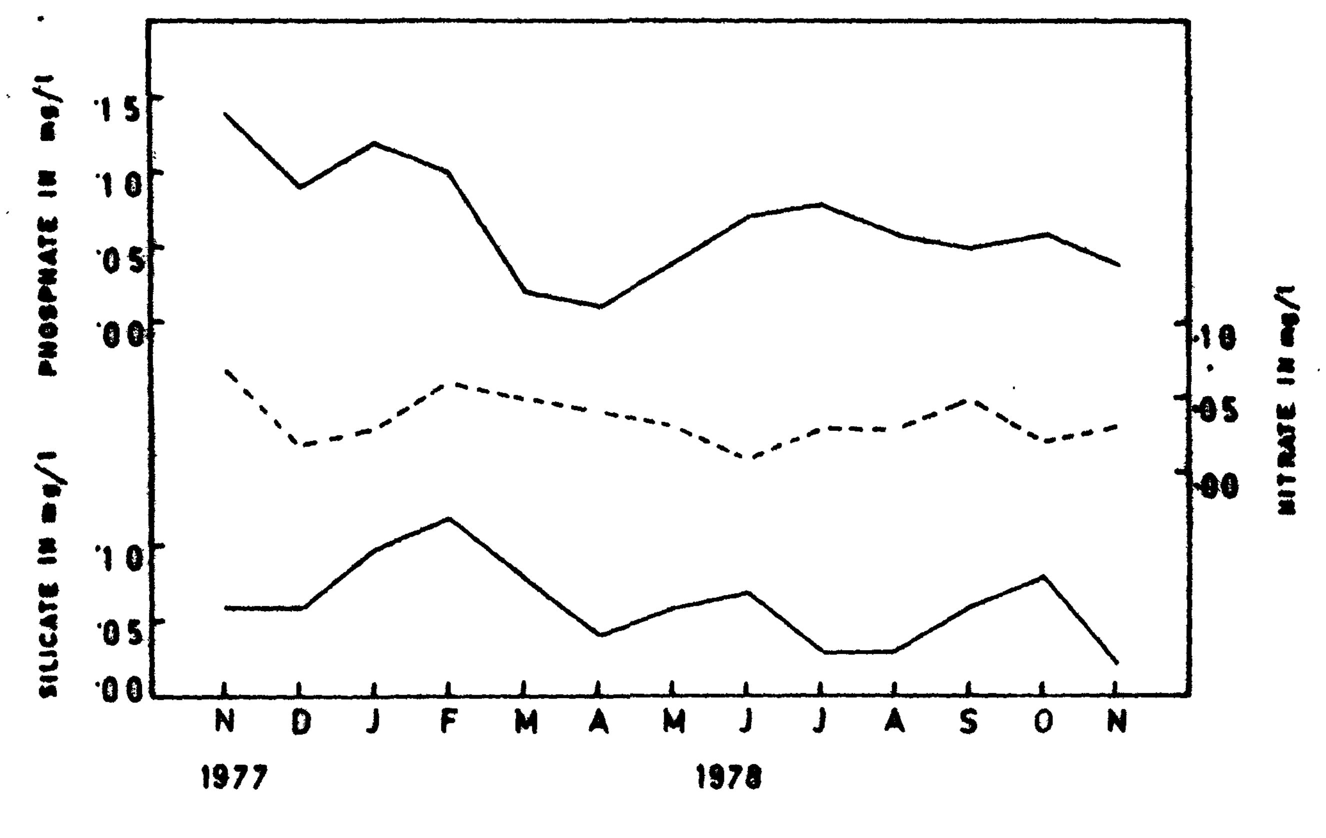
Nitrate :

The nitrate content in this pond during the experimental period (November 1977 to November 1978) is presented in Fig.12. It has been shown that the pond water had low nitrate content ranging between 0.01 to 0.07 mg/l with the maximum recorded in November 1977 and the lowest in June 1978. A trend of steady drop in nitrate content was observed in the following months and mostly ranged around the value of 0.03 mg/l.

FIG. 12

Graph showing the seasonal fluctuation in dissolved phosphate, nitrate and silicate during the rearing of Fingerlings to Table size fish of Common Carp, *Cyprinus carpio communis* L. at Fish Dale Farm, Shillong.

FIG. 12


PHOSPHATE IN mg/l
·15
·10
·05
·00
SILICATE IN mg/l
·10
·05
·00
NITRATE IN mg/l
·10
·05
·00
N
D
J
F
M
A
M
J
J
A
S
O
N
1977
1978

Silicate :

The amount of silicate present in this pond water ranged between 0.02 to 0.12 mg/l as shown in Fig. 12. The highest value was recorded in February and the minimum in November 1978. Throughout the 12-month period of study the silicate content was more or less steady fluctuating within a range of 0.06 mg/l.

(ix) Biological factors of the Pucca Nursery Pond :-

The seasonal fluctuations of phytoplankton and zooplankton were analysed at only the major subdivision levels. Though specific determinations of the different organisms have been made wherever possible, it was thought that the importance of the major group would suffice rather than either their or specific variations. In any case the genera are outlined below for the knowledge of their presence and have not been presented either graphically or in a tabular form except under major groups (Table-XX).

Phytoplankton :

The phytoplankton organisms collected from this pond belonged to the five major groups, Euglenophyceae, Chlorophyceae, Chrysophyceae, Bacillariophyceae and Cyanophyceae (Table-XX). Euglenophyceae was represented by only a single genus Euglena. Chlorophyceae or green algae recorded were Dictyosphaerium, Pediastrum, Zygnema, Spirogyra, Coelasphaerium, Scenedesmus, Pandorina, Westella, Peridinium, Cosmarium, Uronema, Staurastrum, Haematococcus, Hormidium, Eudorina; while Chrysophyceae included Chrysococcus, Botryococcus, Dinobryon. The group Bacillariophyceae was represented by Navicula, Tabellaria, Amphora, Synendra, Diploneis, Nitzchia, Meridion, Caloneis and Rhopalodina, while Anabaena, Merismopedia, Spirullina, Gleocapsa, Aphanocapsa, Oscillatoria formed part of the group Cyanophyceae.

(i) Euglenophycoan :

As mentioned above, Euglena sp. was the only genera dominating throughout the study period, though they were present in a very restricted number in comparison with the other major groups (Fig. 13). It was found to be present between the months of March and December, both months inclusive and totally absent during January and February. This group ranged from about 1.61% (180 units/litre) to about 17.9% (2,960 units/litre) of the total plankton throughout the study period. From March onwards it recorded to a steady increase to maximise in the month of May and thereafter fell slowly with minor fluctuations to become minimum in December.

Chlorophyceae :

The group Chlorophyceae recorded a minimum relative percentage of 6.44% in the month of June and a maximum of 37.04% in the month of February. However, throughout the annual cycle of investigation it was seen that the actual numbers present did not tally with the percentage, as the maximum number were recorded in the month of March when the percentage was 27.83% and in the month of February it was only 1,600 cells/litre and also though 29.79% was the relative percentage in January, the cells actually count was only 1,450 which is about 200 cells more than the minimum recorded (Table-XX).

Chrysophyceae :

This group was the least abundant of all the phytoplankton groups recorded. Moreover, they were found only in the month of February, March, April and May and were absent during the remaining period of investigations. A similar phenomenon as seen in the group Chlorophyceae was also observed here in that, though the maximum cell count occurred in the month of May, the relative percentage of importance of nearly 3.70% was recorded in February when the cells were 80 counts less than the maximum recorded.

Bacillariophyceae :

The organisms under this group was present throughout the study period and also formed a major part of the total plankton. The maximum occurrence of these was seen in the month of November and December, though the numbers were more in the former than in the latter, with the percentage difference being about 3% increase in the latter. Similarly though the minimum count was seen in February, yet they formed the least relative abundance among the total plankton in the month of July (Table-XX).

Cyanophyceae :

In this group, both the actual counts and their relative percentages did tally at least for the minimum and maximum recorded. This was observed as maximum during the month of January and minimum during June, which rose rapidly in July and with minor oscillations around that for the subsequent months, rose to maximum in January. Thereafter, it fell drastically to ebb reasonably on April to fall in the next two months to minimum.

Zooplankton :-

Protozoa :

The major genera encountered under this group of fauna were- Arcella sp, Centropyxis sp, Difflugia sp. The maximum recorded as a group was seen in the month of May, though the maximum relative abundance in percentage was observed in July, Similarly, their least occurrence was in January and yet formed nearly 30% of the total plankton, when in the month of December, with nearly 100 more numbers they formed only 13.80% of the total plankton

Rotifera :

Brachionus, Keratella and Lecane sp. were the major genera observed under the group Rotifera. It occurred throughout the study period and increased steadily from the month of January onwards till they reached their maximum peak in May and slowly decreased thereafter till November when they were recorded the least. A small but a significant rise was seen in the month of December

Cladocera :

The important cladocera species and genera encounting during the present investigation were : Chydorus sp, Scapholeberis kingi, Alona sp, Bosmina longirostris, Daphnia sp, Moina micrura and Simocephalus exspinosus. The group Cladocera was seen to rise significantly in the month of March and continued a steady increase till they reached a maximum in May. Thereafter their number decreased in a slow but steady fashion till November

FIG. 13

Graph showing the relative percent abundance of different groups of Phytoplankton and Zooplankton in the rearing of Fingerlings to Table size fish of *Cyprinus carpio communis* L. at Fish Dale Farm, Shillong.

FIG.13

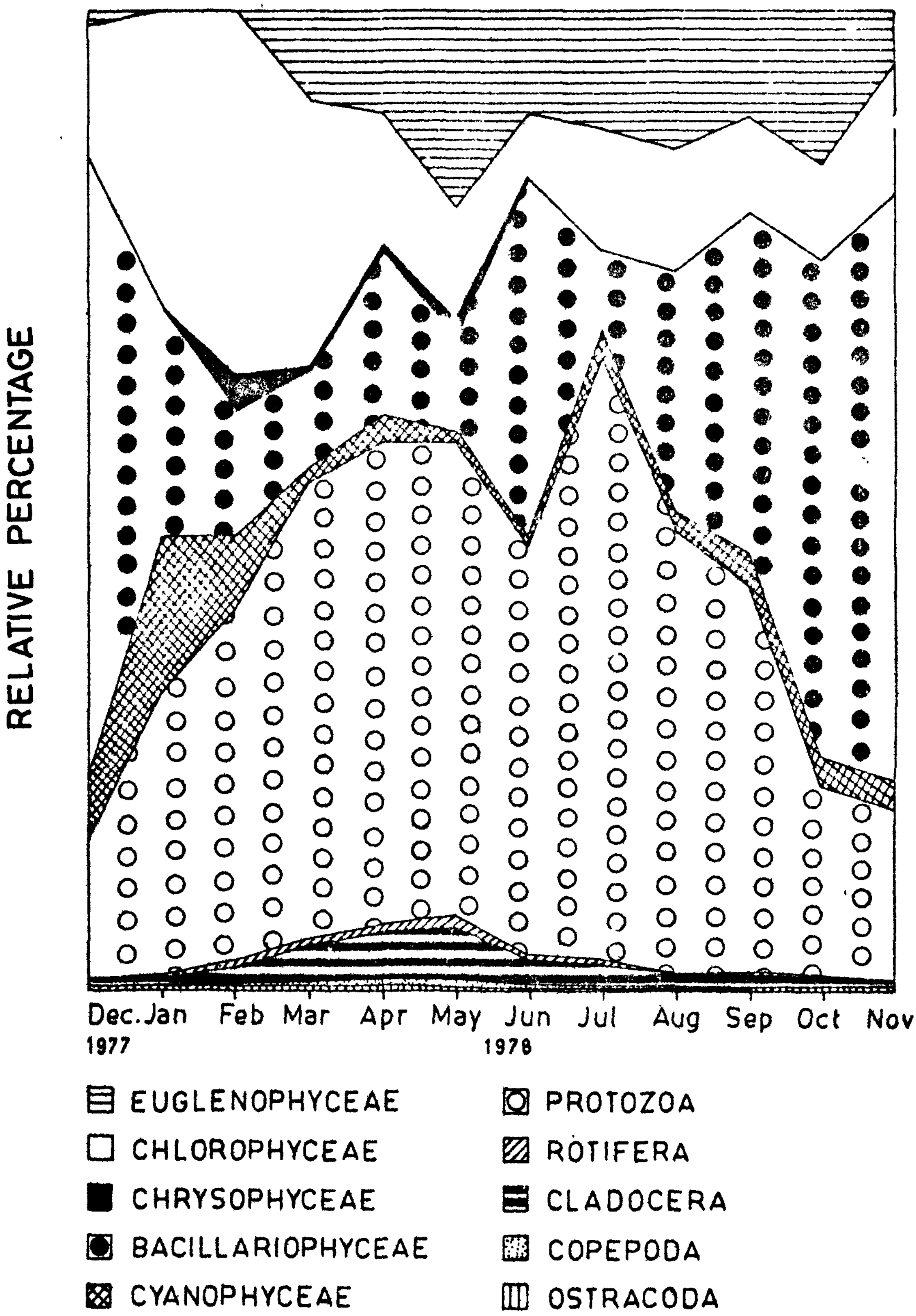

RELATIVE PERCENTAGE
Dec. 1977
Jan
Feb
Mar
Apr
May
Jun 1978
Jul
Aug
Sep
Oct
Nov
EUGLENOPHYCEAE
CHLOROPHYCEAE
CHRYSOPHYCEAE
BACILLARIOPHYCEAE
CYANOPHYCEAE
PROTOZOA
ROTIFERA
CLADOCERA
COPEPODA
OSTRACODA

TABLE XX : Showing the groupwise seasonal abundance of different Phytoplankton and Zooplankton in the rearing of Fingerlings to Table size fish of *Cyprinus carpio communis* L. at Fish Dale farm, Shillong expressed as numbers per litre (Figure in parenthesis denote percentage value).

(i) Phytoplankton :

Month & Year	Euglenophyceae	Chlorophyceae	Chrysophyceae	Bacillariophyceae	Cyanophyceae
DEC. 1977	180 (1.61)	1560 (13.96)	- -	7040 (63.04)	720 (6.45)
JAN. 1978	- -	1450 (29.79)	- -	1120 (23.01)	800 (16.44)
FEB. 1978	- -	1600 (37.04)	160 (3.70)	560 (12.96)	321 (7.44)
MAR. 1978	1050 (8.39)	3480 (27.83)	80 (0.64)	1200 (9.60)	180 (1.44)
APR. 1978	1575 (11.02)	1880 (13.15)	80 (0.56	2400 (16.80)	400 (2.80)
MAY 1978	2960 (17.96)	1600 (9.70)	240 (1.46)	1560 (9.46)	180 (1.09)
JUN. 1978	2150 (11.02)	1256 (6.44)	- -	7120 (36.48)	150 (0.77)
JUL. 1978	1450 (11.49)	1581 (12.53)	- -	1040 (8.24)	400 (3.17)
AUG. 1978	1825 (12.62)	1875 (12.96)	- -	3580 (24.75)	300 (2.07)
SEP. 1978	1550 (10.63)	1425 (9.72)	- -	5040 (34.56)	500 (3.43)
OCT. 1978	1250 (10.38)	1150 (9.56)	- -	6115 (50.81)	350 (2.90)
NOV. 1978	650 (4.46)	1925 (13.22)	- -	8780 (60.31)	450 (3.09)

P.T.O.

(ii) Zooplankton :

Month & Year	Protozoa	Rotifera	Cladocera	Copepoda	Ostracoda
DEC. 1977	1550 (13.88)	37 (0.33)	60 (0.54)	5 (0.04)	15 (0.13)
JAN. 1978	1425 (29.28)	14 (0.29)	42 (0.86)	8 (0.16)	8 (0.16)
FEB. 1978	1571 (36.37)	21 (0.48)	53 (1.23)	22 (0.50)	12 (0.28)
MAR. 1978	5870 (46.94)	80 (0.64)	475 (3.79)	50 (0.40)	40 (0.32)
APR. 1978	6975 (48.80)	133 (0.93)	650 (4.55)	85 (0.59)	115 (0.80)
MAY 1978	8715 (52.86)	168 (1.02)	880 (5.34)	60 (0.36)	125 (0.76)
JUN. 1978	8155 (41.79)	79 (0.40)	500 (2.56)	45 (0.23)	60 (0.30)
JUL. 1978	7720 (61.17)	64 (0.51)	315 (2.49)	15 (0.12)	35 (0.28)
AUG. 1978	6590 (45.55)	56 (0.39)	211 (1.46)	15 (0.10)	15 (0.10)
SEP. 1978	5815 (39.87)	49 (0.34)	160 (1.09)	18 (0.13)	25 (0.17)
OCT. 1978	3000 (24.93)	25 (0.21)	100 (0.83)	5 (0.04)	40 (0.33)
NOV. 1978	2600 (17.86)	10 (0.07)	75 (0.51)	12 (0.08)	55 (0.38)

Ostracoda :

Only the genus Cypris was encountered in the Ostracod group. Like Cladocera, this group Ostracoda had nearly the same number in December and February and recording the least in January. However, unlike Cladocera, though they rose from March to reach the peak in May, yet they fell steadily only till August and thereafter steadily increased till November.(Fig. 13).

Copepoda :

Cyclops, Diaptomus, Calonoid and Harpactocoid sp species were the dominant genera of this group. The maximum recorded for this group was observed in the month of April while they reached their minimum during the months of December and also in October. The fluctuation of their numbers showed a steady increase from December till April to fall thereafter till October with a very small peak in November. (Fig. 13).

(x) Rearing of fingerlings of the Common Carp, Cyprinus Carpio communis L. to Table size fish in an enclosed stretch of a feeder stream, 'Ka Wah Dienglieng'.

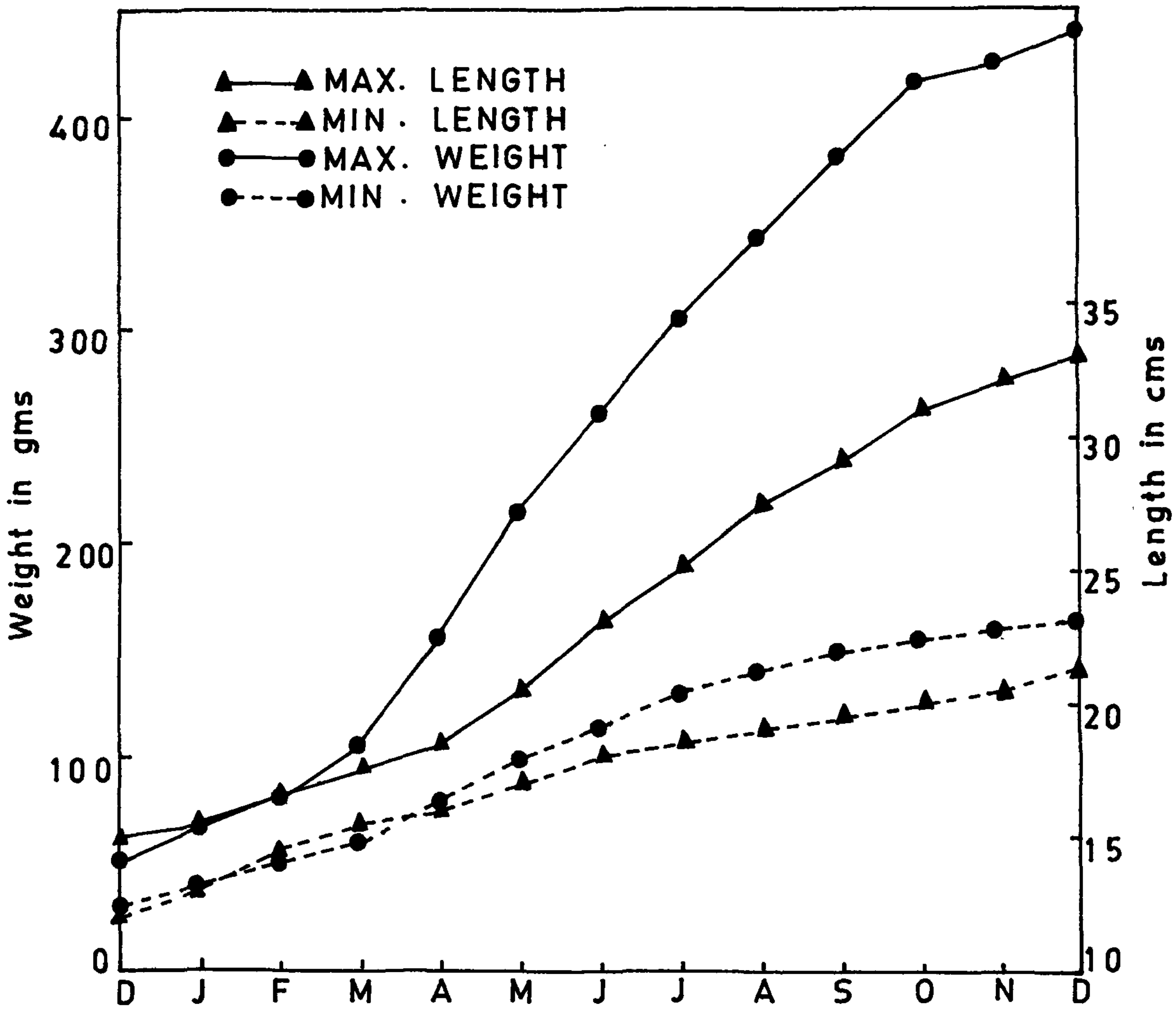
In the second year of 1978-79 of the same physical facilities, the rearing experiments was carried out in one of the enclosed stretched of a feeder stream, Ka Wah Dienglieng at Fish Dale farm, Shillong. The data gathered were more or less of confirmatory nature and hence deal only with the growth rate of fish.

The fingerlings used, ranged between 12.0-15.0 cm in length and 30.0-50.0 gm in weight (Table-XXI). Out of the 200 fingerlings stocked, 138 survived and grow ranging between 21.5 to 33.0 cm long and 165.0 to 440.0 gm in weight (Fig.14). The total fish harvested were 40,170 gm/200 sq m estimating a production of about 2,010 kg/ha/yr.

FIG. 14

Graph showing the maximum and minimum (length and weight) of Common Carp, Cyprinus carpio communis L. during the rearing of Fingerlings to Table size fish in an enclosed stretch of a feeder stream, Ka Wah Dienglieng at Fish Dale Farm, Shillong.

FIG. 14



MAX. LENGTH
MIN. LENGTH
MAX. WEIGHT
MIN. WEIGHT
Weight in gms
400
300
200
100
0
Length in cms
35
30
25
20
15
10
D
J
F
M
A
M
J
J
A
S
O
N
D

TABLE XXI : Showing the monthly sampling of fish *Cyprinus carpio communis* L. conducted in a Feeder Stream 'Ka Wah Dienglieng' at Fish Dale farm, Shillong during the year 1978 to 1979.

Month and Year	Minimum Size		Maximum Size	
	Length (cm)	Weight (gm)	Length (cm)	Weight (gm)
DEC. 1978	12.0	30.0	15.0	50.0
JAN. 1979	13.0	40.0	15.5	65.0
FEB. 1979	14.5	50.0	16.5	65.0-80.0
MAR. 1979	15.5	60.0	17.5	95.0-105.0
APR. 1979	16.0	80.0	18.5	130.0-155.0
MAY 1979	17.0	100.0	20.5	175.0-215.0
JUN. 1979	18.0	115.0	23.0	190.0-260.0
JUL. 1979	18.5	130.0	25.0	280.0-305.0
AUG. 1979	19.0	140.0	27.5	330.0-345.0
SEP. 1979	19.5	150.0	29.0	360.0-380.0
OCT. 1979	20.0	155.0	31.0	395.0-415.0
NOV. 1979	20.5	160.0	32.0	400.0-425.0
DEC. 1979	21.5	165.0	33.0	410.0-440.0

DISCUSSION

DISCUSSION

Fish culture as a commercial enterprise in the Indo-Pacific region owes its inception to the Chinese and even today the fish culture practices followed in many of the countries of the region were either adopted from the Chinese or inspired by them. The earliest clear record in Chinese literature is said to be the classic of fish culture, believed to have been written by Fanlai in 475 B.C. With the experience gained through generations and with infinite patient and attontion to details, the Chinese have brought fish culture to a very high level of development. Even those emigrant from China to Malaya, Formosa, Indonesia and Thailand carried with them this traditional knowledge of Carp culture and established the industries in those countries. They took Carp fry from China every year and reared them and encouraged the local people to take up fish culture (Lin, 1940).

The origin of fish culture in India is largely unknown though the eastern Indian States of Bihar, West Bengal and Orissa have extensively practised pisciculture for a long time and on a large scale. During later years however, the culture of sport fishes in altitudinal lakes and streams were introduced with the ushering in of the British rule.

The Common carp which probably had its origin from Chinese rivers was later exported to several countries all over the world and at present its culture has achieved a very high degree of perfection (Jhingran, 1975). The culture of more than one species in the same pond with a view to utilize all available food resources appear to have been first developed in China. Even though fish farming has been in existence for several centuries, a sound scientific approach of the method employed had changed fish culture from its empirical status to that of a scientifically managed industry (Hora and Pillay, 1962).

The Common carp, *Cyprinus carpio* is a highly domesticated pond breeding fish now having a world wide distribution. It is widely cultured alone as well as a compatable species in multi-species culture owing to its fast growth, hardy nature, omnivorous habit and its readiness to accept supplementary feeds. Though Common carp is known to breed naturally in confined waters it could also be artificially induced to broed. The eggs of Common carp are adhesive in nature and hence in the absence of suitable egg collectors, get deposited at the pond bottom where they usually disintegrate and or are predated upon, resulting in a low fry yield. Extensive data are available on the various cultural aspects of the Common carp even since this species had been used as a culturable species as reviewed by workers in different parts of the world, such as for India (Alikunhi and Chaudhuri, 1959; Alikunhi, 1966) for Indo-Pacific region (Hora and Pillay, 1962) and for Near East and Europe (Sarig, 1966). Interestingly enough, these investigations have highlighted the differences in fecundity, growth and mortality rates and production, probably influenced both by localised geographical habitat variations and the racial characteristics of a given stock. It is with this background in view, the present investigations were taken up on the Common carp since this was the only species which had been used for pond culture in this hill State and needed a detailed regional study.

The results obtained during the present investigations on the entire operation of breeding and rearing of Common carp are discussed. Common carp naturally breeds in confined waters and spawning occurs in shallow marginal and weed infested areas. The diverse breeding techniques employed on Common carp have been described in detail by Schaperclaus (1933), Hofstede and Ardiwinata (1952), Sahin (1955), Hora and Pillay (1962), Alikunhi (1966), Sarig (1966), Jhingran (1975 and 1977) and Jhingran and Sehgal (1978).

Since raising of an adequate number of healthy brood fish is the first essential step for successful fish breeding, brooders were segregated into the males and females and were reared in separate ponds prior to the proposed breeding season. For proper gonadal development the brooders were reared and regularly fed with a mixture of mustard oil cake and rice bran in 1:1 ratio at 2-3% of the total body weight. Usually for a breeding experiment a set of one female and three males are introduced in the breeding hapa.

A good deal of practical experience is required by the fish culturists in the choice of breeders. The criteria employed in the present study relate to body form, fecundity and age. Thus the fully mature females were chosen on the basis of almost rounded, soft and bulging abdomen and vent slightly projecting like a small papilla with a median slit. Only those males were selected having a bulging and soft abdomen with tubercles on the pectoral fin and with rough scale on the dorsal body surface and freely releasing milt when the abdomen is pressed. Though the present criteria followed for the selection of brooder is similar to that of Lin (1950) for the females, the males in the present study had the additional feature of roughened scales on the dorsal body surface which enabled to distinguish them more easily. In rest of the characters including the presence tubercles in the fins, the males of the present stock resembled those reported earlier (Lin, 1950; Alikunhi, 1966).

The attainment of maturity in Common carp depends on the prevailing climatic conditions under which it is grown. The size and age at first maturity of Common carp obtained under the present climatic conditions and an altitude of 1,550 m has been compared with data from different countries of the world as shown in Table-XXIII. It is seen that in Fish Dale farm, Shillong, the Common carp matures within the second year at an average annual water temperature ranging between 11°C to 24.5°C. Comparable results for the other regions of India are the attainment of maturity within six months of hatching in the plains, while in the other Indian upland lakes it takes almost a year to mature (Jhingran, 1977) although reports are in record of males and females in cold water region of India even extending upto 2-3 years and 3-4 years of age respectively (Jhingran and Sehgal, 1978).

In the present experiments two year old female brooders ranging in size of 250 to 650 gm and males ranging between 220 to 765 gm were used which gave satisfactory results. The size and age of brooders of Common carp used in breeding experiments from different parts of India and elsewhere are shown in Table-XXIII. It will be seen that the size of brooders employed for the present study are the smallest among those, though the breeding experiment always yielded positive results. From the present breeding experiments it has been shown that small sized brooders are not only easy to handle but are observed to be more functional and active during breeding in contrast to the sluggishness of larger brooders as seen from experiments conducted by the local state fishery workers.

Based on the results of the present experiments, the fecundity of Common carp at Fish Dale farm, Shillong, ranges between 61,052 to 90,000 eggs per kilogram body weight which shows a relatively low fecundity rate as compared to that achieved in the plains of India with 1,60,000 to 2,16,000 as reported by Dey (1978). Fecundity data from other parts of the World presented in Table-XXII for purpose of comparison also lend evidence to the fact that the fecundity rate of the present investigations are still lower than other reports. However, when a comparison is made of fecundity in relation to absolute weight of the fish, it is seen that the number of eggs spawned by the brooders at Fish Dale, yielded more, where females weighing 250 gm produced 90,000 eggs/kg; 310 gm - 88,710 eggs/kg, 425 gm - 85,647 eggs/kg, 510 gm - 89,510 eggs/kg, 520 gm - 61,052 eggs/kg and 650 gm - 69,230 eggs/kg as compared to the report of a 58-290 gm fish producing 6,360 - 25,942 eggs and fish of 309 to 799 gm producing 46,648 to 60,720 eggs from the plains of India (Alikunhi, 1966).

TABLE XXII (a) : Showing the fecundity in turms of absolute weight of the Common Carp (*Cyprinus carpio communis* L.) in India.

Place	Length (cm.)	Total weight (gm.)	Nos. of eggs	Source
Plains of India	15.0-25.0	58-290	6360-25942	Alikunhi, 1966
"	25.0-35.0	309-795	46648-60720	"
"	35.0-45.0	817-2043	120448-146328	"
"	45.0-55.0	2143-3632	281790-551580	"
"	55.0-65.0	2902-7600	776020-1748000	"
"	Over 65.0	13629	2045552	"
Himachal Pradesh	44.0-43.0	765-1100	172000	Jhingran & Sehgal,1978
"	34.0-45.5	580-930	123000	"
Meghalaya Fish Dale, Shillong	-	250-650	22500-45000	Present Study

TABLE XXII (b) : Showing the growth of Common Carp (*Cyprinus carpio communis* L.) in various countries.

Country	Weight (gm.) at the end of				Source
	1st Year	2nd Year	3rd Year	4th Year	
CHINA	300	900	1500	2100	Alikunhi, 1966
MALAYSIA THAILAND INDONESIA	400	800	-	-	"
USSR	600-800	1200-1900	2000-3500	-	"
EUROPE	35-50	350-500	1250-1500	2500	"
ENGLAND	15	200	600	1300	"
ISRAEL	500-700 (in 90 to 120 days)				Sarig,1966
INDIA	600-1000	1500-2000	-	-	Jhingran,1977
Meghalaya : i) Fish Dale Shillong	65-585	-	-		Present Study
ii) Kyrdem Kulai Fish Farm	150-655	-	-	-	"

Spawning of fishes in general are influenced by many extrinsic and intrinsic factors and the Common carp is no exception to this. A review of literature on this fish shows that the spawning season differs from place to place. Thus the spawning season in open running waters appears to be in early spring in tropical climates at the beginning of rainy season, with the flooding of river margins, whereas cultivated Carps are known to spawn in December in Canton, in Hongkong in January, in the Yang-tze Region of China from April to June and from April to May in Japan (Hora and Pillay, 1962).

In the present experiments conducted from 1977 to 1979 on the Common carp, it is seen that during all the three years spawning took place from late March to May with the optimum reached during April with the rising of ambient temperature. While this appears to be the major spawning period of Common carp at this altitude and latitude, during all the three years, a second spawning season was always observed in August-September, though less intense, the broaders being of smaller size. It is reported that Common carp could spawn throughout the year in tropical climate, though with two peak breeding periods, one lasting from mid January to March and the other during July and August (Singh, 1968; Jhingran, 1977). In the hilly regions this fish is known to spawn during March and April in Himachal Pradesh, whereas in the month of May to June in Jammu & Kashmir (altitude 1585m) (Jhingran and Sehgal, 1978). Thus the present findings of a biannual breeding pattern probably reflect the subtropical condition of the Shillong area with a climate somewhat intermediate between hot plains and truely cold water habits of India.

A detailed review on the spawning of Common carp in various countries under different climatic conditions has been given by Alikunhi (1966) and thus the favourable temperature ranges are 15-18°C for Europe; 17-19°C for USSR; 12-30°C for Japan; 19-30°C for Indonesia; 26-29°C for Thailand; 18-35°C for the Indian Plains; 23-30°C for Israel and 20-25°C for Southern America. In the present experiments conducted at Fish Dale farm, Shillong where the annual water temperature ranges between 11 to 24.5°C, spawning occurred during March and May, with the rise of the water temperature. There were also instances when even in late February and early June spawning did take place though with poor results due to wide fluctuations of temperature caused by suddon hailstorm and rains during these months. It is noticed that the favourable temperature range for spawning at Shillong was between 16.5 to 20°C (March-May), with maximum fertilization brought about at 19-20°C, with the percentage of fertilization ranging between 75 to 85% (Table-I to IV). When the present data on the temperature range for spawning was compared with earlier records from different parts of the world, it appears that though the Common carp is considered as an eurythermal species, effective spawning seems to occur only within a narrow temperature range, in spite of the fish surviving in a much wider range of ambient temperature.

The present breeding experiments have shown that spawning of Common carp occurs only during night and morning hours, as was also seen in the plains when the maximum spawning took place, though some brooders did spawn during day hours also

TABLE XXIII : Showing the size and age of first maturity of Common Carp (*Cyprinus carpio communis* L.) under different climatic conditions.

Country	Water Temp. during spawning season (°C)	At first maturity: Age (Years)	Length (cm.)	Weight (gm.)	Spawning season	Source
EUROPE	15.0-18.0	3.0-4.0	40.0-45.0	1500 -2500	May to June	Alikunhi, 1966
USSR	17.0-19.0	2.0-5.0	-	-	April to May	"
CHINA	-	2.0-3.0	-	-	-	"
JAPAN	12.0-30.0	0.2-0.3	30.0-38.0	500 -900	April to June	"
INDONESIA	19.0-30.0	1.0-1.5	30.0-40.0	1000 -2000	All Year round	"
THAILAND	26.0-29.0	1.0-1.5	-	-	-	"
MALAYSIA	-	1.0-1.5	-	-	-	"
ISRAEL	23.0-30.0	1.0	-	-	March to August	"
USA (SOUTH)	20.0-25.0	1.4	-	-	March to June	"
NEPAL	18.0-20.0	3.0-4.0	-	2000 -5000	March onward	Woynarovich, 1975
INDIA :-						
a) Plains	18.0-35.0	0.5	15.0-20.0	80 -170	All Year round	Alikunhi, 1966
b) Hills	-	1.0	37.0-46.0	908 -1360	"	"
1) Kashmir		2.4	-	-	June	Jhingran & Sehgal, 1978
2) Himachal Pradesh						
i) Dooli Farm	15.0-26.0	2.0-4.0	40.0-43.0	765 -1100	March to April	"
ii) Kangra	19.7-22.7	2.0-4.0	34.0-45.5	580 -930	"	"
3) Meghalaya						
i) Fish Dale Shillong	16.5-22.0	2.0	22.0-37.0	250 -650	March to May	Present Study
			17.5-20.0	85 -165	August to September	"

(Dey, 1978). Such definite periodicity of spawning was probably related to the sustained critical temperature as sudden change of temperature caused by wind, heavy showers or cloudy weather was always found to interfere with the spawning process and subsequent fertilization of eggs.

As mentioned earlier, the fertilized eggs could always be distinguished by their pale dirty yellow colour and less conspicuous nature as compared to unfertilized ones. In the breeding experiment conducted in 1977 the average size of an egg ranged between 1.4-1.8 mm in diameter and 0.0020 gm in weight contributing to about 500 number of eggs per gram. In the first experiment during 1978, the egg size ranged between 1.2-2.0 mm in diameter and 0.0024 gm in weight with about 415 number of eggs/gm, while in the second experiment of the same year it ranged between 1.3-1.7 mm and 0.0020 gm in weight amounting to 500 eggs/gm. During 1979, of the three sets of experiments, the egg measurements were 1.2 to 1.8 mm and 0.0018 gm forming 555 eggs/gm in the first. In the second experiment the values ranged between 1.5-1.8 mm with 0.0022 gm of weight and with 455 eggs/gm, whereas in the third set egg sizes ranged between 1.4-2.0 mm and 0.0024 gm each and amounting to 415 eggs/gm. Thus it is seen that in the Common carp at Fish Dale from Shillong the total number of eggs/gm during the breeding experiments in all the three years remained more or less uniform with the mean range being 415-555 eggs/gm whereas in the Plains the total numbers released is calculated at about 700 eggs per gram (Alikunhi *et al* 1966). In other upland lakes of

India 550 eggs/gm is the average number given for mirror Carp and Scale carp (Jhingran and Sehgal, 1978). The latter report from cold water lakes of India agrees well with the present findings.

Subsequent to fertilization of the eggs, the weeds/artificial egg collectors along with the attached eggs were transferred for incubation and hatching into the hatching hapa, at a density of approximately 40,000-60,000 eggs in a single hapa. It is of interest to note that the mean values for the three year period (1977-to 1979) of the incubation period varied from 3.5 to 7.0 days which inversely correlated with the rise in ambient temperature. These incubation duration and temperature relationships are presented and compared with other available data in Table-VI(b). It is quite evident from the Table that in Shillong waters, the period of incubation is directly influenced by the temperature. Even when compared with the rest of the data, the present findings corroborate the earlier works that incubation period is directly dependent upon temperature. Further, the apparently longer duration of incubation of the present study as compared to earlier data (at 18°, 20°, 22°, 25°C) is attributed to the shorter duration of warmer hours in a diel cycle obtained at Shillong resulting in prolongation of the hatching of eggs.

It was presented in the results that the weed as an egg collecting device usually underwent rotting and decay especially during the low temperature breeding experiments when the incubation and hatching periods are naturally prolonged. Such decomposition of the weed enhances the growth and bloom of the fungi, particularly *Saprolegnia* sp. which first infects the unfertilized eggs and later on spreads to the fertilized eggs thus interfering considerably with the hatching rate. Similar instances of spoilage of unfertilized and fertilized eggs by *Saprolegnia* are reported by Waynarovich (1975) from Nepal waters and Suzuki (1963) who found that the production of bloom of *Saprolegnia* in Japanese lake was at peak between 16 and 20°C and at a pH range of 4.0 to 6.0. It is coincident that more or less the same prevailing conditions with a temperature of 16°C and a pH range of 5.6 to 6.2 favoured *Saprolegnia* infection at Fish Dale, Shillong. Another report pertinent to the present context is a similar attack of *Saprolegnia* throughout the year in the hatchery at Windermere, England, causing considerable damage to the Trout eggs (Willoughby, 1969).

The eggs of Common carp are known to be adhesive in nature and hence in culture practices suitable substrata for attachment of eggs are always provided. While in the Far Eastern countries, artificial spawning nests made of vegetation fibre (Palm, *Arenga pinata*) called Kakaban are used, in Japan rafts made of vinyl leaves and in Europe, solid branches of briar that would not rot in the spawning pond are employed (Guenaus, 1923). In India, various materials viz., water plants (*Hydrilla*, *Najas*, *Nymphaea*, *Eicchornia*) or palm and coconut fibres are commonly used (Dey, 1978). In the present breeding experiments conducted at Shillong the materials used for egg collection were the aquatic plant, Rotalla rotundifolia, coconut fibre raft, wooden frame with curtain nylon net flap and aluminium wire frame with nylon net. Of the three years of investigations on the breeding of Common carp, Rotalla was used for the first two years (1977 and 1978), whereas in 1979 the above mentioned four different types of egg collectors were experimented upon in order to work out their relative efficiencies.

It is seen from the results that the percentage attachment of fertilized eggs in the breeding experiment of 1977 is 80% with a total of 36,000 fertilized eggs with 22,400 hatchlings finally harvested, reflecting a hatching rate of 62.2%. The remaining 37.8% loss of fertilized egg during this incubation period is to be accounted for and mostly attributed to the bloom and attack of the fungus Saprolegnia on the eggs. Results for the year 1978 revealed that the percentage fertilization is 55% with the total number of fertilized eggs to be 17,460. This lower percentage of fertilization obtained for the second year needs to be explained. It is felt that while the bloom of Saprolegnia took its usual toll as in the previous year, the loss of eggs could also be attributed to the heavy shower and prevailing low temperature below 16°C during the incubation period. It was further seen that while conducting the breeding experiments in the second year, cold weather prevailed during the breeding hours with low water temperature which probably reduced successful fertilization, as such sudden change of temperature caused by wind or heavy shower is known to affect spawning and subsequent mortality of many of the fertilized eggs as reported from the studies on Common carp of the Indo-Pacific region (Hora and Pillay, 1962). Despitu the low percentage of fertilization, the hatching rate was more or less similar to that of the previous year with 64.2% and a loss of 35.8% during incubation. Similar causative agencies are offered to explain the estimated loss of 46.3% during incubation in the second experiment of the same year when the percentage fertilization was 75% with 16,875 fertilized eggs and the hatching rate being 53.7% and the harvested spawn to be 9,055.

During the third year of investigation in 1979, three sets of breeding experiments were conducted and the results are discussed. As mentioned before, during these experiments the efficiency of different egg collectors were also assessed. In the first experiment of 1979 the fertilized eggs obtained were 23,375 with 85% fertilization which are the avarage values for all th: egg collectors. However, the actual spawn collected were 17,875 indicating a 76.4% of hatching rate. Apart from these breeding experiments the results of the relative efficiency of different egg collectors have shown that the most efficient among these in terms of percentage attachment appear to be the coconut fibre raft with the maximum attachment rate of 50%, compared to 25% in Rotalla, 15% in the wooden frame nylon flap, while the aluminium wire frame nylon net yielded only 10% attachment. This shows that in terms of substrate suitability the coconut fibre was 5 times more efficient than aluminium frame, 3.5 times than the wooden frame and twice efficient as the aquatic weed. It was also noted that the percentage of fertilized eggs attached to the different substratum were 95% for Aluminium wire frame, 90% in wooden frame, 85% in the coconut fibre raft and 75% in Rotalla. In this context, it may be referred that Jhingran and Sehgal (1978) have summarised the data on the percentage of egg attachment and hatching rate in various materials. Thus the percentage of egg attachment was reported to be 84.7-96.0%, while the hatching rate was 65.8-85.9%. On the other hand in the pine needle kakaban the attachment rate was found to be 62-80% against a hatching rate of 45.0-63.0%. These above data when compared with the present findings show that while the results for the present weed Rotalla (percentage attachment 55-75%; hatching rate 53.7-76.4%) was less efficient than Hydrilla, the coconut fibre raft was found to be far superior in its efficiency with percentage attachment rate of 85-93% and a hatching rate of 76-88%, as compared to the kakabans.

In the second experiment of the same year, the total number of fertilized eggs spawned were 25,480 of which 15,380 hatchlings were harvested working out a hatching rate of 61.9%. In this series too, coconut fibre raft showed the maximum attachment with 55%, followed by Rotalla and wood frame yielding 20% each and that of Aluminium wire frame with 5% in that order. Once again in terms of substrate efficiency it was seen that the coconut fibre raft was 11 times efficient than Aluminium wire frame and 2.5 times each as that of the aquatic weed and the wooden frame. The percentage of fertilized eggs attached to the different substrata were 96% in Aluminium wire frame, 93% in coconut fibre raft, 92% in wooden frame and 70% in Rotalla.

A similar kind of breeding experiment was repeated for the third time during 1979 although it was conducted in a Plastic pool. It was seen that the total percentage of fertilization was 75% with a hatching rate of 81.8% giving a total harvest of 28,010 hatchlings. The egg attachment in coconut fibre raft was 60% with 90% fertilized eggs, on the other hand the aquatic weed has 20% of attachment with 75% fertilization. The wooden frame showed the attachment capacity of 15% with the fertilized eggs forming 95% and the Aluminium frame showed only 5% attachment yet having 98% fertilized eggs. Once again the coconut fibre raft proved to be the most efficient for the egg attachment, with 12 times more than that of the Aluminium wire frame, 4 times of the wooden frame and 3-fold increase as compared to the aquatic weed Rotalla.

Thus the three sets of experiments conducted in 1979 showed that the first experiment produced 76.4% of spawns and hatchlings as the fungal infection was minimal during this period and was restricted mostly to the aquatic weed Rotalla. No Saprolegnia infection was noticed at anytime on the rest of the egg collectors, which clearly indicates that the inert and non-living nature of the artificial substrata very much restrict the fungal growth, as these do not provide any form of organic leachate. These results are somewhat comparable to the experiments in Europe with solid branches of briar that would not rot during spawning (Guenaus, 1923). In contrast to the first experiment, lower percentage of hatchlings and spawns amounting to only 61.9% were obtained in the second experiment and these are attributed to Saprolegnia infection among the unfertilized eggs attached mostly to Rotalla although a minor infection was also present in the unfertilized eggs attached to the coconut fibre raft. However no infection occurs in the wooden frame and Aluminium wire frame. The infection of Saprolegnia on to the coconut fibre was likely to be due to the transfer of this fungus from the aquatic weed as during this experiment the incubation period was rather prolonged favouring the spread. In the third experiment of 1979, which was conducted in the Plastic pool the percentage of hatchlings and spawns was recorded to be 81.8%. The high hatching rate may be attributed to the prevailing constant water temperature in the Plastic pools as the confined nature of the environment excluded the extremes in most physical, chemical and biological factors that will affect the hapa in nursory pond under open natural conditions. Consequently this system was also free of the fungal infection not even observed in the aquatic weed, though as shown earlier it was present throughout the period of incubation in the hapa fixed in nursery ponds. This observation points to the fact that this fungal infection is brought about by the transportation and dispersal of the same from the source of water which feeds the pond, though this needs further confirmation by actual experiments. Nevertheless, such possibilities were suggested by Willoughby (1969) who showed that *Saprolegnia* though present throughout the year in the hatchery at Windermere at a concentration of 400 zoospores/l, the same was found at a concentration of only 200 zoospores/l in a stream feeding the hatchery and lake. Thus it may be concluded that the breeding experiments in Plastic pools offer a most efficient and suitable substitute in lieu of the present traditional breeding practices in hapas and nursery ponds, because these pools facilitate controlled manipulation and maintenance resulting in high rate of fertilization and hatching.

Nursery Pond

It is known that specific types of ponds are required for the culture of particular species of fish or their life history stages. Schaperclaus (1933) has given the different categories required for a fish farm under European conditions where the allocations for different purposes are as breeding pond (0.25%) nursery pond (2.75%) and fingerling pond (10.00%). Under Indian conditions, according to Alikunhi (1957) the pond sizes needed are 0.2 ha for nursery ponds, 0.8 ha for rearing ponds and 3.0 ha for stocking ponds. However, in the present experiments due to want of adequate flat lands in these hill areas, all the three categories of ponds used were small in size ranging from 0.01 ha to 0.02 ha.

Successful rearing of young carp fry released in nursery ponds is of fundamental importance in carp culture and hence extreme care at all stages of operation is essential to ensure successful results, fully bearing in mind that the nursery problems confronting the pisciculturist are more akin to those of child welfare. It is also known that in earlier years at every stage of the various cultural operations starting from collection of spawn from rivers, the frys are usually subject to unfavourable conditions (Hora and Pillay, 1962). Even subsequent stocking and rearing practices were not effective due to lack of proper preparation and management of ponds in torms of removal of predators, lack of manuring and proper supplementary feeding. Nevertheless, in recent years with the introduction of scientific methods of fish culture, we are fully aware of the possible causes of mortality of spawn to fry which has enabled us to get a precise idea of the magnitude of the problems, besides indicating the lines along which we have to tackle the same. Thus, we now know that defective methods have no doubt to be corrected. Several experiments in improvement of spawn and fry rearing already carried out in differents parts of India have clearly indicated that to achieve successful results, rearing in the pucca nursery ponds and feeding with mustard oil cake and rice bran as food with regular manuring by cowdung are steps to be taken under field conditions so as to ensure maximum survival.

Extension of such available knowledge indiscriminately to the altitudinal hill regions of India has not always yielded the same successful results (Annual Report, Meghalaya State Fishery Department, 1976, 1977). This necessitated different approaches and the present experiments were directed towards this goal. Thus in addition to the conventional pucca nursery ponds, rearing was also attempted in hapas and plastic pools and results are presented and discussed.

The first set of experiments in this series is the rearing of spawn to fry and early fingerling. These rearing experiments were conducted for a period of 60 to 90 days in pucca nursery ponds, hapas and plastic pools. The data obtained on the average production of fry in these systems along with the prevailing physicochemical factors are shown for the three years period (Table-VII to IX).

In the first rearing experiment of 1977, it is seen that from the 8,000 spawn stocked in a 100 sq m (0.01 ha) pucca nursery pond, 5,805 were finally harvested indicating a 72.5% survival rate with a 7-fold gain in length and 1,000-fold in weight and with a mortality rate of 27.5%. The second experiment of the same year in a 200 sq m (0.02 ha) pond with 15,000 spawn reared for 90 days, 9,124 fry were finally harvested indicating a 60% survival with 15 times and 1,643 times gain in length and weight respectively. The mortality rate was 40%.

Similarly, in 1978 from the two pucca nursery ponds of 100 sq m (0.01 ha) each, of the first experiment with 10,000 spawn reared for 75 days, 7,659 were harvested reflecting a survival of 76.5% with a mortality rate of 23.5%. The growth increment was 6.5 and 909 times in length and weight. In the second experiment out of the 8,000 spawn, 4,460 were finally harvested amounting to 55.7% survival and 44.3% mortality, with the growth increment of 9 and 1,160 times in length and weight.

In these experiments the rate of stocking ranged between 8,000 to 10,000/100 sq m or 8,00,000 to 10,00,000 spawn/ha, which is much lower than that reported by Alikunhi (1956) (12,00,000 to 20,00,000/ha) and Hora and Pillay (1962) (78,12,500/ha), but is about 10 times lesser than that of the maximum of 1,00,00,000/ha (Jhingran, 1977). As far as the survival rate is concerned, 60% and 72.5% in 1977 and 76.5% and 55.7% in 1978 were reached which is somewhat higher compared to the results of the pond culture division of the CIFRI (Central Inland Fisheries Research Institute) where the survival rate reached a maximum of 66.6% (Jhingran 1975, 1977). Nevertheless, according to the above author, from one hectare of water, 6.6 million fry can be produced in a single crop of 15 days duration as against 20,000-40,000 obtained by conventional methods.

In the present study from an initial spawn size of 8.0-10.0 mm, the final sizes ranged between 20.0-50.0 mm and 60.0-90.0 mm in 1977, while in 1978 from 40.0 to 80.0 mm and 60.0-100.00 mm for the average rearing period of 60-90 days. In the report of Lakshmanan et al (1967) the initial size of 6.0-6.5 mm reached the final size of 18.6 mm in Catla, 19.53 mm in Rohu and 24.8 mm in Silver carp in 15 days period. Similarly, Hora and Pillay (1962) also reported that the major carps of India from an initial size of 6.0 mm reached the final size of 35 mm in 15 days period. It is thus very clear that at the present altitude in spite of the species differences the growth rate in the Common carp fry is certainly retarded about 3 to 5 times lesser since what is obtained in 15 days at the plains is reached only in a mean period of 75 days. Thus the faster growth achieved in the tropics is due to much warmer temperature and whereas at Fish Dale farm, Shillong the slow growth rato was mainly due to the prevailing low water temperature in addition to the water having an acidic pH range, low alkalinity and low plankton production. It is a well known fact that the water temperature influences the metabolic processes of various organisms living therein. Most activities of living organisms, particularly those of poikilotherms like fish slow down with drop in temperature. Even eurythermal species of fish like the Carps stop feeding at about 10°C and become torpid at about 5°C (Hickling, 1971). During the present rearing experiments the temperature ranged between 18-22°C as compared to the rearing temperature ranges between 28-37.5°C in the plains (Jhingran, 1975). It is undoubtedly the difference in these two temperature ranges being higher by an order of magnitude has retarded the growth. The pH of water in the present study which is always in the acidic range between 5.8-6.6 could not have been favourable as Swingle (1957) considers that productive waters with a pH ranging from 6.5-9.0 and values below or above this are unproductive or even lethal to fish. In India too, water on acidic soil has been found to be generally less productive of fish than that on the alkaline soil (Alikunhi, 1957). Similarly the low alkalinity recorded in these rearing ponds ranging between 20.0-50.0 mg/l is also one another factor causing the slow growth of fish as it is known that productive waters for fish culture should have an alkalinity range of at least above

100 mg/l (Jhingran, 1977). In conclusion, it may be added that despite these somewhat adverse environmental conditions along with low plankton production, the frys probably survived subsisting mostly on the supplementary feed of rice bran and mustard oil cake fed every alternate day, augmented by weekly addition of nutrients by manuring with cowdung.

As population growth of mankind is fast outstripping the natural food supply, all the world over these is redoubled efforts to increase food production per unit area per unit time in the fields of agriculture, animal husbandry and fisheries. Fishery biologists are of the opinion that the biological limit of yield for marine fisheries is not likely to exceed beyond 150 m tonnes which is still inadequate to meet the demands of the ever increasing population growth. It is precisely for this reason that fishery scientists are not only suggesting aquaculture for production of additional fish food, but also advocate intensifying production per unit area since available land for such practices are also hard to come by in future years. It is in this context that net cage culture where stagnant or running water surfaces are utilised with the same objective of maximising fish growth. Thus culture of fishes in floating cages has assumed the dimension of a full scale enterprise in Japan where among the freshwater fishes, the Common carp (Cyprinus carpio) is used in a large scale for such culture in lakes, reservoirs and tanks (Suzuki, 1976). With such practices an average yield of Common carp production of 444 tons/ha was estimated (Brown, 1969). Natarajan (1976) reported that among the Indian major

Carps, Catla catla and Cirrhinus reba are especially suited for cage culture in reservoirs and other lentic habitats and similar experiments at Jari, Allahabad in tank habitat has already yielded a production of 22.5 kg/cage of 3.5 sq m area (75 tonnes/ha) in the first year of growth from spawn stage. The foregoing results not only encourage better utilization of water surfaces but also reflect the present day limitations of using only the ground nurseries to develop the fishery in ponds, tanks and reservoirs to their maximum potential.

Keeping this view in mind to find suitable alternatives, in the present experiments at Fish Dale, Shillong, the rearing of spawn to fry stage was also attempted in 2 X 1 X 1 m nylon hapas fixed in manured nursery ponds. In the first rearing experiment in April 1978 out of the 1,000 spawn stocked, 724 were finally harvested with their maximum size attained ranging between 50.0-80.0 mm and 4,500 to 8,000 mg with a 7-fold growth in length and 568 times in weight. The survival rate of 75.2% was achieved with a mortality rate being 27.6%. In the second series of experiment out of the 1,000 spawns, 752 were harvested with the size attained to 40.0-80.0 mm and 3,500 to 6,500 mg. The growth increment from stocking to harvest was 6.6 times more in length and 455 times in weight. The survival was 75.2% with a mortality rate of 24.8%. The third set of experiment conducted in May 1978 which lasted for 60 days, out of the 1,000 spawn, 856 fry were harvested with the growth of 40.0-70.0 mm and 3,500-6,000 mg. The growth rate in length and weight was 6.1 and 432 times from their initial sizes. Thus the survival worked out to 85.6% with a low mortality rate of 14.4%. The fourth experiment showed a growth rate of 5 times and 384 times more from initial length and weight. The final numbers of fry harvested were 813 with a survival rate of 81.3% with the mortality at 18.7%.

In the year 1979 for purposes of replication and confirmation of earlier results of 1978, again four sets of rearing experiments were conducted. From the results of the first experiment carried out for 75 days, 891 fry were harvested implying a survival rate of 89.1% with a mortality of 10.9%. The final growth attained in this series was 40.0-65.0 mm and 4,000 to 6,000 mg with the growth rate estimated to be 6.5 and 1,066 times in length and weight respectively. The second experiment yielded a harvest of 847 fry amounting to a survival of 84.7% with the mortality rate being 15.3%. The final growth attained was 30.0 to 70.0 mm and 3,000 to 6,500 mg with 6.2 and 766 times gain in length and weight from the initial sizes. The third experiment showed a survival of 855 out of 1,000 frys forming a survival of 85.5% with a mortality rate of 14.5%. The maximum growth recorded ranged between 50.0-75.0 mm and 6,000 to 9,000 mg in the 60 days estimated to be 7 and 682 times gain in length and weight respectively. In the fourth experiment out of the 1,000 spawn initially stocked 873 were finally gleaned making a survival of 87.3% with the mortality amounting to 12.7%. The ultimate growth in the 60 days rearing period ranged between 45.0 to 65.0 mm and 4,000 to 7,500 mg with 6.1 and 545 times increase in length and weight.

Comparable results of spawn rearing from other Indian experiments in closed and fixed nurseries have shown that cages made of bamboo frames and nylon hapas of 3.5 sq m area with the stocking rate of 30,000 hatchlings showed a growth rate of 45.6 mm from initial size of 7,8 mm in 28 days (Natarajan and Saxena, 1978) as compared to the present growth of spawn to fry in 60 to 75 days from an initial size of 6.0 to 10.0 mm to the final size of 30.0 to 80.0 mm. Once again it is quite evident that the rate of growth is retarded at this altitude and the reasons presented earlier may be applicable to these findings as well caused by low water temperature, acidic pH, low alkalinity and low plankton production as discussed above. However, the mortality rate in the present experiments ranged between 10.9% to 27.6% only as compared to 75% mortality shown by Natarajan and Saxena (1978), thereby indicating 3 to 7 times reduction in mortality. The possible explanation for this could only be found in the contrasting differences in stocking rates. Thus while the present stocking rate works out to about 50,00,000/ha the earlier report in bamboo nylon cages is much higher with 8,50,00,000/ha (Natarajan and Saxena, 1978).

From the present experiments in the nylon hapa it could be inferred that the major advantages of rearing spawn in such closed and fixed nurseries are that these are primarily predator free in addition to the maintenance of a fair degree of constancy and free from the influence of some of the physical factors such as heavy rains and hailstorm which do not normally affect such hapas as these are covered at the top. Nevertheless, in addition to the supplementary feed provided, the meshes of the hapa always facilitated the entry of phytoplankton and zooplankton that are available to the baby fish. Further due to its submerged presence in the water for a period of nearly three months the sides of the hapa encourages the growth of periphyton which also form added nutrition as these organisms are known to be a primary fish food. The other benefits of such confined rearing of spawn are that the hapas serve to be hygienic since the waste mattor as unused food or faecal matter are easily seeped down through the meshes and also reduces the elaborate manual labour which are otherwise needed in nursery ponds. Such closed rearing reduces the strain and injury to the fry while netting which could not be avoided in nursery ponds.

Thus, the present findings once more emphasise that such floating nurseries is the obvious answer to meet the short fall in rearing space, though the technique will have to be further improved in many ways, since the elaborate nursery management with the resultant increase in cost of production could be minimised considerably.

In another series of rearing experiments during 1978 and 1979 aimed at attaining results on comparative efficiencies of the fry habitat, the Common carp spawn were reared in Plastic pools. From the first rearing experiment of 1978, the fry attained the size of 35.0-50.0 mm and 3,000 to 5,000 mg in 60 days. The growth rates recorded were 3.8 and 364 times in terms of length and weight increment with the survival of 358 out of 500 spawn amounting to 71.6% survival and 28.4% mortality rate.

The second experiment showed a final growth of 45.0-60.0 mm and 5,000 to 7,000 mg with 60.4% survival and a mortality rate of 39.6%. The growth increment from stocking to harvesting was 5 and 545 times respectively in terms of length and weight.

Similar experiments were repeated in 1979. In the first experiment the total growth in 60 days was 45.0-65.0 mm long and 4,000 to 6,000 mg in weight with 8 and 714 times growth attained from stocking to harvesting. The survival was 78.6% with a mortality rate of 21.4%. The second experiment showed the attainment of growth in 60 days to be 40-60 mm and 3,500 to 5,500 mg, showing a 6-fold and 500-fold increment in terms of length and weight. The survival rate of 83.4% was achieved with a mortality of 16.6% only.

In the present experiments the stocking density of spawn in both the years were at the rate of 500 fry/Plastic pool of 2.0 m diameter which works out to a stocking rate of 25,00,000/ha, as compared to more or less half this density as that used in the Nylon hapa of the previous experiments and about 35 times less the density of the experiments in the plains reported earlier. The survivality during 1978 was 71.6% in the first and 60.4% in the second experiments, with the growth increment in 60 days of 35.0 to 50.0 mm and 45.0 to 60.0 mm respectively. During 1979 the rate of survival was 78.6% and 83.4% with a rise in growth to be 45.0-65.0 mm and 40.0-60.0 mm in the 60 days period. Thus the gross growth increment in those Plastic pools is almost similar to that achieved in the Nylon hapas as well as the rate of growth is retarded as was also seen in hapa. These results once again confirm the altitudinal effects of the physicochemical and biological factors in the present study, as compared to the findings in the plains areas as discussed earlier (Natarajan and Saxena, 1978). However, the mortality rates in the plastic pools (28.4%, 39.6%, 21.4%, 16.6%) are on the higher side when compared with the Nylon hapas. While it is not possiblebleble to pinpoint the causes precisely, it may be suggestod that the total isolation and confined nature of the plastic pool habitat with no physical contact with the surrounding water medium probably led to accumulation of toxic metabolites in addition to lack of inflow of any food material from the surrounding environment as was the case in the immersed nylon hapas. However, the mean mortality rate (28%) in these plastic pools when compared to the results of the experiments from the plains (75%) is still relatively low which may be attributed to the low stocking rate, while the high mortality in net cages may be due to heavy stocking. Such a situation with low stocking, with a high survival and heavy stocking with low survival in Rohu and Catla was also reported by Sen (1978).

During the present investigations, the rearing experiments of fry to fingerling stages of Common carp were conducted in the plastic pools of varying sizes for a period of 6 months in the premises of the University campus. These experiments were designed with a primary purpose of finding out the growth and survival of Carp fry to fingerling size by employing not only different feed combinations but also during the off season of the annual cycle, in contrast to the conventional practice of fry rearing from May-July, soon after the breeding season in March and April. Normally, in this hill region these frys are reared to fingerlings of about 3-6 cm length and 5.0 gm weight for a 3 month period (May-July) before they are distributed for stocking. It was felt therefore that if proved successful then the fingerlings could be made available almost throughout the year for rearing purposes. It is well known that in the country as a whole and particularly in the hill regions, availability of frys or fingerlings act as a major constraint in fish culture practices.

It has been shown in the results (Table-XIV) from these experiments that the Pool 1 with cowdung, rice bran and mustard oil cake showed the highest growth rate where from an initial weight of 0.5-1.0 gm the fry had grown to a maximum weight of 35.0-51.0 gm in the 6 months period, with an average growth rate of 6.8 gm/month. The gross total production in this pool was 3,600 gm for the entire period. The mortality rate was very low in this pool with only 16%. The growth in Pool 2 with rice bran and mustard oil cake also showed satisfactory results, from an initial stocking weight of 0.5 to 1.0 gm to the maximum range of 22.0 to 35.0 gm. The gross production was calculated to be 1,815 gm, with an average monthly growth rate of 4.85 gm. This pool showed 88% survival with a low mortality rate of 12%. In Pool 3, with only rice bran as the feed, the growth rate recorded in 6 month period was between 18.0 to 26.5 gm with an mean growth of 3.5 gm/month. The total gross production in this pool was 462 gm with the mortality rate of 20%. In Pool 4, with the only feed being mustard oil cake at 4%.body weight, the weight ranged between 25.0-38.0 gm with an average growth rate of 5.3 gm/month. The production of fingerlings was 590 gm in the 6 month period with a mortality rate of 28%. The Control Pool 5, with no addition of any supplementary food showed the least growth rate, and from the initial size of 0.5 to 1.0 gm, the fry grew to a maximum weight of 9.0 to 12.0 gm yielding a total production of 126 gm in 6 months. There was a heavy mortality of fry in this system with 78% and with the lowest survival rate of 22%.

A comparison of the growth and production in the different plastic pools, reveals that the optimal yield was obtained in Pool 1, followed by those of Pools 4, 2, 3 and 5 in that order. This could be undoubtedly due to the differences in the nutritive value of diets offered in the pools, which enabled the fry in Pool No. 1 and 4 to grow better, probably by efficient conversion. Such possibilities of better yield of frys are reported by Jhingran and Sehgal (1978), who pointed out that by using more nutritive diet and improving feeding methods much higher yields in Common carp farming was obtained in Europe, Israel and Japan. The present results have further shown that while addition of organic manure certainly encouraged better growth as seen between Pools 1 and 2, oil cake alone could probably enhance growth as seen in Pool 4, since the growth in this system was even more than in Pool 2 with rice bran and mustard oil cake. The growth in Pool 3 with rice bran alone did not yield good results. It may therefore be suggested that even oil cake alone or when supplemented by cowdung would probably yield optimal growth rate at this altitude. In this context, it is of interest to note that Smith and Swingle (1942) also obtained increased fish production with somewhat similar feed combinations in ponds fertilized with cotton seed meal, soyabean meal and poultry mash with or without the addition of superphosphate over those obtained in unfertilized control ponds in Alabama, USA. Coming nearer under Indian conditions too, mustard oil cake is used singly or in combination with cowdung for manuring fish ponds in gaining higher fish yields (Jhingran, 1975, 1977).

In the present Plastic pool experiments it was seen that the survival rate ranged between 72 to 88% in Pools 1, 2, 3, 4 whereas in the control Pool 5, the survival rate was only 22%. The high survival percentages achieved in most of the pools could be because that the pools were not only predator free but also maintained at a more or less steady state environment as compared to that of the nursery ponds in the open with the attendant fluctuations. It may be however, added that in recent years with much controlled facilities, experiments conducted in ponds by CIFRI on rearing of Indian and exotic Carp fry to fingerlings in various combination have yielded an average survival of 76.6% (Jhingran, 1977). The low survival observed in Pool 5 could be mainly due to the nonavailability of food, though certain physicochemical factors prevailing in the system also probably contributed as will be discussed later.

Apart from the data presented above on the growth of fry to fingerlings some of the relevant variables of the water were also analysed in the pools for the entire growing period, with a view to assess the suitability of such artificial habitats as substitute for natural systems. One of the important factors as could naturally be expected to influence the growth of fry is temperature. Hickling (1971) reported that even eurythermal species of fish like the Carps stop feeding at about 10°C and become torpid at about 5°C. During the present 6 month long experiments, though the temperature of water in the plastic pools ranged generally between 10-21°C, because of intervening cold winter months there was always retarded growth during this period due to the prevailing lower temperatures. Thus while the maximum growth was recorded from September to October and throughout the month of March, growth during the rest of the months was less (Table-XIII).

Similarly, of the various chemical factors governing fish life in aquatic ecosystem the ambient dissolved oxygen is of primary importance as all fishes as well as their food organisms depend on an optimal level of the gas in the medium for the normal respiratory metabolism. The oxygen content of less than 3.5 mg/l is estimated to be lethal to Common carp in European waters and values below 5 mg/l are known to be critical for other Carps and Salmonids in summer (Hora and Pillay, 1962). During the present investigations dissolved oxygen content ranged between 8.0-12.4 mg/l in Pool 1, 6.4-11.6 mg/l in Pool 2, 4.0-11.6 mg/l in Pool 3, 4.0-10.8 mg/l in Pool 4 and

2.0-12.8 mg/l in Pool 5. Thus in Pools 1 to 4, the dissolved oxygen always remained high and hence could not have been a limiting factor in adversely affecting the metabolism of the fish. However, it may be mentioned that just after stocking of the fry in September the oxygen content temporarily declined to a value of 4.0 mg/l each in Pools 3 and 4 and to 4.8 mg/l in Pool 3 in December. While these levels are not too low to be lethal, yet these temporary drops in values could have caused the observed mortality in these pools. Similarly in Pool 5 of the control system, low oxygen values were recorded in the month of September just after stocking of fry with the oxygen the value reaching 2.0 mg/l which actually resulted in heavy loss of fry due to oxygen depletion further confirming the earlier report of Hora and Pillay (1962) that oxygen content of less than 3.5 mg/l is lethal to Common carp. Again the thick bloom of phytoplankton in Pool 5 throughout the rest of the growing period suggests that the oxygenation of the surface layer of water occurs during the period of bright sunshine as seen from a rise of values from 6.8 mg/l in October to 12.8 mg/l in March. Whether this high dissolved oxygen content also contributed to the high rate of mortality in this control pool is not known though supersaturation of the water with oxygen during the night hours is known to be the cause of mortality of fish frys and fingerlings in nursery ponds (Alikunhi _et al_ 1957).

Swingle (1957) considers that most productive waters in terms of fish growth are those with a pH ranging from 6.5-9.0, whereas values below 4.0 and above 11.0 are critical to fish life. In the present experiments conducted in the Plastic pools the pH was maintained in the alkaline range with the Pool 1, showing 7.0-8.6, Pool 2 with 7.0-9.2, Pool 3 with 7.0-8.3, Pool 4 at 7.0-8.8 and Pool 5 at 6.6-10.1. Thus from a fishery point of view the pH obtained in these systems could be considered optimal for the growth of fish, since acid waters are generally known to be less productive than that of alkaline waters, although the exact influence of pH on the fish growth is yet to be determined (Alikunhi, 1957).

From the results one clear emerging observation is that in all the Plastic Pools under study the two groups of Phytoplankton viz. Scenedesmus and Haematococcus dominated in all the system in comparison to the total plankton. Further the interesting phonomenon in all the pools was the inverse relationship between these two groups to the extend that in all the pools they reveal a mirror image of each other (Fig.3 to 7). However, it was noticed that in Pools 1,2 and 5, the rise and fall of these two groups were similar in the sense that Haematococcus continued increasing beginning the period of investigation till around December, when it maintained a plataau. The reverse was true for Scenedesmus. Unlike these three pools Pools 3 and 4 reveal an opposite phenomena in the sense, that what was true for Scenedesmus in the earlier three pools is revealed by Haematococcus in the two pools and vice versa.

The maximum planktonic group was observed in Pool 1 while the minimum was seen in Pool 2. Moreover, Pools 4 and 5 had only Phytoplankton, while the remaining pools did have one or more groups of Zooplankton. However, the Phytoplankton group other than Haematococcus and Scenedesmus were in so negligible amount to have really played any important role in the interrelationship with physico-chemical factors or fish growth. This was true in all cases except Pool 3 where Staurastrum revealed an inverse trend to Haematococcus.

Regarding the Zooplankton the group Protozoa and Rotifera had similar trends of fluctuation at least for the initial period of investigation and true for the 3 Pools - 1,2,3. Their peaks was seen in November and December, when Rotifera drop to minimum and continue so for the remaining period, while Protozoa during the same time increased to an extent of the formation of another peak.

While inter relating the seasonal fluctuating trends of various groups of Phytoplankton and in particular the dominant groups of Haematococcus and Scenedesmus with physico—chemical factors it was seen that in Pools 1,2,5, Haematococcus reveal a positive relationship during the first 3 months of the study period, while it was negatively related for the remaining period. A similar trend was observed for Scenedesmus for Pools 3 and 4. Among the Zooplankton, however a positive trend for Protozoa and Rotifera was seen for the pools where they occurred with the physico-chemical factors under consideration.

One of the possible reasons for the trends as observed for Scenedesmus and Haematococcus could be due to the incorporation of Phosphorus by decaying Phytoplankton in the benthic region and the utilization of the remaining phosphorus in the pools being incorporated by these producer organisms (Czeczuga and Gradzki, 1974). During winter, the population of Scenedesmus and Haematococcus could be seen to utilize the low aquatic energy very efficiently as is observed that if Haematococcus increase, Scenedesmus decreased thereby setting limitation to the effects of light adaptation in addition to natural depletion. Our results may be blurred by some factors but the high variation in light intensity and limited range of temperature variations relates to the fact that the species composition varied much less during the study period than in natural aquatic ecosystems(Tilzer and Schwarz, 1976). This is further confirmed from the fact that the probability of less organic matter has particularly been utilized by this species of fish Cyprinus carpio communis L. which goes to the bottom and side walls for feeding. Hence this limited diversity and abundance relationship is observed in the present study (Biswas, 1970). The Zooplankton densities as recorded for the fertilized pools being higher than the control agrees closely with the classification according to inorganic Nitrogen levels, proving thereby the possibility of a direct relationship between the levels of nutrient input and the resulting components (O'Brien and De Noyelles, 1974).

The primary aim of these experiments though was to relate the possibility of supplementary feeding to maximising the fish yield in the early stages of fish growth. If, so, from the present study it is clearly observed that Pool 1 revealed as much as 5 times the growth rate in the fishes, in comparison to the remaining pools. This fact is understandable because it was in this pool only that in addition to Rice Bran and Mustard Oil Cake, cowdung was added confirming thereby the possibility of oxidisable organic matter as mentioned earlier to play the most important role in the feeding propensities and growth utilization of these fishes. The Pools 2 and 4 were next in order to Pool 1 in terms of growth rate of fishes being 3.5 times the increase. Here too though cowdung was eliminated, the common factor probably responsible for this rate of growth could be attributed to the presence of Mustard Oil Cake in both these systems. This proves thereby that Mustard Oil Cake like cowdung has the possibility of rapid utilization but not to the extend of the latter. In conclusion we might therefore add that it is not only the importance of addition of single supplementary feed but the combination of these feedsin the right proportions which determine the highest possible growth of these fishes.

Thus the above series of experiments have shown that fry could be successfully reared to fingerlings with minimal rate of mortality and these pools could probably be suitably substitutes for natural nurseries. The present experiments have also given an important clue that frys could be reared even during the offseason in these hill regions. The various feed combinations employed in the present study have further validated their utility and differential importance in the rearing of Common carps in these Hill States. Thus, while attempts are underway to augment fish seed supply by more efforts by way of bundh or induced breeding in addition to the riverine source, there is correspondingly an urgent need to enlarge the rearing space by evolving suitable alternatives to augment the rearing of fry and fingerlings of common economic fishes. The existing ground nurseries have proved to be too inadequate to meet this shortfall in rearing space and thus the present Plastic pool nurseries with their encouraging results can be the obvious solution, though these techniques will have to be further improved and perfected. Thus the advantages of the Plastic pool nurseries could be summarised as follows :-

(i) The minimum space with limited water supply.

(ii) Easy handling and hence better management.

(iii) Quick control and manipulation of most of the physical, chemical and biological variables.

(iv) Low percentage of mortality.

(v) Possibility of greater growth in shorter time period with supplementary feeds of more nutritive value in different combinations.

One of the important problems always facing both the fishery scientist and fish culturist in the hill regions of North-Eastern India is the low yield of fish coupled with slow or retarded growth of the stock. In order to understand this problem in depth, rearing experiments of fingerlings to table size fish of 500 gm weight were undertaken during both years of 1977-78 and 1978-79. However, it must be mentioned that in the first year (1977-78) the rearing experiment was conducted in a 0.025 ha pond of 1.5 m depth with the detailed recording of physicochemical factors. In the second year of 1978-79 for lack of availability of the same physical facilities, the rearing was carried out partially in an enclosed stretch of a feeder stream, Ka Wah Dienglieng. During this year, data gathered were more or less of confirmatory nature and hence deal only on the growth rate of the fish (Table-XXII).

The fingerlings used for the first experiment (1977-78) ranged between 6.0 to 16.0 cm in length and 5.0 to 50.0 gm in weight and the fish were fed with a mixture of rice bran and mustard oil cake in addition to manuring the pond with cowdung. The results of this experiment revealed the maximum weight attained by these fingerlings was 585.0 gm in the 12-month period in the first year and 440.0 gm in the second year. The total production of fish in the first year was 106 kg/0.025 ha or 4,240 kg/ha/yr while in the second year at 40 kg/.02 ha or 2010 kg/ha. The present studies have shown therefore that if properly managed, waters of these altitudinal hill regions could yield an average of 3,125 kg/ha/yr, which compare well with production rates of exotic Carps in the plains of India (Grass carp, Silver carp and Common carp) with the value ranging from 2,896-3,281 kg/ha/yr (Singh et al 1972), though less than the reported values for Common carp of 1,000/kg/ha in 3½ months in wheat fields of Madhya Pradesh (Tripathi, 1978). Of course, the present figures are much higher when the natural fish production of the country as a whole is taken into account where only an yield of 200-500 kg/ha/yr is obtained without any management practices (Sinha, 1972). However by adopting the present composite fish culture method of Indian and Chinese Carps the production figures are in the upward trend with 1,000-4,900 kg/ha/yr achieved ten year ago (Alikunhi et al 1971), while the highest so far obtained is 9,397 kg/ha/yr (Chaudhuri et al,1974). Outside India, Brown (1969) estimated the Common carp production in Japan with 4.1-8.2 t/ha in small ponds and irrigation tanks, 112-338 t/ha in recirculating and filtering ponds, 616-1,950 t/ha in running water ponds and 444 t/ha in impounding nets, which as could be seen are several times higher in comparison to the present production rate which is evidently due to the very high protein rich feeds administered to these fishes under controlled environments.

As mentioned before, in both the 12-month experimental duration of 1977-78 and 1978-79, it was noted that the Common carp reached a maximum growth of 585.00 gm and 440 gm in the two different habitats of the nursery pond and enclosed stretch of a feeder stream. Data on the growth of Common carp from different latitudes and temperature regimes are given along with the present results (Table-XXIVb). It will be seen that the present growth rate for this altitude and temperature favourably compares with findings from most of the tropical countries, though higner than for the rest of the countries which are truly temperate with low prevailing tumperatures with the single exception of USSR. Such temperature-dependant growth rate once again reiterates the cardinal importance of this environmental variable on the life of poikilotherms like the fish. This fact was further amplified that even within the annual cycle of growth, the maximum was obtained for the first 5 months after stocking, mainly attributed to the distinct rising temperature of March and April, since within this period the size already reached from an initial of 6 to 16.0 cm and 5.0-50.0 gm weight to a mean of 29.0 cm and the weight from 390.0 to 405.0 gm. One of the sidelights of the present rearing experiments in the first year is the unexpected rise in numbers of the harvested fish particularly of the lower size group and weights (Table-XIX). Thus from the initial stock of 300 fingerlings a total of 864 were finally taken out. This was certainly due to the rapid maturity of some of the large sized fingerling which were already in their second year of growth as they belong to the stock of the previous year. Further confirmation of this was also obtained from the slight reduction in the mean weight of the stocked fish in the month of May evidently due to loss of weight in spawning and as well as from the presence of very early frys 3.0-3.5 cm of 0.6-1.0 gm weight in the pond during the month of June.

It is known that the attainment of maturity in Common carp depends on the prevailing climatic conditions under which it is grown (Lakshmanan *et al* 1971, Hickling, 1971). The size and age at first maturity of Common carp obtained under the present climatic conditions and altitude of 1,550 m has been compared with data from different countries of the world as discussed earlier in connection with the breeding experiments. Thus it was seen that while in Fish Dale farm at Shillong, the Common carp matures within the second year, comparable results for the other Indian region are within six months in the plains and 1, 2, 3 or 4 years of age for populations in upland lakes (Jhingran, 1977). Thus the voluntary breeding of some of the stocked fish in their second year of growth with the resultant fry not only confirmed our earlier findings but also contributed towards the entire fish biomass and in turn to total production of fish. A similar case to that of the present observations was also reported by Sukumaran (1978) who showed that the low average monthly growth rate recorded in the case of Common carp at Gujartal centre was due to the breeding of this fish which consequently increased the population and contributed more towards the total production of fish.

During the first year of these rearing experiments detailed estimations were made of the environmental factors. Since these data were collected from the natural rearing ponds their influence on fish growth are of significance in future fish cultural practices in this hill state and hence discussed. During the present experiments the temperature of the pond water ranged between 10-24.5°C, although during November to early March a fairly low temperature prevailed ranging between 10.0-16.0°C with corresponding slow growth increment of Common carp. That the temperature range affects the rate of growth of indigenous Carp had already been confirmed by Alikunhi (1966) and Jhingran (1974), where it was reported that Indian major carps thrive well in a temperature ranging from 18 to 37°C, while temperature below 16°C and above 40°C are limiting to their growth. On the other hand, the present studies showed that while the finger-lings of Common carp exhibited satisfactory growth during the 8 months of warmer period, yet continued to grow though at a slower rate even during the other four colder months as this species is known to have a wider range of temperature tolerance of 14-40°C, unlike that of Indian major carps.

During the present investigations dissolved Oxygen content always remained high at the experimental pond and ranged between 8.4-14.0 mg/l and hence could not have been a limiting factor in adversely affecting the metabolism of the fish and other fauna. It may however be said that the measurement of dissolved oxygen content proved to be one useful parameter with regard to the pond fitness for fish culture, as with the introduction of intensive fish farming practices all over the world, the maint-enance of proper oxygen balance will be an essential pre-requi-site especially with superintensive production, as suggested by Szumiec (1978).

While it is now a common knowledge that in most of the routine limnological studies the hydrogen ion concentration (pH) is often used as an index of the prevailing water conditions, the pH of water has also been used as an indicator of fertility or potential productivity. At Fish Dale farm in Shillong even after treatment by the addition of lime at the rate of 1,000 kg/ha in the pond, the pH value though initially rose upto 7.55still remained throughout the period of growth in the acidic range between 6.3-6.9. This was probably due to the constant inflow of low pH water (5.6-5.8) from the feeder stream to maintain the pond level. Thus from a fish culture point of view the pH level could be considered suboptimal as is well known that such conditions are not so favourablo for optimal fish growth (Alikunhi 1957, Swinglo 1957).

Water contains free carbondioxide mostly contributed from the decomposition of organic matter in varying quantities and as well from the atmosphere, or as a result of respiration of aquatic animals and plants. Hora and Pillay (1962) suggested that normally a value about 5 mg/l of carbondioxide content may not be suitable for fish life as besides preventing the oxygenation of water, it might also adversely affect the extraction of dissolved oxygen from the water. Similarly the high concentration of carbondioxide has also been observed to increase losses of fry and produced a number of deformed specimens in Salmonids. However, the 12-month results presented for the carbondioxide content in the present pond show that range of variation never exceeded 2.0-4.0 mg/l thereby showing that as far as this environmental factor is concerned the pond habitat was optimal for normal fish life.

Generally a total alkalinity value of 100-500 ppm as $CaCO_3$ is prescribed to be a measure of productivity and productive waters (Schaperclaus, 1933; Alikunhi, 1957), eventhough the natural bodies of Indian waters are known to show the widest range of values from 4-1,000 ppm (Ramchandran, unpublished). In the pond under study the total alkalinity levels ranged between 22.0 to 44.0 mg/l which from a fish growth point of view is certainly low and could have much limited the growth, although its effects could have been indirect by even slowing down the growth and production of fish food organisms. In this context, it is relevant to point out that soil in moderate to heavy rainfall areas and especially with lack of modern practice of liming and fertilization, ponds located in such places generally show a total alkalinity range equivalent to 10-50 ppm of Calcium Carbonate (Swingle, 1967). The above findings adequately explain the low alkalinity records of the present study area as this region is known for its very high rainfall, since Cherrapunji and Mawsynram the places of World's highest rainfall are only 50 km away from Shillong.

Of the major nutrients, Nitrogen in its varied form constituted one of the basic elements contributing to the fertility of natural waters. It is well known that ponds derive the major supply of nitrogen through the biodegradation cycle and of extreme importance in the maintenance and nutrient economy for prolonged aquatic life. It has been reported earlier that the best production of plankton is obtained when the water contains 4 ppm, 1 ppm and 1 ppm of Nitrogen, Phosphorus and Potassium respectively (Hora and Pillay, 1962). The present pond showed a nitrate level of 0.01 to 0.07 ppm for the entire period of study. Thus it is seen that the estimate of nitrate, phosphate and silicate were at very low levels in the present experimental pond. The significance of such low values could only be surmised, since their synergestic effects could certainly indirect by slowing down the production of plankton in the system and in turn fish growth.

Unlike nitrogon and carbondioxide, the phosphorus source to an aquatic system is not usually derived from the atmosphere but released from dead organisms through bacterial mineralization which in turn helps the growth of phyto- and zoo- biota in the water. Even though present only in very small quantities in natural waters, phosphate together with silica, are intimately associated with the growth and production of phytoplankton. Thus a concentration of 1 ppm of phosphorus is found to be the optimum for good growth of plankton and fish pond having more than 0.2 ppm phosphate are likely to be quite productive (Jhingran, 1977). However, only low phosphate content of 0.01 to 0.14 ppm was recorded in the present experimental pond almost throughout the year. In addition to these two nutrients, the silicate levels in the pond were also measured which was considerably low at 0.02 to 0.12 ppm.

The present studies have shown therefore that if properly managed, these altitudinal hill regions could yield an average of 4,000 kg/ha/yr which compares well with the production of exotic carps (Grass carp, Silver carp, Common carp) with the values ranging from 2,896-3,281 kg/ha/yr (Singh et al 1972) though less than the reported value for Common carp to be 1,000 kg/ha in $3\frac{1}{2}$ months in wheat fields of Madhya Pradesh (Tripathi, 1978) Of course, as pointed out before, the present figures are much higher when the natural fish production of the country as a whole is taken into account where only an yield of 200-500 kg/ ha/yr is obtained without any management practices. Further, when the growth rate is computed on a monthly basis the overall average growth achieved was 48.7 gm/month at Fish Dale, Shillong which appears to be relatively higher than that reported for Gujartal centre (Uttar Pradesh) with 27 gm/month, though much lower as compared to that of Karnal centre (Haryana) with 179 gm/month (Sukumaran, 1978).

An outcome of the above rearing experiments is an attempt to calculate the overall economics of the monoculture of Common carp in Shillong area in terms of expenditure incurred and the total return of fish from the experiment (Table-XXIV). The results of the present experiments at Fish Dale, Shillong, indicate that on the basis of a total input of Rs.408/-, the cost of production of a kilogram of fish worked out to Rs.3,85 as compared to the cost price range of Rs.2.38 to Rs.2.93 kg reported earlier from the composite fish culture experiments conducted by the Central Inland Fisheries Research Institute in different regions of the country (Jhingran, 1978). This production cost of under Rs.4/- in the present study is to be compared with the

TABLE-XXIV(a): Showing the cost of Inout for Production of Fish in Shillong during the rearing experiments of fingerling to Table size fish of *Cyprinus carpio communis* L. for one year (1977-1978) at Fish Dale farm, Shillong.

Size of the Pond	Expenditure on inputs items	Total production of Fish (kg.)	kg/ha	Cost for the production of fish (kg.)
0.025 ha	a) Rice bran - 226 kg @ 0.30 p/kg =Rs.67.80 b) Oil cake - 226 kg @ 1.20 p/kg =Rs.271.20 c) Cowdung - 500 kg @ 1.00p20 kg =Rs.50.00 d) Quick lime - 2 tins @ Rs.10.00 p/tin=Rs.20.00 Total --- --Rs.408.00	105.525	4240	Rs. 3.85

TABLE-XXIV(b): Showing the Cost of input for production of Fish in Shillong during the rearing experiments of Fingerling to Table size fish of *Cyprinus carpio communis* L. for one year (1977-1978) at Fish Dale farm, Shillong,

Cost of Inputs Rs. P.	Per hectare production (kg./yr.)	Total production of Fish (kg.)	Cost of fish in local market (Rs./kg.)	Total amount of Rupees realized by selling 106 kg. of fish	Total cost of inputs (Rs.)
408.00	4,240	106	16	106 X 16 =Rs.1,696/-	408.00

prevailing market rate of fish price at Rs.16/- kg. Thus, the cost of production is just one fourth of the current selling price, in spite of the fairly high cost of supplementary feeds in the hill regions used in the present study.

The results obtained from the study of the seasonal fluctuations of the planktonic organisms at the Fish Dale farm, Shillong could be looked at from the two major sub-groups viz. Phytoplankton and Zooplankton.

Among the five groups of Phytoplankton encountered all revealed just one peak of abundance except Bacillariophyceae which had two prominent peak - one in Winter and the other in Summer. Further, this group comprised of the largest relative abundance amongst the total plankton. In the other groups Cyanophyceae and Chlorophyceae had winter peaks while the first group (Euglenophyceae) had a summer peak.

Among the Zooplankton it was seen that except for Protozoa which had two prominent peaks - one in early spring and the other in mid-summer all the others revealed a peak only in the early spring.

From the above it is quite obvious that since the collections were made beginning winter period, it is natural to attribute the building up of the levels of these groups as summer is set. However, except for Bacillariophyceae and Euglenophyceae this phenomenon was not only true for the other three groups but infact showed a decline. Even though such a relationship did exist for the maximum between Bacillariophyceae and Euglenophyceae, however, in totality during the period of investigation it could be seen that abundance of Bacillariophyceae always had a negative relationship with all the groups under consideration.

While comparing these phytoplankton groups and their fluctuations with the physicochemical parameters undertaken, it is seen that there is a positive relationship between Silicate and Bacillariophyceae and so also in the case of Phosphate.

Euglenophyceae, Chrysophyceae and Cyanophyceae though reveal a positive relationship among the two factors but only for the beginning of the experiment. However, these groups definitely revealed a negative relationship with temperature, carbon-dioxide and dissolved oxygen.

One of the reasons attributed to the phosphate levels and Bacillariophyceae could be due to the fact that this group being a higher nutrient needer, the phosphate level had to fall much below 0.3 mg/l to allow the growth of blue-greens (Hammer, 1969). It is further clear that temperature and phosphate concentration played important roles in determining the abundance of blue-green algae which is known to predominate as well as to produce more individual species (Hammer, 1969).

Further, in winter when the nutrient levels were high the other factor responsible for Bacillariophyceae abundance could be atttibuted to light which may act as a regulating factor in this case. However, one cannot eliminate the fact that the temporal or spatial segregation certainly suggests competition avoidance (Stewart and Blinn, 1976), but additional data needs to be collected to substantiate this statement.

Another reason to be attributed about the phosphate relationship to the phytoplankton could be that at lower temperatures (winter) algae lyse phosphate at decreased levels preventing their own growth showing a picture of phosphate level high in the water body unutilized (Golterman, 1960). Further it is known that small green and blue-green algae are accepted as indicators of Eutrophy (Golterman, 1975). If so, one would look to the levels of pH and alkalinity and in this case we see that both these factors show a trend in reverse, meaning thereby that with extreme nutrient enrichment there is a very low buffering capacity proving no mortality effects due to these (O'Brien and De Noyelles, 1972).

It is also known that for conditions like in India, high temperature and high pH usually coincides with low phytoplankton densities (Choudhury et al 1979). However, it is not true in our case as the system is situated at much higher altitude and latitude which shows a negative relationship with temperature and pH.

All the above mentioned interrelationships is only true if both the numbers and seasonal abundance and the relative abundance for the season is the same. In our case there are discrepencies between what could be considered as a nutrient determined phytoplankton, density-potential and the actual observed density. Therefore, controls in any nutrient trophic system should be viewed from as different levels, largely determined by the rate of input and output (O'Brien and De Noyelles, 1974). This fact is proved from out study in the sense that photosynthetically active living organisms being related to released oxygen level is quite true when their relative percentage is correlated than with the density of population (Biswas, 1972). Further low values of dissolved oxygen is known to be associated with high organic matter due to primarily by the oxidation of organic matter discharged into the system (Venkateswarlu, 1969).

While considering the intricate relationships between the zooplankton and physico-chemical parameters one could observe no definite relationship between any of these factors with the group Ostracoda, Copepoda, Cladocera and Rotifera. However, the peaks of Protozoa do show an inverse relationship to the nitrate levels and phosphate levels though in the latter during summer, it was not so. Oxygen and temperature were the only two factors which showed a definite positive relationship. One reason attributed to this would be the lack of diversity in above four groups mentioned except Protozoa, similar to the general fluctuations of the general planktonic community as pointed by Pennak (1957). Moreover, the analysis did not take into consideration either the true species or the common species and hence their impact on the general phytoplankton as food source could be due to the limitation of the possible types of feeding specialization (Nordlie, 1975). Protozoa as shown for phytoplankton could probably have had the peaks of abundance again due to the higher average concentration of oxidizable organic matter directly proportional to the oxygen levels and true particularly to flagellates (Munawar, 1970).

The rapid development of protozoan colonies during summer coincides with higher temperatures which is true for succession of species among organisms despite temperature conditions varying from year to year (Larsson et al 1978).

While relating these groups of plankton to the growth of fish it was seen very clearly that among the phytoplankton it was Euglenophyceae and among the zooplankton it was Protozoa which showed positive correlation with the growth rate of the fish. It is known however, that very high production of fish are noted from waters with blue-green algae specially the plankton feeders in the lowest trophic levels grew well and high yield (Sreenivasan, 1966) though occasional mortality due to oxygen depletion simultaneously have been recorded (Sreenivasan, 1964). However, in our case it is an omnivorous feeder and has proved that it is the disturbance created by these fishes on the sides and bottom of the ponds releasing the necessary protozoans and flagellates like *Euglena* which has definitely improved in their growth rate.

PREDATION EXPERIMENTS ON THE SPAWN OF COMMON CARP, *CYPRINUS CARPIO COMMUNIS* L. WITH DRAGON-FLY NYMPHS, HEMIPTERAN BUGS AND FROGS.

II. PREDATION EXPERIMENTS ON THE SPAWN OF COMMON CARP, *CYPRINUS CARPIO COMMUNIS* L. WITH DRAGONFLY NYMPHS, HEMIPTERAN BUGS AND FROG.

The results obtained from the predation experiments by using a few of the most common and abundant predators encountered in the experimental ponds at Fish Dale farm, Shillong are presented below. These experiments on the predatory propensities of dragonfly nymphs (*Aeshna* sp. and *Cordulia* sp.), Notonectids (*Anisops* sp.) and frog (*Rana limnocharis*) were conducted under laboratory conditions.

In the first set of the 5 series of experiments conducted in May 1977, nymphs of *Aeshna* of sizes ranging between 5.0-6.0 cm were used and the duration of the experiments was for a period of 24 hours in each of the 5 jars. 20 spawns of Common Carp of 0.5-0.6 cm long were released in each of the jars. It is seen from the experiment that the mean loss of spawn from these 5 series was 6, 6, 7, 5 and 8 numbers. Since the total numbers of spawn used/day for all the 5 series were 100, the loss due to predation when expressed as percentage amounted to 30%, 30%, 35%, 20% and 40% respectively (Table-XXV).

In the second set of the 5 series of experiments conducted in May 1977 with nymphs of the dragonfly, *Cordulia* nymphs of 2.0-3.0 cm size were used in groups of four, with five such replicates and for a duration of 24 hours in each of the jars. 20 spawn of Common Carp of 0.5-0.6 cm were used as the prey in each of the individual experiment. From the results it was noted that the average loss of spawn per 24 hours in all the 5 series were 14, 11, 8, 10 and 13 numbers amounting to 70%, 55%, 40%, 50% and 65% respectively (Table-XXVI).

The third set of the 5 series of experiments were conducted with the hemipteran bug Anisops in May 1977. 10 of these notonectids of 7.0-10.0 mm size were used in each of the two trays used as replicates. 50 spawn of 0.5-0.6 cm in length were used for each individual experiment. From these series of experiments it is seen that the average loss of spawn per 24 hours in terms of consumed : injured fry were 9 : 5, 7 : 4, 8 : 4, 6: 3 and 6 : 9. Thus the mortality rate in terms of percentage worked out to 28%, 22%, 24%, 18% and 30% respectively in all the five series of experiments (Table-XXVII).

The fourth set of the 5 series of experiments were conducted in May 1977, using the vertebrate predator, Rana limnocharis. Only froglets of 1.5 cm in length were chosen for these experiments as this was the size range always found associated at the spawning and breeding seasons of Common Carp. For each of the individual experiments conducted for a 24 hours period, predators were used only individually. 25 spawn of Common Carp 0.5-0.6 cm long were offered as prey. These experiments showed that the loss of spawn due to the predatory habits of Rana limnocharis worked out on an average to 4 spawn in the first series, 3 in the second and fifth, 5 spawn in the third and fourth series for the experimental duration of one day. In terms of percentage, these results show a predatory propensity rate of 16%, 12%, 25%, 25% and 12% in all the five series of experiments respectively (Table-XXVIII).

TABLE-XXV: Showing the experimental results on the predatory propensities of the Dragonfly nymph (*Aeshna* sp.) on the spawn of Common carp, *Cyprinus carpio communis* L. in the laboratory during the year 1977.

Date, Month and Year of the Experiment.	Nos. of sets of experiment conducted.	Nos. of predator used per jar.	Size of the predator (cm.)	Nos. of spawn used per jar	Size of the spawn (cm.)	Mean Nos. of spawn consumed per day.
9.5.1977	5 jars	1	5.0-6.0	20	0.5-0.6	6
10.5.1977	5 jars	1	5.0-6.0	20	0.5-0.6	6
11.5.1977	5 jars	1	5.0-6.0	20	0.5-0.6	6
12.5.1977	5 jars	1	5.0-6.0	20	0.5-0.6	7
13.5.1977	5 jars	1	5.0-6.0	20	0.5-0.6	5
14.5.1977	5 jars	1	5.0-6.0	20	0.5-0.6	8

TABLE-XXVI: Showing the experimental results on the predatory propensities of the Dragonfly nymph (*Cordulia* sp.) on the spawn of Common carp, *Cyprinus carpio communis* L. in the laboratory during the year 1977.

Date, Month and Year of the Experiment	Nos. of sets of experiment conducted.	Nos. of predator used per jar	Size of the predator (cm.)	Nos. of spawn used per jar	Size of the spawn (cm.)	Mean Nos. of spawn consumed per day
10.5.1977	5 jars	4	5.0-6.0	20	0.5-0.6	14
11.5.1977	5 jars	4	5.0-6.0	20	0.5-0.6	11
12.5.1977	5 jars	4	5.0-6.0	20	0.5-0.6	8
13.5.1977	5 jars	4	5.0-6.0	20	0.5-0.6	10
14.5.1977	5 jars	4	5.0-6.0	20	0.5-0.6	13

TABLE-XXVII: Showing the experimental results on the predatory propensities of the Notonectids (<u>Anisop</u> sp.) on the Spawn of Common carp, <u>Cyprinus carpio communis</u> L. in the laboratory during the year 1977.

Date, Month and year of the Experiment	Nos. of sets of experiment conducted	Nos. of predator used per jar	Size of the predator (cm.)	Nos. of spawn used per jar	Size of the spawn (cm.)	Mean Nos. of spawn consumed per day		
						Dead	Injured	Total
10.5.1977	2 trays	10	0.7-1.0	50	0.5-0.6	9	5	14
11.5.1977	2 trays	10	0.7-1.0	50	0.5-0.6	7	4	11
12.5.1977	2 trays	10	0.7-1.0	50	0.5-0.6	8	4	12
13.5.1977	2 trays	10	0.7-1.0	50	0.5-0.6	6	3	9
14.5.1977	2 trays	10	0.7-1.0	50	0.5-0.6	6	9	15

TABLE-XXVIII: Showing the experimental results on the predatory propensities of the Frog (<u>Rana limnocharis</u>) on the Spawn of Common Carp, <u>Cyprinus carpio communis</u> L. in the laboratory during the year 1977.

Date, Month and Year of the Experiment	Nos. of sets of experiment conducted	Nos. of prodator used per jar	Size of tho predator (cm.)	Nos. of spawn used per jar	Size of the spawn (cm.)	Mean Nos. of spawn consumed por day.
10.5.1977	4 jars	1	1.5	2.5	0.5-0.6	4
11.5.1977	4 jars	1	1.5	2.5	0.5-0.6	3
12.5.1977	4 jars	1	1.5	2.5	0.5-0.6	5
13.5.1977	4 jars	1	1.5	2.5	0.5-0.6	5
14.5.1977	4 jars	1	1.5	2.5	0.5-0.6	3

DISCUSSION :

In aquatic ecosystems, the study of predation as one of the prime biotic factors that control and regulate community structure is being increasingly realised (Brooks and Dodson, 1965 and Zaret, 1969; 1972). In fish culture practices, one of the attendant problems facing aquaculturists is that of predation. The magnitude of predatory pressure on carp fry is further accentuated by the fact that generally monocultural practices are ecologically more vulnerable due to lack of stability in the ecosystem by low species diversity (Odum, 1971). Several vertebrate and invertebrate predators are found to be harmful agents in fish culture (Alikunhi, 1957; Huet, 1970; Hickling, 1971; Jhingran, 1975; 1977; Woynarovich, 1975). Pennak (1953) reported that the aquatic insects form less than 4% of the total number of existing insect fauna of the world. The destructive role of aquatic insects in carp nurseries with special reference to Indian situation has been described by several earlier workers like Khan and Hussain (1947), Prakasi (1953), Alikunhi et al (1955), Alikunhi (1957), Choudhuri (1960), Ganguli and Mitra (1961), Gorai and Raychaudhuri (1961) and Julka (1965 and 1969). The role of most of the aquatic insects as larvae or adults has been pointed out that in addition to preying directly upon carp spawn and fry they also compete with the latter for food (Jhingran, 1975, 1977). Recently even the freshwater cyclopoid crustaceans Acanthocyclops vernalis and Cyclops bicuspidatus have been reported to cause mortality to young carp fry (van Duijn, 1973).

At this juncture it must be pointed out that in spite of these various earlier reports of the alleged predation of carp spawn by several aquatic organisms, specific experimental data are not coming forth in terms of quantification of the predatory pressure and as well as the relative importance of different predator organisms. Hence attempts were made to conduct these predatory experiments in the present study, though this work is not without limitations.

In the present study, the most common and large sized predators encountered in the nursery ponds at Fish Dale, Shillong are the nymphs of the dragonfly genera, Aeshna and Cordulia, Notonectids and Frog (Rana limnocharis). The results of the series of experiments conducted in the laboratory on the predatory propensities of the above three groups on Carp spawn are presented in Table- XXV to XXVIII.

In the first set of experiments with the dragonfly nymph of Aeshna of 5.0-6.0 cm size on carp spawn of 0.5-0.6 cm resulted in a loss amounting to 30% in the first and second, 35% in the third, 20% in the fourth and 40% in the fifth series of experiments. When these results are computed for all the five series the total average loss was found to be 31% of spawn for a 24 hour duration.

Similarly, the second set of experiments with another species of dragonfly nymph, Cordulia of 2.0-3.0 cm size resulted in a predatory loss of 70%, 55%, 40%, 50% and 65% in the five series of experiments. The mean loss of spawn when calculated for all the five experimental series it work out to 65%. As mentioned earlier though there are frequent references in the literature to the predatory habits of nymphs of Anisoptera and Zygoptera, no specific data are presented in any of them. However, Alikunhi et al (1952) have briefly reported on the predatory habits of dragonfly nymphs, that a specimen of 15 mm long can swallow 7 carp spawn of 6.0-7.0 mm size within 3 hours in the laboratory. In the present study it is seen that the first two sets of the five series of experiments conducted with nymphs of Aeshna and Cordulia clearly showed that in spite of their being about four and two times larger in size (60 and 30 mm) even then their feeding voracity on carp spawn was quite low with only 6 numbers/24 hours and 3 numbers per 24 hours/ nymph as compared to the rate of 56 numbers/24 hours (7 nos/3 hours) by earlier workers (Alikunhi et al loc.cit.). The latter results are for the plains of India. It is not quite appropriate to make the comparison with the present study as the differences in feeding propensities could be due to species differences or their sizes involved, although temperature variations even within the laboratory in these two cases could have influenced the feeding rates.

The third set of experiments was conducted with 10 numbers of Notonectids with 50 spawn in each tray. It is seen from the results that the average loss of spawn per day in all the five series worked out to 14, 11, 12, 9 and 15 numbers/day amounting to 28%, 22%, 24%, 18% and 30% loss respectively. Distant (1906), Gorai and Raychaudhuri (1962) and Julka (1965) have made brief references to the predatory habits of these adult backswimmers and their nymphal instars that they are known to attack and kill carp spawn, fry, small fishes of 10.0 -13.0 mm size, tadpoles and even small frogs. These workers, however, did not provide any specific data on predatory intensities. From the present study, it is clearly seen that these insects on an average cause a mortality of about 1 spawn/animal/day (12 spawn/10 animals/day). However, it must be mentioned that though these spawn are killed or injured collectively, yet they are not totally consumed by these insects. Thus, it can be concluded from the present investigations on notonectids that their importance cannot be underestimated even at this altitudinal situation, for, despite their smaller size, their presence warrant immediate control for higher survival of spawn and fry in carp ponds as already suggested for the plains (Alikunhi, 1957 and Jhingran, 1975, 1977).

In the fourth set of experiments conducted with the Anuran species, Rana limnocharis on carp spawn, it was seen that the predatory propensity worked out to an average of 4 spawns/24 hours, in the first series, 3 in the second, 5 in the third, 5 in the fourth and 3 in the fifth series, showing a mortality rate of 16%, 12%, 25%, 25% and 12% respectively. Huet (1970) and Woynarovich (1975) have reported upon the predatory habits of the frog species Xenopus both as larvae or adults upon the spawn and fry and as well can also compete for food. Though the tadpoles and adult of several frog species are of ubiquitous occurrence in the carp culture ponds throughout India, their predatory effects have not so far been precisely quantified for the various species. The present results on the predatory nature of Rana limnocharis of 1.5 cm size range with a feeding rate of 4 spawn/day point out to the necessity of further detailed studies on this aspect.

The present series of predatory experiments on one vertebrate and the three invertebrate predators have shown the relative importance and their possible impact on carp culture, though it is admitted that these experiments are still of a preliminary nature. It is seen that the overall predatory propensities on 100 carp spawn in terms of percentage are 31% and 56% for the dragonfly nymphs, while 22.4% and 18% for the notonectids and frogs respectively. Thus it may be concluded that the most important predatory pressure at these altitudinal ponds are due to the dragonfly nymphs followed by the notonectids and the frogs in that order of descending magnitude.

INDUCED BREEDING, HATCHING AND REARING EXPERIMENTS ON THE ROHU *LABEO ROHITA* (Hamilton)

III. INDUCED BREEDING, HATCHING AND REARING EXPERIMENTS ON THE ROHU, LABEO ROHITA (HAMILTON).

A. Induced breeding experiments.

The results obtained from the experiments on induced breeding of one of the Indian major carps (Rohu) are presented below. These experiments on breeding and rearing were carried out in the Mawpun Fish farm located about 25 km from Shillong at an altitude of 1,100 m.

Induced breeding experiments conducted on the Rohu, *Labeo rohita* (Hamilton) in Hapas :

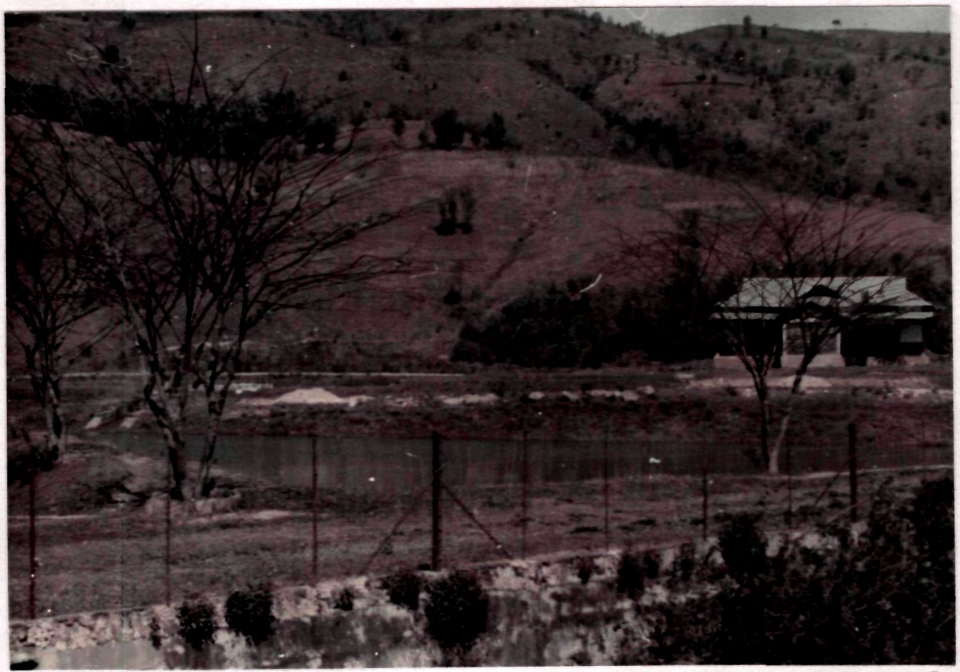
In the first of the two series of induced breeding experiments the female brooder weighed 450 gm and the males 440 and 500 gm in weight and was conducted in July 1979 (Table- XXIX). On the same day of the experiment the fish spawned during the night between 5-6 hours after the second injection when the atmospheric and water temperature ranged between 23-29°C and 26-28°C respectively (Table-XXX). Meteorological factors involved during the experimental period was that in the morning hours the weather was clear, sunny and hot whereas from 1,100 hours onward on that day there was an overcast and cloudy sky with the weather beginning to cool down by gentle breeze. Toward the evening around 1800 hours there were rains, thundershowers and lightning lasting for one and half hours. Soon after, spawning occurred and the female brooder was found to have lost 75 gm of its body weight of which nearly 90% is estimated to be the weight of the eggs and the rest forming the faecal and other waste products. The individual egg varies in size from 1.16 to 1.34 mm prior to fertilization and 2.5-3.5 mm in diameter when

PLATE - XVII

(a) Showing an overall view of the Mawpun Fish Farm where the Induced Breeding experiment on *Labeo rohita* was conducted.

(b) A Breeding Pond and a Breeding Hapa with a nullah feeding the pond.

PLATE XVII



a

b

PLATE - XVIII

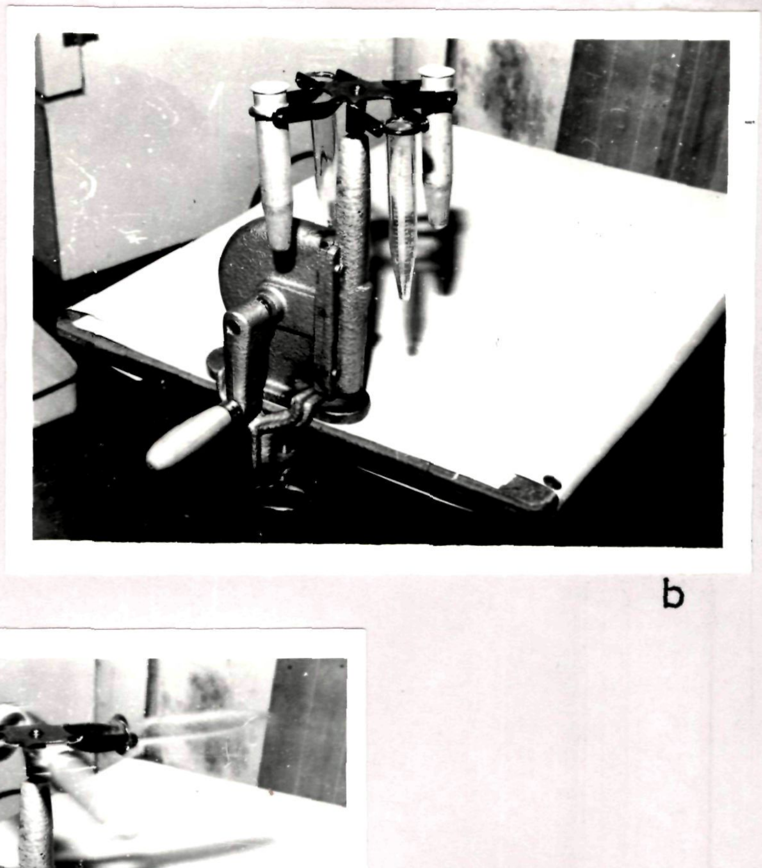
(a) A breeding hapa where the induced breeders of Rohu, Labeo rohita were kept and also showing the creation of an artificial current by the using of a bamboo pipe leading into the breeding Pond.

(b) A hand centrifuge used for extracting the pituitary hormone from the pituitary gland.

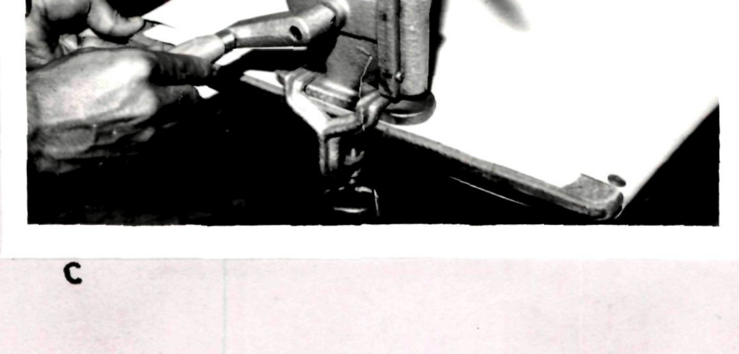
(c) A hand centrifuge at work.

PLATE XVIII

a



b



c

fully swollen after fertilization. The total number of eggs spawned by the fish was estimated to be a total of 10 mugs at the rate of 150 eggs/cup and 10 cups/mug (150 X 10 X 10). Out of these the number of fertilized eggs were estimated to be 5,250. The fertilization worked out to be 35% and was visually estimated by counts of 500 eggs randomly selected from the different mug samples. Among these fertilized eggs a total of only 1,048 hatchlings and spawns were harvested indicative of a hatching rate of 20%.

The second set of the Induced breeding experiment was conducted during the same period with the female weighing 460 gm and males 430 and 375 gm (Table-XXIX). Spawning took place during the night at the temperature range between 26 to 28°C. The loss in weight due to spawning was 100 gm and the estimated number of eggs were 18,000 ranging in size between 3.5-4.0 mm. It has been calculated that the fertilization was only 8-10% with the total number of fertilized eggs varying between 1,440-1,880. Subsequently, though there was some evidence of hatching, all the spawn died probably at the yolksac stage itself, since no hatchling could be harvested.

B. Hatching experiments.

Incubation and hatching of the Rohu, *Labeo rohita* (Hamilton) in Nylon Hapas :

It was seen from the Table-XXIX that the percentage of hatching of eggs in both these experiments was very poor with only 20% in the first and nil in the second set of experiments. The range of temperature during the hatching period was 18.5 to

PLATE - XIX

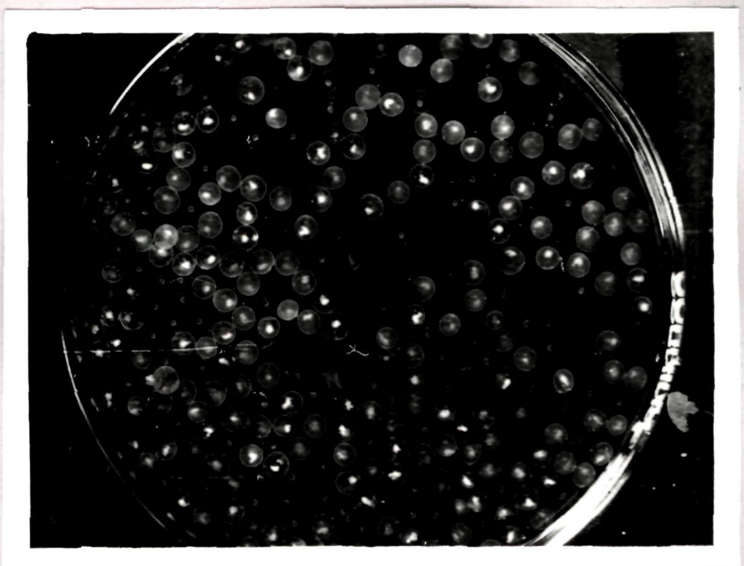
(a) Showing a brooder of Rohu, <u>Labeo rohita</u> being injected with the Pituitary hormone.

(b) Fertilized eggs of Rohu, <u>Labeo rohita</u>.

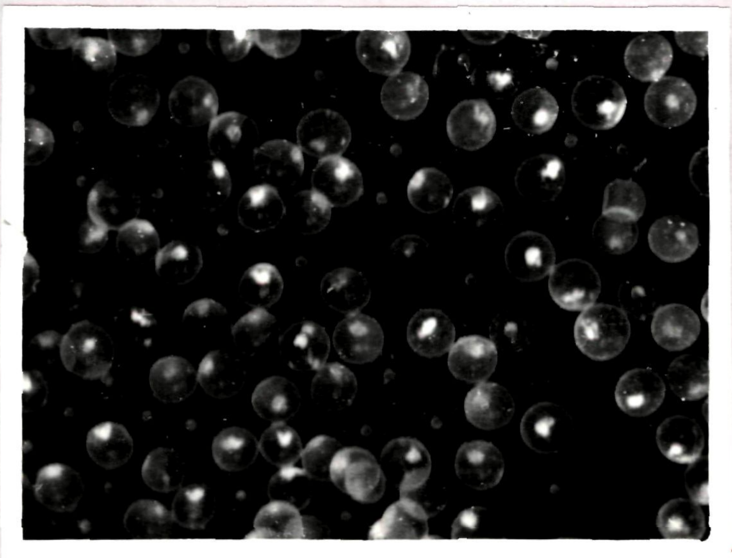
(c) Fertilized eggs of Rohu, <u>Labeo rohita</u> (magnified).

PLATE XIX

a



b



c

TABLE XXIX : Showing the induced breeding experiment on the Rohu, *Labeo rohita* at Mawpun Fish Farm, Meghalaya on the 24th July, 1979.

Experiment No. and Time	Temperature Air °C	Temperature Water °C	Weight of the recepient fish before spawning Female (gm.)	Weight of the recepient fish before spawning Male (gm.)	Weight of the fish after spawning Female (gm.)	Dosage of Pituitary gland administered Female (mg/kg)	Dosage of Pituitary gland administered Male (mg/kg)
1	2	3	4	5	6	7	8
EXPT.I 12.30 P.M.	29	28	450	440	375	4	-
6.00 P.M.	23	26	-	500	-	8	-
EXPT.II 12.30 P.M.	-	-	460	430	360	4	-
6.00 P.M.	-	-	-	375	-	8	4

Experiment No. and Time	Time of spawning (hr.)	Nos. of eggs spawned	Fertilization (%)	Expected Nos. of fertilized eggs	Percentage of hatching (%)	Nos. of hatching
9	10	11	12	13	14	15
EXPT. I 12.30 P.M.	11.30 PM	15,000	35	5,250	20	1,048
EXPT.II 12.30 P.M.	11.30 PM	18,000	8-10	1,440-1,800	Nil	Nil

TABLE XXX : Showing the Physico-chemical factors analysed during the induced breeding experiment of Rohu (<u>Labeo rohita</u>) at Mawpun Fish Farm.

Date, Month & Year.	Time	Temperature		pH	Oxygen (mg/l)	Carbon dioxide (mg/l)	Alkal-inity (mg/l)	Remarks
		Air (°C)	Water (°C)					
23.7.79	10.00 A.M.	28.5	29.0	6.0	12.0	2.0	24.0	Before spawning
24.7.79	09.30 A.M.	29.0	28.0	6.2	11.6	2.0	24.0	During spawning
"	06.00 P.M.	23.0	26.0	-	-	-	-	-
25.7.79	10.00 A.M.	20.0	18.5	6.4	11.6	2.0	20.0	After spawning
26.7.79	10.00 A.M.	25.0	26.0	6.1	12.4	2.0	20.0	During incubation.
27.7.79	10.00 A.M.	26.0	27.5	6.3	10.8	2.0	22.0	"
28.7.79	10.00 A.M.	29.0	27.0	6.4	11.2	2.0	20.0	"

26.5°C. Further, there were rains before and during the transfer of eggs into the hatching hapa and also during the incubation period. The incubation period took approximately between 24-40 hours at the mean temperature range of 18.5-26.5°C.

C. Rearing experiments.

(i) Rearing of spawn to early Fry of the Rohu, *Labeo rohita* (Hamilton) in Nylon Hapas :

With the available spawn thus harvested the rearing experiments on *Labeo rohita* were conducted. These experiments were commenced in the month of August 1979, in a nylon net hapa of 2 X 1 X 1 m placed within in a well managed nursery pond and extended for a duration of 30 days with the feeding regimes as reported earlier (Table-XXXI). A total of 1,048 spawn of *Labeo rohita* of sizes ranging between 6.5-8.5 mm in length and 6.0-9.0 mg in weight were reared. At the end of the rearing period 603 early fry ranging in size from 10.0-15.0 mm of 300-600 mg were harvested. The survival rate was computed to be 57.7% and the loss due to mortality was 445 with a loss of 42.3%.

(ii) Rearing of early Fry to Early Fingerlings of the Rohu, *Labeo rohita* (Hamilton) in Nursery Pond :

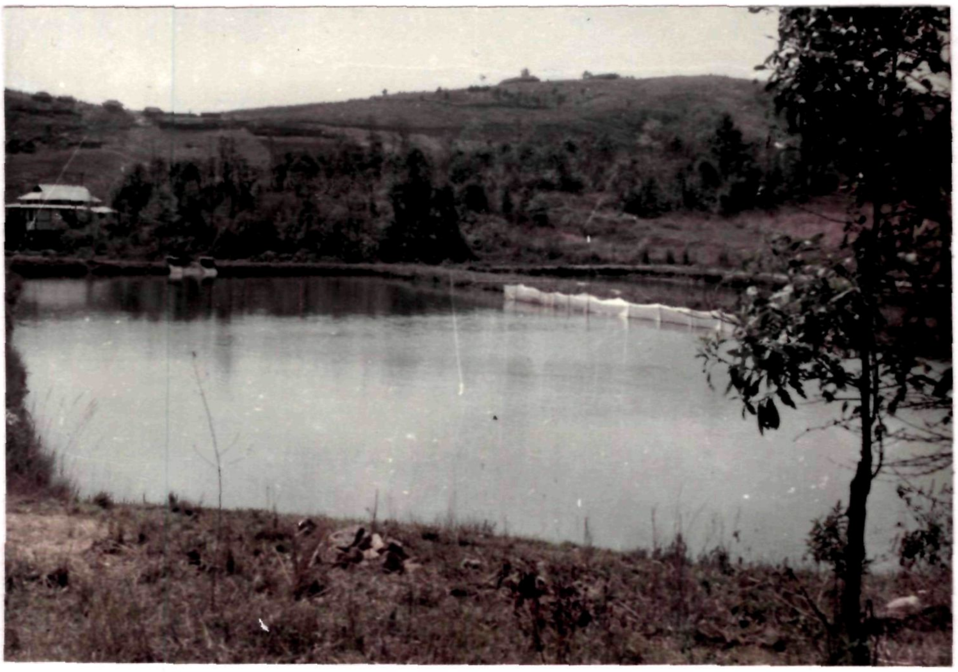
From the harvested early frys of *Labeo rohita* further rearing was continued in order to assess their viability at this colder hill region. So in the month of September 1979, the rearing of early fry was started in a managed Katcha nursery pond of 0.01 ha size for a duration of 90 days with feeding every alternate day (1:1 ratio of rice bran and mustard oil cake) and manuring with cowdung. The physicochemical variables were also measured at weekly intervals and data computed monthwise and presented (Table- XXXII).

PLATE - XX

(a) Showing Nylon Hapas in a pond, using for the rearing of spawn to early fry stage of Rohu, *Labeo rohita* at Mawpun Fish Farm.

(b) A hatching hapa in a Stocking Pond used for the incubation of the uggsoof Rohu, *Labeo rohita* at Mawpun Fish Farm.

PLATE XX



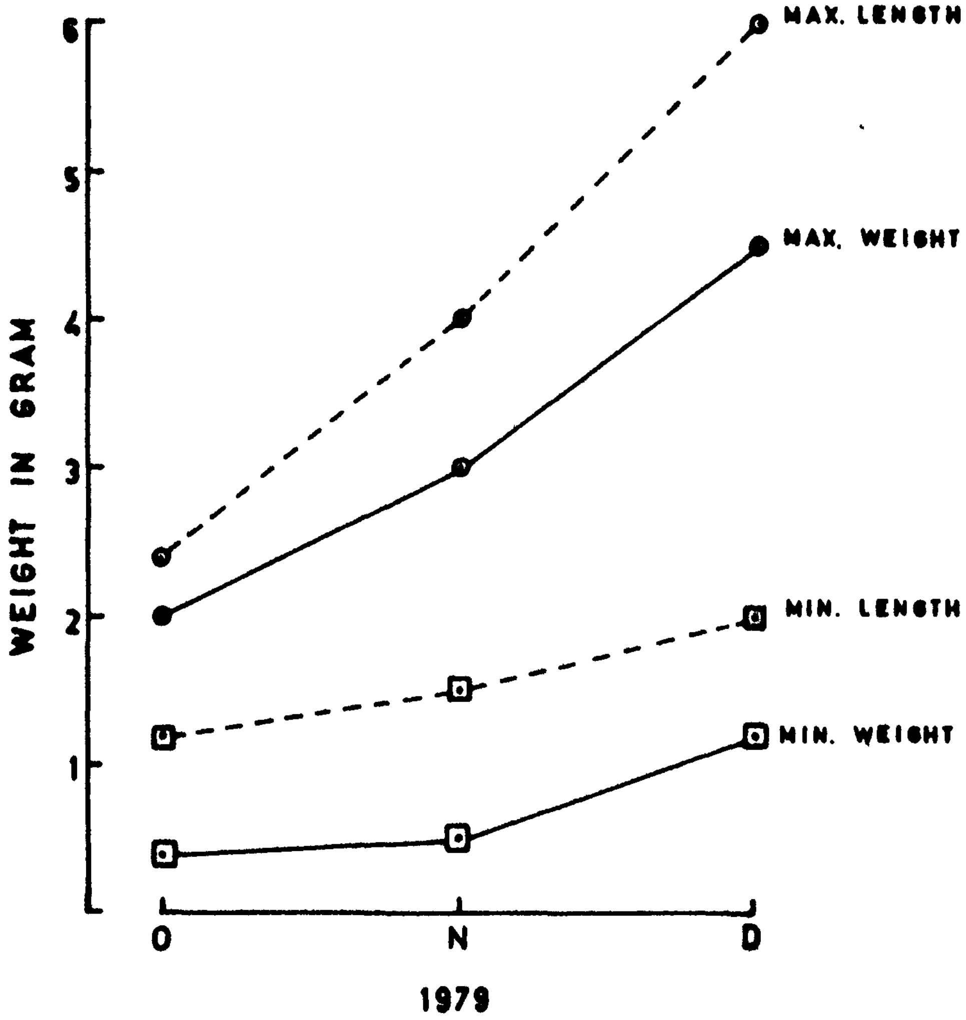
a

b

FIG. 15

Graph showing the total length and weight of different size groups of Rohu, *Labeo rohita* (Ham.) fry at Mawpun Fish Farm.

FIG. 15


MAX. LENGTH
MAX. WEIGHT
MIN. LENGTH
MIN. WEIGHT
WEIGHT IN GRAM
6
5
4
3
2
1
O
N
D
1979

In this rearing experiment 600 early fry of Rohu, Labeo rohita ranging between 1.0-1.5 cm in length and 0.3 to 0.6 gm in weight were stocked in a 0.01 ha pond (Table-XXXII). During this period of rearing from this initial size, the early fry had grown to fry and early fingerling stages reaching the size of 2.0-6.0 cm long and weighing 1.2-4.5 gm. Out of the 600 numbers stocked, 387 were finally harvested indicating a survival rate of 64.5%. The mortality rate with an actual loss of 213 number of fry worked out to 35.5%.

(iii) Physico-chemical factors :-

Temperature :

The temperature recorded in this pond from October to December, 1979 ranged between 19-23°C. The trend of temperature fluctuation showed that from November there was a steady drop in the water temperature till a minimum was recorded in December at 19°C (Fig. 16).

pH :

The pH was always in the acidic range and varied between the minimum of 6.0 recorded in October to the maximum of 6.3 in November with a drop to 6.2 in December (Fig. 16).

Conductivity :

The conductivity value recorded during the three months period of the present growth experiment ranged between 9.45-12.60 umhos/cm. The lowest value were observed in November while the highest value was in December. During October the value recorded was 10.50 umhos/cm (Fig. 16).

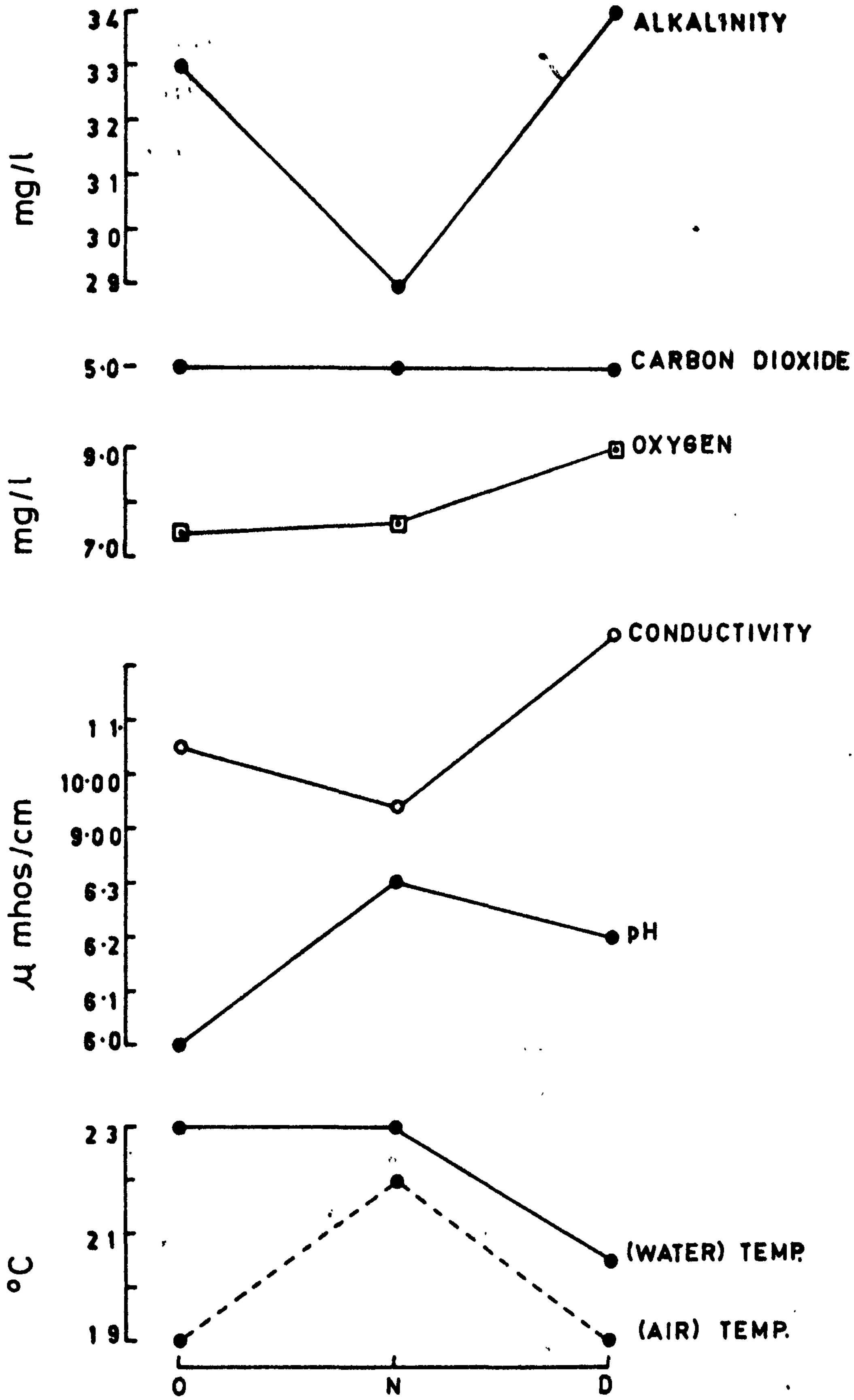
Dissolved Oxygen :

The amount of dissolved oxygen varied between 7.4 to 9.0 mg/l during the three months study period (Table-XXXIV). As seen

FIG. 16

Graph showing the fluctuation of the physico-chemical factors (alkalinity, free carbon-dioxide, dissolved oxygen, conductivity, pH, water and air temperature) during the induced breeding experiments of Rohu, *Labeo rohita* (Ham.) at Mawpun Fish Farm.

FIG.16



34
33
32
31
30
29
mg/l
ALKALINITY
5·0
CARBON DIOXIDE
9·0
7·0
mg/l
OXYGEN
CONDUCTIVITY
11·
10·00
9·00
6·3
6·2
6·1
6·0
μ mhos/cm
pH
23
21
19
°C
(WATER) TEMP.
(AIR) TEMP.
O
N
D

TABLE XXXI: Showing the rearing experiment of Spawn to early Fry of Rohu, Labeo rohita (Ham.) in Nylon Hapa at Mawpun Fish Farm during August to September, 1979.

Total Nos. of Spawn stocked in Aug.79	Initial size range Length (mm.)	Initial size range Weight (mg.)	Total Nos. of Fry harvested Sep. 79	Final size range Length (mm.)	Final size range Weight (mg.)	Survival %	Mortality Nos.	Mortality %
1040	6.5-8.5	6.0-9.0	603	10.0-15.0	300.0-600.0	57.7	437	42.3

TABLE XXXII : Showing the rearing experiment of Fry to Fingerling of Rohu, Labeo rohita (Ham.) in a Nursery Pond at Mawpun Fish Farm during September to December 1979.

Total Nos. of Fry stocked (Sep. 79)	Initial size range Length (mm.)	Initial size range Weight (mg.)	Total Nos. of Fingerling harvested (Dec. 79)	Final size range Length (mm.)	Final size range Weight (mg.)	Survival %	Mortality Nos.	Mortality %
600	1.0-1.5	0.3-0.6	387	2.0-6.0	1.2-4.5	64.5	213	35.5

TABLE XXXIII: Showing the Monthly Sampling of Rohu, Labeo rohita (Ham.) fry at Mawpun fish farm during October to December, 1979.

Month and Year	Total length of different size groups (cm.)	Total weight of different size groups (gm.)
October, 1979	1.2	0.4
	1.6	0.8
	2.0	1.5
	2.4	2.0
November, 1979	1.5	0.5
	1.8	1.0
	2.5	2.0
	3.0	2.5
	4.0	3.0
December, 1979	2.0	1.2
	2.2	1.8
	3.0	2.0
	4.5	3.5
	6.0	4.5

TABLE XXXIV: Showing the analysis of the physico-chemical factors of the Pond water during the rearing experiment of Fry of Labeo rohita (Ham.) at Mawpun fish farm.

Month and Year.	Time (P.M.)	Temperature Air °C	Temperature Water °C	pH	Conductivity (umho/cm)	Oxygen (mg/l)	Carbon Dioxide (mg/l)	Alkalinity (mg/l)
OCT. 1979	10.45	19	23	6.0	10.50	7.4	5.0	33.0
NOV. 1979	10.30	22	23	6.3	9.45	7.6	6.0	29.0
DEC. 1979	10.30	20.5	19	6.2	12.60	9.0	5.0	34.0

in Fig. 16, the maximum was recorded in December and the minimum in October, while in November it values was 7.6 mg/l (Fig.16).

Free Carbondioxide :

The free Carbondioxide was seen to be present throughout the period of study and ranged between 5.0 to 6.0 mg/l with minor fluctuation (Fig. 16).

Total Alkalinity :

The total alkalinity recorded ranged between 29.0 to 34.0 mg/l with the maximum value observed in December and the lowest in November (Fig. 16). In October the value was 33 mg/l but dropped in November to again finally rise in December with 34.0 mg/l.

DISCUSSION

So far, the trend of development of the State Fisheries in Meghalaya hinges entirely on the production and supply of seeds by controlled breeding experiments of the exotic Common Carp without any attempt to try the rich indigenous varieties of major carps which may be suitable for at least the lower altitudes and the plains of this Hilly State. However, before such introduction of major carps and cultural practices are taken up two basic questions need to be answered which are the suitability of the environment and the production of seeds. It is in this context, experiments on the induced breeding, hatching and rearing of one of the most favoured Indian major carps Labeo rohita was undertaken as one of the aspects of the present thesis. Since this experiment was of a preliminary nature, only limited results were achieved, that are presented and discussed below.

Development of the method of induced breeding of Indian major carps like Catla catla, Labeo rohita and Cirrhinus mrigala by hypophysation achieved for the first time in this subcontinent in 1957 is a great landmark in the development of fish culture (Chaudhuri and Alikunhi, 1957). Since its first success in the country, a great deal has been accomplished in regard to method of collection, preservation and storage of the pituitary materials, assessment of variation in the gonodotropic potency in relation to phylogenetic and sex specificity, season, problems of dosage and of bioassay techniques (Alikunhi et al 1960; Das and Khan, 1962; Sundaraj and Goswami, 1966; Chaudhury, 1967, 1976; Jhingran, 1969, 1975; Chondar, 1970; Shehadeh, 1970; Tripathi and Bhimachar, 1972; Chaudhuri and Singh, 1978).

Two sets of experiments on induced breeding, hatching and rearing of L. rohita were conducted for a total period of 6 months (July to December, 1979) at the Mawpun fish farm of the Meghalaya State Fisheries Department located at an altitude of 1,100 m and about 25 km from Shillong. While the results of induced breeding and hatching experiments are presented in this chapter, the data on rearing are discussed in the following chapter. As presented in the results, the brooders for the induced breeding experiments were procured from the State Fishery Department at Gauhati, Assam State during July 1979. The females ranged between 450-460 gm and the males of 375 to 500 gm in weight. Rao (1978) has studied in detail the maturation of major carps under the environmental conditions prevailing in Assam and has shown that both females and males of Rohu and Mrigal attained maturity only in the second year, with two peaks of gonodal maturation, one occuring in early March and

April and the other in May and June. The brooders procured for the present experiments were ripe enough for spawning and hence thought to be in their second year of growth. However, although the peak gonadal maturity of Rohu females is reported to be in the months of May and June in the plains of Assam (Rao, 1978), the present induced breeding experiments were conducted in July in keeping with the other earlier reports that the most favourable period of maturation and breeding of major carps always shows positive correlation with the South West or North East monsoon (Khan, 1924, 1942; Hora, 1945; Das and Dasgupta, 1945; Chacko, 1946; Ahmed, 1948; Chacko and Kurian, 1950; Ganapati et al 1951; Karamchandani et al 1957; Jhingran, 1959; Ibrahim, 1961; Qasim and Quyyum, 1962; Natarajan and Jhingran, 1963).

During the present induced breeding experiments a preliminary dose of the pituitary gland at the rate of 4 mg/kg and a final dose of 8 mg/kg body weight were administered to the females at an interval of 6 hours, while the males received only a single dose at the rate of 4 mg/kg coinciding with the administration of the final dose to the female. It is known that in other induced breeding centres of India the dosages to the females were only 2-3 mg and 5-6 mg in the first and second administration and the males received at the rate of 2-3 mg/kg body weight with successful results (Khan, 1978). The dosage of pituitary gland was purposely increased in the present experiment following the findings of Rao (1978) who stated that successful spawning in the neighbouring State of Assam at Gauhati was achieved by injecting higher doses of 3 mg and 6-9 mg/kg body weight to female during the first and second injections respectively in order to augment if any, the possible environmental and physiological constraints.

The mean number of eggs released in the first breeding was estimated at 15,000 and in the second experiment more number of eggs were obtained with 18,000. Thus the average number of eggs released by the female fish in the present experiment ranges between 33,300 to 70,000 number/kg body weight with the egg dimension of 2.5-4.0 mm in diameter. Comparable results on Labeo rohita from the Gauhati fish farm in Assam where the same brooder matures twice a year and with an average production of 1,43,400 eggs in the first and 1,66,900 eggs/kg body weight in the second breeding with the egg sizes ranging between 4.0-5.25 mm and 3.2 to 3.75 mm respectively (Rao, 1978). The relatively low fecundity as shown in the present experiments needs to be explained. When the overal differences of the environmental conditions observed in these two centres are compared, they show that a temperature of 30-36°C and pH of 7.4-8.6 were recorded at the Gauhati fish farm whereas in the present Mawpun fish farm a temperature range at 18.5-29.0°C and a pH range between 6.0-6.4 prevailed. In the first instance the contrasting differences observed in the ranges of these two important variables could definitely be offered as the causative factors to explain the differences in fecundity. One another factor which could be attributed to the low fecundity may be that the brooders in July have probably passed already their peak, although the antecedent spawning history of them are not known for certain.

But it has been observed in the plains that with the prolonged breeding, most of the ripe eggs have undergone the stage of re-sorption, thereby limiting the further production of eggs. Thus it is known that in Gauhati, Assam, whenever the same fish spawned for the second time in the month of May and June most of the eggs of brooders in July are in a stage of resorption. Even the release of small sized eggs in both the present experiments further indicates that the eggs were already undergoing such reductive changes. Lastly it is also felt that, the long journey, stress and strain underwent by the mature brooders during transportation has brought about changes in the total numbers and quality of eggs.

As mentioned before, since this set of experiments was the first of its kind on the major carps of India at this altitude, the suitability of the environment was also given due consideration. Thus several of the physicochemical factors of the pond water were estimated and are discussed here.

The depth of water maintained for the present study ranges between 100 to 135 cm and breeding was successful, though Khan (1924) advocated a depth of 4 inches to 12 inches for spawning of Indian major carps, although Dubey and Tuli (1961) observed successful breeding in a wider range of depth from 6 inches to 6 feets. Of course, it is now generally accepted that the depth requirement varies dependant upon the species and size of the parent fish, though Mrigal and Rohu are generally known to prefer to breed in shallow waters (Wishard, 1978). In this context it may be pointed out that Ghosh and Ghosh (1922) and Khan (1924) found that major carps conqregate either near the entrance or exit where there is a mild current of water, which was found responsible for stimulating the fish to spawn. A similar facility was simulated to facilitate and enhance the spawning at Mawpun by diverting a nullah and feeding the water through a bamboo pipe into the breeding pond. In recent years, that faster current especially during the flooding of rivers could excite the brood fish for spawning has been reported (Wishard, 1978 and Rao, 1978).

It is noticed in the present study that spawning took place at a narrow temperature range of 26-28°C which fall favourably within the range given by different workers in the past who have suggested the conducive temperature regimes to be 22-33°C for spawning (Ahmed, 1948; Chacko and Kurian, 1950; Dubey and Tuli, 1961). However, even when the temperature range was between 24-31°C, Khan (1945) believed that temperature alone may not initiate the process unless rain and flood are present which induce the fish to ascend to the spawning ground.

At Mawpun fish farm, the pH of water was in the acidic range of 6.0-6.4 and with low alkalinity content of 20.0-24.0 mg/l. While the direct effect of the two factors are not known, these might have still interfered with fertilization since only a low percentage was achieved, and it is generally known that water close to neutral or slightly alkaline conditions, not only favour the inducement of spawning but also create successful fertilization (Saha et al 1957). It is well known that the oxygen levels in the habitat are not only essential for normal growth and meeting the physiological requirements of the fish but could also affect breeding as it is suggested that high oxygen content of water induces the fish to sexual activity by stimulating the pituitary activity (Khan, 1924; Mookerjee et al 1944; Singh, 1978). In this respect the oxygen content at Mawpun fish farm was never a limiting factor with the prevailing high values of 10.8 to 12.4 mg/l, evidently due to the inflowing current of water.

In the present study it was noticed that the Carbondioxide content in the breeding pond was always very low at 2.0 mg/l, obviously due to the correspondingly low pH and alkalinity. However, the successful spawning observed in this situation may still be related to the findings of Sinha et al (1974) that decreased levels of Carbondioxide and bicarbonates could bring about physiological stress and in turn trigger spawning. It must however, be admitted that no experimental evidence is available from the present studies.

In the present series of experiments on the Labeo rohita subsequent to breeding and fertilization, the eggs were transferred for incubation and hatching into the hatching hapa at a density of approximately 15,000 to 18,000 eggs. It is seen that the mean duration for the incubation period varied between 24-40 hours at the recorded temperature range of 18.5-26.5°C. The duration of incubation observed at present along with the temperature prevailed at the Mawpun fish farm is much longer as compared to that achieved in the plains of India with 14-20 hours at a temperature range between 24-31°C (Chondar, 1970). Further the same author confirmed that lower the temperature, longer is the period of incubation as in some cases the eggs take even about 40 hours to hatch. It appears from the above reports that the period of incubation is inversely proportional to the temperature of the water, although Alikunhi et al (1964) found that 29°C ± 1°C is the most suitable for the hatching of eggs in major carps for optimum results.

The rearing experiments at Mawpun fish farm were conducted with the spawn to early fry stage of Rohu, Labeo rohita in a 2 X 1 X 1 m nylon hapa fixed in manured nursery ponds. In the experiment during August 1979, out of the 1,048 spawn stocked, 603 early fry were finally harvested with their maximum sizes reaching between 10.0-15.0 mm and 300-600 mg with 1.6 fold growth in length and 60 times in weight. The survival rate of 57.7% was achieved with a mortality rate being 42.3%.

Comparable results of spawn rearing from other Indian experiments in closed and fixed nurseries have shown that cages made of bamboo frames and nylon hapa of 3.5 sq m area with a total number of 30,000 hatchlings showed a growth of 45.6 mm, from an initial size of 7.8 mm in 28 days (Natarajan and Saxena, 1978), as compared to the present growth of spawn to early fry in 30 days from 6.5-8.5 mm to a final size of 10.0-15.0 mm. It is quite evident that the rate of growth is retarded at this altitude and the causative factors such as low water temperature, acidic pH and low alkalinity presented earlier in the discussion of the rearing of Common carp may be applicable to the present findings as well. However, the mortality rate in the present experiment was 42.3% as compared to 75% of mortality shown by Natarajan and Saxena (1978), thereby indicating much lower rate. One of the plausible explanations for this could only be found in the contrasting differences in stocking rates of the two studies. Thus, while the present stocking rate works out to about 50,00,000/ha the earlier report in bamboo nylon cages is much higher with 8,50,00,000/ha (Natarajan and Saxena, 1978).

From the present rearing experiments in nylon hapa it could be inferred that the major advantages by rearing spawn in such closed and fixed nurseries are that they are primarily predator free in addition to the easy maintenance and fair degree of constancy atleast in some of the physical factors which do not normally affect such hapa since these are covered at the top. Nevertheless, in addition to the supplementary feed provided, the meshes of the hapa always facilitated the entry of phytoplankton and zooplankton that are available to the baby fish. The other benefits of such confined rearing of spawn are that the hapas serve to be hygienic since waste matter as unused food or faecal matter easily seeped down through the meshes and also the reduction of elaborate manual labour which are otherwise needed in nursery ponds. Such closed rearing also reduces the strains and injury to the fry while netting which could not be avoided in open nursery ponds. Most of these beneficial aspects have already been discussed in an earlier context with the rearing of Common carp seeds.

The rearing experiments of early fry to fry and early fingerling stages of Labeo rohita were conducted for a period of 90 days in a Katcha nursery pond. The data obtained on the average production of fry in these systems along with the prevailing physicochemical factors are presented (Table-XXXII-XXXIV). In the rearing experiment of 1979, it is seen that from 600 early fry stocked in a 0.01 ha pond, 387 were finally harvested indicating a 64.5% survival rate with 3.3 times gain in length and about 6-fold increase in weight with a mortality rate of 35.5%.

When the rate of stocking was worked out per hectare for the present study, it was found to be 60,000/ha which form only about 20% of the maximum of 3,00,000/ha (Rao, 1978) and 15% of the high rate of 3,50,000/ha (Jhingran, 1978). As far as the survival rate is concerned the present record of 64.5% matches well with earlier results of 70% obtained at pond culture division of the CIFRI (Rao, 1978) and somewhat lower than the reported 80% of Jhingran (1978).

With regard to growth, in the present study from an initial size of 10 mm--15 mm, the final sizes ranged between 20.0-60.0 mm for the rearing period of 90 days. In the report of Hora and Pillay (1962) the initial 6.0 mm Carp fry reached a final size of 35 mm in 15 days period. Similarly Rao (1978) also reported that from an initial size of 20.0-30.0 mm the frys reached a final size of over 100 mm in 90 days period. It is thus very clear that at the present altitude the growth rate of Rohu is certainly retarded buth in terms of length and weight increments as compared to what is obtained elsewhere in the plains. During the present rearing experiments the temperature ranged between 19-23°C as compared to the rearing temperature ranges of 28-37.5°C in the plains (Jhingran, 1975, 1977). Among other factors, it is undoubtedly these differences in two temperature ranges almost by an order of magnitude which has largely influenced the retarded growth. As pointed out before, even the pH of water in the present study which was always in the acidic range between 6.0-6.3 could be one more of the factors not so favourable for growth as Swingle (1957) considers that while productive waters have a pH range of 6.5-9.0 values below and above this are unproductive and even lethal to fish. Along with pH, even the low alkalinity recorded in the rearing ponds which ranges between 29.0-34.0 mg/l is also attributed as another environmental variable causing the slow growth of fish as it is known that productive waters should preferably have an alkalinity value above 100 mg/l (Jhingran, 1977). Such correlation of the growth of fish with the pH and alkalinity of the medium have been established by most workers. In conclusion it may be added that despite these adverse environmental conditions coupled with low plankton production, the fry probably still survived subsisting mainly on the supplementary feed along with added nutrients derived from manuring with cowdung though resulting in their retarded growth.

Thus from the foregoing account on the breeding, spawning and rearing experiments on the Indian major Carp, *Labeo rohita* at this altitude, it may be concluded that this naturally acclimated tropical species from the plains of India could be bred and reared at intermediate altitudes, though with limited success. The present consensus based on available information points to the fact that breeding and growth of major carps, perhaps, cannot be attributed to any one single factor as a combination of several abiotic and biotic factors of the environment is involved. The present experiments conducted only reveal that induced breeding and subsequent rearing of Rohu (Labeo rohita) are possible at the lower altitudes of these hill regions and the environmental factors are not totally unsuitable. With proper alkalinisation of water, enhancement of plankton growth and timing of the breeding experiments to synchronise with the period of most favourable temperature further success is possible. The present studies have therefore only highlighted the problems to be tackled in future years, rather than offering readymade solutions. Thus comprehensive studies are needed in order to achieve successful results at the varied topographical conditions existing in Meghalaya. The detailed studies on the acclimatisation of both the indigenous and exotic carps in different regions as well as the effect of environmental variables on their maturation are urgently needed.

COMPOSITE FISH CULTURE EXPERIMENTS AT KYRDEMKULAI FISH FARM.

IV. COMPOSITE FISH CULTURE EXPERIMENTS AT KYRDEM KULAI FISH FARM.

A. Rearing experiments.

(i) Composite rearing experiments on the four species of Carps (Labeo rohita, Cirrhinus mrigala, Cyprinus carpio communis and Hypophthalmichthys molitrix) :

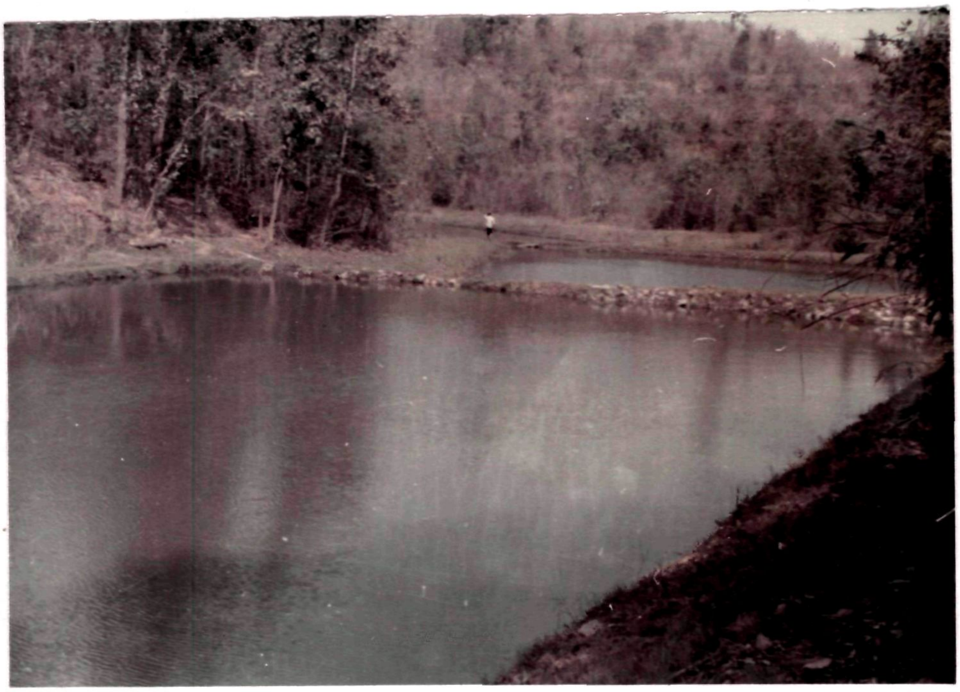
The Composite fish culture experiment by employing two of the indigenous and two exotic carps was tried at Kyrdem Kulai fish farm for a duration of one year, during February 1979 to February 1980 at a warmer altitude of 850 m. An attempt to combine culturing more than one of these fishes was made for better utilization of the food resources in the ponds. Thus the present polyculture experiment had the Phytoplankton feeding Silver carp, the benthophagic Common carp, the column feeding Labeo rohita and Cirrhinus mrigala feeding on detrital and semi-decayed vegetable matter. This experiment was taken up in a pond for which no previous record of fish culture is available. However the existing data on the physicochemical and biological factors of the pond wator appeared to be favourable and hence satisfactory results were anticipated for the production and growth of fish (Fig.XVII-XX). Details of the pond area, depth, fish stocked, their initial size and the feed employed are presented in Table-XXXV. It will be seen that Rohu (Labeo rohita) the column feeder showed the least growth rate when it grew from an initial stocking size of 7.0-8.5 cm and 4.0-6.0 gm weight to a size range of 16.0-27.0 cm and weighing 50.0-240.0 gm in the 12 month period. In this species it was also noted that the growth tends to increase from the month of May (40gm) to October (190 gm) with a peak attained in September (175 gm) showing an increment of 45 gm from August to September. Beyond

PLATE - XXI

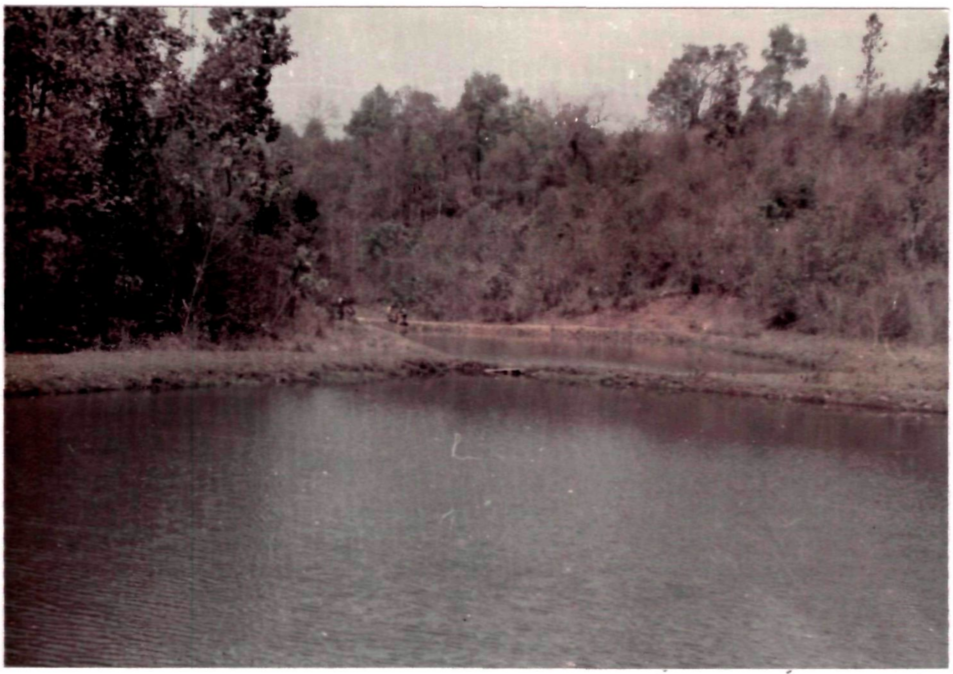
(a) Showing the Stocking Ponds 1 and 2 at Kyrdem Kulai Fish farm, the source of water used for the composite fish culture experiment.

(b) Showing the Stocking Pond Nos. 2 and 3 at Kyrdem Kulai Fish Farm.

PLATE XXI



a



b

PLATE - XXII

(a) Showing the Stocking Pond No. 3 used for the composite fish culture experiment at Kyrdem Kulai Fish Farm.

(b) Showing the netting of fish from the stocking pond at Kyrdem Kulai Fish Farm.

PLATE XXII

this period the growth gradually decreased from November 1979 till February 1980. It is then clearly seen that the optimum growth takes place only during the warmer months, from late April to October and thus active growth being limited to only six months out of the twelve month experimental period. Out of the 200 fish stocked of this species, 127 survived and grow accounting for a mortality rate of 36.5%.

Cirrhinus mrigala (Mrigal) was the other indigenous Carp which is well known for its bottom feeding habits. In this species from an initial stocking size of 8.5-9.0 cm long and 5.0-10.0 gm weighing fish, a maximum size of 19.0-29.0 cm and 65.0-305.0 gm in growth was attained in the 12 months period. The growth shows increase for the month of May with a 65 gm weight to November with 275 gm and the maximum weight of 245 gm having reached in October. This increment works out to a rate of 45 gm increment for a period of just 30 days, September to October. Subsequently, growth was retarded in December 1979, January and February 1980. In this species the period of fast growth was spread over 8 months from late April to November. This fish readily accepted supplementary feed and hence the growth rate was found to be favourable in warmer months. Out of the 125 numbers stocked in this species, 92 survived and grew accounting for a 73.6% survival and 26.4% mortality rate.

The Common carp (Cyprinus carpio communis L.) from an initial stocking size (6.0-8.0 cm and 5.0-10.0 gm) grew to a maximum size (19.5-37.0 cm in length and 150.0-655.0 gm in weight) in the 12 month study period. It was noticed that this species from the very first month after stocking showed increase in growth throughout the year with their mean weights during the month of July (200 gm), August (300 gm), September (415 gm), October (500 gm) and November (580 gm) being always on the increase. However, the peak growth rate was recorded during September (415 gm) which shows a 115 gm increment in a one month period from the previous month of August. In total 175 numbers of the Common carp were stocked, out of which 135 survived accounting for 77.1% survival and a rate of 22.9% mortality.

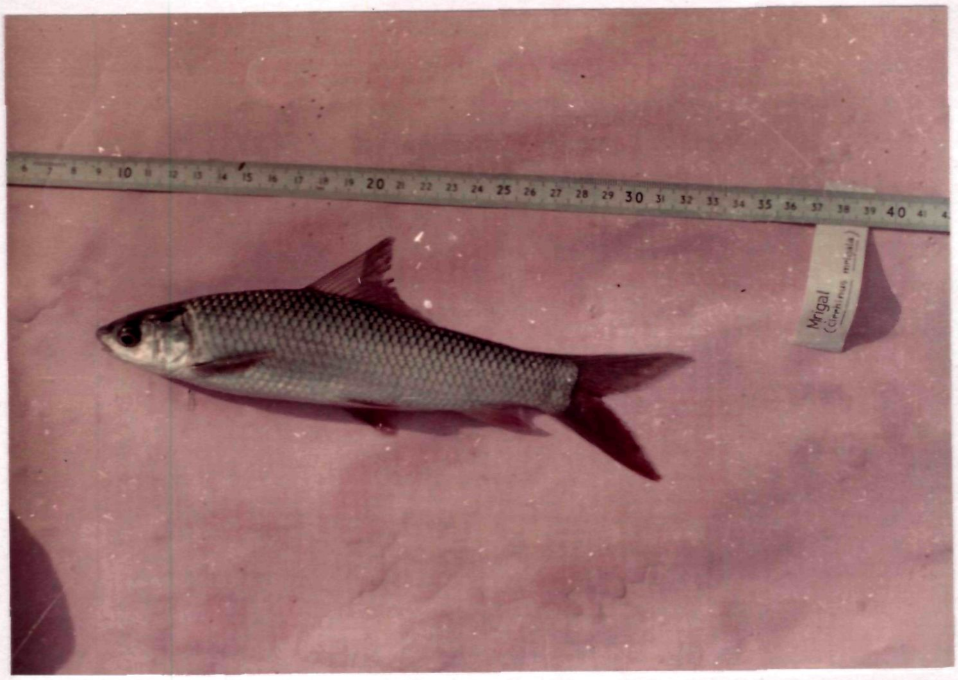
Silver carp (Hypophthalmichthys molitrix) the last of the species employed in the present composite culture experiment gave the best results, which from an initial size (6.0-11.0 cm and 4.0-10.0 gm) of stocking in February 1979 the fish grew to a considerable size (30.5-42.5 cm in length and 300.0-715.0 gm) during the 12 month rearing period. The growth of this fish was steady throughout the year with an increase in weight during April to November. The peak growth was achieved in September (485 gm) showing a 105 gm increase from August. The number of Silver carps stocked in the pond was very low with only 40 out of the total stocking of 540. The primary food of phytoplankton and the nutritious supplementary feed for this species were always in abundance (Table-XXXVI). The total number of fish harvested was 31 out of the 40, which accounted for a survival rate of 77.5% with the mortality rate at 22.5%. It may be mentioned that even this mortality was mainly due to the disturbance during a demonstration netting in September 1979 when the pond became too turbid followed by the death, the next day

PLATE - XXIII

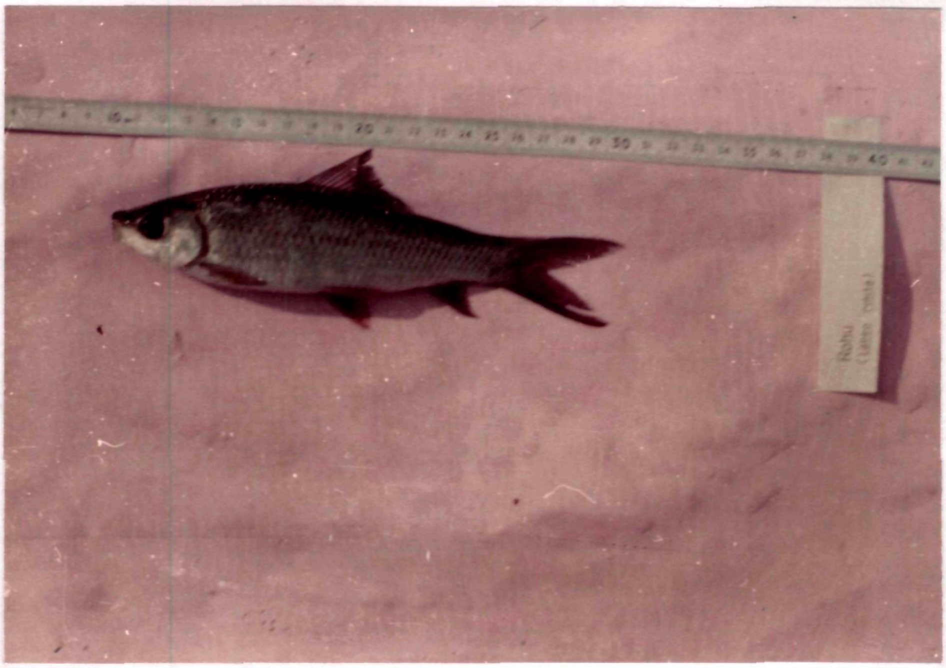
(a) The final size attained by Mrigal, *Cirrhinus mrigala* during one annual cycle.

(b) The final size attained by Rohu, *Labeo rohita* during one annual cycle.

PLATE XXIII



a



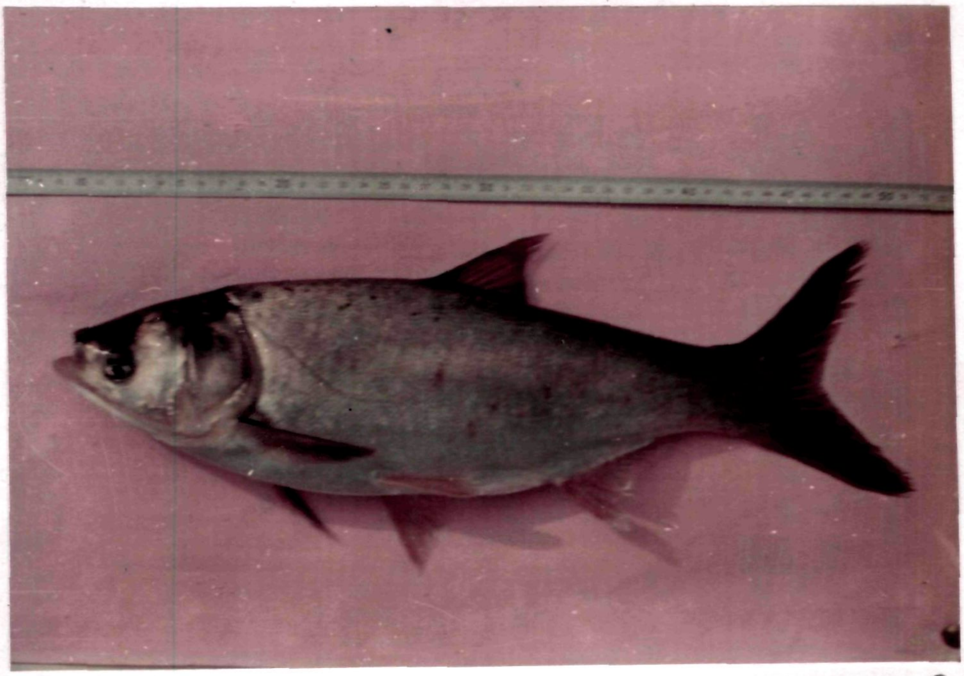
b

PLATE - XXIV

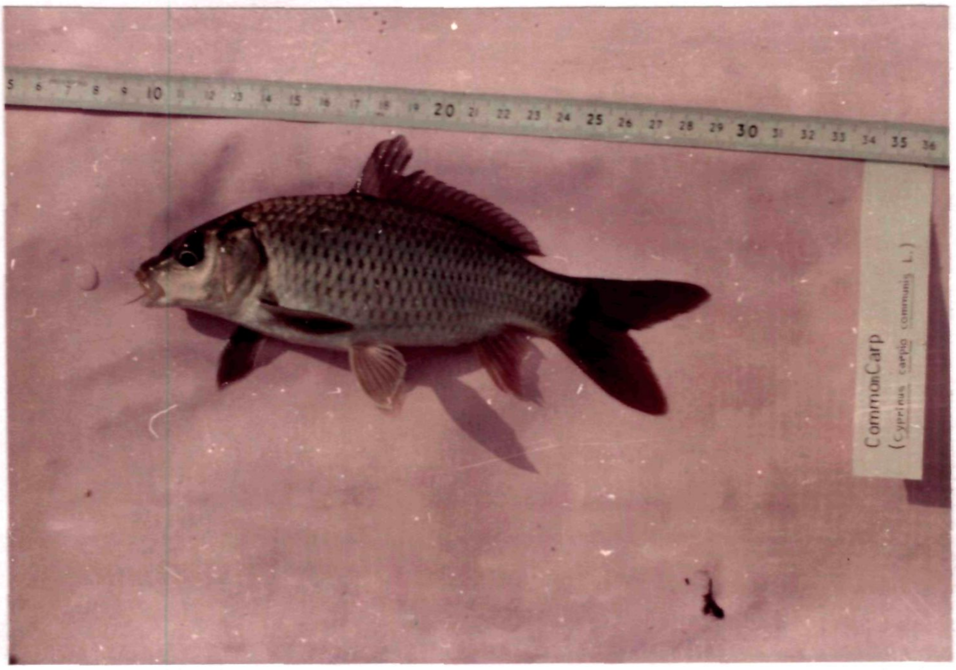
(a) The final size attained by Silver Carp, _Hypophthalmichthys molitrix_ during one annual cycle.

(b) The final size attained by the Common Carp, _Cyprinus carpio communis_ L. during one annual cycle.

PLATE XXIV



a



b

PLATE - XXV

(a) Final weight attained by the Silver Carp, *Hypophthalmichthys molitrix* during one annual cycle at Kyrdem Kulai Fish Farm.

(b) Final weight attained by the Common Carp, *Cyprinus carpio communis* L. during one annual cycle at Kyrdem Kulai Fish Farm.

PLATE XXV

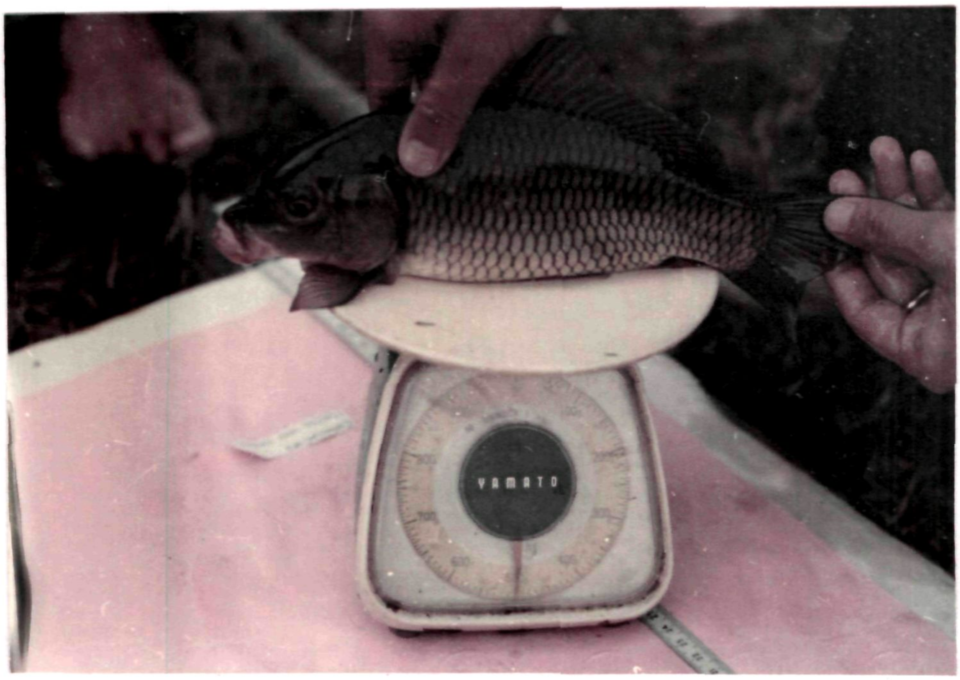


PLATE - XXVI

(a) Showing one haul of fish during the final harvest at the Kyrdom Kulai Fish Farm.

(b) Showing another haul of fish during the final harvest at the Kyrdem Kulai Fish Farm.

PLATE XXVI

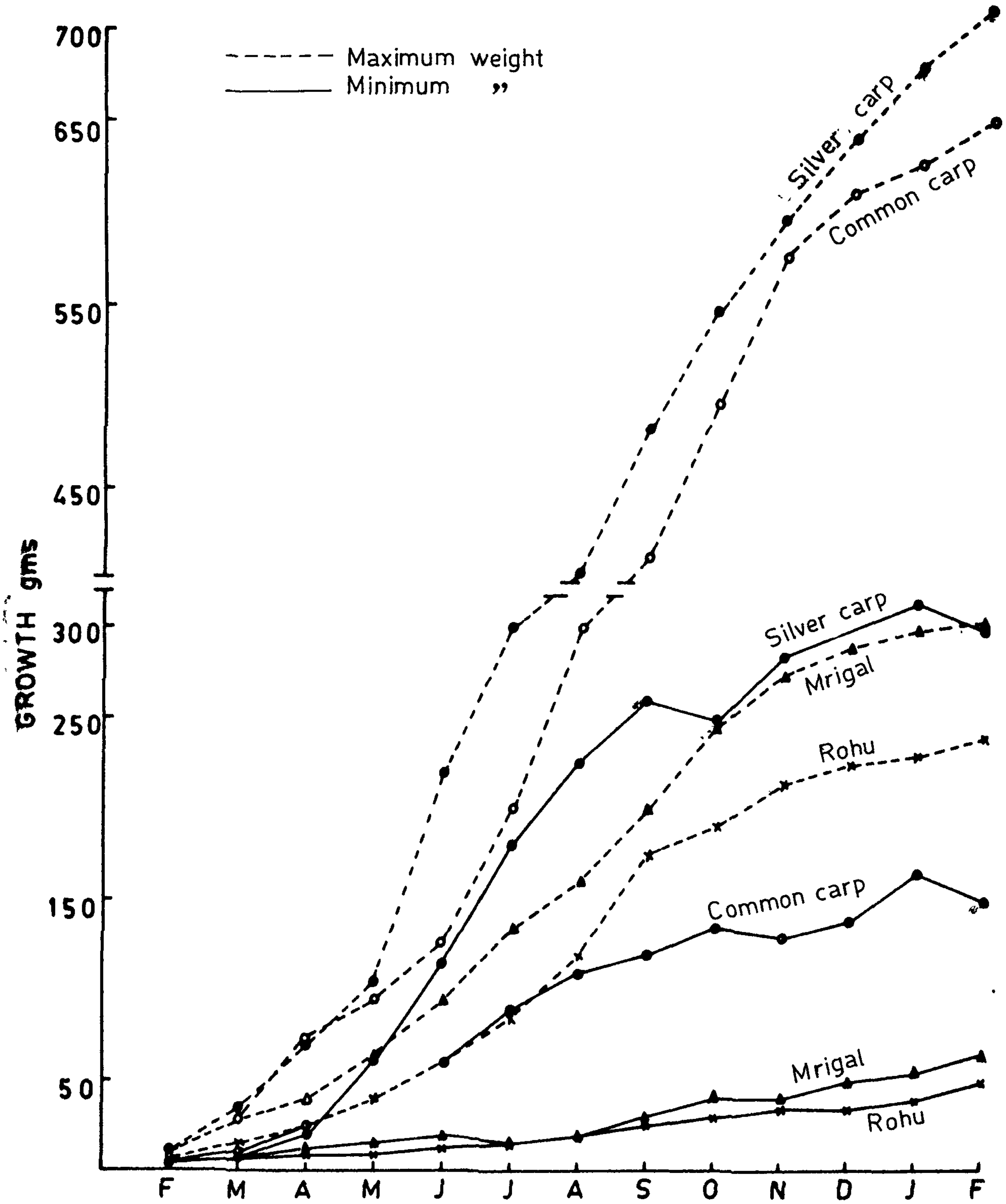
a

b

FIG. 17

Graph showing the growth rate and weight of different species of fishes, Cyprinus carpio communis L., Hypophthalmichthys molitrix (Val.), Labeo rohita (Ham.) and Cirrhinus mrigala (Ham.) in a composite fish culture experiment at Kyrdem Kulai Fish Farm.

FIG. 17



Maximum weight
Minimum ,,
Silver carp
Common carp
Silver carp
Mrigal
Rohu
Common carp
Mrigal
Rohu
GROWTH gms
700
650
550
450
300
250
150
50
F
M
A
M
J
J
A
S
O
N
D
J
F

TABLE XXXVa: Showing the details of the composite fish culture at Kyrdem Kulai Fish Farm during February 1979 to February 1980.

Site	: Kyrdem Kulai Fish Farm, Meghalaya.
Pond area	: 1,000 sq m.
Type of Pond	: Katcha.
Depth	: 0.5 to 1.5 m.
Fish stocked	: Rohu, Mrigal, Silver and Common Carp.
Feed employed	: a) Rice bran and oil cake (1:1 ratio) at 4% body weight at every alternate day. b) Cowdung @ 15,000 kg/ha/yr at weekly intervals.

TABLE XXXVb : Showing the details of the composite fish culture at Kyrdem Kulai Fish Farm during February 1979 to February 1980.

Name	Total Nos. stocked (Feb. 1979)	Initial size range		Total Nos. harvested (Feb. 1980)	Final size range		Survivality		Mortality	
		cm.	gm.		cm.	gm.	Nos.	%	Nos.	%
Rohu	200	7.0 to to 8.5	4.0 to 6.0	127	16.0 to 27.0	50.0 to 240.0	127	63.5	63	36.5
Mrigal	125	8.5 to 9.0	5.0 to 10.0	92	19.0 to 29.0	65.0 to 305.0	92	73.6	33	26.4
Common Carp	175	6.0 to 8.0	5.0 to 10.0	135	19.5 to 37.0	150.0 to 655.0	135	77.1	40	22.9
Silver Carp	40	6.0 to 11.0	4.0 to 10.0	31	30.5 to 42.5	300.0 to 715.0	31	77.5	9	22.5

of six Silver carps that were recovered at the bank of the pond evidently showing symptoms of asphyxia and consequent death.

(ii) Physical factors :

Temperature :-

The temperature recorded in this pond ranged between 12-33°C as seen in Fig. 18. It will be seen that low temperatures were recorded in late December, January, February and early March, when the temperature ranged between 12-22°C. From April onwards till October there was a rise of water temperature between 24-31.5°C with a maximum in September (33°C).

Water level :-

The water level measurements taken during the 12-month period were found to be higher in the month of June, July, August, September and October 1979. From November onwards a gradual decrease was observed till February 1980. Again the low water levels was observed during March and April 1979. The rise in the water level in June to October was due to heavy rainfall during this period, and the low water level especially in February and March was due to the dry and windy season.

(iii) Chemical factors :

pH :-

The pH of the water was always found to be in the acidic range and varied between 6.4-6.9. The different values are indicated in Fig. 18. During the 12 month study the value was steady in February and March 1979 with the pH of 6.8, which tended to drop in April and May with 6.6 and 6.5 respectively. Again in June and July there was a rise to 6.8 and 6.9 with a

FIG. 18

Graph showing the fluctuations of air and water temperature and pH of the composite fish culture pond at Kyrdem Kulai Fish Farm.

FIG. 18

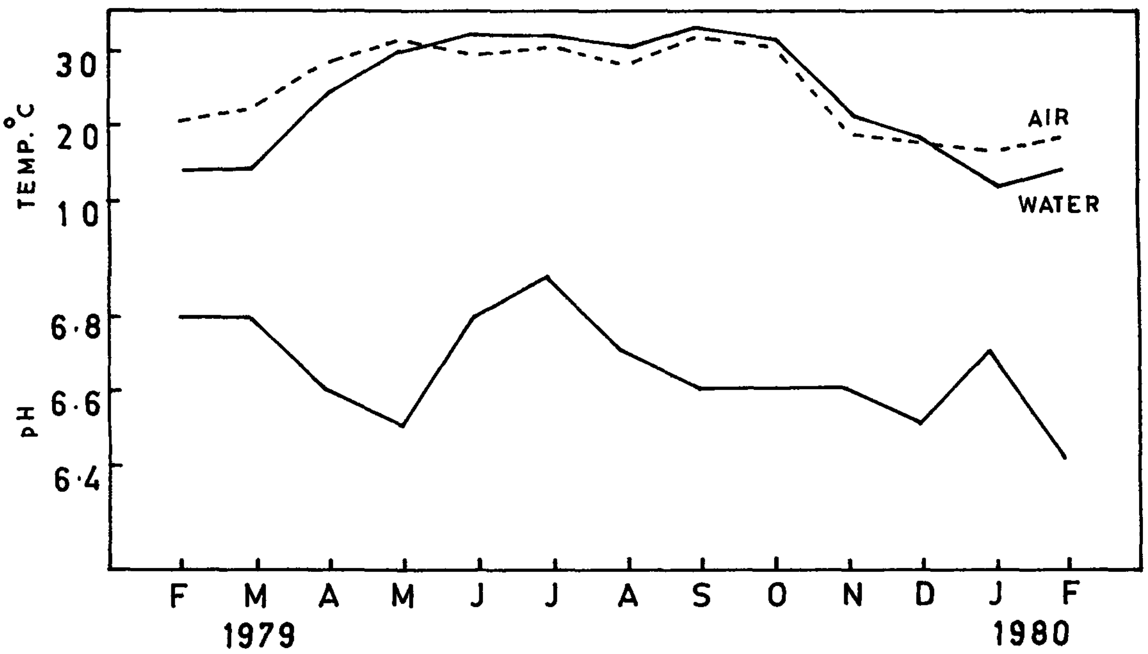
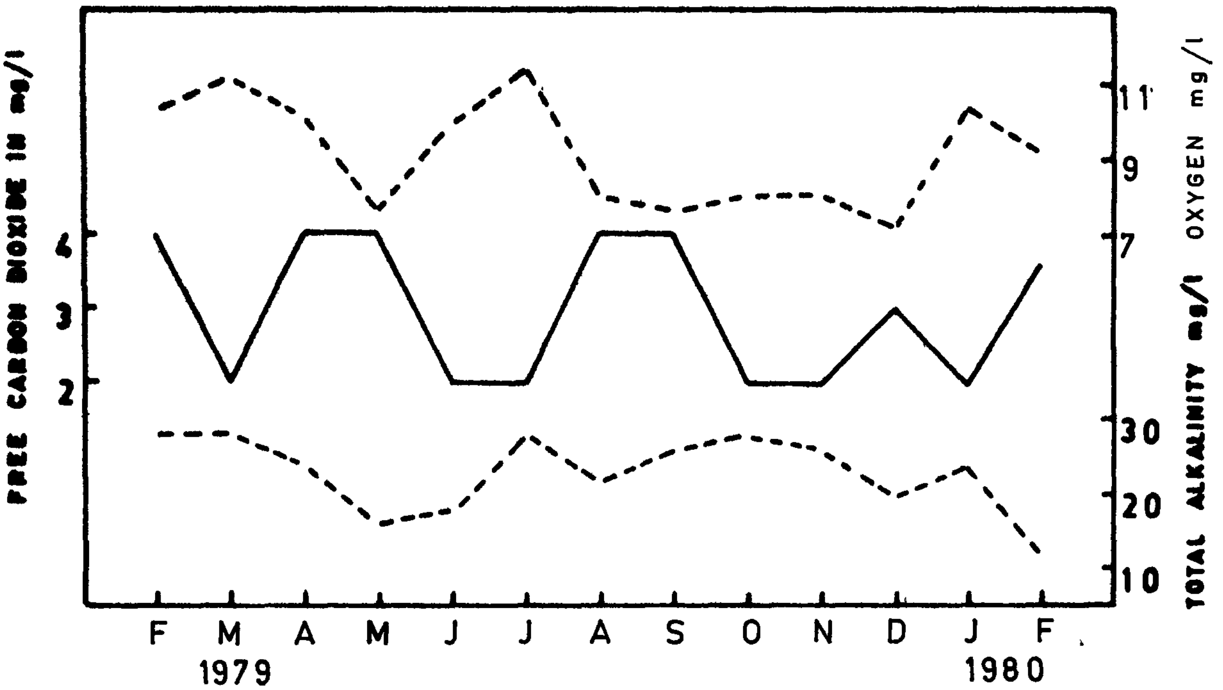


FIG. 19

Graph showing the fluctuations of free carbon-dioxide, O_2 and total alkalinity at the composite fish culture pond at Kyrdem Kulai Fish Farm.

FIG. 19


FREE CARBON DIOXIDE IN mg/l
4
3
2
OXYGEN mg/l
11
9
7
TOTAL ALKALINITY mg/l
30
20
10
F M A M J J A S O N D J F
1979
1980

degree of stability between 6.6-6.7 from August 1979 to January 1980. Finally the pH drops to 6.4 in February 1980.

Dissolved oxygen :-

The amount of dissolved oxygen present showed marked fluctuations during the 12-month study period, the values ranging between 7.2 to 11.2 mg/l as shown in Fig.19.

Free Carbondioxide :-

The values for the free Carbondioxide in this pond estimated to be present during the 12-month period are presented in Fig.19. Throughout this period the free Carbondioxide was present in the medium with less of fluctuations ranging between 2.0-4.0 mg/l.

Total Alkalinity :-

As shown earlier the water was acidic with a pH value always lower than 7.0. The amount of total alkalinity showed very clear seasonal differences as will be seen from Fig.19. Throughout the period of study the amount of total alkalinity was low ranging from 12.0-28.0 mg/l, with the maximum of 28.0 observed in February, March, July and October 1979. The low values recorded in February 1980 was 12.0 mg/l, 16.0 in May, 18.0 in June and 20 mg/l in December.

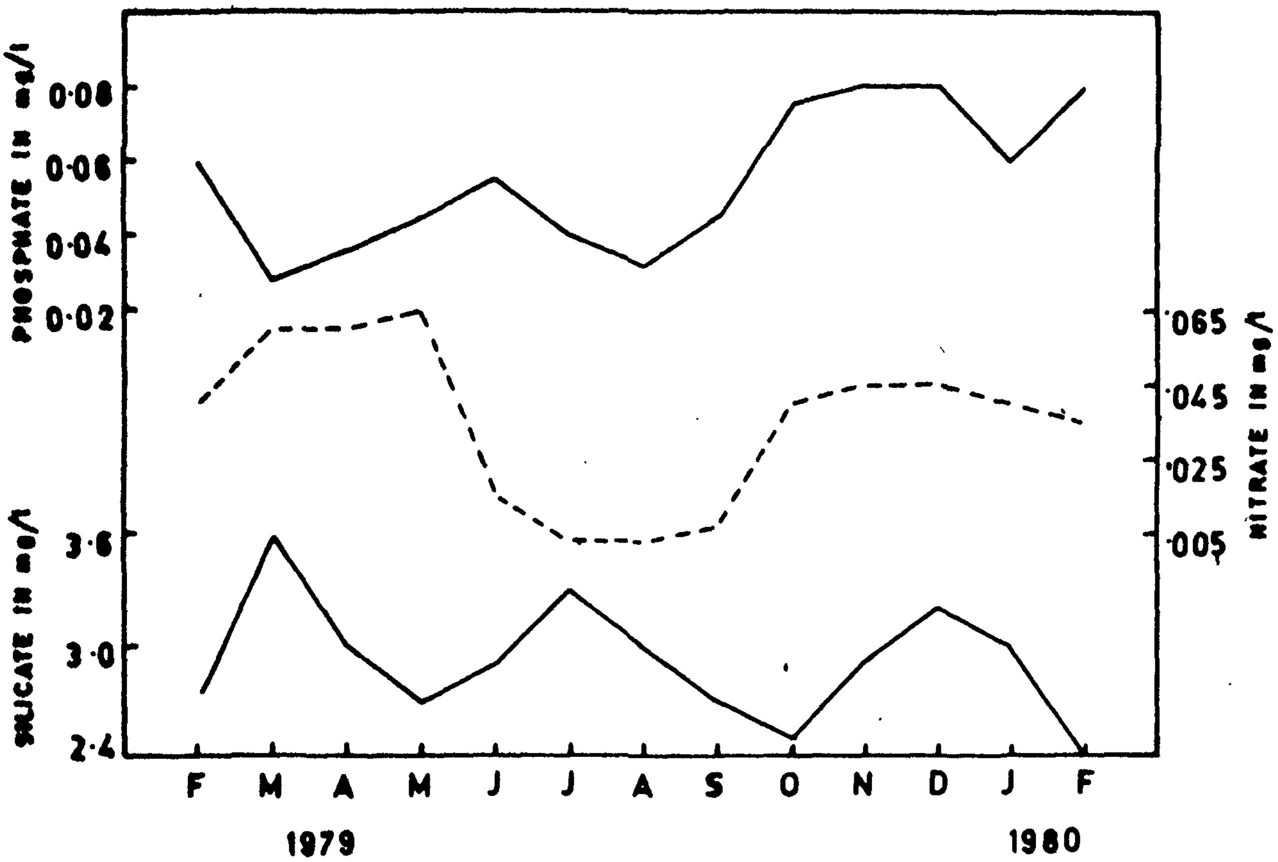
Phosphate :-

The inorganic phosphate content of the pond expressed as PO_4 was shown in Fig. 20. The pond water contained very low amount of this nutrient, the maximum being only 0.08 mg/l while the minimum was 0.028 mg/l. In February 1979, the phosphate recorded was 0.06 mg/l and soon after stocking (March) the value dropped down to a minimum of 0.028 mg/l. Subsequently,

FIG. 20

Graph showing the fluctuations of dissolved phosphate, nitrate and silicate at the composite fish culture pond at Kyrdem Kulai Fish Farm.

FIG. 20



PHOSPHATE IN mg/l
0·08
0·06
0·04
0·02
SILICATE IN mg/l
3·6
3·0
2·4
·065
·045
·025
·005
NITRATE IN mg/l
F M A M J J A S O N D J F
1979
1980

it was noted that there was a steady rise in April, May and June. Again in July and August there was a steady drop whereas from September 1979 to February 1980 an upward trend was noted in the phosphate content from 0.045 to 0.080 mg/l.

Nitrate :-

The nitrate content in this experimental pond was low ranging from a minimum of 0.004 mg/l to a maximum of 0.06 mg/l as shown in Fig. 20. From February to May 1979, there was a steady rise of nitrate content from 0.04-0.065. In June 1979 it dropped to 0.015, when again in July, August and September there was an abrupt drop ranging from 0.004 to 0.006 mg/l. In October 1979 to February 1980 a rise was again noticed with 0.04, 0.045 and 0.035 mg/l.

Silicate :-

The silicate content was high ranging between 2.4-3.6 mg/l as shown in Fig. 20. The fluctuations were not much as there was an increasing trend all throughout, except a slight drop in May 1979 to 2.7 mg/l, in October to 2.5 mg/l and in February 1980 to 2.4 mg/l.

(iv) Biological factors :-

Phytoplankton : (Table-XXXVI and Fig. 21) :-

Euglenophyceae :

The group was represented by two common flagellates, *Euglena* and *Phacus* species. This algae was found to present from February to July 1979 and October to December 1979 till February 1980 and was absent in August and September 1979. The maximum occurrence of this group was seen in the month of January and February 1980, though the number were more in the latter than inthe former, the percentage differences was about 2% increase in the former. In February 1979 though the cell counts were the maximum recorded for the period of investigation being nearly 75-200 cells more than in January and February 1980. Yet these relative abundance in terms of total plankton was very negligible. Similarly, though the minimum count was seen in July, yet the relative percentage of abundance was observed in the month of May.

Chlorophyceae :

The group of organisms represented among the Chlorophyceae are Pediastrum, Anthrodesmus, Staurastrum, Coelastrum, Scenedesmus, Dictyosphaerium, Closterium, Cosmarium, Hormidium, Penium, Pleurotaenium, Spirogyra, Ankistrodesmus. This group ranged from 36.04% to 95.61% of the total plankton throughout the study period. In this group, both the actual counts and their relative percentage did tally at least for the minimum and maximum recorded. The maximum was observed during the months of February with 31,440 cells/litre of 95.61% and the minimum in January with 1,000 cells/litre and 36.04%. A steady rise was noticed in March, April and May which then dropped in June and again rise in July, August and September. From October onwards there was a steady decline in the population till January and again in February 1980, a trend of increase was observed.

Chrysophyceae :

The Chrysophyceae are represented by Dinobryon and Chrysococcus species. This group was found to be present during March to July and from October to February of 1979 and 1980, but absent in February 1979 and in the months of August and September of 1980. The minimum number recorded was seen in the months of June with 15 cells/litre and 0.55%, whereas the maximum relative abundance was observed in January of nearly 16.04%. However, in April the maximum number of cell counts was recorded being more than nearly 500 cells more than January 1980, though the relative abundance was nearly 4% less in the former. A rise in number was noticed from March to April but began to drop from May to July, when it completely disappeared in August and September. From October, a steady rise was observed till it reached a peak in January and a small drop in February 1980.

Bacillariophyceae :

Navicula, *Nitzchia* and *Asterionella* were among the Bacillariophyceae encountered in the collection of the plankton samples. This group was seen to be absent in March and October. From April onwards a steady rise was noticed until a peak was reached in July with 500 cells/litre and a percentage of 14-38% being the maximum. A drop in numbers was noticed in August and September when it completely disappeared in October, to be recorded again in November which continued to show a steady rise till the month of February.

Cyanophyceae :

The group Cyanophyceae were represented by *Anabaena* sp. and *Oscillatoria* sp. This group was the least abundant of all the phytoplankton groups recorded and were found only in the months of May, June, July and August. The maximum relative occurrence was seen in June with a percentage of 3.62%, whereas in the month of May the number of occurrence was with nearly 60 cells/litre more, but the percentage abundance was only 2.27% The minimum number was recorded in the month of August with 15 cells/litre and thereafter completely disappeared throughout the rest of the period of investigation.

Zooplankton :-(Table XXXVI and Fig. 21):-

Protozoa :

The Protozoa encountered in the plankton sample are Diffugia sp, Arcella sp, Paramaecium sp. The maximum number recorded as a group was seen in the month of September, though the maximum relative abundance in percentage was seen in August. The least occurrence was observed in February 1979 with 185 cells/litre and 0.56% relative abundance. From the month of March onwards a rise was observed till it reached the peak in September. Thereafter it fell steadily till February 1980.

Rotifera :

The Rotifera was represented by Keratella and Lecane species. This group was found to be present throughout the period of investigation with the maximum number recorded in the month of April, though the maximum relative percentage was observed in March. From the month of May onwards till February 1980, a trend in the decrease of number though observed was not steady but had significant fluctuations of rise and fall. In February 1979 till April 1979 it was a steady increase.

Cladocera :

Chydorus sp. and Bosmina longirostris were the Cladoceran encountered in the plankton samples. Like Rotifera, the Cladocera also showed the same pattern of differences between the maximum number of abundance and the maximum relative percentage throughout the period of investigation. It was seen that the maximum number was recorded in the month of April with 160 cells/litre followed by November with 150 cells/litre; whereas the maximum relative percentage of abundance was observed in July with 3.75% for only 130 cells/litre. Similarly, the minimum number recorded was 25 cells/litre of 0.67% in February 1980, though the minimum relative percentage was noticed only in February 1979 with 45 cells/litre of 0.14%. From February 1979 till April there was a steady rise in numbers but tended to drop during May and June with again a rise in July and further drop in August. From September till November there was a steady increase in the numbers which fall for the subsequents of investigations.

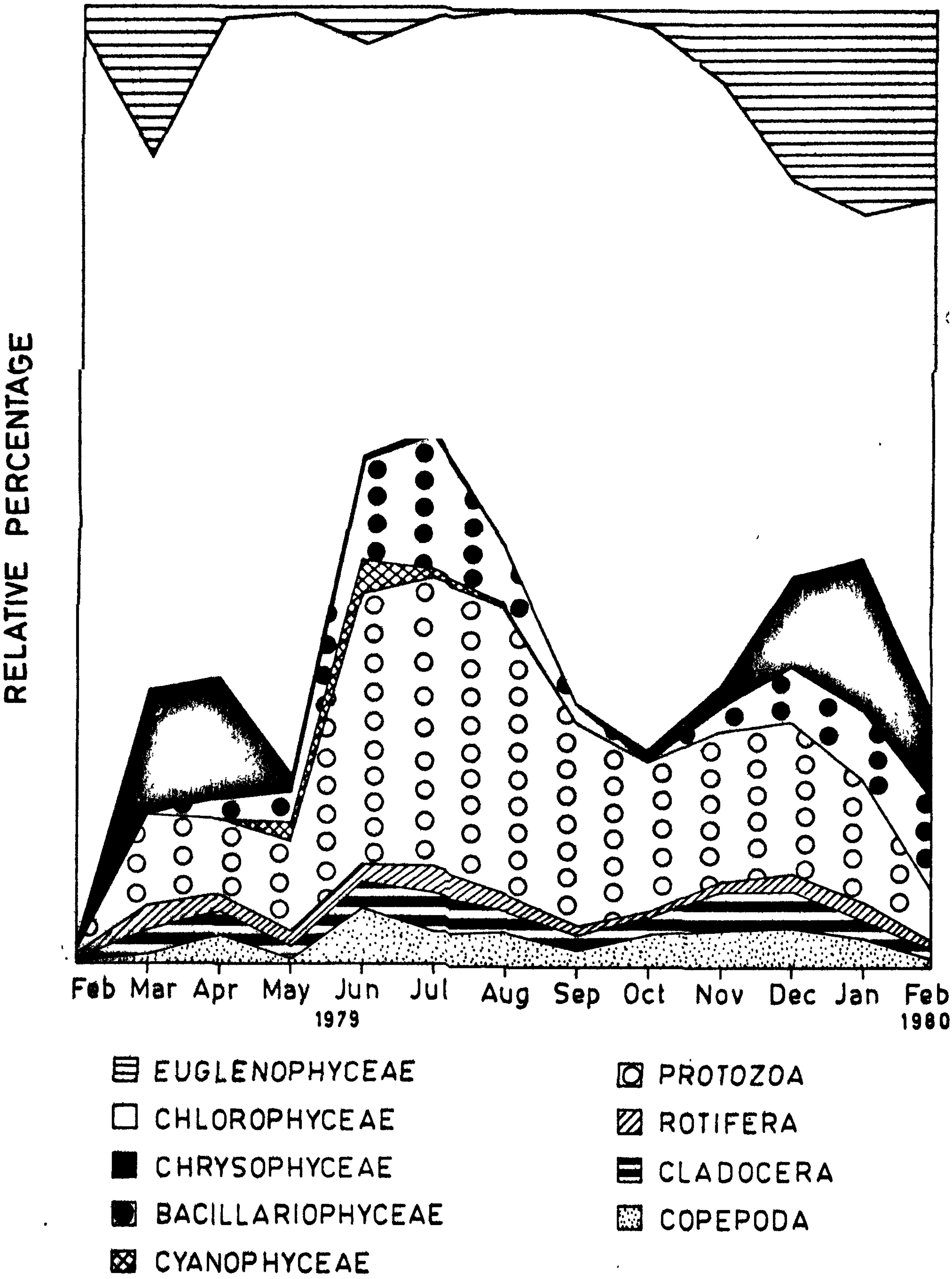
Copepoda :

The Copepods encountered in the plankton samples were the Cyclops, Diaptomus and Nauplius. This group was found to present throughout the period of investigation with the minimum recorded in February 1979 with 12 cells/litre of 0.03% and the maximum number of 240 cells/litre was observed in June with 5.43% for only 150 cells/litre. From the minimum in February 1979, a logrithmic rise in numbers was observed till April which fell drastically in May to again rise significantly in June and a small decrease in July. From August a similar rise was seen till October, which fell thereafter steadily in the remaining months.

FIG. 21

Graph showing the relative percent abundance of different groups of Phytoplankton and Zooplankton in composite fish culture experiment at Kyrdem Kulai Fish Farm.

FIG.21



RELATIVE PERCENTAGE
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
1979
1980
EUGLENOPHYCEAE
CHLOROPHYCEAE
CHRYSOPHYCEAE
BACILLARIOPHYCEAE
CYANOPHYCEAE
PROTOZOA
ROTIFERA
CLADOCERA
COPEPODA

TABLE XXXVI: Showing the groupwise seasonal abundance of different Phytoplankton and Zooplankton in the Composite Fish Culture Experiment at Kyrdem Kulai Fish Farm, Kyrdem Kulai expressed in numbers per litre.

Name of the species	FEB	MAR	APR	MAY	JUN	JUL	AUG
1	2	3	4	5	6	7	8
EUGLENOPHYCEAE	800 2.43%	500 15.87%	100 1.30%	45 0.64%	100 3.62%	30 0.86%	- -
CHLOROPHYCEAE	31440 95.61%	1760 55.87%	5280 69.06%	5600 79.42%	1200 43.48%	1500 43.16%	2200 55.94%
CHRYSOPHYCEAE	- -	400 12.70%	960 12.56%	135 1.92%	15 0.55%	30 0.86%	- -
BACILLARIOPHYCEAE	320 0.97%	- -	160 2.09%	240 3.40%	300 10.87%	500 14.38%	250 6.36%
CYANOPHYCEAE	- -	- -	- -	160 2.27%	100 3.62%	45 1.30%	15 0.38%
PROTOZOA	185 0.56%	300 9.53%	625 8.17%	655 9.30%	780 28.26%	1050 30.22%	1200 30.51%
ROTIFERA	80 0.24%	85 2.69%	120 1.57%	90 1.27%	50 1.81%	80 2.30%	45 1.14%
CLADOCERA	45 0.14%	80 2.54%	160 2.09%	100 1.42%	65 2.35%	130 3.75%	88 2.24%
COPEPODA	12 0.036%	25 0.79%	240 3.14%	26 0.37%	150 5.43%	110 3.16%	135 3.43%

Name of the species	SEP	OCT	NOV	DEC	JAN	FEB
9	10	11	12	13	14	15
EUGLENOPHYCEAE	- -	120 1.87%	400 7.90%	550 17.57%	600 21.62%	725 19.49%
CHLOROPHYCEAE	5100 72.03%	4850 75.43%	3200 63.12%	1300 41.53%	1000 36.04%	2000 53.76%
CHRYSOPHYCEAE	- -	75 1.16%	120 2.36%	300 9.58%	445 16.04%	350 9.41%
BACILLARIOPHYCEAE	140 1.97%	- -	145 2.84%	180 5.75%	200 7.21%	350 9.41%
PROTOZOA	1500 21.18%	1000 15.55%	800 15.80%	500 15.97%	350 12.61%	200 5.38%
ROTIFERA	65 0.92%	35 0.55%	55 1.08%	60 1.92%	45 1.62%	40 1.08%
CLADOCERA	95 1.35%	115 1.79%	150 2.96%	110 3.52%	55 1.98%	25 0.62%
COPEPODA	180 2.55%	235 3.65%	200 3.95%	130 4.15%	80 2.88%	30 0.81%

DISCUSSION

Composite fish culture in India is an age old and popular practice in which one or more of the major Indian Carps and sometime even other indigenous species are reared together in one and the same pond (Alikunhi, 1977; Hora and Pillay, 1962). Traditionally these fish cultural practices were mostly confined to the eastern Indian States of Bengal, Orissa and Bihar. In North Eastern Region of India the conventional method used to be to stock the ponds with locally available species of fish fry without adopting any rational and scientific management and as such the production obtained remained very low, somewhere in a range of 600 kg/ha/yr on an average (Sukumaran, 1978). In China too, the technique is widely practised (Lin, 1954) where the production ranging from 3,863 to 4,815 kg/ha/yr were recorded by a practice of multispecies culture using Silver Carp (Hypophthalmichthys molitrix), Grass Carp (Ctenopharyngodon idella), Black Carp (Mylopharyngodon piceus) and Mud Carp (Cirrhina moliterella). Of late fish culturists throughout the world increasingly recognise the importance of this technique for maximising fish production. The guiding principles for such studies have been proper species selection, species combination, ecological management, stock manipulation, artificial feeding and pond fertilization (Chimits, 1961; Ling, 1961; Rebanal,1968; Swingle, 1968; Yashouv, 1968, 1969).

Introduction of Silver Carp and Grass Carp into India (Alikunhi and Sukumaran, 1964) and the first success in inducing them to breed in captivity (Alikunhi et al 1963) along with the then already established breeding technique on Indian major carps (Chaudhuri and Alikunhi 1957) assured the supply of quality fish seed, which paved the way for multispecies culture and is termed herein as composite fish culture.

In our country experiments conducted from 1961-64 with the surface feeder Catla catla, the column feeder Labeo rohita, the Benthic feeders Cirrhinus mrigala and Cyprinus carpio communis L., predominating phytoplankton feeding Chinese Carp, Hypophthalmichthys molitrix and the macrovegetation feeder Ctenopharyngodon idella in varying combinations and ratios yielded a high production between 1,000-4,900 kg/ha/yr (Alikunhi et al 1971). During 1965-68, by composite fish culture using Indian major Carps and Chinese Carps the above results were confirmed by obtaining a production rate of 2,229-4,210 kg/ha/yr in Cuttack, Orissa State (Lakshmanan et al 1971), whereas by exotic carp alone the production ranged from 2,896-3,281 kg/ha/yr (Singh et al 1972). Subsequently with still better management technique a consistently high production of 9,397 kg/ha/yr was achieved with more than a six species combination at Cuttack substation of CIFRI, India (Chaudhuri et al 1974).

For mixed farming in India, the combination ratio of Catla 4:Rohu 3:Mrigal 3 has been generally accepted as the most advantageous, though empirical. While assuring scientific fish farming practices, Alikunhi (1957), suggested a tentative ratio of 3:3:4 and remarked that the fish farmers could use their discretion in choosing different combinations and densities of fry to experiment upon and gain experience. Both in India and China (Lin, 1954) the widely cultivated carps are known to have more or less distinct feeding habits. However, a combination of fishes from these two countries brings together species which compete to some extent the same type of food. The competition is more pronounced between Mrigal and the Common Carp and between Catla and Silver Carp (Alikunhi and Sukumaran, 1964; Sukumaran _et al_ 1968; Natarajan, 1980). In this context it may be pointed out that the results of the prosent experiment too appear to suggest that the competition between the former two species are rather acute adversely affecting the growth of _C. mrigala_, the lattor of the two species. However, data on the present composite culture suggest that the relative proportions of growth was recorded to be the highest in Silver Carp followed by Common Carp, then Mrigal and lastly Rohu in that order of magnitude. The interspecific competition among the four species was met to a great extent by supplementary feeding and manuring with cowdung.

The fairly high percentage of survival obtained in all species except Rohu, seems to suggest that survival was independent of stocking densities adopted in the present study. Further, it also reflects the favourable physicochemical mileu of the pond for fish growth. Apart from these, the main and perhaps the only factor governing survival of properly transplanted and healthy seeds is freedom from predation as stressed by Soong and Mingkong (1951). Such was also the case as confirmed in the present experiment by a very high survival percentage of 77.5% in Silver carp, 77.1% in Common carp, 73.6% in Mrigal and 63.5% in Rohu, originally stocked as early sized fingerlings which grew in the absence or predators and under favourable ecological conditions. However, even the mortality reported in the results was unusual, caused by disturbance in the system by intensive netting for demonstration in September 1979 when the water become too muddy and turbid. As a result several fishes were found dead the next day (21 Rohu, 11 Mrigal, 18 Common carp and 6 Silver carp), clearly showing symptoms of Asphyxia and consequent death. The turbidity due to silt and mud are considered to be harmful and usually cause death of both fish and fish food organisms (Hora and Pillay, 1962). The depth of water in the fish pond is most important since the penetration of light to the bottom contributes in a large measure to the productivity of the system. In temperate regions it had been shown that a water level below 3-4 m and in tropical regions below 1.5-2.0 m favours maximum light ponetration and influence biological productivity. In Indonesia, Carp ponds with a maximum depth of 0.3 m is considered suitablo for healthy growth. In general, fish ponds should not be too shallow as extremely high temperature could also adversely affect productivity and may lead to loss of fish. During the present study the water levels at the experimental pond in the month of February, March and early April were fairly low upto a mean depth of 0.75 m. While it is not possible to exactly correlate this factor to growth of fish, probably the slow growth rate of Rohu and Mrigal in this pond could be related to this low water level among other influencing factors. Further, this low level with virtually no extended water column might have limited the foraging propensities of Rohu which is a well known column feeder.

It is a well known fact that the temperature of the water influences the metabolic processes of the various organisms living therein. Most activities of living organisms particularly the poikilotherms like fish slow down the drop in temperature. Even eurythermal species of fish like the carps stop feeding at about 10°C and become torpid at about 5°C (Hickling,1971). During the present experiment the temperature of the pond water ranged between 12.8-33.0°C but in January, February and March a fairly low temperature range of 12-14°C prevailed. During this period increment of Rohu and Mrigal was recorded to be very low and increase in length and weight was almost nil. That the temperature range affect the rate of growth of indigenous carp had already been confirmed by Alikunhi (1966) and Jhingran (1974), where it was reported that Indian major carps thrive well in temperature ranging from 18-37.8°C, while temperature below 16° and above 40° are limiting to their growth. On the other hand, fingerlings of Silver carp and Common carp exhibited satisfactory growth even during these colder months as these species are known to have a wide range of temperature tolerance between 14-40°C.

Of the various chemical factors governing fish life in aquatic ecosystems, the dissolved oxygen is of primary importance as all fishes as well as their food organisms depend on an optimal level of this gas in the medium for normal respiratory metabolism. Oxygen content of less than 3.5 mg/l is estimated to be lethal to Common carp in European waters and values below 5 mg/l are known to be critical for other carps and salmonids in summer (Hora and Pillay, 1962). During the present investigations dissolved oxygen content always remained high at the experimental pond and ranged between 7.2-11.2 mg/l and hence could not have been a limiting factor in adversely affecting the metabolism of the fish and other fauna. It may however be said that the measurement of dissolved oxygen content proved to be an useful parameter with regard to the pond fitness for fish culture.

It is now a common knowledge that in most of the routine limnological studies the hydrogen ion concentration is often used as an index of the prevailing water conditions and thus a pH above 7.0 shows an alkaline reaction whereas values below which indicate an acidic medium. The pH of water has also been used as an indicator of the fertility or potential productivity. Swingle (1957) considers that most productive waters in terms of fish growth are those with a pH ranging from 6.5-9.0 whereas values below 4 and above 11 are critical for fish life. At Kyrdem Kulai fish farm in the present study even after treatment by the addition of lime at the rate of 1,000 kg/ha, the pH value still remained in the acidic range between 6.4-6.8. Thus from a fishery point of view the pH could be considered suboptimal for the growth of fish as also reported by Alikunhi (1957) that waters on acid soil are generally less productive than that on an alkaline soil, although the exact influence of pH on the fish growth is not clear.

Water receives free carbon-dioxide mostly from the decomposition of organic matter in varying quantities, from the atmosphere, or as a result of respiration of aquatic animals and plants. Hora and Pillay (1962) suggested that normally a value of 5 mg/l of carbon-dioxide proved lethal to fish life. Besides preventing the oxygenation of water it might also adversely affect the extraction of dissolved oxygen from the water. Similarly a high concentration of carbon-dioxide has also been observed to increase losses of fry and produce a number of deformed specimens in salmonids. However, the 12 month results presented for carbon-dioxide of the present pond show that the range of variation never exceeded 2.0-4.0 mg/l, thereby showing that as far as this environmental factor is concerned the pond habitat was quite satisfactory for normal fish life.

The measurement of total alkalinity, originally used by Schaperclaus (1933) as a measure of productivity and productive waters is that which titrate 2 ml to 5 ml of 1N HCL/l or 200-500 ppm equivalent of $CaCO_3$. Alikunhi (1957) stated that in highly productive wators alkalinity ought to be over 100 ppm. For the pond under study the alkalinity levels never went high and ranged between 12.0-28.0 mg/l which from a fishery point of view is certainly low and could have much limited their growth although its effects could have been indirect by slowing down the growth of fish food organisms. In this context it is pointed out by Swingle (1967) that where soils located in areas of moderate to heavy rainfall and where modern practice of liming and fertilization are not adopted, such ponds fall within the total alkalinity value equivalent to 10-50 ppm of

$CaCo_3$. However, a range of 4 to over 1,000 ppm has been encountered in natural bodies of Indian waters (Ramachandran, Unpublished).

Nitrogen forms one of the basic attempts contributing to fertility of ponds. It is well known that ponds derive the major supply of nitrogen through the biodegradation cycle and this element is of extreme importance in the maintenance and nutrient economy resulting in a balanced aquatic life. It has been reported earlier that the best production of plankton is obtained when the water contains 4 ppm of nitrogen with 1 ppm of phosphorous and 1 ppm of potassium (Hora and Pillay, 1962). As shown in the present results this nutrient was at very low levels in the experimental pond which probably affected the growth of fish, though the effects could have been largely indirect by lessening the production of plankton in the system.

Unlike nitrogen and carbondioxide the phosphorus source to an aquatic system is not usually from the atmosphere but are released from death of organisms and through bacterial mineralization which in turn helps the growth of phyto- and zoo- biota in the water. A concentration of 1 ppm of phosphorus is found to be the optimum for good growth of plankton and fish ponds having more than 0.2 ppm of phosphate are likely to be quite productive (Jhingran, 1975 and 1977). The low content recorded in the present experimental pond almost throughout the year is likely to have limited the bloom of plankton which form the primary source of fish food and thereby restricting the growth of fish to a good extent.

Among the various species used in the present composite culture experiments fingerlings of Labeo rohita indicated a consistently low survival and slow growth rate. On the other hand the growth of Silver carp in the present experiment was on a steady increase throughout the period of study thereby reflecting the favourable nature of the habitat. The net annual increase in weight of this species reported from China ranges from 560-2,000 gm (Lin, 1954) at a stocking ratu of 250-400/ha as compared to 300-715 gm recorded in the present experiment. Further, Hickling (1962) states that the growth of this species in two Chinese ponds is 337-422 gm under high population density of 3,700 and 3,000/ha respectively. Again in the plains of India at warmer latitudes, Sukumaran et al (1969) studied the relative growth rate of Silver cap in combination with Catla and other indigenous and exotic carps in ponds not subject to fertilization or feed. They found an average growth rate of 466 in six months (range 239-548 gm) when reared in combination with Catla, Rohu and Common carp, 326 gm in 6 months (range 153-677 gm) in combination with Catla and Grass carp and 422 gm in 6 months (range 199-987 gm) in combination with only Catla. Similarly in another set of experiments the fish registered a net growth of 393 gm in 5 months, 2,100 gm in 17.5 months, 4,400 gm in 28 months (Natarajan et al 1978).

The growth indicated by Labeo rohita in India under stocking densities of 3,750 and 3,335/ha is 680 gm/yr as was also recorded for Pakistan under a stocking density of 178-1,332/ha (Rabanal, 1968). But the present stocking rate of 2,000/ha was much lower when compared with that of the Indian records though comparable to that of the rate of stocking in Pakistan waters. Nevertheless the growth achieved for Rohu in this system was indeed very low with only a mean weight of 190 gm/yr from the fingerling stage. It appears therefore that while the differences in stocking density do not seem to affect the growth rate, yet factors such as temperature, depth of water, pH and available nutrients certainly limit the growth of this species.

From the present studies more or less similar results were also obtained for Cirrhinus mrigala, though the recorded growth rate from the present experiments ranged between 65-305 gm with a mean value of 275 gm/yr. Although this is an improvement over that of Rohu, yet not optimal in comparison to the growth rate of 454 gm/yr (Alikunhi, 1957) and 681 gm/yr (Ganapati and Chacko 1950) as obtained at a lower altitude in the plains of India with warmer water temperature and an alkaline pH.

Jhingran (1968) and Alikunhi (1966) have summarised available information on the growth of Common carp from different parts of the world. The weight as obtained by this fish during the first year has also been reported by Alikunhi (1966) to be 38 gm and 375 gm in Japan, 300 gm in China, 400 gm in Malaysia, Thailand & Indonesia and 600-800 gm in USSR, 35-50 gm in Europe, 15 gm in England and 600-1,800 gm in India. Hora and Pillay (1962) reported the rate of growth to be as 1,000 gm in India and 350-400 gm in China. In the present experiment, the growth rate obtained was 150-655 gm with a low mortality rate of 22.9%

which compares favourably with the rest of the findings on this species, in spite of the prevailing low temperature, acidic nature of the water and the low nutrient content of the present study area.

As in the case of Fish Dale farm, Shillong, the seasonal fluctuation of the planktonic organism could be broadly divided into Phytoplankton and Zooplankton.

However, unlike the Fish Dale, though all the five groups of Phytoplankton were also present, in this system (Kyrdem Kulai fish farm), the dominant group was Chlorophyceae. Further Chlorophyceae had two peaks of abundance in contrast to the remaining four groups of Phytoplankton obtained in the present system which had only one peak. The interesting observation as can be seen from Figs. 21, is that the two peaks of abundance in Chlorophyceae was inversely related to the remaining four groups. The groups Euglenophyceae and Chrysophyceae had their peaks during winter as revealed by their presence of a peak during March and a trend toward a peak again in next March, as they started increasing in their relative abundance from November onwards. The two groups Bacillariophyceae and Cyanophyceae had only the summer peak, while Chlorophyceae predominated during spring and autumn.

As in the case of Fish Dale, so also in this system the group Protozoa among Zooplankton dominated over the other group, throughout the study period. However, unlike Fish Dale farm, this dominant group Protozoa revealed only one peak of relative abundance in mid summer, which was also observed for Copepoda, though much less in their relative abundance. The other group follows more or less a similar pattern as in Fish Dale.

If a relationship thus exists while comparing the Phytoplankton with that of the nutrients it is seen that there is a near to positive relationship between Chlorophyceae and Phosphate and Nitrate. In the other groups of Phytoplankton, though intricate relationship might have existed between the nutrients and the remaining four groups it does not get expressed in the seasonal fluctuating trend brought into monthly phenomena. One clear emerging fact remains that Chlorophyceae dominated in this system bringing down the levels of Chrysophyceae and Cyanophyceae, proving thereby as mentioned earlier that their latter utilization by planktonic feeders with Phosphate levels below 0.3 mg/l could have had some relationship if any. This is confirmed from the fact that this Kyrdem Kulai fish farm had a composite fish culture of carps in contrast to the Fish Dale farm where only monoculture of carps was done.

Among the gases it was seen that Chlorophyceae was positively and directly related to only free Carbondioxide levels. It is known that the stage of succession from blue-green to green is a phenomenon attributed to the direct increase of the Carbondioxide levels Shapiro (1973). All other relationships probably could have been similar to what have been discussed for the Fish Dale farm.

While observing the relationship between the physicochemical parameters with that of the Zooplankton fluctuation, an exact relationship for Fish Dale as Protozoa was seen here too, in that Nitrate and Phosphate were inversely related. Similarly no definite relationship was observed for the remaining groups. The reason for Protozoa abundant as mentioned earlier could be due to concentration of oxidisable organic matter in high levels (Munawar, 1970). This is corroborated by the fact that Protozoa and the Oxygen in this system is directly related.

When the growth of fish was compared with Phytoplankton and Zooplankton levels it is seen that Euglenophyceae did show a direct relationship with most of the group in the sense that with their increase in relative percent of abundance, simultaneously a take off in the growth rate of fishes was observed. Further the Silver carp had a trend seemingly affecting the trends of Chlorophyceae. These facts are in concordance with earlier reports not only but also to the fact that they are Phytoplankton feeders. There was really no emerging relationship among the Zooplankton and the growth rate of fishes. However, there does exist a relationship in the sense that except for the Protozoa all other groups of Zooplankton were much less than 10% indicating their prevention of abundance by predation of Zooplankton feeders in such a composite fish culture system.

SUMMARY

SUMMARY

The present investigations were focussed on the various breeding and culture aspects of the Common carp, Cyprinus carpio communis L. and the Indian major Carp, Labeo rohita during the years of 1977, 1978 and 1979 was carried out at different altitudinal situations in Meghalaya State. These experiments included breeding, suitability of different egg collectors, rearing of spawn to fry, fry to fingerlings and fingerlings to table size fish along with an year round experiment on composite fish culture.

During the breeding experiments conducted in 1977, the total number of eggs were estimated to be 45,000 of which 80% were fertilized, amounting to 36,000 fertilized eggs. The ambient temperature during this period was 20°C. The total number of hatchlings and spawns harvested were 22,400, indicative of a hatching rate of 62.2%.

Two sets of breeding experiments were again conducted in 1978. The first of these showed that the fish spawned at 18.5°C and gave an estimated total number of 31,747 eggs. The percentage of fertilization was 55% with the fertilized eggs to total about 17,460. The final number of hatchlings and spawn procured were 13,160 working out to a hatching rate of 64.2%. In the second experiment only a small sized brooder was used, with the percentage fertilization amounting to 75% with 16,875 numbers of fertilized eggs. The total number of spawn harvested, however was 9,055 indicating a 53.7% hatching rate.

In 1979, three sets of breeding experiments were conducted in breeding hapa and Plastic Pools, using different substrates for egg collection, viz., the aquatic weed (Rotalla), Coconut fibre raft, Wooden frame with nylon flap and Aluminium wire frame nylon net.

In the first experiment in hapa, breeding took place at the temperature range of 19 to 20°C. The percentage of fertilization was 85% with the eggs measuring 1.2-1.8 mm and 0.0018 gm in weight forming 555 number of eggs/gm and an estimated total of 27,500 eggs. The fertilized eggs amounted to 23,375. The total spawn collected were 17,875 indicating 76.4% hatching rate.

The most efficient of the egg collectors, proved to be the Coconut fibre raft with the maximum attachment rate of 50% compared to Rotalla (25%), Wooden frame nylon flap (15%) and Aluminium wire frame nylon net with 10%. This implies that the Coconut fibre raft was five times more efficient than the Aluminium wire frame nylon net, 3.5 times than the Wooden frame nylon flap and twice efficient than the aquatic weed. The percentage attachment of fertilized egg ranged between 85% in Coconut fibre raft, 90% in Wooden frame nylon flap, 95% in Aluminium wire frame nylon net and 75% in Rotalla.

The second set of experiments during 1979 conducted in the hapa, with the same four types of egg collectors showed that the fish spawned at the temperature ranged of 19-20°C. The total number of eggs released with a 80 gm loss in weight of the brooder was 36,400. With a 70% fertilization, the total number of fertilized eggs was estimated to be 25,480. The final number of hatchlings and spawn harvested were 15,380 working out at a hatchling rate of 61.9%. In this experiment too the

Coconut fibre raft showed the maximum percentage of egg attachment with 55%, followed by Rotalla 20%, Wooden frame nylon flap 20% and Aluminium wire frame nylon net 5% in that order. The percentage of fertilized eggs attached to the different egg collectors were 93% in Coconut fibre raft, 92% in Wooden frame nylon flap, 96% in Aluminium wire frame nylon net and 70% in Rotalla.

The third series of breeding experiments during 1979 were conducted in a Plastic pool when the fish bred at the temperature range of 18.5-19.0°C. The percentage of fertilization was 75% with the egg size ranging between 1.4-2.0 mm of 0.0024 gm in weight amounting to 415 eggs/gm. The estimated total number of eggs spawned were 46,650 of which only 34,235 fertilized. Thus the total number of spawn produced was 28,010 with the hatching rate of 81.8%. The attachment of eggs in Coconut fibre raft was 60% with 90% fertilized eggs, in the aquatic weed Rotalla 20% of attachment with 75% fertilization, in the Wooden frame with an attachment capacity of 15% with the fertilized eggs forming 95% and in the Aluminium wire frame nylon net attachment value being 5% having 98% fertilized eggs. The Coconut fibre raft thus showed the maximum efficiency with 12 times more than that of the Aluminium wire frame nylon net, 4 times of the wooden frame nylon flap and 3 fold increase as compared to the aquatic weed Rotalla rotundifolia.

Based on the experiments conducted during the 3-year period, the percentage of hatching in the different years were

62.2% in 1977, 64.2% and 53.7% in 1978 for the two experiments and 76.4%, 61.9% and 81.8% in 1979. It has boen shown that the loss of most of the fertilized eggs and their hatchability were due to a fungal infection caused by Saprolegnia which were seen to bloom in the rotting weed even from the very first day of egg incubation and spreads to the unfertilizod eggs specially at low temperatures. However, in 1978 in addition to the fungal infection the low hatching was also attributed to rain and hailstorm and the prevailing cold temperature (14.5 to 19.5°C) during incubation.

In the three sets of experiments in 1979, the first showed a hatching rate of 76.4% with low fungal infection which was restricted mostly to the aquatic weed. In the second series, Saprolegnia spread among the unfertilized eggs attached to Rotalla as well as to the Coconut fibre raft, although no infection occurred in the other two collectors, with an overall hatching of 61.9%. The third experiment in Plastic pools yielded a percentage hatching of 81.8% with all the difforent types of egg collectors practically free of any fungal infections.

The rearing experiments on Common carp were also carried out for the three year period (1977-79) in various combinations of habitats and feeding regimes. Further, these experiments relate to the rearing of the spawn to fry, fry to fingerlings and fingerlings to table size.

These rearing experiments with spawn normally extended for a duration of 60 to 90 days, with daily observations. The first experiment in 1977 conducted in a pucca nursery pond with 8,000 spawn (4.0-6.0 mm and 5.0-8.0 mg in weight), showed that these grew to fry stage of 20.0-50.0 mm length and 3,000-8,000 mg in weight with a final harvest of 5,805 frys indicating a 72.5% survival rate, with the mortality percentage of 27.5%. During the second experiment in 1977 with 15,000 spawn the growth attained was 60.0 to 90.0 mm and 8,000 to 15,000 mg in weight. The total number of fry harvested was 9,124 giving a 60% survival with a mortality rate of 40%.

The first experiment in 1978 with 10,000 spawn showed that they grew upto 40.0 to 80.0 mm in length and 5,000 to 15,000 mg in weight with a final number of 7,659 harvested with a survival rate of 76.5%. The rate of mortality worked out to 23.5%. In the second experiment of the same year for a duration of 75 days the growth obtained was from 60 to 100 mm in length and 7,500 to 18,000 mg in weight. The total number of fry harvested were 4,460 with a survival of 55.7%. The mortality rate was 44.3% with an estimated fry loss of 3,540 numbers.

One another series of spawn rearing experiments in 1978-79 were in a nylon hapa placed within in a well managed nursery pond with adequate feeding. Of these four experiments, the first two lasted for 75 days and the other two for 60 days. 1,000 spawn were used in each of the experiments, the spawn size ranging between 8.0 to 10.0 mm and 10.0 to 12.0 mg in weight. The first two experiments showed that the spawn grew to a size range of 40.0 to 80.0 mm and 3,500 to 8,000 mg in length and weight with a final harvest of 724 to 752 numbers of fry indicating 73.8% survival with a mortality of 26.2%. In the other two experiments of 60 days duration the spawn grew to the fry size of 30 to 70 mm and 2,500 to 6,000 mg. The total number harvested ranged between 813 to 856 with the mean survival of 83.4% and 16.6% mortality.

For purposes of replication, four sets of rearing experiments were again conducted during 1979. Of these, the first two lasted for 75 days with the final size ranging from 30 to 70 mm and 3,000 to 6,500 mg. The total number of fry harvested ranged between 847 to 891 amounting to 86.9% survival and 13.1% of mortality. The other two experiments extended for 60 days when the spawn grew to fry stage of 45 to 75 mm and 4,000 to 9,000 mg. The final number of fry harvested varied from 855 to 873 with a survival rate of 86.4%. The mortality worked out to a mean of 13.6%.

In yet another series of rearing experiments aimed at the comparative efficiencies of the fry habitat, the Common carp spawn were reared in Plastic pools during 1978 and 1979. The source of water in the Plastic pools was from a pond originally manured prior to these experiments, in addition to supplementary feed that was provided. The two rearing experiments in 1978 with 500 spawns lasted for 60 days. The spawn grew to fry stage of 35 to 60 mm in length and 3,000 to 7,000 mg in weight. The final number which survived ranged from 302 to 358 indicating an average gain of 66% with a mortality rate of 34%. During tho two experiments in 1979 with the same number of 500 spawn reared for 60 days, the growth attainment ranged from 40 to 65 mm and 3,500 to 6,000 mg. The total number of fry taken out were between 393 to 417 in the two experiments giving a mean survival of 81% and the mortality being 19%.

The experiments on the rearing of fry to fingerling stages of the Common carp were conducted in the Plastic pools of varying sizes for a period of six months and by using different feed combinations. The experiments were carried out in the premises of the University campus and most of the factors were kept under control in these Plastic pools.

In Pool 1, stocked with 100 fry and fed with rice bran, mustard oil cake and cowdung showed the highest growth from an initial of 0.5-1.0 gm to a maximum weight range of 35.0-51.0 gm. The total number of fingerlings finally harvested were 84 accounting for a survival rate of 84% with a mortality of 16%.

In Pool 2, with feed combinations of only rice bran and mustard oil cake, the 75 fry stocked therein grew to 22.0 to 35.0 gm with an average monthly growth rate of 4.85 gm. The final number of fingerlings collected from this experiment was 66 accounting for a survival of 88%. The loss due to mortality was estimated at 12%.

In Pool 3, the 25 fry stocked, grew to 18.0-26.5 gm with an average monthly growth rate of 3.5 gm. The feed comprised only of rice bran. 20 fingerlings were finally harvested resulting in 80% survival with a mortality rate of 20%.

In Pool 4, where 25 fry were stocked, these grew to sizes ranging between 25.0-38.0 gm with the average growth rate of 5.3 gm per month. 18 fingerlings were harvested ultimately amounting to a survival rate of 72% with a mortality of 28%. The feed in this pool comprised of mustard oil cake only.

The Control Pool 5, with 55 fry showed the least growth reaching a maximum of only 9.0-12.0 gm with an average monthly growth rate of 1.59 gm. At the close of this experiment, only 12 numbers of the fingerlings remained alive. The rate of survival was 22% with the highest mortality rate of 78%.

The water temperature recorded in the Pools under study revealed the overall range of 10-21°C in all of them, showing the maximum values during September and October (20-21°C) with a decreasing trend from November to February (18-10°C). The pH of water remained in the alkaline range between 7.0-8.6 in Pool 1, 7.0-9.2 in Pool 2, 7.0-8.3 in Pool 3, 7.0-8.8 in Pool 4 and 6.6-10.1 in Pool 5. The conductivity values of the five Plastic pools ranged between 58.80-63.00, 78.75-98.70, 105.00-168.50, 115.00-168.50 and 42.00-52.50 µmhos/cm respectively. The amount of dissolved oxygen showed marked fluctuations with the content ranging between 8.0-12.4, 6.4-11.6, 4.0-11.6, 4.0-10.8 and 2.0-12.8 mg/l in the five pools.

The third and final phase of the present series of experiments on the Common carp was the rearing of fingerlings to table size as conducted in a pucca nursery pond at an altitude of 1,550 m at the Fish Dale farm, Shillong for one year during

1977-1978. The size range of fingerlings used were between 6.0-16.0 cm and 5.0-50.0 gm. As a result of this experiment the mean weight attained by these fingerlings was between 65-585 gm, with the individual maximum of 585 gm. Based on this rate of growth the total production worked out to 4,240 kg/ha/yr. The monthly record maintained on growth increment showed that most fish attained their maximum growth during the first five months of the rearing. This period extended from November to April which included the months with rising temperature soon after winter. An interesting sidelight of this experiment is the attainment of sexual maturity and subsequent spawning of a few of the larger females as clearly evidenced by the presence of newly recruited fry of 3.0-3.5 cm long and 0.6-1,0 gm in weight in the population. The significance of this had been discussed.

The physical and chemical factors studied for the entire rearing period showed that the temperature ranged between 10-24.50C, pH 6.3-6.9, conductivity 33.60-66.15 umhos/cm, dissolved oxygon between 8.4-14.0 mg/l, free carbondioxide 2.0-6.0 mg/l, total alkalinity 20.0-44.0 mg/l, phosphate 0.01-0.14 mg/l, nitrate 0.01-0.07 mg/l and the silicate contents from 0.02-0.12 mg/l.

Experiments on the predatory propensities of dragonfly nymphs (Aeshna sp and Cordulia sp), Notonectids (Anisops sp) and frog (Rana limnocharis) conducted during 1977 under laboratory conditions yielded the following results. The first of the five series of experiments with the nymphs of Aeshna on the Common carp spawn of 0.5-0.6 cm lasted for 24 hours which showed the mean loss of 6, 6, 7, 5 and 8 numbers of spawn amounting to a percentage loss of 30%, 30%, 35%, 20% and 40% respectively. The second set of the five series with the nymphs of Cordulia amounted to a predatory loss of 70%, 55%, 40%, 50% and 65%. The third set of the five series of experiments using the hemipteran bug, Anisops resulted in an average spawn loss of the consumed : injured to be 9:5, 7:4, 8:4, 6:3 and 6:9. The mortality rate in terms of percentage worked out to 28%, 22%, 24%, 18% and 30% in these experiments. The fourth and the final series using the vertebrate predator, Rana limnocharis of 1.5 cm size on the spawn of Common carp showed the predatory propensity rate to be of 16%, 12%, 25%, 25% and 12% for this series of experiments.

The induced breeding and rearing experiments on one of thn Indian major carps, Labeo rohita (Rohu) were carried out at Mawpun fish farm about 25 km from Shillong during 1979 at an altitude of 1,100 m.

The two series of the induced breeding experiments brought about spawning of the fish at a water temperature range of 26-28°C. The total number of eggs obtained in the first series was 15,000 and in the second 18,000 with the percentage fertilization amounting to 35% and 10% respectively. The total harvest of spawn in the first experiment was 1,048 of hatchlings while the second experiment yielded no hatchling at all. The incubation period took approximately 24-40 hours at the ambient temperature of 18.5-26.5°C.

The rearing experiment on *Labeo rohita* conducted with the available spawn in a nylon net hapa placed within a well managed nursery pond lasted for a duration of 30 days. The initial number of 1,048 spawn of size ranging from 6.5-8.5 mm and 6.0-9.0 mg grew to early fry stage attaining a length of 10.0-15.0 mm and weight of 300-600 mg. A total of 603 fry were finally harvested with the survival rate forming 57.7%, while the loss of the rest of the 445 frys caused a mortality rate of 42.3%.

The subsequent rearing of the early frys continued in a managed nursery pond for 90 days, saw their growth through the early fingerling stage reaching a length of 20.0 to 60.0 mm and weighing 1,200-4,500 mg. From this part of the experiment it was seen that out of the 600 numbers originally stocked, 387 were finally caught indicating a survival rate of 64.5%. The mortality of the remaining 213 frys worked out to a rate of 35.5%.

The composite fish culture experiment tried at the warmer altitude of 850 m at Kyrdem Kulai fish farm, Khasi Hills, Meghalaya for a duration of one year 1979-1980 by employing the Silver carp (*Hypophthalmichthys molitrix*), Common carp (*Cyprinus carpio communis* L.), Rohu (*Labeo rohita*) and Mrigal (*Cirrhinus mrigala*) was indeed a maiden effort in this Hill State.

Of these various species stocked, the growth of Rohu showed the least rate of growth from an initial size of 7.0-8.5 cm and 4.0-6.0 gm in length and weight, to a final size of 16.0-27.0 cm and weighing 50.0-240.0 gm. Out of the 200 fish stocked, 127 survived accounting for a survival of 63.5% and a mortality rate of 36.5%.

The Mrigal fingerlings grew from an initial size of 8.5-9.0 cm long and 5.0-10.0 gm in weight to a maximum size range of 19.0-29.0 cm and 65.0-305.0 gm. Out of the 125 numbers stocked, 92 survived and grew resulting in a 73.6% survival and 26.4% mortality rate.

The Common carp fingerlings of initial size of 6.0-8.0 cm and 5.0-10.0 gm reached a maximum size of 19.5 to 37.0 cm and 150.0-655.0 gm. Of the total 175 numbers of this species, 135 remained and grew resulting in a 77.1% survival and a mortality rate of 22.9%.

The fingerlings of Silver carp showed the best growth rate from an initial length of 6.0-11.0 cm and weight of 4.0-10.0 gm, to a final size reaching 30.5-42.5 cm in length and 300-715 gm in weight. A total of 31 fish were recaptured out of the initial of 40, which accounted for a survival rate of 77.5% and a mortality of 22.5%.

From the environmental factors measured during the one year duration of this experiment it was shown that the temperature ranged between 12-33°C, pH 6.4-6.9, dissolved oxygen 7.2-11.2 mg/l, free carbondioxide 2.0-4.0 mg/l, total alkalinity 12.0-28.0 mg/l, phosphate 0.028-0.08 mg/l, nitrate 0.004-0.06 mg/l and silicate 2.4-3.6 mg/l.

While relating the groups of plankton to the growth of fish it was seen very clearly that among the Phytoplankton it was Euglenophyceae and among the Zooplankton it was the Protozoa which showed positive correlation with the growth rate of the fish. In the present study, the Common Carp, an omnivorous feeder has proved that it was the disturbance created by these fishes on the sides and bottom of the pond releasing the necessary protozoans and flagellates like Euglena which has definitely improved their growth rate.

In composite fish culture, the Silver Carp had a trend seemingly affecting the trends of Chlorophyceae. There was really no emerging relationship among the Zooplankton and the growth rate of fishes. However, there does exist a relationship in the sense that except for the Protozoa all the other groups of Zooplankton were much less than 10% indicating their prevention of abundance by predation of Zooplankton feeders in such a composite fish culture system.

Both the abiotic and biotic factors of the environment in relation to the growth of the fish are discussed as to their importance on fish production.

GENERAL CONCLUSION AND RECOMMENDATIONS

GENERAL CONCLUSION AND RECOMMENDATIONS

The present studies on various cultural aspects of the Common Carp, *Cyprinus carpio communis* L. and the Indian Major Carp, *Labeo rohita* along with an experiment on the composite culture in the Hill State of Meghalaya have yielded certain results. Based on these, the following conclusions oould be drawn.

Firstly, at the altitude of Shillong (1550 m) the Common Carp matures within the second year at an average annual water temperature ranging between 11° to 24.5°C with the fecundity ranging from 61,052 to 90,000 eggs/kg body weight. It was seen that during all the three years of study, spawning took place from late March till May corresponding with the rising ambient water temperature. A second spawning was always observed in August-September, though less intense, brooders being smaller in size.

The favourable temperature range for spawning was found to be from 16.5° to 20°C with the maximum fertilization taking place around 19° to 20°C. The mean egg size was 1.2 to 1.8 mm in diameter and weighing from 0.0018 to 0.0024 gm. Usually about 415 to 555 eggs were counted in a gram of spawn. The incubation period varied from 3.5 to 7.0 days and was inversely correlated with the rise in temperature. The apparently longer duration of incubation period is attributed to the shorter duration of warmer hours in a diel cycle at Shillong.

It was noted that the weed *Rotalla rotundifolia* as an egg collecting device always underwent rotting and decay,especially when the incubation and hatching periods are prolonged. This favoured the development and spread of the fungus *Saprolegnia* which first infects the unfertilized eggs and later spreads to fertilized eggs as well and interferes with hatching. Of the various egg collectors that were explained upon, the Coconut fibre frame showed maximum efficiency with 12 times more than of Aluminium wire frame, 4 times better than the Wooden frame and 3 times increase as compared to *Rotalla rotundifolia*.

The experiments on the rearing of spawn to fry and early fingerling stages clearly showed that at this altitude, the growth rate of Common Carp fry was considerably slower and resulted in a growth which took 75 days, though the same size could be achieved in about 15 days in the warmer plains of India. This slow growth rate was mainly due to the prevailing low water temperature, in addition to the water being acidic, with low conductivity and alkalinity with lean plankton production. The mortality rate in the present experiments showed an overall average of 10.9% to 27.6%, as compared to a 75% mortality in the plains.

The present experiments of rearing of fry to fingerlings with different kinds of habitats have yielded the following results. For instance, the use of nylon hapas as nurseries has the advantage of being predator free, hygienic, less injurious to delicate fry maintaining a fairly constant microenvironment. These present findings once more emphasise that such floating nurseries are the obvious answer to meet the demands of rearing space, while simultaneously reducing the cost of production and avoiding elaborate nursery management practices.

One another result that has emerged from these set of experiments is that with the use of such artificial habitats, frys could be reared even in the off season in these Hill Regions, since the seed production is an important constraint in the development of fisheries in the hill areas. These various experiments on hapas and plastic pools with their resultant advantages could be summarised as:

(i) maximum space available with limited water supply;
(ii) easy handling and hence better management;
(iii) quick control and manipulation of most of the physical, chemical and biological variables;
(iv) low percentage mortality; and
(v) possibility of better growth in shorter time with supplementary feeds of different composition.

The rearing of fingerlings to table size fish has yielded a growth of about 440.0 to 585.0 gm amounting to a mean production of about 4,240 kg/ha/yr. Based on this figure, the cost of fish production worked out to Rs.3.85/- per kg. This amount is approximately one fourth of the selling price of Common Carp at the local markets. It is thus considered that even as a commercial proposition, the culture of this species offers ample potentiality.

The predatory experiments using several invertebrate and a vertebrate have shown the overall predatory intensities on 100 carp spawn in terms of percentage, were 31%, 56% for the dragonfly nymphs, 22.4% and 18% for notonectids and frogs respectively. The conclusions drawn from these studies show that at this altitudinal situation, the dragonfly nymphs are the most harmful to the young carp fry followed by the notonectids and the frogs in that order of descending importance.

The trend of development of the state fisheries in Meghalaya hinges entirely on the production and supply of seeds by controlled breeding experiments of Common Carp without any attempts to try the rich indigenous varieties of major carps which may be suitable for at least the plains and lower altitudes of this Hilly State. It is in this context, experiments on the induced breeding, hatching and rearing of Labeo rohita were undertaken.

It may be concluded from these experiments that this naturally acclimated tropical species from the plains of India could be bred and reared at intermediate altitudes, though with limited success. The presently available information on breeding and growth of major carps shows that we cannot attribute anyone single factors since it is controlled by a combination of several abiotic and biotic factors of the environment. The present experiments conducted, only reveal that induced breeding and subsequent rearing of Labeo rohita are possible at the lower altitude of these hill regions as the environmental factors are not totally unsuitable. With proper alkalinisation of water, enhancement of plankton growth and timing of the breeding experiments to synchronise with the period of most favourable temperature, further success is possible. The present studies have therefore, only highlighted the problems to be tackled in the coming years, rather than offering readymade solutions.

The composite fish culture experiment tried for the first time in the State of Meghalaya at a relatively warmer altitude of 850 m with fingerlings of Silver Carp, Common Carp, rohu and mrigal showed that rohu had the least growth reaching a maximum of 240.0 gm, mrigal fingerlings obtaining a maximum of 305.0 gm, Common Carp growing to 655.0 gm and the Silver Carp showing the best growth of 715.0 gm at the end of the growing period.

These different experiments discussed above have given some baseline information on the culture potential of water systems in the State of Meghalaya in the North-Eastern India. It is admitted that various constraints beset such field oriented researches, particularly in countries like ours. These studies had to be undertaken in collaboration with the local State Fisheries Department who offered their field facilities. Since this Department itself is in a state of infancy, not much help could be obtained. Nevertheless, the present studies have opened up some problem areas for further intensive work. It is hoped that a combination of the available technology in the country and the few techniques evolved in the present study will ultimately help in establishing sound aquacultural practices in this part of our country.

REFERENCES

REFERENCES

Ahmad, N. 1948. A note on carp ova and their hatching. Curr. Sci., 17 : 362-363.

Alikunhi, K.H. 1952. On the food of young carp fry. J. Zool. Soc. India. 4 : 77-84.

Alikunhi, K.H. 1956a. Fish culture technique in India, Progr. Fish. Developm. India : 63-73.

Alikunhi, K.H. 1956b. Observation on the fecundity, larval development and early growth of Labeo bata (Hamilton). Indian J. Fish., 3(1) : 216-229.

Alikunhi, K.H. 1957. Fish culture in India. Fm. Bull. Indian Coun. Agri. Res., 20 : 144 P.

Alikunhi, K.H. 1966. Synopsis of biological data on Common Carp, Cyprinus carpio (Linnaeus), 1758 (Asia and Far East) FAO World Symp. warm-water Pond Fish. Cult. Rome, No. FR/S, 31.1 : 80 (Mimeo).

Alikunhi, K.H., A. Dutta, V.D. Singh, A. Singh and G.P. Dubey. 1964a. Observations on the breeding of carps in bundhs, near Nowgong, Madhya Pradesh during July-August 1964. Bull. Cent. Inst. Fish. Educ. Bombay, (1) : 22 P.

Alikunhi, K.H. and H. Chaudhuri. 1959. Preliminary observations on hybridization of the Common Carp (Cyprinus carpio) with Indian carps. Proc. Indian Sci. Congr., (3) : 46.

Alikunhi, K.H., H. Chaudhuri and V. Ramachandran. 1952. Response to transplantation of fishes in India with special reference to conditions of existence of carp fry. J. Asiat. Soc. (Sci.), 18(1) : 35-54.

Alikunhi, K.H., H. Chaudhuri and V. Ramachandran. 1955. On the mortality of Carp fry in nursery ponds and the role of plankton in their survival and growth. Indian J. Fish., 2(2) . 257-313.

Alikunhi, K.H. and K.K. Sukumaran. 1964. Preliminary observations on Chinese Carps in India. Proc. Indian Acad. Sci. (B), 60(3) : 171-188.

Alikunhi, K.H., K.K. Sukumaran and S. Parameswaram. 1963. Induced spawning of Chinese Carp, Ctenopharyngodon idellus (CPV) and the Silver Carp, Hypophthalmichthys molitrix (CPV) in ponds at Cuttack, India. Proc. Indo. Pacif. Fish. Coun., 10(2) : 181-204.

Alikunhi, K.H., K.K. Sukumaran and S. Parameswaran. 1971. Studies on composite fish culture, production by compatible combination of Indian and Chinese Carps. J. Ind. Fish. Assoc., 1 : 26-57.

Alikunhi, K.H., K.K. Sukumaran, S. Parmeswaran and S.C. Banerjee. 1964(b). Preliminary observations on commercial breeding of Indian Carps under controlled temperature in the laboratory. Bull. Cent. Inl. Fish. Res. Inst. Barrackpore, 3 : 19 (Mimeo).

Alikunhi, K.H., M.A. Vijayalakshmanan and K.H. Ibrahim. 1960. Preliminary observations on the spawning of Indian Carps, induced by injection of pituitary hormones, Indian J. Fish., 7(1) : 1-19.

Alikunhi, K.H., V. Ramachandran and H. Chaudhuri. 1951. Mortality of carp fry under supersaturation of dissolved oxygen in water. Proc. Nat. Inst. Sci. India, 17(4) : 261-264.

A.P.H.A. 1955. Standard methods for the examination of water, sewage and industrial waters. Now York : 522.

Annual Plan Report, Meghalaya State Fishery Department, 1976, 1977 and 1980.

Bardach, J.E., J.H. Ryther and W.O. Melarney. 1972. Aquaculture. The farming and husbandry of freshwater and marine organisms. New York, John Wiley & Sons, Inc. 868 P.

Bhimachar, B.S. and S.D. Tripathi. 1967. A review on culture fisheries activities in India. FAO Fish Rep., (44)2 : 1-33.

Birtwistle, W. 1931. Rearing of carps in ponds. Malayan Agr. J., August 1931.

Bishara, N.F. 1979. Fertilizing fish ponds. Aquaculture, 16 : 47-55.

Biswas, S. 1970. Changes in the Phytoplankton of the developing Volta lake. Ghana Journal of Science, 10(2) : 85-92.

Biswas, S. 1972. Correlation between dissolved oxygen and phytoplankton in the lower reaches of Volta lake, Ghana. Verh. Internat. Verein. Limnol., 18 : 622-627.

Brooks, J.L. and S.I. Dodson. 1965. Predation, body size and composition of plankton. Science, 150 : 28-35.

Brown, E.E. 1969. The freshwater cultural Fish Industry of Japan. Univ. Georgia. Coll. Agri. Expt. sta., Res. Rep., 41 : 1-57.

Buschkiel, A.L. 1937. Lehren aus tropischer Teichwirtschaft. Z. Fischerei, 35 : 181 P.

Carbine, W.F. 1948. Bangos culture in the Philippines. Progr. Fish. Cult., 10(4) : 187-197.

Chacko, P.I. 1946. A note on the carp spawning in the rivers Godaveri and Krishna (Madras). Proc. Indian Sci. Congr., 33(3) : 211.

Chacko, P.I. and G.K. Kuriyan. 1950. The bionomic of the carp, Catla catla in South Indian waters. Proc. Zool. Soc. Lond., 120 : 39-42.

Chaudhuri, H. 1960. Experiments on induced spawning of Indian carps with pituitary injections. Indian J. Fish., 7(11) : 20-49.

Chaudhuri, H. 1963. Induced spawning of Indian carps, Proc. nat. Inst. Sci. India, 29B(4) : 478-487.

Chaudhuri, H. 1967. Breeding and selection of cultivated warm-water fishes in Asia and the Far-East. FAO Fish. Rep., (44) 4: 30-36.

Chaudhuri, H. and K.H. Alikunhi. 1957. Observations on the spawning in Indian carps by hormone injection. Curr. Sci., 26(12) : 381-382.

Chaudhuri, H., R.D. Chakraborty, N.G.S. Rao, K. Janakiram, D.K. Chatterjee and S. Jena. 1974. Record high production with intensive culture of Indian and exotic carps. Curr. Sci., 43 : 303-304.

Chaudhuri, H. and S.B. Singh. 1978. ICAR Monograph (In Press).

Chimits, P, 1961. Management of fish stocks in open systems - Introduction of Exotic species. Third International Inland Fisheries Training Centre, Bogor, Expanded Programme of Technical Assistance. FAO, Rome, 1 : 3.21, 1-9.

Chondar, S.L. 1970. Handbook of breeding of Indian Major Carps by Pituitary Hormone injection. Agra, Satish Book Enterprise, 100 P.

Choudhury, N.K., P.K. Pradhan and M.C. Dash. 1979. Certain physicochemical factors and phytoplankton of Hirakud Dam. Geobios, 6 : 104-106.

Czeczuga, B. and F. Gradzki. 1974. Phosphorus (^{32}p) uptake by various algae species in light and in darkness. Bulletin De L'Academic Polonaise Des Sciences. Cl. II, 22(6) : 425-429.

Das, K.N. and B.N. Das Gupta. 1945. Breeding of principal carps in Bengal. Proc. Nat. Inst. Sci. India, 11 : 324-327.

Das, S.M. and H.A. Khan. 1962. The pituitary and pisciculture in India with an account of the pituitary of some Indian fishes and review of techniques and literature on the subject. Ichthyologica, 1(1) : 43-58.

Dehadrai, P.V., R.N. Pal, M. Choudhury and D.N. Singh. 1974. Observations on cage culture of air breathing fishes in swamps in Assam. J. Inland. Fish. Soc. India, VI : 89-92.

Depasse, P. 1956. Monographie piscicole de la province orientale. Bull. Agric. Congo Belge, XVII, No. 4.

Dey, R.K. 1978. Induced breeding of Common Carp. Summer Institute on "Inland Aquaculture (ICAR)" held at C.I.F.R.I. Barrackpore, June 19 - July 80, 8 P. (Mimeo)

Dubey, G.P. and R.P. Tuli. 1961. Observations on the breeding of major carps in Madhya Pradesh. J. Bombay Nat. Hist. Soc., 58(1) : 18-91.

Ganapati, S.V. and P.I. Chacko. 1950. Suggestions for stocking fish ponds in Madras. Madras Agric. J., 37 : 1-5.

Ganapati, S.V. and P.I. Chacko. 1951. A comparative study of the transport of fish seed in oxygen tin carrier and in ordinary tin carriers. Ind. Com. J., 6 : 564-586.

Ganguly, D.N. and B. Mitra. 1961. Observations on the fish fry destroying capacity of certain aquatic insects and the suggestion for their eradication. Indian Agric., 5(11) : 184-188.

Ghosh, A.C. and S.N. Ghosh, 1922. Notes on carp breeding and culture in confined water of Bengal and Bihar. Bull. Dep. Fish. Beng., 18 : 9.

Golterman, H.L. 1960. Studies of the cycle of elements in freshwaters. Acta. Bot. Neerl., 9 : 1958.

Golterman, H.L. 1975. The sediments and their importance, relative to the inflow, as a source of nutrient for the growth of algae. In: Proc. of Symp. The Effects of Storage on water quality, Reading Univ., March 1975, 48-59.

Gorai, A.K. and D.N. Ray Chaudhuri. 1962. Food and feeding habits of Anisops bouvieri Kirk. (Heteroptera : Notonectidae), J. Asiat. Soc., 4(3/4) : 135-139.

Gribanov, L.V., A.N. Korneev and L.A. Korneeva. 1968. Use of thermal waters for commercial production of carps in floats in U.S.S.R., W.P.F.C. (5) : 218-226.

Guenause, G. 1923. Pisciculture, Paris (as cited in coldwater fisheries of India by Jhingran and Sehgal, 1978).

Gunther, A. 1968. Cat. Fish. Brit. Mus. Lond., 7: P 25 (as cited in Fish and Fisheries of India by V.G. Jhingran,1977).

Hammer, U.T. 1969. Blue-green algal bloom in Saskatchewan lakes. Verh. Internat. Verein. Limnol., 17 : 116-125.

Hickling, C.F. 1962. Fish culture: London, Faber and Faber,295 P.

Hickling, C.F. 1971. Fish culture: London, Faber and Faber,317 P.

Hoffman, W.E. 1934. Preliminary notes on the freshwater fish industry of South China, especially Kwangtung Province. Lingnan Univ. Sci. Bull. No.5, Canton, 1934.

Hofstede, A.E. and R. Ardiwinata. 1950. Compiling statistical data on fish culture on irrigated rice fields in West Java. Landbouw, XXII, 1950.

Hofstede, A.E. and R.Q. Ardiwinata. 1952. The breeding of Indonesian food fishes. FAO Fish. Biol. Tech. Pap., (14): 203 P.

Hofstede, A.E., R.Q. Ardiwinata and F. Botke. 1953. Fish culture in Indonesia. Special Publi. Indo-Pac. Fish. Counc., 2, 129 pp.

Hora, S.L. 1945. Analysis of factors influencing the spawning of major carps. Proc. nat. Inst. Sci. India, 11(3) : 303-312.

Hora, S.L. and T.V.R. Pillay. 1962. Handbook on fish culture in the Indo-Pacific region. FAO Fish. Biol. Tech. Pap., No. (14) : 204 P.

Howell, G.C.L. 1916. The making of the Himalayan trout water. Jour. Bombay Nat. Hist. Soc., 24(2) : 301-328.

Huet, M. 1970. Textbook of Fish Culture: Breeding and Cultivation of Fish. London, Fishing News (Books) Ltd. 436 P.

Ibrahim, K.H. 1957. Bionomics of forage fishes: Observations on the fecundity of three common species of minor barbels. J. Bombay Nat. Hist. Soc., 54(4) : 826-834.

Ibrahim, K.H. 1961. Some observations on the carp fry resources of the River Godavari near Rajahmundry, Andhra Pradesh. Indian J. Fish., 8(2) : 403-412.

Jana, B.B. and R.N. Das. 1980. Changes of chemical composition of water in two fish farming ponds with air breathing teleosts. Proc. Indian Acad. Sci. (Anim. Sci.), 89 : 1-8.

Jenkins, J.T. 1961. The Fishes of the British Isles. 2nd ed. London, Fredrick Warne and Co.

Jhingran, V.G. 1959. Studies on the age and growth of Cirrhinus mrigala (Ham.) from the river Ganga. Proc. Nat. Inst. Sci. India, (B):25 : 107-137.

Jhingran, V.G. 1968. Synopsis of biological data on Catla catla (Hamilton, 1882). FAO Fish. Synops., (32) Rev. 1 : pag. Var.

Jhingran, V.G. 1969. Review on the present status of knowledge on induced breeding of fishes and problems for future research. FAO/UNDP Regional Seminar on Induced Breeding of cultivated fishes, Calcutta, FRI/IBCF/27 : 48 P (Mimeo.).

Jhingran, V.G. 1974. Fish and Fisheries of India. Delhi (India), Hindustan Publishing Corporation. 522 P.

Jhingran, V.G. 1975. Fish and Fisheries of India. Delhi (India), Hindustan Publishing Corporation. 954 P.

Jhingran, V.G. 1977. Fish and Fisheries of India. Delhi (India), Hindustan Publishing Corporation. 954 P.

Jhingran, V.G. 1978. Inland Aquaculture in India. Summer Institute on "Inland Aquaculture (ICAR)", held at CIFRI, Barrackpore, June 19-July 18, 5 P (Mimeo.).

Jhingran, V.G. and P.V. Dehadrai. 1974. Inland Fisheries of the North Eastern Region of India. CIFRI, Barrackpore, West Bengal, 15 P (Mimeo.).

Jhingran, V.G. and K.L. Sehgal. 1978. Coldwater Fisheries of India. Inland Fisheries Society of India, Barrackpore, West Bengal. 239 P.

Jones, S. and K.K. Sarojini. 1952. History of transplantation and introduction of fishes in India. Jour. Bombay Nat. Hist. Soc., 50(3) : 594-609.

Joshi, S.N. 1980. Certain environmental parameters during induced breeding of Labeo gonius (Ham.). Geobios, 7 : 140-141.

Joshi, S.N. and S.S. Khanna. 1980. Relative fecundity of Labeo gonius (Ham.) from Nanaksagar reservoir. Proc. Indian Acad. Sci. (Anim. Sci.), 89 : 493-503.

Julka, J.M. 1965. Observations on the biology of aquatic bugs (Hemiptera) injurious to the pond fishes. I. Anisops bouvieri Kirkaldy. Proc. Indian Acad. Sci., 61B(1) : 49-61.

Julka, J.M. 1969. Aquatic bugs of a fish pond. Entomologist Record, 81 : 174-176.

Kawamoto, N.Y., Y. Inouye and S. Nakanishi. 1957. Studies on effect by the pond areas and densities of fish in the water upon the growth rate of the carp (Cyprinus carpio L.). Rept. of Faculty of Fisheries Perfectural University of Mie, Vol. 2, No. 3, July 30, 1957.

Khan, H. 1924. Observations on the breeding habits of some fresh-water fishes in the Punjab. J. Bombay Nat. Hist. Soc., 29(4) : 958-962.

Khan, H. 1942. Spawning of carp and their spawning ground, J. Bombay Nat. Hist. Soc., 43(3) : 416-427.

Khan, H.A. 1971. Artificial feeding in composite fish culture. In: Workshop of First All-India Coordinated Project on composite culture of Indian and Exotic fishes. CIFRI, Cuttack, September 17-20 : 19 P.

Khan, H.A. 1978. Induced breeding of Indian major carps. Summer Institute on "Inland Aquaculture (ICAR)", held at CIFRI, Barrackpore, June 19 - July 18, 7 p. (Mimeo).

Khan, H.A. and A. Hussain. 1947. A note on the destruction of carps fry by larvae of aquatic insects. Proc. Indian Sci. Congr., 34(3) : 184.

Khan, H.A. and V.G. Jhingran. 1975. Synopsis of biological data on rohu, *Labeo rohita* (Hamilton, 1822). *FAO Fish. Synops.*, (111) : 100 P.

Krumholz, L.A. 1949. Rates of survival and growth of Bluegill yolk fry stocked at different densities in hatchery ponds. *Trans. Amer. Fish. Soc.*, 76(1946) :190-203.

Kuronuma, K. 1968. New systems and new fishes for culture in the Far East. *W.P.F.C.*,(5) : 123-142.

Lake, J.S. 1967. Rearing experiments with five species of Australian freshwater fishes. I. Inducement to spawning. *Aust. J. Mar. Freshwat. Res.*, 18 : 137-153.

Lakshmanan, M.A.V., D.S. Murthy, K.K. Pillai and S.C. Banerjee. 1967. On the new artificial feed for carp fry. *FAO Fish. Rep.*,(44)3 : 373-387.

Lakshmanan, M.A.V., P.R. Sen, D.S. Murthy and D.P. Chakraborty. 1968. Preliminary study on the rearing of carp fingerlings. *Indian J. Fish.*,15(1 and 2) : 40-52.

Lakshmanan, M.A.V., K.K. Sukumaran, D.S. Murthy, D.P. Chakraborty and M.T. Philipose. 1971. Preliminary observations on intensive fish farming in freshwater ponds by the composite fish culture of Indian and exotic species. *J. Inland. Fish. Sci. India*, 3 : 1-21.

Larsson, P., J.E. Brittain, L. Lien and A. Lillehammer. 1978. The lake ecosystem of Øvre- Heimadalsvatn. *Holarct. Ecol.*, 1 : 304-320.

Lin, S.Y. 1940. Fish culture in ponds in the new territories of Hongkong. *J. Hongkong Fish. Res. Stn.*,1(2):161-193.

Lin, S.Y. 1949. Notes on fish fry industry of China. *Proc. Indo-Pacific Fish. Council*, 1st meeting, Singapore, 65-71.

Lin, S.Y. 1950. Fish culture in Ponds. *FAO Fish. Biol. Tech. Pap.*, (14) : 204 P.

Lin, S.Y. 1954. Chinese system of pond stocking. Proc. Ind. Pac. Fish. Coun., 5 : 113-125.

Ling, S.W. 1961. Management of fish stocks in open systems - population manipulation. Third International Inland Fisheries Training Centre, Bogor, Expanded Programme of Technical Assistance, FAO, Rome, 1:3.21,1-9.

Ling, S.W. 1967. Feeds and feeding of warm-water fishes in ponds in Asia and the Far-East. FAO Fish. Rep., (44)3 : 291-309.

MacCrinon, H.R. 1971. World distribution of rainbow trout (Salmo gairdneri). Fish. Res. Bd. Canada, 28 : 663-704.

Mackay, W.S. 1945. Trout of Travancore. Jour. Bombay Nat. Hist. Soc., 45(3-4) : 352-373 and 542-557.

Manea, G. 1969. Methods for artificial spawning of sturgeons (Acipenseridae) and hatching of fry. Rev. Italiana: Piscicoltura e Ittiopatologica. Ann. IV(4) : 81-86.

Markham, G. 1613. The English Husbandman, London, John Browne. 1613.

Mitchell, F.J. 1918. How trout were introduced in Kashmir? Jour. Bombay Nat. Hist. Soc., 76(1) : 295-299.

Molesworth, C. and J.F. Bryant. 1921. Trout culture in the Nilgiris. Jour. Bombay Nat. Hist. Soc., 27(4):898-910.

Mookerjee, H.K., S.R. Majumdar and B. Das Gupta. 1944. Observations on the breeding grounds and spawning habits of certain Indian carps in the Midnapore Dist., West Bengal, with suggestions for their breeding, collection of eggs and rearing of fry. J. Dep. Sci. Calcutta Univ., 11 : 383-384.

Mortimer, C.H. and C.F. Hickling. 1954. Fertilizers in fish ponds. London, Colonial Fish. Res. Pubns. No.5, H.M.S.O., 1954.

Munawar, M. 1970. Limnological studies on freshwater ponds of Hyderabad, India. II. The Biocenose Distribution of unicellular and colonial phytoplankton in polluted and unpolluted environments. Hydrobiologia, 36(1) : 105-128.

Natarajan, A.V. 1976. Rearing of carp fry in nylon cages for stocking Indian reservoirs. Summer Institute on "Fish seed production and mobilization for culture fisheries of Inland waters", CIFRI, Barrackpore. (Mimeo).

Natarajan, A.V. 1980. Introduction of the exotic carp, Hypophthalmichthys molitrix in Indian rivers and reservoirs - an ecological risk - Benefit analysis- CIFRI (ICAR), Barrackpore. (Mimeo).

Natarajan, A.V. and A.G. Jhingran. 1963. On the biology of Catla catla (Ham.) from the river Jamuna. Proc. Nat. Inst. Sci. India (B). 29(3) : 326-355.

Natarajan, A.V. and R.K. Saxena. 1978. R ole of floating nurseries in Aquaculture. Summer Institute on "Inland Aquaculture (ICAR)", held at CIFRI, Barrackpore, June 19 - July 18, 8 P (Mimeo).

Nordlie, F.G. 1975. Plankton communities of three central Florida lakes. Hydrobiologia, 48(1) : 65-78.

O'Brien, W.J. & F. De Noyelles, Jr. 1972. Photosynthetically elevated pH as a factor in zooplankton mortality in nutrient enriched ponds. Ecology, 53(4) : 605-614.

O'Brien, W.J. and F. De Noyelles, Jr. 1974. Relationship between nutrient concentration, phytoplankton density and zooplankton density in nutrient enriched experimental ponds. Hydro-biologia, 44(1) : 105-125.

Odum, E.P. 1971. Fundamentals of Ecology, London, W.B. Saunders, Co. 574 P.

Okada, Y. 1960. Studies on freshwater fishes of Japan. J. Fac. Fish. Univ. Mie., 4(2) : 267-588.

Pakrasi, B. 1954. Preliminary observations on the control of aquatic insects in nursery ponds. Proc. Indian Acad. Sci., 38B(5) : 211-213.

Pardhasaradhi, A. and J.R.B. Alfred. 1980. Fishing methods in the North-East India. In: Symposium on Development without destruction. Shillong. Nov. 1980 (In Press).

Pedro Noriega-Curtis. 1979. Primary productivity and related fish yield in intensely manured fish pond. Aquaculture, 17 : 335-344.

Pennak, R.W. 1953. Freshwater invertebrates of the United States. New York, The Ronald Press Co. 769 P.

Pennak, R.W. 1957. Species composition of limnetic zooplankton communities. Limnol. Oceanogr., 2(3) : 222-232.

Pickford, G.E. and J.W. Atz. 1957. The Physiology of the Pituitary gland of fishes. New York, New York Zoological Society. 613 P.

Prashad, B. 1919. Notes on carp culture in Bengal, Bihar and Orissa. Bull. Dep. Fish. Beng., 13.

Probst, E. 1950. Teichdungung. Allgemein Fisch. Zeit., 8/9, 79 Jahrg. 1950.

Qasim, S.Z. and A. Qayyum. 1962. Spawning frequencies and breeding season of some freshwater fishes with special reference to those occurring in the plains of Northern India. Indian J. Fish., 8(1) : 24-43.

Rabanal, H.R. 1968. Stock manipulation and other biological methods of increasing production of fish through pond fish culture in Asia and the Far East. FAO Fish. Rep., (44), 4 : 274-288.

Ramachandran, V. (Unpublished). A practical guide to the chemistry of freshwaters for fishery workers. (MS).

Rao, K.G. 1978. Experiences of Induced breeding of carps in Assam-Summer Institute on "Inland Aquaculture (ICAR)", held at CIFRI, Barrackpore, June 19-July 18, 7 P (Mimeo.).

Rose, S.M. 1959. Failure of survival of slowly growing members of a population. Science, New York, 129, P 1026, Apr. 1959.

Saanin, H. 1955. Pond culture in Indonesia in general. Lecture In: Third International Inland Fisheries Training Centre, Bogor : 29 P (Mimeo.).

Saha, K.C., D.P. Sen, A.K. Roy Choudhury and S.K. Chakravarty. 1957. Studies on the factors influencing spawning of Indian major carps in bundh fisheries. Indian J. Fish., 4(2) : 284-294.

Sarig, S. 1966. Synopsis of biological data on Common Carp, Cyprinus carpio (Linnaeus) 1758 (Near East and Europe) FAO Fish. Synops., (31.2).

Schaperclaus, W. 1933. Lehrbuch der Teichwintschaft. Paul Parey, Berlin, 1933. Textbook of pond culture: rearing and keeping of carp, trout and allied fishes., Fish Loaflet. Wash. (311) : 260 P.

Schaperclaus, W. 1959. Die karpfenteichswirt schaft in der Deutsche Demokratischen Republik. Sitz. Ber. Bd. VII. Hft. 7. Deutsche Akad. Landwirtschaftwiss. Berlin.

Schuster, W. 1949. Fish culture in Brackish water ponds of Java. Indo. Pac. Fish. Pubns., No. 1, F.A.O.

Schuster, W.H. 1952. A provisional survey of the introduction and transplantation of fish throughout the Indo-Pacific Region. Proc. Indo-Pac. Fish. Coun., 3rd meeting, Section II and III : 187-196.

Sehgal, K.L. 1974. Trout culture in India, its present status and future scope. J. Inl. Fish. Soc. India, 6 : 185-193.

Sen, P.R. 1978. Management of carp nursery ponds. Summer Institute on "Inland Aquaculture (ICAR)", held at CIFRI, Barrackpore, June 19-July 18, 6 P (Mimeo.).

Shapiro, J. 1973. Blue-green algae: Why they become dominant. Science, 179 : 382-384.

Shehadeh, Z.H. 1970. Controlled breeding of culturable species of fish- a review of progress and current problems. In: Symposium on Coastal Aquaculture. Indo-Pacific Fisheries Council, IPFC/C 70/SYM, 19 (Mimeo.):27 P.

Shell, E.W. 1967. Feeds and feeding of warm-water fish in North America. FAO Fish. Rep., (44)3 : 310-325.

Shimadata, M., K. Nakamura, H. Koyama, T. Ito and J. Toi. 1957. Effect of fertilization and significance of artificial feeding to fish production. Bull. Freshwater Fish. Res. Lab., Fisheries Agency, Tokyo, Vol.7,No.1.

Singh, S.B. 1968. Production of Common Carp seed. Proceeding of the seminar on "Production of quality fish seed for fish culture", held at Central Inland Fisheries Research Institute, Barrackpore, Nov. 1 and 2 : 286-296.

Singh, S.B., K.K. Sukumaran, P.C. Chakraborti and M.M. Bagchi. 1972. Observations on composite culture of exotic carps. J. Inland Fish. Soc. India, 4 : 38-50.

Sinha, V.R.P. 1972. Report of the second workshop on All India Coordinated Research Project on Composite Fish Culture of Indian and exotic carps.

Sinha, V.R.P., V.G. Jhingran and S.V. Ganapati. 1974. A review on spawning of the Indian major carps. Arch. Hydrobiol., 73(4) : 518-536.

Smith, E.V. and H.S. Swingle. 1941. The use of fertilizers for controlling several submerged aquatic plants in ponds. Trans. Amer. Fish. Soc., 71 : 94-101.

Smith, E.V. and H.S. Swingle. 1943. Percentage of survival of Bluegills and large mouth Black Bass when planted in new ponds. Trans. Amer. Fish. Soc., 72(1942) : 63-71.

Sneed, K.E. and H.P. Clemens. 1960. Hormone spawning of warm-water fishes its practical and biological significance. Progr. Fish. Cult., 22(3) : 109-113.

Sneed, K.E., W.H. Hastings and Harry K. Dupree. 1972. Accomplishments and future priorities in warm water fish nutrition. In: Progress in Fishery and Food Science, Univ. of Washington, College of Fisheries 50th Anniversary celebration symp. Univ. of Washington-Publication in Fisheries - New Series, V : 151-157.

Soong Min Kong. 1951. The fitness of ecological niches into which fish are introduced at various ages and the survival of transplanted fish. Proc. Indo-Pacif. Fish. Council, 3 : 218-227.

Sreenivasan, A. 1964. Fish mortality in an upland lake in Madras State. Ecology, 45(5) : 737-744.

Sreenivasan, A. 1966. Fish production: some rural demonstration ponds in Madras (India) with an account of the chemistry of water and soil. Proc. FAO World Symposium on Warm Water Pond. Fish. Culture, Rome, 182-197.

Sten, H.W. 1975. Meghalaya Year Book. Jaiaw Langsning, Shillong (Meghalaya), Salemfort Khonglah, N.E. India News and Features Service. 108 P.

Stewart, A.J. and D.W. Blinn. 1976. Studies on Lake Powell, USA: Environmental factors influencing phytoplankton success in a high desert warm monomictic lake. Arch. Hydrobiol., 78(2) : 139-164.

Sukumaran, K.K. 1978. Composite Fish Culture in different States of India. Summer Institute on "Inland Aquaculture (ICAR)", held at CIFRI, Barrackpore, June 19-July 18, 9 p (Mimeo.).

Sukumaran, K.K., S.B. Singh, D.S. Murthy and P.C. Chakraborty. 1969. Studies on compatibility and competition between Silver Carp, Hypophthalmichthys molitrix (Val.) and Catla, Catla catla (Ham.). Proc. Indo-Pacif. Fish. Coun., 13(2) : 185-194.

Suzuki, R. 1976. The culture of Common Carp in Japan. FAO Technical Conference on aquaculture, Kyoto, Japan. FAO Fish. Rep., 188 : FIR : Aq/Conf/76.E 51.

Swingle, H.S. 1957. Relationships of pH of pond water to their suitability for fish culture. 9th Pac. Sci. Congr. Bangkok, Thailand, 1957.

Swingle, H.S. 1967. Standardization of chemical analysis for waters and pond muds. FAO Fish Rep., 44(4);397-421.

Swingle, H.S. 1968. Fish kills caused by Phytoplankton blooms and their prevention. FAO Fish Rep., 44(5):407-411.

Szumiec, J. 1978. Range of changes in fish pond environment influenced by intensive carp farming. Verh. Internat. Verein. Limnol., 20 : 2137-2141.

Tang, Y. 1964a. Progress on the hormone spawning of pond fishes in Taiwan. Proc. Indo-Pacif. Fish. Coun., 11: 1-15.

Tang, Y. 1964b. Induced spawning of striped Grey Mullet by hormone injection. Japan J. Ichthyol., 12(1-2):23-28.

Taverner, J. 1600. Certain experiments concerning Fish and Fruites. London, William Ponsonby, 1600.

Tilzer, M.M. and K. Schwarz. 1976. Seasonal and vertical patterns of phytoplankton light adaptation in a high mountain. Arch. Hydrobiol., 77(4) : 488-504.

Tripathi, S.D. and B.S. Bhimachar. 1972. Hypophysation of fishes with particular reference to India. Jabalpur, The Directorate of Research Services, Jawaharlal Nehru Krishi Vishva Vidyalaya. 80 P.

Tripathi, S.D. 1978. Role of Aquaculture in rural development. Summer Institute on "Inland Aquaculture (ICAR)", held at CIFRI, Barrackpore, June 19-July 18, 7 P. (Mimeo.).

Vaas, K.F. and Sachlan, M. 1956. Cultivation of Common Carp in running water in West Java. Proc. 6th Session I.P.F.C. Tokyo, 1955, FAO Bangkok.

Van Duijn, C., Jnr. 1973. Diseases of fishes. London, Butterworth & Co. (Publishers) Ltd., 372 P.

Venkateswarlu, V. 1969. An ecological study of the algae of the river Moosi, Hyderabad (India) with special reference to water pollution. I. Physico-chemical complexes. Hydrobiologia, 33 : 117-143.

Willoughby, L.G. 1969. Salmon disease in Windermere and the River Leven: the fungal aspect. Salmon and Trout Magazine, 186 : 124-130.

Wishard, S.K. 1978. Factors responsible for Indian major carp spawning in bundhs. Summer Institute on "Inland Aquaculture (ICAR)", held at CIFRI, Barrackpore, June 19-July 18, 8 P (Mimeo.).

Woynarovich, E. 1975. Elementary guide to Fish Culture in Nepal. Food and Agriculture organization of United Nations, Rome, 131 P.

Wu, H. and L. Chung. 1964. Progress and achievement in the artificial propagation of four farm fishes in China. Paper GEN:160 in contributions to the 1964 Peking Symposium.

Wunder, W. 1949. Fortschrittliche karpfenteichwirtschaft. Stuggart, Erwin Nagele. 1949.

Wurtz, A. 1956. Ertragssteizerung in Teichen mit saurem Boden durch Hoferkultur. D. Fischerei Zeit. Oct.3, 1956.

Yashouv, A. 1958. The excreta of carp as a growth limiting factor. Bamidgeh, Vol. 10, No. 4, Dec. 1958.

Yashouv, A. 1959. Studies on the productivity of fish ponds. I. Carrying capacity. Proc. tech. Pap. gen. Fish. Coun. Mediterr., 5 : 409-419.

Yashouv, A. 1968. Mixed Fish Culture - An ecological approach to increase pond productivity. FAO Fish. Rep., (44): 4 : 258-273.

Yashouv, A. 1969a. Preliminary report on induced spawning of M. cephalus reared in captivity in freshwater ponds. Bamidgeh, 21(1) : 1969.

Yashouv, A. 1969b. Mixed fish culture in ponds and the role of tilapia in it. Bamidgeh, 21(3) : 75-92.

Yashouv, A., M. Nussbaum, Samsonov Berner and M. Abraham. 1969. Relative potencies of carp pituitaries collected for spawning induction. Bamidgeh, 20(4) : 125-127.

Zaret, T.M. 1969. Predation- balanced polymorphism of Ceriodaphnia cornuta Sars. Limnol. Oceanogr., 14 : 301-303.

Zaret, T.M. 1972. Predator- prey interaction in a tropical lacustrine ecosystem. Ecology, 53 : 48-57.

-:ooOoo:-

BRIEF BIODATA OF AUTHOR

Name	:	MR. DONBOR ROY THANGKHIEW.
Date of birth	:	15th April, 1950
Occupation	:	Lecturer in Zoology, St. Edmund's College, Shillong.
Academic qualification	:	B.Sc. (Hons.), Gauhati University. M.Sc., North-Eastern Hill University, Shillong.
Field of specialization	:	Fish and Fisheries.
Research Experience	:	Junior Research Fellow, From March 1977 to September 1980.
Teaching Experience	:	M.Sc. (Ecology, Fish and Fisheries) - 3 (three) Years. B.Sc. (Zoology) - 8 (eight) months.