SECONDARY PRODUCTION IN BRACKISHWATER CULTURE PONDS

By

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THESIS

Submitted in Partial fulfilment of the requirement for the degree

MASTER OF FISHERIES SCIENCE

Faculty of Fisheries

Kerala Agricultural University

Department of Aquaculture

COLLEGE OF FISHERIES

Panangad Cochin

1988

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TO MY PARENTS

DECLARATION

I hereby declare that this thesis entitled "SECONDARY PRODUCTION IN BRACKISHWATER CULTURE PONDS" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

Aneykutty Joseph

Place: Panangad
Date . 10.6.1988.

Aneykutty Joseph.

CERTIFICATE

Certified that this thesis, entitled "SECONDARY PRODUCTION IN BRACKISHWATER CULTURE PONDS" is a record of research work done independently by Miss. Aneykutty Joseph under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associateship to her.

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ACKNOWLEDGEMENTS

This thesis is the outcome of the most valuable guidance and encouragement which I received from Dr. K. Jayasree Vadhyar, Associate Professor of Aquaculture, College of Fisheries, Panangad. I am ever grateful to her for the timely guidance, constructive criticism and thought provoking suggestions throughout the course of this study.

Dr. Suseela Jose, Associate Professor of Aquaculture, Dr. C.J. Cherian, Associate Professor of Biological Oceanography and Dr. Thresiamma James, Assistant Professor of Algology, who are members of my Advisory Committee, have given useful suggestions during the study, and have gone through the manuscript very meticulously. Their timely advice has helped in ameliorating the quality of this thesis. I am indeed, greatly indebted to each one of them.

I am grateful to Dr. M.J. Sebastian, Dean, College of Fisheries, for providing necessary facilities for my work.

I owe a great deal to Dr. D.M. Thampy, Professor and Head of the Department of Aquaculture, who evinced a keen and genuine interest in my work and gave useful suggestions during the course of this study.

I wish to express my gratitude to Mr. T.M. Sankaran, Associate Professor and Head of the Department of Fishery Management , Mr. P.S. Mrithunjayan, Assistant Professor of Chemical Oceanography and Mr. P.M. Sherief,Assistant Professor of Biochemistry, College of Fisheries, Panangad, for their help and encouragement during the course of this study.

The timely supply of fish/prawn seed for this study effected by Mr. K.S. Purushan, Associate Professor, Fisheries Station, Puduveypu and by Mr. K. S. Joseph, Deputy Director, Regional Shrimp Hatchery, Azhikkode, is highly appreciated and gratefully acknowledged.

The valuable help and co-operation rendered by the staff of the Department of Aquaculture are deeply acknowledged.

I wish to thank Mr R C Datt, Assistant Librarian and Mr. T.J. Joseph, Reference Assistant, College of Fisheries, Panangad for their invaluable and timely help in obtaining important references.

Many of my friends have helped me during this research work. No doubt, I recall with a deep sense of gratitude, the help extended by them during the course of this work and the preparation of this thesis.

I have got a special word of thanks to Mr. P.K. Azad, Proprietor, M/s. Copy Centre and Miss. Sulochana Pillai, Typist for their help in typing thesis.

Finally, I am indeed grateful to my parents for their unfailing encouragement which gave me enough enthusiasm in carrying out this work.

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1 INTRODUCTION AND REVIEW OF LITERATURE

1.1. INTRODUCTION

A brackishwater fish pond constitutes an interesting aquatic ecosystem wherein organisms at different trophic levels (i.e. primary, secondary and tertiary levels) co-exist with varying degrees of unity and diversity. The productivity of a fish culture pond implies its capacity to produce cultured fish (Huet, 1975). A good yield of fish from a culture pond is the end product of a harmonious and healthy ecological balance maintained in the pond. The ecological balance of the aquatic communities is governed by the intricate interactions amongst themselves as well as by the abiotic factors such as temperature, salinity, dissolved oxygen, p^H, nutrients etc.

Winberg (1971) has stated that the process of production in aquatic ecosystems acts by means of trophic interrelationship of organisms which result in the transfer of quantities of matter and energy from one trophic level to subsequent ones. The natural mechanisms involved in the balanced maintenance of such trophic interrelationships is far from clear. A deep insight into the interactions amongst the organisms at different trophic levels as well as into the abiotic elements in the fish culture pond is necessary to elucidate the complex mechanisms taking place in the pond.

The photosynthetic primary producers are of special significance in the pond ecosystem as they occupy the lowest trophic level and hence form the foundation for the food pyramid. As Barnes and Mann (1980) rightly stated, primary production is the major store of energy fuelling the whole system in many aquatic habitats. In majority of fish culture ponds, phytoplankton production forms the major share of primary production. Since phytoplankton is largely constituted by nannoplankton of minute size ranging from 5 to 50 μm (Barnes, 1980) which is likely to pass through the gill rakers of majority of planktivorous cultivable fishes, it may not have direct food value to these fishes unless it is obtained in a larger conglomerated form such as scum (Hillbricht - Ilkowska *et al*. 1972, Schroeder, 1978).

Several of the cultivable fishes and prawns are known to feed on zooplankton such as rotifers, cladocerans, copepods and insect larvae as well as on zoobenthos such as tanaids, amphipods, copepods, nematodes, polychaetes and small molluscs (Gopalakrishnan, 1952, 1973; Thomas, 1973; Kuttyamma, 1974). Hence it may not be extravagent to assume that these invertebrate secondary producers play an important role in the growth, survival and yield of several cultivable fishes and prawns.

Although the physico-chemical characteristics of water and soil in culture ponds, as well as the flora and fauna are well studied, their relationship to fish production is less known. Although there are several studies devoted to the establishment of relationship between primary production and fish production, studies on secondary production in relation to fish production have been very few. The present study is oriented towards acquiring additional information on the latter scarcely studied field with due importance to the former, since these two are interdependent.

1.2 REVIEW OF LITERATURE

There have been several studies carried out by various authors on the primary, secondary and tertiary production of open waters either singly or in a combined manner both in the western and eastern countries. However, investigations on these trophic level production in fish culture ponds are relatively less and more recent. The review is restricted to those studies pertaining to fish culture ponds. Studies on these lines have been conducted mainly in the United States of America, Canada, South American countries, European countries such as France, Germany, Israel, Poland, Hungary, Bulgaria, Czeckoslovakia and the U.S.S.R, Australia, Africa and several Asian countries like Japan, Indonesia and India.

The earliest work on these lines has been reported from the U.S.A where studies on plankton production in fish ponds have been carried out by Wiebe, way back in 1930. Subsequent studies in the U.S.A include the following. Hayne and Ball (1956) made investigations on the benthic production in fish ponds. Kirby-smith and Barber (1974) studied the effect of phytoplankton concentration on the growth of the Bay Scallop Argopecton irradians in culture systems. Romaire and Kilgen (1977) reported benthic macrofauna in closed off brackishwater canals. Almazan and Boyd (1978) studied plankton production in relation to tilapia yield in culture ponds. Zur (1981) investigated the

primary production of intensely stocked fish ponds. Research on similar lines carried out in Canada is limited to the study carried out by Fernando (1983) on zooplankton in relation to fish production with special reference to tilapia production in culture ponds.

Of the South American countries, Brazil and Argentina have contributed to a limited extent, Sobue and Castagnolli (1980) investigated the relationship of plankton and benthic production with fish production in culture tanks in Brazil, and Pizzolon and Quiros (1984) studied primary production in a fish pond in Argentina.

In Europe, several studies in this direction have been carried out mainly in Poland. These include the work carried out by Hillbricht-Ilkowska (1964) and that by Ferenska and Lewkowicz (1966) who studied the influence of fish production on pond ecosystems, as well as that by Grygierek (1966,1971, 1973,1978) who studied the various aspects of zooplankton production in relation to carp production in culture ponds. A series of investigations have been conducted in Poland to establish the relationship of carp yield with Phytoplankton production (Wrobel, 1970, Januska, 1978) and with benthic production (Wasilewska, 1978; Dimitrov, 1981).

Investigations on zooplankton production of fish ponds were carried out by Liudskanova (1971) in Bulgaria. In Czechoslovakia, three studies i.e, (1) composition and dynamics of plankton of carp fry ponds by Losos and hetesa (1973), (2) zooplankton and benthic biomass and their relationship to carp production by Prikryl (1979) and (3) phytoplankton, zooplankton and benthic production of carp nursery ponds by Matena (1982) have been conducted. Similar work was carried out in the U.S.S.R, where studies on primary production of fish ponds were carried out by Kuźmicheva (1976) and on zooplankton and zoobenthic production of fish ponds were conducted by Krazhan et al. (1977) and Ruttkay (1978).

In Israel, study on primary production of fish ponds was conducted by Hepher (1962), and on primary and secondary production in intensely manured fish ponds were carried out by Schroeder (1978). Similar work conducted in France include studies made by Castel (1977) on phytoplankton production in brackishwater fish ponds in the Arcachon region, and that by Vicente et al. (1979) on phytoplankton production in relation to bivalves in saline water. Work in this direction carried out in Germany is limited to the study on zooplankton production in fish ponds by Amren (1964).

In Africa, similar work has been conducted by Noriega-Curtis (1979) who studied primary production in relation to production of carps and tilapia in intensely manured ponds in Cameroon. Investigations on primary production and meiofauna production in relation to prawn production in culture ponds have been carried out in Australia by Moriarty (1984) and Moriarty et al (1984).

Of the Asian countries, work in this direction include the following. In Indonesia, studies on trophic relationships between plankton and fish have been conducted by Vaas (1954). In Japan, detailed investigations on plankton and benthic production have been carried out in culture ponds by Mori et al. (1979). Benthic fauna of fish ponds in Dacca, Bangladesh was studied by Ali (1978).

In India, similar studies have been carried out by various authors. The earliest work is that by Sreenivasan (1964, 1968) on primary production in relation to fish production in freshwater culture ponds in Madras. Subsequently, Michael (1966, 1969) made investigations on the dynamics of plankton in freshwater fish ponds Investigations on primary production of a freshwater fish pond have been carried out in Aligar by Khan and Qauuym (1971), Nasar and Datta-Munshi, (1975) and at Kalyani in West Bengal by Jana (1979, 1980). Datta and Sarangi(1980) studied macrofauna of a brackishwater Bheri at Taldi in West Bengal. Detailed studies

on benthic microalgae and fauna of freshwater fish ponds in relation to production of bottom feeding fishes have been conducted by Chellappa and Nair (1982). Studies on primary production in relation to fish yields under different pond management practices have been carried out by Olah *et al.* (1986) in Orissa. Bandyopadhyay and Datta (1987) conducted studies on the benthic macroinvertebrate communities of a brackishwater impoundment (Bheri) of Hoogly - Matlah estuary.

1.3. OBJECTIVES OF THE STUDY

1. To study fortnightly fluctuations in the total and group wise biomass, percentage dominance and frequency of occurrence of zooplankton, meiobenthos and macrobenthos in brackishwater culture ponds.

2. To study fortnightly fluctuations of the physico-chemical parameters of brackishwater ponds in order to evaluate the influence of these variables on secondary production.

3. To find out the influence of fortnightly fluctuations of primary production on that of zooplankton.

4. To assess the relationships of the fortnightly biomass of zooplankton, meiobenthos and macrobenthos with the fortnightly growth increment of C.chanos, P. indicus and P. monodon separately.

2 MATERIALS AND METHODS

2.1 BRACKISHWATER PONDS STUDIED

Two uniform sized brackishwater ponds, A and B, each having an area of 0.042 hectare and an average water depth of 50 cm, fitted with a wooden sluice, at the Instructional Brackishwater Fish Farm of the College of Fisheries, Panangad, Cochin, formed the area of the present study (Fig. 1). These ponds are situated on the south west coast of India between latitude 9°58'N and longitude 76°16'E; the ponds face each other and are connected to the Cochin backwaters via a common feeder canal having a length of 50 meters and width of 5 meters. The materials for the study were collected from these two ponds. The methods adopted for pond management, sampling, collection of materials and analyses for the present investigations are detailed below.

2.2 PREPARATION OF THE PONDS

The ponds were prepared before the commencement of each set of stocking of fish/prawn. The pond water was drained as much as possible during the low tide and the left out water was pumped out by means of a 5 H.P pumpset, retaining approximately 10 cm of water depth. Mahua oil cake at a rate of 250 ppm was applied after that for the eradication of predatory and weed fishes. Lime was then applied at a rate of 500 kg/ha for buffering the pond medium. Bleaching powder at a

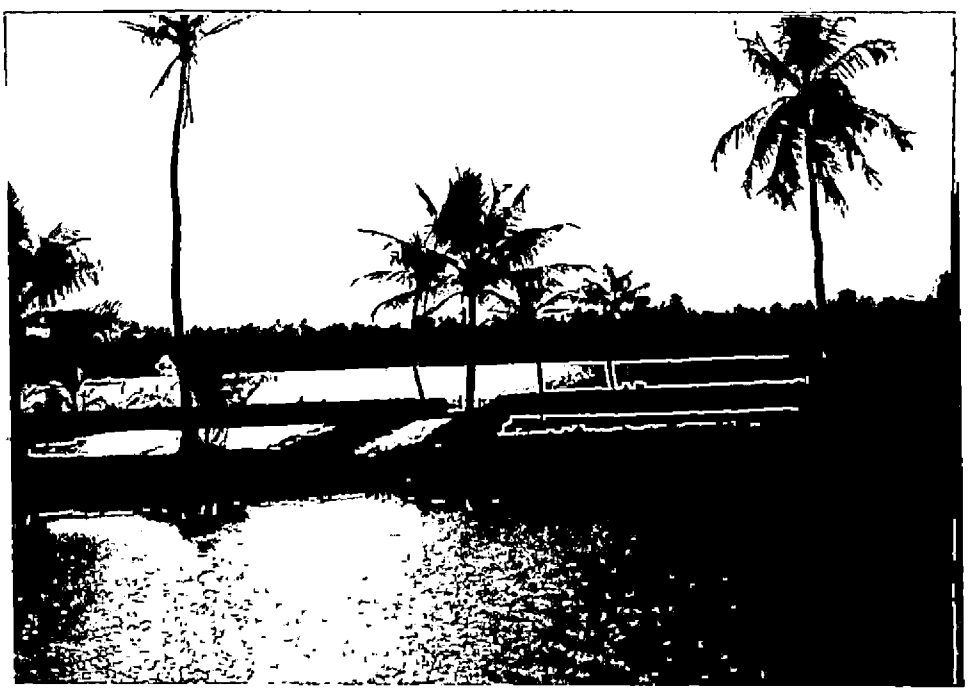


Fig. 1. Brackishwater ponds studied.

rate of 40 ppm was also applied in the ponds as a disinfectant. Brackishwater was let into the ponds through the sluice screen from the feeder canal on the following day, during high tide. Pond A was fertilised with organic manure, i.e. cowdung, at a rate of 24,000 kg/ha/year and Pond B was fertilised with inorganic fertilizers, i.e. single super phosphate and urea at a rate of 266.67 kg/ha/year and 240 kg/ha/year respectively, equating the N_2 and P_{205} value contained in the organic manure applied in Pond A No supplementary feed was given during the culture period. Organic manure was applied weekly while inorganic fertilizers were applied only fortnightly because of the prolonged action of the latter. Water exchange was done only when threat of dense phytoplankton blooms occurred.

2.3 DETAILS OF STOCKING

Both the ponds were first stocked with Chanos chanos fingerlings brought from the Fisheries Station of Kerala Agricultural University at Puduveypu, at a stocking rate of 4500 Nos /ha The initial average length and weight of the fingerlings were 8.6 cm and 6 g respectively. While stocking, uniformity with regard to length and weight of the fingerlings was ensured in both the ponds. The duration of this culture (Culture I) was 120 days during August-December, 1986 after which C. chanos individuals were harvested and the ponds were prepared for the next culture.

Subsequently, both the ponds were stocked with Penaeus indicus at a stocking rate of 30,000 Nos/ha. The juveniles of P. indicus obtained from the Fisheries station of Kerala Agricultural University at Puduveypu were used as rearing material. At the time of stocking the initial average length and weight of the prawns were 1.2 cm and 0.113 g respectively. The duration of this culture (Culture II) was 60 days during January-March, 1986, after which the prawns were harvested and the ponds were prepared for the next culture.

For 45 days, from mid May to June (Culture III) Penaeus monodon was cultured in both the ponds. The post larvae were brought from the Regional Shrimp Hatchery of the State Department of Fisheries at Azhicode, Kerala and reared in nursery ponds for two weeks. At the time of stocking the initial average length and weight of the prawns were 2.2 cm and 0.268 g respectively. The stocking rate was 20,000 Nos /ha.

2.4 MAINTENANCE OF THE PONDS

The ponds were observed daily every morning and evening to make sure that the stocked fishes behaved normally and that no undesirable conditions occurred in the ponds. In the event of any damage of the embankments of the ponds caused by burrowing organisms such as eels and crabs and also by natural

erosion, it was repaired immediately. Occasionally, dense phytoplankton blooms appeared in Pond A, on such days, brackish-water from the exterior was let into the pond at high tide for thinning the bloom. Simultaneously, Pond B was treated similarly inspite of no dense bloom for keeping the water level same in both the ponds.

2.5 SAMPLING FREQUENCY

Collection of samples for physico-chemical and biological parameters was done fortnightly. Sampling of the fishes and prawns was carried out in order to record their length and weight simultaneously Samples for soil particle size, organic carbon and available phosphorus were collected on the starting and final day of each culture.

2.6 SAMPLING METHODS

2.6.1 COLLECTION OF WATER SAMPLES

Water samples were collected from the ponds for determining temperature, pH, salinity, dissolved oxygen and primary production. For dissolved oxygen and primary production, water samples were collected by means of a bucket and then transferred to 250 ml dissolved oxygen bottles using a narrow rubber tube which was dipped into the bottle and by overflowing

double the volume of water from the bottle before closing it with the stopper. The samples for analyses of dissolved oxygen were fixed immediately with manganous sulphate and potassium iodide.

2.6.2 COLLECTION OF ZOOPLANKTON

50 litres of pond water was taken from the four corners of the ponds and filtered through a conical plankton net made of bolting silk No.25 (63 μm mesh size). The plankton was transferred to 50 ml plastic bottles and preserved in 5 % formalin for further analyses.

2.6.3 COLLECTION OF BENTHOS

2.6.3.1 Macrobenthos

Duplicate samples for macrobenthos were collected from the ponds using van Veen grab having a biting area of 625 cm^2 (25 x 25 cm). While collecting the grab sample, it was ensured that the grab was full and the top layer was undisturbed by opening the window of the grab and observing the grab contents superficially. The contents of the grab was transferred to enamel trays, sieved through a 500 μm mesh Standard Test Sieve for separating the macrobenthos from the finer sediment particles, using filtered pond water. The contents of the sieve was

transferred to plastic containers and preserved in 5% formalin for further analyses.

2.6.3.2 meiobenthos

Sediment samples for meiobenthos were collected in duplicate by inserting a graduated hard PVC core tube of 2.2 cm internal diameter (surface area 3.8 cm^2) and about 30 cm long, into the van Veen grab contents to a depth of 4 cm and thence by withdrawing the tube after closing its top end with a tight fitting rubber bung (Uhlig et al. 1973). The sediment core was collected in a plastic jar by gently releasing the top bung, with the core tube held in a vertical position (Fig 2). The samples were preserved in 5% formalin for further analyses.

2.6.4 COLLECTION OF SEDIMENT SAMPLES FOR PARTICLE SIZE, ORGANIC CARBON AND AVAILABLE PHOSPHORUS

Sediment samples were collected from ten locations in the pond at random using a container of 100 ml capacity. The random samples were mixed together, spread in a large polythene tray and allowed to dry in shade. The dried samples were ground in a mortar so that aggregate particles were crushed well. The ground samples were sieved through 2 mm mesh Standard Test Sieve to remove larger particles and were kept

Fig. 2. PVC core tube used for collection of meiobenthos samples.

in plastic bags tied air tight for further analyses of particle size, organic carbon and available phosphorus.

2.6.5 COLLECTION OF FISH AND PRAWN SAMPLES

Collection of fish and prawn samples from the ponds was carried out using a cast net. During every sampling a minimum of 10% of the fish/prawn stocked were caught at random, in order to record their individual length as well as weight for growth assessment. This was done carefully and the sampled specimens were returned to the ponds immediately.

2.7 METHODS OF ANALYSES

2.7.1 PHYSICAL METHODS

2.7.1.1 Temperature

The temperature of surface water was recorded using a precise grade mercury thermometer having a range from zero to 50°c and graduations of 0.1°c.

2.7.1.2 Secchi disc transparency

A Secchi disc was lowered into the pond water and the depth at which it disappeared was noted. It was slowly raised upwards and the depth at which it reappeared was noted. The average value of these two readings was calculated in cm.

2.7.1.3 Water depth

Water depth was taken from different parts of the pond using a wooden metre scale. The average value of these readings was calculated in cm.

2.7.2 CHEMICAL METHODS

2.7.2.1 Water p^H

The p^H was determined by electrometric method using a Digital p^H meter (Elico model L-I-122). The instrument was calibrated using Buffer solutions having p^H 4.2,7 and 9.2.

2.7.2.2 Salinity

Standard Argentometric method as described in Strickland and Parsons (1968) was followed for the estimation of salinity of pond water.

2.7.2.3 Dissolved oxygen

The dissolved oxygen was determined following Winkler's method as detailed in Strickland and Parsons (1968).

2.7.2.4 Soil particle size

The particle size of the soil sample and the percentages of sand, silt and clay were determined using pipette analysis as detailed by Krumbein and Pettijohn (1938).

2.7.2.5 Organic carbon

The organic carbon of the soil samples was estimated following Walkley and Black's method detailed in Jackson, 1973. Oxidisable matter in the soil was oxidised by chromic acid and adding excess sulphuric acid with a measured excess of potassium dichromate. The heat of dilution was utilised for the wet digestion of organic matter. Unreacted potassium dichromate was estimated by back titration with standard ferrous ammonium sulphate using a redox indicator ferroin. The amount of organic carbon in the soil was calculated from the amount of potassium dichromate reacted with organic carbon.

2.7.2.6 Available phosphorus

Phosphorus in the soil samples was estimated by Bray and Kurtz's method as detailed in Jackson, 1973. The soil sample was extracted with hydrochloric acid-ammonium chloride mixture. The extracted phosphorus was made to react with acid ammonium molybdate to form heteropoly - phosmolybdate complex. This complex was reduced by a reducing agent, stannous chloride and it formed a blue coloured complex. The absorbance of the solution was read on a spectrophotometer at 660 nm. Concentration of the phosphorus was calculated from the calibration curve prepared by measuring absorbance of the standard phosphorus solution treated in the same way.

2.7.3 BIOLOGICAL ESTIMATIONS

2.7.3.1 Phytoplankton primary production

The phytoplankton primary production was determined using light and dark bottle method as detailed in Strickland and Parsons (1968). Narrow mouthed 250 ml bottles, one dark and two light, were filled with pond water sample collected from the surface and oxygen in the initial bottle was determined by the Winkler method. This gave the initial oxygen content. The remaining light and dark bottles were incubated in pond water for 6 hours from 10 a.m to 4 p.m, after which the bottles were taken out and the dissolved oxygen was determined. The determination was conducted in duplicate. From these values, net and gross primary production were calculated.

2.7.3.2 Zooplankton

The preserved samples of zooplankton were made upto 50 ml in the measuring cylinder and stirred uniformly. Soon after stirring the sample, 1 ml was transferred to a plankton counting chamber and observed under the microscope for identification and counting. This was repeated thrice, the average numbers of each group calculated for estimating the numbers of organisms per m^3. The wet weight of copepods and nauplii was measured by using Klekowski and Shushkina's

formula, $W = 0.055\ L^{2.75}$, where L = length of the organism as detailed in Edmondson and Winberg (1971). The wet weight of rotifers was calculated on the basis of volume and specific gravity measurements. The volume was determined by using Andrassy's formula, $a^2b/1.7$, where 'a' is the maximum body diameter and 'b' body length of the rotifer (Andrassy, 1956). The specific gravity was taken as 1.0 (Edmondson and Winberg, 1971). Ten individuals from each group were randomly selected and measurements were taken under a compound microscope using an eyepiece micrometer, the average measurements were taken for calculating the individual wet weight of the organisms. The total wet weight of each group in a sample was calculated by computing the individual wet weight with the numbers of that particular group in the sample obtained by counting.

2.7.3.3 Meiobenthos

The meiobenthos was concentrated from the core sample by first sieving the sediment through a 53 µm mesh Standard Test Sieve and then by elutriating the contents of the sieve (Uhlig et al. 1973). A simpler model of glass elutriation apparatus than that of Hockin (1981) designed by Dr. K. Jayasree Vadhyar, College of Fisheries, Panangad (unpublished) was used for the purpose (see Fig. 3). The apparatus consists of a 250 ml pear shaped separating funnel whose lower tubular portion can be attached to the tap water supply via a PVC tube.

Fig. 3. Glass elutriator and accessories.

The neck of the funnel was fitted with a tight fitting rubber bung which in turn was fitted with a narrow glass outlet tube leading to the sieve via a PVC tube. The sieved sediment was stained with 1% Rose Bengal and transferred to the elutriator using a funnel. While transferring, the water supply tap was kept open at a slow pace to avoid the sediment running down the lower tubular portion of the separating funnel. After transferring the sediment, the elutriator was closed with the rubber bung and the tap water supply adjusted to bring out the percolating and floating organisms from the separating funnel to the sieve kept in a plastic funnel fitted on a clamp. It was ensured that all the organisms contained in the sieved sediment were brought into the sieve, by randomly checking the sediment retained in the elutriator after about 20-30 minutes operation. However, the separated material also contained some flocculent matter which floated along with the meiofauna. This difficulty has also been expressed in the elutriation method described by Uhlig et al.(1973) and Hockin (1981). The contents of the sieve was then transferred to a Petri dish for identification and counting of the meiofauna groups.

The wet weight of nematodes was determined on the basis of volume and specific gravity measurements. The volume was determined by using Andrassy's formula, $a^2b/1.7$, where 'a' is the maximum body diameter and 'b' is the body length of the nematode

(Andrassy, 1956). The specific gravity, 1.13 determined by Wieser (1960) was taken as characteristic of nematodes. The wet weight of the copepods was determined by using Klekowski and Shushkina's formula as described earlier. Measurements of at least ten randomly selected organisms were made under a compound microscope with an eye piece micrometer and the average measurements were used while calculating the individual wet weight of the organism. The total wet weight of each group in a sample was determined by computing the individual wet weight with the numbers of that particular group in the sample obtained by counting.

2.7.3.4 Macrobenthos

The macrobenthos was sorted out using a fine needle and a fine pipette. They were identified upto group level, counted and wet weight was determined for each group. Wet weight of the macrobenthos (groupwise) was determined by weighing the organisms in an electric monopan balance. Before weighing, the samples were washed with distilled water, dried until no more wet spots appeared on the filter paper following Ulomski's method as described in Edmondson and Winberg (1971).

2.7.3.5 Growth assessment of fishes and prawns

The fortnightly growth of the cultured fishes and prawns was assessed by measuring the length and weight of the sampled individuals. From this their average length and weight gain per fortnight were calculated.

3 RESULTS

3.1 PHYSICO-CHEMICAL CONDITIONS OF WATER AND CHARACTERISTICS OF SOIL IN THE PONDS

The physico-chemical parameters of water in the two ponds on each fortnightly sampling day during August-December, 1986 (Culture I), January-March, 1987 (Culture II) and mid May-June, 1987 (Culture III) respectively are detailed below.

3.1.1. PHYSICAL CONDITIONS OF WATER

3.1.1.1 Temperature

The fortnightly variations in temperature were not remarkable during each culture period. The water temperature fluctuated between 25°C and 35°C during the overall culture period (see Tables 1,2 and 3 as well as Figs. 4 and 5).

3.1.1.2 Secchi disc transparency

The Secchi disc transparency was relatively less in Pond A than in Pond B and it varied mainly by phytoplankton growth. The secchi disc readings ranged from 36 cm to 46 cm. during the overall culture period (see Tables 1,2 and 3; Figs. 4 and 5).

3.1.1.3 Water depth

The pond water depth ranged from 45 cm to 64 cm in Pond A and from 45 cm to 61 cm in Pond B (see Tables 1,2 and 3; Figs. 4 and 5).

3.1.2 CHEMICAL CONDITIONS OF WATER

3.1.2.1 Water pH

The pH of water in Pond A was found as alkaline throughout the culture period, whereas in Pond B, it was mostly acidic during Culture I and also at the start of Culture II. The pH values ranged from 7.21 to 10.00 in Pond A while in Pond B it ranged from 6.63 to 9.05. In Pond A, the maximum value of 10.00 was obtained during the first half of Culture III whereas in Pond B, the maximum of 9.05 was found during the first half of Culture I. The lower pH values in both the ponds occurred during November-December months coinciding with the North East monsoon (see Tables 1,2 and 3, Figs. 4 and 5).

3.1.2.2 Salinity

The highest salinity of 30.02 ppt and 31.05 ppt in ponds A and B respectively was observed in early March i.e., during the first half of Culture II and the lowest salinity of 2.50 ppt and 2.72 ppt in ponds A and B in early September and early November respectively i.e., during the first half of Culture I. The salinity varied from 2.5 ppt to 25 ppt and from 2.72 ppt to 22.5 ppt during Culture I, from 12.00 ppt to 25.5 ppt and from 10.5 ppt to 25.00 ppt during Culture II, from 7.5 ppt to 20.20 ppt and from 8.00 ppt to 18.02 ppt during Culture III in ponds A and B respectively.

3.1.2.3 Dissolved oxygen

The dissolved oxygen varied from 3.60 ppm to 16 ppm in Pond A and from 4.40 ppm to 9.60 ppm in Pond B. The dissolved oxygen was generally higher in Pond A than in Pond B. The lowest value (3.60ppm) in Pond A was observed on the 15th day of Culture II while the highest value (16ppm) in the same pond was observed on the 60th day of Culture I (see Tables 1,2 and 3; Figs. 4 and 5).

3.1.3 SOIL CHARACTERISTICS OF THE PONDS

Details of the soil characteristics of the two ponds studied on the starting and final day of the three cultures are given below.

3.1.3.1 Particle size

In both the ponds, the soil particle size was constituted by sand (89%) silt (3%) and clay (8%) (see Tables 4 and 5).

3.1.3.2 Organic carbon

The Organic carbon ranged from 0.92% to 1.72% in Pond A while in Pond B the values ranged from 0.5% to 1.42% (see Tables 4 and 5).

3.1.3.3 Available phosphorus

Available phosphorus values (mg p/100g soil) ranged from 0.275 to 0.683 in Pond A, while in Pond B the values ranged from 0.380 to 0.629 (see Tables 4 and 5).

Table 1. Physico-chemical parameters of water in the two fish ponds during each fortnightly sampling day during August-December (Culture I).

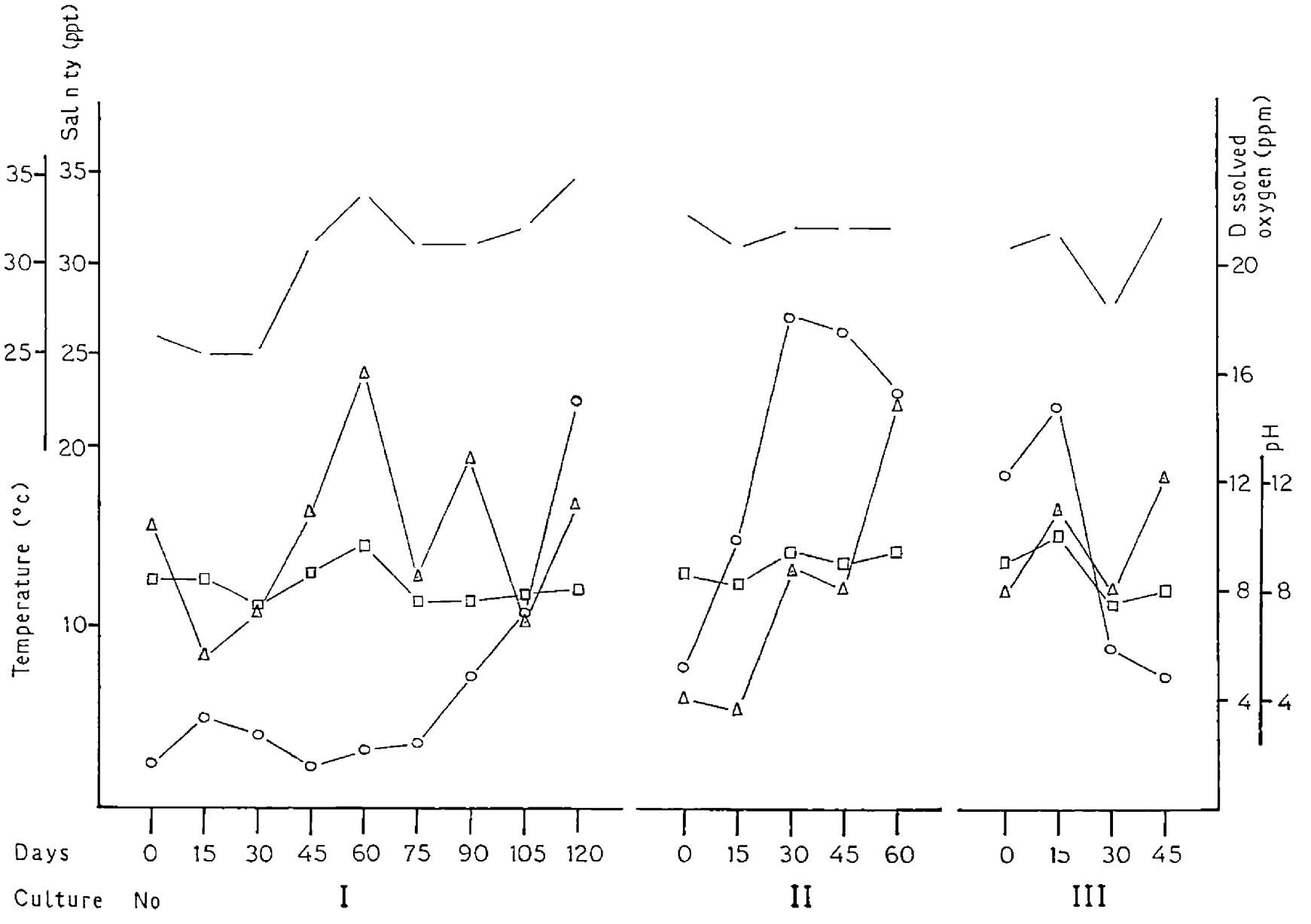
Days	Physico-chemical parameters											
	Pond A						Pond B					
	Temperature (°C)	Transparency (cm)	Water depth (cm)	Salinity (ppt)	Dissolved oxygen (ppm)	pH	Temperature (°C)	Transparency (cm)	Water depth (cm)	Salinity (ppt)	Dissolved oxygen (ppm)	pH
1	26.00	44.00	47.50	2.64	10.40	8.26	26.00	45.00	49.50	2.72	8.40	7.68
15	25.00	45.00	49.00	5.50	5.60	8.40	26.00	46.00	48.00	5.00	5.20	7.79
30	25.00	44.00	62.00	4.50	7.20	7.21	25.00	46.00	58.00	5.00	6.40	6.86
45	31.00	45.00	49.00	2.50	10.80	8.65	31.00	46.00	51.00	3.00	8.40	8.50
60	34.00	43.00	50.00	3.50	16.00	9.51	34.00	46.00	51.00	3.50	7.80	9.05
75	31.00	40.00	64.00	4.00	8.40	7.53	31.00	45.00	61.00	4.00	6.80	6.91
90	31.00	36.00	57.00	8.00	12.80	7.58	31.00	39.00	59.00	7.50	6.40	6.79
105	32.00	44.00	53.00	12.00	8.80	7.69	32.00	45.00	48.00	10.50	8.40	6.63
120	35.00	38.00	45.00	25.00	11.20	7.89	35.00	40.00	45.00	22.50	8.40	6.72

Table 2. Physico-chemical Parameters of water in the two fish ponds during each fortnightly sampling day during January - March (Culture II).

Days	Physico-chemical Parameters											
	Pond A						Pond B					
	Temperature (°C)	Transparency (cm)	Water depth (cm)	Salinity (ppt)	Dissolved Oxygen (ppm)	pH	Temperature (°C)	Transparency (cm)	Water depth (cm)	Salinity (ppt)	Dissolved Oxygen (ppm)	pH
1	33.00	42.00	55.00	12.00	4.00	8.50	33.00	42.00	45.00	10.50	4.40	6.50
15	31.00	40.00	53.00	16.26	3.60	8.20	30.00	43.00	49.00	21.19	9.60	7.38
30	32.00	41.00	49.00	30.02	8.80	9.06	32.00	41.00	52.00	31.05	8.40	7.40
45	32.00	36.00	54.00	29.25	8.00	9.00	32.00	40.00	51.00	28.00	7.60	7.20
60	32.00	43.00	57.00	25.50	14.80	9.16	32.00	4.00	55.00	25.00	7.80	7.00

Table 3. Physico-chemical parameters of water in the two fish ponds during each fortnightly sampling day during mid May-June. (Culture III)

Physico-chemical parameters												
	Pond A						Pond B					
Days	Temperature (°C)	Transparency (cm)	Water depth (cm)	Salinity (ppt)	Dissolved oxygen (ppm)	pH	Temperature (°C)	Transparency (cm)	Water depth (cm)	Salinity (ppt)	Dissolved oxygen (ppm)	pH
1	31.00	44.00	56.00	20.26	7.68	9.00	31.00	42.00	55.00	18.02	7.36	8.50
15	32.00	36.00	54.00	14.76	10.88	10.00	32.00	38.00	56.00	16.72	8.96	8.30
30	28.00	43.00	53.00	9.84	8.00	7.50	28.00	44.00	56.00	9.34	7.68	8.50
45	33.00	43.00	55.00	7.50	12.16	8.00	33.00	42.00	57.00	8.00	5.12	8.00


Sal n ty (ppt)
35
30
25
20
10
Temperature (°c)
D ssolved oxygen (ppm)
20
16
12
8
4
pH
12
8
4
Days
0 15 30 45 60 75 90 105 120
0 15 30 45 60
0 15 30 45
Culture No
I
II
III

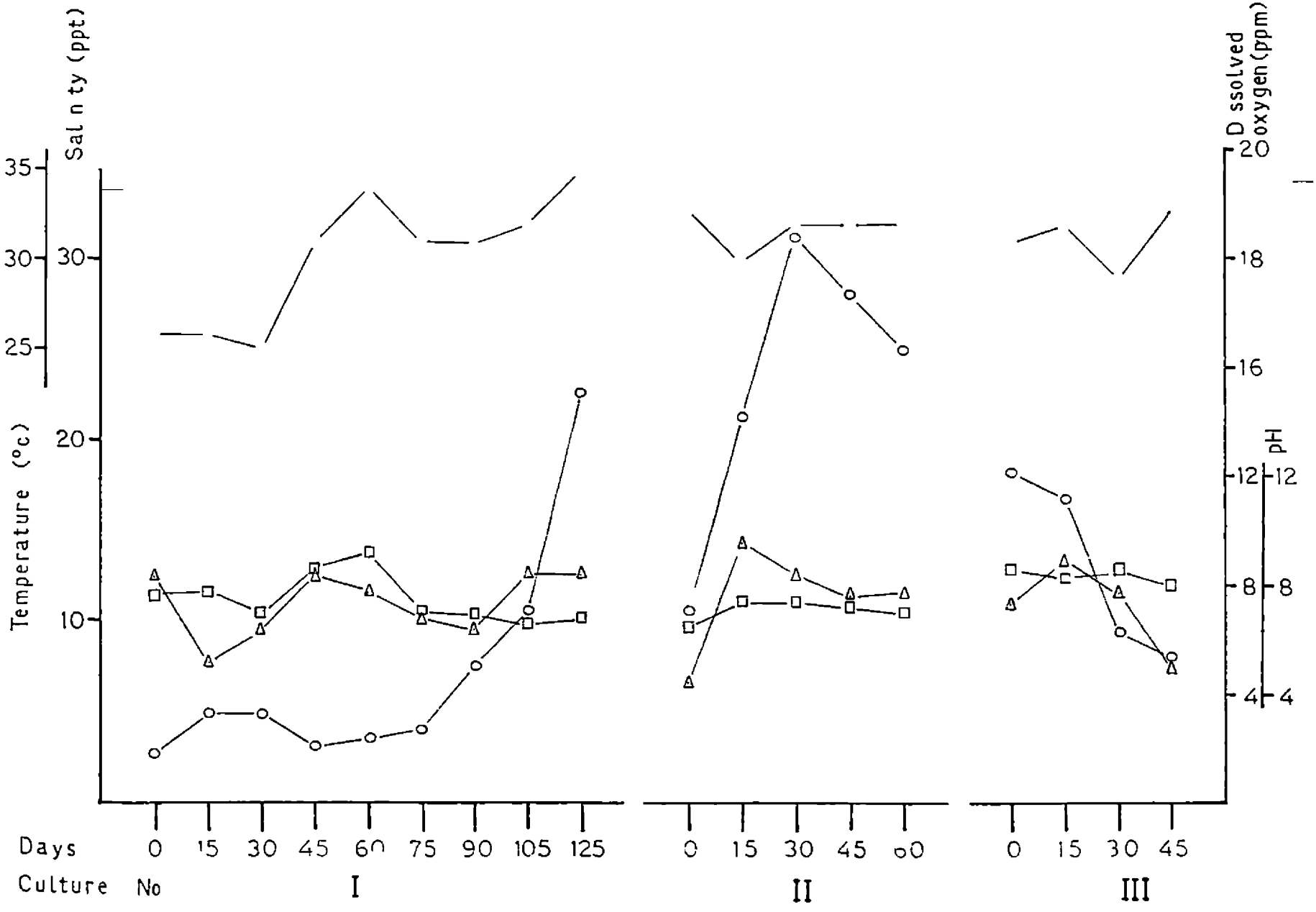

Sal n ty (ppt)
D ssolved oxygen(ppm)
Temperature (°c)
pH
35
30
25
20
10
18
16
12
8
4
Days
0 15 30 45 60 75 90 105 125
0 15 30 45 oO
0 15 30 45
Culture No
I
II
III

Table 4. Soil characteristics of Pond A on the starting (a) and final day (b) of the three cultures.

		Particle size			Soil Nutrients	
Culture	Day	Sand(%)	Silt(%)	Clay(%)	Organic carbon (%)	Available phosphorus (mgp/100g soil)
I	a	89	3	8	1.01	0.427
	b	89	3	8	1.22	0.342
II	a	89	3	8	0.94	0.683
	b	89	3	8	1.72	0.615
III	a	89	3	8	0.92	0.275
	b	89	3	8	1.38	0.295

Table 5. Soil characteristics of the Pond B on the starting (a) and final day (b) of the three cultures.

		Particle size			Soil Nutrients	
Culture	Day	Sand(%)	Silt(%)	Clay(%)	Organic carbon (%)	Available phosphorus (mgp/100g soil)
I	a	89	3	8	0.50	0.384
	b	89	3	8	1.55	0.384
II	a	89	3	8	1.38	0.598
	b	89	3	8	1.42	0.629
III	a	89	3	8	0.53	0.388
	b	89	3	8	0.87	0.380

3.2 PHYTOPLANKTON PRIMARY PRODUCTION

Fluctuations in phytoplankton primary production (net and gross) values in mg $C/m^3/6$ hrs in the two ponds during the culture periods are given in Table 6 and in Figs. 6 and 7. There were marked differences between the primary (net and gross) production values of ponds A and B.

The lowest net primary production value, 120 mg $C/m^3/6$ hrs was observed on the 60th day in Pond A and on the 75th day in Pond B, during Culture I. The highest net primary production value i.e., 4680 mg $C/m^3/6$ hrs in Pond A and that in Pond B i.e, 3240 mg $C/m^3/6$ hrs were observed on the 90th day during Culture I. The lowest gross primary production value, 720 mg/$C/m^3/6$ hrs was observed on the 45th day, and 240 mg $C/m^3/6$ hrs on the 75th day in ponds A and B, respectively during Culture I. The highest gross primary production values 5760 mg $C/m^3/6$ hrs and 3720 mg $C/m^3/6$ hrs were observed on the 90th day in ponds A and B respectively, during Culture I.

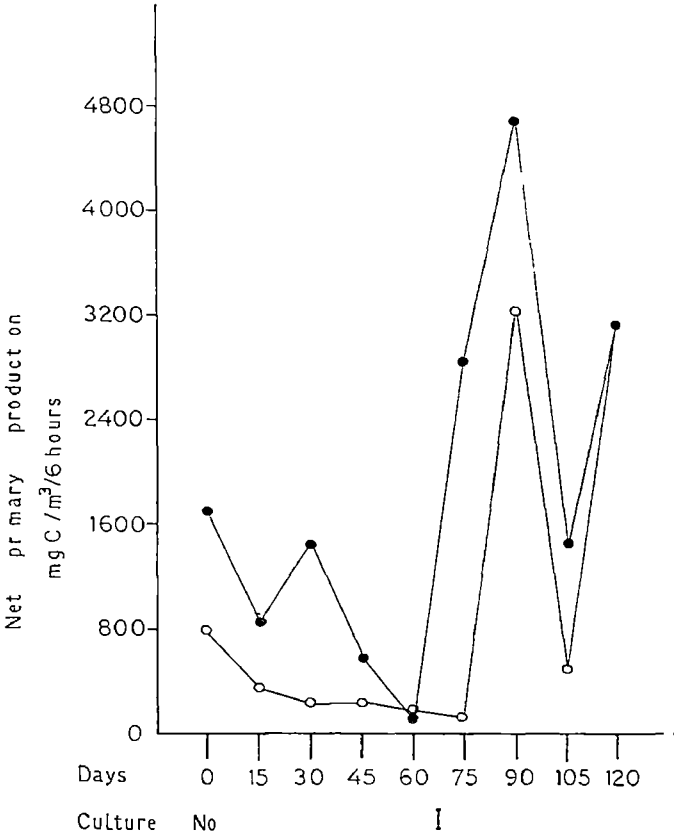
During Culture II, the lowest net primary production valueof 1140 mg $C/m^3/6$ hrs was observed on the 15th day in Pond A and that of 720 mg $C/m^3/6$ hrs on the starting day in Pond B. The highest value of 2640 mg $C/m^3/6$ hrs was observed on the 45th day in Pond A, while in Pond B, 2160 mg $C/m^3/6$ hrs was recorded on the 60th day. The lowest gross primary production

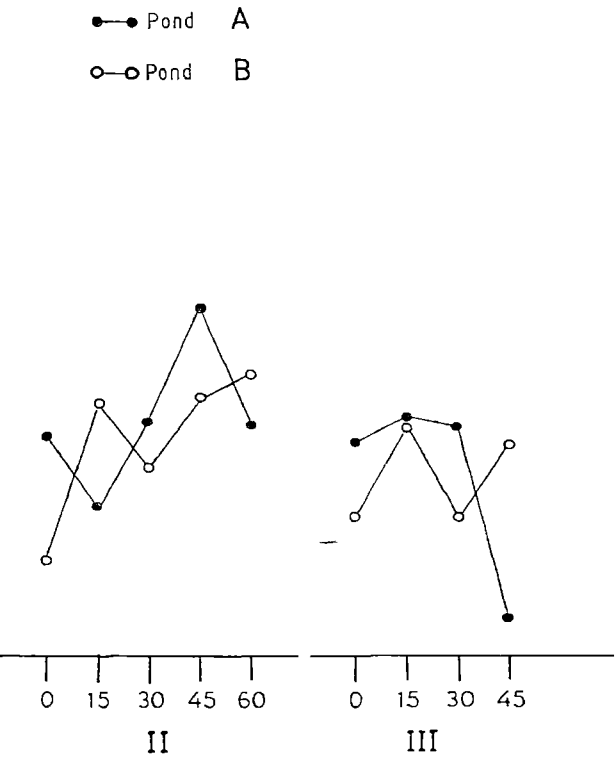
value of 2175 mg $C/m^3/6$ hrs and 840 mg $C/m^3/6$ hrs were observed on the 15th day and on the starting day while the highest value of 3420 mg $C/m^3/6$ hrs and 3240 mg $C/m^3/6$ hrs on the 45th and 15th day in ponds A and B respectively.

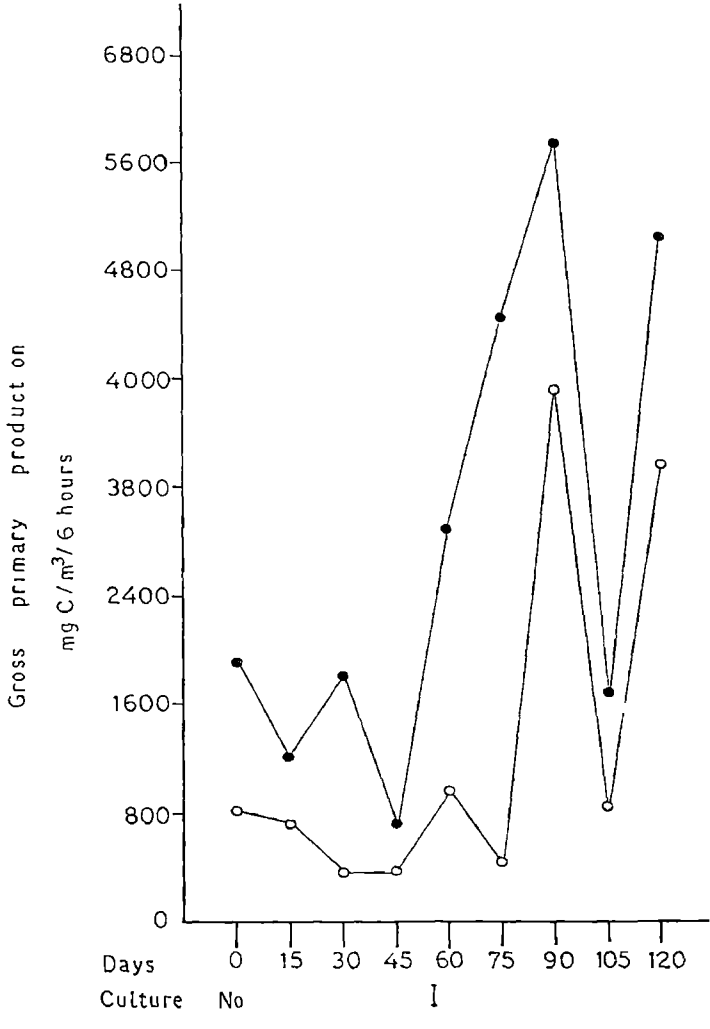
During Culture III, the lowest primary production values 288 mg $C/m^3/6$ hrs and 1056 mg $C/m^3/6$ hrs were observed on the 45th day and on the starting day, while the highest values 1824 mg $C/m^3/6$ hrs and 1728 mg $C/m^3/6$ hrs were noted on the 15th day in ponds A and B respectively. The lowest gross primary production values, 1920 mg $C/m^3/6$ hrs and 1440 mg $C/m^3/6$ hrs were observed on the 45th day and on the starting day, while the highest values, 4800 mg $C/m^3/6$ hrs and 3936 mg $C/m^3/6$ hrs on the 15th day in ponds A and B respectively. It can be noted from Table 6 as well as Figs. 6 and 7 that on majority of the sampling days the net and gross primary production values were higher in Pond A than in Pond B during all the three cultures.

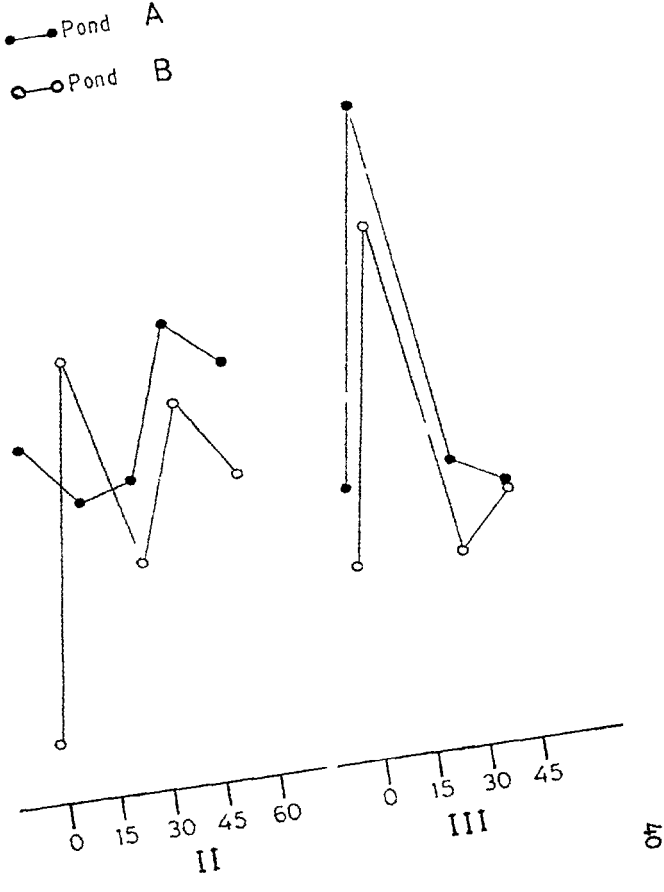
Table 6. Fluctuations in primary production (net and gross) in $mgC/m^3/6$ hrs in the two ponds during the three cultures.

Culture No.	Days	Pond A		Pond B	
		Net primary production	Gross primary production	Net primary production	Gross primary production
I	0	1680	1920	780	1020
	15	840	1200	360	720
	30	1560	1800	240	360
	45	600	720	240	360
	60	120	2880	180	960
	75	2640	4440	120	240
	90	4680	5760	3240	3720
	105	1440	1680	480	840
	120	>120	5040	>120	3360
II	0	1680	2640	720	840
	15	1140	2175	1920	3240
	30	1800	2280	1440	1680
	45	2040	3420	1980	2820
	60	1860	>060	2160	2640
III	0	1632	2016	1056	1440
	15	1824	4800	1728	3096
	30	1728	2112	1152	1>>0
	45	288	1920	1632	1824


Net primary production
mg C /m³/6 hours
4800
4000
3200
2400
1600
800
0
Days
0
15
30
45
60
75
90
105
120
Culture No
I


Pond A
Pond B
0 15 30 45 60
II
0 15 30 45
III


Gross primary product on
mg C / m³ / 6 hours
6800
5600
4800
4000
3800
2400
1600
800
0
Days
0
15
30
45
60
75
90
105
120
Culture No
I


Pond A
Pond B
0 15 30 45 60
II
0 15 30 45
III

3.3 SECONDARY PRODUCTION

3.3.1 ZOOPLANKTON

Abundance of zooplankton groups in mg/m^3 wet weight, their dominance in percentage and frequency of occurrence in the two ponds during each culture period are given in Tables 7 to 12. The zooplankton consisted mainly of rotifers, copepods and nauplii throughout the duration of the three cultures.

During Culture I, biomass of rotifers showed a minimum of 1.230 mg/m^3 and 3.690 mg/m^3 on the final day in Pond A, and on the 30th as well a on the 75th day in Pond B respectively. The maximum biomass of rotifers 405.900 mg/m^3 and 360.390 mg/m^3 were noted on the 90th day and on the 15th day in Ponds A and B respectively. Biomass of copepods showed a minimum of 7.200 mg/m^3 on the 15th day in Pond A and of 4.800 mg/m^3 on the 60th as well as on the 75th day in Pond B. Copepods showed the maximum of 168 mg/m^3 on the 30th day in Pond A and in Pond B the maximum of only 16.800 mg/m^3 on the 45th day. The lowest biomass value of nauplii, 0.285 mg/m^3 was observed on the final day in Pond A and on the 15th, 60th and 120th day in Pond B. The maximum biomass of nauplii was 12.420 mg/m^3 noted on the starting day in Pond A and that in Pond B, 1.571 mg/m^3 on the 105th day (see Tables 7 and 8; Figs. 8 and 9).

During Culture II, biomass of rotifers was at its minimum, being 27.060 mg/m^3 and of 3.690 mg/m^3 on the 30th day in Pond A and on the starting day in Pond B respectively. The maximum biomass of rotifers, 4797 mg/m^3 occurred on the 45th day in Pond A while in Pond B the maximum was only 282.900 mg/m^3, occurred on the 15th day. The minimum biomass of copepods, 4.800 mg/m^3 was observed on the 30th day in Pond A and on the starting day in Pond B, while the highest values of 100.800 mg/m^3 and 26.400 mg/m^3 were recorded on the starting day as well as on the 15th day in Pond A and on the 60th day in Pond B respectively. Biomass of nauplii showed its minimum values of 0.286 mg/m^3 and 0.571 mg/m^3 on the 30th day in Pond A and on the 45th day in Pond B, while the maximum values of 7.140 mg/m^3 and 10.995 mg/m^3 were noted on the 60th day in ponds A and B respectively (see Tables 9 and 10, Figs. 10 and 11).

During Culture III, the lowest biomass values of rotifers, 93.480 mg/m^3 and of 7.380 mg/m^3 were observed on the 45th day in Pond A and on the 15th day in Pond B respectively, while the highest values, 4551 mg/m^3 and 1211.550 mg/m^3 were noted on the 30th day in Pond A and on the starting day in Pond B respectively. Biomass of copepods showed its minimum of 74.400 mg/m^3 and of 31.200 mg/m^3 on the 45th day in ponds A and B respectively. The maximum biomass values of copepods, 878.400 mg/m^3 and

96 mg/m^3 were observed on the 30th day in Pond A and on the starting day in Pond B respectively. The lowest biomass values of nauplii, 9.139 mg/m^3 and 0.996 mg/m^3 were observed on the 45th day in ponds A and B respectively; the highest values, 47.550 mg/m^3 and 9.282 mg/m^3 were noted on the 30th day in Pond A and on the starting day in Pond B respectively (see Tables 11 and 12; Figs. 12 and 13).

From Table 13 and Fig.28 it is obvious that fortnightly zooplankton biomass in Pond A was higher than in Pond B throughout the period , approximately three times higher during Culture I, over ten times higher during Culture II and six times higher during Culture III.

Table 7. Abundance*('a') dominance †('d') and frequency of zooplankton groups in Pond A during Culture I.

Days	Zooplankton groups					
	Rotifers		Copepods		Nauplii	
	a	d	a	d	a	d
0	394.830	94.712	9.620	2.307	12.420	2.979
15	14.760	65.939	7.200	32.159	0.428	1.913
30	24.600	12.585	168.000	85.952	2.856	1.461
45	-	-	40.800	98.619	0.571	1.381
60	13.530	43.784	16.800	54.366	0.571	1.848
75	275.520	94.252	16 800	5.748	-	-
90	405.900	84.930	72.000	15.070	-	-
105	94.710	98.661	-	-	1.285	1.339
120	1.230	3.759	31.200	95.360	0.285	0.881
Frequency	88.888		88.888		77.777	

* Wet weight in mg/m^3

† % of the total wet weight

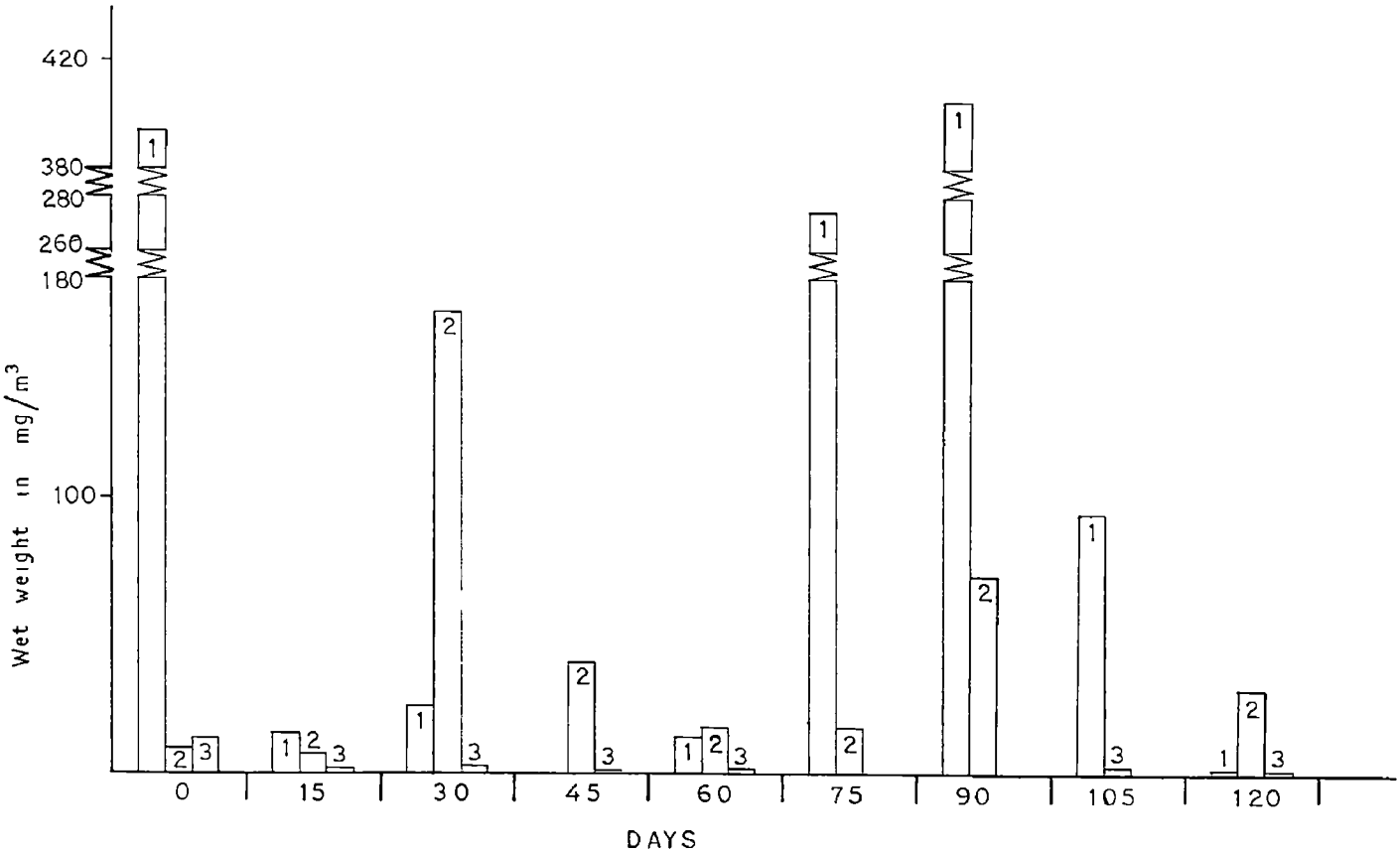

420
380
280
260
180
100
Wet weight in mg/m3
1
2
3
0
15
30
45
60
75
90
105
120
DAYS

Table 8. Abundance *('a') dominance †('d') and frequency of zooplankton groups in Pond B during Culture I.

Days	Zooplankton					
	Rotifers		Copepods		Nauplii	
	a	d	a	d	a	d
0	13.530	63.094	7.200	33.575	0.714	3.331
15	360.390	99.529	-	-	0.285	0.471
30	3.690	22.692	12.000	73.790	0.571	3.512
45	7.380	29.640	16.800	67.486	0.714	2.868
60	-	-	4.800	94.384	0.285	5.616
75	3.690	43.462	4.800	56.540	-	-
90	6.150	33.102	12.000	64.591	0.428	2.305
105	22.140	93.375	-	-	1.571	6.625
120	18.450	71.137	7.200	27.760	0.286	1.101
Frequency	88.888		77.777		88.888	

* Wet weight in mg/m^3

† % of the total wet weight

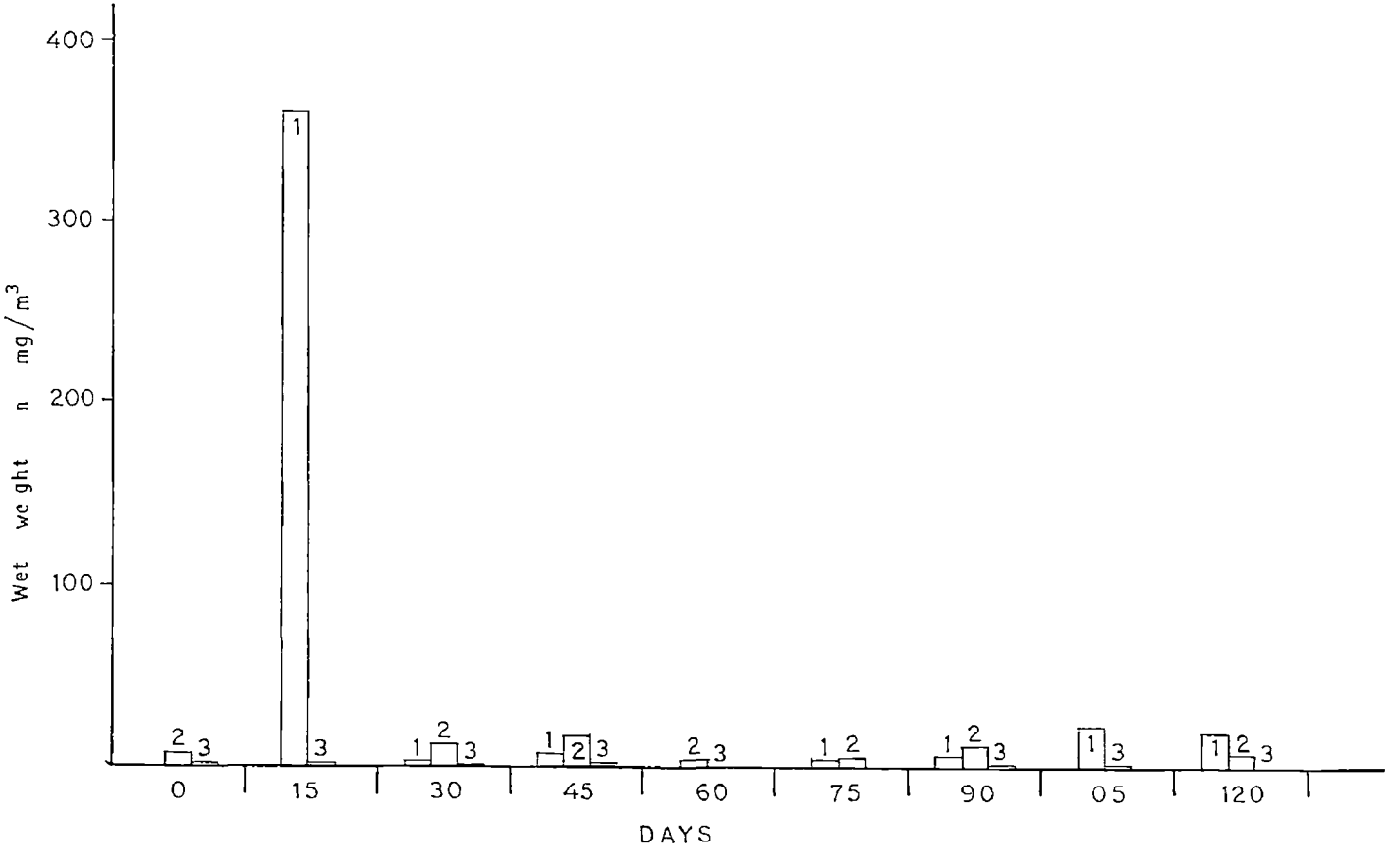

400
300
200
100
Wet weight in mg/m3
0
15
30
45
60
75
90
05
120
DAYS

Table 9. Abundance *('a') dominance †('d') and frequency of zooplankton groups in Pond A during Culture II.

Days	Zooplankton groups					
	Rotifers		Copepods		Nauplii	
	a	d	a	d	a	d
0	82.410	43.920	100.800	53.720	4.426	2.359
15	-	-	100.800	97.244	2.856	2.755
30	27.060	84.179	4.800	14.930	0.286	0.891
45	4797.000	100.000	-	-	-	-
60	276.500	74.240	88.800	23.840	7.140	1.910
Frequency	80		80		80	

* Wet weight in mg/m^3

† % of the total wet weight

Fig.10. Fortnightly fluctuations in the biomass of important zooplankton groups (1. rotifers, 2. copepods and 3. nauplii) in Pond A during Culture II.

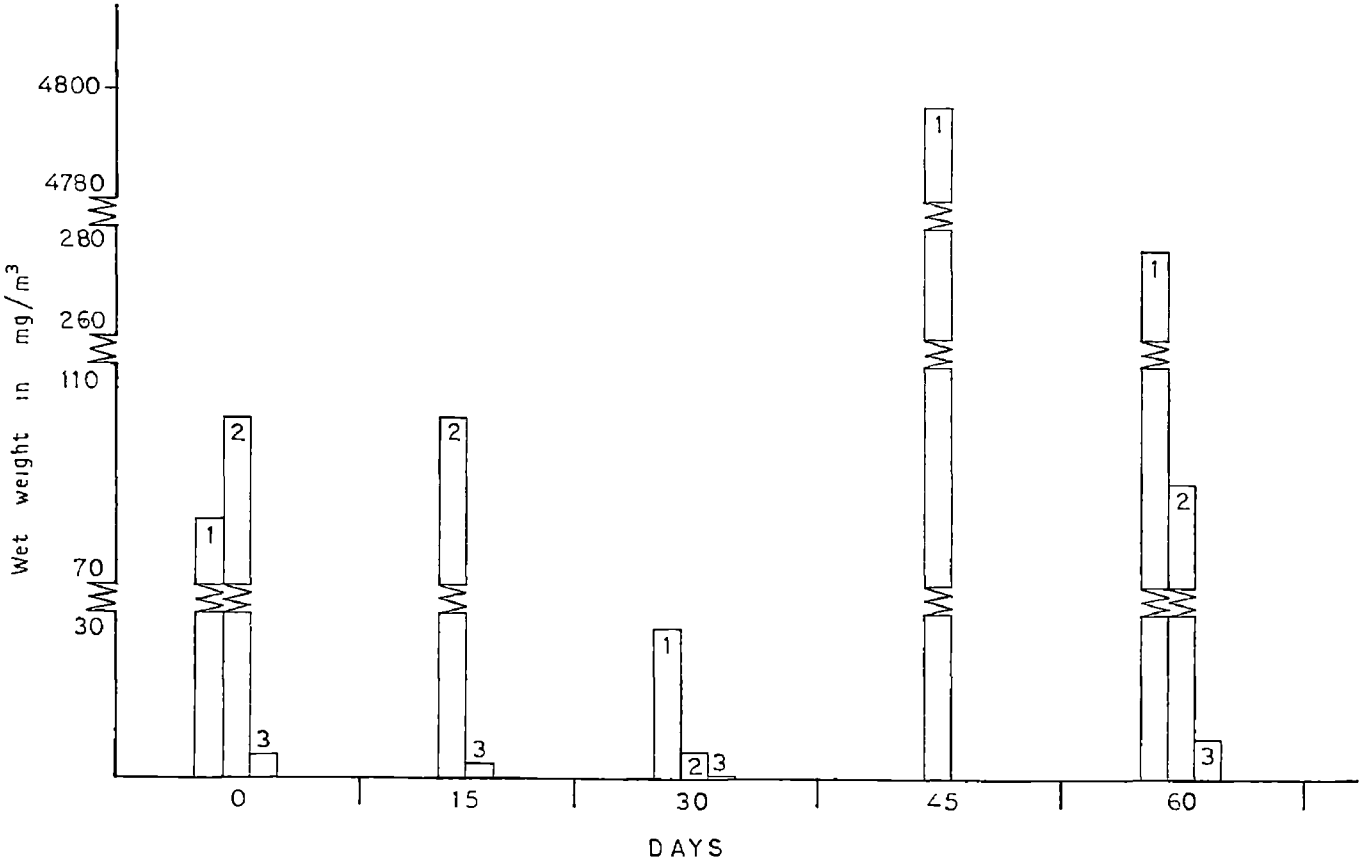

4800
4780
280
260
110
70
30
Wet weight in mg/m3
1
2
3
0
15
30
45
60
DAYS

Table 10. Abundance *('a') dominance†('d') and frequency of zooplankton groups in Pond B during Culture II

Days	Zooplankton groups					
	Rotifers		Copepods		Nauplii	
	a	d	a	d	a	d
0	3.690	40.090	4.800	52.150	0.714	7.750
15	282.900	99.298	-	-	1.999	0.702
30	4.920	31.412	9.600	61.295	1.142	7.293
45	39.360	63.067	21.600	35.104	0.571	0.929
60	123.000	76.685	26.400	16.459	10.995	6.854
Frequency	100		80		100	

* Wet weight in mg/m^3

† % of the total wet weight

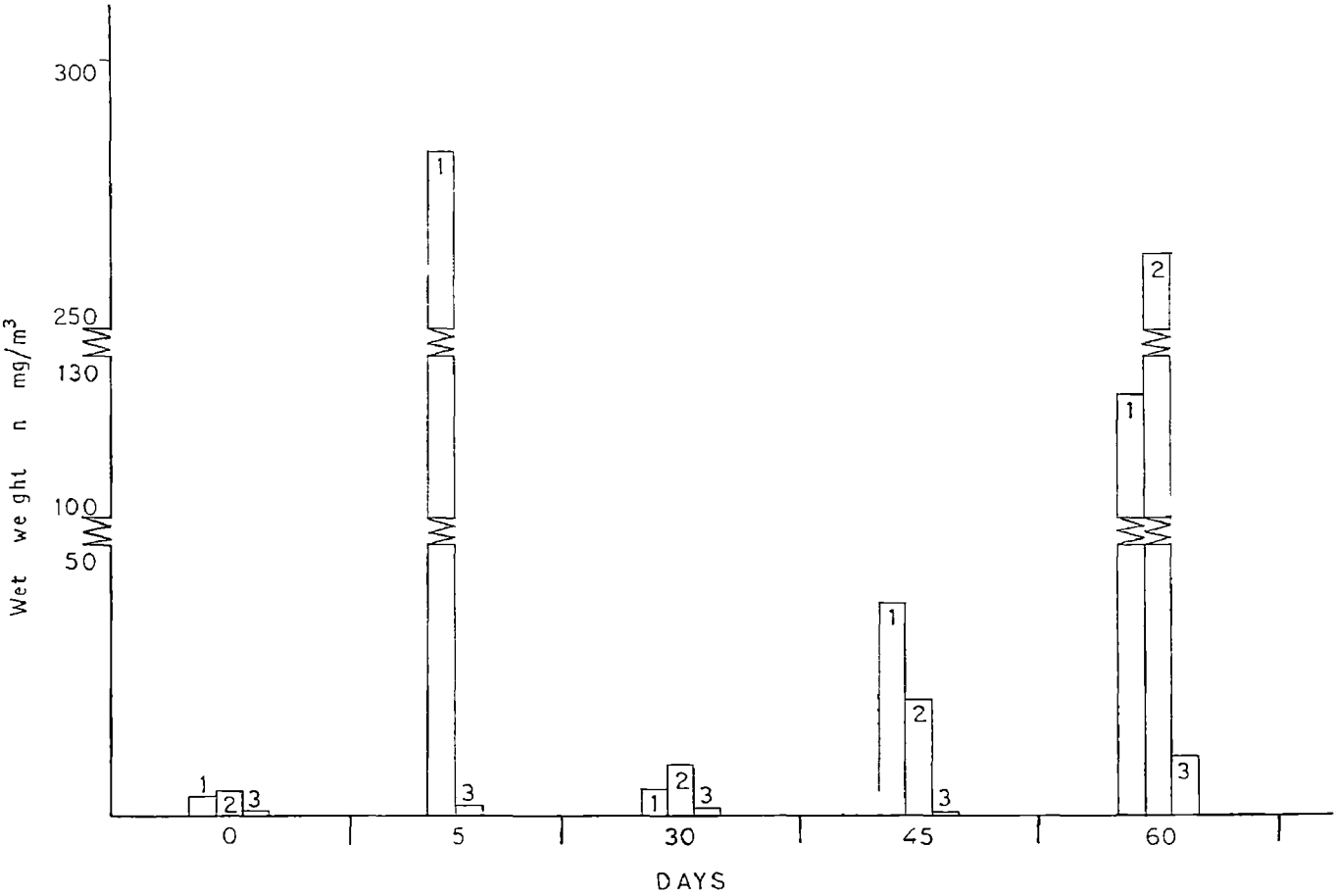
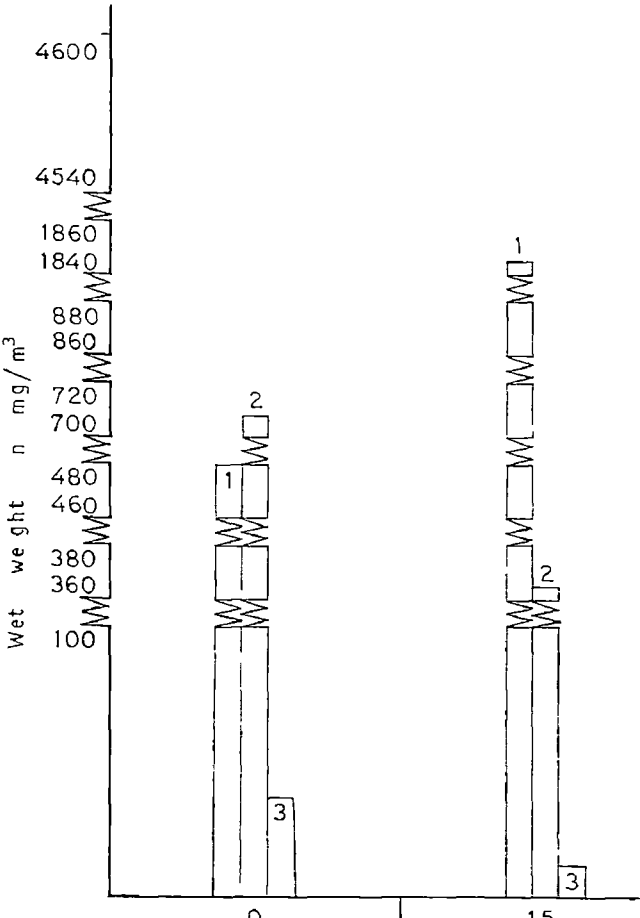

Wet weight in mg/m³
300
250
130
100
50
0
5
30
45
60
DAYS
1
2
3

Table 11. Abundance *('a') dominance †('d') and frequency of zooplankton groups in Pond A during Culture III.

Days	Zooplankton groups					
	Rotifers		Copepods		Nauplii	
	a	d	a	d	a	d
0	479.700	39.187	708.000	57.838	36.414	2.974
15	1845.000	82.972	367.200	16.513	11.424	0.513
30	4551.000	83.093	878.400	16.038	47.550	0.868
45	93.480	52.807	74.400	42.029	9.139	5.162
Frequency	100		100		100	

* Wet weight in mg/m^3

† % of the total wet weight


4600
4540
1860
1840
880
860
720
700
480
460
380
360
100
Wet weight mg/m3
1
2
3
1
2
3
0
15

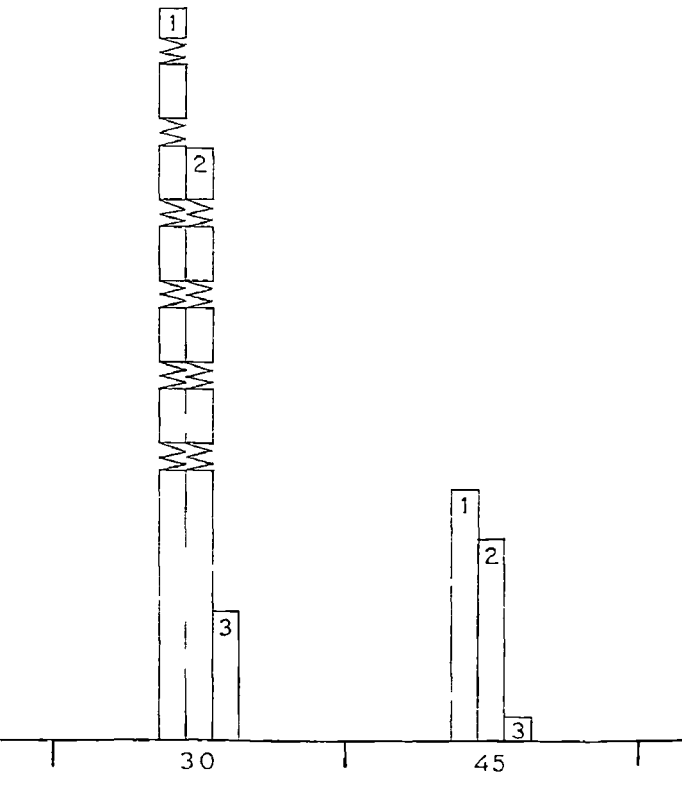
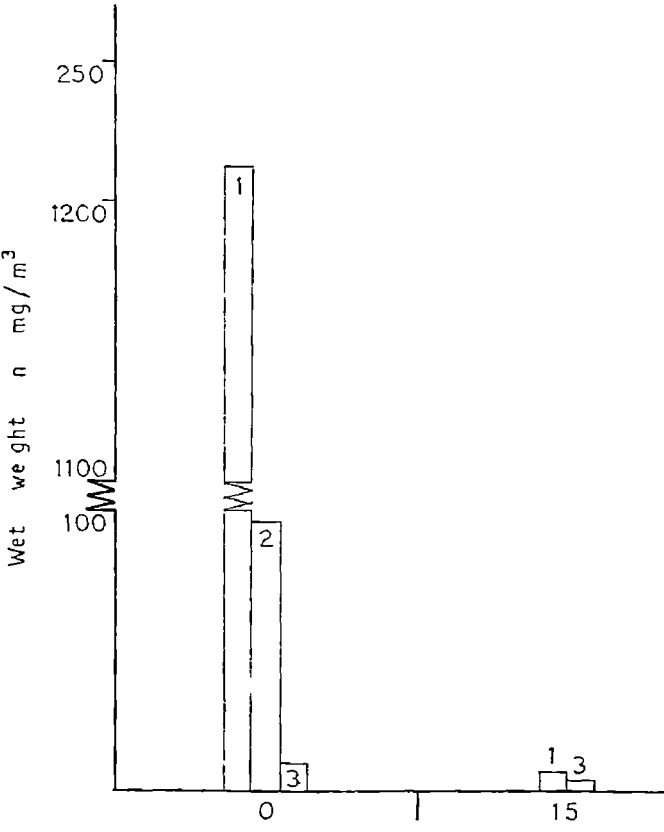

1
2
3
1
2
3
30
45
DAYS

Table 12. Abundance* ('a') dominance †('d') and frequency of zooplankton groups in Pond B during Culture III.

Days	Zooplankton groups					
	Rotifers		Copepods		Nauplii	
	a	d	a	d	a	d
0	1211.550	92.004	96.000	7.290	9.282	0.704
15	7.380	65.687	-	-	3.855	34.313
30	18.450	34.316	33.600	62.490	1.713	3.187
45	12.300	27.640	31.200	70.112	0.999	2.248
Frequency	100		75		75	

* Wet weight in mg/m^3

† % of the total wet weight


250
1200
1100
100
Wet weight in mg/m³
1
2
3
1
3
0
15

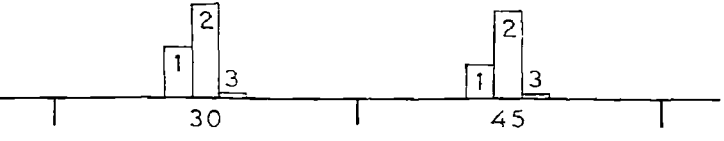

1
2
3
1
2
3
30
45
DAYS

Table 13. Fluctuations in zooplankton biomass (Wet weight in mg/m^3) in the two ponds during the three cultures.

Zooplankton biomass (mg/m^3)			
Culture No.	Days	Pond A	Pond B
I	0	416.870	21.444
	15	22.388	360.675
	30	195.456	16.261
	45	41.371	24.894
	60	30.901	5.085
	75	292.320	8.490
	90	477.900	18.578
	105	95.995	23.711
	120	32.715	25.936
II	0	187.636	9.204
	15	103.656	284.899
	30	32.146	15.662
	45	4797.000	61.531
	60	372.440	160.395
III	0	1224.114	1316.832
	15	2223.624	11.235
	30	5476.950	53.763
	45	177.019	44.499

3.3.2 MEIOBENTHOS

The abundance (wet weight in $\mu g/10cm^2$), dominance (%) and frequency of occurrence of meiobenthic groups in ponds A and B during Culture I,II and III are detailed in Tables 14 to 19 and Figs. 14 to 19. The meiobenthos was mainly constituted by two groups viz, nematodes and copepods, both representing most of the fortnightly samples during the three cultures.

During Culture I, the lowest biomass values of nematodes, 13.08 $\mu g/10cm^2$ and 17.44 $\mu g/10cm^2$ were observed on the 90th day in Pond A and on the starting day in Pond B respectively while the highest values, 1815.44 $\mu g/10cm^2$ and 1510.74 $\mu g/10cm^2$ on the 105th day and on the 60th day in ponds A and B respectively. The biomass of copepods showed its minimum, 15.292 $\mu g/10cm^2$ and 22.938 $\mu g/10cm^2$ on the final day in Pond A and on the 30th day in Pond B respectively, while the maximum values, 512.282 $\mu g/10cm^2$ and 519.928 $\mu g/10cm^2$ occurred on the 105th day in ponds A and B respectively (see Tables 14 and 15; Figs. 14 and 15).

During Culture II, the lowest values of nematode biomass, 102.46 $\mu g/10cm^2$ and 47.960 $\mu g/10cm^2$ were observed on the 30th day in Pond A and on the 60th day in Pond B respectively while the highest values, 1403.92 $\mu g/10cm^2$ and 185.300 $\mu g/10cm^2$ were noted on the 60th day and on the 30th day in ponds A and B respectively. The biomass of copepods showed its minimum

values of 45.876 $\mu g/10cm^2$ and 15.292 $\mu g/10cm^2$ on the 60th day in ponds A and B respectively, while the maximum values, 699.609 $\mu g/10cm^2$ and 263.787 $\mu g/10cm^2$ occurred on the 15th day and on the 30th day in ponds A and B respectively (see Tables 16 and 17, Figs. 16 and 17).

During Culture III, the lowest values of nematode biomass, 17.440 $\mu g/10cm^2$ and 4.360 $\mu g/10cm^2$ were observed on the 15th day in ponds A and B respectively. The highest values of nematodes biomass, 115.540 $\mu g/10cm^2$ and 30.520 $\mu g/10cm^2$ were noted on the 30th day in Pond A and on the starting day in Pond B respectively. The copepod biomass values showed a minimum of 91.752 $\mu g/10cm^2$ and of 30.584 $\mu g/10cm^2$ on the 15th day in Pond A and on the starting day in Pond B respectively, while the maximum values of 2423.782 $\mu g/10cm^2$ and 122.336 $\mu g/10cm^2$ occurred on the 30th day in ponds A and B respectively (see Tables 18 and 19; Figs. 18 and 19).

From Table 20 and Fig. 28 it is apparent that the mean fortnightly biomass from Pond A was higher than that in Pond B throughout the period, slightly over two times, three times and fourteen times higher during Culture I, II and III respectively.

Table 14. Abundance* ('a') dominance †('d') and frequency of meiofauna groups in Pond A during Culture I.

Days	Meiofauna groups			
	Nematodes		Copepods	
	a	d	a	d
0	93.740	43.380	122.330	56.620
15	137.340	34.240	263.787	65.760
30	651.820	74.940	217.910	25.060
45	368.420	61.230	233.203	38.770
60	1722.200	100.000	-	-
75	119.900	83.940	22.933	16.060
90	13.080	36.315	22.938	63.980
105	1815.440	77.992	512.282	22.007
120	318.280	95.410	15.292	4.590
Frequency	100		88.888	

* Wet weight in $\mu g/10cm^2$ surface area

† % of the total wet weight

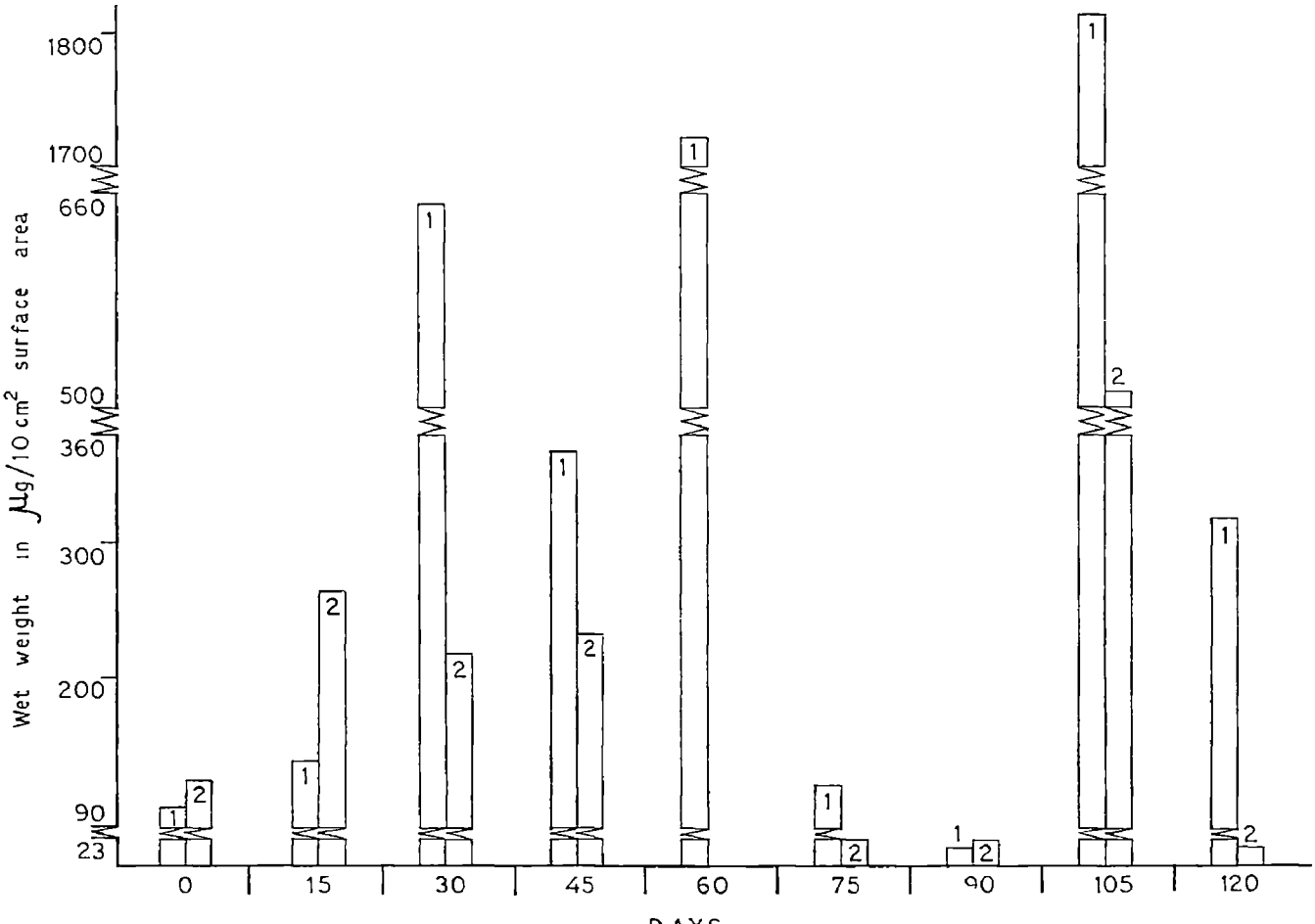
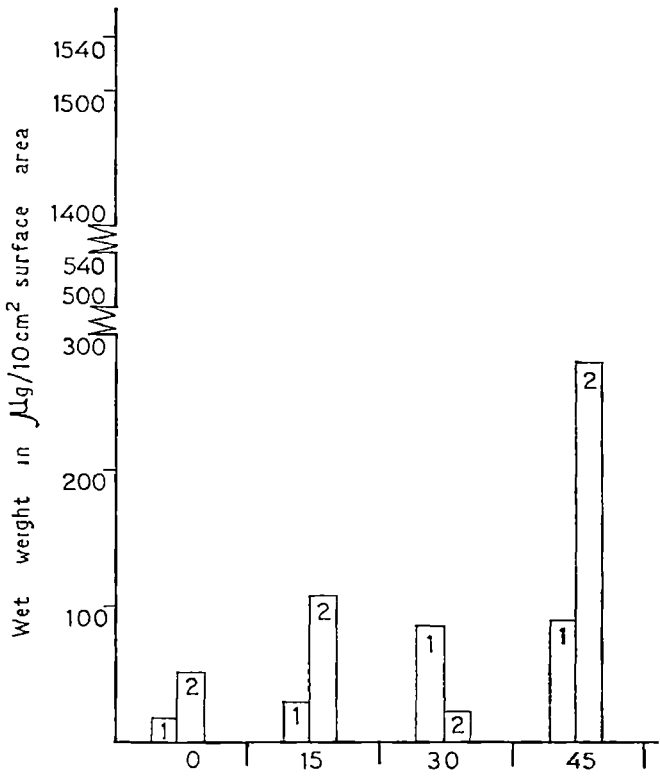

Wet weight in µg/10 cm² surface area
1800
1700
660
500
360
300
200
90
23
0
15
30
45
60
75
90
105
120
DAYS
1
2

Table 15. Abundance *('a') dominance†('d') and frequency of meiofauna groups in Pond B during Culture I.

Days	Meiofauna groups			
	Nematodes		Copepods	
	a	d	a	d
0	17.440	24.570	53.520	75.430
15	30.520	22.180	107.044	77.820
30	85.020	78.750	22.938	21.250
45	80.380	24.250	279.079	75.750
60	1510.740	96.460	45.876	3.540
75	92.740	43.380	122.336	56.620
90	21.800	26.270	61.168	73.730
105	209.280	28.690	519.928	71.310
120	248.520	56.030	194.970	43.970
Frequency	100		100	

* wet weight in $\mu g/10cm^2$ surface area

† % of the total wet weight


Wet weight in µg/10cm² surface area
1540
1500
1400
540
500
300
200
100
1
2
1
2
1
2
1
2
0
15
30
45

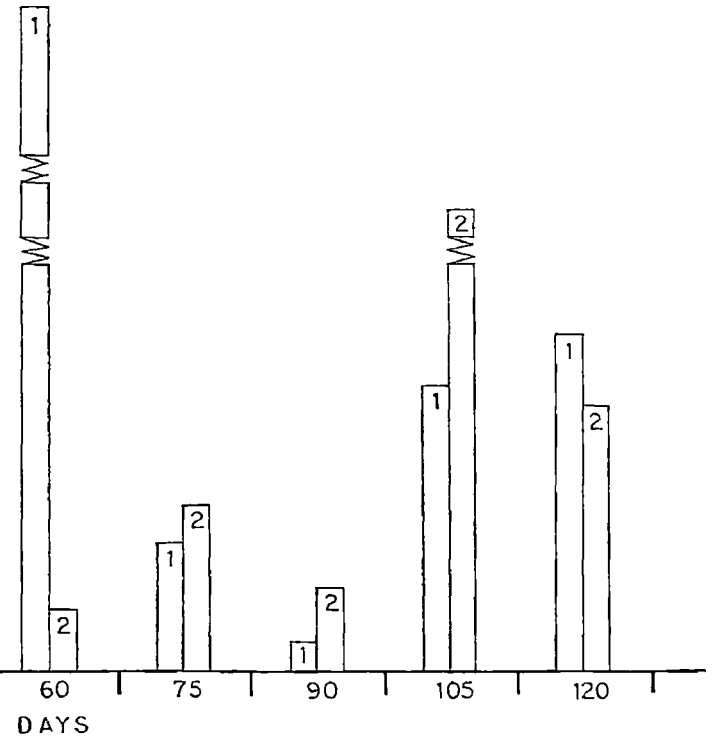

1
2
1
2
1
2
1
2
1
2
60
75
90
105
120
DAYS

Table 16. Abundance *('a'), dominance †('d') and frequency of meiofauna groups in Pond A during Culture II.

Days	Meiofauna groups			
	Nematodes		Copepods	
	a	d	a	d
0	128.620	65.145	68.814	34.855
15	163.500	18.890	699.609	81.110
30	102.460	52.750	91.752	47.250
45	900.340	71.040	367.008	28.960
60	1403.920	96.830	45.876	3.170
Frequency	100		100	

* Wet weight in $\mu g/10cm^2$ surface area

† % of the total wet weight

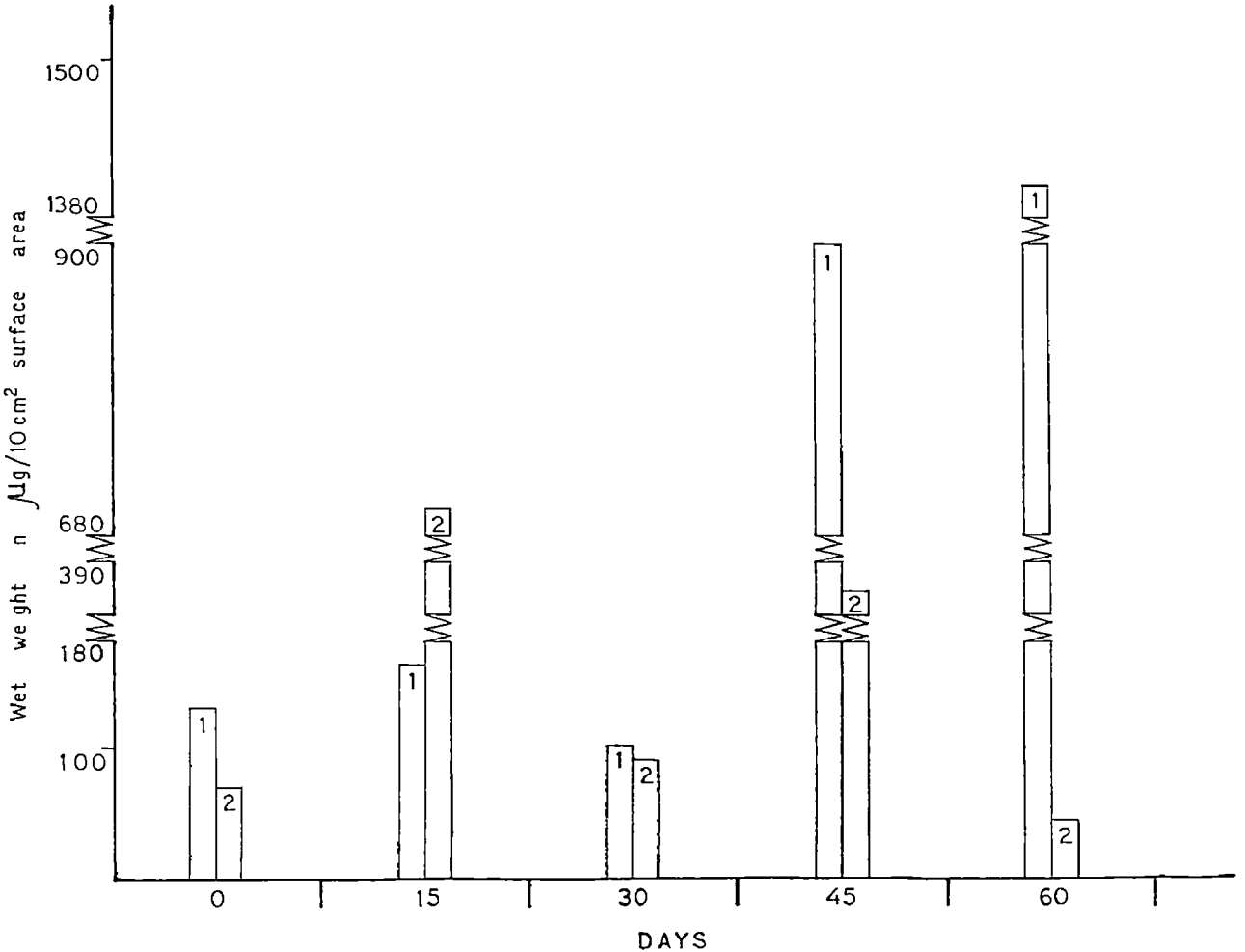
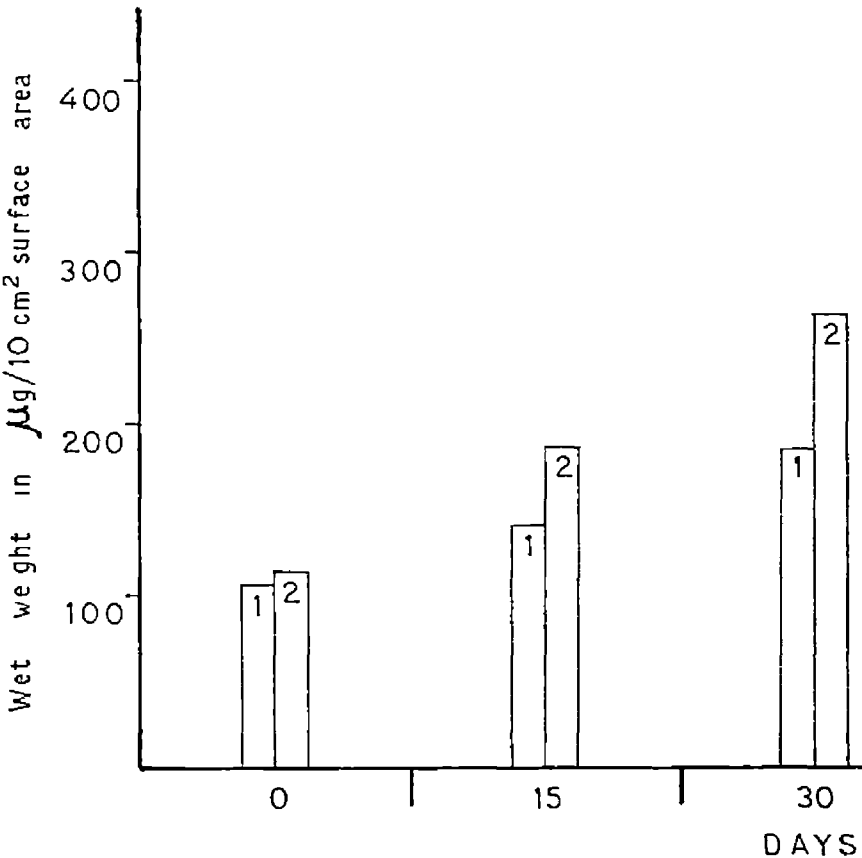

1500
1380
900
680
390
180
100
Wet weight in µg/10 cm² surface area
1
2
0
15
30
45
60
DAYS

Table 17. Abundance *('a'), dominance †('d') and frequency of meiofauna groups in Pond B during Culture II.

Days	Meiofauna groups			
	Nematodes		Copepods	
	a	d	a	d
0	106.820	48.220	114.690	51.780
15	141.700	43.060	187.327	56.940
30	185.300	41.260	263.787	58.740
45	137.850	56.198	107.044	43.802
60	47.960	75.823	15.292	24.177
Frequency	100		100	

* Wet weight in $\mu g/10cm^2$ surface area

† % of the total wet weight


Wet weight in µg/10 cm² surface area
400
300
200
100
1
2
1
2
1
2
0
15
30
DAYS

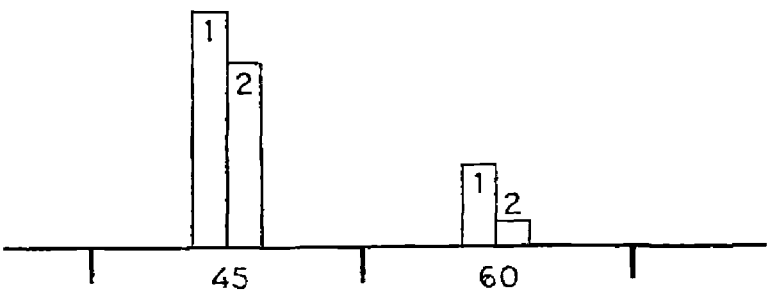

1
2
1
2
45
60

Table 18. Abundance *('a'), dominance †('d') and frequency of meiofauna groups in Pond A during Culture III.

Days	Meiofauna groups			
	Nematodes		Copepods	
	a	d	a	d
0	47.960	21.800	172.035	78.200
15	17.440	15.970	91.752	84.030
30	115.540	4.550	2423.782	95.450
45	34.880	2.097	1628.598	97.903
Frequency	100		100	

* Wet weight in $\mu g/10cm^2$ surface area

† % of the total wet weight

Wet weight in µg/10cm² surface area
2440
2400
1640
1600
180
100
1
2
1
2
0
15

2
2
1
1
30
45
DAYS

Table 19. Abundance *('a'), dominance †('d') and frequency of meiofauna groups in Pond B during Culture III.

Days	Meiofauna groups			
	Nematodes		Copepods	
	a	d	a	d
0	30.520	49.947	30.584	50.052
15	4.360	7.533	53.522	92.467
30	8.720	6.660	122.336	93.340
45	-	-	61.168	100.000
Frequency	75		100	

* Wet weight in $\mu g/10cm^2$ surface area

† % of the total wet weight

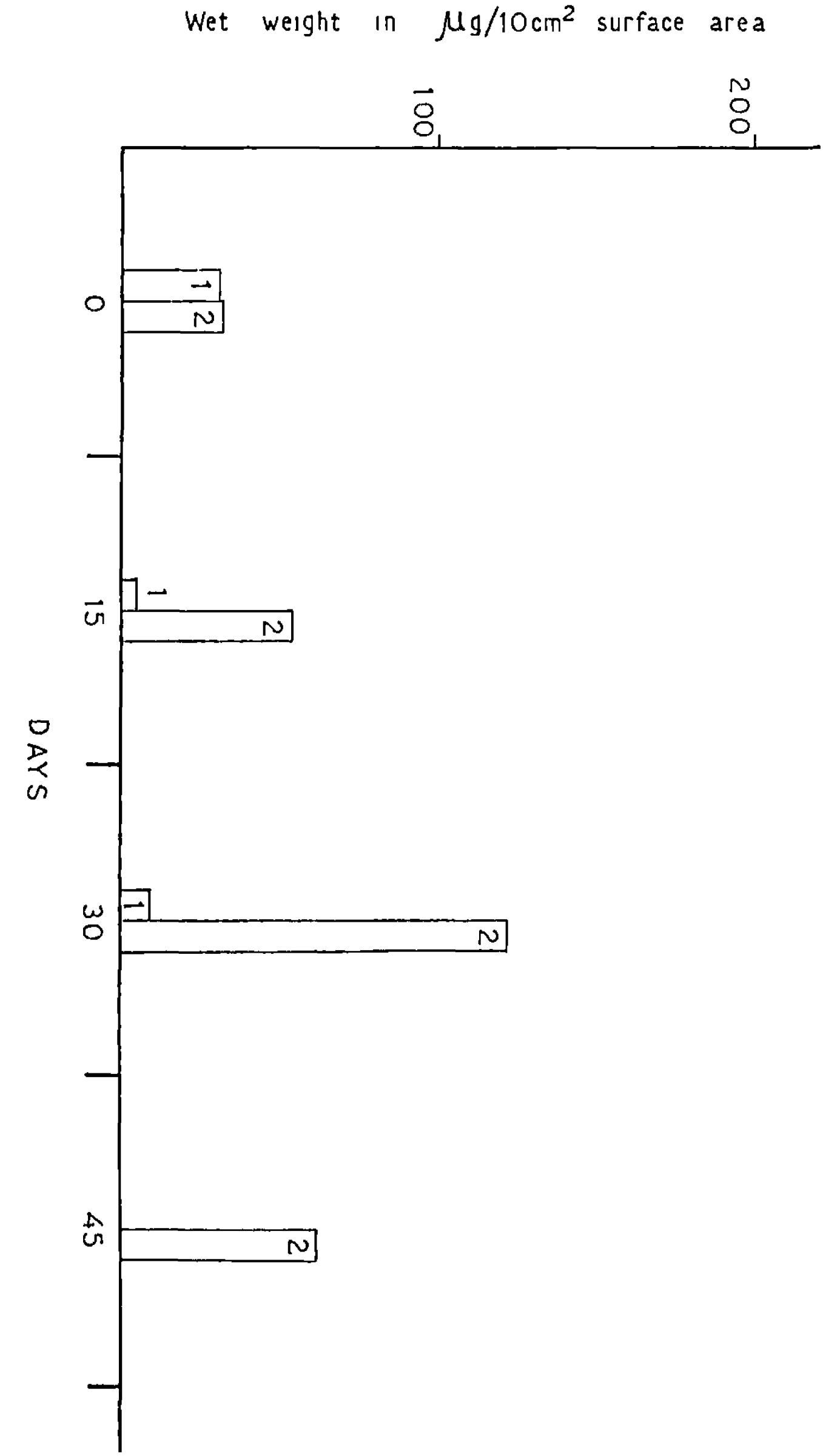

Wet weight in µg/10cm² surface area
100
200
0
15
30
45
1
2
DAYS

Table 20. Fluctuations in meiofauna biomass (Wet weight in $\mu g/10cm^2$) in the two ponds during the three cultures.

Culture No.	Days	Meiofauna biomass $\mu g/10cm^2$ Pond A	Pond B
I	0	216.070	70.96
	15	401.127	137.564
	30	869.730	107.958
	45	601.623	368.459
	60	1722.200	1556.616
	75	142.833	216.076
	90	36.018	82.968
	105	2327.722	729.208
	120	333.572	443.490
II	0	197.434	221.510
	15	863.109	329.027
	30	194.212	449.087
	45	1267.348	244.894
	60	1449.796	63.252
III	0	219.995	61.104
	15	109.192	57.882
	30	2539.322	131.056
	45	1663.478	61.168

3.3.3 MACROBENTHOS

The abundance (wet weight in g/m^2), dominance (%) and frequency of occurrence of macrobenthic groups encountered in the fortnightly samples are given in tables 21 to 26 and Fig. 20 to 25. The macrobenthos was mainly composed of amphipods with a frequency of 77.77,80 and 50 in Pond A and 33.33,40 and 75 in Pond B during cultures I,II and III respectively. It was followed by tanaids with a frequency of 33.33,80 and 50 in Pond A and 22.22,40 and 50 in Pond B during cultures I,II and III respectively. Polychaetes were observed in Pond A with a frequency of 33.33,80 and 50 and in Pond B, with a frequency of 22.22 and 60 during cultures I and II respectively. They were completely absent from Pond B during Culture III. The black clam Villorita cyprinoides var. cochinensis was present in Pond B throughout the three cultures, but it was completely absent from Pond A.

During Culture I, the lowest values of amphipod biomass, 0.035 g/m^2 and 0.640 g/m^2 were observed on the 90th day in Pond A and on the 105th day in Pond B respectively, while the highest values of 7.568 g/m^2 and 1.056 g/m^2 were noted on the 45th and 90th day in ponds A and B respectively. The biomass value of tanaids showed its minimum of 0.880 g/m^2 and 0.688 g/m^2 occurred on the 120th day and 90th day in ponds A and B respectively. The polychaete biomass values showed a minimum of 0.230 g/m^2 and a maximum of 23.200 g/m^2 on the final and

105th day respectively in Pond A, while in Pond B, the biomass values of polychaetes showed a minimum 0.688 g/m^2 on the 90th day and maximum, 1.552 g/m^2 on the 30th day. The lowest biomass value of chironomids, 4.539 g/m^2 was observed on the starting day while the highest biomass value, 9.880 g/m^2 on the 30th day in Pond A. In Pond B, the maximum biomass value of V cyprinoides var. cochinensis, 7200 g/m^2 was observed on the 60th day while the minimum biomass value, 160 g/m^2 on the 15th day (see Tables 21 and 22, Figs. 20 and 21).

During Culture II, the lowest values of amphipod biomass, 5.024 g/m^2 and 2.672 g/m^2 were observed on the 45th day in Pond A and on the 15th day in Pond B respectively while the highest biomass values, 6.400 g/m^2 and 2.720 g/m^2 on the 15th and 30th day in ponds A and B respectively. The biomass values of tanaids showed a minimum of 2.152 g/m^2 and 0.48 g/m^2 on the 45th day in Pond A and on the 15th day in Pond B respectively, while the maximum values, 6.112 g/m^2 and 1.44 g/m^2, on the 15th and 30th day in ponds A and B respectively. The lowest values of polychaete biomass,4.512 g/m^2 and 0.480 g/m^2 were observed on the 60th day in Pond A and on the 15th day in Pond B respectively. The highest values, 30.562 g/m^2 and 1.552 g/m^2 on the 15th and 30th day in ponds A and B respectively. In Pond B, the lowest biomass value of V. cyprinoides var. cochinensis, 192.00 g/m^2 was observed on the 30th day while the highest value, 5902 g/m^2 on the fifteenthday (see Tables 23 and 24, Figs. 22 and 23).

During Culture III, the lowest values of amphipod biomass, 0.816 g/m^2 and 0.144 g/m^2 were observed on the 30th day in Pond A and on the 45th day on Pond B respectively, while the highest values, 3.019 g/m^2 and 4.240 g/m^2 on the 45th and on the starting day in ponds A and B respectively. Tanaid biomass values showed a minimum of 0.128 g/m^2 on the 30th day in both the ponds, while the highest values, 3.120 g/m^2 and 1.120 g/m^2 on the 45th day in Pond A and on the starting day in Pond B. The lowest value of polychaete biomass, 2.960 g/m^2 was observed on the 45th day while the highest value, 2.991 g/m^2 on the starting day in Pond A. The V. cyprinoides var. cochinensis biomass value showed its minimum of 4.800 g/m^2 on the 45th day, while the maximum value of 316.20g/m^2 on the Ist day in Pond B during Culture III (see Tables 25 and 26, Figs.24 and 25).

In comparison with Pond A, the biomass and frequency of occurrence of macrobenthic groups viz., amphipods, tanaids and polychaetes in Pond B were low. The black clam V. cyprinoides var. cochinensis constituted the most dominant macrofauna in Pond B. Insect larvae were totally absent from Pond B during the three cultures. From Table 27 and Fig. 28 it is obvious that the mean macrobenthos biomass value excluding the black clam was about two times greater in Pond A than that in Pond B, during Culture I. The corresponding value was about six times and two times higher in Pond A than in Pond B during Culture II and III respectively.

Table 21. Abundance * ('a') dominance † ('d') and frequency of macrofauna groups in Pond A during Culture I.

	Macrofauna groups									
	Amphipod		Tanaids		Polychaetes		Chironomids		Nuculana sp.	
	a	d	a	d	a	d	a	d	a	d
0	-	-	-	-	-	-	4.539	100.000	-	-
15	-	-	-	-	-	-	9.040	100.000	-	-
30	-	-	-	-	-	-	9.880	100.000	-	-
45	7.568	75.348	1.964	19.550	0.512	5.090	-	-	-	-
60	0.904	100.000	-	-	-	-	-	-	-	-
75	1.115	100.000	-	-	-	-	-	-	-	-
90	0.035	100.000	-	-	-	-	-	-	-	-
105	2.640	3.241	5.968	7.339	23.200	28.480	-	-	49.636	60.940
120	3.179	73.974	0.880	20.664	0.230	5.362	-	-	-	-
Frequency	77.77		33.33		33.33		33.333		11.11	

* Wet weight in g/m^2 surface area

† % of the total wet weight

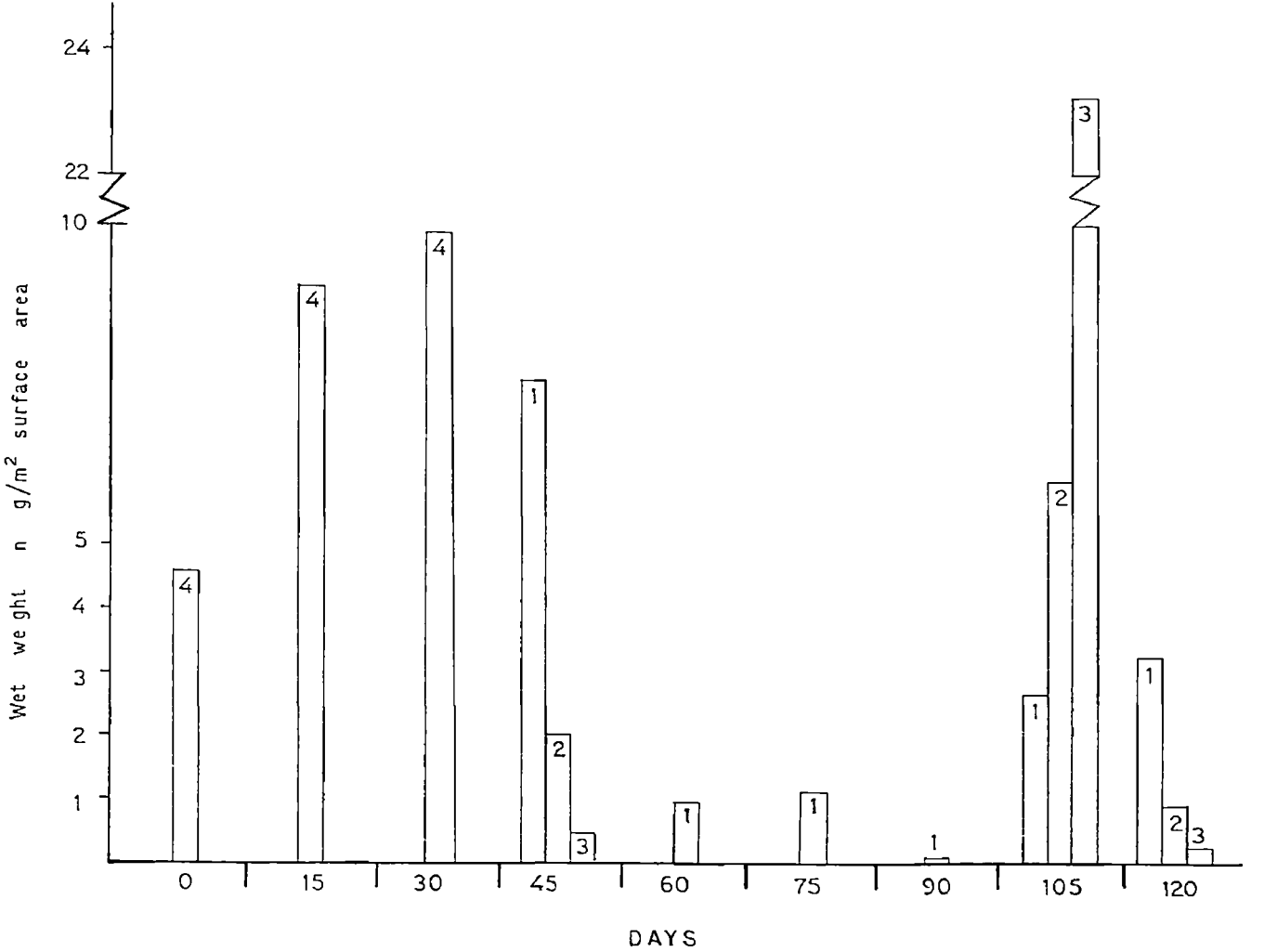
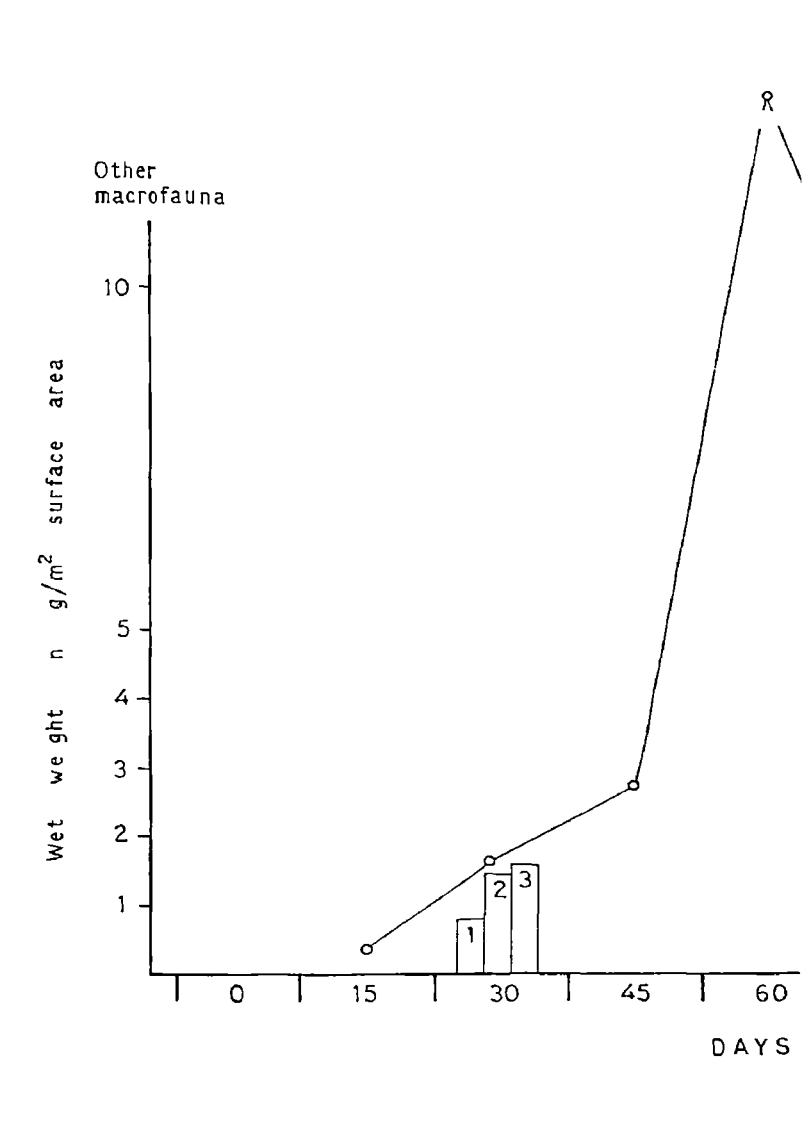

Wet weight n g/m² surface area
24
22
10
5
4
3
2
1
0
15
30
45
60
75
90
105
120
DAYS

Table 22. Abundance *('a') dominance †('d') and frequency of macrofauna groups in Pond B during Culture I.

Days	Macrofauna groups							
	Amphipods		Tanaids		Polychaetes		Villorita sp.	
	a	d	a	d	a	d	a	d
0	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	160	100.000
30	0.768	0.1085	1.440	0.203	1.552	0.214	704	99.468
45	-	-	-	-	-	-	1200	100.000
60	-	-	-	-	-	-	7200	100.000
75	-	-	-	-	-	-	3520	100.000
90	1.056	0.040	0.688	0.026	0.688	0.026	2592	99.930
105	0.640	0.014	-	-	-	-	4640	99.970
120	-	-	-	-	-	-	5600	100.000
Frequency	33.333		22.222		22.222		88.888	

* Wet Weight in g/m^2 surface area

† % of the total wet weight


R
Other
macrofauna
10
5
4
3
2
1
Wet we ght n g/m² surface area
1
2
3
0
15
30
45
60
DAYS

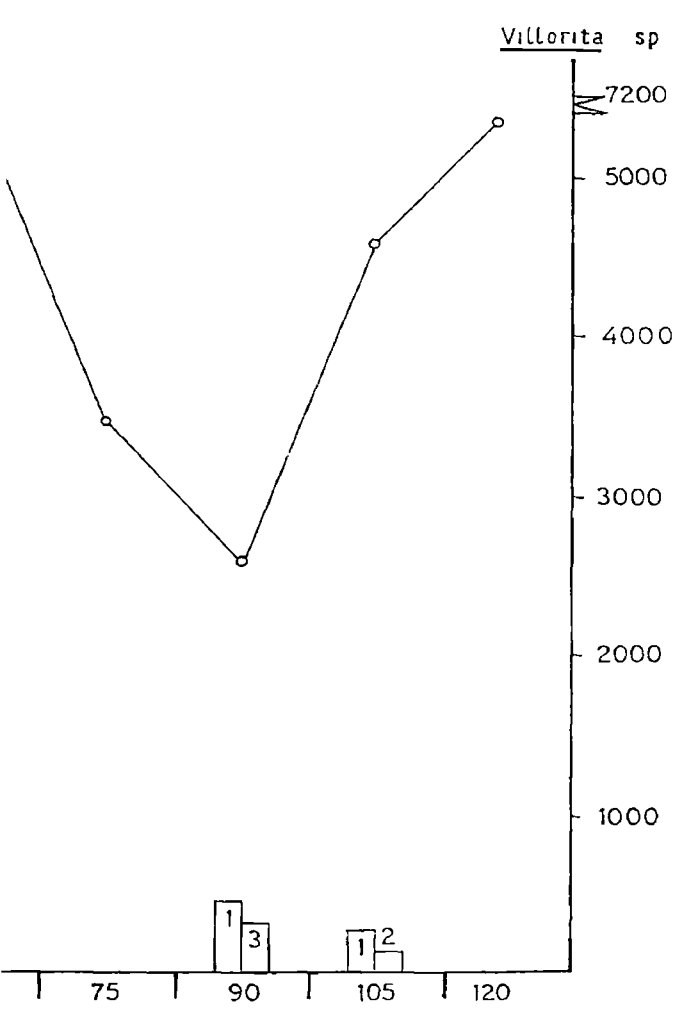

Villorita sp
7200
5000
4000
3000
2000
1000
1
3
1
2
75
90
105
120

Table 23. Abundance *('a'), dominance †('d') and frequency of macrofauna groups in Pond A during Culture II.

Days	Macrofauna groups									
	Amphipods		Tanaids		Polychaetes		Chironomids		Nuculanasp.	
	a	d	a	d	a	d	a	d	a	d
0	5.040	27.003	4.752	25.460	8.312	44.534	0.560	3.00	-	-
15	6.400	5.630	6.112	5.370	30.562	26.858	-	-	70.688	62.141
30	5.696	15.985	3.040	8.532	-	-	-	-	26.896	75.482
45	5.024	35.740	2.152	15.310	6.880	48.940	-	-	-	-
60	-	-	-	-	4.512	100.000	-	-	-	-
Frequency	80		80		80		20		40	

* Wet weight in g/m^2 surface area

† % of the total wet weight

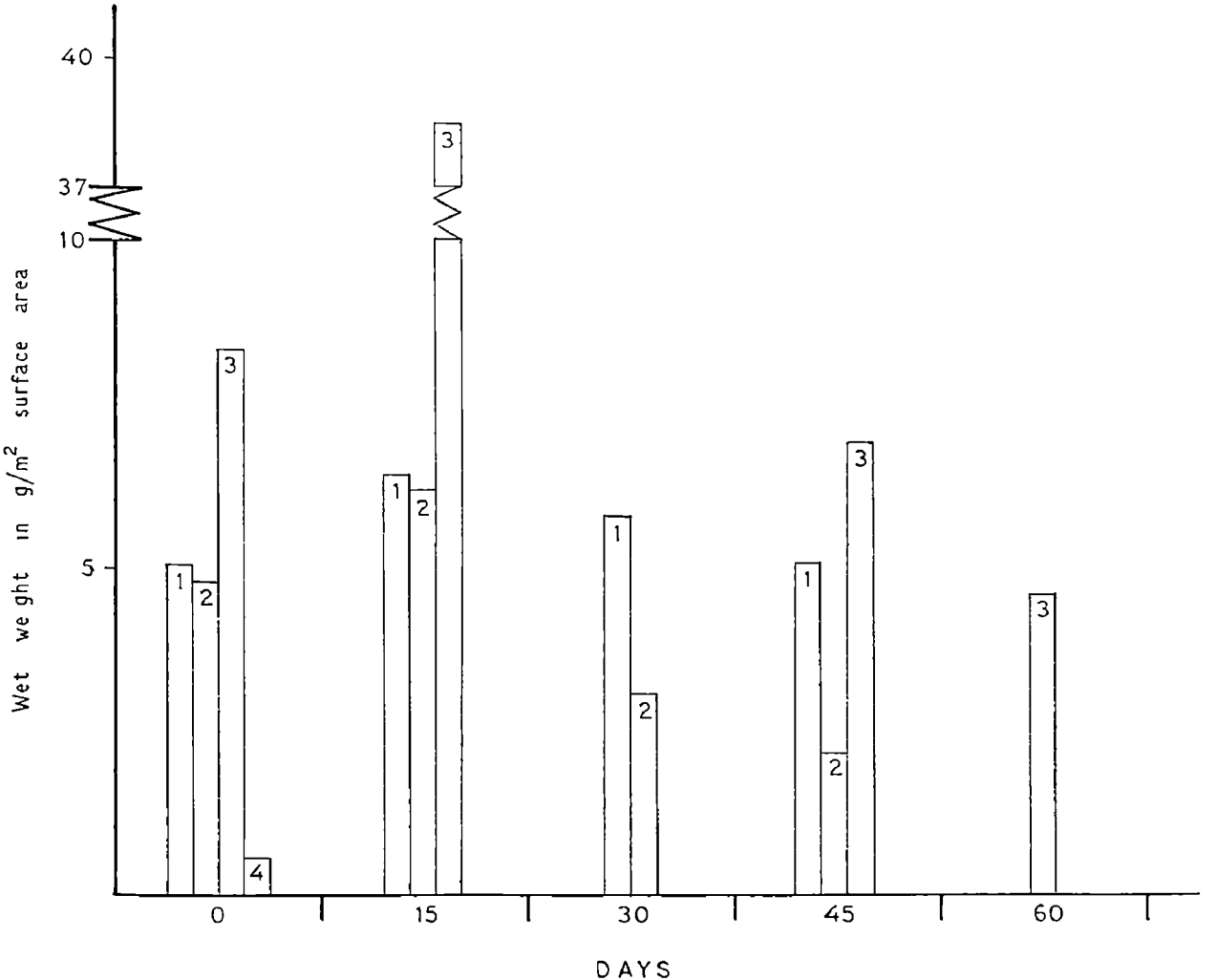
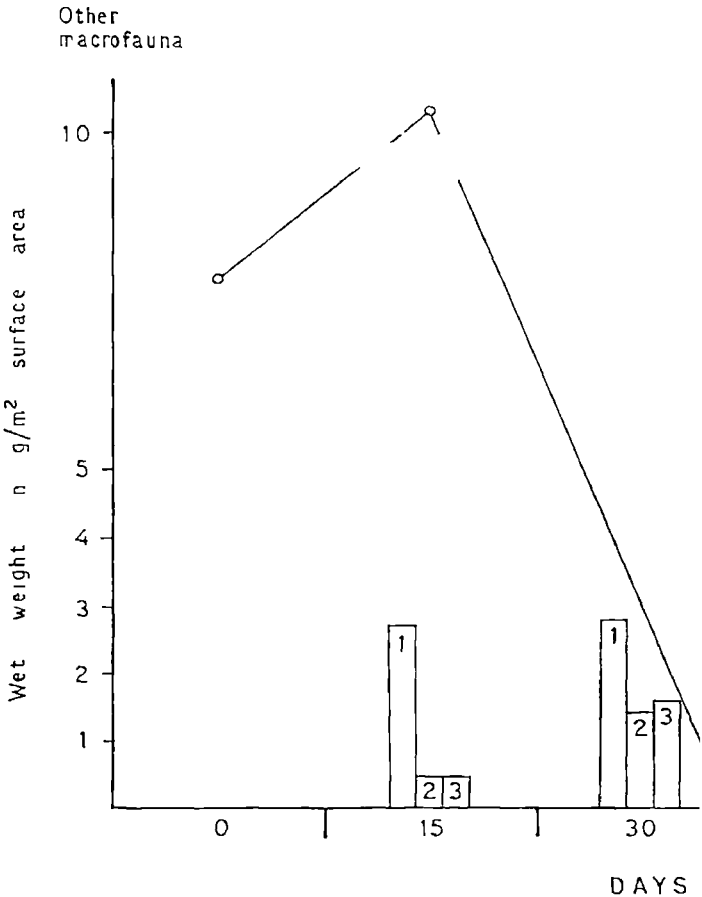

40
37
10
5
Wet weight in g/m² surface area
1
2
3
4
1
2
3
1
2
1
2
3
3
0
15
30
45
60
DAYS

Table 24. Abundance *('a'), dominance †('d') and frequency of macrofauna groups in Pond B during Culture II.

Days	Macrofauna groups							
	Amphipods		Tanaids		Polychaetes		Villorita sp.	
	a	d	a	d	a	d	a	d
0	-	-	-	-	-	-	3408.000	100.000
15	2.672	0.045	0.480	0.017	0.480	0.017	5902.000	99.988
30	2.720	1.376	1.440	0.728	1.552	0.785	192.000	97.110
45	-	-	-	-	-	-	1280.000	100.000
60	-	-	-	-	1.104	100.000	-	-
Frequency	40		40		60		80	

* Wet weight in g/m^2 surface area

† % of the total wet weight


Other
macrofauna
10
5
4
3
2
1
Wet weight n g/m² surface area
1
2
3
1
2
3
0
15
30
DAYS

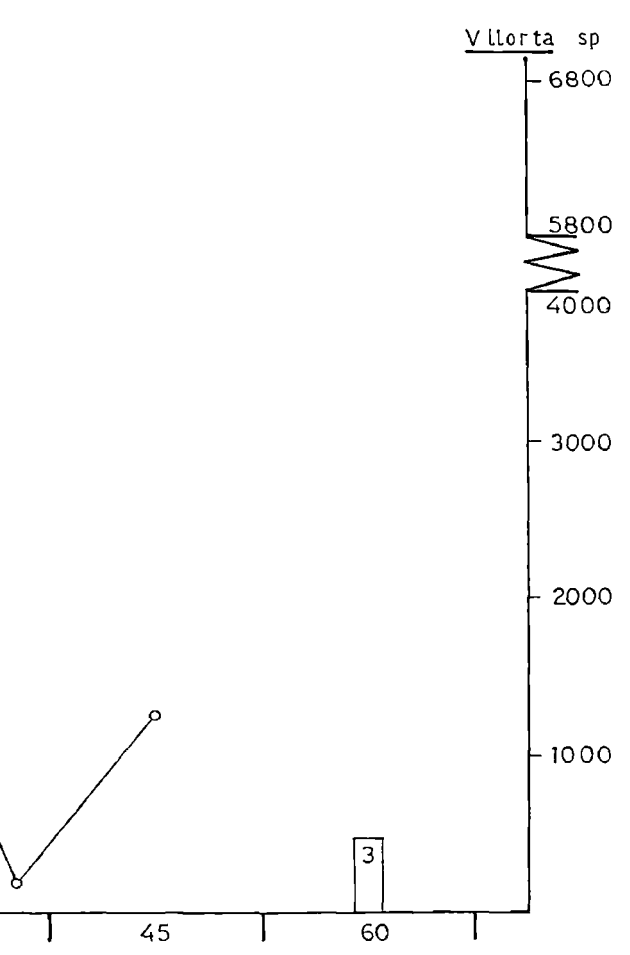

V llorta sp
6800
5800
4000
3000
2000
1000
3
45
60

Table 25. Abundance *('a'), dominance †('d') and frequency of macrofauna groups in Pond A during Culture III.

Days	Macrofauna groups							
	Amphipods		Tanaids		Polychaetes		Chironomids	
	a	d	a	d	a	d	a	d
0	-	-	-	-	2.991	97.395	0.080	2.604
15	-	-	-	-	-	-	-	-
30	0.816	86.440	0.128	13.559	-	-	-	-
45	3.019	33.180	3.120	34.289	2.960	32.630	-	-
Frequency	50		50		50		25	

* Wet weight in g/m^2 surface area

† % of the total wet weight

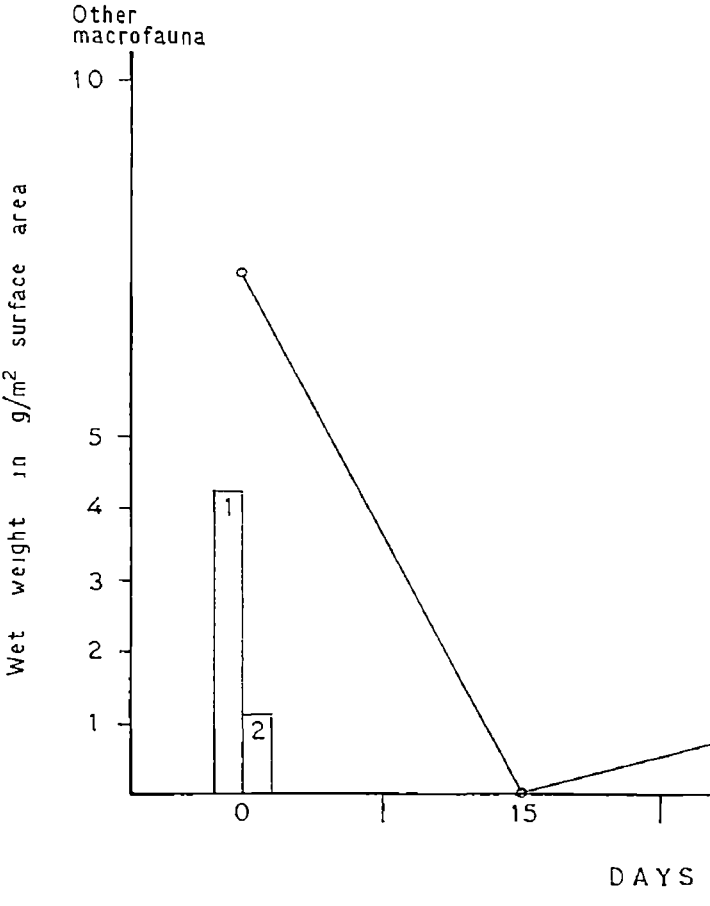
Wet weight in g/m² surface area
1
2
3
4
5
10
DAYS
0
15
30
45
3
4
1
2
1
2
3

Table 26. Abundance *('a'), dominance †('d') and frequency of macrofauna groups in Pond B during Culture III.

Days	Macrofauna groups					
	Amphipods		Tanaids		Villorita sp.	
	a	d	a	d	a	d
0	4.240	0.134	1.120	0.035	316.200	99.840
15	-	-	-	-	-	-
30	0.816	0.169	0.128	0.027	64.000	99.803
45	0.144	0.224	-	-	4.800	99.775
Frequency	75		50		75	

* Wet weight in g/m^2 surface area

† % of the total wet weight


Other
macrofauna
10
5
4
3
2
1
Wet weight in g/m² surface area
1
2
0
15
DAYS

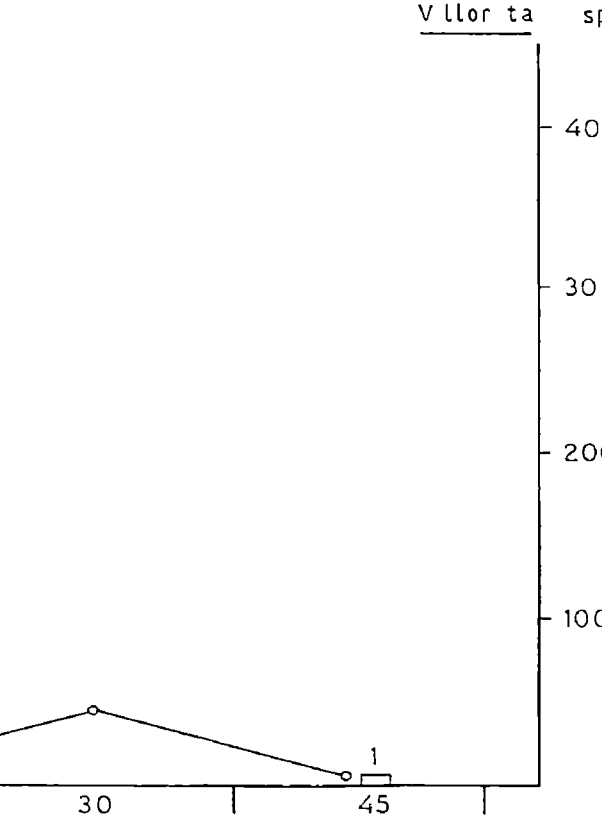

V llor ta
sp
400
300
200
100
1
30
45

Table 27. Fluctuations in macrofauna biomass excluding Villorita sp. (Wet weight in g/m^2) in the two ponds during the three Cultures.

Culture No.	Days	Macrofauna biomass (g/m^2) Pond A	Pond B
I	0	4.539	-
	15	9.040	-
	30	9.880	-
	45	10.044	3.760
	60	0.904	-
	75	1.115	-
	90	0.035	2.432
	105	31.808	0.640
	120	4.289	-
II	0	18.664	-
	15	43.074	3.632
	30	8.736	5.712
	45	14.056	-
	60	4.512	1.104
III	0	3.071	5.360
	15	-	-
	30	0.944	0.944
	45	9.099	0.144

3.4 CULTURED ORGANISMS

The details of fortnightly mean wet weight (g), growth increment (mm/g), and standing crop/m^2 of the cultured organisms viz., C. chanos, P. indicus and P. monodon are given in Tables 28 to 30 and Figs. 26 to 27.

C. chanos showed a remarkable fortnightly increase in the standing crop in Pond A through out the culture period of 120 days. In Pond B, although there was a gradual increase in its standing crop, the fortnightly increment was quite low. The mean wet weight of C. chanos increased from 6g to 237 g in Pond A, while in Pond B, it increased from 6 g to 63 g only. The corresponding standing crop values increased from 2.700 g/m^2 to 107.100 g/m^2 in Pond A and that in Pond B, from 2.700 g/m^2 to 28.350 g/m^2. The growth increment (in g) values of C. chanos showed remarkable increase from 15th day to 60th day and thereafter the values declined and again rose on the 105th and on the final day in Pond A. The lowest value, 6.44 g was observed on the 15th day and the highest value, 44.54 g on the 90th day. In Pond B, the values showed a gradual increase on the 15th and 30th day, then it showed a decline on the 45th, 60th and 90th day and again a gradual increase was observed on the rest of the culture period. The lowest value, 5.6 mm/0.31 g was observed on the 75th day and the highest value, 21.6 mm/15.6 g on the final day respectively (see Table 28, Fig. 26).

P. indicus cultured in the two ponds, was observed to have a gradual increase in the standing crop during the 60 days culture period. In Pond A, it showed a higher fortnightly increment in standing crop than in Pond B. The mean wet weight and standing crop of this prawn increased from 0.113 g to 8.246 g and from 0.339 g/m^2 to 24.75 g/m^2 respectively in Pond A. In Pond B, the corresponding values increased from 0.113 g to 6.340 g and 0.339g/$m^2$to 19.020 g/m^2 respectively (see Table 29; Fig. 27). The growth increment (in g) values showed a gradual decline from 15th day to 45th day and a gradual increase was noted on the 60th day, in Pond A. In Pond B, the value showed an increase on the 45th day and again declined on the 60th day. The lowest values, 11.4mm/1.205 g and 17.4mm/0.994 g were observed on the 45th day and 30th day in ponds A and B respectively.

P. monodon cultured for a period of 45 days showed a gradual fortnightly increase in the standing crop in both the ponds. Mean wet weight (g) and standing crop (g/m^2) of this prawn increased from 0.268 g to 8.320 g and from 0.536 g/m^2 to 16.640 g/m^2 in Pond A, while in Pond B, the corresponding values increased from 0.268 g to 4.635 g and from 0.536 g/m^2 to 9.280 g/m^2 respectively (see Table 30; Fig. 27). The growth increment values (in g) showed a decline on the 45th day in Pond B

Table 28. Details of fortnightly mean wet weight, growth increment, standing crop/m^2 and standing crop increment/m^2 of *C. chanos* in the two fish ponds (0.042/ha).

Days	Pond A				Pond B			
	Mean wet weight (total length/ weight) (mm/g)	Growth increment (mm/g)	Standing crop increment (g/m^2)	Standing crop (g/m^2)	Mean wet weight (total length/ weight) (mm/g)	Growth increment (mm/g)	Standing crop increment (g/m^2)	Standing crop (g/m^2)
0	86.00/ 6.000	-	-	2.700	86.00/ 6.000	-	-	2.700
15	125.80/ 12.440	39.8/6.44	2.90	5.600	114.00/12.200	28.00/ 6.20	2.80	5.500
30	155.60/ 28.000	29.8/15.56	7.00	12.600	143.55/24.880	29.55/12.68	5.71	11.210
45	189.50/ 52.160	33.9/24.16	10.870	23.470	154.40/36.200	10.85/11.32	0.58	11.790
60	223.10/ 89.000	33.6/36.84	16.580	40.050	160.00/43.690	5.60/ 7.49	4.50	16.290
75	241.10/107.560	18.0/18.56	8.370	48.420	165.60/44.000	5.60/ 0.31	3.51	19.800
90	263.30/152.100	22.2/44.54	19.980	68.400	169.50/45.400	3.90/ 1.40	0.63	20.430
105	293.40/190.600	30.1/38.50	17.370	85.770	182.30/47.400	12.80/ 2.00	0.90	21.330
120	318.20/237.900	24.8/47.30	21.330	107.100	203.90/63.000	21.60/15.60	7.02	28.350

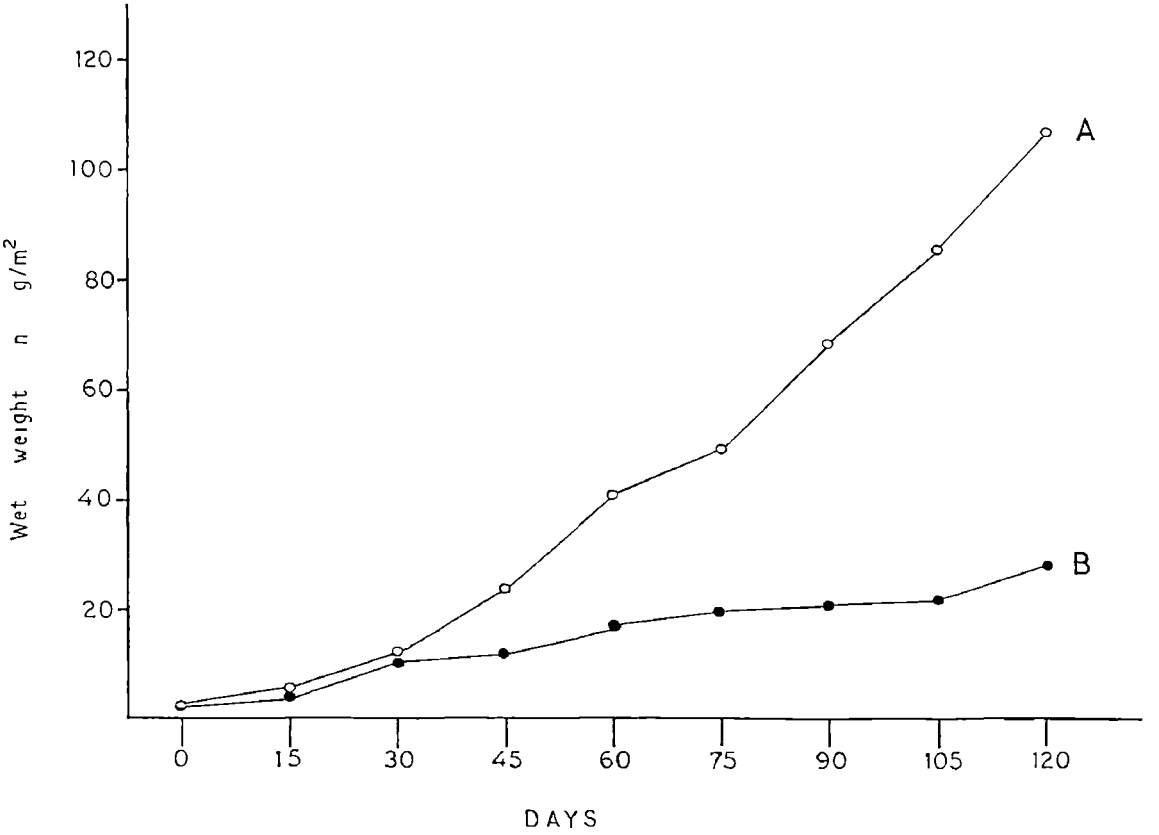

120
100
80
60
40
20
Wet weight n g/m²
A
B
0
15
30
45
60
75
90
105
120
DAYS

Table 29. Details of fortnightly mean wet weight, growth increment, standing crop/m^2 and standing crop increment/m^2 of *P. indicus* in the two fish ponds (0.042 ha).

Days	Pond A				Pond B			
	Mean wet weight (total length/ weight) (mm/g)	Growth increment (mm/g)	Standing crop increment (g/m^2)	Standing crop (g/m^2)	Mean wet weight (total length/ weight) (mm/g)	Growth increment (mm/g)	Standing crop increment (g/m^2)	Standing crop (g/m^2)
0	15.2/0.113	-	-	0.339	15.2/0.113	-	-	0.339
15	79.6/2.687	64.4/2.574	7.731	8.070	51.6/1.612	36.4/1.499	4.497	4.836
30	94.0/4.398	14.4/1.711	5.121	13.191	69.0/2.606	17.4/0.994	2.994	7.830
45	105.4/5.603	11.4/1.205	3.618	16.809	90.0/5.145	25.4/1.539	4.620	12.450
60	115.66/8.246	10.26/2.643	7.941	24.750	94.8/6.340	4.8/1.195	6.57	19.020

Table 30. Details of fortnightly mean wet weight, growth increment, standing crop/m^2 and standing crop increment/m^2 of *P. monodon* in the two ponds (0.042 ha).

	Pond A				Pond B			
Days	Mean wet weight (total length/ weight) (mm/g)	Growth increment (mm/g)	Standing crop increment (g/m^2)	Standing crop (g/m^2)	Mean wet weight (total length/ weight) (mm/g)	Growth increment (mm/g)	Standing crop increment (g/m^2)	Standing crop (g/m^2)
0	22.0/0.268	-	-	0.536	22.0 /0.268	-	-	0.536
15	48.7/2.923	26.7/2.655	5.304	5.840	41.7 /2.335	19.7 /2.067	4.124	4.660
30	75.4/5.020	26.7/2.097	4.800	10.640	69.4 /3.655	27.7 /1.320	2.650	7.310
45	97.0/8.320	21.6/3.300	6.000	16.640	83.202/4.635	13.802/0.980	1.970	9.280

Wet we ght n g/m²
5
10
15
20
25
0
15
30
45
60
A
B
DAYS
0
15
30
45
A
B

4 DISCUSSION

4.1 WATER QUALITY OF THE BRACKISHWATER PONDS

Water quality management forms an integral aspect of aquaculture operations. An understanding of the complex interactions continously taking place between the environment and the stocked organisms is essential to enhance the survival and production, by appropriate manipulation of the aquatic ecosystem. In aquaculture there are many environmental variables that affect the survival, growth and yield of cultured organisms.

4.1.1 TEMPERATURE

According to Schmidt-Nielsen (1979), water temperature has significant effects on respiration, food consumption, digestion, assimilation,growth and behaviour. Each species of fish has preferred water temperatures at which growth and other biological functions are optimum. Warm water fishes and fish food organisms grow best at temperatures between 25°c and 32°c. In some areas surface water temperature may exeed 35°c, which is above the optimum for most warm water fishes (Colt et al 1979, Pope et al. 1981). The temperature variations (range) recorded in the present investigation (25°c to 35°c) fall well within the tolerance range of the three cultured species as well as of their food organisms, which provided conducive environment for the growth.

4.1.2 SECCHI DISC TRANSPARENCY

Factors affecting transparency of water are silt, microscopic organisms and suspended organic matter (McCombie, 1953). In aquaculture ponds, turbidity from planktonic organisms is often desirable, whereas that caused by suspended clay particles is generally undesirable. Secchi disc visibility recorded during the three cultures did not show any set pattern and ranged between 36 cm to 46 cm. Almost all problems related to dissolved oxygen in fish culture ponds are the consequences of heavy plankton blooms (Boyd et al. 1978). Suitable plankton densities result in Secchi disc visibilities of 30-60 cm. The probability of problems with low dissolved oxygen concentration increases as Secchi disc visibility decreases below 30 cm. In ponds with Secchi disc visibilities of 10-20 cm, dissolved oxygen concentration may fall so low at night that fish are stressed or even killed (Romaire and Boyd, 1978). In the present investigation, Secchi disc readings lie within the congenial level especially in Pond A. Higher readings were observed in Pond B which is due to the lesser production of phytoplankton in this pond. Lower values in both the ponds coincided with the primary production peaks.

4.1.3 WATER DEPTH

For brackishwater culture system shallow ponds are recommended. Deep ponds are considered to inhibit the penetration of light, heat etc (Banerjee, 1978). The average water depth of 50 cm was maintained during all the three cultures. This water depth favoured for the light penetration and primary production of the culture ponds.

4.1.4 WATER p^H

The p^H of natural waters is generally influenced by the concentration of carbondioxide, an acidic substance (Stumm and Morgan, 1970). Phytoplankton and other aquatic vegetation remove carbondioxide from the water during photosynthesis which can cause increase of p^H of water during the day and a decrease at night. Waters with p^H values of 6.5 to 9 at day break are considered best for fish production. The suitability of waters for fish growth decreases above and below this p^H range (Depasse, 1956, Swingle, 1961). The water p^H was alkaline throughout the culture period in Pond A, while in Pond B it was acidic during the second half of Culture I and alkaline during Culture II and III. According to Hora and Pillay (1962) a feebly alkaline p^H of 7.8 is characteristic of good water suitable for fish culture. In general, the p^H range recorded in the present

study was suitable for fish culture. However, since well marked differences have not been observed, it is difficult to assess the influence of this factor on the productivity of the ponds.

4.1.5 SALINITY

The level of salinity in water reflects geological and hydrological conditions (Hutchinson, 1957; Hem, 1970). Among the physico-chemical factors studied, salinity was highly variable. During the initial stages of Culture I, salinity was very low and almost nearing fresh water conditions. During the second half of Culture I and the whole duration of Culture II and III, the pond water reached brackish conditions. Such variations in salinity values (2.50 ppt - 31.05 ppt) are typical of brackishwater ponds located along the Cochin backwaters, which are influenced by monsoon rains and influx of fresh water from rivers (Pillai, 1976).

4.1.6 DISSOLVED OXYGEN

Dissolved oxygen is an essential limiting factor for maintaining aquatic life. The effect of dissolved oxygen on fish is influenced by several factors including temperature which in turn affects the solubility of oxygen in water and also the

metabolic rate of cultured organisms. Any reduction in dissolved oxygen value can depress food consumption and growth rate of cultured organisms. Although dissolved oxygen will diffuse into water, the rate of diffusion is quite slow in the near stagnant conditions of culture ponds. Nevertheless, photosynthesis by phytoplankton is the primary source of dissolved oxygen in most aquaculture systems (Hepher, 1963, Boyd, 1979). The primary losses of dissolved oxygen from ponds are caused by respiration of plankton, of benthic organisms and by diffusion of oxygen into the air (Schroeder, 1975; Boyd et al. 1978). As a general rule, most waters contain enough dissolved oxygen to support fish to a depth of two to three times the Secchi disc visibility (Boyd, 1979). In the present study, the observed dissolved oxygen values did not fall below the desired range of 4-8 ppm for warm water species. Fluctuations in the concentration of dissolved oxygen showed an inverse relation with water temperature suggesting that the former was mainly controlled by the latter. According to Brook and Rzoska (1954), the dissolved oxygen concentration can be correlated with the abundance of phytoplankton. However, during the present observation dissolved oxygen did not show any marked variation with phytoplankton production.

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4.2 SOIL CHARACTERISTICS OF THE BRACKISHWATER PONDS

In brackishwater fish culture ponds, the soil acts as a bed for the growth of algal pasture, in addition to being a store house of nutrients Besides, the pond soil is also important in the oxygen balance of water and in pH regulation. Soil condition is a more reliable index than water quality in individual ponds (Banerjee, 1967). The overall productivity of a grow out pond is dependent on various factors such as soil nutrient levels, nature of substratum and on favourable interactions of physico-chemical factors of the pond soil and water. The benthic production which is an important prerequisite for obtaining high yields, is dependent on the nature and fertility of the bottom soil. Knowledge of the various characteristics of pond soil is indispensable in appropriate monitoring of the benthic realm, which would not only help to adopt successful management principles for the pond ecosystem, but also to manipulate the ecosystem by providing the necessary input for obtaining better production.

4.2.1 PARTICLE SIZE

Amongst all the physical environmental factors, the nature of the substratum has the greatest influence on the distribution and abundance of benthic populations (Jones, 1950). The nature

of the bottom soil observed during the course of the present investigation showed that it contains sand (89%), silt (3%) and clay (8%). Pillai (1976) observed that in the Cochin backwaters, dominance of sand fraction supported dense and varied benthic populations dominated by polychaetes. Panikkar and Aiyar (1937) observed absence of animals on substrate of thick clay and their abundance on loose substrate. Desai and Krishnamurthy (1967) observed that medium and small amounts of silt and clay are suited for the abundance of polychaetes and bivalves. A definite relationship between the nature of the substratum and the distribution of the benthic fauna has been reported by Sanders (1958), Kurian (1967), Parulekar (1973, 1975) and Murugan et al. (1980). Investigations on benthic faunal abundance in relation to substrate showed that rich fauna occurred in clayey sand and sandy substrates whereas clay had very poor fauna (Harkantra & Parulekar, 1987). Kurian (1967) observed that sandy deposits have a high abundance of benthos at some places, while at others it was low in similar deposits. This suggests that the type of substratum cannot be considered independently as a master ecological factor determining the distribution and abundance of the benthic fauna. In the present study since both the ponds have bottom soil of sandy nature the variations in the groups and abundance of benthic fauna cannot be attributed to the nature of the pond soil.

4.2.2 ORGANIC CARBON

Estimation of organic carbon in the soil would serve as an important indicator in determining the availability of detritus as food for the benthic fauna as well as for bottom feeding fishes and prawns. Bader (1954) while studying the abundance of bivalves in relation to percentage of organic carbon, has observed a decrease in population at a level of above 3% organic carbon. He pointed out that beyond this level, products of bacterial decomposition resulting in a decline of the available oxygen become limiting factors. Kurian (1967) suggested that high productivity of benthos in the estuary may be due to high percentage of organic carbon content. In the present study, percentage of organic carbon in the soil, ranged from 0.92% to 1.72% in Pond A and from 0.50% to 1.55% in Pond B during all the three cultures. Tang and Chen (1967) have grouped soils into three types based on the amount of organic carbon available. According to them soil with less than 1.5% organic carbon is low in nutrient status, 1.5-3.5% is medium and more than 3.5% is high in nutrient status. According to Banerjee (1967) organic carbon of pond soil less than 0.5% may be regarded as too low for a fish culture pond, 0.5-1.5% as medium and 1.5-2.5% as high, under Indian climatic conditions. The values obtained during the present study varied between 0.5 and 1.72% and hence

lie close to the category of soil with medium nutrient status. Values of organic carbon reported by Rajyalakshmi et al. (1987) from brackishwater ponds connected to Chilka lake were from 0.297 to 0.405% indicating nutrient limitations, which is lower than the present values.

4.2.3 AVAILABLE PHOSPHORUS

Phosphorus is an important limiting element in pond productivity. Several authors have grouped fish ponds into different categories according to the amount of available phosphorus in the pond soil. Based on the degree of availability, the pond soil is grouped into three levels of nutrient status i.e., if soil phosphorus (P_2O_5) is less than 3.5 mg p/100 g soil (low), 3.6-4.5 mg p/100 g soil (medium) and more than 4.6 mg p/100 g soil (high) (Tang and Chen, 1967). According to Banerjee (1967), soil phosphorus level less than 3 mg p/100 g soil is considered indicative of poor while the range of 3-6 mg p/100 g soil is the average level and more than 6 mg p/100 g soil is of high fish production under Indian climatic conditions. In the present study, the concentration of available phosphorus in the pond soil ranged from 0.275 mg p/100 g soil to 0.683 mg p/100 g soil and from 0.380 mg p/100 g soil to 0.620 mg p/100 g soil in ponds A and B respectively indicating nutrient limitations. Rajayalakshmi et al.(1987) reported

available phosphorus from the brackishwater ponds of Chilka lake fringe area where the values ranged from 2.47 to 4.05 mg p/100 g soil indicating nutrient limitations. Even though, both the ponds were fertilized with approximately same amount of phosphorus a lesser production was observed in Pond B than in Pond A. In view of the undoubted complexity of factors concerned in reducing the production levels, it is difficult to suggest a single explanation for the lesser production.

4.3 PHYTOPLANKTON PRIMARY PRODUCTION

Investigations on phytoplankton primary production related to fish production in open waters in India are well documented. But, similar studies in fish culture ponds are scanty. The determination of primary production in fish culture ponds, besides giving information on the magnitude of organic production has its practical considerations. According to Melack (1976) measurements of primary production may be used to improve the assessment of fish yield from tropical lakes.

During the three cultures, the average fortnightly gross primary production in Pond A fertilised with organic manure and in Pond B fertilised with inorganic fertiliser were 2751.22 mg $C/m^3/6$ hrs and 1891.55 mg $C/m^3/6$ hrs respectively. This is higher than the maximum values reported from tropical fish ponds

for eg. 6 g C/m^2/day to 11 g C/m^2/day. The average phytoplankton primary production 458.53 mg C/m^3/hr,in Pond A, fertilised with organic manure, approximately agrees with that reported by Talling (1957) for African waters, where a shallow lagoon had a rate as high as 487.5 mg C/m^3/hr . In the present investigation in Pond A fertilised with organic manure the gross primary production was 1.5 times higher than in Pond B; as high as values 5760 mg C/m^3/6 hrs and 5040 mg C/m^3/6 hrs were obtained in November and December respectively.

Despite the shallow nature of the fish ponds (mean water depth 50-60 cm) compared to the depth of the photic zone in the ocean and most lakes, production measured was nevertheless relatively high. Values ranged from 720 mg C/m^3/6 hrs to 5760 mg C/m^3/6 hrs and from 240 mg C/m^3/6 hrs to 3936 mg C/m^3/6 hrs in Pond A (organic manure) and in Pond B (inorganic fertilizer) respectively. These are close to the values of gross primary production obtained in the pilot plants at Washington, U.S.A for mass algal culture, where daily production was about 8 g/m^2 (Burlew, 1953). Steemann Nielsen (1958) considered such a value to be near maximum for organic production by algae.

Qasim (1973, 1979), Qasim *et al.* (1969) and Gopinathan *et al.* (1984) observed that in the Cochin backwaters the gross primary production ranged from 0.35 to 1.50 g C/m^2/day. However, in the present investigation both the ponds which are connected to the Cochin backwaters showed higher gross primary production than these values.

The gross primary production in Pond B (inorganic fertilization) was much lower than in Pond A (organic manure) even though the nitrogen and phosphorus provided were approximately same in both the cases. The low gross primary production in Pond B during the culture periods could be due to the presence in large numbers of the black clam V. cyprinoides var. cochinensis, a filter feeder throughout the culture period. Moreover, the increased gross primary production in Pond B during cultures II and III which coincided with lesser biomass of V. cyprinoides var. cochinensis provides further support towards this view. However, in Pond A, the average fortnightly gross primary production values were not much variable i.e., 1853.33 mg C/m^3/6 hrs, 1824 mg C/m^3/6 hrs and 1368 mg C/m^3/6 hrs during Culture I,II and III respectively. The gross primary production recorded in the present investigation is comparatively higher than that observed in some temple fish ponds at Madras (Sreenivasan, 1964) as well as in fish ponds treated with and without fertilizers in Israel (Hepher, 1962).

Peaks of primary production almost always coincided with those of growth increment of the cultured organisms in both the ponds. This could be caused by (1) the presence of primary producers at a higher level than required for the growth and maintenance of the cultured organisms in the ponds or (2) lesser utilization of primary producers as direct food by the cultured organisms as reported by Hillbricht-Ilkowska et al. (1972) and

Schroeder (1978), who observed that 90% of the total primary production is constituted by the nannoplankton which become available as a natural food for fishes only after entering further food chains or conglomeration to increase its effective size.

4.4 SECONDARY PRODUCTION

4.4.1 ZOOPLANKTON

Generally, estuarine zooplankton of the Cochin backwaters is reported as volumetrically abundant but limited in species composition (Silas and Pillai, 1971). In the present study, lack of water exchange with the adjacent Cochin backwaters during most of the three culture periods could have resulted in the very limited number of the zooplankton groups in both the ponds. The zooplankton showed three pronounced peaks i.e; in the second half of November, first half of March and June in Pond A during Culture I,II and III respectively. In Pond B, the biomass of zooplankton did not show such pronounced peaks. Nevertheless, small peaks in the first half of September, February and May were observed in Pond B during Culture I,II and III respectively. Of the three zooplankton peaks in Pond A, that in March was found as the period of maximum production. Several workers (Woodmansee, 1958, Byars, 1960) considered water temperature as the most important controlling factor in the production of zooplankton, whereas some others (Gunter et al. 1948; Davis, 1958) correlated zooplankton abundance with the fluctuations in phytoplankton.

In the present study, relationship between water temperature and fluctuations of zooplankton cannot be established because of the narrow range of temperature fluctuations during the three cultures. An increase in zooplankton biomass (wet weight/m^3) was observed during the latter half of all the three cultures in Pond A, while in Pond B such a pattern was not observed. This increase in Pond A almost always coincides with the increase in the gross primary production which indicates a direct correlation of zooplankton production with primary production. Since the production of zooplankton is inherently related to the growth of individuals which in turn is related to the quantity of food eaten, it is likely that its production would increase with the availability of food (Parsons, 1980). Therefore an increase in the primary production of food organisms can lead to a higher production of secondary producers (zooplankton).

It is generally assumed that the abundance of zooplankton follows the abundance of phytoplankton, as a result of which, the peak of the former lags behind the peak of the latter (Riley et al. 1949). On the other hand, Steemann Nielsen (1937) observed that frequently both zooplankton and phytoplankton occur in large quantities simultaneously. Harvey et al. (1935) put forward the theory of grazing to explain the inter relationship between phytoplankton and zooplankton. According to this theory, when the zooplankton population is large their grazing effect on phytoplankton is so great that the latter fail to show an abundance and vice-versa, i.e. when the zooplankton population is small the phytoplankters

have a chance to multiply rapidly resulting in the production of a peak. This theory has been supported by several workers while discussing phytoplankton - zooplankton relationship (Anderson et al 1955; Wright, 1965).

However, many of the recent investigators do not consider that the abundance of zooplankton depends to a large extent on the quantity of phytoplankton. Hanuska (1949) has stated that the quantity of zooplankton depends on the concentration of nannoplankton including bacteria. It has been suggested by Pennak (1955) that tripton, rather than phytoplankton is the main food of zooplankton in lakes, while Darnett (1961) found that suspended organic matter rich with bacteria rather than phytoplankton was the food of zooplankton.

The theoretical concept of zooplankton peaks succeeding phytoplankton peaks was not clear cut in the present study. Mostly the peaks of zooplankton and phytoplankton synchronised and rarely one was followed by the other.

Among the zooplankton groups, rotifers form the major component all through the three culture periods. As a whole, rotifers have several peaks during the three culture periods. During Culture I, the peaks were observed in August and November in Pond A, while in Pond B, a single peak was observed in September. In Pond A, the copepod biomass showed a single peak

in September while in Pond B, lower biomass was observed during the culture period, without any peaks. In both the ponds the nauplii showed the least abundance among the zooplankton groups.

During Culture II, rotifers showed three distinct peaks in January and March while in Pond B, the peaks were observed in February and March. The copepods showed higher biomass throughout this period in Pond A while in Pond B the biomass increased in March. The nauplii biomass was low in both the ponds during this period also in comparison with other zooplankton groups.

During Culture III, both rotifers and copepods showed higher biomass in May and June in Pond A, while in Pond B, the higher biomass of both the groups was observed in May. The nauplii showed higher biomass during this culture period in both the ponds, when compared to the other two culture periods. In the present study, taking all the zooplankton groups into account, their variations in abundance have not clearly shown any relationship with variations in salinity, their maxima and minima having occurred during periods of both low and high salinities. This is in agreement with the observations in the Cochin backwaters made by George (1956).

The relationship between the fortnightly biomass of zooplankton and growth increment of cultured organisms showed no

definite correlation pattern. Mostly, the high biomass of zooplankton showed an inverse relationship with the growth increment values of cultured organisms. On few occasions in Pond A, a direct relation between the increase in biomass of zooplankton and that of growth increment of C. chanos was observed. In Pond B, a direct relation between the increase in biomass of zooplankton and that of growth increment was observed only on the 60th day during Culture I and thereafter the biomass of zooplankton production continued to be very low. In spite of this condition, the growth increment values of C. chanos showed fluctuations in Pond B. The reasons for an apparently continued low zooplankton and the fluctuations in the growth increment of C. chanos in Pond B could be that the growth and multiplication of zooplankton was at a slow pace and the grazing effect by C. chanos perhaps depleted the zooplankton as and when the population appeared. Since P. indicus and P. monodon are benthic feeders (Gopalakrishnan, 1952; Thomas, 1973, Kutt yamma, 1974) there is no direct consumption of zooplankton by these prawns. Zooplankton on dying sink to the bottom and form part of the detritus constituting direct food for the prawns.

4.4.2 MEIOBENTHOS

Meiobenthos, composed of small benthic organisms passing through 0.5 mm mesh and retained in 62 µm mesh (Mare, 1942) constitute an important group among the benthic community that

inhabit the subbottom and bottom grounds. In recent years, renewed interest to understand the dynamic nature of meiobenthos and their relationship with the co-existing or overlying benthos and the associated demersal organisms has been aroused, particularly in the context of more and more efforts directed towards exploring the economically important group of organisms for the benefit of man. Besides, it is now well known that several demersal fin fishes and shell fishes feed on benthic organisms including meiobenthos and that they directly or indirectly contribute to the growth, survival and production of many cultivated organisms.

In the present study, well marked differences have been observed in the mean fortnightly biomass of meiobenthos (wet weight/ 10 cm^2) between ponds A and B. The occurrence of higher biomass of meiobenthic groups in Pond A could be mainly attributed to the application of organic manure in the pond which might have enhanced the benthic microbial production which in turn forms their food. According to Rieper (1978), meiofauna serve as packagers of microbial biomass, making them available to other detritivorous organisms. Tenore et al. (1977) suggested that meiofauna stimulated bacterial productivity as a result of "bioturbation". Coprophagy exhibited by meiobenthos, especially nematodes, helps in the break down of faecal substances degradable by microfauna, so that the material is quickly transformed into nutrients for autotrophs (Gerlach, 1971).

Several authors consider the role of meiofauna as direct food source for other organisms occupying the higher trophic levels as negligible (McIntyre, 1969; Gerlach, 1971; 1978). Others belittled the importance of meiofauna as link in the food chain leading to higher trophic levels by suggesting that the emphasis on meiofauna as food of other organisms is highly exaggerated (Marshall, 1970) or that meiofauna prey mainly on itself (Heip and Smol, 1975) or represent a dead end in the food chain (McIntyre and Murison, 1973). However, several authors have reported preponderance of meiobenthic harpacticoids in the stomachs of fishes (Bleguad, 1917; Muller, 1969; Kaczinski et al. 1973 and Alheit and Scheibel, 1982).

Damodaran (1973) working on the meiobenthic fauna of the mud banks off Cochin, revealed that the meiobenthic population of the area could be correlated to selected demersal species that support the local fishery, and he confirmed the food-web drawn up by Qasim (1972) for the same locality. Parulekar et al. (1980) have reported that there is an inverse relationship between macrofaunal and meiofaunal biomass along the west coast of India and that meiofaunal biomass was affected by macrofaunal predation. In the present study pronounced inverse relationship has not been observed during the culture periods.

Jayasree (1971) has conducted preliminary observations on the meiobenthos of the Cochin Harbour area and reported eleven taxonomic groups from that area. The limited groups of

meiobenthic fauna observed in the present investigation may be due to the newly constructed and confined nature of the brackish-water ponds, wherein colonisation of other meiofauna might not have taken place.

In general, a direct correlation between the fortnightly biomass of meiofauna groups and growth increment values of C. chanos has been observed in the present study. The increase in biomass of meiofauna groups almost coincided with the growth increment values of C. chanos. This may be due to the inadequate utilization of meiofaunal groups as food by C. chanos. An inverse relationship between the increase in biomass of meiofaunal groups and the growth increment of P. indicus and P. monodon has been noticed. This provides strength to the concept that meiofauna groups are utilised by the cultivated prawns. (Gopalakrishnan, 1952, Kuttyamma, 1974).

4.4.3 MACROBENTHOS

From the studies conducted over the years it is now a well known fact that benthic organisms form food of several fishes and prawns cultured in ponds. The importance of benthic fauna as food of brackishwater fishes and prawns has been reported by several workers (Hiatt, 1944, Gopalakrishnan, 1952; Pillay, 1954; George, 1972; Kuttyamma, 1974; Miroshni-Chenko, 1979). The role of benthic fauna as food of culturable species has been emphasised by William (1958), Dall (1968) and Marte (1980). The brackishwater pond usually support a rich fauna of molluscs, polychaete worms and

smaller crustaceans like copepods, amphipods, isopods, tanaids, etc. (Jhingran, 1975). These faunal elements constitute suitable natural food of cultivated fish and prawns. Many of these benthic food organisms are dependent upon the prevailing salinity, temperature and nature of substratum.

In the present study, total macrofauna biomass values (wet weight/m^2) ranged from 0.035 g/m^2 (first half of November) to 43.074 g/m^2 (first half of February) in Pond A while in Pond B, the total biomass excluding V. cyprinoides var. cochinensis ranged from 0.640 g/m^2 (second half of November) to 5.712 g/m^2 (second half of February). In general, high benthic populations were observed during November to March period in both the ponds. A similar observation has been reported from the brackishwater ponds of the Central Inland Fisheries Research Institute at Kakdwip where the biomass of benthic fauna reaches a maximum of 20-50 g/m^2 during the premonsoon months of March - April (Jhingran, 1975).

Of all the macrobenthic groups, amphipods generally formed an important faunal element throughout the culture periods in both the ponds, except during the former half of Culture I in Pond A. This group occurred only occasionally in Pond B during Culture I. Chironomid larvae were recorded during the former half of Culture I and on the starting day of Culture II and III,

while it was totally absent from Pond B during all the three cultures. The control of chironomid larvae by prawns has been reported by Gundermann and Popper (1975, 1977); they observed P. monodon, P. merguinesis and P. japonicus feeding on chironomid larvae in Fiji ponds resulting in total disappearance of the larvae. This may be one of the reasons for the complete absence of chironomids during Culture II and III. Another reason for this may be attributed to the high saline phase during the second half of Culture I, II and III. The likely reason for the reduction in the abundance of macrofauna in Pond B may be due to the occurrence of the thick bed of black clam V. cyprinoides var. cochinensis almost throughout the culture periods, perhaps providing a competition for the living space for other macrofauna. In general, higher biomass of V. cyprinoides var. cochinensis was observed during Culture I, from October to November and it showed a gradual decline during Culture II and Culture III. Occasional appearance of Nuculana sp. was observed in Pond A in the latter half of Culture I and former half of Culture II. The occurrence of Nuculana sp. may be due to the increase of salinity during the culture period. Of all the macrofauna groups, polychaetes were the least dominant in both the ponds. This could be due to the sandy nature of the substratum of the ponds since the dominance of polychaetes in macrofauna has been attributed to the higher percentage of organic matter in fine clayey sediments (Kurian, 1972) The post monsoon rise in polychaete density followed by a fall

during increased salinity and temperature in summer as revealed in the present study is in agreement with the observations made by Datta and Sarangi (1980) who have conducted preliminary studies on the macrobenthos in a brackishwater bheri at Taldi, West Bengal.

A direct relation between the fortnightly increase in biomass of macrobenthos and the growth increment of C. chanos was observed till the 45th day, thereafter it showed a sudden inverse relationship during the rest of the culture period in both the ponds. This may be due to the benthic feeding habit of C. chanos during the later stages of their growth and thereby the utilization of macrobenthos for their growth (Gopalakrishnan, 1972).

A direct correlation between the fortnightly increase in biomass of macrobenthos and the growth increment of P. indicus was noted during the first half(30 days) of the culture period; thereafter it showed an inverse relation in Pond A. In Pond B, an inverse relation was noted during this culture period, except on the starting and final day of the culture. This confirms their utilization by the prawns (Kuttyamma, 1974). An inverse relation between the fortnightly increase of macrobenthos biomass and the growth increment of P. monodon was also observed throughout this culture period in ponds A and B which indicates that macrobenthos is directly utilized by P. monodon (Kuttyamma, 1974).

5 SUMMARY

5. SUMMARY

1. The present study covers fortnightly investigations on secondary production of zooplankton, meiobenthos and macrobenthos together with physico-chemical parameters and primary production in two brackishwater ponds (0.042 hectare area) connected to the Cochin backwaters during three cultures viz., Culture I. C. chanos (120 days, during August to December, 1986,) Culture II. P. indicus (60 days, during January to March, 1987) and Culture III. P. monodon (45 days, during mid May to June, 1987).

2. Detailed study of zooplankton, meiobenthos and macrobenthos includes fortnightly fluctuations of groupwise biomass in wet weight, percentage dominance and frequency of occurrence of each group. The results obtained are correlated with the growth increment values of the corresponding cultured organisms.

3. Since zooplankton production is mainly dependent on the primary production of phytoplankton, fortnightly fluctuations of gross and net primary production are studied. The results are correlated with the corresponding zooplankton biomass.

4. Physico-chemical parameters of the pond water and soil viz., temperature, water depth, Secchi disc transparency, pH, salinity, dissolved oxygen, soil particle size, organic carbon and available phosphorus in the soil are investigated fortnightly to determine the causative abiotic variables underlying the biotic fluctuations.

5. The relationship between the fortnightly biomass of zooplankton and growth increment of cultured organisms is mostly an inverse relationship.

6. The theoretical concept of zooplankton peaks succeeding phytoplankton peaks is not evident at all times in the present study. Sometimes the relationship between the zooplankton and phytoplankton is found as a direct one while at other times one was followed by the other.

7. Meiofauna biomass reveals a direct correlation with the growth increment of C. chanos. It shows an inverse relationship with the growth increment of prawns, P. indicus and P. monodon.

8. A direct relationship between the fortnighly increase in biomass of macrofauna and that of growth increment of C. chanos is observed during the former half of the

culture period, thereafter it shows a sudden inverse relationship till the end of the culture period.

9. Studies on primary production reveal that its peaks almost always synchronise with those of growth increment of the cultured organisms in both the ponds.

10. Physico-chemical parameters studied are not highly variable except salinity and they fall within the congenial level required for the production of zooplankton and zoobenthos as well as for the maintenance of healthy aquatic environment.

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SECONDARY PRODUCTION IN BRACKISHWATER CULTURE PONDS

By

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ABSTRACT OF A THESIS

Submitted in Partial fulfilment of the requirement for the degree

MASTER OF FISHERIES SCIENCE

Faculty of Fisheries

Kerala Agricultural University

Department of Aquaculture

COLLEGE OF FISHERIES

Panangad Cochin

1988

ABSTRACT

Secondary production of zooplankton and zoobenthos (macrobenthos and meiobenthos) of two brackishwater ponds, A and B, each having 0.042 hectare area and connected to the Cochin backwaters, in the instructional fish farm of College of Fisheries, Panangad, Cochin have been studied for three culture periods. viz., Culture I. C. chanos (120 days, during August to December, 1986), Culture II. P. indicus (60 days, during January to March, 1987) and Culture III. P. monodon (45 days, during mid May to June, 1987).

Fortnightly fluctuations in the biomass of zooplankton, meiobenthos and macrobenthos both group wise and total, their percentage dominance and frequency of occurrence have been studied during each culture period. Attempts have been made to correlate the fortnightly biomass of zooplankton, meiobenthos and macrobenthos with the fortnightly growth increment of C. chanos, P. indicus and P. monodon separately.

Since zooplankton production is mainly dependent on primary production, fortnightly estimations of net and gross primary production have been carried out. The physico-chemical parameters of the pond water and soil have been studied

fortnightly since both primary and secondary productivity of a culture pond depends mainly on these variables.

The zooplankton groups are constituted by rotifers, copepods and crustacean nauplii. The total biomass of zooplankton ranges from 22.388 mg/m^3 to 5476.950 mg/m^3 and 5.085 mg/m^3 to 1316.832 mg/m^3 in ponds A and B respectively. The zooplankton biomass shows three peaks i.e., 1) in November, 2) in March and 3) in June in Pond A during Culture I,II and III respectively while in Pond B, it does not show such pronounced peaks. Neverthless, small zooplankton peaks are apparent in Pond B in the former half of September, February and May during Culture I, II and III respectively. The relationship between the fortnightly biomass of zooplankton and that of growth increment of C. chanos is mostly an inverse one which could be because of the grazing effect of the latter on the former.

An inverse relation is also observed between the biomass of zooplankton and growth increment values of P.indicus and P. monodon. Since the prawns are benthic feeders such an inverse relation cannot be attributed to direct consumption of zooplankton by them. However, zooplankton on dying sink to the bottom and form part of the detritus, constituting direct food for the prawns.

The meiobenthos in both the ponds is constituted by nematodes and copepods. The total biomass of meiofauna ranges from 36.018 $\mu g/10cm^2$ to 2539.322 $\mu g/10cm^2$ in Pond A and from 57.882 $\mu g/10cm^2$ to 1556.616 $\mu g/10cm^2$ in Pond B. A direct correlation is observed between the biomass of meiofauna with growth increment values of C.chanos whereas an inverse relation is noted between the former and the growth increment value of P. indicus and P. monodon. This suggests that meiofauna may not from direct food to C. chanos while it may be the contrary to the prawns.

The macrobenthos is composed of amphipods, tanaids, polychaetes and molluscs. The total biomass of macrofauna groups ranges from 0.035 g/m^2 to 43.074 g/m^2 in Pond A and from 0.144 g/m^2 5.712 to g/m^2 (excluding Villorita cyprinoides var. cochinensis) in Pond B. One peculiarity observed in Pond B is the presence of thick bed of black clam V. cyprinoides var. cochinensis during all the culture periods. A direct correlation between the fortnightly biomass of macrofauna with growth increment of C. chanos during the former half of culture period and inverse relation during the latter half of culture period are observed. This may be attributed to the utilization of macrofauna by C. chanos during the later stages of their growth. This supports the previous views put forward by several authors. An inverse

relation is observed between the fortnightly biomass of macrofauna and growth increment values of P. indicus as well as P. monodon. This is in agreement with the views of several authors which highlight the utilization of macrofauna by the prawns.

Fortnightly observations on primary productivity of phytoplankton as well as physico-chemical parameters of pond water and soil have also been discussed in general.

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