

**STUDIES ON THE EFFECT OF TEMPERATURE AND SALINITY
ON GROWTH AND FEEDING RATE OF
THE BLACK CLAM *VILLORITA CYPRINOIDES* (GRAY)**

DISSERTATION SUBMITTED BY

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IN PARTIAL FULFILMENT FOR THE DEGREE OF
MASTER OF SCIENCE (MARICULTURE)
OF THE
COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

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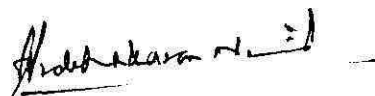


POST-GRADUATE PROGRAMME IN MARICULTURE
CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
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NOVEMBER 1990

C E R T I F I C A T E

This is to certify that this Dissertation is a bonafide record of the work carried out by Miss Preetha Panikkar under my supervision and that no part thereof has been presented before for any other degree.



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P R E F A C E

Clams are perhaps the most widely distributed and utilized aquatic invertebrates providing protein-rich food in much greater abundance than mussels and oysters. In India, their exploitation at present is limited to the natural resources which may get depleted in course of time. Clam culture has not been taken up in our country on any commercial or semi-commercial scale, though there is scope for it because of the availability of vast stretches of suitable areas as well as seed clams, either from nature or by producing them in hatcheries. Such a proposition may become imperative in future since the demand for more food has to be met by resorting to new methods for augmenting food production.

For successful culture operations, knowledge of the effects of environmental factors on the selected species becomes imperative. Of these parameters, temperature and salinity assume greater importance among all abiotic factors, especially in a tropical country like India.

One of the important aspects to be considered in the selection of suitable species for cultivation is the ability of the species to withstand wide fluctuations of environmental conditions. The fact that these environmental factors exert

great influence on distribution, development, survival and growth is well recognized. Growth is one of the most important parameter to be considered for taking conservation and management measures in culture practices.

With this aspect in view, the present study was carried out using the black clam Villorita cyprinoides (Gray). The objectives of the investigation were the following.

1. Effect of temperature and salinity on growth.
2. Effect of temperature and salinity on feeding rate.
3. Comparison of growth in field and laboratory.
4. Comparison of feeding rates using two different feeds.

The black clam, Villorita cyprinoides (Gray) was used for the present study because it is easily available in this area and is known to withstand wide fluctuations of environmental conditions, especially salinity. This clam is an important resource in the Cochin backwaters and it supports regular clam fishery in the major backwater systems of Kerala, namely, Vembanad, Kayamkulam and Ashtamudi.

I wish to express my immense gratitude to Shri K. Prabhakaran Nair, Scientist-in-Charge, Molluscan Fisheries Division, Central Marine Fisheries Research Institute, under whose guidance and supervision this work has been carried out. I am grateful to Dr. P.S.B.R.James, Director, C.M.F.R.I., for providing all facilities and for the keen interest shown through out the investigation. This work would not have been

completed without the timely help, guidance and advice of many of the members of the staff of C.M.F.R.I. and for this I am particularly thankful to Dr. C.P.Gopinathan, Scientist, Tuticorin Research Centre, Dr. K.Satyanarayana Rao, Head, Molluscan Fisheries Division, Madras Research Centre, Shri K. Narayana Kurup, Head, Fishery Resources Assessment Division, Dr. A.Noble, Scientist-in-Charge, P.G.P.M., Shri D.S.Rao, Principal Scientist, Smt. V.Kripa, Scientist, Shri Mathew Joseph, Technical Assistant, Shri V.K.Balachandran, Technical Assistant, Shri A.Nandakumar, Technical Assistant, Shri P. Raghavan, Photographer and Shri Saji Chacko, Senior Research Fellow. I am also thankful to the administrative staff of the Institute, P.G.P.M. office staff in particular and to my class mates for the valuable help.

The award of Junior Research Fellowship by the Indian Council of Agricultural Research during the Post Graduate Programme is gratefully acknowledged.

I N T R O D U C T I O N

Clams are heterodont bivalve molluscs widely distributed in the estuaries, backwaters and rivers, though a few are marine. They are economically important either as food or as industrial raw material. Clams have been traditionally exploited by the coastal people as a sustenance fishery in many parts of the Indian coasts especially of Maharashtra, Goa, Karnataka and Kerala. The advantages of clam fishery over other fisheries are that it employs very simple methods of hand-picking or slightly improved dredging, sometimes using a canoe, fishing effort is very inexpensive and that anyone irrespective of sex and age can do the fishing. Though clam eating is more or less restricted to the coastal belt, in the last few years there has been considerable increase in demand for meat of certain species of clams for export to other countries. According to Alagarswami and Meiyappan (1989), the present clam production in India is approximately 53,000 t. Apart from live clams, there are vast sub-fossil deposits of dead shells in many estuaries and adjacent paddy fields and these are regularly being exploited.

Clams are filter-feeders, ingesting food material collected by ciliary currents from water that enters the mantle cavity. As they feed low in the food chain, and because of their very slow mobility, they are well suited for on-bottom culture. However, clam culture has not gained any importance

when compared to oyster and mussel culture, though there have been attempts to culture them on experimental basis.

The black clam Villorita cyprinoides (Gray), selected for the present study, supports a regular fishery in many estuaries of Kerala, providing cheap source of protein by way of meat, besides the shell as industrial raw materials for manufacture of cement and lime. This clam is also distributed in Goa and Karnataka; in the latter state the species constitutes a fishery in some estuaries. The distribution shows definite settlement pattern, in the interior of backwaters and upper reaches of the rivers where fresh water or low saline conditions exist, the clams form exclusive beds but towards barmouths where estuarine conditions prevail, they form multispecies beds in combination with other species (Rao et al., 1989).

There are several studies on Indian clams in regard to their taxonomy, distribution, biology, ecology, fishery, resource characteristics and processing. Of these, references on Villorita cyprinoides are very few. Apart from the taxonomic description by Prashad (1921) and Satyamurti (1960), Cherian (1968) has studied its substrate selectivity and distribution in Cochin Harbour area. The rate of growth of this clam was studied by Nair (1975) and the salinity tolerance by Nair and Shynamma (1975). Some biological aspects and fishery of this clam from Netravathi estuary were studied by Rao (1987); Achary (1988) has made a case study of its resource characteristics in the Vembanad lake, and Rao et al. (1989) reported on

the status of exploitation (along with other clams) in Karnataka estuaries. Kunju Panicker (1957) dealt with the lime shell industry, and Rasalam and Sebastian (1976) reported on the lime shell fisheries of the Vembanad Lake.

Practice of clam culture has not become as widespread as oyster culture, probably because some species are abundant and can be easily harvested from nature. However, clam culture is adopted in many countries like Japan, Southeast Asian countries, U.S.A., France and Tunisia. In many western countries, clams are considered a luxury food whereas in most Asian countries these are one of the cheapest and important sources of protein.

In an excellent review on the effect of salinity and temperature on marine and brackish water invertebrates and fishes, Kinne (1964) states that these parameters are of special importance for two reasons. First, they represent the ecological master factors for most of the aquatic organisms, and secondly, they are easier to measure and control.

Evaluation of bivalve nutrition may be based on the rate of clearance of particles from the medium (Malouf and Breese, 1977; Wilson, 1979, 1980) or by the use of radioactive labelled phytoplankton (Walne, 1965; Ukeles and Sweeney, 1969) or observations with fluorescent microscopy (Babinchak and Ukeles, 1979; Lucas and Rangel, 1983). Since bivalves feed by

filtration, an estimate of their filtration or clearance rate determines how much or what kind of food is consumed by them (Fretter and Montgomery, 1968; Malouf and Breese, 1977; Gerdes, 1983; Narasimham, 1988). In the present study, the clearance rate was estimated by measuring the decrease of the cell concentration over time, and this was taken as the feeding rate. The ingestion of food by the bivalve molluscs mainly depends on the filtration rate, but other factors like bio-deposition by ejection of faeces and pseudofaeces also control ingestion rate (Rajaretnam et al., 1988). The chances of this influence were minimized by estimating the initial and final algal concentrations within a short duration of 3-6 hours.

This study is an attempt to investigate by laboratory experiments, whether temperature and salinity have any effect on the growth and feeding rate of the clams of small and large sizes, and to compare the results obtained in the laboratory with that obtained from the field observations. This may give new information on the influence of variations in environmental parameters on the growth and feeding rate of the black clam, Villorita cyprinoides (Gray).

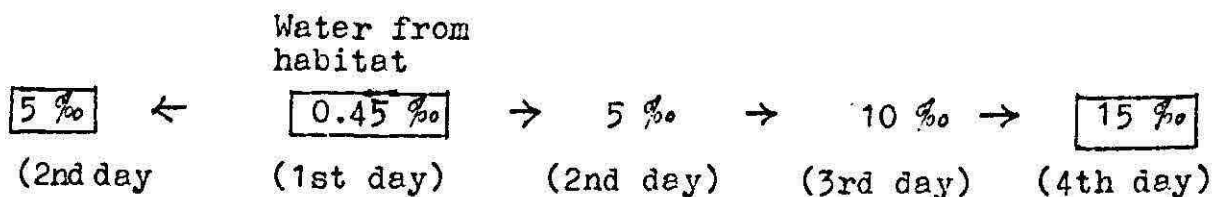
M A T E R I A L A N D M E T H O D S

Experiments in laboratory

The material for the study was collected from Nettur situated about 13 km. southeast of Cochin harbour. Extensive beds of Villorita cyprinoides occur in this area supporting a good fishery. The clams were brought from the field to the laboratory in a plastic bucket containing water collected from the clam bed. Clams of two different length groups, 10-15 mm and 25-30 mm were selected for the experiment in order to compare the relative growth and feeding rates.

Acclimation

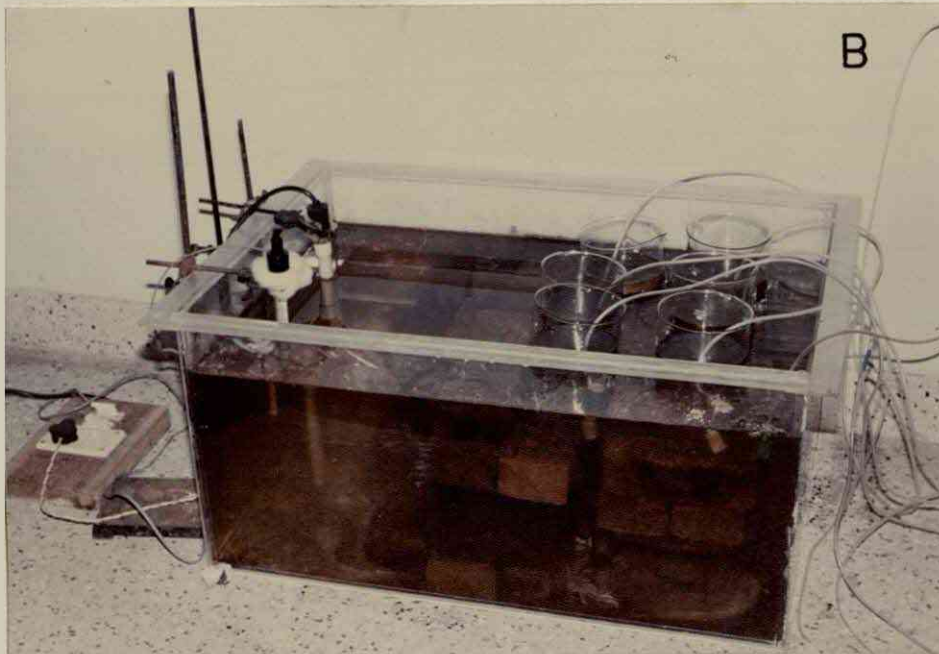
The clams were acclimated in the laboratory in water collected from the habitat which had a salinity of 0.45 ‰. They were gradually transferred to test-salinity levels in different containers by increasing the salinity by 5 ‰ every day, to a maximum of 15 ‰. By this technique within four days, the clams were acclimated to the required levels of 5 ‰ and 15 ‰ as shown below:



During acclimation continuous aeration was provided.

Plate I : Part of experiment set up in laboratory.

- A. Three sets in room temperature -
5 ‰ combination, with one
control for algal feed
- B. One set of 33°C-5 ‰ and 15‰
combinations with two controls
for algal feed in respective
salinities



Experiment set up for room temperature

Fourteen plastic basins of 35 cm diameter, 18 cm height were used for the experiment as shown in Fig:1 A. Of these, seven containers each were filled with 2 litres of water having salinity of 5 ‰ and the other seven with 15 ‰ salinity water. In the first set with 5 ‰ salinity, ten small clams of 10-15 mm were put in 3 containers and ten large clams of 25-30 mm in another 3 containers; one container was kept without clams as control of algal feed. The same arrangement was made for the second set. The temperature of the water medium was around 28°C with variations within $\pm 1^\circ\text{C}$ through out the experiment.

Experiment set up for 33°C

Fourteen 2 litre glass beakers were used as shown in Fig:1.B. Each set of seven beakers was kept in an aquarium tank 3/4 filled with water. A jumo thermometer with heating coil and relay system was used for maintaining the water temperature constant at 33°C. Since the experimental beakers were kept in the aquarium tank with the mouth above water level, uniform temperature was maintained in all the beakers. To avoid over crowding of clams, only 5 clams were kept in each beaker.

During the experiment there was no difference in temperature between the water in the aquarium tank and that in the beakers.

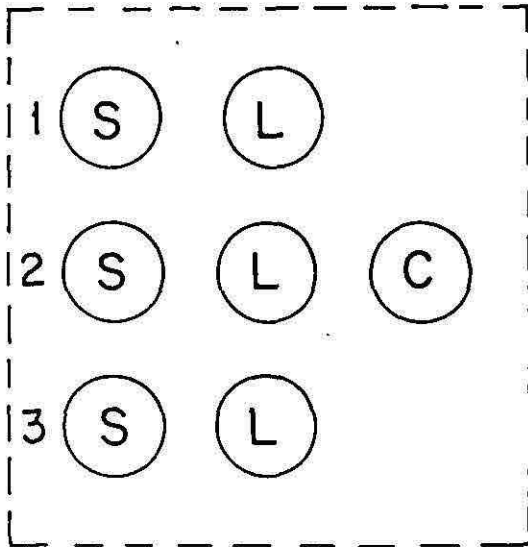
Fig: 1. Diagrammatic representation of the experiment set up in laboratory.

A. Salinities 5‰ and 15‰ in room temperature ($28 \pm 1^\circ\text{C}$)

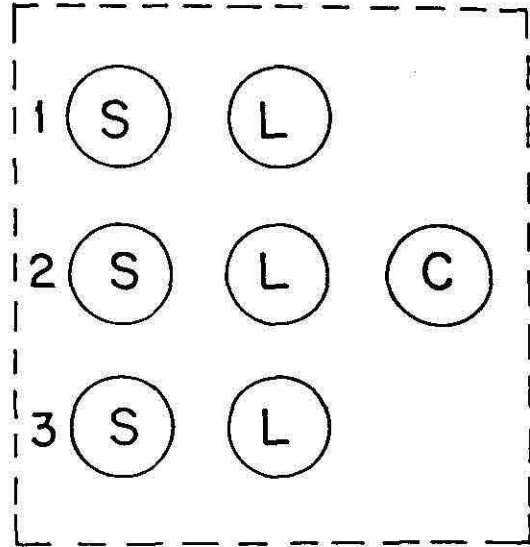
B. Salinities 5‰ and 15‰ in 33°C

Containers with clams are in three series in each combination of temperature and salinity.

Room - Temperature ($28 \pm 1^\circ\text{C}$)

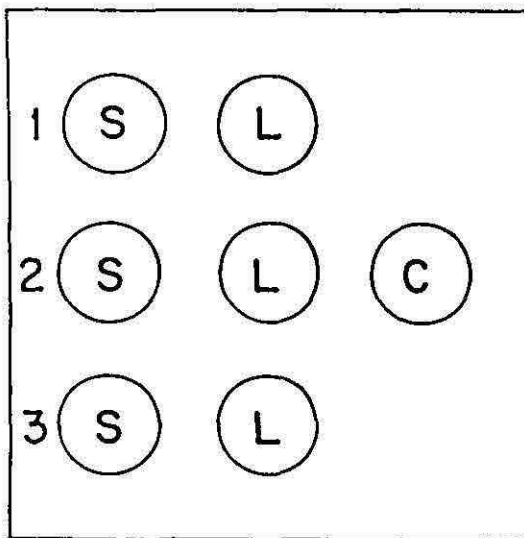


Set I 5‰

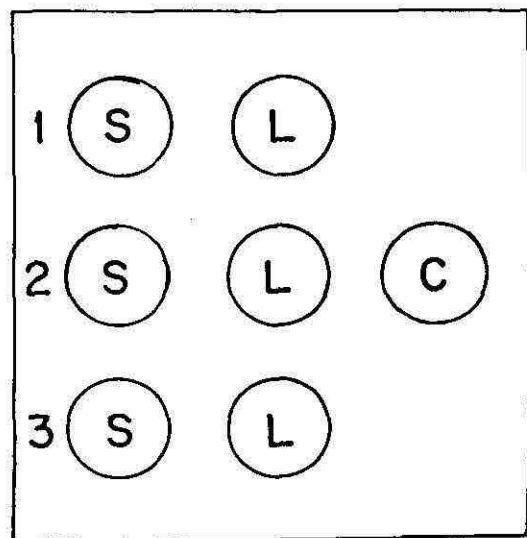


Set II 15‰

33°C



Set I 5‰



Set II 15‰

S: SMALL CLAMS

L: LARGE CLAMS

C: CONTROL (Without clams)

Throughout the experiment, water in the containers was changed every three days. Constant aeration was provided in all the containers.

The maintenance of clams in different combinations of temperature and salinity was replicated three times as shown in Fig.1 marked 1, 2, 3.

Experimental medium

The water medium for the experiment was prepared with sea water collected off Cochin by diluting with fresh water to 5 ‰ and 15 ‰ salinity levels using the following formula:

$$V = \frac{\text{desired salinity}}{\text{salinity of sea water (known)}} \times 1000$$

'V' gives the volume of sea water of the known salinity to be taken in order to make 1 litre of the media of desired salinity; (1000 - V) gives the volume of fresh water to be added.

Culture of algae

The materials used for investigating the feeding rate were unicellular flagellate, Tetraselmis sp., and mixed phytoplankton.

The strain of Tetraselmis was from the stock culture maintained in the C.M.F.R.I. laboratory.

Culture conditions

The flagellate was grown in enriched low saline (10-15 ‰) water collected from Cochin backwaters. The sea water was allowed to age in carbuoys. This was then filtered and heat-sterilized. The cool sterilized medium was transferred to sterile culture flasks. Miquel's medium was used in the present study. The composition of the medium is given below:

Miquel A

Potassium nitrate	- 20.2 g
Distilled water	- 100 ml

Miquel B

Sodium phosphate	- 4 g
Calcium chloride	- 4 g
Ferric chloride	- 2 g
Concentrated Hcl	- 2 ml
Distilled water	- 98 ml

To each litre of filtered sea water 0.55 ml of A and 0.5 ml of B are added.

The culture was done in 500 ml medium in 2 litre flasks (corning) plugged with sterilized cotton and was maintained in logarithmic phase. An aliquot of the culture was replaced with fresh medium every 7-10 days. Aeration was

Plate II. Phytoplankton culture in laboratory for feeding
clams.



was not provided to the cultures. Instead the culture was shaken manually to give 3 to 4 rotations every now and then to keep them in uniform suspension. Settling was not noticed for a month but later on developed a tendency to settle down.

Mixed phytoplankton

In addition to the unialgal species, phytoplankton collected from Cochin backwaters was cultured in perspex tanks in the laboratory and used for feeding the clams.

The water collected was filtered with bolting silk to remove zooplankton and was fertilized to bloom the retained phytoplankton with the chemicals in the following ratio for 100 l of water.

Potassium nitrate	- 1.32 g
EDTA	- 0.66 g
Sodium phosphate	- 0.66 g
Sodium silicate	- 0.33 g

The water used for phytoplankton culture was low saline (10-15 ‰) collected from Cochin backwaters during southwest monsoon. The tank of 200 l capacity was covered with a transparent polythene sheet and exposed to sunlight. Two day old blooms in the tank were examined microscopically for the presence of phytoplankton. The mixed culture was maintained by reculturing with fresh media till the end of the experiment.

The algal components of the mixed culture were mainly species of Scenedesmus, Coscinodiscus and Skeletonema; other algae which were also observed were species of Navicula, Pleurosigma, Nitzschia, Pyrocystis, Thalassionema.

Growth measurements in the laboratory

At the start of the experiments small and large clams of known length, width and thickness and weight were introduced in the culture containers. Linear measurements of all the clams in all the containers were taken every month without causing disturbance to the animals and the average values for clams in each container was calculated. Length denotes the maximum distance from the anterior to the posterior end; height the maximum distance between the umbo and the gaping end and thickness the distance between two valves. All the linear measurements were taken to the nearest 0.1 mm with a vernier calipers and the weight to the nearest milligram on an electronic balance.

For taking initial meat weight, clams identical in length and total weight to those introduced for experiment were used. For final meat weight values, the test clams themselves were utilized at the close of the experiment.

Estimation of feeding rate

Feeding rate was estimated at intervals of 3-6 hours after introduction of feed. As in the case of growth studies,

this was done for a combination of two temperature and two salinities. For each combination, one container was kept without clams as control (marked 'C' in Fig. 1) for determining the possible multiplication of algal cells in the medium during the experiment.

At the start of every experiment, 250 ml of the algal culture was introduced in all the plastic basins (room temperature; 5 ‰ and 15 ‰) and 50 ml in the glass beakers (33°C; 5 ‰ and 15 ‰).

Algal consumption was monitored at regular intervals after feeding. Samples of 3 ml water was removed from the rearing containers, fixed in formalin and the cell counts taken microscopically using a plankton counting chamber. From this the level of algal concentration at the end of fixed time intervals from introduction of feed was estimated. From the initial and final concentration, the feeding rate was estimated using Quayle's (1948) equation.

$$m = \frac{M}{nt} \left[\left(\log_e \frac{\text{conc}_0}{\text{conc}_t} \right) - \left(\log_e \frac{\text{conc}_{0'}}{\text{conc}_{t'}} \right) \right]$$

where 'm' is the feeding rate/clearance rate; 'M' the volume of the suspension. 'n' the number of animals per container. 'conc₀', the initial concentration, 'conc_t' final concentration after time 't'. 'conc₀', 'conc_t', the initial and final concentrations in the control suspension.

The scope of feeding rate investigated here is limited to the gross clearance rate.

Estimation of dissolved oxygen, pH and nutrients

Estimation of dissolved oxygen, pH, nitrite, nitrate and phosphate of the experimental medium was done eight times, every time one immediately after introducing water to the containers and one just before replacing it.

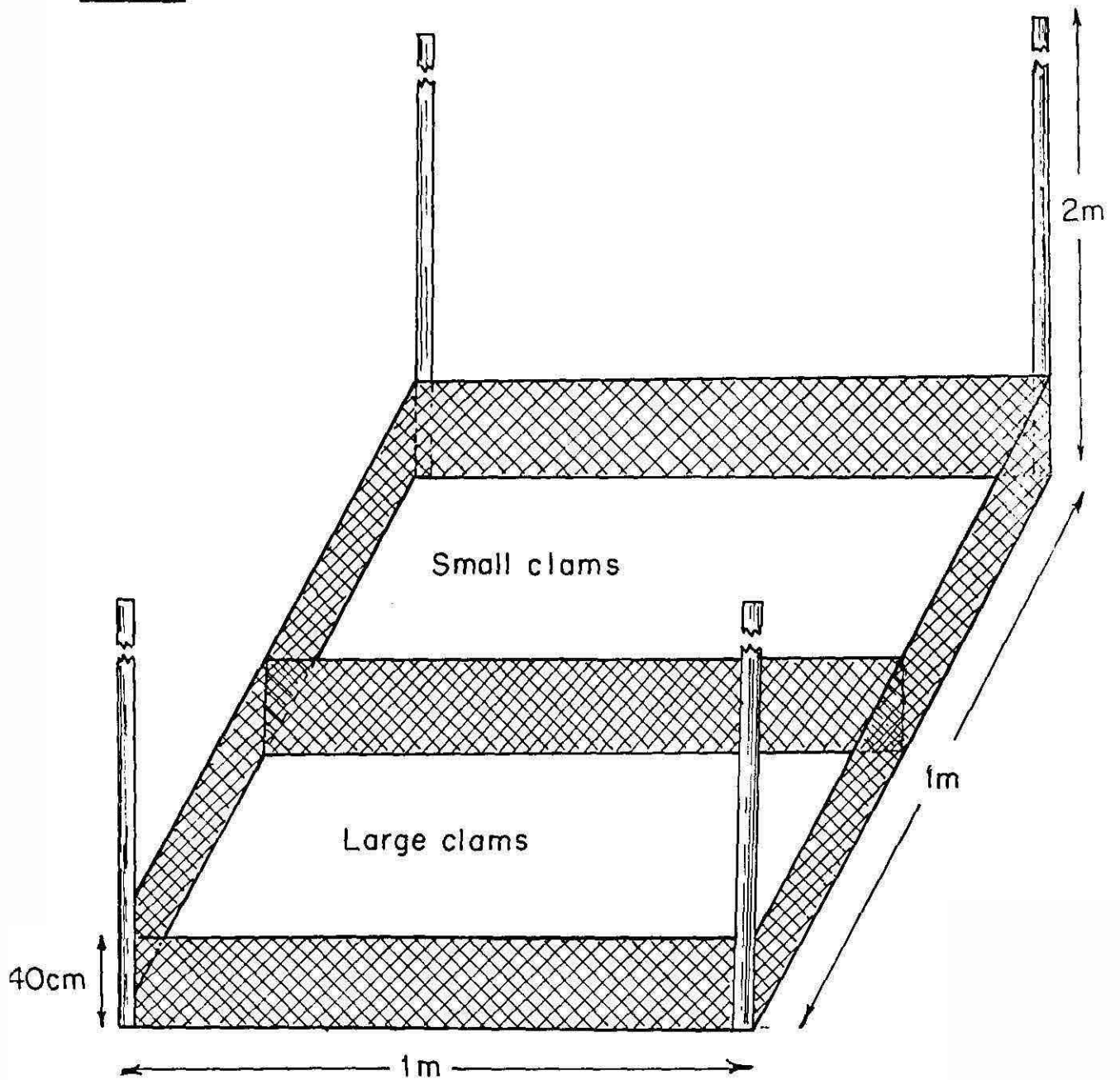
The methods used for the estimation of dissolved oxygen, pH and nutrients are given in a subsequent section.

Field Experiments

The field experiment was done in a small pen of 1 sq.m. area set up at Nettur (Fig.2) from where the material for laboratory experiments was collected. The pen consisted of four wooden poles erected on the bottom. The area was fenced off on the four sides by using 40 cm high chicken wire mesh. The pen was divided into two equal compartments by putting another piece of wire mesh through the middle. In one half 1000 small clams of 12-16 mm were stocked from wild and in the other 300 large clams of 27-32 mm. The bottom of the pen area consisted of fine sand and clay. The water level at this area was 0.5-1.0 m. The experiment lasted for 3 months from 10th July, 1990.

Fig: 2. Schematic diagram showing the 1 x 1 m pen erected at Nettur.

PEN



Fortnightly sampling was done for studying the growth of clams. Water temperature was noted in the field and water samples for estimating salinity, pH, nitrite, nitrate and phosphate were collected in 250 ml polythene bottles and the samples for dissolved oxygen were collected in 125 ml standard oxygen bottles. All the samples were analysed in the laboratory.

Hydrographic studies

The following hydrographic parameters of the pen site were studied.

1. Temperature: Water temperature was measured with an ordinary thermometer of 0-50°C range, having 0.1°C division.
2. Salinity: Salinity was estimated by Mohr-Knudsen method as given by Strickland and Parsons (1968).
3. Dissolved oxygen: This parameter was estimated by using the modified Winkler method as given by Strickland and Parsons (1968). The samples were collected in 125 ml stoppered glass bottles and the oxygen was fixed immediately by using Winkler A and B solutions.
4. pH: The pH value of water was measured using a digital pH meter within 2 hours of the collection of samples.
5. Nitrite: The nitrite-nitrogen was estimated following Shinh method modified by Bardschneider and Robinson (Strickland and Parsons, 1968). The absorbance was measured at 543 nm.

6. Nitrate: The nitrate-nitrogen estimation was done according to Morris and Riley method as described by Strickland and Parsons (1968). The absorbance was measured at 543 nm.
7. Phosphate: This was determined by Murphy and Riley method (Strickland and Parsons, 1968). The absorbance was measured at 885 nm.

The absorbance values through out the experiment were measured using the same spectrophotometer.

Growth measurements

The initial length, width, thickness and weight of clams were measured from random samples. Measurements for growth studies were made every fortnight on 25 small and 10 large clams. Vernier calipers was used for taking all linear measurements.

For determining meat weight, 25 small and 10 large clams of known length and total weight were opened and the meat extracted. This was then blotted with a filter paper to remove the free adherent water and then weighed on an electronic balance.

Statisticals analysis

Correlation coefficients (Snedecor and Cochran, 1967) were calculated to test the mutual relationship of various

parameters observed at pen site. ANOVA test (Snedecor and Cochran, 1967; Federer, 1974) was carried out in order to test the significance of length, width, thickness, meat weight and total weight of small and large clams in the two temperature and two salinity combinations. Analysis of variance on feeding rates of two feeds mixed phytoplankton and Tetraselmis sp., were separately carried by following the method for factorial experiment on three factors, each at two levels, the factors being temperature, salinity and size of the animal. Mean feeding rate under different combinations were computed and significance of difference between pairs of mean was tested by computing standard error of difference as

$$SE (di) = \sqrt{\frac{2 \times EMS}{n \times r}}$$

where EMS is the Error Mean Square; 'n', the number of combinations and 'r', the number of observations and computing the least significant difference,

$$LSD = t_{(0.01)} \times SE (di).$$

R E S U L T S

LABORATORY EXPERIMENTS

Growth

The growth in length, width and thickness of small and large clams in different combinations of temperature and salinity are shown in Figs: 3 & 4 and Tables: 1, 2, 5 & 6; growth in total weight and meat weight in Tables: 3, 4, 7 & 8.

Growth of small clams in room temperature ($28 \pm 1^{\circ}\text{C}$)

Length

In 5 ‰, small clams of average length 14.7 mm had a growth increment of 2-3 mm in the first two months, but in the subsequent months it was very small. The length at the end of the experiment was 20.9 mm registering an increment of 6.2 mm in four months.

In 15 ‰ also the trend was similar but growth was more. Clams of average length 13.1 mm reached a length of 22.1 mm, with an increment of 9.0 mm.

Width

In 5 ‰, small clams of average width 16.2 mm reached a width of 17.7 mm at the end of fourth month.

Fig: 3. Growth of Villorita cyprinoides in length, width and thickness in combination of

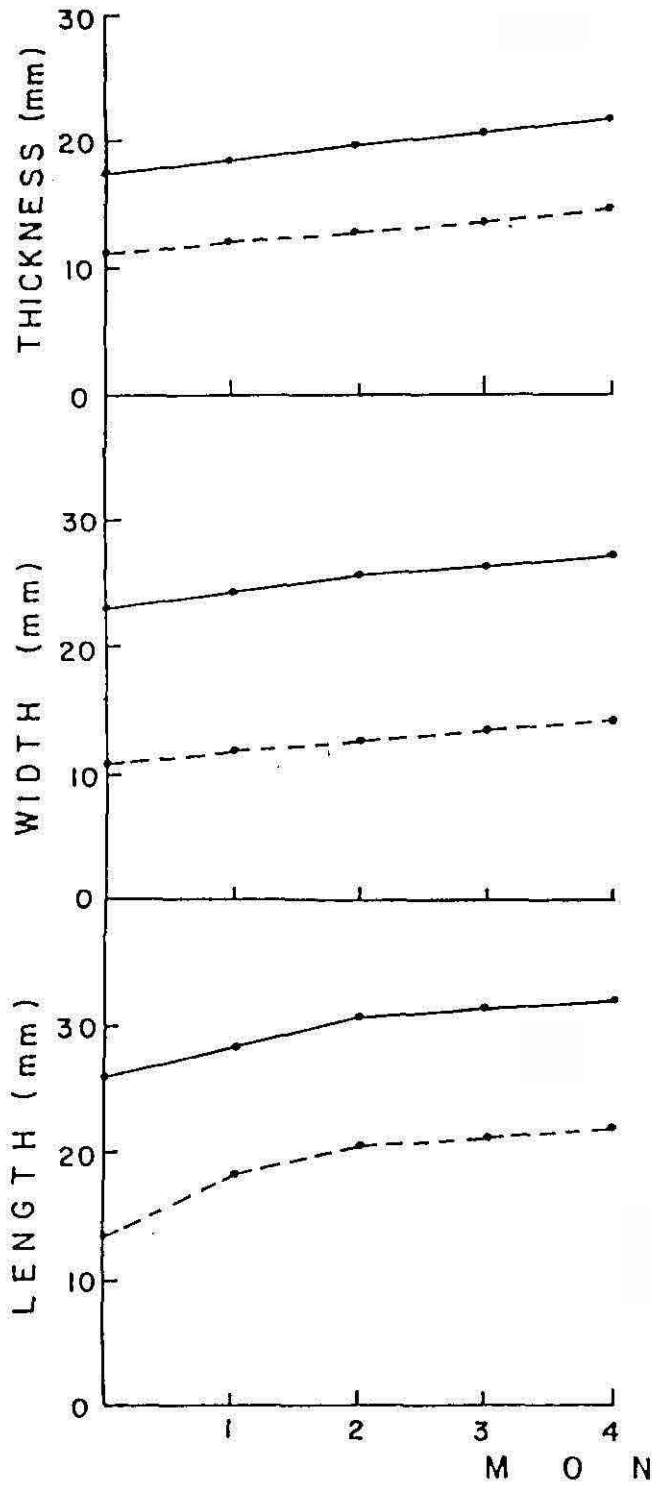
A. Room temperature ($28 \pm 1^{\circ}\text{C}$) at 15 ‰ salinity

B. Room temperature ($28 \pm 1^{\circ}\text{C}$) at 15 ‰ salinity

Solid line : Large clams

Broken line: Small clams

A: Room temp, 15‰



B: Room temp, 5‰

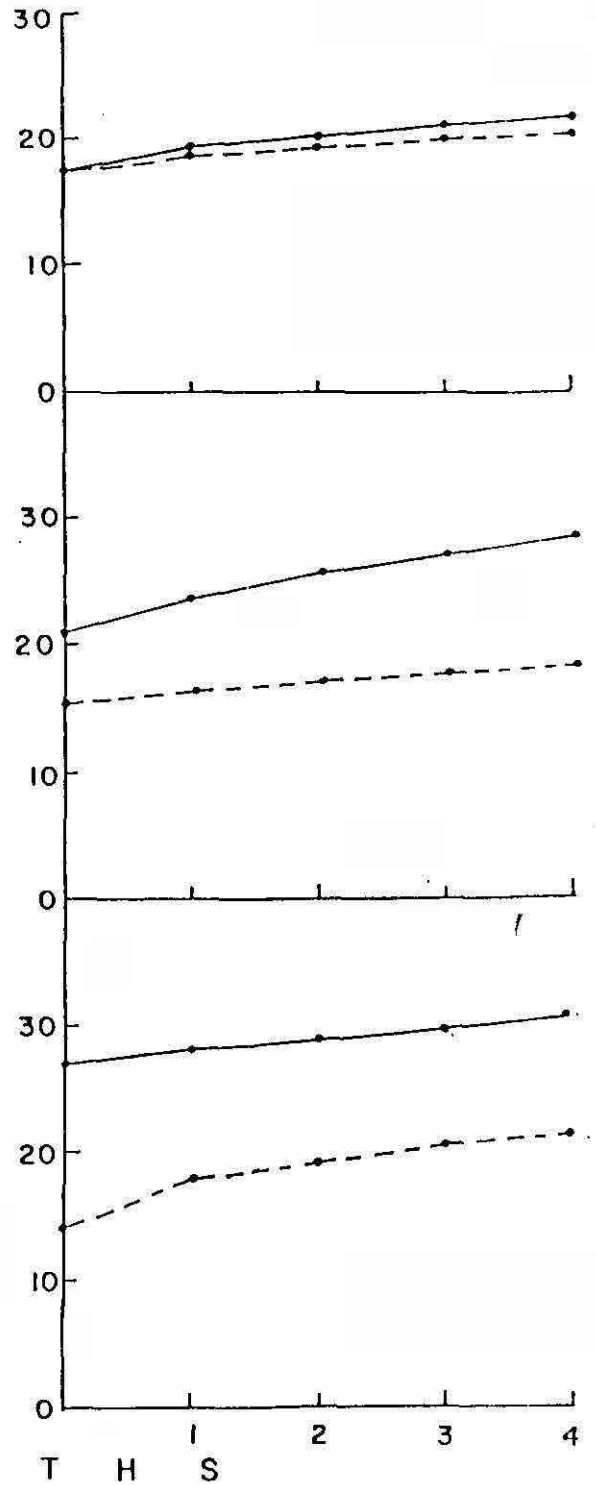


Table:1. Growth in length, width and thickness of Villorita cyprinoides maintained in the laboratory.

A. Small clams at room temp. and 5 ‰

Date	Length (mm)	Cumulative increment (mm)	Width (mm)	Cumulative increment (mm)	Thick- ness (mm)	Cumulative increment (mm)
Jun 20	14.7 ± 0.3	-	16.2 ± 0.1	-	17.4 ± 0.9	-
Jul 20	17.7 ± 0.1	2.9 ± 0.1	16.7 ± 0.2	0.5 ± 0.1	18.4 ± 1.1	1.0 ± 0.2
Aug 20	19.7 ± 0.1	5.0 ± 0.1	17.2 ± 0.4	1.1 ± 0.3	19.4 ± 0.9	1.90 ± 0.2
Sep 20	20.2 ± 0.3	5.5 ± 0.3	17.4 ± 0.4	1.2 ± 0.2	19.5 ± 0.8	2.1 ± 0.2
Oct 20	20.9 ± 0.3	6.2 ± 0.2	17.7 ± 0.4	1.5 ± 0.3	20.0 ± 0.8	2.6 ± 0.3

B. Small clams at room temperature and 15 ‰

Date	Length (mm)	Cumulative increment (mm)	Width (mm)	Cumulative increment (mm)	Thick- ness (mm)	Cumulative increment (mm)
Jun 20	13.1 ± 0.1	-	11.4 ± 1.0	-	10.9 ± 1.7	-
Jul 20	18.5 ± 0.5	5.5 ± 0.4	11.8 ± 0.9	0.4 ± 0.2	13.5 ± 1.0	2.5 ± 0.9
Aug 20	20.6 ± 0.4	7.5 ± 0.4	12.4 ± 0.8	1.0 ± 0.2	16.2 ± 0.4	3.9 ± 1.4
Sep 20	21.2 ± 0.3	8.2 ± 0.2	13.5 ± 0.2	2.1 ± 0.8	17.3 ± 1.0	6.4 ± 0.1
Oct 20	22.1 ± 0.2	9.0 ± 0.1	14.0 ± 0.3	2.6 ± 0.7	17.9 ± 1.3	6.9 ± 1.0

Table:2. Growth in length, width and thickness of Villorita cyprinoides maintained in the laboratory

A. Large clams at room temperature and 5 ‰

Date	Length (mm)	Cumulative increment (mm)	Width (mm)	Cumulative increment (mm)	Thick- ness (mm)	Cumulative increment (mm)
Jun.20	27.1 ± 0.1	-	21.7 ± 1.7	-	17.4 ± 0.8	-
Jul.20	28.9 ± 0.6	1.8 ± 0.4	24.4 ± 1.1	2.6 ± 0.5	18.2 ± 0.9	0.7 ± 0.3
Aug.20	29.5 ± 0.5	2.5 ± 0.3	26.5 ± 0.3	4.7 ± 1.4	19.8 ± 0.3	2.4 ± 0.7
Sep.20	29.9 ± 0.4	2.7 ± 0.2	27.1 ± 0.4	5.3 ± 1.3	20.2 ± 0.4	2.7 ± 0.6
Oct.20	30.3 ± 0.3	3.2 ± 0.1	27.3 ± 0.4	5.6 ± 1.3	20.7 ± 0.5	3.2 ± 0.3

B. Large clams at room temperature and 15 ‰

Date	Length (mm)	Cumulative increment (mm)	Width (mm)	Cumulative increment (mm)	Thick- ness (mm)	Cumulative increment (mm)
Jun.20	26.6 ± 0.5	-	22.7 ± 1.6	-	17.3 ± 1.7	-
Jul.20	28.5 ± 0.3	1.9 ± 0.2	24.4 ± 1.3	1.6 ± 0.4	18.3 ± 1.2	1.0 ± 0.6
Aug.20	30.3 ± 0.3	3.7 ± 0.2	26.3 ± 0.6	3.6 ± 1.0	19.7 ± 0.7	2.4 ± 1.2
Sep.20	30.6 ± 0.3	4.0 ± 0.3	26.8 ± 0.7	4.2 ± 0.9	20.6 ± 1.3	3.3 ± 0.4
Oct.20	31.1 ± 0.5	4.4 ± 0.1	27.2 ± 0.8	4.5 ± 0.8	20.8 ± 1.3	3.6 ± 0.3

Table:3. Increase in total weight and meat weight of Villorita cyprinoides maintained in the laboratory

A. Small clams at room temperature and 5 ‰

	Total weight (g)	Increment (g)	Meat weight (g)	Increment (g)
Jun.20	0.75	-	0.16	-
Oct.20	3.56	2.81	0.65	0.49

B. Small clams at room temperature and 15 ‰

	Total weight (g)	Increment (g)	Meat weight (g)	Increment (g)
Jun.20	0.74	-	0.14	-
Oct.20	3.65	2.91	0.64	0.5

Table:4. Increase in total weight and meat weight of Villorita cyprinoides maintained in the laboratory

A. Large clams at room temperature and 5 ‰

	Total weight (g)	Increment (g)	Meat weight (g)	Increment (g)
Jun.20	4.4	-	0.46	-
Oct.20	7.1	2.7	1.16	0.7

B. Large clams at room temperature and 15 ‰

	Total weight (g)	Increment (g)	Meat weight (g)	Increment (g)
Jun.20	4.7	-	0.48	-
Oct.20	7.9	3.2	1.28	0.8

Fig: 4. Growth of Villorita cyprinoides in length, width and thickness in combination of

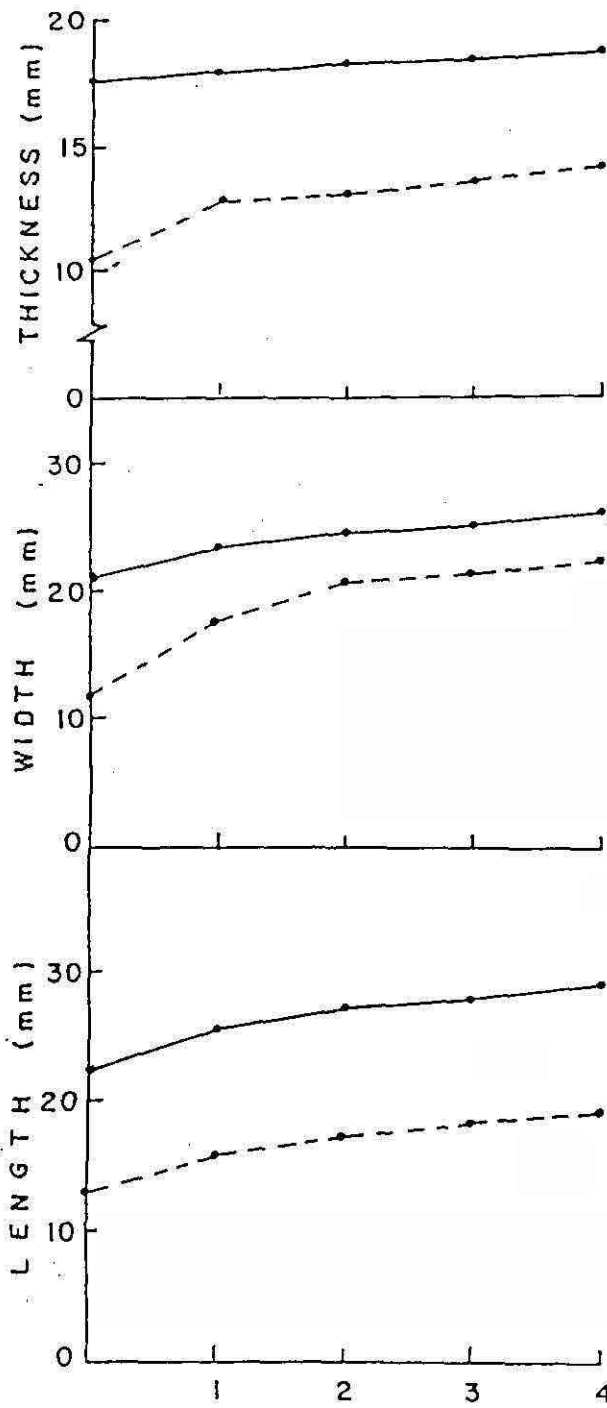
A. Temperature 33°C at 5 ‰ salinity

B. Temperature 33°C at 15 ‰ salinity

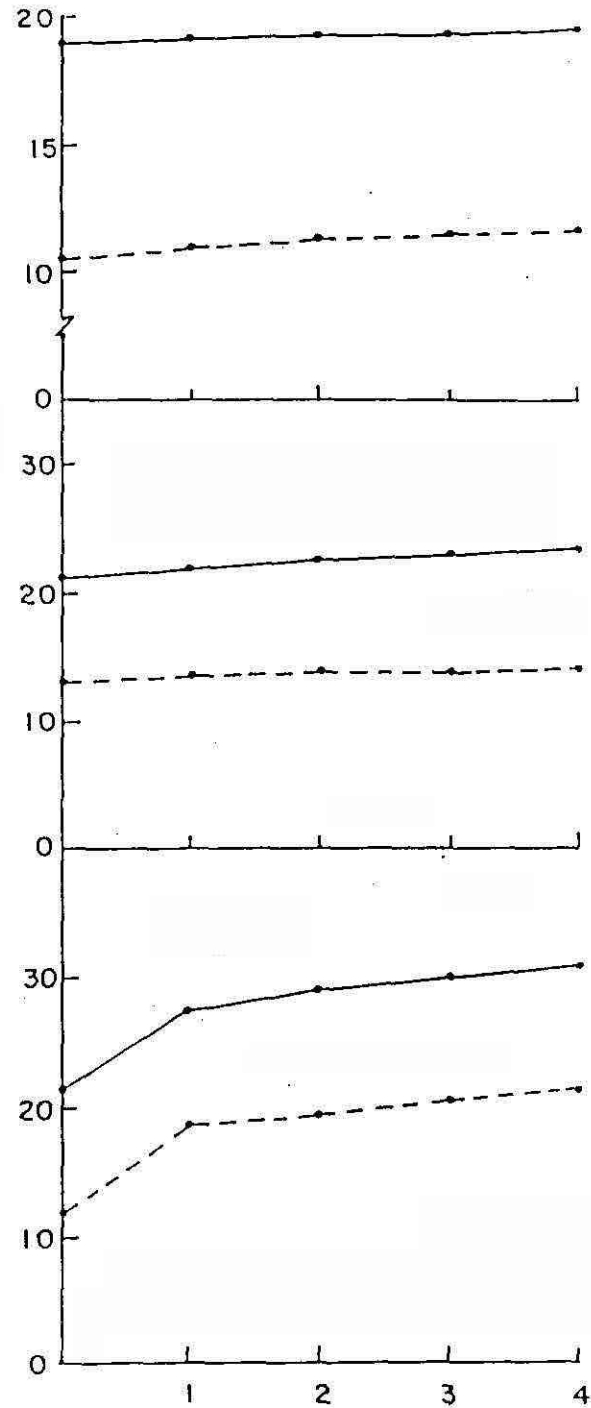
Solid line : Large clams

Broken line: Small clams

A: 33°C, 5‰



B: 33°C, 15‰



M O N T H S

Table:5. Growth in length, width and thickness of Villorita cyprinoides maintained in the laboratory.

A. Small clams at 33°C and 5‰

Date	Length (mm)	Cumulative increment (mm)	Width (mm)	Cumulative increment (mm)	Thick-ness (mm)	Cumulative increment (mm)
Jun.20	12.8 ± 0.4	-	12.3 ± 0.5	-	10.4 ± 0.7	-
Jul.20	16.0 ± 0.4	3.2 ± 0.1	17.8 ± 0.5	5.5 ± 0.1	12.8 ± 0.4	2.4 ± 0.3
Aug.20	17.2 ± 0.3	4.4 ± 0.2	20.4 ± 0.2	8.1 ± 0.3	13.2 ± 0.5	2.8 ± 0.3
Sep.20	17.8 ± 0.3	5.0 ± 0.2	20.6 ± 0.5	8.3 ± 0.3	13.5 ± 0.5	3.1 ± 0.3
Oct.20	18.9 ± 0.2	6.1 ± 0.2	20.9 ± 0.3	8.6 ± 0.3	13.9 ± 0.5	3.5 ± 0.3

B. Small clams at 33 °C and 15‰

Date	Length (mm)	Cumulative increment (mm)	Width (mm)	Cumulative increment (mm)	Thick-ness (mm)	Cumulative increment (mm)
Jun.20	11.9 ± 0.4	-	13.0 ± 0.6	-	11.6 ± 0.9	-
Jul.20	18.4 ± 0.3	6.5 ± 0.3	13.2 ± 0.6	0.2 ± 0.1	11.9 ± 0.8	0.3 ± 0.1
Aug.20	19.4 ± 0.3	7.5 ± 0.2	13.3 ± 0.6	0.3 ± 0.1	12.1 ± 0.8	0.5 ± 0.1
Sep.20	20.2 ± 0.4	8.3 ± 0.2	13.4 ± 0.4	0.4 ± 0.1	12.2 ± 0.8	0.6 ± 0.1
Oct.20	21.3 ± 0.1	9.2 ± 0.3	13.5 ± 0.6	0.5 ± 0.1	12.3 ± 0.8	0.7 ± 0.1

Table:6. Growth in length, width and thickness of Villorita cyprinoides maintained in the laboratory

A. Large clams at 33°C and 5‰

Date	Length (mm)	Cumulative increment (mm)	Width (mm)	Cumulative increment (mm)	Thick-ness (mm)	Cumulative increment (mm)
Jun.20	22.5 ± 0.3	-	21.2 ± 0.6	-	17.8 ± 0.7	-
Jul.20	26.3 ± 0.4	3.7 ± 1.5	23.0 ± 0.5	1.7 ± 0.1	18.0 ± 0.6	0.2 ± 0.1
Aug.20	27.2 ± 0.4	4.6 ± 0.1	24.6 ± 0.5	3.4 ± 0.1	18.3 ± 0.6	0.50 ± 0.1
Sep.20	27.7 ± 0.3	5.2 ± 0.1	25.0 ± 0.5	3.8 ± 0.1	18.4 ± 0.7	0.6 ± 0.1
Oct.20	28.4 ± 0.3	5.9 ± 0.1	25.6 ± 0.5	4.3 ± 0.2	18.5 ± 0.7	0.7 ± 0.1

B. Large clams at 33°C and 15‰

Date	Length (mm)	Cumulative increment (mm)	Width (mm)	Cumulative increment (mm)	Thick-ness (mm)	Cumulative increment (mm)
Jun.20	20.7 ± 0.5	-	21.5 ± 0.7	-	19.1 ± 0.6	-
Jul.20	27.7 ± 0.3	6.9 ± 0.1	21.9 ± 0.6	0.4 ± 0.1	19.4 ± 0.6	0.3 ± 0.1
Aug.20	29.7 ± 0.5	9.0 ± 0.2	22.0 ± 0.7	0.5 ± 0.1	19.5 ± 0.6	0.4 ± 0.1
Sep.20	30.0 ± 0.5	9.3 ± 0.2	22.1 ± 0.7	0.6 ± 0.4	19.6 ± 0.6	0.5 ± 0.1
Oct.20	30.2 ± 0.6	9.5 ± 0.2	22.2 ± 0.7	0.7 ± 0.1	19.7 ± 0.6	0.6 ± 0.1

Table:7. Increase in total weight and meat weight of Villorita cyprinoides maintained in the laboratory

A. Small clams at 33°C and 5 ‰

	Total weight (g)	Increment (g)	Meat weight (g)	Increment (g)
Jun.20	0.74	-	0.14	-
Oct.20	3.65	2.91	0.64	0.5

B. Small clams at 33°C and 15 ‰

	Total weight (g)	Increment (g)	Meat weight (g)	Increment (g)
Jun.20	0.75	-	0.15	-
Oct.20	4.05	3.3	0.68	0.53

Table:8. Increase in total weight and meat weight of Villorita cyprinoides maintained in the laboratory

A. Large clams at 33°C and 5‰

	Total weight (g)	Increment (g)	Meat weight (g)	Increment (g)
Jun.20	5.4	-	0.52	-
Oct.20	8.5	2.9	1.42	0.9

B. Large clams at 33°C and 15‰

	Total weight (g)	Increment (g)	Meat weight (g)	Increment (g)
Jun.20	5.2	-	0.49	-
Oct.20	8.7	3.5	1.59	1.1

In higher salinity the width increment was slightly more, 2.6 mm as against 1.5 mm in lower salinity.

Thickness

The average thickness in 5 ‰ measured at the start of the experiment was 17.4 mm, had a growth increment of 2.6 mm at the end of fourth month.

In 15 ‰, increment in thickness was higher, 6.9 mm as against 2.6 mm in 5 ‰. The average initial thickness was 10.9 mm which increased to 17.9 mm at the end of fourth month.

Total weight

In 5 ‰, the initial average total weight was 0.75 g which increased to 3.56 g at the end of fourth month, the increment being 2.81 g.

Increase in total weight was higher in high salinity the increment over a period of four months being 3.29 g as against 2.81 g in low salinity. The initial average total weight was 0.74 g which increased to 4.03 g at the end of fourth month.

Meat weight

The average meat weight in 5 ‰ measured at the start of the experiment was 0.16 g and 0.65 g at the end of the experiment. Increment over a period of four months was 0.49 g.

The increase in meat weight in 15 ‰ was almost similar to the increase in 5 ‰, the increment being 0.51 g. The initial and final meat weight registered was 0.15 g and 0.66 g respectively.

Growth of small clams in 33°C

Length

In 5 ‰ small clams of average length 12.8 mm had a growth increment of 3.2 mm in the first month but it was very small in the subsequent months. The length at the end of the experiment was 18.9 mm, registering an increment of 6.1 mm in four months.

In 15 ‰ also the trend was similar. The increment in the first month was 6.5 mm but in the subsequent months the increment was very small. Increase in length at the end of fourth month was 9.2 mm.

Width

Average initial width of small clams measured in 5 ‰ was 12.3 mm and the width at the end of the experiment was 20.9 mm registering an increment of 8.6 mm in four months. The increment in width in the first month was 5.5 mm, very high compared to the subsequent months.

In 15 ‰ the increment in width over a period of four months was very small 0.5 mm as against 8.6 mm in 5 ‰. The initial width measured was 13.0 mm and the width at the end of the experiment was 13.5 mm.

Thickness

In 5 ‰, clams of average initial thickness 10.4 mm had an increment of 2.4 mm in the first month, but it decreased in the following months. The increment at the end of the fourth month was 3.5 mm

In 15 ‰, monthly increment in thickness was very small as compared to 5 ‰. Clams of initial thickness 11.6 mm measured 12.3 mm at the end of fourth month, registering an increment of 0.7 mm.

Total weight

In 5 ‰, the initial average total weight measured was 0.74 g which increased 3.65 g at the end of fourth month. Increment obtained was 2.91 g.

In 15 ‰, clams of initial total weight, 0.75 g grew to 4.05 g, registering an increment of 3.3 g in four months.

Meat weight

The initial meat weight in 5 ‰ was 0.14 g which increased to 0.64 g, in four months, the increment being 0.5 g.

In 15 ‰ the increment in meat weight, at the end of fourth month was 0.53 g.

Growth of large clams in room temperature (28 ± 1°C)

Length

In 5 ‰, the clams of average length 27.1 mm had a growth increment of 1.8 mm in the first month, but it was very less in the following months. The length at the end of fourth month was 30.3, increment being 3.2 mm.

In 15 ‰, the increment in length during the first two months was almost similar. Clams of average length 26.6 mm reached a length of 31.1 mm, registering an increment of 4.5 mm in four months.

Width

In 5 ‰, large clams of average width 21.7 mm reached a width of 27.3 mm at the end of fourth month, total increment being 5.6 mm.

In 15 ‰, the total width increment was less, 4.5 mm compared to 5 ‰. The average initial width was 22.7 mm which increased to 27.2 mm at the end of fourth month.

Thickness

The average thickness in 5 ‰ measured at the start of the experiment was 17.4 mm, had a growth increment of 3.3 mm at the end of fourth month.

In 15 ‰, the increment in thickness was almost similar, total increment at the end of fourth month was 3.6 mm.

Total weight

In 5 ‰, initial average total weight was 4.4 g which increased to 7.1 g after a period of four months, the increment being 2.7 g.

In 15 ‰, also the increment in total weight was 3.2 g; the total weight at the start and end of the experiment was 4.7 g and 7.9 g respectively.

Meat weight

In 5 ‰, the initial average meat weight was 0.46 g and the final meat weight after a period of four months was increased to 1.16 g, the increment being 0.7 g.

The total increment in meat weight in 15 ‰ was 0.8 g the initial and final meat weight being 0.48 g and 1.28 g respectively.

Growth of large clams in 33°C

Length

In 5 ‰ clams of average length, 22.5 mm had a growth increment of 3.7 mm in the first month, but in the subsequent months it was very small. The length at the end of the

experiment was 28.4 mm; total increment being 5.9 mm at the end of fourth month.

In 15 ‰, the total increment in length over a period of four months was 9.4 mm. As in 5 ‰, the length increment was maximum in the first month. The initial and final length measured was 20.7 and 30.2 mm respectively.

Width

In 5 ‰, large clams of average width 21.2 mm increased to 25.6 mm, registering an increase of 4.3 mm in four months.

The total width increment in 15 ‰ was 0.7 mm, the initial and final width of clams being 21.5 and 22.2 respectively.

Thickness

The average thickness in 5 ‰ measured at the start of the experiment was 17.8 mm and at the end of the experiment was 18.5 mm, registering an increment of 0.7 mm in four months.

In 15 ‰, the total increment in thickness was 0.6 mm, the initial and final thickness being 19.1 mm and 19.7 mm respectively.

Total weight

In 5 ‰, average total weight initially measured was

5.4 g and after a period of four months, the weight was 8.5 g, the increment in weight being 2.9 g.

Average initial total weight in 15 ‰ was 5.2 g which increased to 8.7 g after a period of four months, the increment was 3.5 g.

Meat weight

The average meat weight in 5 ‰ measured at the start of the experiment was 0.52 g and 1.42 g at the end of the experiment. Increment over a period of four months was 0.9 g.

In 15 ‰, the meat weight increment in four months was 1.1 g.

Feeding rate

The results of experiments on feeding rate are shown in Table: 9. Feeding rate is expressed as number of cells/ml of water/hour/clam.

Feeding rate at room temperature ($28 \pm 1^{\circ}\text{C}$)

In 5 ‰

The average feeding rate of small clams using mixed phytoplankton as feed was 3344 and the feeding rate with Tetraselmis sp. was 10544.

Table:9. Feeding rate ($\times 10^2$ cells/ml/hour/clam) of small and large clams fed with mixed phytoplankton (Feed 1) and Tetraselmis sp. (Feed 2) in the laboratory

	Feed 1		Feed 2	
	Small clams	Large clams	Small clams	Large clams
$T_1 S_1$	33.44 \pm 4.11	41.13 \pm 4.75	105.44 \pm 7.54	126.86 \pm 7.08
$T_1 S_2$	35.54 \pm 3.77	43.43 \pm 3.32	110.14 \pm 7.24	134.83 \pm 8.61
$T_2 S_1$	59.88 \pm 2.48	78.83 \pm 2.58	123.56 \pm 2.72	150.94 \pm 3.54
$T_2 S_2$	63.81 \pm 2.75	84.28 \pm 1.95	128.06 \pm 2.60	156.16 \pm 2.91

T_1 : Room temperature ($28 \pm 1^\circ\text{C}$)

T_2 : 33°C

S_1 : 5 ‰

S_2 : 15 ‰

In large clams the average feeding rate was found to be 4113 cells when mixed phytoplankton feed was used; whereas the feeding rate with Tetraselmis sp. was found to be 12686.

In 15 ‰

Average feeding rate of small sized clams was 3554 when mixed phytoplankton was used. Feeding rate obtained with Tetraselmis sp. was 11014.

When mixed phytoplankton was used, the average feeding rate in large clams was found to be 4343. Feeding rate with Tetraselmis sp. as feed was 13483.

Feeding rate at 33°C

In 5 ‰

The feeding rate of small sized clams with mixed phytoplankton was 5988 and with Tetraselmis sp. was 12356.

In large sized clams, the feeding rate was 7883 when mixed phytoplankton feed was used. The feeding rate obtained with Tetraselmis sp. was 15094.

In 15 ‰

Feeding rate in small sized clams was 6381 when mixed phytoplankton was used. Feeding rate with Tetraselmis sp. was 12806.

Table:10. pH values in laboratory experiments with salinities 5‰ & 15‰ at A. Room temperature ($28 \pm 1^\circ\text{C}$) and B. 33°C .

A. Room temperature ($28 \pm 1^\circ\text{C}$)

Date	5 ‰			15 ‰		
	S	L	C	S	L	C
Jul.5	6.9	7.1	7.3	6.9	7.1	7.3
Jul.8	7.1	7.3	7.4	7.2	7.3	7.5
Aug.5	7.2	7.3	7.4	7.2	7.2	7.4
Aug.8	7.4	7.5	7.5	7.4	7.5	7.5
Sep.5	7.4	6.9	7.2	7.3	6.9	7.2
Sep.8	7.5	7.1	7.3	7.5	7.2	7.3
Oct.5	7.1	7.2	7.1	7.3	7.1	6.9
Oct.8	7.3	7.4	7.3	7.4	7.3	7.2

B. Temperature 33°C

Date	5 ‰			15 ‰		
	S	L	C	S	L	C
Jul.5	7.1	6.9	7.2	7.2	7.3	7.1
Jul.8	7.3	7.2	7.4	7.4	7.4	7.3
Aug.5	7.4	6.9	7.1	6.9	7.3	7.4
Aug.8	7.5	7.1	7.3	7.1	7.5	7.5
Sep.5	7.1	7.2	7.1	7.1	6.9	7.2
Sep.8	7.2	7.4	7.4	7.2	7.1	7.3
Oct.5	7.1	7.2	7.3	7.3	7.2	7.4
Oct.8	7.3	7.4	7.5	7.4	7.4	7.5

S : Culture medium of small clams
 L : Culture medium of large clams
 C : Culture medium without clams

Table:11. Dissolved oxygen values in laboratory experiments with salinities 5‰ & 15‰ at A. Room temperature ($28 \pm 1^\circ\text{C}$) and B. 33°C

A. Room temperature ($28 \pm 1^\circ\text{C}$)

Date	5 ‰			15 ‰		
	S	L	C	S	L	C
Jul.5	4.81	3.84	5.78	4.19	4.20	4.28
Jul.8	5.62	4.66	6.54	6.48	6.16	5.32
Aug.5	3.92	5.12	3.86	4.66	4.02	5.44
Aug.8	4.68	5.89	4.42	4.89	4.34	6.51
Sep.5	5.68	3.97	4.53	5.16	5.03	4.48
Sep.8	6.21	4.78	6.12	6.32	5.44	4.97
Oct.5	4.11	4.19	5.13	4.28	5.14	4.66
Oct.8	4.78	5.12	5.92	5.38	6.23	5.21

B. Temperature 33°C

Date	5 ‰			15 ‰		
	S	L	C	S	L	C
Jul.5	4.26	4.33	4.18	4.23	5.16	5.22
Jul.8	5.38	5.43	5.28	5.41	6.12	6.18
Aug.5	4.17	4.18	4.04	4.78	5.06	5.19
Aug.8	5.04	5.61	5.16	5.06	6.04	6.23
Sep.5	3.99	4.26	3.92	4.61	3.99	5.40
Sep.8	4.78	5.07	4.15	4.78	4.13	6.09
Oct.5	4.30	4.22	4.24	4.77	4.18	3.94
Oct.8	4.98	5.08	4.89	5.62	5.22	4.67

S : Culture medium of small clams
 L : Culture medium of large clams
 C : Culture medium without clams

Table:12. Nitrite values in laboratory experiments with salinities 5‰ & 15‰ at (A) Room temperature ($28 \pm 1^\circ\text{C}$) and (B) 33°C

A. Room temperature ($28 \pm 1^\circ\text{C}$)

Date	5 ‰			15 ‰		
	S	L	C	S	L	C
Jul.5	0.05	0.04	0.03	0.00	0.00	0.45
Jul.8	1.13	0.93	0.65	0.45	0.45	0.75
Aug.5	0.00	0.65	0.40	0.00	0.00	0.00
Aug.8	1.10	2.20	1.40	1.20	0.95	1.10
Sep.5	1.70	0.00	0.00	0.15	1.25	0.00
Sep.8	2.25	1.70	1.38	1.93	2.16	1.85
Oct.5	1.43	1.08	0.28	0.40	1.93	0.65
Oct.8	3.00	2.10	1.60	0.85	2.70	1.30

B. Temperature 33°C

Date	5 ‰			15 ‰		
	S	L	C	S	L	C
Jul.5	0.00	0.65	0.00	0.00	0.40	0.00
Jul.8	0.65	3.10	0.17	2.90	3.02	1.70
Aug.5	0.00	0.05	0.00	7.0	1.57	0.00
Aug.8	1.57	1.82	1.45	1.82	2.10	1.55
Sep.5	0.15	0.00	0.15	0.05	0.00	0.00
Sep.8	2.22	0.27	2.45	1.80	0.32	0.37
Oct.5	1.50	1.42	1.62	0.75	1.57	1.57
Oct.8	2.35	2.17	3.15	1.75	2.45	2.85

S: Culture medium of small clams
 L: Culture medium of large clams
 C: Culture medium without clams

Table:13. Nitrate values in laboratory experiments with salinities 5 ‰ & 15 ‰ at A. Room temperature ($28 \pm 1^\circ\text{C}$) and B. 33°C

A. Room temperature ($28 \pm 1^\circ\text{C}$)

Date	5 ‰			15 ‰		
	S	L	C	S	L	C
Jul.5	1.6	3.4	2.2	2.0	2.2	0.5
Jul.8	6.9	10.3	9.4	2.7	3.1	0.8
Aug.5	0.4	3.8	0.5	4.4	13.0	1.9
Aug.8	8.0	10.0	4.8	13.5	18.5	8.3
Sep.5	0.8	0.2	1.7	0.4	1.2	0.7
Sep.8	6.0	3.7	5.6	3.4	2.9	3.2
Oct.5	0.8	1.9	2.3	1.4	1.7	2.3
Oct.8	1.6	3.7	5.2	3.2	2.5	3.2

B. Temperature 33°C

Date	5 ‰			15 ‰		
	S	L	C	S	L	C
Jul.5	3.5	5.1	2.4	1.2	1.4	3.1
Jul.8	10.5	12.4	11.2	7.2	9.3	11.6
Aug.5	3.8	5.0	1.2	0.1	0.5	0.4
Aug.8	7.7	11.6	6.0	4.4	6.2	4.6
Sep.5	3.1	5.1	3.3	4.2	5.6	2.1
Sep.8	10.0	14.0	10.8	12.5	14.0	9.0
Oct.5	4.7	6.6	4.6	1.0	2.1	2.6
Oct.8	7.1	11.0	8.0	5.2	5.6	5.7

S : Culture medium of small clams
 L : Culture medium of large clams
 C : Culture medium without clams

Table:14. Phosphate values in laboratory experiments with salinities 5 ‰ & 15 ‰ at (A) Room temperature (28 ± 1°C) and B. 33°C

A. Room temperature (28 ± 1°C)

Date	5 ‰			15 ‰		
	S	L	C	S	L	C
Jul.5	3.6	5.5	1.7	9.4	10.7	6.8
Jul.8	6.4	8.7	4.3	11.5	11.8	8.7
Aug.5	2.6	1.8	1.7	2.6	3.8	1.7
Aug.8	11.1	9.0	8.4	11.5	16.2	12.2
Sep.5	0.2	2.8	0.2	1.1	1.6	0.5
Sep.8	7.8	12.0	6.8	6.6	12.0	5.3
Oct.5	0.1	1.9	0.0	1.3	1.7	0.0
Oct.8	14.7	15.2	14.5	15.4	16.6	16.8

B. Temperature 33°C

Date	5 ‰			15 ‰		
	S	L	C	S	L	C
Jul.5	2.7	4.0	2.0	8.1	10.6	7.7
Jul.8	6.6	10.4	5.3	12.1	14.1	9.8
Aug.5	2.6	5.2	0.9	2.2	6.0	1.3
Aug.8	7.3	9.8	2.6	6.8	10.7	5.5
Sep.5	0.0	2.2	0.0	0.2	2.0	0.5
Sep.8	10.9	13.7	5.5	10.0	12.4	6.4
Oct.5	5.7	5.3	0.0	0.1	1.0	0.0
Oct.8	13.7	12.7	3.5	11.5	10.6	6.0

S : Culture medium of small clams
 L : Culture medium of large clams
 C: Culture medium without clams

In large clams when mixed phytoplankton was used, the feeding rate was found to be 8420. Feeding rate was .15616 when Tetraselmis sp. was used.

Hydrographic parameters

The values of dissolved oxygen and pH content in the culture medium are shown in Tables: 10 & 11.

The dissolved oxygen content varied from 3.84 ml/l to 6.54 ml/l. pH of the laboratory experimental medium varied between 6.9 and 7.5.

The values of nitrite, nitrate and phosphate in the laboratory experiments are given in Tables: 12, 13 and 14 respectively.

The nitrite, nitrate and phosphate values noted just before changing the water were found to be high compared to the values noted just after introducing the water to the containers in the two temperature and two salinity combinations.

FIELD EXPERIMENTS

Growth of clams in pen

The growth in length, width and thickness of small and large clams in the pen is shown in Fig: 5; growth in total weight and meat weight in Fig: 6. (Tables: 15 & 16 respectively).

Fig: 5. Growth of Villorita cyprinoides in length, width and thickness, maintained in pen at Nettur.

Solid line : Large clams

Broken line: Small clams

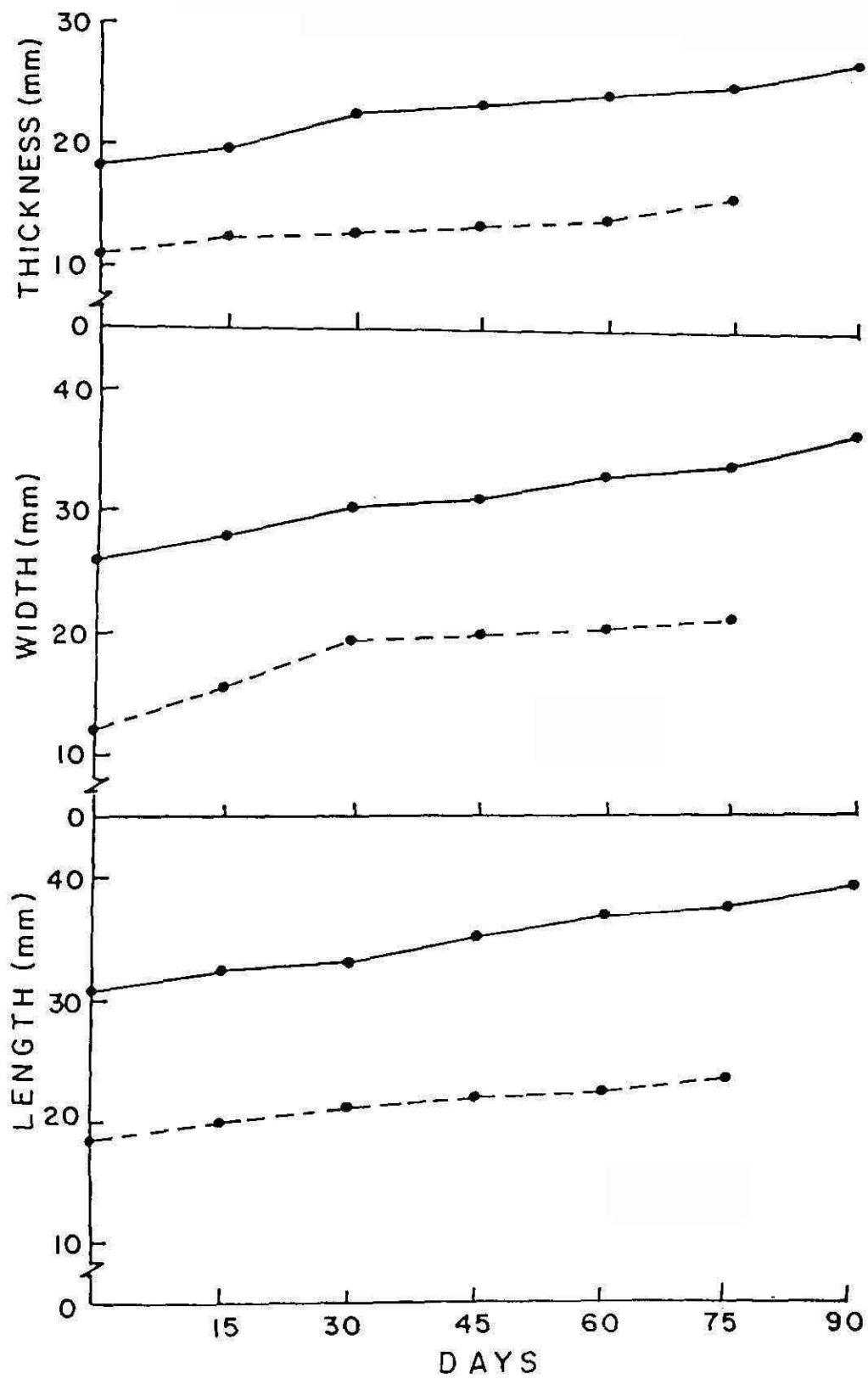


Table:15. Growth in length, width and thickness of Villorita cyprinoides maintained in pen

A. Small clams

Date	Length (mm)	Cumulative increment (mm)	Width (mm)	Cumulative increment (mm)	Thick- ness (mm)	Cumulative increment (mm)
Jul.10	15.7 ± 3.7	-	12.2 ± 3.2	-	11.6 ± 3.1	-
Jul.25	19.9 ± 2.8	4.16	15.6 ± 3.1	3.44	13.5 ± 2.5	1.93
Aug.10	20.3 ± 2.3	4.46	19.0 ± 2.8	6.80	13.5 ± 3.1	1.94
Aug.25	21.5 ± 2.1	5.69	19.8 ± 2.4	7.63	13.5 ± 2.1	1.95
Sep.10	22.1 ± 2.5	6.28	20.0 ± 2.4	7.84	13.6 ± 2.3	2.07
Sep.25	22.8	7.09	21.3 ± 1.9	9.14	16.2 ± 1.9	4.66

B. Large clams

Date	Length (mm)	Cumulative increment (mm)	Width (mm)	Cumulative increment (mm)	Thick- ness (mm)	Cumulative increment (mm)
Jul.10	30.8 ± 2.2	-	25.8 ± 2.7	-	18.4 ± 2.9	-
Jul.25	32.4 ± 2.6	1.63	27.7 ± 3.3	1.90	19.7 ± 2.9	1.34
Aug.10	33.2 ± 2.0	2.39	30.2 ± 2.7	4.38	23.0 ± 2.6	4.62
Aug.25	35.4 ± 2.2	4.60	30.6 ± 2.8	4.77	23.5 ± 3.0	4.09
Sep.10	36.4 ± 2.5	5.56	33.0 ± 2.2	7.25	24.7 ± 3.4	6.35
Sep.25	37.1 ± 3.2	6.34	33.1 ± 2.8	7.30	24.9 ± 1.8	6.57
Oct.10	39.6 ± 1.5	8.80	37.0 ± 2.4	11.20	27.1 ± 2.8	8.70

Fig: 6. Increase in total weight and meat weight of small (broken line) and large (solid line) sized Villorita cyprinoides maintained in pen at Nettur.

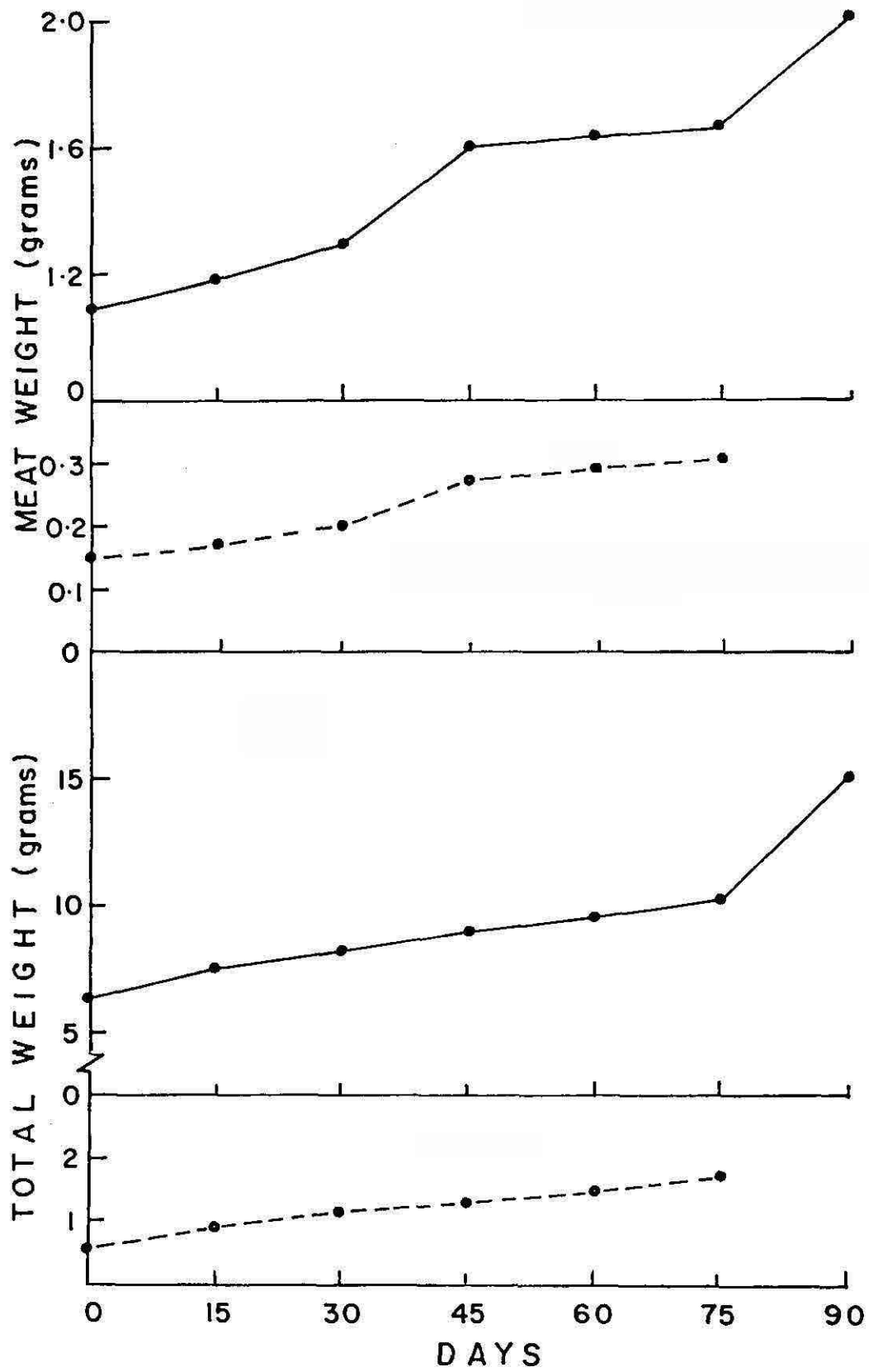


Table:16. Growth in total weight and meat weight of Villorita cyprinoides maintained in pen

A. Small clams

Date	Total weight (g)	Cumulative increment (g)	Meat weight (g)	Cumulative increment (g)
Jul.10	0.65	-	0.15	-
Jul.25	0.91	0.26	0.16	0.00
Aug.10	1.19	0.54	0.20	0.04
Aug.25	1.35	0.70	0.29	0.13
Sep.10	1.56	0.90	0.30	0.14
Sep.25	1.68	1.02	0.31	0.15

B. Large clams

Date	Total weight (g)	Cumulative increment (g)	Meat weight (g)	Cumulative increment (g)
Jul.10	6.69	-	1.11	-
Jul.25	7.62	0.93	1.19	0.08
Aug.10	8.11	1.42	1.37	0.26
Aug.25	9.11	2.42	1.64	0.53
Sep.10	9.73	3.04	1.65	0.54
Sep.25	10.53	3.84	1.66	0.55
Oct.10	15.00	8.31	2.02	0.93

Growth of small clams

Length

The small clams having a size of 15.7 mm at the time of stocking have attained a length of 20.3 mm in one month and 22.1 mm in 2 months. The growth increment in the first month was 4.4 mm, but it has greatly come down to 1.8 mm in the second month. In 2 1/2 months, they attained a length of 22.8 mm at an average of 2.4 mm per month. After this, all the clams died because of predation, probably by crabs, and only broken shells were observed.

Width

Initial width of small clams which measured 12.2 mm has increased to 21.3 mm at the end of 2 1/2 months. As in the case of length, the increment in width also was high during the first month, 6.8 mm; in the second month the increment was only 1.0 mm.

Thickness

The increment in thickness was 1.9 mm in the first month and 1.1 mm in the second month. During the 2 1/2 month period the average increment in thickness was observed to be 1.8 mm per month.

Plate III: Clams (Villorita cyprinoides) grown in pen.

- A. Small clams of 12-16 mm at start (left) and close (right) of the experiment.
- B. Large clams of 28-33 mm at start (left) and close (right) of the experiment.



Total weight

The small clams which weighed 0.65 g at the time of stocking have increased to 1.19 g in one month and 1.56 g in two months. At the end of the experiment, the weight was 1.68 g, indicating a growth increment of 0.4 g per month.

Meat weight

The average meat weight of the small clams was 0.15 g initially and this has increased to 0.30 g over a period of 2 1/2 months, at an average rate of increment of 0.01 g per month.

Growth of large clams

Length

The large clams stocked in the pen had an initial length of 30.8 mm. They attained a length of 39.6 mm at the end of the third month adding 8 mm during the period. The increment in length measured at the end of first, second and third months were 2.4 mm, 3.2 mm and 3.2 mm respectively. This indicates that the rate of growth was showing an increasing trend from the first month to the third month.

Width

Initial width of the clams at the time of stocking was 25.8 mm, which increased to 37.0 mm by the end of the

third month. Increment of width was 4.4 mm in the first month, 2.8 mm in the second month and 4.0 mm in the third month. This shows that the increase was not in a uniform rate.

Thickness

This dimension of large clams was 18.4 mm at the time of stocking which increased to 27.1 mm in a period of 3 months, with a total increment of 8.7 mm. As in the case of width, thickness also increased at a faster rate in the first month, 4.6 mm, then decreased, 1.7 mm and again increased in the third month, 2.4 mm.

Total weight

The initial average total weight of the clams was 6.68 g which grew to 15.0 g in three months, adding 8.3 g to the weight. The increment in the first, second and third months was 1.42 g, 1.62 g and a high value of 5.27 g respectively.

Meat weight

The average meat weight of the clams in the pen was 1.11 g which has increased to 2.02 g over a period of three months, the total increment being 0.9 g. Rate of increment

Table:17. Comparison of growth (in length) of Villorita cyprinoides in the pen and laboratory

	Initial length (mm)	Increment (mm)			
		I month	II month	III month	IV month
<u>Pen</u>					
Small	15.7	4.5	1.8	-	-
Large	30.8	2.4	3.2	3.3	-
<u>Laboratory</u>					
28 ± 1°C & 5‰					
Small	14.7	2.9	2.1	0.5	0.7
Large	27.1	1.8	0.7	0.2	0.1
28 ± 1°C & 15‰					
Small	13.1	5.5	2.1	0.7	0.8
Large	26.6	1.9	1.7	0.3	0.5
33°C & 5‰					
Small	12.8	3.2	1.2	0.6	1.1
Large	22.5	3.7	0.9	0.6	0.7
33°C & 15‰					
Small	11.9	6.5	1.0	0.8	0.9
Large	20.7	6.9	2.1	0.3	0.2

apparently results from increased activity of the enzyme system at higher temperature (Cain, 1973).

The effects of temperature and salinity on bivalve development have a more direct application to the ecology of the animal in their natural environment than do the effects of feeding selected species of algae as food (Stickney, 1964). The feeding experiments are in a sense artificial, since the extent to which the species are used in nature is not known. However, it is of importance for laboratory work, and for possible eventual hatchery operations, to provide a suitable feed for experimental animals, suitable not only in producing good growth, but also in being conveniently and economically produced.

In considering relationships between organisms and their environment, both field and laboratory approaches are essential parts of the total enquiry. It is only reasonable to imply that interpretation of ecological events in the field would be aided by knowledge gained through laboratory study of the living organisms. Laboratory studies tend to define fundamental attributes of organisms; field studies help to find out whether or not, or to what extent, these attributes can be utilized by the organism under habitat conditions. Comparisons between laboratory and field studies are complementary and provide a means of iterating towards improved knowledge. The present study thus may be considered a step towards this direction.

S U M M A R Y

In order to study the effect of temperature and salinity on growth and feeding rate of the black clam Villorita cyprinoides (Gray), laboratory experiments were conducted in a combination of two temperatures (room temperature and 33°C) and two salinities (5 ‰ and 15 ‰) for a period of four months. The experiments were replicated three times. Clams of two different groups, 10-15 mm and 25-30 mm, were selected for the experiment in order to compare their relative growth and feeding rates by giving them algal feed. In each combination of temperature and salinity, one container was kept without clams as control of algal feed. Growth in length, width and thickness was measured at monthly intervals; total weight was taken at the beginning and close of the experiment. Feeding rate was studied using two different types of feed, Tetraselmis sp. (unicellular flagellate) and mixed phytoplankton. The feed was cultured in the laboratory and maintained till the end of the experiment. Dissolved oxygen, pH and nutrients (nitrite, nitrate and phosphate) of the experimental medium were estimated.

To compare the growth of clams in the laboratory to that in the field, a pen of 1 sq.m. area was constructed with two compartments, where clams of the size 12-16 mm were stocked in one compartment and 28-33 mm clams in the other.

The pen was maintained for a period of 90 days. Fortnightly sampling was done for studying the growth of clams and for the estimation of hydrographic parameters.

Dissolved oxygen, pH and nutrients estimated in the laboratory experiments were in the normal range throughout the experimental period. Temperature at the pen site varied from 27.5°C to 31.5°C and salinity ranged between 0.45 ‰ and 9.7 ‰. The dissolved oxygen concentration was always high (4.13 - 5.2 ml/l). The nutrients were found to be high during the monsoon.

Clams in the higher temperature and higher salinity combination (33°C and 15 ‰) showed significantly higher growth rate than the those in low temperature and low salinity combination (room temperature and 5 ‰).

The feeding rate was found to be significantly higher in higher temperature (33°C), higher salinity (15 ‰) and in larger clams. Feeding rate was higher in both small and large clam with Tetraselmis sp. than with mixed phytoplankton.

Statistical analysis of the field experiments also show that growth was more rapid in high temperature and high salinity conditions.

Comparison of growth rate in the field and laboratory revealed that growth rate was more in the field.

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