

ECOLOGICAL STUDIES ON THE SEASONAL PRODUCTION
OF THE EDIBLE OYSTER, *CRASSOSTREA MADRASENSIS*
(PRESTON) IN COCHIN BACKWATER, KERALA

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ABSTRACT

Seasonal variation in the standing crop of intertidal oyster *Crassostrea madrasensis* (Preston) at Ramanthuruth and Vallarpadom in the Cochin backwater for the period July 1974 to December 1975 showed that the maximum yield (whole weight) was about 20 kg/m² in July during 1974 and 10-18 kg/m² in March-April during 1975 at both stations. The average biomass at Ramanthuruth was significantly higher than that at Vallarpadom. In general, oysters in closeby deeper waters were significantly larger in size than the intertidal ones, but as regards percentage meat weight the latter out-weighed the former. Among environmental variables, salinity seemed to be the foremost factor in influencing the production of oysters. A large majority (90-98%) of the intertidal oysters perished during the monsoon and early postmonsoon while the subtidal population was seen to be relatively more stable. The increased rates of siltation, turbidity and pollution arising out of man made changes in the backwater seem to exert a negative influence on the existence of edible oysters and at the same time pose a threat to their consumers.

INTRODUCTION

Among the eleven species of edible oysters known to occur along the Indian coasts (Awati and Rai, 1931) four species *Crassostrea madrasensis*, *C. cucullata*, *C. gryphoides* and *C. discoidea*, are available in sizeable quantities. Most of the earlier studies on these oysters deal mainly with their general biological aspects such as morphology, breeding and development. The importance of the oysters in the commercial fishery and the possibility for their cultivation have been highlighted in a series of papers by Hornell (1910, 1917, 1922, 1951). Among the four species of edible oysters, *C. madrasensis* has been studied in greater detail (Rao 1951, 1953, 1956; Rao and Nayar, 1956). A comprehensive review of the work related to Indian oysters by Rao (1974) reveals that most of the earlier studies have been done on the oyster populations of the northwest and southeast coasts of India.

Though available in appreciable quantities from localities like Cochin backwater, the edible oysters were not exploited much in the commercial fishery of this region on account of the large scale availability of more popular items like shrimps and fishes. The fishing rights of oysters from oyster beds in the Cochin backwaters were used to be leased out till 1960s. There was only a small section of people who used to fish for oysters for their sustenance. However, in recent years there is growing

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demand for oyster meat and the rate of fishing is getting considerably accelerated. Nevertheless, no quantitative information is available on this resource as in other regions in India (Rao, 1974).

Apart from the studies as fouling organisms (Nair, 1967; Balasubramanyan and Nair, 1970) and as indicators of metallic pollution (Sankaranarayanan, Purushan and Rao, 1978) we have no information on the edible oysters of Cochin region. It is against this background a comprehensive investigation on the ecology of the economically important oysters in Cochin backwater was commenced in 1974 and the present communication deals with seasonal production of *C. madrasensis* in relation to environmental parameters during the period July 1974 to December 1975.

MATERIAL AND METHODS

Regular sampling was carried out at fortnightly intervals at two stations namely Ramanthuruth (Stn. I) and Vallarpadom (Stn. II) lying on the northern side of Cochin Harbour (Fig. 1) where there were heavy encrustations of intertidal oysters on the granite embankments (Fig. 2). Encrusted oysters were taken from an area $25 \times 25 \text{ cm}^2$ in duplicate using a chisel and hammer. Oysters in closeby deeper waters were sampled from the bed lying at a depth of 3–4 m adjacent to Station I by diving. Animals were removed afresh to the laboratory in plastic buckets where they were thoroughly cleaned with a wire

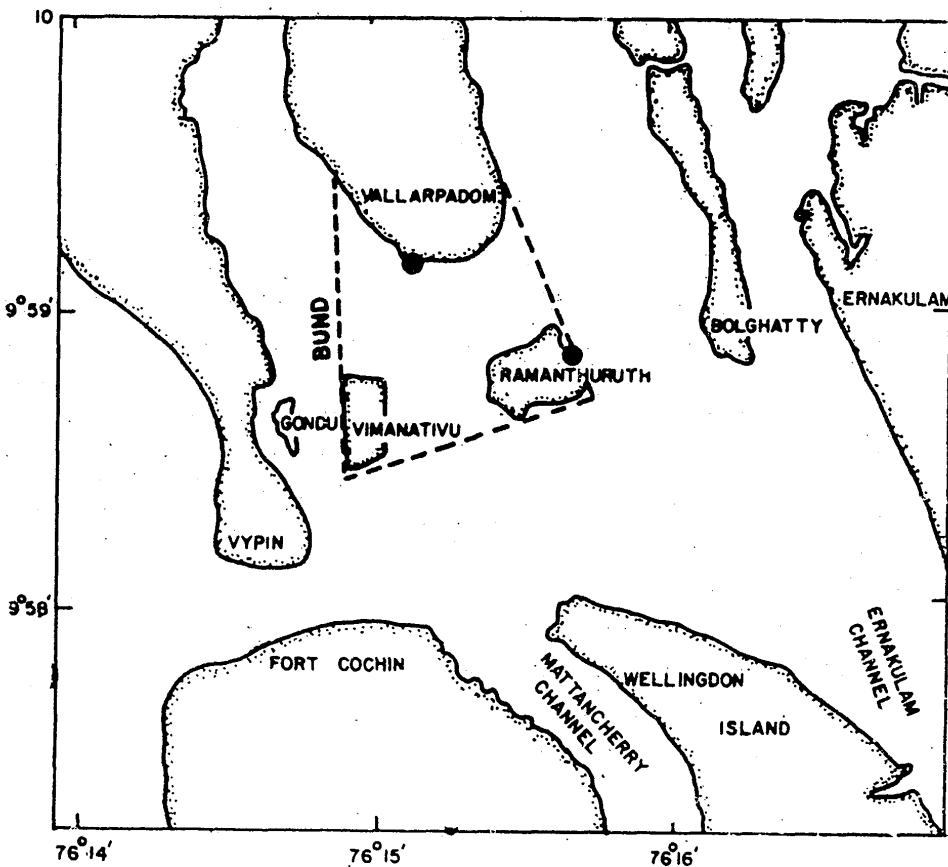


Fig. 1. Map showing the sampling centres.

brush using water brought from sampling sites. Live oysters and dead shells were sorted out, measured using a vernier calipers and weighed on a precision balance. The distance between the umbo and the extremity of the shell was taken as length. After shucking the oyster with a knife, the meat was blotted, wet weight determined and from this the percentage meat weight was calculated ($\text{meat weight} \times 100 / \text{whole weight}$).

In order to examine whether the biomass/m² in the two stations differ significantly or not, the biomass data were subjected to statistical analysis using Anova techniques.

Hydrographic parameters such as, salinity and oxygen were measured adopting standard procedures (Strickland and Parsons, 1965). Temperature was measured using a thermometer graduated to measure up to 0.05°C, light penetration and turbidity conditions were recorded by using a secchi disc.

Rainfall data was collected from daily weather report published by the India Meteorology Department.

RESULTS

Monthly variations in the environmental characteristics of the two stations for the period of study have been presented in Table I. It can be seen from the table that there



Fig. 2. Encrustation of intertidal oysters on the granite embankment at Ramanthuruth.

is no noticeable difference between the general ecological features at Ramanthuruth and Vallarpadom. Surface temperature at both the stations reached a maximum (33.1°C) in March–April and the minimum (26.5°C) in July. As regards salinity, the highest value (30.59‰) was recorded in February–April and the lowest was (0.17–0.74‰) in July–September. Dissolved oxygen values were the highest (6 ml/l) during the peak of monsoon and the lowest values (2–3 ml/l) were obtained during the premonsoon. The amount of suspended matter varied between 0.39 mg/l in October and 2.75 mg/l in December at Ramanthuruth. Light penetration (Secchi disc readings) was more or less the same at both the stations. The postmonsoon period from October to December 1975 showed higher values of light penetration.

The biomass of intertidal oyster population during various months has been presented as an index of the seasonal variation of the standing stock of oysters. Seasonal variation in biomass per metre square from Ramanthuruth and Vallarpadom is presented in the form of histograms in Figs. 3 and 4 respectively. This is illustrative of the fluctuation in the standing crop of oysters during 18 months ending December 1975. It can be seen from the figures that the maximum yield was about 20 kg/m² in July 1974 and there was a general similarity in the trend of seasonal fluctuation of the biomass at both stations. The biomass values showed a downward trend thereafter reaching the minimum of 1 kg/m² at Ramanthuruth in November and then progressing gradually from December onwards to reach the peak in April 1975 (18 kg/m²) but for a decline noticeable in February. The peak coincided with the usual fishing season, *i.e.*, March to June for oysters. After April the biomass of the intertidal oysters again started declining

Table I. Environmental parameters of the sampling stations during the period July 1974–December 1975.

Month	RAMANTHURUTH				VALLARPADOM				Cochin Rainfall (mm)
	Temp. (°C)	Sal. (‰)	Oxygen (ml/l)	Light penetration (cm)*	Temp. (°C)	Sal. (‰)	Oxygen (ml/l)	Light penetration (cm)*	
1974 July	26.5	0.34	5.20	—	26.5	0.32	5.00	—	810.0
Aug.	28.0	0.50	6.10	—	29.5	0.46	6.10	—	507.0
Sep.	28.0	1.48	3.70	—	28.0	1.30	4.00	—	289.0
Oct.	29.0	3.50	3.65	—	29.7	5.16	3.60	—	129.0
Nov.	28.2	20.54	3.80	—	28.2	24.14	3.30	—	194.0
Dec.	29.5	23.24	3.10	—	29.8	25.90	3.50	—	—
1975 Jan.	30.0	28.90	4.05	—	29.3	29.20	3.50	—	0.1
Feb.	30.8	30.00	4.00	—	31.6	29.60	5.70	—	23.0
Mar.	31.6	28.00	3.30	—	31.7	28.75	3.85	—	18.0
Apr.	32.8	29.60	2.30	—	33.1	30.59	2.66	—	150.0
May	30.6	23.60	2.94	52.0	30.3	25.91	3.39	56.0	173.0
June	28.2	6.20	3.30	49.5	28.6	5.20	4.00	46.0	841.0
July	27.5	0.20	3.70	48.0	28.1	0.17	4.50	50.0	431.0
Aug.	27.5	0.23	4.10	52.0	28.0	0.20	4.20	50.0	416.0
Sep.	28.1	0.74	3.90	55.0	28.3	0.62	4.80	—	416.0
Oct.	28.5	4.50	3.75	81.5	28.6	3.50	5.40	89.0	516.0
Nov.	29.6	8.02	4.00	80.5	29.8	6.82	3.90	75.0	184.0
Dec.	29.1	21.15	3.80	80.5	30.0	21.80	3.90	75.0	21.0

* Secchi disc reading.

and reached the minimum in November 1975 (3.75 k/m²). Thereafter an ascending trend was seen towards December.

A conspicuous feature observed at Vallarpadom was the considerable reduction in the yield towards the late monsoon and early postmonsoon months of 1975 when compared to that of the previous year and also to that of the same year at Ramanthuruth.

Dead shells were common in the samples from both stations throughout the period of observation as seen from Figs. 3 and 4. During the period October–January dead shells dominated the live ones at both stations. The highest percentage of live weight was available in June and August at Ramanthuruth during 1975 and at Vallarpadom it was in March and June (Fig. 5). The percentage mortality was more apparent at Vallarpadom where the oyster encrustations were relatively thinner.

The analyses of variance of biomass at Ramanthuruth and Vallarpadom are given in Table II. The variations were found to be significant at 5% level between stations and months (Table IIa). On comparing the two stations the average biomass/m² at Ramanthuruth was significantly higher than that at Vallarpadom. Among months, March and August were found to be the peak months for biomass.

Analysis of variance of the weight of deadshells showed that variations between months were also significant at 1% level (Table IIb). However, variations between stations were not significant which indicated that oyster populations at both stations were

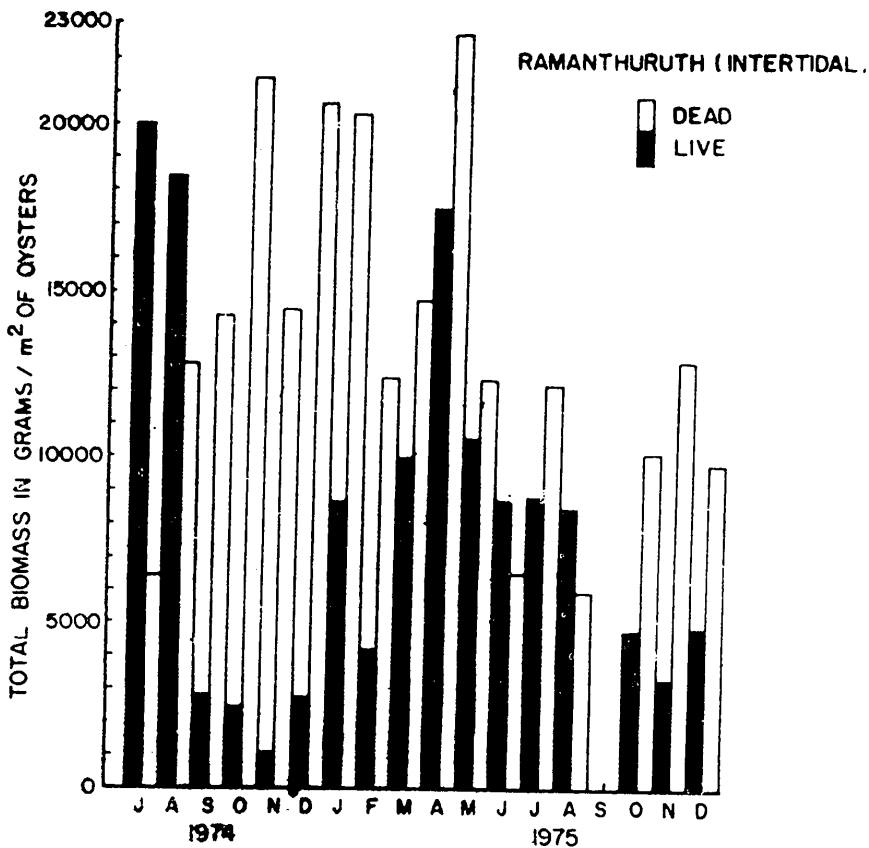


Fig. 3. Seasonal variation in oyster biomass (gm/m²) at Ramanthuruth.

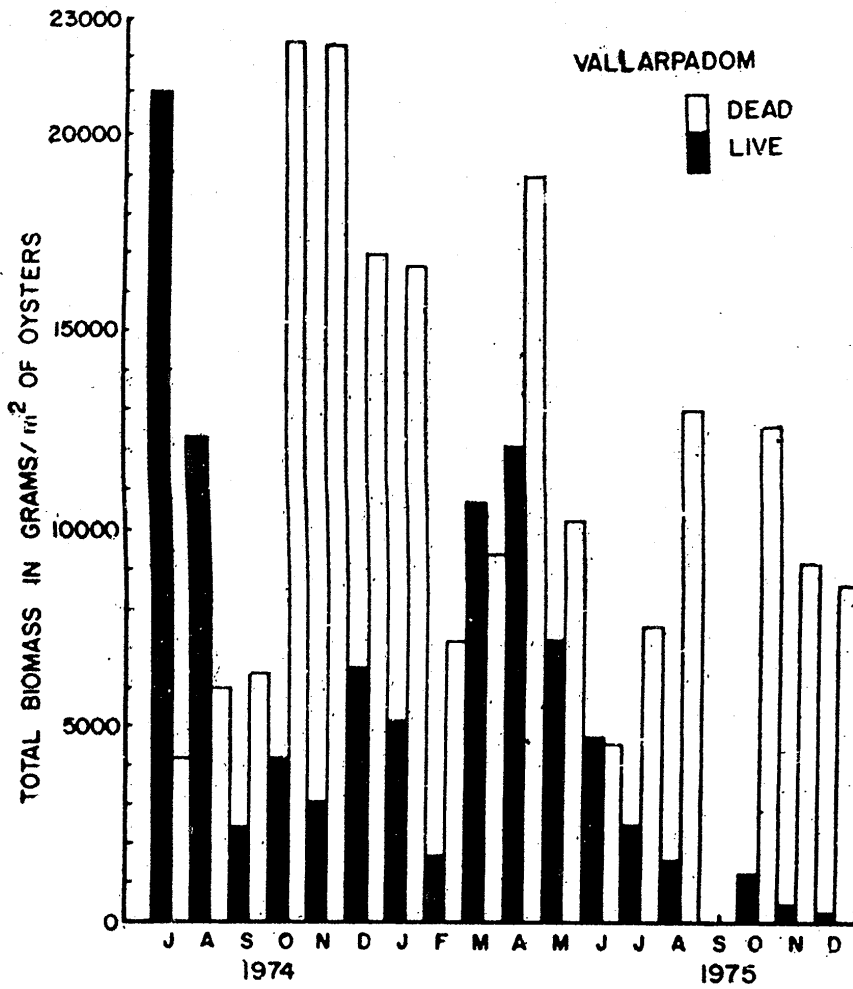


Fig. 4. Seasonal variation in oyster biomass (gm/m²) at Vallarpadom.

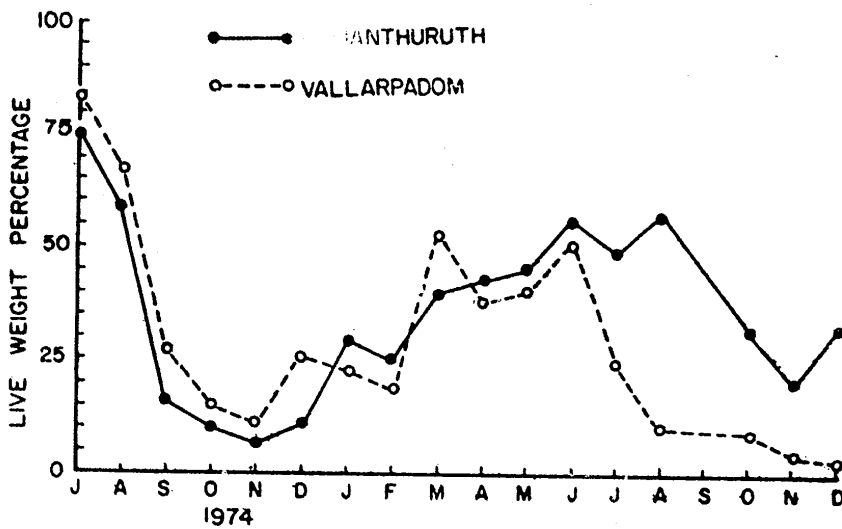


Fig. 5. The percentage live weight of oysters at Ramanthuruth and Vallarpadom.

Table IIIa. Analysis of variance of biomass (live ones) of edible oysters at Ramanthuruth and Vallarpadom.

Crassostrea madrasensis

Source	Sum of squares	Degrees of freedom	Mean square	F
Total	7.0093	35.0	—	—
Between stations	0.6460	1.0	0.6460	6.854*
Between months	4.7610	17.0	0.2801	2.972*
Error	1.6023	17.0	0.0943	—

* Significant at 5% level.

Table IIIb. Analysis of variance of the weight of dead shells of edible oysters at Ramanthuruth and Vallarpadom.

Crassostrea madrasensis

Source	Sum of squares	Degrees of freedom	Mean square	F
Total	1.7304	35.0	—	—
Between stations	0.0419	1.0	0.0419	2.465
Between months	1.3995	17.0	0.0823	4.841**
Error	0.2890	17.0	0.0170	—

** Significant at 1% level.

having more or less the same mortality eventhough the figures reflected apparantly a higher mortality at Vallarpadom.

The monthly variations in the mean total weight of oysters irrespective of size were studied in the intertidal and subtidal areas (Table IIIa) at Ramanthuruth for a period of one year ending December 1975. The mean total weight of oysters of the intertidal area varied from 13.71 g in October to 32.82 g in June 1975. Higher values were noted in April-June. The values increased from January to June and afterwards declined. Less variability was seen during February and October 1975. In the subtidal area the mean total weight ranged from 49.6 g in September to 106.59 g in March 1975, with high values in the months of January, February and March. Except for September and November 1975 all other months showed high variability. Generally the subtidal oysters were 2-3 times the size of intertidal oysters.

Comparison between mean total weight of *C. madrasensis* at Ramanthuruth and Vallarpadom intertidal areas (Table IIIb) for the period July 1974 to August 1975 showed a slight increase in the mean total weight during 1975 at Ramanthuruth than that of 1974 while at Vallarpadom, mean total weight showed a declining trend from July 1974 to November 1974 and then onwards there was an increasing trend except during March 1975. At Vallarpadom the variability was high during July 1974 and low during May 1975. At Ramanthuruth, the minimum of mean total weight observed during 1974 was 8.25 g in November with a maximum of 30.25 g in July 1974. But in 1975, the minimum was 17.25 g in August with a maximum of 32.82 g in June.

This clearly showed increased growth rate at Ramanthuruth intertidal area and a decreased growth rate at Vallarpadom intertidal area in the gregarious natural population. Ramanthuruth station was found more favourable for oyster growth and

Table IIIa. The monthly variation in the mean \pm standard deviation of total weight calculated for the whole *Crassostrea madrasensis* from the intertidal and subtidal areas of Ramanthuruth.

Months	<i>Crassostrea madrasensis</i>	
	Intertidal	Subtidal
	Mean total \pm S.D. weight	Mean total \pm S.D. weight
1975		
Jan.	17.33 \pm 13.29	76.40 \pm 62.16
Feb.	20.30 \pm 8.98	85.00 \pm 72.06
Mar.	23.88 \pm 40.59	106.59 \pm 94.42
Apr.	29.40 \pm 20.80	—
May	28.41 \pm 14.19	58.20 \pm 44.51
June	32.82 \pm 32.57	69.40 \pm 65.07
July	18.78 \pm 11.34	51.20 \pm 80.07
Aug.	17.25 \pm 15.03	66.00 \pm 79.96
Sep.	—	49.60 \pm 9.87
Oct.	13.71 \pm 10.66	59.46 \pm 64.87
Nov.	—	49.91 \pm 18.27
Dec.	—	56.65 \pm 35.23

Table IVa. Monthly variation in the mean \pm standard deviation of percentage meat weight calculated for the whole *Crassostrea madrasensis* from the intertidal and subtidal areas of Ramanthuruth.

Months	<i>Crassostrea madrasensis</i>	
	Intertidal	Subtidal
	Mean % \pm S.D. meat wt.	Mean % \pm S.D. meat wt.
1975		
Jan.	14.50 \pm 2.86	8.59 \pm 1.53
Feb.	11.07 \pm 2.67	8.20 \pm 2.66
Mar.	12.38 \pm 2.97	7.10 \pm 1.91
Apr.	7.81 \pm 0.04	—
May	8.54 \pm 1.49	7.78 \pm 1.35
June	8.36 \pm 2.10	11.31 \pm 1.89
July	9.62 \pm 2.68	10.04 \pm 1.86
Aug.	8.42 \pm 2.51	9.20 \pm 1.58
Sep.	—	11.13 \pm 1.13
Oct.	9.06 \pm 2.46	5.70 \pm 1.17
Nov.	—	7.82 \pm 2.33
Dec.	—	6.68 \pm 2.84

Table IIIb. The monthly variation in the mean \pm standard deviation of total weight for the whole *Crassostrea madrasensis* from the intertidal areas of Ramanthuruth and Vallarpadom.

Months	<i>Crassostrea madrasensis</i> (intertidal)	
	Ramanthuruth	Vallarpadom
	Mean total \pm S. D. weight	Mean total \pm S. D. weight
July 1974	30.25 \pm 23.98	36.39 \pm 37.05
Aug.	23.43 \pm 23.60	17.20 \pm 11.82
Sep.	—	10.93 \pm 10.54
Oct.	19.25 \pm 9.54	10.85 \pm 10.97
Nov.	8.25 \pm 5.44	10.89 \pm 7.37
Dec.	14.45 \pm 10.75	12.34 \pm 7.38
Jan. 1975	17.33 \pm 13.29	13.59 \pm 11.34
Feb.	20.33 \pm 8.98	17.33 \pm 10.75
Mar.	23.88 \pm 40.59	7.70 \pm 11.13
Apr.	29.40 \pm 20.80	17.50 \pm 12.44
May	28.41 \pm 14.19	14.00 \pm 7.00
June	32.82 \pm 32.57	15.58 \pm 23.49
July	18.78 \pm 11.34	12.79 \pm 10.31
Aug.	17.25 \pm 15.03	15.00 \pm 8.40

Table IVb. Monthly variation in the mean \pm standard deviation of percentage meat weight calculated for the whole *Crassostrea madrasensis* from the intertidal areas of Ramanthuruth and Vallarpadom.

Months	<i>Crassostrea madrasensis</i> (intertidal)	
	Ramanthuruth	Vallarpadom
	Mean % \pm S.D. meat wt.	Mean % \pm S.D. meat wt.
Jul. 1974	17.57 \pm 12.76	8.13 \pm 1.63
Aug.	9.54 \pm 4.31	7.40 \pm 1.17
Sep.	—	14.01 \pm 2.43
Oct.	13.94 \pm 2.02	14.52 \pm 3.16
Nov.	11.33 \pm 2.80	11.98 \pm 3.05
Dec.	12.30 \pm 2.62	6.78 \pm 6.35
Jan. 1975	14.50 \pm 2.86	13.19 \pm 3.42
Feb.	11.07 \pm 2.67	13.56 \pm 5.25
Mar.	12.38 \pm 2.97	11.67 \pm 3.19
Apr.	7.81 \pm 0.04	11.48 \pm 1.61
May	8.54 \pm 1.49	14.15 \pm 1.58
June	8.36 \pm 2.10	10.47 \pm 2.37
July	9.62 \pm 2.68	13.09 \pm 3.90
Aug.	8.42 \pm 2.51	10.20 \pm 1.78

here too deeper waters could sustain better population. The Vallarpadom station showed a declining population, the area getting uneconomical for oyster exploitation.

Percentage meat weight of *C. madrasensis* from the natural population irrespective of size is presented in Table IVa for the period January–December 1975 for a comparison of intertidal and subtidal populations at Ramanthuruth. The percentage meat weight varied from 7.81 g in April 1975 to 14.5 g in January 1975 in intertidal area and from 5.7 g in October 1975 to 11.31 g in June 1975 in subtidal area. Percentage meat weight was high during January, March and June–September in intertidal and subtidal oysters respectively. The comparison of the two intertidal regions as regards meat production (Table IVb) showed that the intertidal oysters at Vallarpadom maintained a more or less uniform condition for most part of the observation period. The conspicuous reduction noticed in the percentage meat production in the intertidal oysters at Ramanthuruth during 1975 was not encountered in their counterparts at Vallarpadom.

DISCUSSION

Results of the studies on the seasonal variation of oyster biomass indicate that highest standing crop was during the premonsoon in the intertidal region, while in the subtidal region the production attained the peak in monsoon. The most important environmental factor influencing the oyster season is the intensity and duration of the monsoon and the resultant salinity levels. In 1974 the onset of monsoon was rather unusually late and that provided a highly favourable condition for the prolonged survival of oysters. But in 1975 the peak rainfall was in June and population was correspondingly affected owing to the resultant lowering of salinity. Decline in the population in October–November was obviously due to the heavy rains occurred in June–July (841 mm) (Table I). This is accompanied by land runoff which affects the intertidal oysters directly in the immediate surroundings of the oyster habitat by the drastic salinity changes. The influence of fresh water was more intense at Vallarpadom than at Ramanthuruth which is nearer to barmouth than the former.

As estimated from the dead shells 90 to 98% of the intertidal oysters perish towards the end of the monsoon whereas majority of the subtidal oysters survive the rainy season as revealed by the occurrence of advanced age groups of oysters in the subtidal region. Intertidal oysters were found to attain a maximum length of 9.7 cm whereas the largest specimens from subtidal measured 16.8 cm. Large subtidal oysters were found only on the wellknown oyster beds lying nearer the barmouth where the stratified layer of water with higher salinity was available at the bottom even during the heavy monsoon periods. Nair (1967) has observed that oysters were eliminated in this locality during the monsoon and early postmonsoon periods. Poor benthic biomass coinciding with low salinity was observed by several earlier workers (Desai and Krishnankutty, 1967; Kurian, 1972).

The percentage meat weight of subtidal and intertidal oysters presented in Tables IVa and IVb showed that the maximum percentage meat weight was available for intertidal oysters than subtidal ones. It is seen again that each tidal region is different in its meat production. This can be presumably due to the

prevailing ecological conditions peculiar to each region. Since larger sized individuals were available from subtidal region, total meat weight was also higher in them. At the same time individuals above 9.5 cm in length indicated that their percentage meat weight was lower in the subtidal region owing to the heaviness of their shells. It has to be noted here that a large share of the energy assimilated by the older year class of oysters is used for their shell growth and maintenance. Also it has to be mentioned that though oysters increase in size after an year, corresponding increase in their meat weight is not seen. This suggests that harvesting of oysters at an optimum growth will be more advantageous from the fishery point of view. At Cochin, maximum percentage meat weight was recorded during premonsoon and early monsoon in the intertidal region while it was during the monsoon in the subtidal oyster beds.

When compared to salinity, temperature seems to have only a limited role in the ecology of oysters in Cochin backwaters. The maximum variation in temperature at the bottom (21–30°C) was during the monsoon and at the surface it was (25–33°C) during premonsoon. Eventhough there was a general lowering of temperature during the monsoon, its effect on the oysters could not be measured. However, Kurian (1972) concluded that temperature is not an important factor affecting the distribution of fauna in the Cochin backwaters. But in the case of Kali estuary, Harkantra (1975) has suggested that temperature plays a significant role in the distribution and abundance of the benthos. The lowering of temperature associated with the lowering of salinity during the monsoon results in a general decline of oyster population in Cochin backwater which might be due to a synergistic effect.

Dissolved oxygen values which varied from 2.3 ml per litre in April to 6.1 ml per litre in August do not seem to exert any appreciable influence on the oysters at the sampling centres.

One of the major factors affecting the distribution of the edible oysters in Cochin estuary appears to be the siltation and resultant turbidity conditions (Gopinathan and Qasim 1971). Apart from the monsoonal land drain, the constant dredging activity for reclamation and harbour development largely contribute to the increased turbidity in recent years. *Crassostrea* is capable of withstanding fairly high levels of turbidity and siltation but cannot cope with any drastic increase in these factors. Settlement of suspended matter smothers benthic oysters, prevents settling and survival of spats and in other ways bury oysters at the bottom or reduce their efficiency of production (Galtsoff, 1960).

Recently it has been observed that considerable quantities of oil enter the Cochin backwater (Gopalan, 1970) by way of accidental spillage, oil terminal operation, ships and motor boats activities. At certain localities, particularly in the harbour area the clusters of intertidal oysters were found to get smothered in oil and subsequently destroyed. The adverse effects of oil on the oysters, mussels and similar benthic organisms in various parts of the world have been studied by many authors (Blumer, Souza and Sass, 1970; Blumer, 1972).

It has to be observed again that the periods of high percentage meat weight and high concentration of heavy metals (Sankaranarayanan, Purushan and Rao, 1978), coincide with the fishing season (premonsoon) for oysters. Nowadays it has been heard from

the consumers that the oyster meat from Cochin is not as palatable as before. This can be due to the accumulation of pollutants including heavy metals. The presence of high percentage of heavy metals in *C. madrasensis* of Cochin (Sankaranarayanan, Purushan and Rao, 1978) indicates their high tolerance to metallic pollution and at the same time poses a potential threat to the consumers.

As regards man-made changes affecting the oyster population in the sampling area during the period of study, the construction of the Super Tanker Berth bund in 1975 (Fig. 1) needs special mention. The granite bund has thoroughly altered the water flow pattern in the sampling centres. This has adversely affected the oyster fauna inhabiting the intertidal region impounded by the bund. It could be seen from the Fig. 4 that the production of oysters particularly at Vallarpadom showed dramatic decline as the bund construction progressed and got fully eliminated thereafter. The influence of man-made alterations in Cochin backwater leading to the difference in the qualitative and quantitative distribution of the fauna is also enunciated in the present study.

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