BIOLOGY OF WINDOWPANE OYSTER *PLACENTA PLACENTA* (LINNAEUS) IN KAKINADA BAY

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ABSTRACT

The windowpane oyster, *Placenta placenta,* attains an average length of 122 mm in 1 year and 157 mm in 2 years. Spawning is biannual, in February-April and October-December, with minor variations. The oyster may spawn more than once during the same spawning season. Majority of the oysters mature for the first time at 53 mm length. The condition index (% meat wt. in total wt.) varies from 8.7 to 18.7 and is higher prior to or at the beginning of spawning and declines with the completion of spawning. The condition index is slightly lower in the oysters infested by pea crab *Pinnotheres placunae*.

INTRODUCTION

The windowpane oyster *Placenta placenta* (Linnaeus) forms a considerable fishery in the Kakinada Bay (Narasimham 1973). Except for brief remarks on its biology in the Gulf of Kutch (Hornell 1909 and Moses 1939) there seems to be no other published information on the biology of this species from India.

MATERIAL AND METHODS

About 100 windowpane oysters were collected, usually at fortnightly intervals, by hand-picking, during April 1977-December 1981 from the Kakinada Bay about 1 km east of Yetimoga village when, at low tide, the water depth was about 1 m. After 2-3 weeks of preservation in 5% formalin, length (antero-posterior axis), height and thickness of the oysters were measured to the nearest mm. Weights of whole oyster, two valves and meat (after draining excess moisture) were recorded to 0.1 g and the weight < 5 g to the nearest mg. Total volume of the oyster was measured in fresh condition by the displacement method. The relationship between length and other body measurements was studied by fitting the regression equation of the type $Y = a + bX$; where required logarithmic transformation was applied. For age and growth studies, during 1979-80, 11 oysters were kept in a dealwood box of 0.25 m^2 filled with mud collected from the natural bed and the box was kept in the natural environment of the oyster. Periodically the oysters were measured for length.

For maturity studies (by gonad smear) and condition index, 50 or 25 preserved oysters were examined from each collection. Standard histological techniques were employed to prepare 7-10 μm thick sections of the gonads of a total of 78 oysters fixed in Bouin's fluid and the sections were stained with Delafield's haematoxylin and eosin. These 78 oysters measured 90-123 mm in length and were collected in 1978 in all the months except July-October.

Age and Growth

The overall size range of 20-172 mm were divided into 5 mm class intervals. The various modes obtained in the monthly length-frequency histograms are plotted in Fig. 1. The developing larvae of the species are planktonic for only about 10 days (Young and Serna 1982). Oysters of modal length 42-52 mm have attained modal sizes of 77-97 mm in 3 months indicating a fast growth rate in the early part of life. On this basis, it is reasonable to assume that the oysters reach 42-52 mm length in 2-3 months after spawning. Bearing this in mind and also considering the peaks in the spawning activity, the various modes traced in Fig. 1 are assigned to particular spawning month and their ages determined (Table 1). In the first 6 months the oysters attained modal lengths

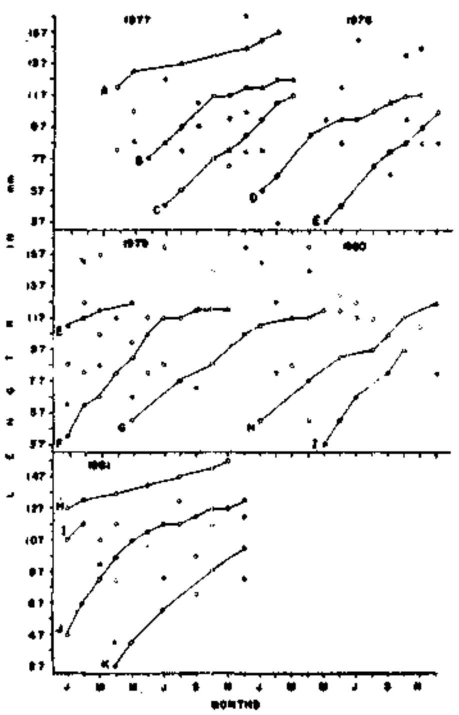

FIG. 1. Model lengths during different months in *P. placenta*.

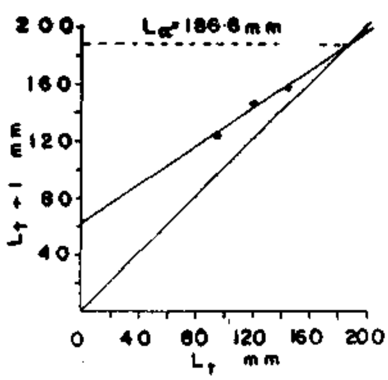

FIG. 2. Ford-Walford plot in *P. placenta*.

TABLE 1. *Model lengths in mm at 6 months intervals of* P. placenta.

Modes	Spawning month	Months 6	12	18	24
A	Apr 76	—	122	142	—
B	Feb 77	97	127	—	—
C	Apr 77	77	—	—	—
D	Oct 77	92	117	—	—
E	Feb 78	87	—	—	—
F	Nov 78	92	122	—	—
G	Mar 79	—	117	—	—
H	Nov 79	—	—	—	157
I	Mar 80	82	—	—	—
J	Nov 80	107	127	—	—
K	Mar 81	—	—	—	—
	Average	90.6	122.0	142.0	157.0

77-107 mm (average 90.6 mm), in 1 year 117-127 mm (average 122 mm), in 1.5 years 142 mm and in 2 years 157 mm (Table 1). From the Ford-Walford plot (Fig. 2) of the initial lengths (L_t) and final lengths (L_{t+1}) after 6 months given in Table 1 the asymptotic length L_∞ and K, a constant equivalent to 1/3 of catabolic coefficient, were estimated as 186.6 mm and 0.7802 (on annual basis) respectively. By taking the length of 1-year old oysters as 122 mm the lengths at successive ages were calculated from the For-Walford plot. From these data t_o, the arbitrary origin of the growth curve, was determined as 0.3543 years. The von Bertalanffy growth equation in *P. placenta* is written as

$$L_t = 186.6 \ (1\text{-exp} - 0.7802 \ (t + 0.3543)$$

where L_t is length in mm at time t. The calculated lengths by the above equation at ages 1 to 4 are 121.8, 156.9, 173.0 and 180.4 mm respectively. For ages 1 and 2 the estimated lengths by the growth equation are identical with the observed average modal lengths indicating the goodness of the fit of the growth equation to the observed data.

The initial lengths of the 11 oysters introduced into the box are 60, 70, 81, 90, 100, 111, 122, 142, 150 and 161 mm and after one year they have grown to 133, 134, 138, 144, 144, 154, 156, 160, 169, 170 and 175 mm respectively. The growth of these experimental oysters is remarkably similar to the growth of the oysters as determined by the length-frequency method. For example the 90 mm oyster (6-months old as per Table 1) has grown to 142 mm and the 122 mm (1 year old) oyster reached 160 mm in 1 year.

Dimensional Relationships

The various parameters studied and the relationships obtained are given in Table 2. Only in the case of length-meat weight regression equation b is not significantly different from 3, confirming that the growth of this parameter is isometric. Only in the length-total weight relationship there appeared to be a break at 50 mm length. Two separate regression equations for the groups 20-50 mm and 53-170 mm were therefore calculated. Analysis of covariance showed (Table 3) that the regression lines differ significantly at 5%. The rate of increase in weight of the oysters is higher in the 53-170 mm group compared to 20-50 mm length group and this is probably related to the onset of sexual maturity which is attained at 53 mm length.

Reproduction

Maturity stages

Four stages were recognised following Ropes (1968).

Active: In the early active phase the gonad is developing. The ovaries are light yellow and testes pale white. Sexes cannot be distinguished by colour with certainty. The follicular walls are mostly contracted. In females oogonia appear at the periphery of the follicles, often before the gonads are completely empty of ripe ova (Pl. 1A). In males a few follicles have developed which are packed with spermatocytes and spermatids (Pl. II A). In the late active phase the gonad is well developed. The gonad of females is yellow and that of male cream white. The follicles are greatly expanded. In females the oocytes are large in size, oval or round in shape and are attached to the follicular wall by a stalk (Pl. IB). In males there is an increase in the number of follicles which are densely packed with spermatids and some spermatozoa (Pl. IIB).

Ripe: The gonad is well developed; the females have orange yellow appearance and male cream white colour. Ripe gonads typically have a dense appearance since the follicles are crowded together and packed with gametes. In females the ova are mostly free in the lumina of the follicles (Pl. IC). The ripe ova are oval and measure 39-52 μm in diameter and the nucleus measures 26-32 μm. In males the interfollicular space is very much reduced as the follicles have grown to large size packed with sperms (Pl. IIC).

Partially spawned: The gonad has flaccid appearance. The gonad of female is yellow and that of male ivory white. In females large ripe ova are present in the lumina of some follicles while other follicles are mostly empty due to discharge

TABLE 2. *Dimensional relationships in* P. placenta.

Parameters	Length range mm	Number	Equation	Wether b is significantly different from 3
Length (X) and total wt. (Y)	20-50	45	Log Y = −4.3384 + 2.8089 Log X	Yes
—do—	53-170	100	Log Y = −5.3995 + 3.4835 Log X	Yes
Length (X) and shell wt. (Y)	53-170	100	Log Y = −5.3679 + 3.3875 Log X	Yes
Length (X) and Meat wt (Y)	53-170	100	Log Y = −5.2999 + 3.0017 Log X	No
Length (X) and wt. (Y)	20-172	105	Y = 1.9161 + 0.9354 X	—
Length (X) and Thickness (Y)	20-172	105	Y = −0.0883 + 0.0569 X	—

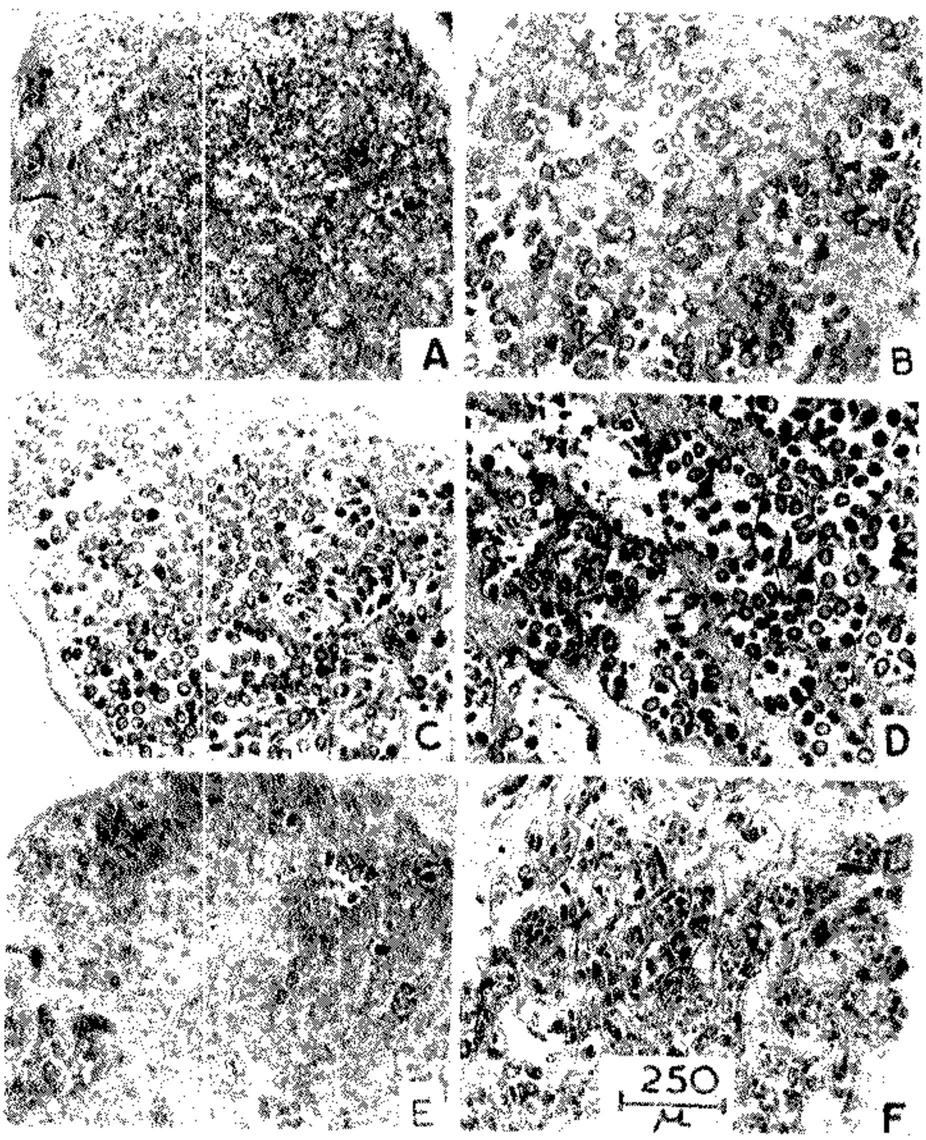

PLATE I. Photomicrograph of the sections of ovary: A. Early active phase showing the proliferation of small follicles and few residual eggs; B. Late active phase with expanded follicles and large oocytes; C. Ripe stage showing densely packed ova which are mostly free in the lumina of the follicles; D. Partially spawned stage showing some ripe ova in some follicles while others are mostly empty; E. Spent/resting stage with few residual ova undergoing cytolysis; F. Infected by bucephalid parasites.

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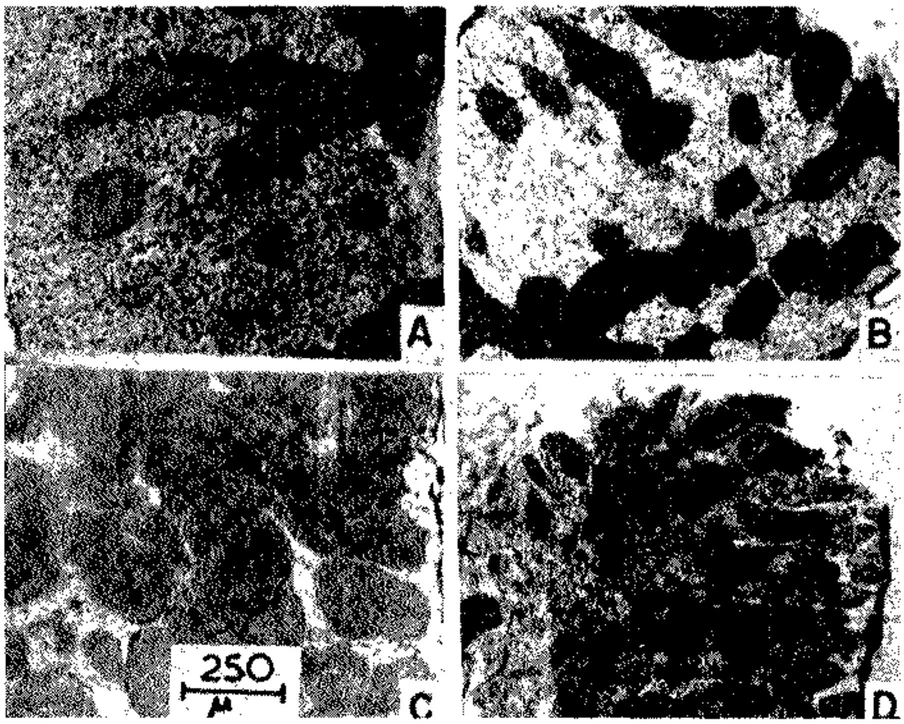

PLATE II. Photomicrograph of the sections of testis: A. Early active phase showing many developing follicles; B. Late active phase showing follicles packed with spermatids and some spermatozoa; C. Ripe stage with follicles densely packed with sperms; D. Partially spawned stage with collapsed follicular wall in many cases.

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TABLE 3. *Comparision of regression lines.*

	Source	d.f.	d.f.	S.S.	M.S.
1	20-50 mm group	44	43	0.07171834	0.00166788
2	53-170 mm group	99	98	0.39553056	0.00403603
3	Pooled	143	141	0.46724890	0.00331382
4	Total	144	143	0.63116380	
5	Difference		2	0.16391490	0.08195745

$F (2,141) = 24.7380$; $5\% = 3.91$

of ova (Pl. ID). In some cases ripe ova are cytolysed. In males the follicular walls have collapsed in many cases and some follicles are empty (Pl. IID). Sperms are present in other follicles.

Spent/resting: The gonad is much shrunken and the colour may be light yellow to pale white. Sex cannot be distinguished by colour. In females a few follicles may contain residual ova undergoing cytolysis (Pl. I E). In males the follicles are empty except for the presence of some residual sperms. It was often observed that several follicles are not at the same level of development in the same gonad. For example partially spawned oysters showed some follicles with active gametogenesis.

Reproductive cycle: The reproductive cycle showed biannual spawning in April-May and October-December in 1977. During 1978 biannual spawning in February-May and November-December is indicated (Fig 3). After the spawning reached peak in late February the gonads were spent and shruken in majority of the oysters in March. In this month while a few were still spawning, some follicles showed gametogenesis before the residual gametes were absorbed. In April again majority of the oysters were spawning. This is a clear case of a second reproductive cycle within the same spawning period. Gametogenesis must have been very fast so that the spent oysters in March have rematured and spawned in April. Biannual spawning in February-April and October-December is obvious in 1979 and 1980 (Fig. 3). A second reproductive cycle within the same spawning period is clear in both the spawning periods in 1980 (Fig. 3). In this year spawning initiated in early February reached peak by the month end. By March end the number of spawning oysters came down to 18% and majority (60%) were in early active stage. By April end peak spawning occurred with 82% oysters releasing gametes. After spawning in October 1980 there was active gametogenesis in early November and further spawning during late November/early December. The spawning period was unusually prolonged during 1981 and the oysters spawned in January-April and September-December.

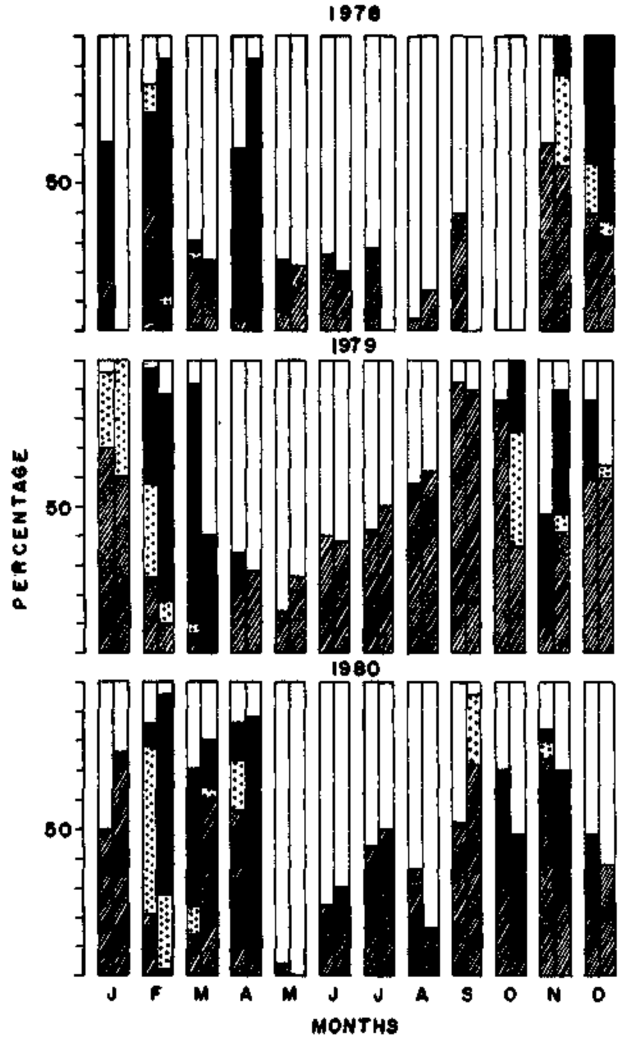

FIG. 3. Monthly percentages of maturity stages in *P. placenta*. Active stage indicated by oblique stripes, ripe by dots, spawning by shade and spent/resting by open bar.

Size at first maturity: Sex of oysters below 30 mm length could not be determined. In both the sexes, majority (53.3%) of the oysters measuring 53 mm were mature and cent percent maturity was observed at 68 mm length.

Sex ratio: Hermaphrodites which formed a negligible 0.35% were excluded in this study. It was observed that either females outnumbered males or the proportion of the two sexes was equal in most of the months, except in April and December 1978, March, September and October 1979, January, March and November 1980 and April, May and July 1981 (Table 4). On annual basis

TABLE 4. *Sex ratio in P. placenta (M—Male: F—Female).*

Sex	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1977													
M	—	—	—	48.1	36.0	25.0	39.0	38.0	26.0	36.1	42.0	37.0	36.6
F	—	—	—	51.9	64.0	75.0	61.0	62.0	74.0	63.9	58.0	63.0	63.4
1978													
M	37.0	32.0	30.0	60.0	41.0	50.0	43.0	48.0	37.0	44.4	50.0	53.0	43.8
F	63.0	68.0	70.0	40.0	59.0	50.0	57.0	52.0	63.0	55.6	50.0	47.0	56.2
1979													
M	48.0	45.0	55.0	41.0	44.0	37.0	49.0	49.0	69.1	53.1	49.5	45.5	48.7
F	52.0	55.0	45.0	59.0	56.0	63.0	51.0	51.0	30.9	46.9	50.5	54.5	51.3
1980													
M	52.0	33.0	58.0	46.0	48.0	40.0	36.0	39.4	49.0	45.0	51.0	48.0	45.5
F	48.0	67.0	42.0	54.0	52.0	60.0	64.0	60.6	51.0	55.0	49.0	52.0	54.5
1981													
M	32.0	38.0	42.0	53.1	54.0	48.0	56.0	49.0	46.0	50.0	40.0	50.0	46.5
F	68.0	62.0	58.0	46.9	46.0	52.0	44.0	51.0	54.0	50.0	60.0	50.0	53.5
Pooled													
M	43.7	36.9	46.9	49.5	44.5	40.8	43.3	44.9	47.5	45.6	47.2	46.3	44.8
F	56.3	63.1	53.1	50.5	55.5	59.2	56.7	55.7	52.5	54.4	52.8	53.7	55.2

females outnumbered males in all the years. In relation to size, data pooled for all the years, showed that females outnumbered males from 63 to 153 mm size range (Fig. 4). At the larger sizes of 158 to 173 mm all the oysters were females.

Hermaphroditism: The windowpane oyster is dioecious. Nevertheless, the examination of the gonads of 4811 oysters revealed the presence of 17 functional hermaphrodites occurring during October-November in different years. Their length varied from 110 to 139 mm.

Parasites: Infestation of the gonad and digestive diverticula of the windowpane oyster by an unidentified bucephalid parasite was observed (Pl. I F) in 48 oysters (1%) out of a total of 4811 oysters examined. Infected males and females occurred during all the months with a peak in February-April. In advanced stages of parasitisation, the gonad is distended and coral red in colour. The parasite invades the gonad tissue leaving very little room for the development of gametes thus affecting the reproductive potential and finally leading to sterility.

CONDITION INDEX

Condition index (C.I.). is used in this study to denote the percentage of meat weight in total weight and also the percentage of meat volume in shell cavity volume. The C.I. based on the two methods showed the same trend (Fig. 5). To test the closeness of the relationship a regression equation was fitted which is written as:

$$Y \quad 17.68 + 1.0916\ X$$

where Y = % meat volume in shell cavity volume and X = % meat weight in total weight. The correlation coefficient was found to be 0.9589 (d.f = 10. r 1% 0.708) which is significant, suggesting that a study of the C.I. by any one of the methods would give identical results. Further discussion of C.I. is limited to the percentage of meat weight in total weight. The C.I. in relation to seasonal changes, sexual cycle and pea crab infestation was studied in the 90-130 mm size oysters as they were commonly available in the collections.

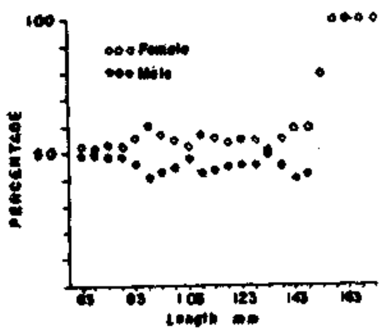

FIG. 4. Sex ratio in relation to size in *P. placenta*.

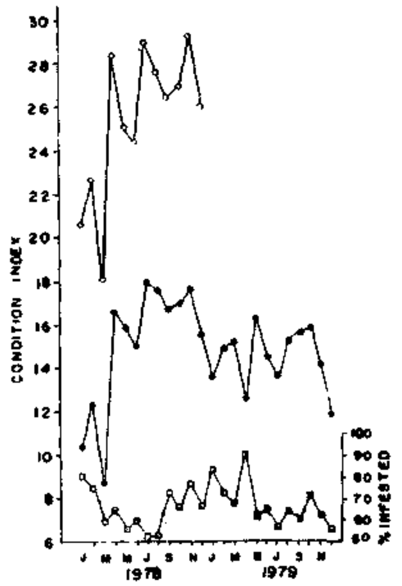

FIG. 5. Condition index and pea crab infestation in *P. placenta*. Open circles denote C.I. based on volume, closed circles C. I. on weight and dotted squares represent % pea crab infestation.

Condition in relation to size: The average condition in 151 oysters (collected on 25-5-1981 which is not the spawning time) divided into 1 cm length groups indicates that the C.I. decreases with increase in the length of oysters (Fig. 6). Analysis of variance (Table 5) showed that C.I. is significantly different at 5% level between length groups. From equations in Table 1 it is noted that with increase in length there was a decrease in the percentage of both meat and shell

TABLE 5. *Analysis of variance of condition index in 1 cm length groups in* Placenta placenta.

Source of variation	d.f.	S.S.	M.S.	F.
Between groups	10	211.78	21.178	5.4808
Within groups	140	540.96	3.864	
Total	150	752.74		

F (d.f = 10,140), 5% = 1.89 and 1% = 2.44

weights in total weight but the percentage of water retained in the mantle cavity increased. It is suggested that for comparative studies of C.I. it is necessary to restrict the length of oysters.

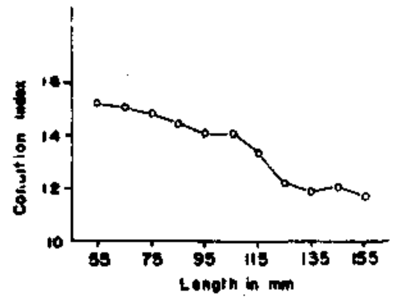

FIG. 6. Condition Index in relation to length in *P. placenta.*

Seasonal changes in the condition index:In 1978 the C.I. was low during January-March and June, attained peaks in April, July and November and moderate in other months (Fig. 5). In 1979 it was low in January, April, July and December, attained peak values in March, May and August-October and moderate in other months. The C.I. showed considerable variations for the same month between years during 1978-81; monthly average C.I. varied from 8.7 to 18.7. It was generally higher in 1981 than in other years.

Condition in relation to sexual cycle: The low C.I. in March 1978 is correlated with the completion of spawning in majority of oysters. In April there was a recovery of the gonad coinciding with fairly high C.I. and with the completion of spawning in May there was a fall in the C.I. in the following month. In November the oysters were in prime condition with spawning just initiated and the C.I. decreased by January 1979 with the completion of spawning. The fall in C.I. in April coincided with the completion of spawning in majority of oysters. In October the C.I. was high with spawning just initiated. Spawning was completed in majority of the oysters in December which is correlated with the lowest

C.I. of the year. In 1980-81 also the C.I. showed similar correlation with the sexual cycle. Thus in general, prior to or at the commencement of spawning the C.I. was found to be high and it showed a fall when the spawning was completed.

Condition in relation to infestation by pea crabs: It was observed that the windowpane oyster was heavily infested by the pea crab *Pinnotheres placunae* Hornell and Southwell (Fig. 6). The infestation varied from 46% in May 1980 to 91% in April 79. Multiple infestation was common. In 34% of the infested oysters slight to moderate lesions on the mantle, labial palps or gills were observed. In certain months as in January 1978 and 1979, April 1979 (Fig.5), June-July 1980 and March 1981 low C.I. in the oysters coincided with high infestation rate. Similarly high C.I. was obtained in the oysters in July 1978, May 1979, April 1980, August 1980 and 1981 when the percentage occurrence of crabs in the oysters was relatively low. A study of the C.I. in infested and uninfested oysters in each sample collected during 1978-80 showed that the condition was slightly lower in infested oysters when compared to uninfested oysters in all the 72 samples except for 4 samples in which the reverse was true. The difference in the C.I. in 72 samples were tested by t test which showed significant differences at 5% in only 20 samples.

Discussion

Hornell (1909) considered of windowpane oyster of 15 mm in Rann Bay as about three months old. In the Philippines, where mariculture of this oyster is practised in Capiz province, 30-35 mm seeds planted in farms in October-November at a rate of 80,000-120,000/ha are harvested in April at an average length of 90 mm; those planted in April reach 80-100 mm length after 4 months (Young and Serna 1982). This compares favourably with the 77-107 mm length attained in the first 6 months at Kakinada.

According to Hornell (1909), *P. placenta* appears to spawn at the onset of northeast monsoon in October along the Okha coast. From the same area Moses (1939) inferred biannual spawning in October-December and in April-May, the first being more intensive. There is much agreement between the present study and the observations of Moses (1939). In the Philippines the windowpane oyster matures at a comparatively larger size of about 70 mm and has extended reproductive cycle for 8-12 months and spawning usually occurs from February to May (Young and Serna 1982). Hornell (1909) stated that *P. placenta* is dioecious. The present study shows that in this species hermaphoditism is a very rare phenomenon and only 0.35% were hermaphrodites.

Advanced stages of infestation of *P. placenta* by the bucephalid parasite resulted in gonad invasion and sterility. Similar observations were made in the edible oysters by Galtsoff (1964) and Samuel (1976).

Among the various factors known to affect the condition in bivalves the reproductive cycle has received much attention. In this study the C.I. is related to the reproductive cycle and similar observations were made by Durve (1964), Ansell *et al.* (1964), Alagarswami (1966) and Narasimham (1980) in the bivalves studied by them.

Damage to gills, mantle and other soft parts was known to occur in many bivalves due to infestation by pea crabs (Christenson and McDermott 1958). Sandoz and Hopkins (1947) found that *Crassostrea virginica* showed poor condition when infested with *P. ostreum* than when uninfested. On the other hand, Silas and Alagarswami (1965), Krishnakumari and Rao (1974) did not notice any marked difference in the condition of infested and uninfested clams. The present study showed that only to a limited extent the condition was affected in *P. placent* by pea crab infestation.

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