J. mar. biol. Ass. India, 1970, **12** (1 & 2): 125-135

ON THE GROWTH OF THE CLAM *MERETRIX CASTA* (CHEMNITZ) FROM THE MARINE FISH FARM*

By V. S. DURVE**

Central Marine Fisheries Research Institute, Cochin

FROM the observations made during the management of the marine fish farm of the Central Marine Fisheries Research Institute, Mandapam Camp, it was felt that the farm may give sustained yield of edible hard clam, *Meretrix casta*, without perhaps disturbing the normal fish stocking operations. Accordingly, a study was conducted on some aspects of physiology and the biology of this clam in order to ascertain whether the farm is suitable for culture practices or could at least be used as a fattening ground for this clam. The present paper on the growth of the clam *M. casta* is sixth on the subject. The earlier five being on the rate of filtration (Durve, 1963), seasonal gonadal changes and spawning (Durve, 1964), the dimensional relationship (Durve and Dharma Raja, 1965), Experimental transplantation (Durve, in press) and fatness of the clam (Durve and Dharma Raja, in press).

The general topography and the description of the marine fish farm have been given by Tampi (1960). The clam *M. casta* had already established itself in the marine fish farm when the study commenced. It was present in all the seven ponds but was in abundance in 1st, 3rd, 4th and 7th ponds. The periodical excavation of mud from the ponds to deepen them, used to disturb the density of clam fauna to an appreciable extent. However, during the course of this study, the excavation was not done in the concerned pond.

MATERIAL AND METHODS

The clams for the present study were collected from the first pond of the fish farm. This pond has the dimensions of 30.5 meters in length and breadth, with an average depth of 0.5 meter and the water area of 930 sq. meter (Tampi, 1960). The clams were collected in fortnightly random samples of about 300 numbers per sample. The study extended for 22 months from August 1961 to May 1963. The area of work being very compact and limited, the collections were very representative of the population of the clam *M. casta* in the pond 1.

In addition, 300 clams were numbered and reared in iron cages in the same pond. This was done to confirm the results obtained by random sampling. The details about the method have been given in the relevant part of this paper.

Clams were brought to the laboratory and kept in clean sea water to clear them of their faeces. They were then measured individually by a vernier calliper correct up to 0.1 mm. The dimensions measured were height, length or width and depth.

---

* Published with the permission of the Director, Central Marine Fisheries Research Institute.

** Present address :—Dept. of Zoology, University of Udaipur, Udaipur.

Height denotes the maximum distance between the umbo and the gaping end, length the maximum distance from the anterior to posterior end and the depth the distance between two valves. Weights were taken correct up to 0.1 g. on a beam balance.

Results and Discussion

At the commencement of the study, all clams in the pond were more or less of the same size and there was no fresh recruitment to the stock during the course of study. The fortnightly data was, therefore, pooled to represent monthly observations which gave a good picture of the growth trend of this clam in the fish farm. Since the clams were of almost the same size, monthly averages were calculated for each dimension.

The monthly increase in each dimension is given by the differences between the means of two consecutive months. Figure 1 shows the free hand curves representing the growth in height, length (width) and depth. It appears from this figure that the growth though continuous from August 1962, slackens from May to September 1962, as evidenced by the curve taking a different turn during this period. This retardation of growth may perhaps be attributed in some way to the increase in salinity during these summer months. The salinity in the pond never falls below 30‰ and in the latter part of summer, *i.e.*, from August to September or early October, water becomes hypersaline showing the values above 45‰. The amount of food available to clams may perhaps get lessened due to the hypersaline more or less stagnant water prevailing during this period. Higher salinity is also known to retard the rate of filtration of water in the clam *M. casta* and consequently the feeding (Durve, 1963). However, it is found that this clam has a remarkable degree of adaptability to the higher salinities (Durve, *op. cit.*). The period of retarded growth mentioned above also coincides with the period of no sexual activity of the clam *M. casta* from the marine fish farm (Durve, 1964). The temperature of water during the summer months of May to September is high (32°-33°C). However, this is unlikely to affect the growth as it has been shown in the oysters *Crassostrea madrasensis* and *C. gryphoides* that temperature plays little role in the growth (Rao and Nayar, 1956 and Durve, 1961). The spurt in the growth rate of *M. casta* after a prolonged more or less resting period is expected and is evidenced by the upward turn of the graphs from September or October 1962 onwards in Fig. 1.

Growth in height : From the monthly averages of the samples of clams drawn during August 1961 to December 1961 (Table I), it is seen that during this initial period of investigation, the clams had grown in height by about 1.00 mm. per month. It is unlikely that this rate of growth would remain the same throughout the life of the clam. Normally, the rate of growth is expected to be very high in the early life of the clam (Newcombe, 1935). Rao (1951) found that in the case of the clam *Katelysia opima*, the length of 22.5 mm. is attained at the end of the first year, while it is only 31.5 and 40.5 mm. at the end of second and third years respectively. Rao *et al.* (1962) have recorded an average growth of 11 mm. per month in the early life of the Razor-shell *Solen kempi*. These authors noticed a decline in the rate of growth after the first six months. A similar observation of a early rapid growth and its later gradual decline has recently been recorded in the case of the wedge-clam *Donax faba* by Alagarswami (1966). The author himself has observed *M. casta* from the natural clam beds of Athankarai estuary, about 15 km. from Mandapam Camp, to attain the size of 14.8 mm. in height within four months (Durve, unpublished).

Table I, column 1 shows the growth in height of *M. casta* from the fish farm for 22 months of study. The value of height in the month of June 1962 appears to be an

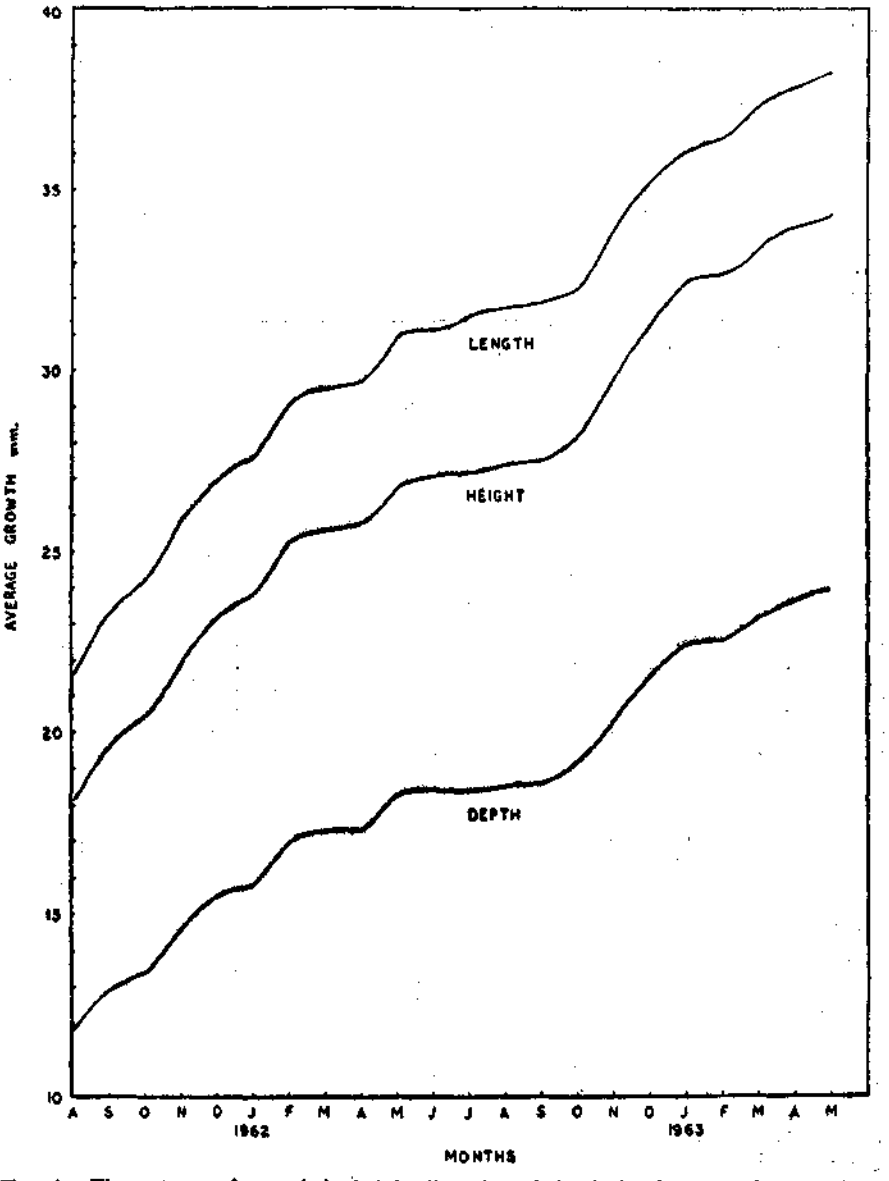

FIG. 1. The pattern of growth in height, length and depth in the case of *Meretrix casta* (Chemnitz) during the period August 1961 to May 1963.

observational error. The height increases by 16.28 mm. at the end of 22 months thereby giving the percentage increase of 90.14. The average growth in height per month for this period works out to 0.78 mm. Table II shows the increase in each dimension in every month of the investigation. It could be seen that the increase in

height is not uniform. It is more in some months and less in others. Only during summer months, *i.e.*, from 8th month to 13th month, the increase in height is consistently low. From 15th month onwards there is a sudden spurt in the increase in height which again lowers by 18th month.

Growth in length or width : Table I, column 2 shows the observed growth in length or width of the clam during the period of study *i.e.*, August 1961 to May 1963. The value of length corresponding to September 1962 is not consistent with the adjacent figures. This perhaps reflects the observational error. The total increase in length for the entire period of 22 months of investigation is 16.63 mm. giving the percentage increase of 76.91 and the monthly average growth as 0.79 mm.

Table II, column 2 gives the monthly increase in length for the period of study. As in the case of height, the monthly increase varies greatly except in summer months (from 8th month to 13th month) when it is very low. The same is on increase from 15th month onwards.

TABLE I

The average growth in height, length, depth and weight in the case of Meretrix casta *for the period August* 1961 *to May* 1963

Month	*Height* mm.	*Length* mm.	*Depth* mm.	*Weight* g.
August 1961 ..	18.06	21.62	11.77	3.08
September ..	19.60	23.30	12.89	4.13
October ..	20.36	24.17	13.42	4.84
November ..	22.02	25.88	14.61	6.21
December ..	23.21	26.96	15.46	7.38
January 1962 ..	23.79	27.58	15.77	8.00
February ..	25.26	29.09	16.95	9.30
March ..	25.64	29.52	17.26	9.77
April ..	25.83	29.73	17.34	10.22
May ..	26.97	30.96	18.32	11.53
June ..	27.49 (?)	31.09	18.80 (?)	11.82
July ..	27.18	31.45	18.38	11.86
August ..	27.42	31.72	18.48	12.39
September ..	27.45	31.67 (?)	18.51	12.83
October ..	28.16	32.26	19.20	13.07
November ..	29.80	33.83	20.38	16.70
December ..	31.33	35.16	21.72	19.52
January 1963 ..	32.45	36.07	22.45	21.66
February ..	32.69	36.44	22.60	22.11
March ..	33.42	37.26	23.21	23.89
April ..	33.98	37.78	23.69	25.15
May ..	34.34	38.25	23.97	26.17
Total increase ..	16.28	16.63	12.20	23.09
Average percentage per month ..	0.78	0.79	0.58	1.10
Per cent increase ..	90.14	76.91	103.6	749.6

Growth in depth : Column 3 in Table I shows the growth in depth for the entire period of investigation. The value of June 1962 appears to be an observational error. The general trend in the growth of depth is the same as in the case of other two dimensions. The average monthly growth in depth for the entire period of investigation

was 0.58 mm. The total increase in depth at the end of 22 months was 12.20 mm, *i.e.*, 103.6%.

Growth in weight : Increase in weight is on a similar pattern as the increase in height, length and depth (Tables I and II). However, total increase in weight for 22 months of growth was 23.09 g. *i.e.*, 749.6%. Average increase per month was 1.10 g. This, perhaps, indicates that the weight increases more rapidly than any other linear dimension. This is to be expected as the former is a summation of all the dimensions. It is also likely that shell deposition is very rapid and this may contribute to the rapid increase in the weight of this clam as compared to all its other linear dimensions.

TABLE II

The increase in each dimension per month for the period of study in the case of Meretrix casta

Month	*Increase in height* mm.	*Increase in length* mm.	*Increase in depth* mm.	*Increase in weight* g.
1.	1.54	1.68	1.12	1.05
2.	0.76	0.87	0.53	0.71
3.	1.66	1.71	1.19	1.37
4.	1.19	1.08	0.85	1.17
5.	0.58	0.62	0.31	0.62
6.	1.47	1.51	1.18	1.30
7.	0.38	0.43	0.31	0.47
8.	0.19	0.21	0.08	0.45
9.	1.14	1.23	0.98	1.31
10.	0.52	0.13	0.48	0.29
11.	—	0.36	—	0.04
12.	0.24	0.27	0.10	0 53
13.	0.03	—	0.03	0.44
14.	0.71	0.59	0.69	0.24
15.	1.64	1.57	1.18	3.63
16.	1.53	1.33	1.34	2.82
17.	1.12	0.91	0.73	2.14
18.	0.24	0.37	0.15	0.45
19.	0.73	0.82	0.61	1.78
20.	0.56	0.52	0.48	1.26
21.	0.36	0.47	0.28	1.02

Growth in the numbered clams : The data for this was collected for the period January 1962 to July 1963. For the purpose, three hundred clams were collected and numbered on their both valves with Indian ink. The numbers when dried were coated with a plastic emulsion. The clams were then kept in iron cages of the dimensions $45 \times 35 \times 15$ cm. with the soil collected from the first pond and returned to the same pond. The cages were taken out once every month, clams measured, renumbered and returned to the pond. Unfortunately, the cages had no mesh covering on top and predators had thus easy entry to the cages. Several clams thereby fell prey to the predation of crabs and puffer fishes. At the end of 19 months of study, only 27 clams survived and the data of these 27 clams alone have been presented in this paper.

Table III shows the average size in each of the three dimensions and weight in every month, for the 27 numbered clams, for the period of 19 months. The total

increase in height, length, depth and weight at the end of 19 months was 11.12, 11.74, 9.14 mm. and 20.39 g. respectively. Average increase per month was 0.62 mm. for the height, 0.65 mm. for length, 0.51 mm. for depth and 1.13 g. for weight. This, when compared with the similar data collected from random sampling, indicates that in the case of the latter the rate of growth is more except for weight. The comparison of the percentage increase in each dimension of the numbered clams with that of clams of random sampling also indicates that the percentage increase in any dimension was more in the latter for an equivalent period. The differences in the rate of growth in these two sets of clams may perhaps be traced to the probable over-crowding and restricted feeding in the cages.

Abraham (1953) noticed the growth of 4.14 mm. in length and 2.77 mm. in height in one month in the case of numbered *M. casta* of about 27.0 mm. in length and 23.0 mm. in height. These values are much more than the similar values obtainable in any single month in the present investigation.

TABLE III

The average growth in height, length, depth and weight in the case of numbered Meretrix casta *during the period January* 1962 *to July* 1963

Month	*Height* mm.	*Length* mm.	*Depth* mm.	*Weight* g.
January 1962 ..	23.24	27.15	15.18	7.51
February ..	23.91	27.91	15.80	8.07
March ..	24.32	28.24	16.04	8.53
April ..	24.71	28.78	16.33	9.20
May ..	25.09	29.18	16.96	9.12
June ..	26.17	30.28	17.27	11.08
July ..	26.51	30.81	17.86	11.36
August ..	26.95	31.20	18.26	11.61
September ..	27.19	31.42	18.41	12.70
October ..	27.87	32.14	18.69	12.72
November ..	28.97	33.32	19.99	15.63
December ..	30.62	34.83	21.59	19.48
January 1963 ..	31.49	35.51	22.65	20.10
February ..	32.22	36.21	22.63 (?)	21.43
March ..	33.04	37.28	23.24	23.85
April ..	33.57	38.03	23.75	24.77
May ..	33.95	38.21	23.93	25.45
June ..	34.15	38.74	24.22	25.97
July ..	34.36	38.89	24.32	27.90
Total increase ..	11.12	11.74	9.14	20.39
Average increase per month ..	0.62	0.65	0.51	1.13
Per cent increase ..	47.85	43.24	60.22	271.8

Table IV shows the growth in each dimension of six selected numbered clams for the whole period of investigation, along with the percentage increase. The tabulated readings are for every three months of growth. It will be seen from this table that growth varies considerably in different individuals inhabiting the same environment. This may be due to the physiological state of each individual.

The average monthly growth in each dimension for the numbered clams when plotted, showed similarity with the graph obtained for randomly collected clams

(Fig. 2). The growth in numbered clams also slackens during summer months and shows a spurt from September or October 1962 onwards. This confirms the observations reported earlier.

TABLE IV

The growth in six numbered Meretrix casta *at the interval of every two months during the period of study*

Number of the clam	*January* 1962	*April*	*July*	*October*	*January* 1963	*April*	*July*	*Increase* %
			——HEIGHT——					
27	23.5	25.3	27.3	28.4	32.3	34.3	35.4	50.63
54	21.0	24.0	25.4	26.4	31.0	33.5	34.7	65.24
115	24.0	25.0	27.0	27.4	30.7	33.0	33.9	41.25
153	24.0	25.5	27.5	28.4	32.0	34.4	35.3	47.09
198	25.3	26.0	27.0	28.0	31.3	33.5	34.3	35.57
268	21.0	23.3	25.3	26.4	31.3	34.0	34.4	63.69
			——LENGTH——					
27	26.3	28.4	30.6	31.9	35.0	38.0	39.0	48.28
54	25.0	28.0	29.9	31.4	35.5	37.9	39.4	57.61
115	28.0	29.5	31.4	32.4	35.3	37.9	38.9	38.92
153	27.8	29.8	32.0	32.5	36.0	39.3	40.0	43.89
198	29.1	30.0	31.0	32.0	34.9	37.3	38.3	31.61
268	24.9	27.0	28.9	30.3	34.3	37.8	38.3	53.81
			——DEPTH——					
27	16.0	17.5	19.3	20.0	23.3	25.3	26.0	60.50
54	13.0	14.8	16.0	17.0	20.9	22.3	23.0	76.93
115	14.4	16.3	17.6	18.0	20.4	22.4	23.3	61.80
153	16.6	18.0	19.7	20.5	23.5	25.4	26.3	58.43
198	17.0	17.4	18.0	19.0	21.3	23.0	23.4	37.65
268	13.3	14.8	16.5	17.5	21.7	23.5	24.3	82.69
			——WEIGHT——					
27	8.1	9.1	12.1	13.0	21.5	27.3	30.0	270.4
54	5.2	7.0	9.1	10.5	19.0	23.3	27.2	423.1
115	8.2	10.0	11.8	12.0	18.0	23.4	26.6	224.4
153	9.2	11.5	13.6	15.0	22.3	28.2	31.3	240.2
198	9.5	10.3	11.0	12.0	17.9	22.4	26.0	173.7
268	5.6	7.8	10.0	11.0	19.2	24.2	27.9	398.2

GENERAL CONSIDERATIONS

The clam *Meretrix casta* is a true backwater clam and never occurs in purely marine conditions. It has been reported to form extensive beds in estuaries and backwaters of south India. Its settlement in marine fish farm where purely marine conditions exist is a matter of great interest. There is no influence of freshwater in the farm except during monsoon which is very feeble around Mandapam. The growth pattern in this clam from the fish farm, thus formed an interesting part of study.

In this connection, reference may be made to the earlier works on the growth of Indian clams. These include the works of Winckworth (1931) on *Paphia undulata*, Paul (1942) on *Mytilus viridis*, Rao (1951) on *Katelysia opima*, Abraham (1953) on *Meretrix casta* from Adyar backwater near Madras, Nayar (1955) on *Donax cuneatus*, Rao *et al.* (1962) on *Solen kempi* and Alagarswami (1966) on *Donax faba*. The results obtained during the present investigation could be compared with those

obtained by some of these earlier workers. Rao (1951) observed that ' in the case of *Katelysia opima* the growth rate is not uniform in all the months of the year, but seems to be markedly rapid in, if not entirely restricted to, the period from January to July'. This he attributed mainly to the higher salinity prevailing during this

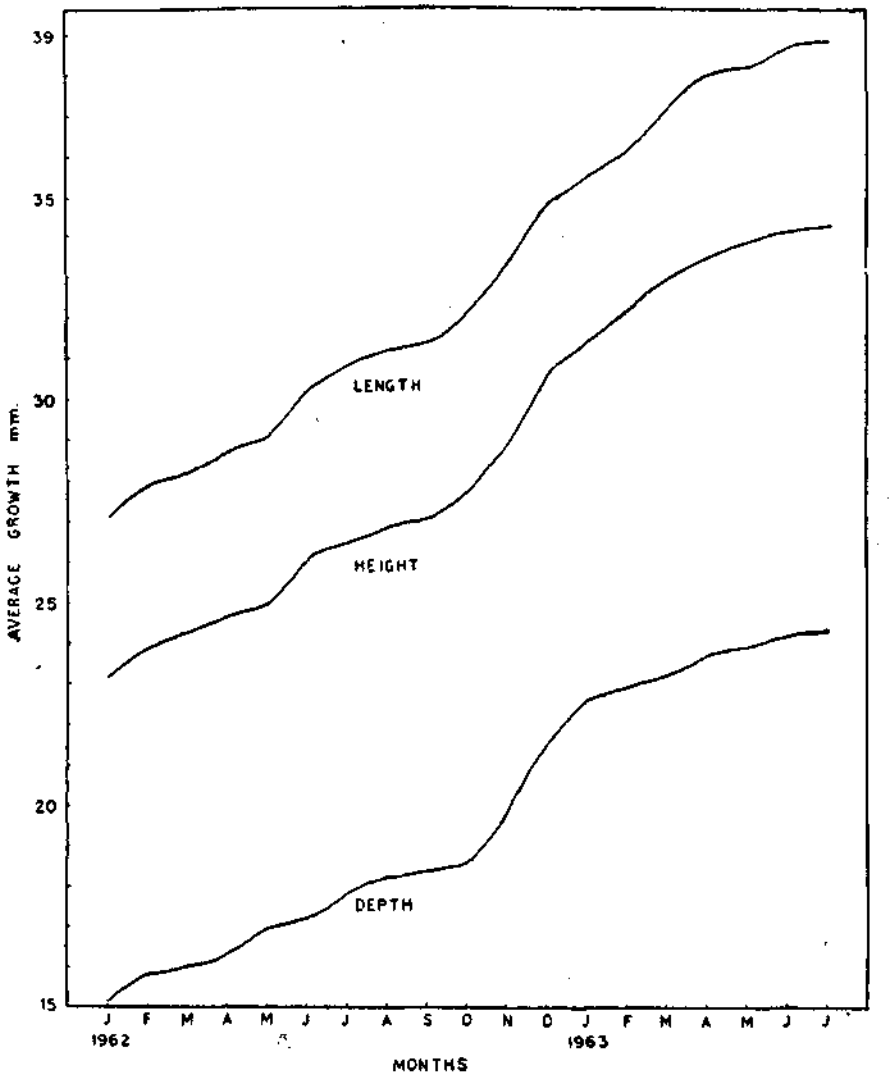

FIG. 2. The pattern of growth in height, length and depth in the case of numbered clams (*Meretrix casta*) for the period January 1962 to July 1963.

period. With a decrease in salinity, there is arrestment in growth. Hamai (1935) and Ansell (1961) have also observed the growth being restricted to summer months of May to August or September in *M. meretrix* and *Venus striatula* respectively. However, this is to be expected in temperate waters. Abraham (1953) observed a period of no growth (February-March) in the clam *M. casta* from Adyar backwater. This

he felt was probably due to the reproductive activity of the clam during this period. He also observed a very rapid rate of growth in *M. casta*, being 29.5 mm. in length within seven months. Nayar (1955) in his work on *Donax cuneatus* observed the growth of 14 mm. in length within 10 months. Alagarswami (1966) reports that the wedge-clam *Donax faba* grows to 19.5 mm. in length within the first year thereby showing the average growth of 1.6 mm. per month.

The cessation of growth has not been observed in the present investigation. There is, of course, a retardation of growth as stated earlier during the period May to September. The probable causes have been discussed earlier. There is a sudden spurt of growth immediately after the period of retarded growth (Figs. 1 and 2). The rate of growth of *M. casta* observed in the present investigation (0.78 mm. per month for height and 0.79 mm. for length) is much lower than that observed by workers cited above on the same species elsewhere. This slower rate of growth in the clam of the present study, could perhaps be attributed to the marine conditions in the fish farm which is not a natural habitat of this clam. This aspect will be discussed later. The difference in races may not be a factor for a slower growth as Spear and Glude (1957) have reported that environment and not heredity is the important factor in determining the growth of the soft clam *Mya arenaria*.

The rate of growth in *M. casta* of the present investigation in its three dimensions namely height, width and depth is also not the same. From the percentage growths of these, it appears that the growth in 21 months is the fastest in the case of depth (103.6%) followed by the height (90.14%). The length has the least rate of growth being only 76.91%. As stated earlier, the rate of increase in weight is the highest of all the dimensions studied (749.6%). However, the rate of growth may be consistently low or high for all the dimensions in any given month.

It is interesting to mention here that while Rao (1951) observed growth in *Katelysia opima* to be rapid during the period of high salinity, the same was found to be retarded during the period of high salinity in the case of *M. casta* from the marine fish farm. Abraham (1953) recorded a period of no growth in *M. casta* from Adyar backwater during the period of its reproductive activity while in the present investigation, the growth is found to be rapid from October to January, the period coinciding somewhat with the sexual activity of this clam (Durve, 1964). Nayar (1955) observed the cessation of growth during November-December in the case of *Donax cuneatus*, which he attributed to the rough weather conditions prevailing in Palk bay due to the north-east monsoon ; while this is a period of rapid growth in the clam of the present study.

The pattern of growth in *M. casta* of the present investigation could thus probably be traced to the sheltered nature of the fish farm, highly nutritious substratum harbouring bacterial and flagellate flora (Tampi, 1960) and also the rich organic content (Durve and Dharma Raja, in press). The bottom contains about 40% of water and high percentage of fine grade along with the probable presence of Ferrous Sulphide as evidenced by a little blackness of the soil. The agencies having adverse effects on growth being, as stated earlier, the excessive increase of salinity during the period of retarded growth, purely marine conditions without the influence of freshwater and the absence of some unknown factors which are present in the localities like estuaries and backwaters that form the natural habitat of this clam. However, detailed study in this direction appears necessary.

The fixation of age in the case of *M. casta* of the present study could be attempted only by general observations on the growth-rate of this clam elsewhere. It is well-

known that clams grow very rapidly immediately after settlement. Hamai (1935) observed *M. meretrix* in Japanese waters to grow to about 20 mm. in length and 18 mm. in breadth in 9 months. Abraham (1953) observed *M. casta* from Adyar backwater to grow to the length of 15 mm. in two months. Author (Durve, unpublished) has observed this clam to grow to 14.8 mm. in height within 4 months after settling. Similar rapid growth immediately after spatting has been recorded in different clams by workers cited earlier and several others all over world. Considering these facts and the knowledge of the author about *M. casta* inhabiting the marine fish farm, the age of this clam from pond 1 of the fish farm at the height of 18.06, length 21.62 and depth 11.77 mm. could be approximately fixed at 8 months, after giving allowance to the purely marine conditions in the fish farm and the higher salinity prevailing during summer months of April to September or early October. The growth in height at the end of first year could thus probably be 23.21 mm., at the end of second year 31.33 mm. and at the end of third year, a little more than 34.34 mm. The equivalent values for length will be 26.96 mm., 35.16 mm. and a little over 38.25 mm. respectively. These values when compared with those obtained by Abraham (*op. cit.*) in the case of *M. casta* from Adyar backwater near Madras, indicate that the clam of Adyar waters grows more rapidly than the clam of the present study.

The disturbance rings of the nature of annual rings have been observed in *Katelysia opima* by Rao (*op. cit.*). These seem to indicate the arrested growth that recur year after year from August to September. Such rings have not been observed by Abraham (1953) in *M. casta* from Adyar backwater. In the present study, several rings seen on the shell were of the nature of disturbance rings and they did not occur with any regularity.

SUMMARY

The growth of the clam *Meretrix casta* from the marine fish farm was studied for 22 months by random sampling and for 19 months by numbering three hundred clams and rearing them in iron cages. The observations of these two studies support each other.

The results indicate that the clam *M. casta* from the marine fish farm has, in general, a slow growth. The growth was found to be continuous throughout the year with a retardation during the summer months from May to September. No cessation of growth was noticed. The growth was found to be rapid immediately after summer months *i.e.*, from October to March or April.

The pattern of growth in the three dimensions, height, length, depth and also in weight was more or less the same. However, the weight appeared to increase more rapidly than any other dimension. Out of the three dimensions *i.e.*, height, length and depth, the latter had the fastest growth followed by height and length. The probable causes for the pattern of growth in this clam have been discussed.

ACKNOWLEDGEMENT

The author is grateful to Dr. S. Jones, then Director, Central Marine Fisheries Research Institute, Mandapam Camp, for his encouragement in the course of this study and the facilities given for its completion. He is also thankful to Dr. R. Raghu

Prasad, presently Asst. Director General (Fisheries), I.C.A.R., for kindly going through the manuscript and suggesting improvement.

REFERENCES

ABRAHAM, K. C. 1953. Observations on the biology of *Meretrix casta* (Chemnitz). *J. Zool. Soc. India*, **5** (2) : 163-190.

ALAGARSWAMI, K. 1966. Studies on some aspects of biology of the wedge-clam, *Donax faba* Gmelin from Mandapam coast in the Gulf of Mannar. *J. Mar. biol. Ass. India*, **8** (1) : 56-75.

DURVE, V. S. AND BAL, D. V. 1962. Preliminary observations on the growth of the oyster *Crassostrea gryphoides* (Schlotheim). *J. Mar. biol. Ass. India*, **4** (2) : 206:-213.

———. 1963. A study on the rate of filtration of the clam *Meretrix casta* (Chemnitz). *Ibid.*, **5** (2) : 221-231.

———. 1964. Preliminary observations on the seasonal gonadal changes and spawning in the clam *Meretrix casta* (Chemnitz) *Ibid.*, **6** (2) : 241-248.

———, AND DHARMA RAJA, S. K. 1965. A study on the dimensional relationship in the clam *Meretrix casta* (Chemnitz) collected from two localities. *Ibid.*, **7** (1) : 69-79.

——— 1971. Experimental transplantation of the clam *Meretrix casta* (Chemnitz) in the marine fish farm. Indian J. Fish., **18** in press.

——— AND DHARMA RAJA, S. K. 1970. A preliminary study on fatness of the clam *Meretrix casta* (Chemnitz) from two localities near Mandapam. *Ibid.*, **17** in press.

HAMAI, I. 1935. On the growth of the shell of *Meretrix meretrix* especially with regards to periodicity of growth relatively to the seasonal variation in the environment. *Sci. Rep. Tohoku Imp Univ.*, 4th series, **9** : 339-372.

NAYAR, K. N. 1955. Studies on the growth of the wedge-clam, *Donax (Latona) cuneatus* Linnaeus *Indian J. Fish.*, **2** (2) : 325-348.

NEWCOMBE, C. L. 1935. Growth of *Mya arenaria* L. in the Bay of Fundy region. *Canad. J. Res.*, **13** D (6) : 97-138.

PAUL, M. D. 1942. Studies on the growth and breeding of certain sedentary organisms in the Madras harbour. *Proc. Indian Acad. Sci.*, **15** (B) : 1-42.

RAO, K. V. 1951. Studies on the growth of *Katelysia opima* (Gmelin). *Proc. Indo-pacific Fish. Coun.*, Sec. II : 94-102.

———, AND NAYAR, K. N. 1956. Rate of growth in spat and yearlings of the Indian backwater oyster, *Ostrea madrasensis* Preston. *Indian J. Fish.*, **3** : 231-260.

———, NARASIMHAM, K. A AND ALAGARSWAMI, K. 1962. A preliminary account of the biology and fishery of the Razor shell, *Solen kempi* Preston, from Ratnagiri in Maharashtra state. *Ibid.*, **9** (2) : 542-579.

SPEAR, H. S. AND GLUDE, J. B. 1957. Effects of environment and heredity on growth of the soft clam (*Mya arenaria*). *Fish. Bull. U.S.*, **57** (114) : 279-292.

TAMPI, P. R. S. 1960. Utilization of saline mud flats for fish culture—an experiment in marine fish farming. *Indian J. Fish.*, **7** : 137-146.

WINCKWORTH, R. 1931. On the growth of *Paphia undulata* (Veneridae). *Proc. Malacol. Soc.*, **19** : 171-174.