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THE AGE AND GROWTH RATE OF RAINBOW SARDINE *DUSSUMIERIA ACUTA* FROM MANDAPAM AREA AND ITS AGE GROUP COMPOSITION IN THE FISHERY*

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ABSTRACT

The age and growth rate of *Dussumieria acuta* of the Gulf of Mannar and the Palk Bay, during April 1969 to March 1971 was studied. According to the Peterson's method of length frequency analysis the fish grows to a total length of 73 mm, 95.5 mm and 113 mm at the end of 1st, 2nd and 3rd quarters of an year and to 128 mm at the end of 1st year, resulting an average growth rate of 10.75 mm per month. Results of the Probability Plot technique of Cassie (1954) applied to the data, showed perfect agreement with those of Peterson's method. Von Bertalanffy's growth equation was fitted and the estimated values of the growth parameters were : $L\infty = 191$ mm, $K = 0.20701$ and $t_0 = -1.34$ quarters. Theoretically the fish grows to a length of 128.05 mm, 163.28 mm and 178.91 mm at the end of 1st, 2nd and 3rd years. No growth rings were traceable on the otoliths, but a straight-line relationship could be noticed between the lengths of otolith and the fish. The growth by weight showed that the optimum age for exploitation of *D. acuta* is when the fish is 1 to 1½ years old. A study of the age composition of *D. acuta* in the commercial catches during 1969-71 showed that in the shore seine and the gill net catches 1-year group dominated, whereas in the trawl net catch the 0-year class dominated during 1969-70 and 1-year class during 1970-71.

INTRODUCTION

RAINBOW sardines of the Genus *Dussumieria* belonging to the family Dussumieriidae are small pelagic fishes widely distributed in the tropical and temperate regions of the Indo-Pacific. In India, these fishes though common all along the coasts, occur in fishable magnitude only in some regions. The Gulf of Mannar and the Palk Bay around Mandapam area on the southeast coast of India, are such centres where rainbow sardines form a good fishery. The two species reported from Indian waters are *Dussumieria acuta* Valenciennes and *D. hasseltii* Bleeker (Nair, 1982). Though considerable informations had been accrued on age and growth on these two species from Indian waters, no information is hitherto available on this aspect of rainbow sardines except for a brief mention by Mahadevan and Chacko (1962) on age at length of *D. hasseltii*. In the present study an attempt has been made to determine the age and growth of *Dussumieria acuta* and its age-group composition in the commercial catch.

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Material and Methods

The Peterson's method of length frequency analysis and the Probability Plot technique of Cassie (1954) were followed to ascertain the age and growth of *D. acuta*. Weekly samples were collected at random from the commercial catches at various fish landing centres in and around Mandapam area (Fig. 1) along the Gulf of Mannar and the palk Bay for two years from April 1969 to March 1971. Shore seine samples were collected from Vedalai, Pudumadom, Periyapatanam, Dhargavalasai and Panaikulam; trawl net samples from Mandapam and gill net samples from Vedalai and Kilakkarai. The data collected from the non-selective gears, *viz.* shore seine and trawl net were utilised for length frequency analysis. A total of 10,362 fish of both the sexes, ranging in size from 47 to 167 mm. collected through 130 samples, were measured for its total length in millimeter. These measurements were grouped into 5 mm size groups with the mid point representing the particular size-group. The samples of a month were pooled to a percentage frequency (Fig. 2). Towards a more direct method of age determination, the otolith of *D. acuta* was examined for growth rings. Sagitta, the largest piece in the otolith complex removed from 230 specimens of various sizes were examined under microscope in reflected light using xylol as the clearing agent. The length of the otolith was measured in micrometer divisions (MD).

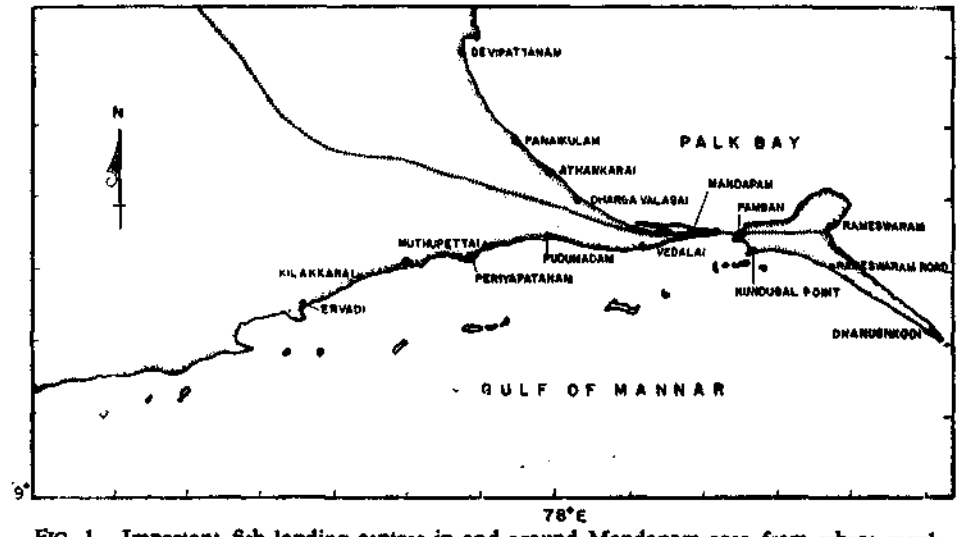

Fig. 1. Important fish landing centres in and around Mandapam area from where regular samples were collected.

Age Determination

Peterson's method of length frequency analysis

The monthwise percentage frequency distribution of *D. acuta* is presented in Fig. 2. The positions of the modes in the monthly frequency polygon and the progression of some selected modes through successive months are presented in Fig. 3.

Fig. 3 shows the progression of 5 broods in the model distributions for a certain period beyond which its identity becomes doubtful. Since all these modes exhibit more or less identical growth trend, an average growth rate was calculated from these modes following

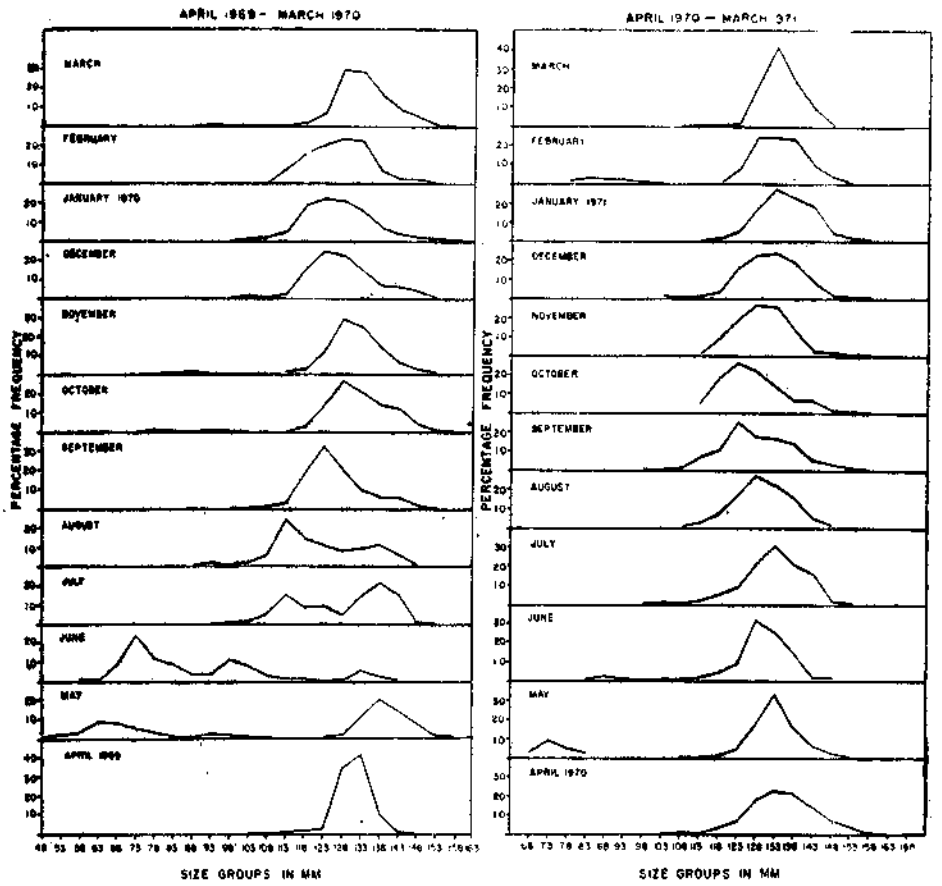

FIG. 2. Length-frequency distribution of *D. acuta* for 1969-70 and 1970-71.

TABLE 1. *Progression of various broods of* D. acuta *in successive months*

Months		Modal position in mm												
1969														
May	..	63	73	—	93	—	—	—	123	123	128	128	133	133
May	..	—	—	—	—	—	—	93	98	113	113	123	128	128
October	..	—	—	—	78	88	103	—	—	—	—	—	128	133
1970														
March	..	—	—	—	—	—	—	93	108	—	—	—	128	—
May	..	—	—	73	88	103	—	123	123	128	133	133	—	—
Average	..	63	73	73	86.3	95.5	103	103	113	121.3	124.7	128	129.2	131.3
Age in months	..	2	3	4	5	6	7	8	9	10	11	12	13	14

the fishery at 63 mm size (as seen from the smallest mode observed in May 1969) its growth for the first month is 10 mm and thereafter the average growth for the first three months is 7.5 mm. According to Ford (1933) a uniform growth rate cannot be expected throughout the life of an individual fish. In earlier stages the rate of growth would be much higher than in the later stages. This phenomenon is noticeable not only between years, but within the year also, where the growth will be faster in earlier months and slower as the fish grows older. So it may be assumed that the growth rate in *D. acuta* would have been still faster earlier to its first appearence in the fishery. The breeding season of D. *acuta* has been observed as March to September. So the 63 mm mode noticed in May 1969 would have been the brood of March 1969 and could be the result of 2 months growth. This indicates that in the first quarter the fish grows to 73 mm with an average growth of 24.5 mm per month. Like-wise the fish attains 95.5 mm at the end of 6 months, 113 mm at the end of 9 months and 128 mm at the end of first year, with an average growth rate of 7.5, 5.8 and 5.0 mm per month during 2nd, 3rd and 4th quarters respectively. Beyond the 1st year it is difficult to trace the growth rate of the fish. In brief, the fish attains 128 mm total length at the end of 1st year growing at the rate of 10.7 mm per month.

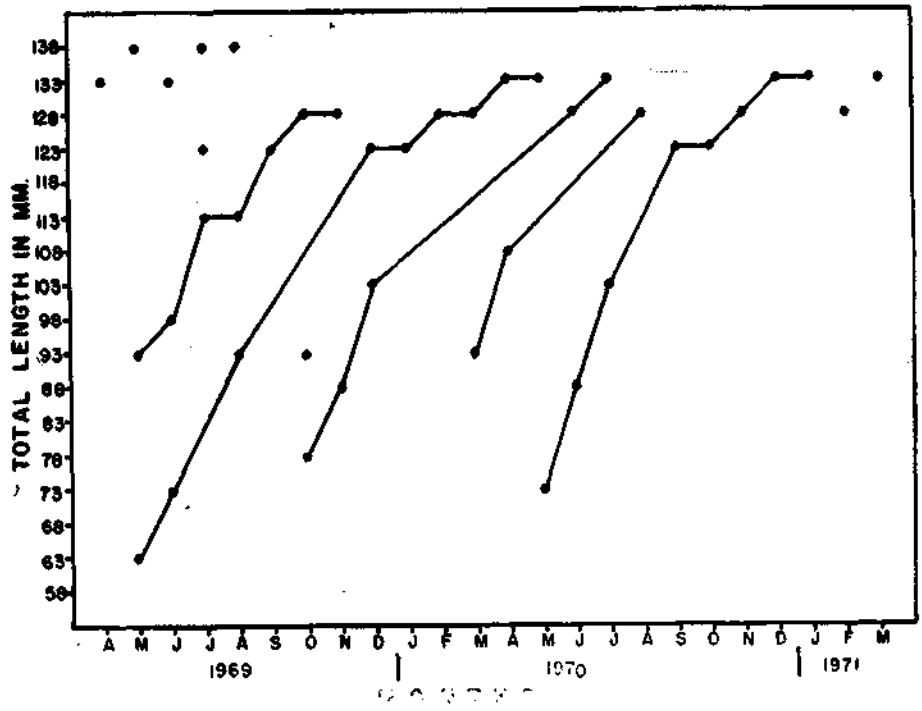

FIG. 3. Distribution and progression of modes of length-frequency data of *D. acuta* during April 1969 to March 1971.

Probability Plot technique

The technique by which the probability paper can be used in solving bimodal and polymodal frequency distributions have been described by Harding (1949) and later modified by Cassie (1954). According to them in a fish with a single restricted spawning season

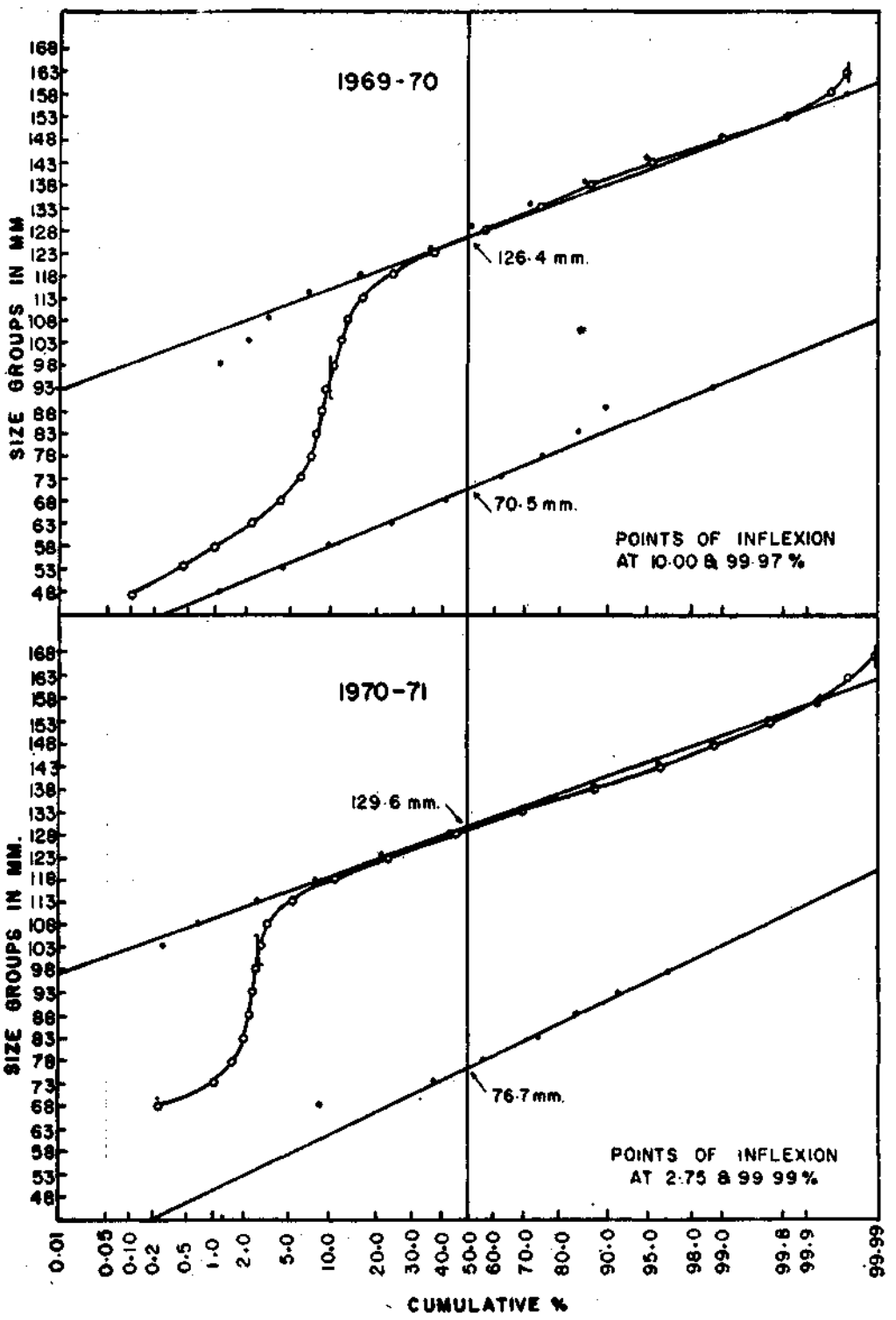

FIG. 4. Probability plot of the length-frequency distribution (cumulative percentage) of *D. acuta* with its theoretical normal curve components for 1969-70 and 1970-71.

the modal length of a size group is usually taken to be yearly in nature. The probability plot technique helps to separate the theoretical normal curves from the polymodal frequency distribution. This method was tried and found very effective in sorting out the yearly modes of *D. acuta* which is having a single spawning season during March to September.

The length frequency data was pooled yearwise and the cumulative percentage frequencies were calculated for the year 1969-70 and 1970-71. These were ploted in arithmetic probability paper, the points of inflexion were noted and the estimated modal values were fitted in Fig. 4.

In 1969-70 the diagram shows two points of inflexion, at 10.00% and 99.97%. On computation the modal lengths were found to be 70.5 mm and 126.4 mm. The mode at 70.5 mm represents the juvenile fish collected in May and June (Fig. 2). Since the spawning season

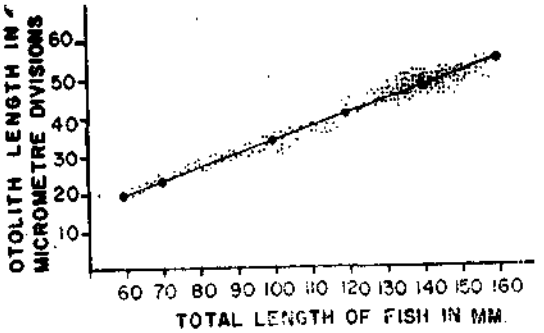

FIG. 5. Relationship between otolith length and total length of *D. acuta*, points represents observed values.

of *D. acuta* is an extended one, the mode at 70.5 mm appeared in May-June cannot be considered as that of 1-year old, instead it is only of juvenile fish. The formation of this mode is mainly due to the large scale appearence of the small-sized fish in shore seine during May-June months. The second mode at 126.4 mm represents the 1-year old fish. In the subsequent year (1970-71) the points of inflexion were at 2.75% and 99.99%. The estimated modal values at 76.7 mm and 129.6 mm represent the Juvenile mode and 1-year old fish respectively. The above results show that the modal sizes in two consecutive years are more or less the same. The average for these years indicates that *D. acuta* attains a size of 128 mm at the end of 1-year. This is in perfect agreement with the results obtained from length frequency analysis.

Examination of otolith

The otoliths showed that in some specimens though one or two faint rings were observed, they could not be correlated with the age of the fish. These rings were neither continuous nor clear. The calculations based on the radius of these rings did not agree with the growth rate obtained by length frequency analysis. Hence it was concluded that the otoliths of *D. acuta* were of no use in ascertaining its age.

The relationship between the otolith length and the fish length was studied. The length of the otolith was ploted against the total length of the fish (Fig. 5). A straight line relationship was noticed between these two parameters. A regression was fitted using the formula $y = a + b X$, where Y = fish length, X = otolith length and 'a' and 'b' two constants. On computation the formula was found to be : $Y = -2.3745 + 0.3553 X$.

Empirical growth curve

Based on the concept that growth is the net result of anabolism and catabolism, von Bertalanffy (1938) formulated a growth equation which, according to Beverton (1954) and Beverton and Holt (1957) produces a growth curve that fits well with the growth rate of many species. As modified by Ricker (1958) the equation reads as follows :

$$L_t = L\infty\ (1-e^{-k(t-t_0)}).$$

The growth parameters in the above equation were estimated by arithmetic and graphical methods.

Arithmetic method : Following Bagenal (1955 a, b) the parameters of the above equation was determined arithmetically and the values were : $L\infty = 191$ mm, $K = 0.20701$ and the average $t_0 = -1.34$ quarters (Table 2).

of $\log_e (L\infty - L_t)$ against the corresponding ages (Fig. 7) the t_0 was obtained as —1.4 quarters.

In both these methods the value of the parameters were identical, except for t_0 which showed a slight variation. Following the arithmetic method the equation may be written as :

$$L_t = 191\ [1-e^{-0.20701(t-(-1.34))}]$$

TABLE 2. *Age length Data : Values of 't_0' at different ages*

Age 't' in quarters	length in mm L_t	$L\infty - L_t$	$\log_e (L\infty - L_t)$	$\log_e L\infty - \log_e (L\infty - L_t)$	$-t_0$
1	.. 73	118.0	4.77068	0.48162	—1.33
2	.. 95.5	95.5	4.55913	0.69314	—1.35
3	.. 113	78.0	4.35671	0.89556	—1.33
4	.. 128	63.0	4.14313	1.10914	—1.36
				Average t_0 =	—1.34

Graphical method : The growth parameters were also obtained graphically following Ford (1933) and Walford (1946) method of ploting $L_t + 1$ against L_t (Fig. 6). The point of intercept of the growth line by the bisector gave the value of $L\infty = 191$ mm. The slope of the growth line is equal to e^{-k} from which K was found as 0.20701. By ploting the values

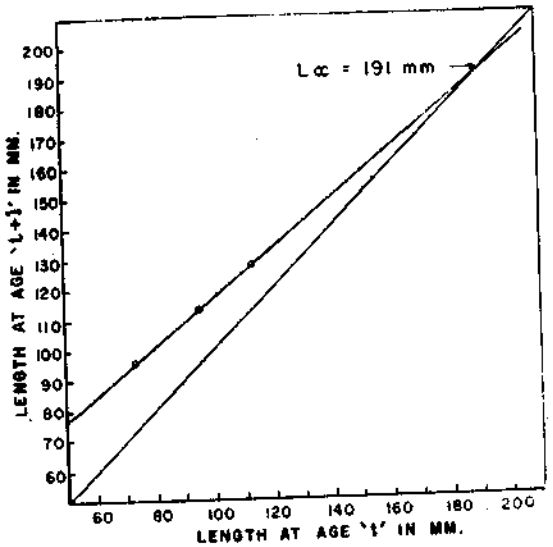

FIG. 6. Ford-Walford plot of the growth of *D. acuta*.

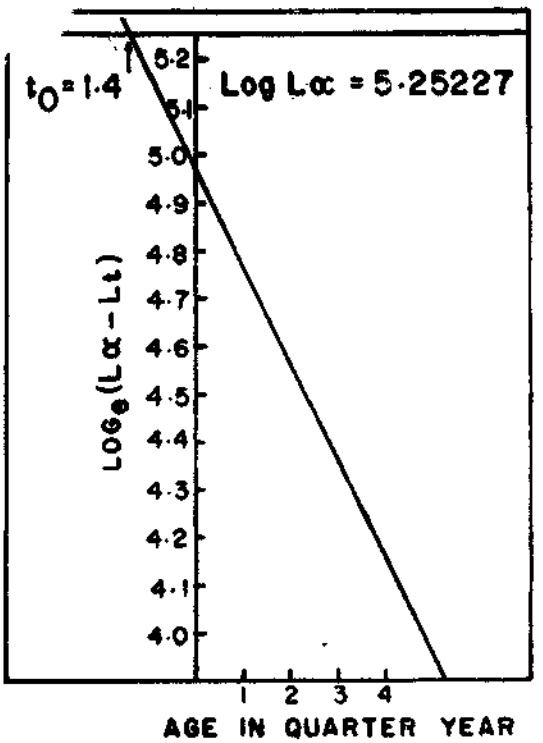

FIG. 7 $\log_e (L\infty - L_t)$ plotted against age 't' for the estimation of 't_0'.

Applying the above equation the theoretical growth and increment of *D. acuta* in quarter years was estimated upto three years. The growth curve and the quarterly increment curve are presented in Fig. 8. The fish grows to 128.05 mm at the end of 1st year which agrees with the observed value. At the end of 2nd and 3rd years the fish may attain 163.28 mm and 178.91 mm respectively.

Growth by weight

The growth of *D. acuta* by weight in relation to length was studied. Theoretical length at age was made use of in splitting up the sample into their constituent age groups. The length at age in different quarters, rounded up to nearest millimeter, were taken as age and their corresponding weights were calculated from the following length-weight equation derived

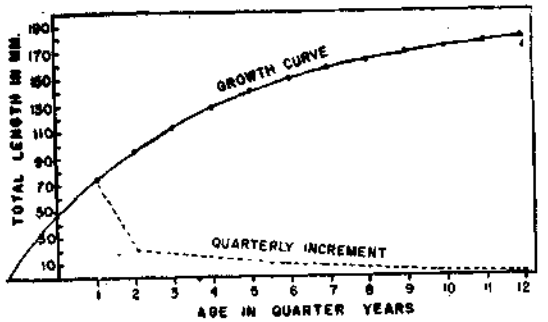

FIG. 8. Calculated growth rate and growth increment (in length) of *D. acuta* in quarter years as estimated by von Bertalanffy's equation.

for the species $W = 0.0000006294\ L^{3.5362}$ or $\log W = -6.2011 + 3.5362 \log L$. The weight at length of *D. acuta* for the first 8 quarters was thus estimated as being 2.4, 6.2, 11.5, 17.8, 23.8, 30.5, 36.6 and 41.8 grams respectively. The quarterly weight and weight increment curves are presented in Fig. 9. The weight increased steadily from 1st to 8th quarters, but the weight increment in each quarter showed steady increase from 2.4 gm in the first quarter to 6.3 gm in the 4th quarter when the length was 128 mm. Then in the 5th quarter the weight increment was little less (6.0 gm) and again increased to 6.7 gm in the 6th quarter when the length was 149 mm. Thereafter the quarterly weight increment decreased steadily. The studies on the size at first maturity has revealed that *D. acuta* spawns first at 126-130 mm size when the fish is one year old. Therefore it could be assumed that the fall in weight increment in the 4th quarter may be due to the first spawning. Steady decrease from the 7th quarter onwards indicates that the optimum age for exploitation is when the fish is 1 to 1½ years old, reaching a length of 128-149 mm, where after the increment in weight will be less and less.

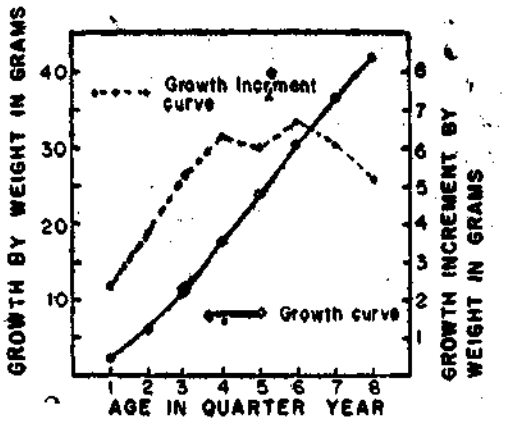

FIG. 9. Calculated growth in weight and increment at ages of *D. acuta* in quarter years.

AGE COMPOSITION OF *D. ACUTA* IN THE COMMERCIAL CATCH

Rainbow sardine was landed almost throughout the year around Mandapam area and the total landings were estimated to 11.7 tonnes in 1969-70 and 15.0 t in 1970-71, with an average annual catch at 13.4 t. The gear-wise monthly catch is presented in Tables 3 and 4 for two years. The average monthly catch ranged between 439 kg in May and 1,902 kg in December. The fish was caught in shore seine, gill net and trawl net and these

gears contributed about 60%, 18% and 22% respectively.

The age-group composition of *D. acuta* in the commercial catch was studied based on the results of the age and growth studies. The calculations were made following the method suggested by Fairbridge (1952). The percentage number of fish in each age-group was estimated monthwise and gearwise for the period April 1969 to March 1971 and presented in Fig. 10.

Shore seine : During 1969-70, in shore seine the 0-year group fish was noticed in all the months except in April and it dominated in June and September. The 1-year old fish was noticed in all the months and it dominated in all the months other than June and September. The 2-year group was noticed only in January forming 0.5%. In this year the 1-year old fish dominated in shore seine forming 66.5% whereas the 0-year and 2-year classes formed 33.5% and 0.2% respectively.

During the subsequent year the 0-year group occurred in all the months, but 1-year old fish

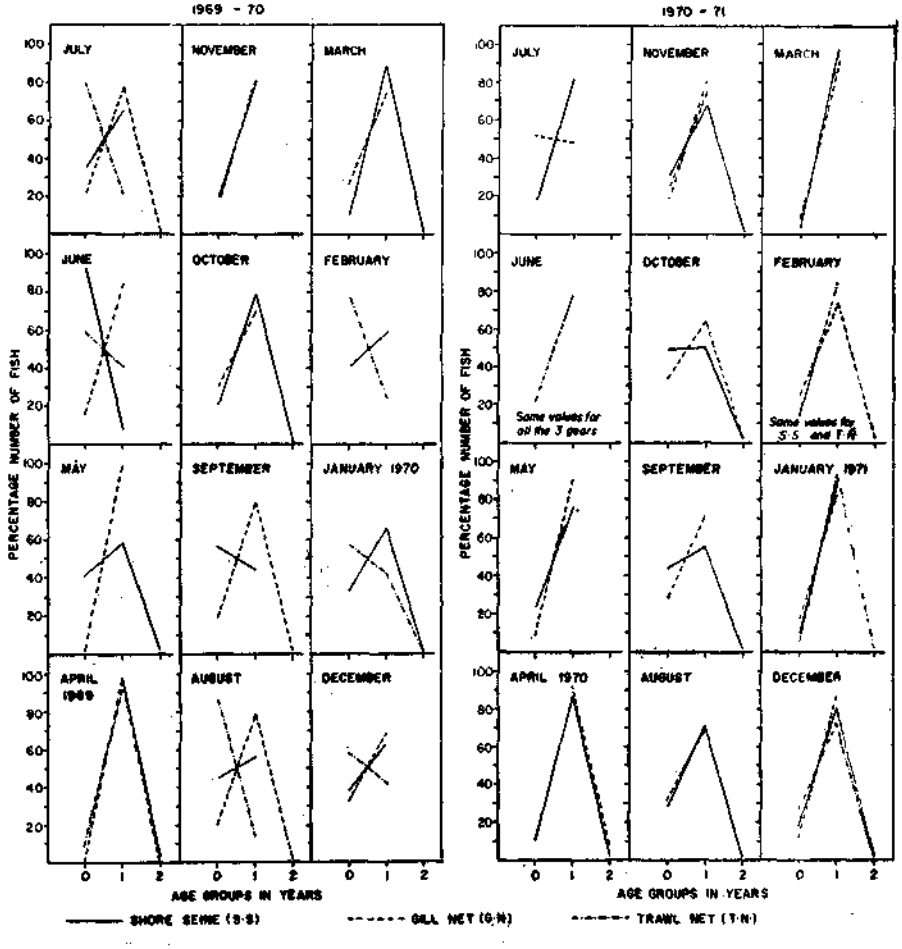

FIG. 10. Age-group composition of *D. acuta* in the commercial catch at Mandapam area during 1969-70 and 1970-71.

TABLE 3. *Monthly total catch (in Kg) of* D. acuta *in different gears at Mandapam area during* 1969-70

Months		Shore seine	Gill net	Trawl net	Total
April	..	250.0	60.0	210.0	520.0
May	..	198.5	82.6	—	281.1
June	..	150.0	84.0	405.0	639.0
July	..	270.0	210.0	390.0	870.0
August	..	540.0	330.6	310.0	1180.6
September	..	507.0	400.0	—	907.0
October	..	1,188.0	383.4	—	1,571.4
November	..	1,126.0	250.0	—	1,376.0
December	..	459.0	62.0	465.0	986.0
January	..	333.3	—	516.7	850.0
February	..	1,090.0	—	224.0	1,314.0
March	..	1,032.8	207.0	—	1,239.8
Total	..	7,144.6	2,069.6	2,520.7	11,734.9
Percentage	..	60.9	17.6	21.5	100

TABLE 4. *Monthly total catch (in Kg) of* D. acuta *in different gears at Mandapam area During* 1970-71

Months		Shore seine	Gill net	Trawl net	Total
April	..	1,508.0	90.0	—	1,598.0
May	..	472.6	124.0	—	596.6
June	..	209.5	114.0	330.0	653.5
July	..	378.0	186.0	—	564.0
August	..	506.3	130.3	—	636.6
September	..	1,105.0	450.0	—	1,555.0
October	..	564.5	299.7	—	864.2
November	..	1,157.0	270.0	900.0	2,327.0
December	..	1,646.0	465.0	707.8	2,818.8
January	..	351.0	62.0	992.0	1,405.0
February	..	674.0	336.0	420.0	1,430.0
March	..	341.0	248.0	—	589.0
Total	..	8,912.9	2,775.0	3,349.8	15,037.7
Percentage	..	59.3	18.4	22.3	100

dominated in all the months. The 2-year fish was represent only in April and December in very low quantities. During the second year also the 1-year fish dominated in shore seine forming 75.5% followed by 0-year (24.4%) and 2-year (0.1%) fishes.

Gill net : *D. acuta* was landed in gill net almost throughout the period from April 1969 to March 1971, excluding January and February 1970. In 1969-70 only 0-year and 1-year classes were represented in the fishery. The 1-year class dominated throughout the period. In the annual catch 78.2% belonged to 1-year and 21.8% to 9-year groups.

During 1970-71, fish belonging to 0-year class was absent only in April and it dominated in the catch in July while the 1-year fish dominated in all other months. The 2-year class was absent. Thus during the 2nd year also the 1-year class fish dominated in the gill net catch forming 76.1% while 0-year class formed only 23.9%.

Trawl net : Though trawling was regularly conducted at Mandapam, *D. acuta* was available only for 7 months in April, June-August, December, January and February in 1969-70 and for 5 months in June and November to February during 1970-71. During the first year the 0-year class was available in all the 7 months and it dominated in 6 months, in April the 1-year class dominated. 2-year class fish was not represented. In the annual catch the 0-year class dominated forming 64.3% and the rest formed 1-year class.

In the subsequent year only 0-year and 1-year classes were noticed and the latter dominated in all the months of occurrence. In this year 87.7% was constituted by 1-year class and the rest by 0-year.

In general, in the shore seine catch, except for June and September 1969, in all the months 1-year class fish dominated in the catch. In gill net the 1-year class dominated throughout the period. Contrary to this the trawl net catch showed variation between the years, the 0-year class dominated in the first year and the 1-year class in the second year.

Discussion

Mahadevan and Chacko (1962) observed in *D. hasseltii* a single growth ring in the otolith of a fish measuring 130 mm. In fish less than 110 mm in size no growth rings could be noticed by them. In the present study on *D. acuta* however, no clear growth rings could be identified in the otoliths.

The life span of *D. hasseltii*, according to Mahadevan and Chacko (1962), is one year only. The present investigations show that the commercial catch of *D. acuta* is mainly depended on the 0-year and 1-year class fish and its maximum life span is 2 years.

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