STUDIES ON THE AGE AND GROWTH OF THE MALABAR SOLE, *CYNOGLOSSUS SEMIFASCIATUS*, DAY*

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CONTENTS

I. INTRODUCTION

FOR the development of a scientific management policy for any fishery, it is essential to know among other things, the rate of growth of the species concerned and the changes in the age-composition of its stocks from season to season and from year to year. The present paper deals with the results of investigations which were designed to collect information on these two aspects in relation to the Malabar sole, *Cynoglossus semifasciatus*. Although this forms a valuable fishery along the Malabar Coast no attention has been paid in the past to a detailed investigation of its biology. There are however, brief general references to certain aspects of this species by Chidambaram and Venkataraman (1946) and Devanesan and Chidambaram (1948) in their accounts of the fisheries of the West Coast of Madras State. A detailed study of the fishery and biology of this species has been carried out by the present authors at Calicut and a short note forming part of this work has recently been published (1951) on the possibility of age determination in this species by means of scales.

II. MATERIAL AND METHODS

The specimens of *C. semifasciatus* used in these investigations were obtained from random samples taken in the inshore fishing grounds near West Hill (Calicut)

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by means of a boat seine ("Paithuvala"). The samples were taken, as far as possible, once a week. Some random samples from the commercial catches served for comparison with those under investigation and proved especially useful in the studies on scales for age-determination. The data treated in this paper refer to the period April 1949 to March 1952.

Total length taken from the tip of the snout to the end of the longest caudal ray (of fresh fish) was measured to the nearest millimetre. The relation established between the total length and the "standard" or body length is being published in a separate paper. In the present investigation only the total length is recorded.

III. LENGTH-FREQUENCY STUDIES

Table I shows the percentage distribution of the different sizes (excluding those below 5 cm.) in monthly totals of random samples of *Cynoglossus semifasciatus* taken in the boat-seine during the period April 1949 to March 1952. Where the totals were too small to be representative of the population, the figures have been left out in the reckoning and the relevant months have been considered as having no samples for the purpose of length-frequency studies. Percentages have been tabulated in preference to total numbers in each size group to facilitate comparison of figures for different months as the total differed from month to month. The size distribution curves for all the months with large samples have been drawn together in Fig. 1 representing at once the general trends over the entire period. Size-grouping and calculation of means were made for all the samples individually. As compilation of the results of the analyses of all the samples would be too voluminous for presentation, monthly totalling and re-calculation of the different values on this basis have been resorted to. This results in the increase of the value of larger samples analysed and in the month to month values being more reliably comparable than the sample to sample values. Any possible variations in the monthly totals due to uncontrollable sampling errors are considerably reduced.

For the year 1949, the total numbers are large enough only for three months, namely April, May and October. In April the mode is seen to be in the 8–8·9 cm. group for the main curve, there being however, a very small second peak in the 14–14·9 cm. group. In May this second peak is no longer visible and the unimodal curve has its mode in the 9–9·9 cm. group. On the very reasonable assumption that the population has been the same throughout, the forward movement of the mode by 1 cm. is a clear indication of the growth that has occurred during the period. The numbers of individuals smaller than the April modal size decreased in May while those larger than that size increased markedly. In both these months the smallest size groups

TABLE I

Percentage Distribution of the Different Sizes (Excluding Those Below 5 cm.) in the Totals of Random Samples Taken During Different Months from April 1949 to March 1952

Size groups	1949				1950								
	April	May	August	October	January	February	March	April	May	September	October	November	December
5—5·9 cm.	0·3	1·9	7·9	..	3·7	6·2	12·2	6·2	4·7	..	0·1	..	7·4
6—6·9	3·3	2·8	15·7	..	9·6	9·7	11·9	6·9	5·5	..	0·1	..	5·2
7—7·9	24·2	7·5	13·2	0·1	12·2	14·4	9·9	11·4	6·5	0·3	0·2	..	2·5
8—8·9	38·8	37·7	13·1	0·5	19·2	16·4	11·2	19·3	15·3	2·3	2·7	0·1	..
9—9·9	22·9	39·6	23·7	8·3	25·3	16·5	14·5	23·0	26·3	11·1	13·8	0·4	0·5
10–10·9	9·7	8·4	21·0	42·1	22·0	19·3	19·4	15·7	24·2	31·7	37·7	10·6	2·1
11–11·9	1·6	1·9	2·6	35·1	5·1	10·9	13·8	9·7	10·8	30·4	29·8	42·3	17·6
12–12·9	0·3	..	..	10·8	1·3	2·5	4·2	4·9	4·2	16·2	10·3	35·0	36·7
13–13·9	..	..	2·6	1·9	0·3	2·6	2·2	1·7	1·4	6·1	3·6	10·3	22·0
14–14·9	0·3	..	..	1·1	0·7	0·7	0·9	0·8	0·8	1·8	0·9	1·0	6·0
15–15·9	..	..	..	0·1	0·3	0·6	0·1	..	0·4	0·3	0·4	0·1	..
16–16·9	..	..	..	0·1	0·1	0·2	0·2	..	0·1	..	..	..	..
17–17·9	..	..	..	..	..	..	..	..	..	..	..	..	..
Total No. in random samples	309	106	38	1063	1348	1072	1102	1082	1081	1899	964	746	283

TABLE I—*Continued*

Size groups	1951										1952		
	January	February	March	April	May	June	August	October	November	December	January	February	March
5—5·9 cm.	12·9	14·1	19·9	18·1	10·9	3·0	..	..	31·0	8·5	7·3	4·1	3·3
6—6·9	17·1	16·1	20·8	27·8	21·1	3·0	..	..	34·5	1·4	16·3	6·2	3·7
7—7·9	23·8	16·7	22·0	23·5	26·6	..	..	..	17·2	24·3	23·1	13·6	8·8
8—8·9	18·7	15·5	16·3	15·6	19·8	3·0	0·3	..	..	30·0	21·9	20·9	19·5
9—9·9	8·6	13·5	10·7	8·1	10·4	23·5	1·0	..	..	25·7	17·9	22·0	22·7
10–10·9	2·0	11·3	5·6	3·2	4·5	20·6	2·1	0·7	..	2·9	10·4	18·5	22·7
11–11·9	0·3	5·6	2·1	1·0	3·0	20·6	16·7	8·9	..	2·8	2·9	10·9	13·3
12–12·9	3·2	1·3	1·3	1·0	1·4	17·7	32·1	45·5	..	1·4	0·2	3·2	4·6
13–13·9	7·4	1·6	0·9	0·5	1·5	3·0	32·1	27·6	6·9	..	..	0·2	1·4
14–14·9	4·4	2·3	0·4	0·7	1·4	6·0	13·0	11·2	10·3	2·9	..	0·2	0·7
15–15·9	1·3	1·2	0·2	0·5	0·4	..	2·4	6·0	..	..	..	..	..
16–16·9	0·3	0·5	0·1	..	..	..	0·3	..	..	..	..	..	0·1
17–17·9	..	..	0·1	0·1	..	..	..	..	..	..	..	..	..
Total No. in random samples	1298	1178	1942	1260	783	34	293	134	29	70	1212	536	803

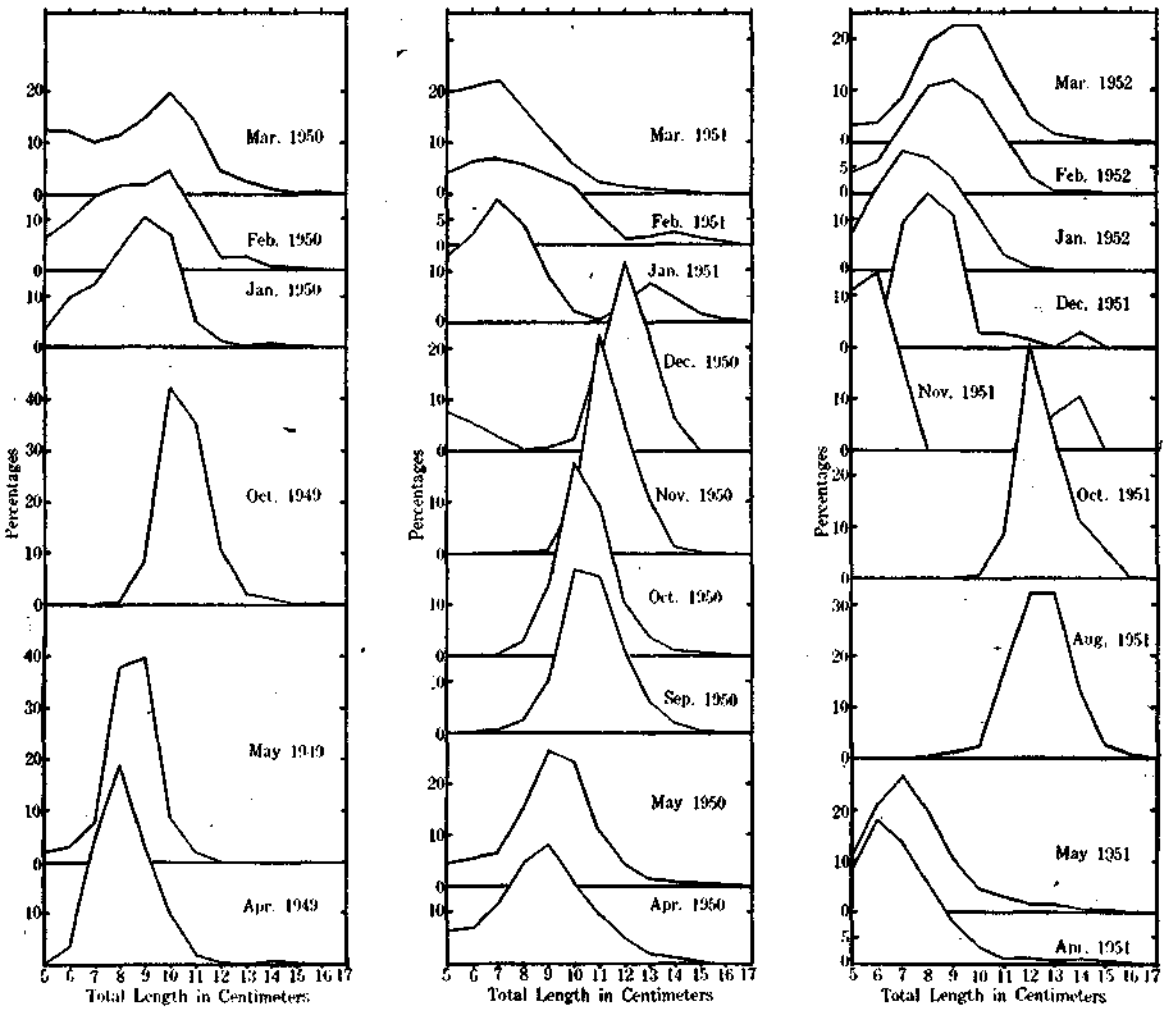

FIG. 1. Percentage size-group distribution curves for *Cynoglossus semifasciatus* at West Hill for the period April, 1949 to March, 1952.

(the 5–5·9 and 6–6·9 cm.) are well represented. In October, on the other hand, these two size groups are unrepresented altogether and the mode has also moved upward to the 10–10·9 cm. group. As October was the main fishery month in the area this size may be said to be the commonest in the commercial catches also during the period. Between April and October the mode has thus moved up only by two centimetres. The curve is still unimodal but at the right end the range has increased. The largest size-group represented during the month is the 16–16·9 cm. group.

In the year 1950, large and representative samples were available throughout the pre-monsoon months, January to May. The first change that is noticed in the January size distribution curve from that of October is the re-appearance of individuals in the lowest size-groups. This is the result of recruitment of a new generation into the population. There is a gradual increase in the proportion of the lowest two groups from January to March and a gradual decrease thereafter. The January curve is a bimodal one, though the second mode is again very low and the proportion of individuals about this mode is also very small. The second mode is in the 14–14·9 cm. group as in April 1949. The first mode on the other hand is very well marked and occupies the 9–9·9 cm. group. In February, the second mode seen in January is not at all seen and the first mode has moved up to the next centimetre-group. The proportion of individuals below 8 cm. has also increased. The highest size remains in the 16–16·9 cm. group. The mode in March is in the same position as in February but some growth is still obvious in that the numbers in the lower size-groups have decreased and those in the higher groups increased. The smallness of the difference between the two months is due to the fact that the total catches of February were dominated by catches of the latter half of the month while those of March were dominated by catches of the earlier half of the month. It is not always possible to prevent such occurrences of asymmetry in the samples because, while sampling is done regularly every week, the actual magnitude of the samples available is limited by uncontrollable natural factors.

In April, the largest size obtained was in the 14–14·9 cm. group. A notable feature in the frequency curve for this month is that the mode has moved downward instead of upward. It is seen to be in the 9–9·9 cm. group, the slope being more or less gradual on either side of the mode. The mode is in the same position in May also although the numbers in the size-groups below and above the modal group have decreased and increased respectively, thus indicating the occurrence of growth between April and May as between February and March; size-groups up to 16–16·9 cm. are also represented. As the numbers in the largest size-groups are very small, little significance can be attached to the differences in size-groups of successive months which cannot be considered to indicate the maximum growth reached in the month. The downward movement of the mode between March and April requires an explanation. In addition to this movement it is also seen that the percentages of individuals are less in all the size-groups above the modal group when compared to the March figures and that the reverse is the case with the percentages in the groups below the modal group. This position may be due firstly, to an increase in the lower sizes as a result of continued recruitment, and secondly to a decrease in the higher sizes due to their being either fished out or their moving away from the area.

During the monsoon months of June to August 1950, there were no good samples for size analysis. In september the curve shows the result of a distinct growth as compared with May. Recruitment having ceased in June, the 5–5·9 and 6–6·9 cm. groups are not at all represented and there are few individuals even in the 8–8·9 cm. group. The mode is in the 10–10·9 cm. groups, the number being only slightly lower in the next higher group. In general, the size-distribution in October is similar to that of September except that a smaller number of individuals has appeared in the 5–5·9 and 6–6·9 cm. groups. These are only stray recruits as can be seen from the November curve where again these groups are unrepresented altogether. The similarities between the September and October distributions are correlated with the fact that the bulk of the sample was obtained late in September and early in October, without being symmetrically spread over the whole month in each case. In November, the mode has clearly moved up to the 11–11·9 cm. group and also there are more individuals above this group than below it. It will be seen that during September to November the frequency curve is unimodal. The September–October mode is also more or less in the same position as in October 1949. Thus in both the years, the commonest size-groups in the months of the commercial fishery belonged to the 10–10·9 cm. category.

December 1950 marks the commencement of recruitment of a new generation to the fishery again. As in 1949, the percentages in the smallest size group (5–5·9 cm.) gradually increase up to March and thereafter decrease gradually. In December the frequency curve is bimodal consequent on the coming in of new recruits in the samples. These have their highest numbers in the 5–5·9 cm. group itself, above which they gradually decrease. The 8–8·9 cm. group has no individuals at all, the older generation having all grown out of the group and the newer one not having yet grown into it. The mode of the older generation lies in the 12–12·9 cm. group, thus showing an increase of 1 cm. over the single mode of November. In January 1951 the new individuals have grown not only into the 8–8·9 cm. group but also beyond it, the numbers of the older generation having gone much farther from it. The two generations are thus still distinct by their two modes, one in the 7–7·9 cm. group and the other in the 13–13·9 cm. group. The two generations meet in the 11–11·9 cm. group which therefore represents the largest size of individuals available among the younger class and the smallest size left of the older class. The curve rises gradually on either side of this group. In February, the second mode has moved up to the 14–14·9 cm. group and while the first mode remains where it was during the previous months, the percentages above the modal group have increased considerably.

The group where the curves of the two generations meet has shifted 1 cm. upward and the percentage of individuals in this group has also increased.

From March onwards the second mode is not seen in the size distribution curves. This is presumably due to a progressive diminution in the frequency of the largest sizes and to the increased merging of the two classes as a result of a more rapid growth of the younger individuals when compared to the older ones. The right side of the curve is drawn out without any distinct peaks and represents a mixture of the two generations, though the extreme right must represent only the older generation; the left side represents purely the new generation.

During the subsequent months therefore, the older generation (or the 1950 class) is insignificant and the mode refers only to the 1951 class. From March to April the mode drops down by 1 cm. to the 6–6·9 cm. group; there is also an increase in the percentage of the lower size-groups and a decrease in the percentage of the higher size-groups more or less as seen between March and April of 1950. Between April and May in 1951, the mode has moved up; the percentages below the mode have decreased and those above the mode have increased thus revealing the growth trend. A point of difference that stands out between the size-distributions of the pre-monsoon months of 1950 and 1951 is that the modes in the latter are markedly in lower size-groups than in the former. This seems to be related to a belated commencement of the spawning season in 1950–51 when compared to that of 1949–50.

The June samples were unreliable for size-distribution studies and there were no collections in July. In August 1951 the range of distribution is found to be from 8–8·9 cm. to 16–16·9 cm. groups. The curve is unimodal and the maximum frequency is shared between the 12–12·9 cm. and 13–13·9 cm. groups. The slope is more or less gradual on either side. The growth rate revealed is high. The October sample which had a total strength of 134 specimens only, showed the mode more or less in the same position and the minimum size to have moved up to the 10–10·9 cm. group. Though the samples were rather small during these two months they have been considered sufficient to give a reliable picture of the size-distribution of the species and there appears no reason to question their reliability except their relatively small size. It will be noticed that the modes and minimum sizes of these months are much higher than those of the early post-monsoon months of the previous years; considering that these modes in the preceding monsoon months were also much lower than in the previous years, the growth rate has been unusually high during the year 1951. A point that is very relevant in this connection is that the fishery during the 1951 season was very poor and during the subsequent months the older generation was very meagrely, if at all, represented in the collections. It seems very likely that a thinning out of the population as indicated by the poor fishery, led to a higher growth rate than usual. This is made further probable by the fact that the observed strength of the new year class also happened to be comparatively poor during the year under consideration. The occurrence of an increase in growth rate as a consequence of thinning out of populations has been proved in a number of species notably in the case of the Plaice (Petersen, 1922; Johansen, 1928; Russell, 1942).

During the season of 1951, spawning started earlier than in the previous years and recruitment of new individuals to the fishery was noticed as early as November. While both the new and the old generations were represented in the collections of November and December, the totals during these months were small (29 and 70 respectively) and could not be used reliably for determining the frequencies of the different sizes. From January onwards large samples were available. In January, the mode was in the 7–7·9 cm. group and the largest individual was in the 12–12·9 cm. group. The recruitment was rather poor during the year and the percentage of the smallest size-groups, instead of increasing up to March as in previous years, decreased even from January onwards. Consequently the mode has shifted progressively to 9–9·9 cm. in February and 10–10·9 cm. in March. By March, the largest individuals of the new generation have reached the 14–14·9 cm. group.

The account given above is based on samples treated without reference to sex. In Table II is given the percentage distribution of males and females treated separately for all the months of the period when the two sexes were sufficiently represented in the samples. Only sizes above 8 cm. have been reckoned in these calculations in order to eliminate all doubtful cases, although usually the sexes are recognizable after dissection even at 6–7 cm. size. Fig. 2 shows the size-distribution curves of the two sexes drawn separately but superimposed for easy comparison.

A glance at the figure and the table reveals the following important points: (1) the size-groups above 16 cm. are represented only by females and never by males during the whole period; (2) during the different months also, in most of the cases females alone constitute the highest sizes represented; (3) the modes of the two sexes are generally different and the mode of the females shows a tendency to run in advance of that of the males in several of the months; (4) the percentages of the two sexes in the different

TABLE II

Percentage Distribution of the Different Sizes (Excluding Those Below 8 cm.) in the Totals of Males and Females Examined in Random Samples During Different Months from October 1949 to December 1951

Size groups	1949		1950																	
	October		January		February		March		April		May		September		October		November		December	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
8—8·9 cm.	0·3	0·3	9·6	11·3	12·2	19·2	20·3	12·5	24·4	15·1	24·4	13·3	2·4	2·2	3·3	2·2	..	0·4	..	..
9—9·9	5·1	7·5	30·9	16·1	24·5	23·4	23·0	18·9	27·7	25·7	35·1	28·7	12·5	9·7	15·4	12·5	6·3	8·6	..	1·1
10–10·9	33·8	46·6	40·4	29·0	22·4	27·7	32·0	24·6	27·7	24·7	27·6	30·2	35·0	28·5	42·6	34·2	33·2	35·2	1·1	1·1
11–11·9	44·2	30·7	9·6	29·0	30·6	14·9	16·6	25·0	12·1	16·7	9·5	15·8	29·9	30·8	27·1	32·3	38·4	32·0	15·3	11·8
12–12·9	13·7	11·3	4·3	9·0	4·1	8·5	5·3	11·1	6·2	11·0	2·7	7·2	12·8	19·2	6·6	13·5	16·8	18·1	45·7	41·9
13–13·9	0·8	3·0	2·1	0·8	6·1	2·1	2·1	5·7	1·3	4·2	0·7	2·3	5·3	6·6	4·2	3·4	4·7	4·7	30·4	34·4
14–14·9	1·6	0·5	2·1	1·6	..	..	0·5	1·4	0·2	2·0	..	1·7	2·0	2·4	0·7	1·1	0·5	0·9	6·5	9·7
15–15·9	..	0·3	..	0·8	..	2·1	..	0·4	0·5	0·6	..	0·8	0·1	0·5	..	0·7	..	0·2	..	..
16–16·9	..	..	..	0·8	..	..	..	0·4	..	..	..	..	..	..	..	..	..	..	..	..
17–17·9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total number in samples	394	371	94	124	49	47	187	280	390	502	402	474	906	995	425	535	190	557	92	93

TABLE II—*Continued*

Size groups	1951																	
	January		February		March		April		May		August		September		October		December	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
8—8·9 cm.	40·5	26·2	42·8	26·9	47·1	42·5	61·4	47·3	41·2	42·2	0·6	..	..	..	..	..	60·6	52·4
9—9·9	12·7	15·9	30·3	29·1	31·7	33·3	25·7	22·0	30·9	19·3	0·6	1·4	..	..	..	..	40·0	38·1
10–10·9	4·4	4·6	16·9	25·6	8·7	10·0	7·1	11·0	19·1	7·2	1·9	2·2	..	..	1·0	..	..	9·5
11–11·9	0·6	0·5	4·0	11·2	2·9	8·3	1·4	7·7	1·5	12·0	21·3	11·6	22·2	20·0	10·5	4·0	..	..
12–12·9	8·9	10·8	0·5	1·8	2·9	2·5	2·9	1·1	4·4	8·2	38·1	25·4	33·3	20·0	46·7	44·0	..	..
13–13·9	23·4	22·6	1·5	1·3	3·8	..	..	2·2	3·0	3·6	24·5	40·6	33·3	20·0	29·5	20·0	..	..
14–14·9	9·5	13·3	3·0	1·3	1·0	0·8	1·4	3·3	..	3·6	10·3	15·9	11·1	33·3	9·5	16·0	..	..
15–15·9	..	6·2	1·0	2·2	1·9	0·8	..	5·5	..	3·6	2·6	2·2	..	6·7	2·9	16·0	..	..
16–16·9	..	1·0	..	0·4	..	0·8	..	..	..	..	..	0·7	..	..	..	..	..	..
17–17·9	..	..	..	..	..	0·8	..	..	..	..	..	..	..	..	..	..	..	..
Total number in samples	153	197	201	223	104	120	70	91	68	83	155	138	9	15	105	25	15	21

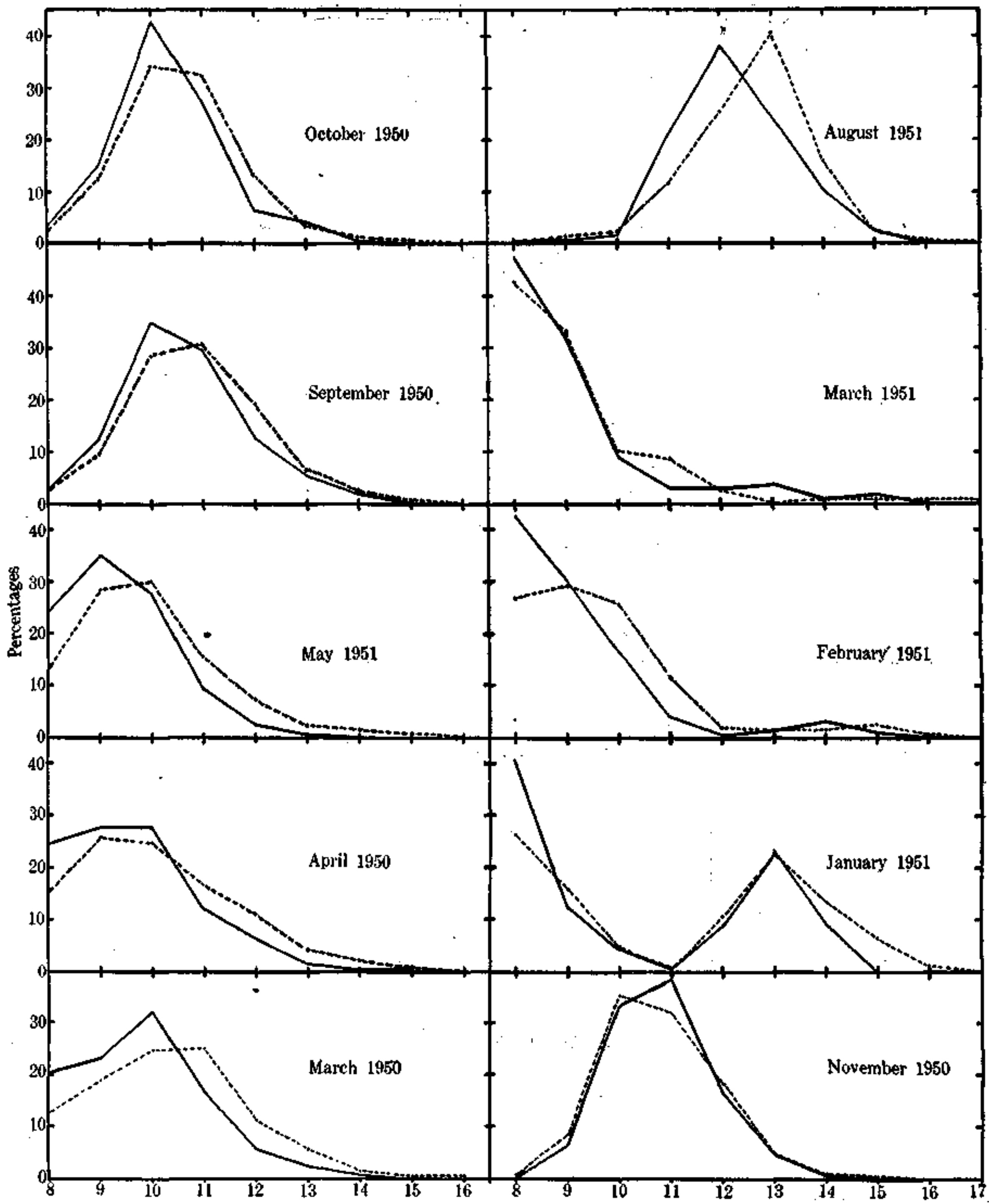

FIG. 2. Percentage size-group distribution curves for male and female *Cynoglossus semi-fasciatus* for the months when both sexes were well represented in the samples.

size-groups show different trends of distribution, the numbers of females in sizes below the male modal group being in general lower and in those in sizes above the male modal group being in general higher than the corresponding size-groups of males.

IV. Studies on Scale-Rings

The existence of certain growth rings (the *monsoon rings*) in the scales of *Cynoglossus semifasciatus* and their usefulness in age-determination and thus in the analyses of the year-class composition of the sole fishery was reported in a previous publication (Seshappa and Bhimachar, 1951). Further examination of the data and samples collected subsequent to the above publication have also justified the reckoning of these rings as annual and indicative of the age of the individual from which the scale is taken. Using these scale-rings as the basis, the year-class composition of the inshore populations of *Cynoglossus semifasciatus* has been analysed from random samples. Table III shows the distribution of growth rings in random samples during the period September 1950 to December 1950.

Table III

Particulars	September	October	November	December
Total number of soles examined	405	81	248	102
Number with no rings	45	16	2	0
Number with one ring and 'closed' margin	178+ 23 not clear	9+ 2 not clear	0+ 2 not clear	0
Number with one ring and 'open' margin	124+ 15 not clear	46+ 1 not clear	234	95
Number with two rings and 'closed' margin	12+ 4 not clear	1	0	0
Number with two rings and 'open' margin	1+ 3 not clear	6	8+ 2 not clear	7

In the analyses from January 1951 onwards, individuals which obviously belonged to the new brood as judged by their sizes and period of occurrence have only been partly examined. A hundred per cent examination of the small sizes is no longer necessary; it is enough on the other hand, in certain months when the products of a particular season's spawning are widely distinct from the older ones, to examine the latter only, in full. But if there are size-groups where the new generation is mixed up with the older ones a complete examination of all individuals in such groups is necessary. In the case of the smallest size-groups during January to May for instance, the fact that they are represented by individuals of the "0" year-class is too obvious to need any scale-examination. The following table (Table IV) shows the total numbers of fish caught in random samples and examined for age during the different months from January 1951 to March 1952 and the proportion of the different year-classes in the same.

TABLE IV

Months	Total no. above 5 cm. in samples	"0" year-class	"1" year-class (*i.e.*, with one monsoon ring on scales)	"2" year-class (*i.e.*, with two monsoon rings on scales)
January 1951 ..	1,291	1,066	225	0
February „ ..	1,178	1,110	64	4
March „ ..	5,484	5,457	24	3
April „ ..	1,431	1,410	20	1
May „ ..	593	573	20	0
June „ ..	34	31	3	0
July „ ..	..	..	..	..
August „ ..	200	0	181	19
September „ ..	..	0	..	..
October „ ..	50	0	44	6
November „ ..	36	0	31	5
December „ ..	74	0	72	2
January 1952 ..	1,258	1,257	1	0
February „ ..	547	546	1	0
March „ ..	1,066	1,054	11	1

The following points become obvious from a study of Tables III and IV:—(1) When the fishery starts in the region immediately after the south-west monsoon, the population consists mostly of the one-ring class of soles, that is, the products of the previous season's spawning; (2) while even in this period the proportion of the two-monsoon ring class is very low in the samples it becomes much lower and insignificant in later months; (3) the no-ring class of individuals dominate the fishery during the pre-monsoon months from January onwards; (4) no specimens with more than two growth-rings on their scales have so far been seen along this coast.

In the case of individuals that show the rings on their scales, it is possible to estimate the growth from the period of formation of the ring to the time of capture. The following table shows the growth recorded by a sample of 220 individuals up to December 1950, after the formation of the first-scale ring. The growth increments have been calculated by using Lee's formula (Lee, 1920) which assumes a straight line relationship between the scale length and the fish length. This formula is considered sufficient for all practical purposes for a small fish like the present species.

TABLE V

Estimated size-group when ring is formed	Number of individuals	Mean increments observed
6– 6·9 cm. ..	3	4·4
7– 7·9 cm.	10	3·9
8– 8·9 cm.	36	3·3
9– 9–9 cm.	70	3·0
10–10·9 cm.	64	2·2
11–11·9 cm. ..	30	1·8
12–12·9 cm.	6	1·4
13–13·9 cm.	1	1·4
All sizes	224	2·7

The growth increments estimated and the observed lengths at the time of examination are depicted graphically in Fig. 3. The decrease in growth rate with increasing size is very obvious.

V. Discussion and Conclusions

The length-frequency analyses give certain important indications on the growth rate of *Cynoglossus semifasciatus* and the year-class composition of its fishery. The spawning season for this species usually starts about October each year. The resultant young ones start entering the fishery from December or January onwards. It is these new recruits that are responsible for the well marked first mode (or the only mode, as the case may be) noticeable in the frequency curves of the pre-monsoon months. The upward movement of the mode from one size-group to another due to the growth of individuals, is to some extent liable to be masked as a result of continued recruitment to the smaller groups. After May, spawning completely stops and recruitment is eventually at a halt. When the fishery starts immediately after the monsoon, the growth of the individuals is therefore, clearly visible in the samples, with the smaller groups unrepresented and the mode correspondingly moved upwards. This progressive upward shifting of the mode can be noticed again until a new generation of young

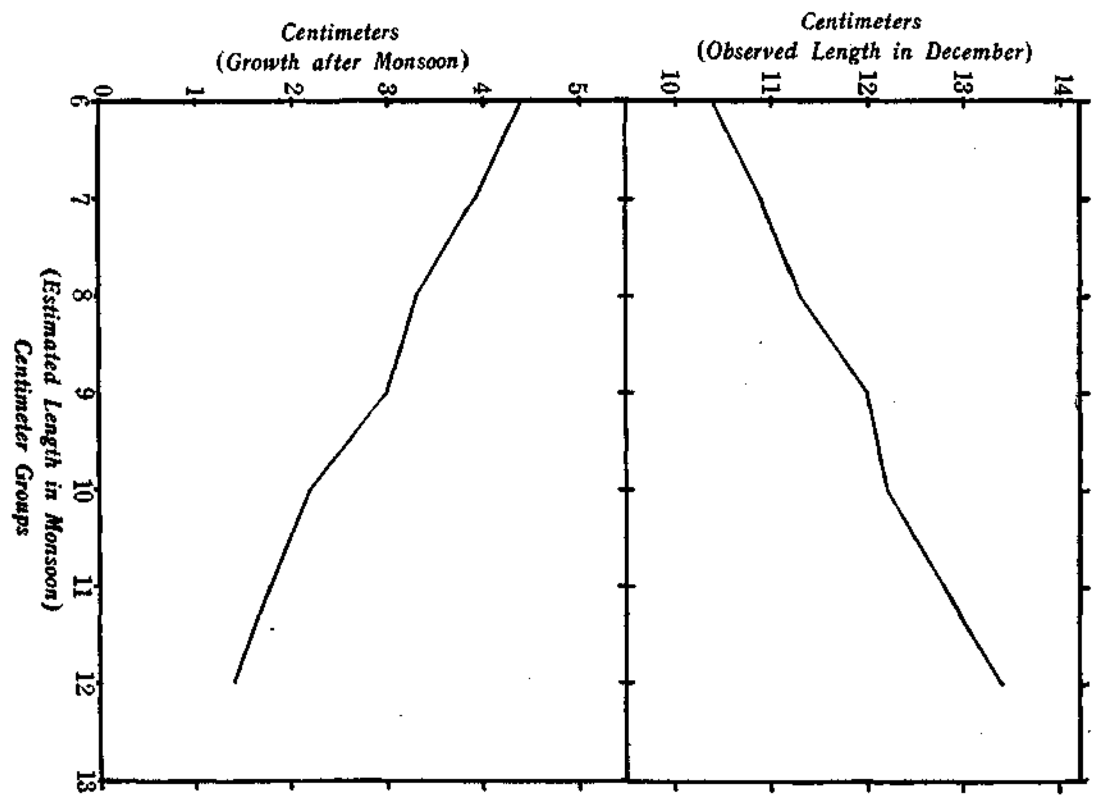

FIG. 3. Curves showing the rate of growth of different size-groups of *Cynoglossus semifasciatus* from the time of ring formation (mansoon, 1950) upto December 1950.

ones starts coming into the fishery as the result of the new season's spawning activity. The single mode of the pre-monsoon months indicates the negligibility of the older generation in the commercial catches of the succeeding fishery season also. It thus appears that the September to October commercial catches of soles which form the bulk of the annual catches consist of only or nearly only "one-year-old" class of individuals. The modal size for these catches was 10–10·9 cm. in 1949 and 1950 but higher (12–12·9 cm.) in 1951. Considering that spawning continues almost up to the commencement of the monsoon and that the fishery starts immediately after it (in August or September), the smallest individuals in the fishery are only a few months old. The largest individuals may be assumed to include the earliest recruits of the previous season. The products of spawning of a given post-monsoon fishery season must therefore, reach the marketable size and enter the commercial catches in the very next post-monsoon season.

The data on scale-rings confirm the conclusions drawn from the size-frequency studies. The absence of a second mode in the frequency curves of the pre-monsoon months is now clearly explained by the numerically small older generations.

These studies have proved that during the main fishery season the bulk of the fishery consists of only a single year-class without any complicated mixing up of a number of broods. The difference in size between the largest member of the "0" ring class and the other classes is also very small during April–May owing to the rapid growth of the new brood and its slowing down in the old ones.

The size-frequency data (see Table II and Fig. 2) also indicate that the females tend to grow faster than the males which not only grow slow but have a lower upper limit for their growth than the females. The differences however, do not appear to be very high because the modes lie close together even when different and the largest female recorded during the whole period was only 1·3 cm. above the largest male recorded. In some months both sexes are represented in the highest size-groups though the females occur in slightly larger numbers.

Among the individuals with two rings on their scales, it was found that the males were extremely rare. It is possible that the females have a greater longevity than the males. Differential growth between the two sexes is also not a rare phenomenon among fishes (Arora, 1951; Morrow, 1951; Orcutt, 1950; and also Pincher, 1947).

The knowledge obtained by these studies, that the bulk of the commercial catches of soles consist of the "one-monsoon ring" class of individuals is likely to prove of considerable practical importance and further studies on this fishery are indicated along the different regions of the coast.

VI. Summary

1. This paper deals with the age and rate of growth of *Cynoglossus semifasciatus*, on the basis of data collected from samples from the inshore fishing grounds at West Hill, Calicut, during the period April 1949 to March 1952.

2. The "monsoon" rings found on the scales of this species (which indicate the seasons when growth ceased temporarily) have been used in the analysis of the year-class composition of the fishery; data on these rings used along with the percentage frequency distribution of the different sizes in random samples during different months of the period have been useful in assessing the rate of growth of the species.

3. The bulk of the commercial catches of soles during the years 1949–50, 1950–51 and 1951–52 consisted of individuals that had a single monsoon

ring, the older individuals being negligible in proportion. The products of spawning of a particular fishery season grow up to the commercial size and directly enter the fishery in the very next season.

4. During the September–October fishery season in 1949 and 1950, the size-group with the highest frequency was 10–10·9 cm; but in the fishery season of 1951 this was 12–12·9 cm. thus showing a higher growth. This was correlated with a decrease in the total catches of the area.

5. The length frequency studies indicated a higher growth for the females than males. A decreasing growth rate has been noticed with increasing sizes.

6. The females were more numerous than the males in the highest sizes and all individuals found above 16·2 cm, were females. No individuals were found in this region during the entire period of investigation, with more than two rings on their scales.

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