AGE AND GROWTH OF THE YELLOW DOG SHARK
SCOLIODON LATICAUDUS MULLER AND HENLE FROM BOMBAY WATERS

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Abstract

The age and growth of the shark *Scoliodon laticaudus* Muller and Henle [(= *S. sorrakowah* (Cuvier)] from Bombay waters have been studied by the length frequency method. The shark, which measures about 140 mm at birth, attains 260, 380, 470, 530 and 590 mm at the end of 1, 2, 3, 4, and 5 years respectively after birth. There is no difference in the growth rates of males and females. The females grow to a larger size and to an older age than the males. The growth is more or less slow as in the case of other sharks. The von Bertalanffy growth equation has been fitted to the observed values, for which the parameters calculated were K (on an annual basis) = 0.2731, L α = 755.23 mm and t_0 = -.5664 years. The length-at-age thus calculated agreed fairly closely with the observed values. The maximum length of this shark in Bombay waters is about 660 mm. Over 75 per cent of the landings were in the age group of 2-4 years ranging from 380 to 530 mm in total length.

INTRODUCTION

Scoliodon laticaudus Muller and Henle, described by many workers as *Scoliodon sorrakowah* (Cuvier) until the revision by Springer (1964), is a small viviparous shark attaining less than a meter in length. It is distributed throughout the Indian Seas particularly in the nearshore waters. Many studies have been made on the taxonomy, anatomy, development and bionomics of this shark by previous authors (Southwell and Prashad, 1919 ; Thillayampalam, 1928 ; Aiyar and Mahadevan, 1938 ; Mahadevan, 1940 ; Choodamani, 1941 ; Aiyar, 1928 ; Setna and Sarangdhar, 1948 ; Prasad, 1951 ; Nair *et al.*, 1974). However, no attempts have been made so far to study the age and growth of not only this shark but any elasmobranch fish from our waters. With a view to filling this gap to some extent, a study of the age and growth rate of *Scoliodon laticaudus* from Bombay waters was undertaken during the period 1972-74, and the results are presented in this paper.

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MATERIAL AND METHODS

The data for this study were collected from Sassoon Docks, an important fish landing centre in Bombay, for a period of 33 months from January 1972 to September 1974. The sharks were landed along with other fishes taken in bag nets, hooks and lines, and trawls operated from small mechanised boats in the nearshore areas. The specimens were measured in fresh condition for total length. Care was taken, as far as possible, to include all the size groups in the representative samples.

Babel (1967) used four methods to determine the growth rate of the round sting-ray *Urolophus hulleri* Cooper, *viz.* Petersen method of length frequency, double sampling and comparing the resultant frequency curves, tagging and recapture, and rearing in captivity. Olsen (1954) adopted length frequency method supplemented by tagging and recapture to determine the age and growth of the school shark *Galeorhinus australis* (Mecleay). In the present investigation the Petersen method is used.

RESULTS AND DISCUSSION

Length at birth : The largest embryo measured during the present study was 128 mm and the smallest free-living shark observed was 160 mm, which means that the length at birth might be somewhere in between. Setna and Sarangdhar (1948) state that this shark measures 130-150 mm at birth ; the average length of embryos at parturition stage calculated from the data given by these authors is about 140 mm. Southwell and Prashad (1919) described embryos measuring 135 mm, which were full-grown and exact replicas of the parent shark. It is thus reasonable that from all these observations, 140 mm can be taken as the average length at birth for this shark.

The length at birth for both the sexes seems to be the same. Setna and Sarangdhar (1948) noticed difference of size between the male and female embryos at the advanced stage of foetal life but the difference was only slight. In the present investigation the average length of 36 male and 50 female embryos above 100 mm was almost the same indicating that the intra-uterine growth is similar for the sharks of both the sexes and that the length at birth is the same. Similar conditions have been noticed in *Galeorhinus australis* (Olsen, 1954), some North Atlantic carcharhinid sharks (Springer, 1960) and *Urolophus hulleri* (Babel, 1967).

Length frequency : Figure 1 shows the quarterly length frequency distribution of male and female sharks grouped by 30 mm size intervals. This is based on 1907 sharks ranging from 160 mm to 640 mm.

Males : The smallest mode is I at 170 mm in April-June and July-September 1974 but this cannot be traced further. The next mode H, appearing first during October-December 1973 at 200 mm progresses to 290 mm in July-September next year at the rate of 10 mm per month. At this rate this mode would have stood at 170 mm during July-September 1973 and at 140 mm 3 months earlier. This means that since the length at birth also is about 140 mm, the shark would be 260 mm in April-June 1974 on completing one year after birth. Mode G appearing in July-September 1973 at 230 mm can be traced to 320 mm after 9 months. This mode would have been at 140 mm in October-December 1972 and the mode at 260 mm in
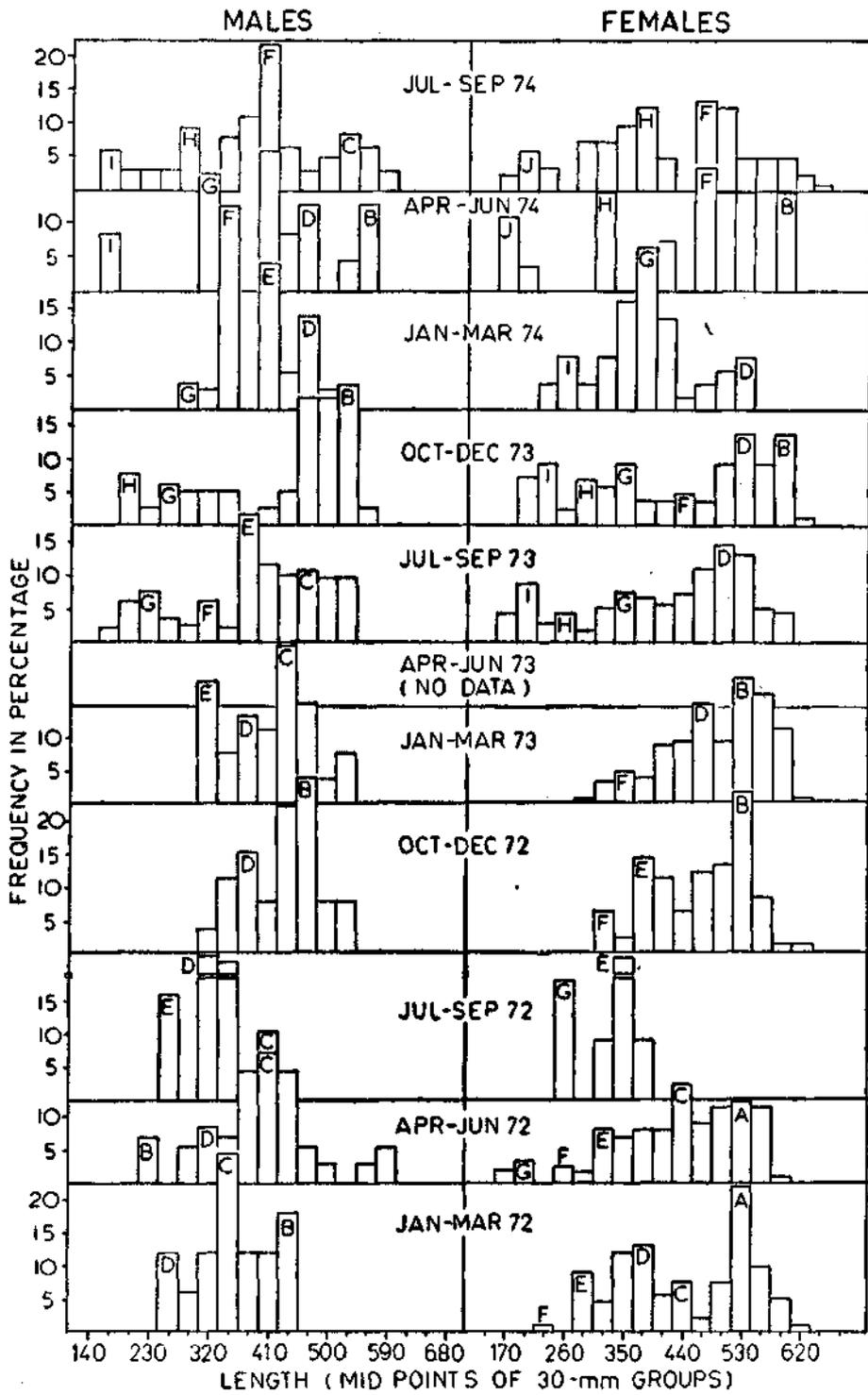
Fig. 1.   Quarterly length frequency distribution of *Scoliodon laticaudus*.

October-December 1973 is expected to be of the sharks that have completed one year after birth. Thus from the progression of the modes G and H, it would appear that the shark is about 260 mm at the end of the first year of free life.

Mode D at 260 mm during January-March 1972 shifts to 380 mm after one year; mode E at 260 mm in July-September 1972 progresses to 380 mm in the same period next year. Both these modes show that the shark adds on 120 mm in the second year, at the end of which it measures 380 mm.

From 380 mm during January-March 1973 the mode D progresses to 470 mm in one year ; mode F at 320 mm in July-September 1973, when the shark is in its second year of life, grows to 410 mm during a period of one year. Combining both these, it appears that 470 mm would be the length of the shark at the end of its third year of life.

Mode C which stands at 470 mm in July-September 1973 reappears at 530 mm after one year. Similarly the mode B at 470 mm in October-December 1972 can be traced to 530 mm in the same period next year. The progression of modes in both these cases indicates that the shark attains the size of about 530 mm at the end of the fourth year.

Hereafter the modal progression, as expected, is not as clear as in the earlier stages. However, it can be assumed that the rate of growth may not be markedly different from that during the previous year. The mode B at 530 mm in October-December 1973 increases to 560 mm in 6 months. Therefore the length of the shark at the end of the fifth year is expected to be about 590 mm.

Females : The smallest mode J is at 170 mm in April-June 1974 and it increases to 200 mm in 3 months at the rate of 10 mm per month. Similarly, mode I at 200 in July-September 1973 moves to 230 mm in 3 months and 260 mm in 6 months. At this rate of growth it would have measured 170 mm 3 months earlier and 140 mm (length at birth) 6 months earlier, that is, in January-March 1973. Thus, it is apparent that the shark grows 120 mm in the first year after birth, at the end of which it measures 260 mm.

Mode H appearing at 260 mm in July-September 1973 can be traced to 380 mm after one year (this mode at 320 mm in April-June 1974 may be due to small sample size). But the mode G which starts at 200 mm in April-June 1972 progresses to 260 mm in 3 months ; this again may be due to small sample size. This mode is expected to be at 380 mm after one year, as evident from mode H, but remains constant at 350 mm for about 6 months. On the contrary, the mode F which stands at 230 mm in January-March 1972 progresses steadily to 350 mm in 12 months at the rate of 10 mm per month. Thus, the mode at 260 mm in April-June 1972 is expected to be at 380 mm in the same period next year for which there are no data. But such a possibility is amply indicated by the mode E which from 290 mm in January-March 1972 grows to 380 mm in 9 months. Thus, the shark adds on another 120 mm during the second year.

If it is probable that mode F is at 380 mm in April-June 1973 as seen above, in the same period next year this mode stands at 470 mm adding 90 mm. Again, the mode D at 380 mm in January-March 1972 reappears at 470 mm after one year and 530 mm after two years. Following the progression of these two modes

it is probable that the shark is about 470 mm and 530 mm at the end of its third and fourth year of life respectively.

Mode C at 440 mm and mode A at 530 mm in January-March 1972 do not seem to progress further, but mode B at 530 mm in October-December 1972 advances to 590 mm in one year. Beyond this length there are no further modes seen in the commercial fishery and therefore aging the shark further is difficult.

Summing up the modal progressions in the case of the males and the females, it may be concluded that the shark attains 260 mm at the end of the first year after birth, 380 mm at the end of the second year, 470 mm at the end of the third year 530 mm at the end of the fourth year and 590 mm at the end of the fifth year, with the annual growth increment of 120, 120, 90, 60 and 60 mm respectively (Table 1).

TABLE 1. *Length-at-age and annual growth increment of* Scoliodon laticaudus

Age (years)	Male		Female	
	Length (mm)	Annual increment (mm)	Length (mm)	Annual increment (mm)
Length at birth	140	—	140	—
1	260	120	260	120
2	380	120	380	120
3	470	90	470	90
4	530	60	530	60
5	590	60	590	60

It is evident from the above conclusion that the growth is similar in both the sexes. Identical rate of growth in males and females has been noticed in other elasmobranchs also (Steven, 1936 ; Templeman, 1944 ; Olsen, 1954 ; Babel, 1967).

The females of *Scoliodon laticaudus* grow to a larger size and thus to an older age than the males ; the maximum size measured during the course of present investigation was 640 mm for a female and 600 mm for a male. There was only one male shark of 600 mm size in the entire sample but there were 31 females at this length and above. Such instances of the females outgrowing the males are not uncommon in elasmobranchs (Ford, 1921 ; Hickling, 1930 ; Ripley, 1946 ; Olsen, 1954 ; Chen and Mizue, 1973).

Growth curve : Since the male and female sharks have identical growth rate and length-at-age, both the sexes have been combined for fitting the growth curve. To the values of length-at-age obtained (Table 1) was fitted the von Bertalanffy growth equation

$$Lt = L\alpha \ (1\text{-}e^{\text{-}K(t\text{-}to)}),$$

where Lt = length at age t ; $L\alpha$ = the asymptotic maximum length of the shark ; K = a constant related to the coefficient of catabolism ; t = age of the shark ; to = the age at which Lt is theoretically zero ; e = base of the Naperian logarithm.

The parameters calculated where $L_\infty = 755.23$, $K = 0.2731$, and $t_o = -0.5664$ years. From these parameters the lengths at different ages were estimated. Figure 2 shows the estimated growth curve. It can be seen that the theoretical lengths calculated using the von Bertalanffy equation are in fairly close agreement with the length-at-age derived from the length frequency method (Table 2.)
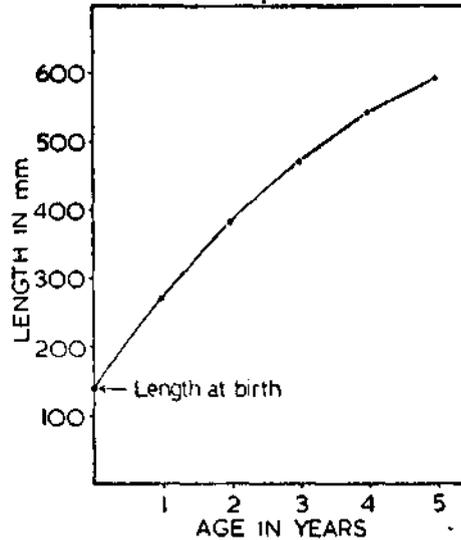

Fig. 2. Calculated growth curve for *Scoliodon laticaudus*.

It is evident from the above results that the growth of *Scoliodon laticaudus* is slow. The literature on the age and growth studies carried out on elasmobranchs in other countries, though limited, point to the fact that the growth of this group of fishes in general is very slow and extremely so in some cases. Holden (1974) says that all species for which there are data available have slow growth rates. Holden and Meadows (1962) and Holden, 1973 found that the females of the Scotish-Norwegian stock of spiny dogfish *Squalus acanthias* grow about 50 mm per year from birth to maturity. According to Olsen (1954) the average annual growth increment of *Galeorhinus australis* ranges from 130 mm for the 1-year old sharks to 30 mm for the 12-year old sharks. From tagging experiments Kato and Carvallo (1967) estimated an average annual growth increment of 31-54 mm for juvenile *Carcharhinus albimarginatus* and 41 mm for juvenile *Carcharhinus galapagensis*; and according to Hansen (1963), as quoted by these authors, *Somniosus microcephalus*, a large shark, grew at an average rate of 7.50 mm per year. Again, Olsen (1954) mentions that a tagged immature female dogfish has grown only 142 mm in the course of about 8 years. Perhaps one example of faster growth rate is given by Springer (1960) who presumed from indirect evidence that the growth is rapid in the sandbar shark *Eulamia milberti* which grew from about 600 mm at birth to 2000 mm in two years at an average growth rate of about 700 mm per year.

Holden (1974) has calculated the growth coefficient (K) for 8 species of elasmobranchs from available growth data; the value tends to be of the order

0.1 - 0.2 for Selachi (sharks) and 0.2 - 0.3 for Batoidei (skates and rays). In the case of *Scoliodon laticaudus* this value has been found to be 0.273, which is slightly higher than that given for sharks by Holden (1974).

TABLE 2. *Observed and calculated length-at-age of* Scoliodon laticaudus

Age (years)	Observed length (mm)	Calculated length (mm)
Length at birth	140	—
1	260	262.90
2	380	380.48
3	470	470.06
4	530	538.18
5	590	590.06

There is great variation in the largest size of this shark recorded by various authors. Day (1878) states that it attains at least 2 feet (about 610 mm) and according to Misra (1959) it is about 457 mm. Setna and Sarangdhar (1948) who made fairly extensive studies on this shark, state that the maximum length of the species in Bombay waters is 26 inches (about 660 mm). The greatest length measured during the present investigation was 600 mm for a male and 640 mm for a female, which more or less agrees with that recorded by Setna and Sarangdhar (1948). The maximum theoretical length (L_∞) calculated statistically as well as obtained from the Ford-Walford growth transformation line (Fig. 3) is the same, 755 mm.
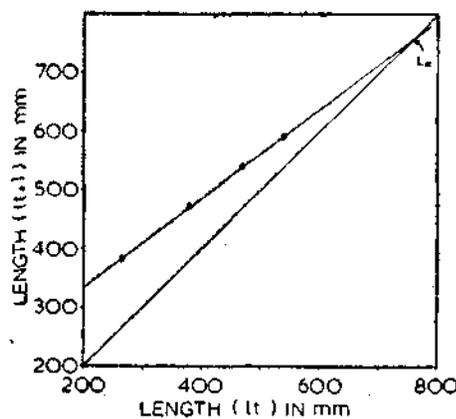

Fig. 3. Ford-Walford plot of length-at-age data for *Scoliodon laticaudus*.

It may be mentioned here that Mahadevan's (1940) samples from Madras included a female shark of 29 inches (about 740 mm). James (1968) says that this shark attains 2½ feet (about 760 mm) ; in Table 2 of the same report the size range of the shark from Gulf of Mannar is given as 300-1200 mm, the dominant length group being 700-900 mm. Not withstanding the contradiction in the second statement, it may be assumed that the sharks from these waters may be of a different

stock, as distinct from that occurring in Bombay waters (Setna and Sarangdhar, 1948). Such possibilities are mentioned by Holden and Meadows (1962) in the case of the spurdog *Squalus acanthias*.

TABLE 3. *Age composition of the shark* Scoliodon laticaudus *in the commercial catches*

Age (years)	Length (mm)	Male No.	Male %	Female No.	Female %	Sexes No.	combined %
1	260	74	10.82	129	10.35	203	10.65
2	380	210	30.70	285	23.81	495	25.96
3	470	258	37.72	267	21.84	525	27.53
4	530	114	16.66	319	26.06	433	22.70
5	590	27	3.95	192	15.70	219	11.48
Above 5	—	1	0.15	31	2.24	32	1.68

Table 3 shows the age composition of catch of the sharks as obtained from the samples collected during the entire period. Since the samples were taken at random, these may more or less reflect the composition of the commercial catches of this shark. It is seen that all the age groups were present with varying degrees of abundance. In the case of males the maximum numbers were the 3-year group and about 85 per cent were 2 to 4-year old. As regards the females, 2 to 4-year old groups were more or less equally represented, together forming about 70 per cent of the female sharks. Both the sexes combined, over 75 per cent were aged between 2 and 4 years, forming the mainstay of the fishery. Sharks older than 5 years were rare.

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