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OBSERVATIONS ON THE MATURITY, BREEDING AND DEVELOPMENT OF *SCOLIODON LATICAUDUS* MULLER AND HENLE OFF CALICUT COAST

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ABSTRACT

In *Scoliodon laticaudus* both right and left ovaries are functional. The eggs are minute, measuring around 1 mm in diameter and have negligible yolk content. The embryos develop early contact with the mother by means of yolk sac placenta for nutrition. Separate compartments are provided for each developing embryo in the uterus. As many as 20 embryos, 10 in each uterus are noticed in a mother. The number of embryos normally varies from 6–18. They are ready for parturition when they reach about 14 cm. Males mature at 30.1–35.0 cm and females at 35.1–40.0 cm size group. Size at first maturity is further determined by calculating the average 'K' value as well as by relating to the percentage of liver weight to body weight. Gestation period is estimated to be 5–6 months.

INTRODUCTION

THE SHARKS of the family Carcharhinidae are economically important because of their fins which are being exported. This group embraces big as well as small sized pelagic sharks found in the tropical and temperate waters of the oceans of the globe. *Scoliodon laticaudus*, the only representative of the genus *Scoliodon* (Springer, 1964) inhabits the shallow waters of the sea. Most of the literature on *Scoliodon* deal with the taxonomy of the group. However few works relating to the description, bionomics and development of *Scoliodon sorrakowah* (Setna and Sarangdhar, 1948), breeding habits of elasmobranchs in the Bombay waters (Setna and Sarangdhar, 1949) and on the structure of uterus and the placenta of certain elasmobranchs (Mahadevan, 1940) are available from Indian waters.

Elasmobranchs exhibit different types of reproduction. The most advanced type of development, viviparous placental type is found in carcharhinid and sphyrnid sharks (Devadoss, 1977). The present observations on *S. laticaudus* are of interest as this belongs to carcharhinid sharks exhibiting an advanced mode of development. Besides size at maturity, gestation period, developmental stages and parturition time are also dealt with.

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MATERIAL AND METHODS

Samples were collected from the Vellayil and Puthiyappa fish landing centres near Calicut on the southwest coast of India. Females, after recording the total length and weight, were cut open and examined for the condition of the ovaries, uterii and embryos. After noting the stages of development, the embryos were preserved in 10% formaldehyde. In the case of males, total length, weight and length of claspers were noted; claspers and cloaca were examined for the presence of milt. Liver was removed and weight taken in fresh condition. Ponderal index or condition factor (K)

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was worked out by the formula $100W/L^3$, when 'W' was the weight of the fish 'W. L' the total length.

Observations and Discussion

Reproductive organs

In males, the sex is externally differentiated by the presence of a pair of hard claspers which are the posterior extensions of the pelvic fins. In *S. laticaudus* the claspers are observed when the embryo is about 30 mm. In mature males a pair of testes are found internally at the anterior end of epigonal organs which are paired structures and lie in between digestive organs and kidney. The posterior portions of the epigonal organs extend near the cloaca. From the anterior end of testes epididymis are produced. These epididymis function as deferent ducts and are connected to the spermiducts in the kidney. The spermiducts which lie in a zigzag line on the ventral side of the kidney dilates at the posterior end to form the sperm sac where milt is collected during the mating period. The sperm sac opens out side in the cloacal aperture.

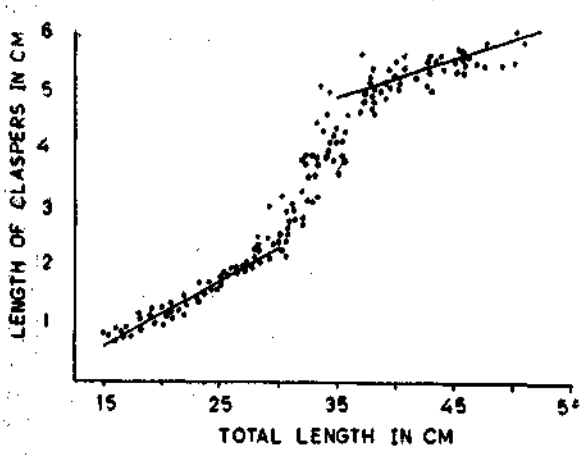

Fig. 1. Growth of claspers in relation to total length of *S. laticaudus*.

Contrary to most elasmobranchs, females of this species develop both right and left ovaries situated at the anterior end of the epigonal organs on either side of oesophagus. The eggs

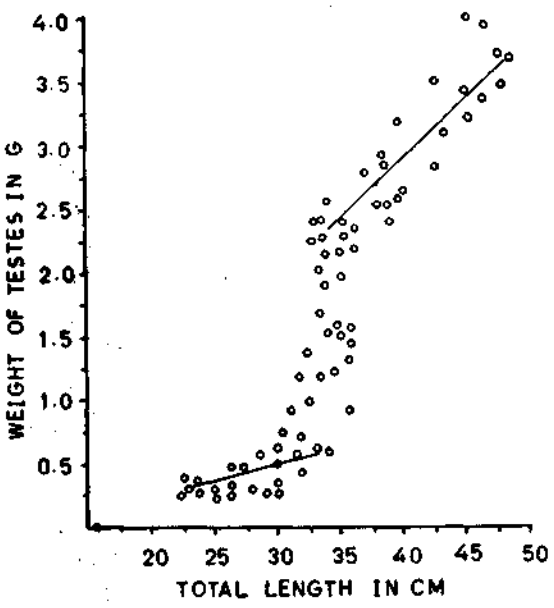

Fig. 2. Relationship between weight of testes and total length.

are minute, about 1 mm in diameter. Oviduct opens below the oesophagus and continues downwards and dilates like a knob to form shell glands or nidamental glands. Below this, oviduct widens to form the uterus. The posterior ends of both the uterii fuse together to open outside in the cloacal aperture. The immature uterus is slender in shape. The wall of the uterus is thick before pregnancy, but as the pregnancy advances the wall becomes thinner, so much so the full-term embryos are seen through the wall. Each uterus is divided into as many compartments as there are embryos in it. This observation confirms the findings of Mahadevan (1940) on *S. sorrakowah* and *S. palasorrah*. However Setna and Sarangdhar (1948) maintained that some uterine compartments did not contain developing embryos, but abortive trophonemata in *S. sorrakowah*.

In *S. laticaudus*, as the gestation progresses the embryo grows in size and the uterine compartment also increases in size. In the early gestation period, the compartments lie somewhat obliquely, but as the gestation advances to parturition, the orientation of the compartments are tilted and are made longitudinal

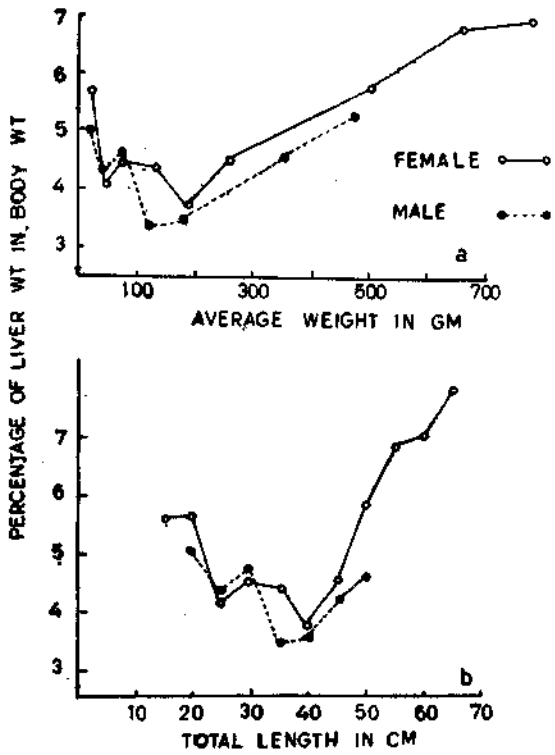

Fig. 3 a. Percentage of liver weight in body weight against body weight and b. Percentage of liver weight in body weight against total length.

as to accommodate the growing foetii. Similar observations were made by Setna and Sarangdhar (1948) on *S. sorrakowah*, Chen and Mizue (1973) on *Galeorhinus japanicus*, Teshima and Koga (1973) and Teshima *et al.* (1974) on *Mustelus griseus*. Formation of uterine compartments has been observed by earlier workers also (Mahadevan, 1940; Setna and Sarangdhar, 1949; Schlernitzauer and Gilbert, 1966; Teshima *et al.*, 1974; Devadoss, 1977).

Sexual maturity

Determination of sexual maturity in the case of males is based on the growth of claspers, growth of testes and collection of seminal fluid in the seminal vesicles (Springer, 1967; Clarke and Katherine, 1965; Devadoss, 1977, 1978). Fig. 1 shows the relationship between the clasper length and total length of males. Claspers in the young stage are soft and short barely reaching the tip of the ventral fins. As the male *S. laticaudus* grows to maturity, the length of claspers also increases and becomes stiff and sturdy. When the maturity is fully attained, the rate of growth of claspers slackens.

In the adolescent males the testes in pairs develop from the anterior portion of the epigonal organs. Fig. 2 shows the relationship between the total length of the males and growth in gross weight of the testes. The gross weight of both the testes increases as the males grow to maturity. The sharp point of uprising in the rate of growth of testes is an indication of the length at which maturity is reached. This is observed when the males measure between 30.1–35.0 cm size which is taken as the minimum length at maturity of males.

There are no external sexual characters in females. So determination of sexual maturity in females is based on the presence of larger eggs in the ovary and the expansion of oviduct as uterus (Springer, 1960) or on the onset of pregnancy or both (Olsen, 1950). In the present study, the maturity of females is determined on the basis of the presence of ripe eggs in the ovary or the presence of zygote and embryo in the uterus. More than 50% of females in the size group 35.1 - 40.0 cm are found sexually mature. Above this group all of them are observed to bear embryos.

Liver as an index for maturity

The weight of liver in relation to body weight is also studied to determine the size at maturity.

The liver exhibits certain significant development before and after first maturity. The maximum average liver weight of 4.4% in relation to body weight was found when the non-pregnant females attained the mean body weight of 134 gm. It was found that liver weight of both sexes increased with the total body weight until the animal started breeding. The females with developing ovary showed the highest liver weight of 5.88% whereas the females of the same body weight bearing pups in advanced pregnancy, showed liver weight of 3.2% to body weight. These observations show that

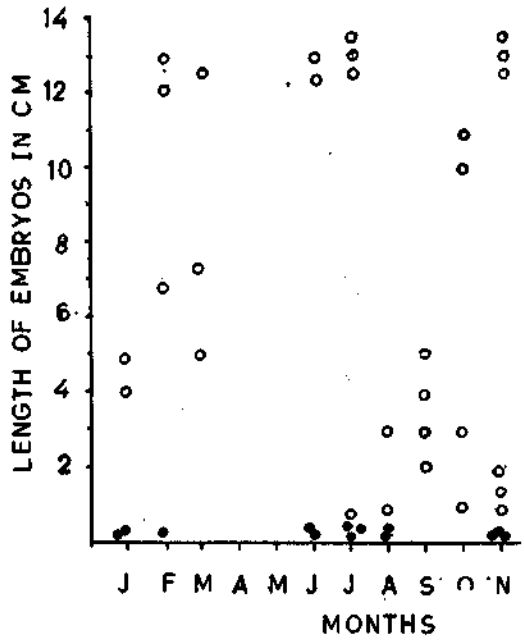

Fig. 4. Growth of developing embryos in the uterii. ○ Presence of development embryos; ● Presence of zygotes

the liver weight gradually declines as the gestation period advances. In other words, the liver functions as a store house of energy which is consumed at the time of gestation for nourishment of embryos. From the Figure 3 it is clear that the percentage of liver weight sharply declined at 30.1–35.0 cm and 35.1–40.0 cm in males and females respectively which are the sizes at which they mature for the first time.

Ponderal index

In fishes, the lower level of condition is associated with the strain of breeding. The point showing the diminution of 'K' with increasing length is thus taken as an approximate indication of the length at which sexual maturity is reached (Hickling, 1938; Devadoss, 1978). From Table 1 the lower 'K' value is registered at 35.1–40.0 cm size group in the female of this shark. This inference is further supported by the data on the maturity as well as the index of percentage of liver weight on the body weight.

Growth of embryos

Fertilized eggs were recorded in the uterii over an extended period from June to August and again from November to February. Active mating is observed at Calicut during both rainy seasons *i.e.* Southwest and Northeast monsoons. Fertilized eggs are traced from June to August (Fig. 4). So gestation starts for the brood around the month of June. The developing embryos in various lengths have been observed from July to November and are ready for parturition by November/December period. Likewise the other brood in October–November months grow through and are ready for liberation by February/March period and so on. Gestation period is reckoned as 5–6 months. Free swimming young with fresh umbilical markings are recorded from October/November to February/March and sporadically in July.

As the yolk stored in the egg is minute and extremely negligible, it is highly necessary for the early foetus to be fed alternatively. So yolk is supplemented by establishing an intimate connection with the uterus by means of yolk sac placenta and drawing nourishment

from the mother's blood stream. All embryos are positioned with the head pointed anteriorly with the mother in the uterine compartment. The number of embryos varies with the individual mothers from 6 – 18 and the average being 13 embryos per pregnant female. In many instances a maximum of 20 embryos have been recorded.

Zygote

The fertilised ovum enclosed with the 'egg-case membrane' at the nidamental gland descends into the uterus. Fig. 5 a shows fertilised ova or zygotes with the membranes. Once the zygote reaches the uterine compartment, the membrane is called 'embryonic membrane' (Chen and Misue, 1973). The 'embryonic membrane' which is highly transparent measured about 8–12 mm. The fertilised ovum (9 mm) is seen intact inside the membrane. Microscopic examination of the zygote revealed that development of embryo has not commensed during its journey from the nidamental gland to the uterine compartment.

TABLE 1. *Average ponderal index in the female* Scoliodon laticaudus

Length group (cm)	Months J	F	M	A	M	J	J	A	S	O	N	D	Average
Upto 15.00	0.40	0.37	0.39	—	—	—	0.30	—	—	0.35	0.41	0.41	0.38
15.1–20.0	0.41	0.35	0.40	0.38	0.44	0.32	0.37	0.34	—	0.39	0.45	0.41	0.38
20.1–25.0	0.39	0.39	0.39	0.40	0.42	0.37	0.38	0.37	—	0.41	0.44	0.37	0.39
25.1–30.0	0.38	0.39	0.36	0.41	0.34	0.36	0.37	0.40	—	—	—	0.38	0.38
30.1–35.0	0.36	0.37	0.35	0.34	0.50	0.39	0.36	0.38	—	0.36	0.39	0.35	0.37
35.1–40.0	0.35	0.29	0.32	0.32	0.32	0.34	0.34	0.34	—	0.35	0.36	0.34	0.34
40.1–45.0	0.36	0.36	0.36	0.35	0.36	0.35	0.36	0.39	—	0.40	0.35	—	0.36
45.1–50.0	0.41	0.35	—	—	—	—	0.38	0.36	—	0.38	0.46	0.38	0.41
50.1–55.0	0.34	0.43	0.48	0.41	—	—	0.42	—	—	0.41	0.49	0.38	0.42
55.1–60.0	0.37	0.47	0.41	—	—	—	—	—	—	0.47	0.40	0.42	0.42
60.1–65.0	0.42	0.37	0.38	—	—	—	—	—	—	—	—	—	0.39
Average	0.38	0.37	0.38	0.37	0.39	0.35	0.36	0.37	—	0.39	0.42	0.38	

9 mm embryo

This is the smallest developing embryo that could be recovered from the uterine compartment during August and then from November to March period. The embryo at this stage is in a rudimentary condition of development, pale in colour and almost transparent. The head portion is bulged and swollen at the anterior region. The cephalic region is well marked out, optical vesicles clearly seen in the head region (Fig. 5 b). The eyes on either side are rounded and clearly visible, but with out any pigmentation. Mouth is distinguishable as a streak on the ventral side. The pharyngeal region is perforated by five gill slits and from all gill pouches are drawn out long and slender branchial filaments called "external gills" which are soft, succulent and highly vascularised.

There are no markings of fin development except a mere out pushing for the ventral fin. The caudal is long and slender, with out any demarcation and the subcaudal lobe is yet to make its appearance.

The embryo has a well developed yolk stalk which is supplied with appendiculae. The yolk stalk appendiculae are long and bifurcated at the distal end. The yolk stalk contain an artery and a vein and is connected to the embryo at a point posterior to the gill opening. The yolk sac has already made connection with uterus forming the yolk sac placenta which is divided into a rounded, pale structure directly connected with yolk stalk and a slightly reddish coloured portion by means

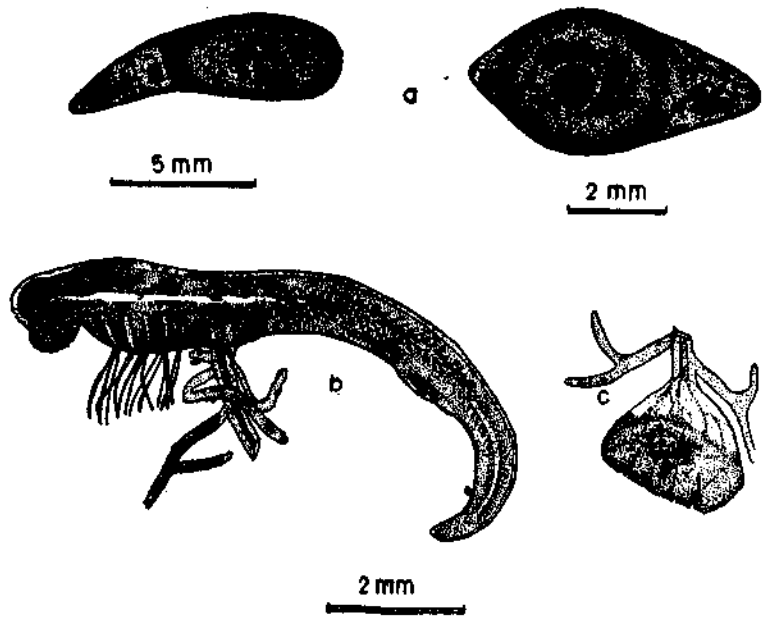

Fig. 5. a. Fertilized eggs, b. Lateral view of 9 mm embryo and c. yolk-sac placenta of the same embryo.

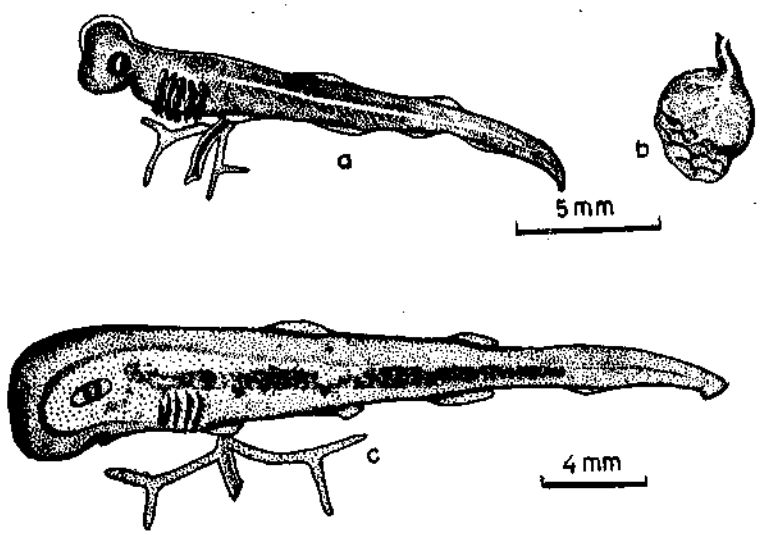

Fig. 6. a. Lateral view of 18 mm embryo, b. Yolk-sac placenta of the same embryo and c. Lateral view of 28 mm embryo.

of which it is attached with the trophonemata of the uterine chamber.

Development of a number of 'V' shaped myotomes on the body is discernible in the region from the gill slits to the tail.

18 *mm embryo*

In this stage, the embryo is less transparent and secured a firm attachment with the uterus. The cephalic flecture is still retained and further extended anteriorly. The mid brain portion is rounded projecting on the dorsal side (Fig. 6 a). The pale colourless body is slowly changing in to grey due to slight pigmentation. The eye is more distinguished with the development of irish and lens and slight pigmentation. Mouth is more visible as a slit on the ventral side anterior to the gill openings. The bunches of "external gill" filaments which are relatively short and blunt are still retained at the gill openings.

Fins have started appearing in their corresponding adult positions as a mere out pushing from the body wall. The first dorsal fin is distinguished on the dorsum over the interspace between pectoral and ventral; pectoral fin originating behind the V gill slit, while the ventral fin below the tip of first dorsal fin. The second dorsal and anal fins are positioned opposite. The lower lobe of the heterocercal caudal fin also makes its appearance.

28 *mm embryo*

The body of embryo has completely lost its transparency due to pigmentation. The head portion is disproportionately large (Fig. 6 c). The development of eye is still in progress. The socket is more linear shaped. The snout started protruding anteriorly, while the mid brain region is more or less in horizontal level with the body axis. The mouth is well developed. The 'external gill' filaments become feable and getting gradually disappeared. All the fins made their appearance but for the rays. Posterior extension of the first dorsal, second dorsal, ventral and anal fins are distinguishable.

The embryonic membrane sac gets disintegrated at very early stage. The embryos lie naked in the uterine compartments for the most part of the existence. Generally they are richly covered with nutritive uterine fluids. The sexes are distinguished externally when the embryo reach about 30 mm in total length. The external gills are very feably seen even at 60 mm. At 80 mm length, the embryo resembles almost like the adult. At the time of parturition they attained a length of about 140 mm and are extruded out tail first.

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