

OBSERVATIONS ON THE BREEDING AND DEVELOPMENT OF SOME SHARKS

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ABSTRACT

Size at maturity, developmental stages and breeding seasons of five sharks from the Portonovo Coast are described. A maximum of twenty embryos with an average of twelve embryos of *Sphyrna blochii* have been collected. The relationship between the number of embryos and the total length of the mothers was also worked out. The other sharks studied for the breeding habits were *S. lewini*, *Rhizoprionodon acutus*, *Carcharhinus limbatus* and *C. sorrah*. All these have a developed placental system for nourishing their developing embryos in the uterus.

INTRODUCTION

BREEDING and development in sharks are of much interest. Some lay eggs, others give birth to fully developed young ones while some others fall between these two categories. The development of elasmobranchs is characterised by the elimination of the larval stage found in the majority of the teleostean fishes. As in higher forms the process of fertilization and development takes place inside the body and so there is a tendency in this group to limit the number of offsprings.

Unfortunately information on reproduction in individual sharks is not complete and is based on isolated biological reports. As a result, more is inferred rather than observed. It is not out of place to mention here that collection of sharks of all sizes is very difficult, since they are highly migratory and may therefore be present in different areas at different stages of their development. Sharks of the same size, sex and with the same stage of development are likely to occur in a particular

place at a particular time of the year. Hence constant and continuous survey is essential to obtain detailed information.

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MATERIAL AND METHODS

Several hundreds of specimens of both sexes were examined for this study from the gillnets, hooks and lines and trawl catches. The sizes of specimens mentioned in the text refers to total length from snout to tip of tail. To determine maturity the method adapted by Springer (1960), Teshima and Mizue (1972) and Devadoss (1978) is followed here. The males were considered mature when the claspers were found full grown and rigid with cartilage reinforcement. The presence of enlarged testes, collection of semen in the seminal vesicles, swollen and bleeding claspers are indications of mating activity in males and the occurrence of fully developed ova in the ovary,

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expansion of the posterior region of oviduct as uterus to form a loose sac and mating scars on the pelvic region and near pectoral fins in females.

OBSERVATIONS

Sphyrna blochii (Cuvier, 1817)

Mature specimens of both sexes numbering 188 besides 326 embryos were examined for the present study.

Reproductive organs

The claspers are formed even when the male embryos are developing in the uterus of the mother. The paired epigonal organs found near kidneys show the same histological structures (Chen *et al.*, 1973) in both sexes. The testes and ovaries in males and females respectively are formed at the anterior end of this organ. In *Sphyrna blochii* the left epigonal organ is not developed and remains rudimentary as a result of which there is no ovary on the left side, while the right ovary continues to develop and becomes the sole, true and functional ovary. On the other hand, both the uteri are functional and bear the young ones. The common ostium or the oviducal funnel is just below the oesophagus. This funnel is followed on each side by the oviduct and the shell gland or the nidamental gland. Further down it is dilated into uterus which opens to the out side through the cloaca.

The reproductive system as described above is the same in all species of hammer heads and carcharhinid sharks. But the presence of both ovaries was observed in *Scoliodon sorracowah*, *S. palasorrah* and *S. walbeehmi* by Mahadevan (1940). This was later confirmed by Thillayampalam (1964) and Devadoss (1979). However Setna and Sarangdhar (1949) have reported that only the left ovary was functional in *S. palasorrah* and *S. walbeehmi* from Bombay waters. Both the uteri are functional in all sharks,

Sphyrna blochii was not found to grow beyond 5' (150 cm) in Bombay waters (Setna and Sarangdhar, 1949), but in Portonovo on the east coast the largest female specimen measured was 163 cm and male 154 cm. The males appear to mature earlier than the females when they reach 100-110 cm (Fig. 1) group, as the growth of claspers slackens at this stage. This is further supported by the mature testes and the presence of seminal fluid both in the seminal vesicles and clasper grooves. The females seem to mature at 110-120 cm.

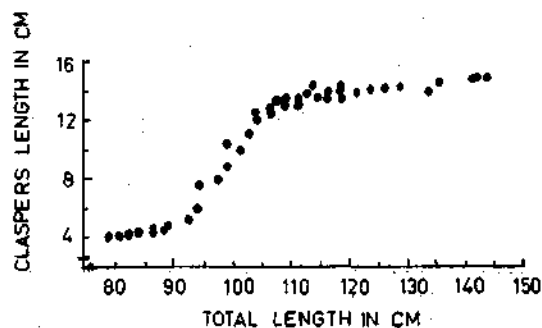


FIG. 1. Relation between total length and clasper length in *Sphyrna blochii*.

Breeding season

S. blochii has a definite breeding season. Embryos, in the early as well as in advanced stages of development were collected from September through May. The actual time of birth seems to be May and June at Portonovo. This is further evidenced by the incidence in July of specimens, which have already brood, with their uteri very much loose and baggy having ridges and wrinkles inside. Setna and Sarangdhar (1949) recorded the parturition during April and May in Bombay waters.

The pregnant female sharks do not carry eggs in a developed condition in the ovaries. Only the breeding females carry eggs. The ova measured 4-6 mm in August-September months, 6-8 mm in November, 8-10 mm in February, 9-11 mm in May and the maximum growth of eggs was seen after May and they

reach 20-25 mm in June and July. Copulation seems to take place during this period since no further development of ova could be noticed afterwards. Occurrence of fresh scars as a result of mating during this period further confirms this. Embryos measuring 100-140 mm were collected from the females during October. Sexual activity among the adults in Bombay waters were reported to be very intense during July-August (Setna and Sarangdhar, 1949).

Developmental stages of embryos

12-16 cm embryos

At this stage the embryos in most cases resemble the adults except in some morphological characters (Fig. 2). But embryos in

as the uterine wall developed folds and interdigitation between them was quite established. The embryo with the yolk sac was covered by means of a membrane secreted by the shell gland. An yellow coloured fluid filled up the space between the embryo and the embryonic membrane. The embryo in the fluid at this stage is colourless with no pigmentation. The head expansion (both arms) project backwards in a round form, instead of having a 'T' shape which is characteristic of the adult and they measured shorter than those in adults. Teeth were not yet formed and so also the pores pattern on the ventral side of the head, found in the adults. The claspers were visible only as thin strips not reaching the pelvic fin end. The umbilical

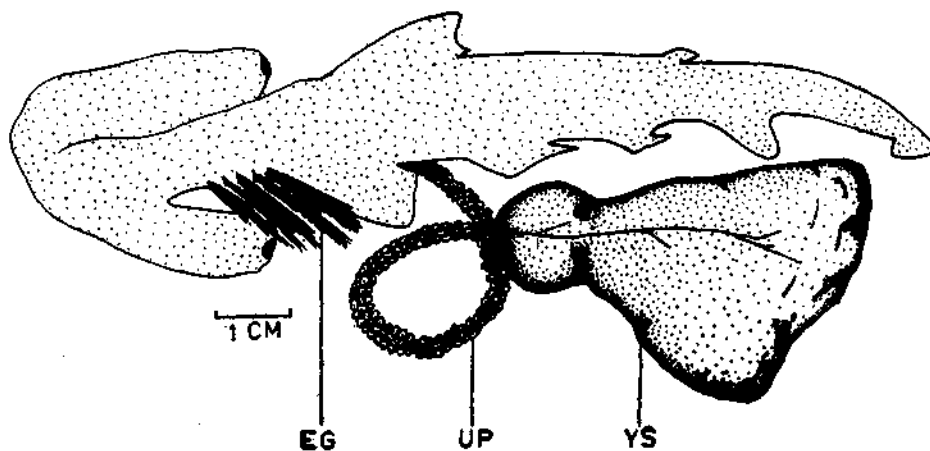


FIG. 2. *Sphryna blochii*: Embryo 155 mm in TL (C: Clasper, EG: External gill filaments, OV: Ovary, NG: Nidamental gland, UP: Umbilical papilla, US: Umbilical stalk, YS: Yolk sac and YSP: Yolk sac placenta).

earlier stage of development upto 40-45 mm pass through the normal 'shark life' stage i.e. the lateral expansion of the head characteristic of this group was not yet developed and yolk sac placenta not yet formed (Setna and Sarangdhar, 1949). At 120 mm size the posterior wall of the yolk sac developed folds to show the beginning of the yolk sac placenta and later upto 160 mm the embryos showed rudimentary placenta, as the yolk sac as well

cord present on the ventral side between pectorals was provided with rounded and globular appendiculae resembling an inflorescence. The cephalic flexure was still retained. The head was soft, eyes large. Tufts of filaments 12 in numbers from each gill cleft could be seen.

Numerous 'V' shaped myotomes could be seen from behind the gill slits to the caudal.

The caudal and other fins are transparent and imperfect.

20-29 cm embryos

In this stage the embryos, covered by a membrane appeared further advanced in development, the lateral expansion of head still projecting backwards. Light pigmentation could be seen on the dorsal surface. The length of placenta increased and the interdigitation of the folds on both foetal and maternal tissues appeared well established. The appendiculae on the umbilical cord appeared large, fleshy and soft. The tufts of external gill filaments have become much reduced (Fig. 3).

and exchange of gases from the mother become soft and thin like leaves. The two arms of hammer-head were still angling back wards.

Position of embryos inside the uterus

There are as many compartments in each uterus as there are embryos. Each embryo is covered by means of an embryonic membrane. The position of embryos at 12-14 cm are oblique. As the embryos grow in length, the compartments become longitudinally positioned. This change in the position is regarded as due to the increase in the length of the embryos and also to facilitate easy parturition (Teshima *et al.*, 1974). The placenta is formed at the posterior region or at the bottom

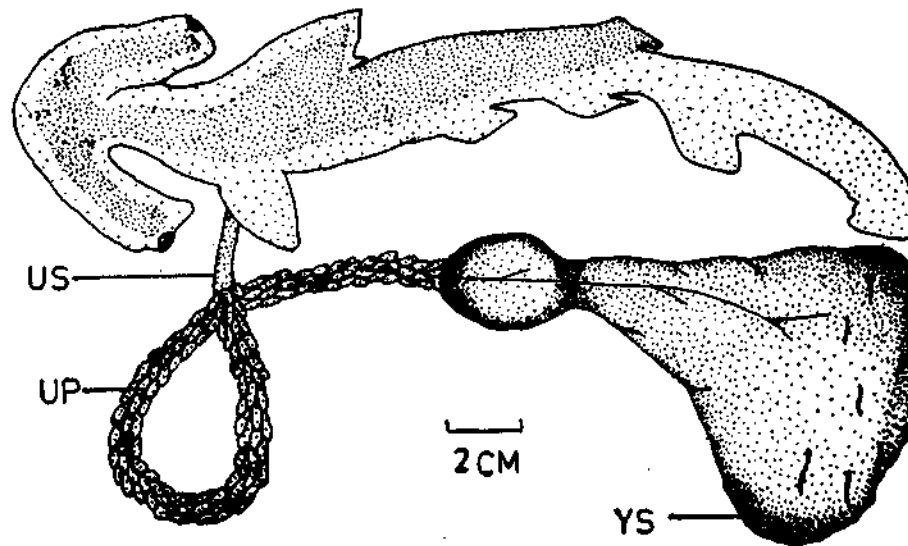


FIG. 3. *Sphyrna blochii*: Embryo 210 mm in TL.

30-49 cm embryos

The embryos at this stage, appeared to be a replica of the adult. The external gill filaments disappeared completely. The presence of minute teeth could be seen now. With the placenta completely established at this stage, the yolk completely disappeared and the locular appendiculae which were large and fleshy to facilitate easy absorption of nutrients and salts

of each uterine compartment on the ventral wall of uterus. In the advanced stage of gestation, the uterus appears very much stretched out due to the growing embryos inside, as a result the embryos can be seen through the uterine wall. The embryos are oriented with their heads pointing anteriorly. They emerged tail first, as many pregnant specimens were landed with caudal tips of the

embryos projecting from the cloacal opening. At birth the umbilical cord disconnected near the surface of the skin of embryo which thus bears an open scar between pectoral fins.

In majority of cases upto 14 embryos were collected from each female during the present study. In one instance a maximum record of 20 embryos were collected. The morphometric measurements of embryos are given in Table 1. Setna and Sarangdhar (1949) collected only upto 9 embryos from Bombay waters.

The total number of embryos collected from 28 litters was 326 with an average of 12 embryos per mother. Of these 162 were males revealing a sex ratio of 1:1 as that of the adults (Table 2) in commercial catches. The growth rate of embryos was shown in Fig. 4.

A relationship between the number of embryos and the total length of the mother is shown in Fig. 5. Females with a total length of below 120 cm produced 6-7 embryos and between 120-130 cm produced 10-12 embryos. Females above 140 cm gave birth to 14 embryos. Such a relationship has been reported in some other species also by earlier workers (Ford, 1921; Teshima *et al.*, 1974; Bass *et al.*, 1975).

Sphyrna lewini (Griffith and Smith, 1834)

Several mature specimens of both sexes were examined and embryos in advanced stages of development were collected during August-September only in all the years and in no other period of the year either the adults or pregnant females could be collected as they are highly migratory and disappeared from the present fishing zone. Most of the times of the year only juveniles up to about 105 cm in total length were found sporadically in the catches. Free swimming just born young ones with open umbilical scars were most common during September-October months.

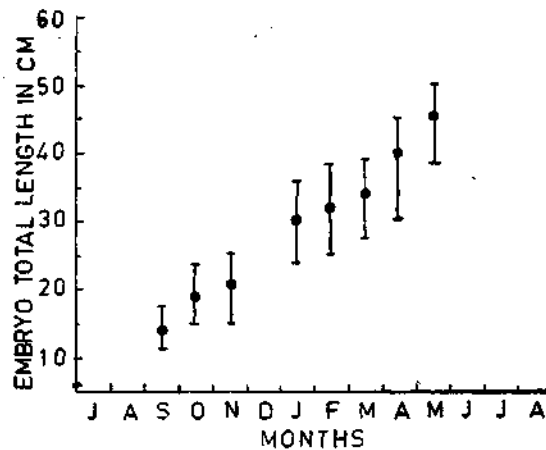


FIG. 4. *Sphyrna blochii*: Growth of embryos against months when the mothers were picked up. Cross represent the smallest free swimming young with fresh umbilical scar.

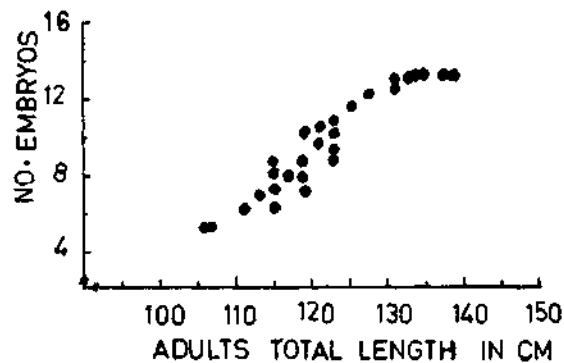


FIG. 5. *Sphyrna blochii*: Number of embryos against total length of mothers.

Full-term embryos 30-45 cm

In all 133 embryos were examined and 67 of them were found to be females forming a sex ratio of 1:1. All the embryos collected were the exact replicas of the adult (Fig. 6). The placenta was of the usual selachian pattern with two distinct sections in the foetal portion of placenta. The umbilical tube was long, in some cases twisted round the embryo. The attachment of placenta was at the posterior region of the uterus. The appendiculae

TABLE 1. *Morphometric measurements (in percentage of TL) of embryos of Sphyrna blochii and S. lewini (Range in parenthesis)*

Size range in mm No sampled	<i>S. blochii</i>		<i>S. lewini</i>	
	140—450	28	300—460	18
Head width ..	50.6	(50.4—50.7)	27.3	(26.2—28.4)
Snout to first gillslit ..	22.6	(19.4—24.9)	18.9	(18.7—19.1)
pectoral fin ..	22.9	(22.1—23.9)	23.1	(22.4—23.9)
pelvic fin ..	44.8	(44.7—44.9)	45.8	(45.6—46.0)
Eye diameter ..	2.6	(2.1—3.4)	2.5	(2.4—2.7)
Between dorsal bases ..	20.7	(20.2—21.5)	21.8	(21.6—21.9)
Internarial distance ..	15.8	(15.2—16.5)	19.4	(19.1—19.7)
Mouth width ..	7.1	(7.0—7.4)	6.6	(6.5—6.8)
First dorsal base ..	11.0	(10.6—14.0)	11.6	(11.1—12.0)
height ..	17.3	(16.9—17.5)	11.9	(10.7—13.1)
Second dorsal base ..	3.3	(2.9—3.8)	3.5	(3.4—3.6)
height ..	2.5	(2.4—2.7)	2.6	(2.5—2.8)
Anal base ..	6.5	(6.5—6.7)	5.5	(5.4—5.6)
height ..	3.8	(3.7—4.0)	3.8	(3.6—4.0)
Pectoral base ..	6.1	(5.3—6.2)	6.2	(5.8—6.5)
length ..	14.8	(14.6—14.9)	14.9	(14.6—15.2)
Caudal upper lobe ..	28.5	(28.0—29.2)	—	—
lower lobe ..	10.4	(9.8—12.3)	—	—

TABLE 2. *Sex distribution in various size groups*

Size (cm)	<i>S. blochii</i>		<i>C. limbatus</i>		<i>C. sorrah</i>	
	Male	Female	Male	Female	Male	Female
50—69 ..	5	5	8	7	128	136
70—89 ..	4	5	5	11	40	48
90—109 ..	15	13	5	2	12	18
110—129 ..	22	24	12	13	23	31
130—149 ..	36	42	2	6	35	39
150—169 ..	8	9	13	12	62	64
170—189 ..	—	—	8	20	—	—
190—209 ..	—	—	3	7	—	—
210—229 ..	—	—	4	6	—	—
230—249 ..	—	—	2	5	—	—
Total ..	90	98	62	89	300	336

were soft and locular and were not so numerous as in the case of *S. blochii*. The free portion of each appendicula was dilated while the proximal portion was narrow and thin. The eyes were big and protruding, teeth not yet

The smallest mature female to carry embryos measured 180 cm while mature males measured 140-165 cm. The maximum size recorded during the present study was 295 cm, a female. According to Gilbert (1967) the

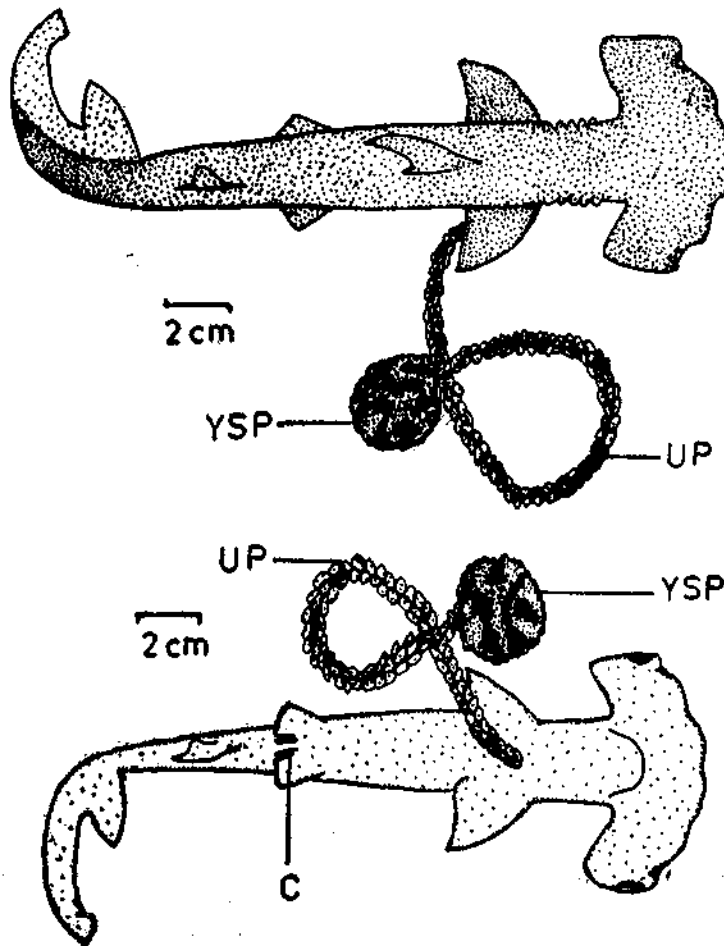


FIG. 6. *Sphyrna lewini*: Embryo 310 mm in TL — Dorsal and ventral views.

cut. The external gill filaments found in early developing embryos were absent. The morphometric measurements are given in Table 1.

The ova at the time of parturition were in very early stage, measuring upto 8 mm in diameter. So mating and spawning were most unlikely to happen immediately after parturition.

maximum length of this species was probably four metres.

Rhizoprionodon acutus (Rüppell, 1835)

Embryos upto six from a female were collected between November and May and the full term embryos measuring 26-27.5 cm were met with only during March-May months

TABLE 3. *Morphometric measurements (in percentage of TL) of embryos of Rhizoprionodon acutus, Carcharhinus limbatus and C. sorrah*

Size range (mm)		<i>R. acutus</i> 250—270	<i>C. limbatus</i> 400—480	<i>C. sorrah</i> 290—340
No sampled		28	14	12
Snout to nostril	..	5.9	5.8	5.2
mouth	..	9.8	9.1	8.8
eye	..	8.3	8.2	9.0
first gillslit	..	19.9	2.17	19.6
pectoral	..	22.9	24.8	21.8
pelvic	..	49.6	48.2	45.1
upper caudal	..	72.2	74.8	70.8
Eye diameter	..	3.0	2.5	2.5
Between dorsal bases	..	21.8	20.2	20.0
Internarial distance	..	5.6	5.6	6.1
Width of mouth	..	7.8	8.3	6.9
Upper labial groove	..	1.8	—	—
Lower labial groove	..	1.2	—	—
First dorsal	base	9.8	11.4	9.8
	height	8.4	11.8	7.1
Second dorsal	base	3.8	5.0	3.1
	height	2.1	3.3	2.0
Anal	base	5.9	5.0	4.1
	height	3.1	3.1	2.2
Pectoral	base	4.9	5.4	5.5
	length	13.3	17.2	15.5
Caudal	upper lobe	28.6	29.8	31.4
	lower lobe	10.4	12.8	11.4

indicating the summer months as the parturition period. This assumption was supported by the incidence of free swimming young with the fresh open umbilical scars in commercial landings at that time.

Full term embryos 20-25 cm TL

Most of the embryos collected during the study period were almost full grown. Their morphometric measurements are given in Table 3. Embryos in the early stages (10-15 cm) were colourless with external gill filaments, which disappeared at later stages when the embryos were pigmented like the

adults, grey above and pale to creamy below and sides. The eyes appeared brownish black with rounded white lens. The embryos were accommodated in separate compartments, devoid of any uterine villi. The placenta was highly developed consisting of two portions, the maternal and foetal portions. The latter was quite distinct by the white colour against the highly vascularised maternal portion. The umbilical cord was supplied with closely set fibre like appendiculae which were not branched (Pl. I) measuring between 15-18 mm. The umbilical cord measured 16.5 cm in an embryo of 25 cm in total length.

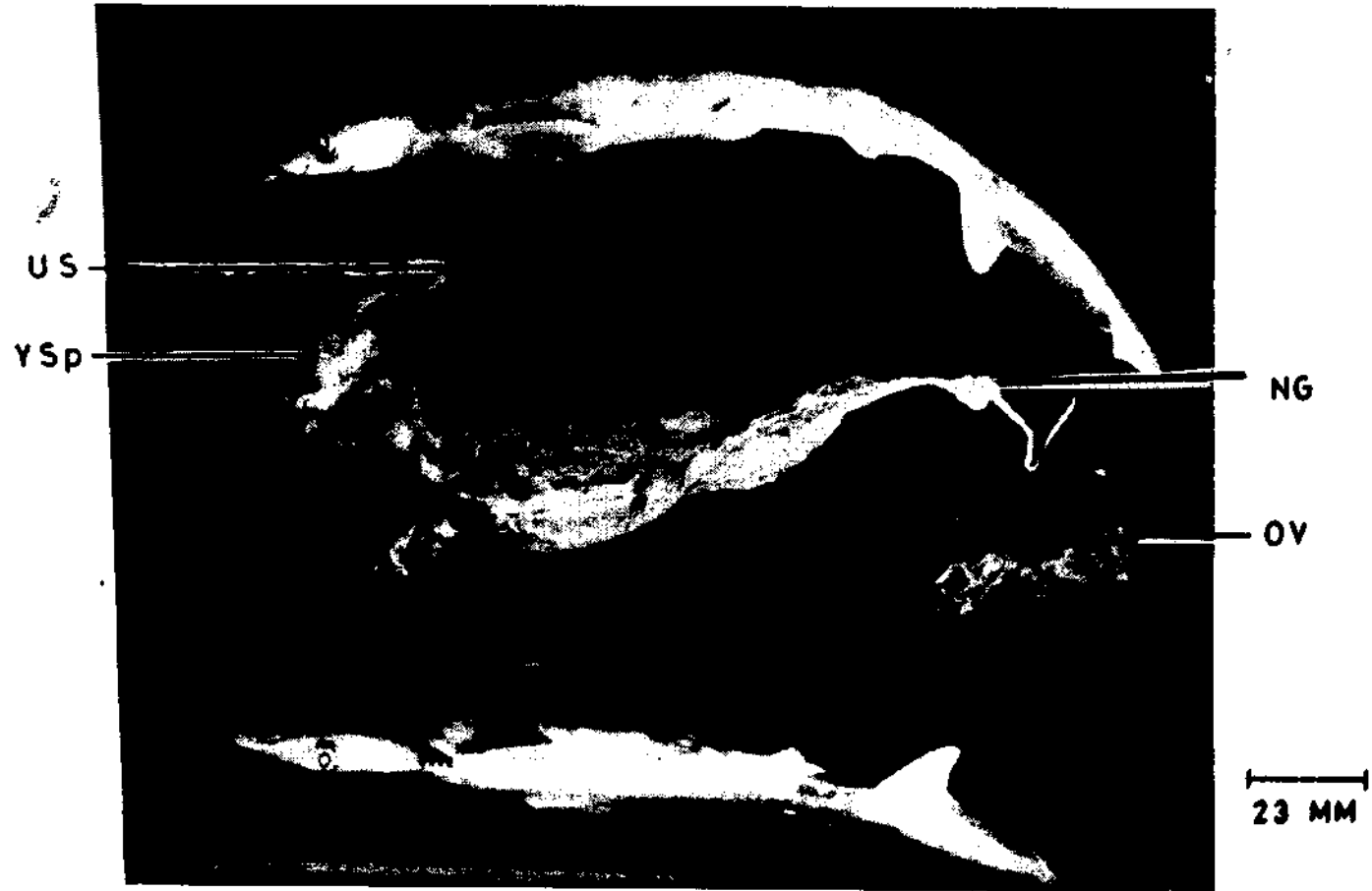


PLATE I. *Rhizoprionodon acutus*: Embryo 205 mm TL with placental connections intact (For abbreviations please see Fig. 7).

The number of embryos per mother was not constant.

The ovary was not developed at the time of parturition and the enlarged yolk laden follicles numbering 3-5 measured 4-6 mm in diameter. Probably they do not spawn immediately after parturition in the same season. The gestation period lasts for a year (Base *et al.*, 1975). The adults which were not pregnant, were found to carry eggs bigger than those found in pregnant ones, measuring 15-20 mm in diameter.

Carcharhinus limbatus (Muller and Henle, 1841)

The total number of specimens examined for this study was 141. The species grow to a length of more than 230 cm and the smallest mature female measured 165 cm and the males 155 cm from Porto novo, but in Bombay waters the size of maturity was 155 cm and 140 cm respectively for females and males (Setna and Sarangdhar, 1949). Sex ratio for various length groups in the commercial catches is given in Table 2.

Gravid females were collected during January to May each year and the embryos from 16 specimens were observed and their growth rate is shown in Fig. 7. Full term embryos were collected during April and May indicating the possibility of parturition then. At birth the embryos measured between 55 and 60 cm and the free swimming young ones with open umbilical scars were recorded in the same period. In Bombay waters, they were reportedly born during January-March (Setna and Sarangdhar, 1949) and during November-March in South African Coast (Base *et al.*, 1975).

Intra-uterine embryos

The embryos collected resembled the adult in all respects. The characteristic colour pattern of the tips of fins are already developed.

Teeth development is yet to start. The eyes are larger than in adult. The morphometric measurements are given in Table 3. An

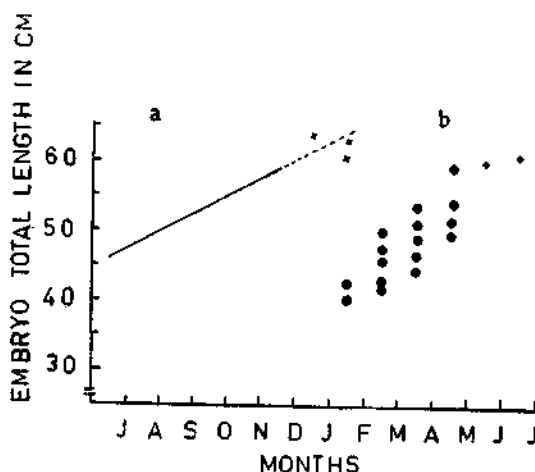


FIG. 7. *Carcharhinus limbatus*: Mean embryo lengths against months when the mothers were taken. Cross represents the smallest free swimming young: a. data taken from South African waters (Bass *et al.*, 1973) and b. present study.

embryo 334 mm in total length is shown in Fig. 10 a. The embryo and the placenta are enclosed in a membranous sheath as in *S. blochii*, but the umbilical cord is not provided with appendiculae.

The position of the embryos in the uterine chambers is as described under *S. blochii*. The gestation period appears to be a little less than a year and the shark may probably reproduce in alternate years as the ova are very much small at the time of parturition. In Northwest Atlantic region the gestation period was reported to be less than a year (Clark and Von Schmidt, 1965).

C. sorrah (Muller and Henle, 1841)

A total of 636 specimens were examined for sexual maturity, breeding and sex ratio. The distribution of sexes in relation to sizes is given in Table 2.

Size at maturity

Males appeared to be mature at 115 cm TL and those between 100-114 cm were maturing as indicated by the clasper development (Fig. 8). Females were found to be mature at 120 cm.

Position of embryos in the uterus

The embryos in the uterus were placed with their heads pointing anteriorly and their

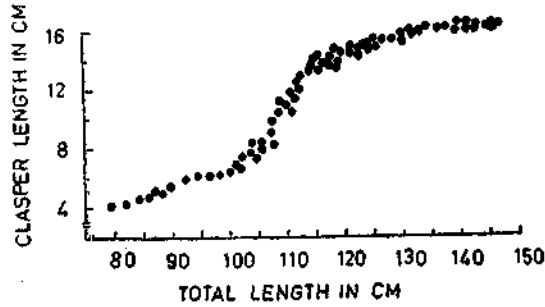


FIG. 8. *Carcharhinus sorrah*: Relationship between total length and clasper length.

tail portion tucked upwards. The placenta was well developed like a disc, highly folded and vascularised. The structure of placenta was as observed in *S. blochii* except in the absence of umbilical appendiculae.

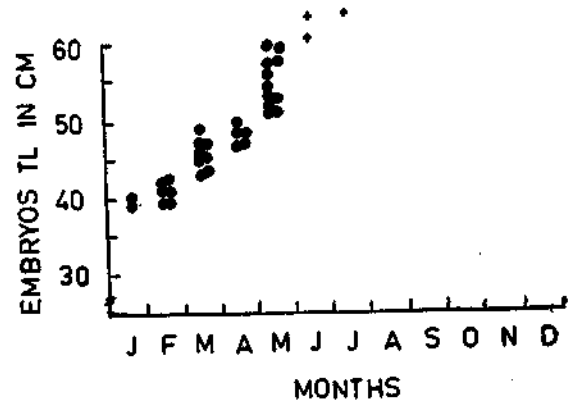


FIG. 9. *Carcharhinus sorrah*: Mean embryo lengths against month when the mothers were caught. Cross represents smallest free swimming young.

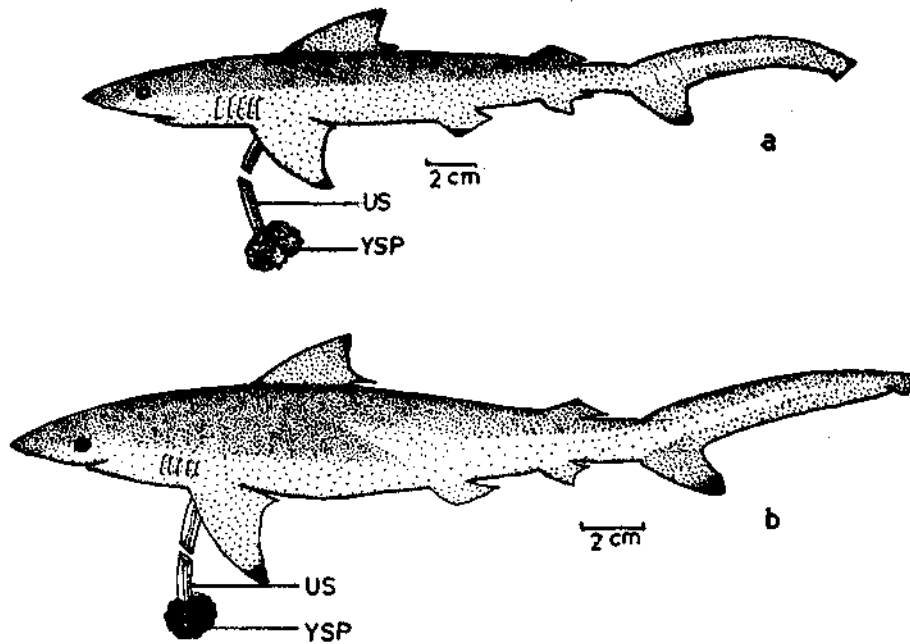


FIG. 10 a. *Carcharhinus limbatus*: Full term embryo 334 mm in TL and b. *C. sorrah*: Embryo 340 mm TL (part of umbilical stalk removed).

Litter size and breeding

The number of embryos varied from 2-6 with an average of 4 embryos per female. A total of 136 embryos was collected from 34 females. Wheeler (1953) recorded two embryos per female based on two samples in Mauritius. Two reports from Red Sea area revealed 5 and 6 embryos per female (Gohar and Mazhar, 1964). A pregnant female shark was found to contain three embryos from Southern Africa (Bass *et al.*, 1975).

Embryos were collected during January to May each year. The growth of embryos was traced in Fig. 9 and their morphometric

characters given in Table 3. An embryo of 340 mm. TL is illustrated in Fig. 10 b. The characteristic blackening of the tips of fins was noticeable when the embryo was 275 mm long. The parturition period appeared to be in April-May which was confirmed by the incidence of juveniles with fresh umbilical scars in the catches in May and June. The embryos measured 35 cm in total length at birth and the breeding does not seem to take place immediately after the birth of young, as the follicles remain undeveloped. The shark appears to breed on alternate years and the gestation period may be less than a year.

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