STUDIES ON THE DEVELOPMENTAL STAGES OF HAMMERHEAD SHARK *SPHYRNA (EUSPHYRNA) BLOCHII* FROM THE GULF OF MANNAR

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ABSTRACT

Various stages of intra-uterine embryos of *Sphyrna blochii* collected from the Gulf of Mannar are described and discussed. Uterine compartments are formed in this species which exhibit multiple pregnancy. An embryonic membrane store chamber is present in each uterine compartment. The placenta of this species is of yolk-sac type and is formed at the stage in between 125 mm and 210 mm; yolk persist in the yolk-sac even when the placental connection is established with the mother. The placentation process observed in this species is almost similiar to that of *S. tiburo* and *Carcharhinus dussumieri*. The probable gestation period and other details of placentation are discussed.

INTRODUCTION

Family sphyrnidae includes the hammerhead or bonnethead sharks, which occur in tropical and temperate waters throughtout the world. Systematic studies by Gilbert (1967) on this group show that there are 9 species of these sharks belonging to 3 subgenera. In India 4 species of hammerhead sharks *viz., Sphyrna (Eusphyrna) blochii, S. (Sphyrna) mokarran, S. (Sphyrna) zygaena* and *S. (Sphyrna) lewini* are common. *S. (Sphyrna) blochii* is restricted to the Indo-west Pacific and is known from Persian Gulf, seas around India, East Indies, Southern China, Southern Philippines and Queensland. Bigelow and Schroeder (1949) have briefly described the developmenal stages of *S. tiburo, S. tudes* and *S. zygaena* and Schlernitzauer and Gilbert (1966) investigated in details the placentation and associated aspects of gestation in *S. tiburo*.

Biological studies on sharks from Indian coasts are meagre and knowledge about the embryonic development of sharks lags behind that of teleosts. Observations on the gestation and development of sharks from Indian region have been made by Alcock (1890), Mahadevan (1940), Setna and Sarangdhar (1948, 1949, 1949a, 1951), Southwell and Prashad (1919) and Nair and Appukuttan (1974). Information on the early development and gestation of hammerhead sharks from Indian region is mainly from the works of Alcock

(1890) and Setna and Sarangdhar (1949, 1949a, 1951). Alcock (*op.cit.*) described the late stages of development of *Zygaena bolchii* and Setna and Sarangdhar (1949) reported the various stages of intra-uterine embryos of *S. blochii* from Bombay coast. Further, Setna and Sarangdhar (1949a) have described the details of development of a 43mm embryo of *S. blochii* from the same coast. Setna and Sarangdhar (1951) have given details of utero-gestation of *S. zygaena* also from Bombay coast. The present report is a detailed account of the intra-uterine embryos, placentation and other associated aspects of gestation in *S. blochii* collected from the Gulf of Mannar.

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Material

Four female *Sphyrna blochii* caught in the gill nets from the Gulf of Mannar off Pamban ranging from 1480 to 1525 mm in total length were utilised for the present study. Two specimens 1480 and 1520 mm collected in March 1973, had functional ovary with yolked eggs and the other two 1505 and 1525 mm in length collected in November 1972 were gravid females with embryos. The details of the length of the adult females, number of embryos in each uterus, sex of the embryos, number of eggs in the ovary and the diameter of the eggs are given in Table 1. All the materials are deposited in the Reference Collection Museum of Regional Centre of Central Marine Fisheries Research Institute, Mandapam Camp, for future reference.

Reproductive system

In the mature females with yolked eggs, the right ovary alone is functional with developing eggs and the left being atrophied. (see Table 1. for number and size of eggs). Apart from developing eggs the right ovary contained a number of small eggs ranging from 1.5 mm to 2.5 mm size embedded to the ovarian tissue. Setna and Sarangdhar (1944) observed the diameter of functional eggs as 10 mm in *S. blochii*. Schlernitzauer and Gilbert (1966) noted that in *S. tiburo* the eggs reach an average size of 18 mm when they are ready for ovulation. In the present observation the maximum size of the yolked eggs noted was 12.5 mm and the ovary was not ready for ovulation. Hence it is assumed that ovulation starts at a later stage when the egg reaches a bigger size and the present stage can be considered as "maturing." The nidamental glands of these specimens are also well developed; the length of the gland is 25 mm and width 24 mm. Prasad (1949) observed that a well developed nidamental gland of *S. blochii* has a length of 22 m and width of 20 mm in a specimen of 1525 mm. The nidamental glands are considered to become active and well developed before gestation starts.

TABLE 1. *The number of embryos, their sex, total length and the number of yolked eggs in* S. *blochii.*

Date and place	Length of the mother (in mm)	No. of embryos	Length and sex of embryos (in mm) In left uterus	In right uterus	No. of developing eggs in ovary	Average diameter of eggs, diameter range (in parantheses)	Length of nidamental gland	Width of nidamental gland
19-3-1973								
Pamban	1520	—	—	—	40	7.3	25 mm	25 mm
			—	—	25	(4.5-12.5)		
						7.3	25 mm	25 mm
29-3-1973			225 M	232 M	—	—	23 mm	23 mm
Pamban	1480	—	238 F	238 F				
			235 M	238 M				
4-11-1972			243 F	236 M				
Pamban	1525	5+6=11	238 M	237 M				
				236 F				
27-11-1972			210 F	132 F	—	—	24 mm	23 mm
Pamban	1505	4+5=9	280 M	246 F				
			280 M	292 M				
			283 F	294 F				
				297 F				

M = Male; F = Female.

Uterine compartments (Fig. 1;1)

In *S. blochii* uterine compartments are formed during gestation. Each compartment is formed by the fusion of dorsal and ventral elevation of the internal wall of the uterus. The materials examined at present do not give an opportunity to study in detail the process of formation of the dorsal and ventral ridges during early stages of pregnancy and its fusion during advanced stages. The number of uterine compartments formed correspond to the number of embryos. The compartments observed in the present material are all somewhat obliquely positioned. The placental attachment to the posterior part of the chamber to the ventral side of the uterus has been established in the embryos except those 132 to 210 mm in size and the uterine wall has become thin in both the specimens. The area where the placenta has been established is thick, spongy and highly vascularised.

Setna and Sarangdhar (1949a) has observed the formation of uterine compartments in 43 mm embryo of *S. blochii*. They recorded five compartments each roughly V-shaped. The greater arm of the 'V' representing the major portion of the compartment, occupied an obliquely transverse position, while the

smaller arm inclined upwards at an angle, lay in more or less vertical narrow corner of the compartment. From this description it could be assumed that at 43 mm stage the uterine compartment folds have not fused completely. Schler-

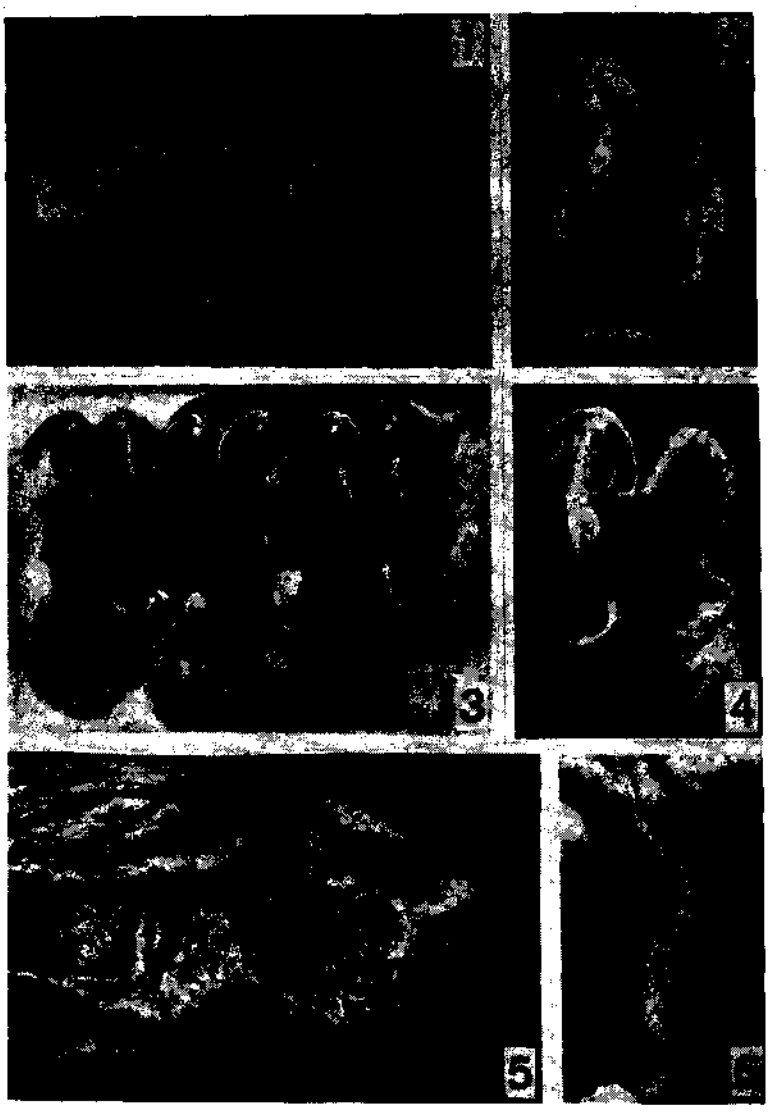

FIG. 1. *S. (E) blochii*: 1. Left uterus of mother 1525 mm in length showing uterine ompartments. 2. 132 mm embryo with external gill filaments protruding out from gill slits. 3. Left uterus of 1525 mm female with 6 embryos showing the head expansion directed backwards. 4. 210 mm embryo with yolk sac showing the begining of convolutions. 5. Yolk sac placenta in a 280 mm embryo showing the maternal and foetal placental folds. 6. The umblical stalk with appendicula of 280 mm embryo.

nitzauer and Gilbert (1966) while examining the placentation process in *Sphyrna tiburo*, described at length the formation of uterine compartment fold in early 7 mm embryo stage and the fusion of these folds in embryos of 125 mm or more, where placentation has just begun. They suggest that it is probable that the uterine ridges do not form in *S. tiburo* until after the fertilized ova reach the uterus but grow rapidly after that. Setna and Sarangdhar (1951) observed horizontally compartmented uterine walls in *Sphyrna zygaena* from Bombay waters. Mahadevan (1940) while observing the uterus and placenta of carcharhinid sharks, *Scoliodon sorrakowah* and *S. palasorrah* found that each uterus is divided into as many compartments as there are embryos. She believes that the partition wall of compartments in both these species are formed by two folds of uterine mucosa coming together and establishing intimate connection between the epithelia. The separating walls are thin and delicate.

Embryonic membrane

The embryos with their appended structure lie enclosed in this embryonic membrane and yolk-sac exists even in the advanced stages with placenta in the present material. A close examination of the uterus showed that there is embryonic membranestore chamber in each compartment of uterus and the embryonic covering the embryo is continuous with the store chamber through a small opening. Teshima and Mizue (1972) observed the embryonic membrane-store chamber in placental type embryo of *Carcharhinus dussumieri* from Japanese waters and found that this chamber appears to exist until parturition. Setna and Sarangdhar ,1951) while observing the development of *S. zygaena* have noticed that all embryos were enclosed in shell membrane sac containing moderate quantities of a whitish opaque liquid. They have not observed any shell membrane-store chamber in this species.

Embryos

The two gravid females examined in the present study contained embryos ranging from 132 to 297 mm in total length. In the specimen 1505 mm in length nine embryos were present, four in the left and five in the right uterus. All the embryos were positioned with the head pointed anteriorly, within the uterine compartment. In the specimen 1525 mm in length there were eleven embryos five in the left and six in the right uterus. The smallest embryo noticed in the present study was 132 mm in length found in the anterior-most chamber of right uterus of 1505 mm specimen.

132 *mm Embryo* (Fig 1; 2)

The embryos at this stage have almost attained the adult shape, the head assuming the characteristic hammer shape. The lateral expansions of the head

are pointed posteriorly at this stage. The eyes are prominent, round in outline and positioned at the tip of the hammer and protrude slightly beyond the tip of the lateral expansion. This is a clear difference from that of the adult specimens. Mouth present in the ventral side of the head is crescent shaped and teeth have not appeared in either jaw. A small lower labial furrow is present in the lower corners of the mouth. Below the mouth, the pharyngeal region is perforated laterally with gill slits, through which issue out long external gill filaments. The length of these gill filaments varies from 15 to 25 mm. Spiracles are not present at this stage. All the fins have developed in their corresponding position and resemble those of the adult in shape. Pectoral originates in between the fourth and fifth gill slit. First dorsal base is less than twice that of the pectoral base length. Origin of second dorsal is far behind the anal origin. Lobes of second dorsal are elongated and pointed. Caudal pit has not made its appearance. The pectoral fins are pointed. Length of caudal fin is more than one third of the total length of the embryo. Dermal denticles have not appeared over the skin. The body musculature is visible as the skin is transparent and the myotomes are V-shaped in the body part, whereas it is more or less verticle in nature towards the caudal region.

The embryo has not established placental connection with the mother. The yolk sac is well developed and fairly big. It contains cream coloured yolk and is covered by a thin membrane. The distal end of the yolk sac is fairly vascularised. The embryo with the yolk sac and yolk stalk is completely enclosed in a thin embryonic membrane. At the upper pole of the yolk sac there is a transparent gelatinous oval disc through which the blood vessels and yolk duct pass into the yolk stalk, and the yolk stalk is in turn connected to the ventral side of the embryo in between the pectoral fins. The length of the yolk stalk is 60 mm. The sheath surrounding the yolk is modified to form the appendicula at this stage. These leaf-like lobes begin to appear as appendicula and are arranged throughout the length of the yolk stalk, except at the anterior end at a length of 10 mm. The appendicula are often simple but some of them are forked in the anterior part of yolk stalk. The length of the lobes varies from 1.5 to 2.0 mm. The distal end of yolk sac does not show any convolution or formation of ridges to establish the placental connection with the mother. Close examination of the uterine wall also does not show any formation of ridges.

In 43 mm embryo observed by Setna and Sarangdhar (1949) the lateral expansions of the head were in the rudimentary stage of development. Fins were also in the rudimentary stage and spiracles were present. At this stage, the yolk stalk was devoid of any appendicula but squarish markings on the sheath were found to occur which evidently are the beginings of the development of appendicula. The gill slits were found with bunches of branchial filaments protruding out and this is the only character retained in 132 mm stage.

210 to 297 mm embryos

Intra-uterine embryos of this length range were all similar to adult in structure and shape. The characteristic lateral expansion (Fig. 1, 3) of the head are still directed backwards and have not attained the perpendicular position as noticed in adults. The anterior margin of the embryos are broadly curved and there is a strong median notch. The inner narial grooves are present and the nasal flaps are conical and blunt tipped. The eyes are well devloped and similar to those of adult and do not protrude beyond the surface of the tip of the hammer. Mouth conical in shape with traces of rudimentary teeth in both the jaws. In the corner of the mouth, on the lower jaw there is a small labial groove. The gills are well developed and there are no branchial filaments protruding out from the gill slits. All the fins have developed in their corresponding position and resemble those of the adult in shape and position. First dorsal origin just above the axil of the pectoral fin, pectoral origin behind the fourth gill slit and slightly ahead of fifth gill slit. The second dorsal originates above the posterior two third of the anal base, and its posterior extension does not reach the upper caudal pit. Anal origin nearer to the caudal origin than to the pelvic origin. Caudal fin almost similar to that of adult in shape and reaches one third of total length. Upper margin of the caudal fin convex and the terminal end broadly pointed. Body pale brownish. Dermal denticles examined from beneath the first dorsal fin in the upper part of the body has three strong teeth with corresponding ridges, the median tooth being the longest.

The proportional body measurements of 12 embryos in per cent of the total length (mean per cent in parenthesis) are as follows: Head length: 30.24-36.13 (33.19), internarial distance: 15.82-17.89 (16.70), mouth width: 5.72-7.62 (6.41), head length: 22.36-25.71 (23.18), snout to first gill slit: 17.22-19.99 (18.11), snout to first dorsal origin: 24.58-26.89 (26.11), snout to second dorsal origin: 56.71-60.16 (58.04), distance between dorsals: 20.17-23.32 (21.85), snout to pectoral insertion: 22.11-24.76 (22.89), horizontal diameter of eye: 1.89-2.57 (2.17), length of first dorsal base: 9.66-11.34 (10.87), length of second dorsal base: 3.33-4.37 (3.89), length of anal base: 5.26-6.73 (6.08), length of pectoral base: 4.59-5.46 (5.05), length of pectoral anterior margin: 13.16-14.16 (13.57), length of pelvic base: 4.59-5.70 (5.09), length of caudal fin: 32.32-35.18 (33.53).

Out of the twenty embryos examined in the present study nineteen embryos fall in this length group in which placentation has just begun or has been completed. The stages of placentation noticed in the same uterus varied considerably.

The 210 mm embryo (Fig. 1; 4), which was found in the anterior-most chamber in the left uterus of 1505 mm adult has a fairly big yolk sac with a thin, transparent yolk sac membrane. The posterior end of the yolk sac is highly

vascularised and there are indications of formation of convolutions in the yolk sac part to from ridges to establish placental connection with the mother. The uterine wall of this compartment also has very minute ridges. However, at this stage the yolk sac contains a large quantity of yolk. In 232 mm embryo of the 1520 mm specimen, found in the first compartment, prominent convolutions are seen in the distal part of the yolk sac and corresponding rudimentary ridges appear in the uterine wall of this compartment. The yolk sac end and the uterine wall surface are touching each other but do not closely interdigitate at this stage. The quantity of yolk in the yolk sac is also much less than in the previous embryo. In the 280 to 297 mm embryos found in the right uterus of 1505 mm adult in the posterior-most chambers, the placenta are completely formed. The distal end of yolk sac has deep convolutions. The epithelial folds in the posterior portion of the ventral side of the uterine wall are well developed (Fig. 1.5), and these folds fill the convolutions present in the yolk sac. The convolutions in the basal surface of yolk sac and the folds in the posterior portion of the uterine compartment closely interdigitate to establish the placenta. This area is highly vascularised. The placentation observed in *Sphyrna blochii* is similar to that of *S. tiburo* (Schlernitzauer and Gilbert, (1966), *Carcharhinus dussumieri* (Teshima Mizue and Koga, 1974). In the present stage yolk is not completely utilized and there are remnants of yolk present in the yolk sac. The placenta in *S. blochii* can be divided into a material portion and a foetal portion. The foetal placenta is divided into the smooth portion which is connected to the umbilical cord and the vascularised basal and lateral portions with convolutions and ridges, which are dark reddish in colour. This division of placenta is similar to that of *S. tiburo* and *C. dussumieri*.

As nutrition required for the embryonic development is supplied by the placenta, the yolk stalk is referred to as the umbilical stalk after establishment of the placenta (Teshma and Mizue, 1972). The umbilical stalk varies from 161 to 225 mm in length the embryos examined and all of them have appendicula arranged throughout its length except at the foetal and of the umbilical stalk at a distance of 25-30 mm length. The appendicula are leaf-like, flattened, bilobed or trilobed structures (Fig. 1.6), the length of which varies from 6 to 11 mm. The smaller appendicula are seen arranged closely towards the yolk sac end and the bigger one in the middle of the umbilical stalk. Alcock (1890) has given a detailed account of the structure of the appendicula from a 15 inch embryo of *S. blochii*. He observed three channels in the umbilical stalk *viz.*, the artery, vein and ductus vitellointestinalis, the last one situated in between the artery and vein.

Sex of all the embryos examined could be recognised and out of 20 embryos, 9 were males and 11 females. In the right uterus of 1505 mm female alone four out of the five embryos were females. Setna and Sarangdhar (1949a) observed that the female foetuses predominated in the gravid females of *S.*

blochii from Bombay waters. In the present material the number of embryos in each uterus varied from 4 to 6. Setna and Sarangdhar (1951) while observing the gestation of *S. zygaena* from Bombay waters also found equal number of male and female embryos in right and left uteri of a 7' 3" mother. James (1973) observed a 1330 mm gravid female of *S. blochii* from Palk Bay off Rameswaram with 11 embryos (8 males and 3 females) of size range 331 to 364 mm in February 1964.

Discussion

Teshima and Mizue (1972) have classified the development of selachii into viviparous and oviparous and the viviparous type is further divided into placentral and non-placental type. Both these type are again subdivided into two. The placental type is classified into one with multiple pregnancy and the other with simple pregnancy. The non-placental type is divided into those with uterine compartments and others without compartments. *S. blochii* falls into the placental type with multiple pregnancy, which is very similar to *S. tiburo*. The non-placental type recognised by Teshima and Mizue (1972) can be considered as ovoviviparous.

Although the number of specimens examined in the present study is very much limited, the present data and those from the earlier descriptions (Alcock, 1890, Setna and Sarangdhar, 1949, 1949a) indicate that mating of this species takes place from July to August and early stages of pregnancy are found during September and October (43 to 70 mm embryos recorded by Setna and Sarangdhar, 1949). In the present study the intermediate stages of embryos (132 to 294 mm) were observed during November and Setna and Sarangdhar (*op. cit.*) and James (1973) recorded advanced stages of embryos (325 to 450 mm and 331 to 364 mm) during February and March respectively. Setna and Sarangdhar (1949) also noted that the peak parturition period of this species in Bombay waters is April and May. The sexual activity of this species appears to be highest during monsoon months in Bombay waters and from September to October the early and intermediate stages were observed, the late stages were found from February to April. These observations suggest that the gestation period of *S. blochii* is about one year. In the Gulf of Mannar the advanced stages were found by James (1973) and he observed a female 1330 mm in total length having 11 embryos ranging 331 to 364 mm in size during February. In the present work adults with yolked eggs ranging from 4.5 to 12.5 mm in diameter, were recorded in March from Gulf of Mannar. Young ones with fresh umbilical marks ranging from 425 to 500 mm in size were observed during April and May and thus it could be suggested that the peak parturition period noted for this species in the Gulf of Mannar is March and April. However, more detailed observations are necessary to confirm the above information on gestation of this species.

The embryonic membrane store chamber found in this species corresponds to that of *Carcharhinus dussumieri* observed by Teshima and Mizue (1972).

The size of the embryos found in a single mother vary considerably and the most advanced embryo is seen in the posterior-most chamber. Similar observations have been made in the dogfish *Mustelus canis* from Woods Hole (TeWinkel, 1950). The sex ratio of the embryos in gestating female of *S. blochii* is almost equal in most of the specimen observed. In the 132 mm embryo of *S. blochii* reported here the placentation has not started, while Setna and Sarangdhar (1949a) have noticed the begining of placentation in 125 mm embryo from Bombay coast. The examination of 210 mm embryo revealed that there are traces of convolutions in the yolk-sac and also in the uterine wall of the compartment, thus showing evidences of begining of placentation. It is thus assumed that the placentation in *S. blochii* starts at a stage in between 125 and 210 mm size.

Mahadevan (1940) concluded that the placenta of *C. dussumieri* is the most primitive, the placenta of *Scoliodon sorrakowah* is most advanced and those of *S. palasorrah* and *S. wallbeehmi* to be intermediate in character between that of *S. sorrakowah* and *C. dussmumieri*. She found best developed appendicula in forms with the best developed placenta where as Teshima (1973) states that simple pregnancy appears to be much more evolved than multiple pregnancy and considers that *C. dussumieri* belongs to the simple type. The placentation in *S. blochii* can be considered as intermediate between *S. sorrakowah* and *C. dussumieri*

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