STUDIES ON THE DEVELOPMENT OF SOME BOMBAY ELASMOBRANCHS.

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INTRODUCTION.

In a previous paper we (1946) gave an account of the Selachian fauna of the Bombay waters and recorded 41 species, of which 39 were either viviparous or ovo-viviparous, the only oviparous forms being *Chiloscyllium griseum* (M. & H.) and *Stegostoma tigrinum* (Forster). Gravid females of a number of viviparous species are landed at Sassoon Dock, Bombay, during the fishing season from September to May, and a study of this material has enabled us to describe the developmental phenomena in some of these viviparous forms which, we believe, are being recorded in India for the first time. These observations have been made on more or less the same lines as have been done previously by Alcock (1890), Woodmason & Alcock (1891), Southwell (1910), Southwell & Prashad (1919) and Mahadevan (1940) on other species of sharks and rays, obtained chiefly off the eastern coast of India.

The terms " intermediate stage " and " advanced stage " used by us to denote different stages of utero-gestation need explanation. The term " intermediate stage " denotes those stages of pregnancy in which the embryonic yolk-sac, while still containing a quantity of yolk within its cavity, displays a rudimentary placental connection with the uterine wall, while the term " advanced state " denotes that the foetal development has advanced to an extent when the yolk-sac no longer contains any yolk and the placental condition has assumed a purely haemotrophic character.

Developmental Stages.

Scoliodon acutus (Rüppell).

Intermediate Stage.—(Parent ♀: total length 28″; app. wt. 3 lb.; November 11, 1942.) In this specimen only the right ovary was present containing pale rounded ova, 2·0 to 3·0 mm. in diameter, only two eggs being 5 mm. in diameter, with pale yellow yolk. The epigonal organ had an elongated, purplish pink ribbon-shaped structure. Unlike the condition in *S. palasorrah* and *S. walbeehmi* each nidamental gland consisted of two coiled horns apposed against the opposite walls of the uterus. The caudal portions of the oviducts were unusually short. The uteri were elongated, sausage-shaped bags united caudally. The right uterus was divided into two compartments by a central longitudinal partition and contained two embryos, a male and a female, while the left had a single compartment with a single male embryo. The embryos were enclosed in membranous sacs of shell membranes which were devoid of any watery, albuminous liquid. The embryos had already become attached to the uterine walls through their yolk-sac placentae.

One of the male embryos (Text-fig. 1*a*) had the following dimensions :—

Total length	157 mm.
Length of caudal fin	47 mm.
Length of umbilical cord	162 mm.
Yolk-sac placenta	25×10 mm.
Length of clasper	3 mm.

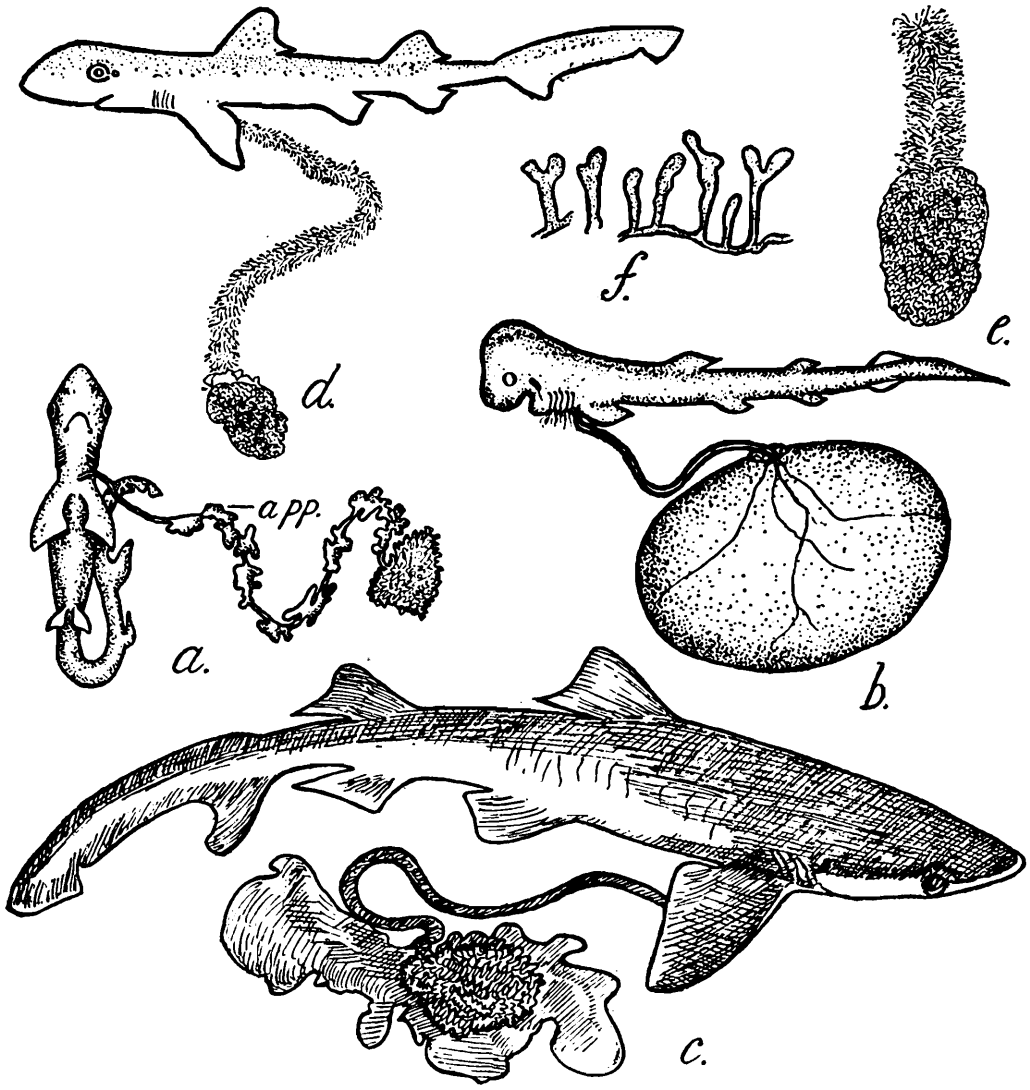
Unlike the adult, the embryo was for the most part cream-coloured, with only very scant pigmentation in the dorsal region and on the edges of the first dorsal and caudal fins. Scales had not yet developed and the branchial filaments had been completely absorbed. The vestigial spiracles devoid of any filaments, were however, discernible behind the eyes just above the angles of the mouth in the form of minute rounded apertures. Eyes are from four to five times as large as the gill-slits, which were comparativly very small, showing in this respect a marked difference from the adult condition.

Yolk-sac placenta.—The foetal placenta is formed by the original yolk-sac, the walls of which were irregularly and densely folded over its *entire* surface, the folds still containing a considerable quantity of yellowish white yolk. These folds were interdigitate with the vascular villi of the more or less circular trophonema, a ridged, villous and highly vascular patch of the uterine mucous membrane, in the posterior part of the compartment. This constituted the maternal placenta.

The foetal and maternal tissues were not, however, in direct contact, as fold of the shell-membrane intervened between them. The wall of the foetal placenta was fairly vascular at this stage. The placenta closely resembles that of *S. palasorrah* and obviously with the complete exhaustion of yolk in its folds, would give rise to an " entire " placenta.

Umbilical cord.—It consists of a central yolk-duct, accompanied by an artery and a vein enclosed in a sheath of connective tissue. The latter was irregularly folded in a peculiar fashion all along its course to give rise to irregularly-contoured, rather narrow and flattened outpushings

—the appendicula—which were only moderately vascularised on their internal surface.



TEXT-FIG. 1.—Embryonic stages of Bombay sharks.

a. Scoliodon acutus (Rüpp.), embryo in intermediate stages of development with umbilical cord and foetal placenta of the 'entire' variety. Note the characterstic appendicula. *b. Carcharinus temminckii* (M. & H.), embryo in early stages of development (27 mm.—stage). *c. C. temminckii*, foetus in advanced stages of development with placental cord and placenta of the 'discoid' variety. *d. Hemigaleus balfouri* Day, embryo in advanced stages of development with placental cord and placenta of the 'entire' variety. *e. H. balfouri*, magnified view of foetal placenta. *f. H. balfouri*, magnified view of appendicula.

On tracing the umbilical vessels within the body of the embryo, the vein was seen to join the hepatic portal vein before the latter bifurcates into the hepatic lobes, while the artery opened into a branch of the coeliaco-mesenteric artery, the other branch of which enters the posterior wall of the intestine. The yolk-duct opened into the colon directly and there was no internal *yolk-sac* at this stage.

Carcharinus temminckii (Müller & Henle).

27 mm. Stage.—(Parent ♀: Total length 5′-3″; App. wt. 60 lb.; Aug. 8, 1942.)—This female specimen possessed a single ovary containing small eggs varying from 2 to 7 mm. in diameter. Only the larger

eggs contained pale-yellow yolk. The epigonal organs formed prominent, strap-shaped, purplish-pink structures. Each of the nidamental glands consisted of two coiled horns and was situated nearer the upper pole of the uterus. Each uterus was divided into four transversely placed compartments, each containing a tiny embryo with its umbilical cord and yolk-sac enclosed in a spindle-shaped, water-filled sac of the shell membrane. While the distal end of the shell-membrane sac was folded and compressed into a compact tuft, the proximal end, was only a folded and twisted cord, passing out of the compartment in an irregular course and lying in a tunnel of the submucosa of the posterior wall of the uterus.

Embryo (Text-fig. 1*b*).

Total length	27 mm.
Length of caudal fin	7 mm.
Length of umbilical cord ..	15 mm.
Diameter of yolk-sac ..	31 mm.
Distance between spiracle and first gill-slit	31 mm.

The embryo was crimson-coloured. Its head region was swollen and quite transparent, the divisions of the brain being distinctly visible. The region of the snout was depressed, rounded in outline and distinctly marked off from the head region. The snouts of some embryos presented a beak-like contour viewed from the side. The rounded outline of the snout contrasts at this stage, markedly with the pointed and triangular outline of the snout in the adult. The eyes were prominent and the pupils large and rounded, there being only a slight pigmentation in front of and behind the pupil. The gill-slits were almost vertical and from each slit emerged a bunch of short crimson-coloured branchial filaments swollen at their tips. A short distance in front of the first gill-slit, situated just above the angle of the mouth, was the prominent, oblique, spiracular slit, possessing a pair of very short spiracular filaments. All the fins had developed in their respective adult positions, though they were in very rudimentary forms of being mere flaps of skin. The subcaudal lobe had not yet been clearly marked. The sexes were also not yet distinct.

Yolk-sac and umbilical cord.—The yolk-sac was a thin-walled bag enclosing pale yellow yolk. Its walls were interspersed with blood-capillaries which ultimately united to form an umbilical artery and a vein. These vessels passed up into the cord through a gelatinous disc at the upper pole of the yolk-sac. The cord consisted of the usual artery, the vein and the yolk-duct. It was devoid of any appendicula.

The features described above tallied exactly with those of the embryos of a female landed at Sassoon Dock on August 19, 1942, except for the fact that the distance between the spiracular slit and the first gill-slit had greatly increased now. This was because these embryos were bigger (average total length 43 mm.) than those obtained on the previous occasion. All the embryos were not equally developed, but differed slightly, in their total lengths.

Intermediate stage.—(Parent ♀: Total length 4′-9″; App. wt. 60 lb.; October 9, 1943). Each uterus of this female contained four embryos. The uterine compartments were disposed obliquely, each containing an

embryo, with its umbilical cord and yolk-sac enclosed in a thin, transparent water-filled sac of the shell-membrane. The embryos did not lie freely in the compartments but were attached to the uterine wall through rudimentary yolk-sac placentae. In each uterus, two embryos were male and the other two female.

Embryo.

Total length	128 mm.
Length of caudal fin	30 mm.
Length of umbilical cord	.. 120 mm.
Yolk-sac	113×100 mm.

Although the various external morphological features of the species had already been developed, there were certain conspicuous differences from the adult condition. The head was thicker and broader than in the adult and the teeth had not yet been formed. The spiracular slits had closed but bunches of crowed branchial filaments still protruded from the gill-slits. The characteristic relative sizes and positions of the various fins were, however, markedly discernible. The process of pigmentation had not yet commenced and the scales not yet made their appearance. The embryos were mostly ivory yellow in colour.

Yolk-sac placenta and umbilical cord.—The yolk-sac formed a spacious, thin-walled sac filled with thin, pale yellow yolk. Its walls were fairly vascular and the folds on its basal region had become firmly interlocked with crypts between the vascular villi of the trophonema, which constituted the maternal portion of the placenta. Folds of the shell-membrane intercepting the foetal and maternal tissues appeared in firm contact with the former.

The structure of the umbilical cord was essentially similar to that of the previous stage. The yolk-duct opened into the colon directly and there was no internal yolk-sac at this stage.

In embryos 205 mm. long, the branchial filaments were no longer present and a minute diverticulum-like internal yolk-sac was seen to have developed between the yolk-duct and the colon.

Advanced stage.—(Parent ♀: Total length 5′; App. wt. 80 lb.; February 5, 1942). Each uterus was divided into four compartments and contained four well-developed embryos enclosed in water-filled sacs of the shell-membrane. The compartments were disposed antero-posteriorly. As in the previous stage, the embryos were connected to the uterine wall through the medium of the yolk-sac placentae. Two of the embryos in one uterus lay in a prone position (mother lying on her back) while two supine. The placental cord in each prone-embryo was seen to twist round the middle of its trunk, and, extending backwards along its dorsal aspect joined the yolk-sac placenta in the posterior part of the compartment. No such twisting of the placental cord existed in the case of the supine embryo and the cord extended directly backwards to join the placenta. Of the four embryos in each uterus, two were males and two females.

Embryo (Text-fig. 1*c*).

Total length	375 mm.
Length of caudal fin	87 mm.
Length of placental cord	193 mm.
Width of the placental disc	43 mm.
Length of clasper ..	12 mm.

The embryos were completely formed externally and resembled the parent in every respect. The dorsal colouration appeared perfect, but the ventral surfaces of the embryos lacked the characteristic pinkish hue, a feature which develops, we believe, with free life. The embryos possessed placental cords and well-developed yolk-sac placentae.

Yolk-sac placenta and palcental cord.—The yolk-sac no longer contained any yolk and had become modified to give rise to a full-fledged yolk-sac placenta of the 'discoid' variety. Its proximal wall was completely devoid of any folding, and extremely thin with a few blood-capillaries, while the distal wall appeared excessively plaited and frayed with the various folds and frills branching and rebranching so as to increase the surface of contact considerably. The result was a more or less compact, crimson-coloured, disc-like mass, roofed over by the proximal unfolded tissue and constituting the foetal placenta which, in the fresh condition, resembled greatly a crimson *Dahlia*. The innumerable crypts between the folds of this foetal placenta were firmly interlocked with the vascular villi on the ridged trophonema—the maternal component of the placenta. Folds of the shell-membrane intervening between the foetal and the maternal tissues, were in firmer contact with the former, having followed it through every fold and frill.

The placental cord consisted of the usual three structures, *viz.*, the artery, the vein and the yolk-duct, though the latter had more or less completely atrophied at this stage, with the absorption of the yolk. The cord was devoid of any appendicula.

Hemigaleus balfouri Day.

Intermediate stage.—(Parent ♀: Total length 32″; App. wt. 4 lb.; October 16, 1942.) This specimen had only the left ovary which contained small, pale, yolkless eggs, even smaller than peas. The right uterus was divided into three compartments and contained three embryos, while the left possessed only a single compartment and a single embryo. All the embryos lay with their heads towards the caudal end of the mother. They were connected to the uterine mucous membranes of their respective compartments through the medium of their yolk-sac placentae. Two of the embryos in the right uterus were female and one male, whereas that in the left was a female.

A peculiar feature in this specimen was that the shell-membranes covering the embryos were not entire, but broken up into small fragments which gave rise to pale yellow, shiny, opaque liquid bathing the embryos. It was thus apparent that the shell-membranes were undergoing degeneration, probably nutritive, and that in this respect the condition resembled that in *Scoliodon sorrakowah* (Setna & Sarangdhar, 1948).

Embryo (Text-fig. 1*d*).

Total length	135 mm.
Length of caudal fin	32 mm.
Length of placental cord .	90 mm.
Yolk-sac placenta .. .	12×17 mm.
Length of an appendiculum ..	5 mm.

The embryo was nearly completely formed and resembled the adult in most of the external morphological features. Unlike the adult its head region was still swollen and sharply depressed in front where it merged into the region of the snout. The embryonic spiracle was circular whereas in the adult it is oval in outline. Branchial filaments had been completely absorbed. The embryo was ivory-coloured, the general process of pigmentation not having yet commenced. The apices of both the dorsal fins were dark and slightly pigmented, whereas in the adult only the top of the second dorsal is blackened. The embryo had an umbilical cord and a yolk-sac placenta.

Yolk-sac placenta.—The yolk in the sac had almost been exhausted and the walls of the sac appeared greatly plaited and folded so as to form a highly wrinkled foetal placenta very much resembling a tuft of wool. Only a few small folds at the umbilical end of this wrinkled mass still contained some yolk. The placental folds were not lax but firm, with a definite tone. Dissection of the placenta revealed ramifications of the umbilical vessels on the internal surface of the folds. The crypts between these folds were firmly interdigitated with the vascular villi on the uterine mucous membrane, thus completing the placental arrangement.

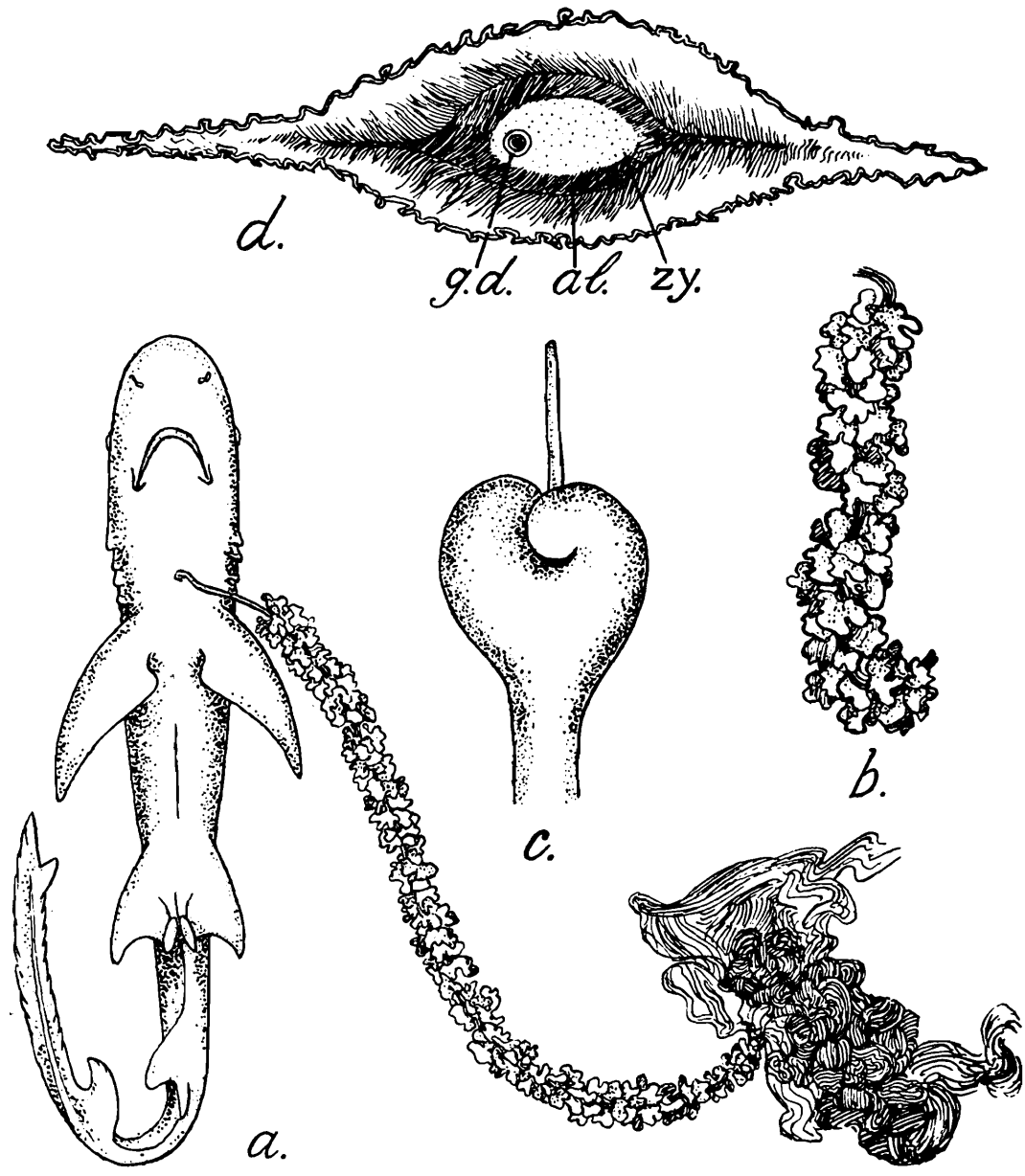
Umbilical cord.—The usual umbilical vessels and the yolk-duct were seen to be enclosed in a sheath of connective tissue which bears innumerable, short, thin, flat and delicate appendicula throughout its entire length giving the cord a very shaggy appearance. The appendicula possessed flat and rounded tips which were occasionally bifid or even trifid. Rarely an appendiculum branched into two terminally (Text-fig. 1*f*). An internal yolk-sac was not yet present in the embryo.

Advanced stage.—(Parent ♀: Total length 33″; App. wt. 4 lb.; November 24, 1942.) Each of the two uteri of this female contained two well-developed foetuses. Three of these were females and one male. The foetuses measured, on an average, 200 mm. in total length and were perfect replicas of the parent fish. There was no trace of yolk in their placentae and even the yolk-ducts had completely atrophied. The placentae were of the 'entire' variety (Text-fig. 1*e*).

Hemipristis elongatus (Klunzinger).

Advanced stage.—(Text-fig. 2*a*).—(Parent ♀: Total length 7′ 3″; App. wt. 300 lb.; October 19, 1943.) In this specimen only the right ovary was present as a large, flattened organ studded with small, pale green ova about the size of peas, none containing yellow yolk. The epigonal organ was an elongated, greyish pink band, merged anteriory into the substance of the ovary. The nidamental glands were large and

situated nearer the upper poles of the uteri. Each measured 40×32 mm. and consisted of two coiled horns, one superposed over the other (Text-fig. 2*c*). The uteri were long, bag-like structures with thin, spongy, vascular walls. The right was divided into four longitudinal compartments and contained four well-grown embryos, while the left had three



Text-fig. 2.—Embryonic stages of Bombay sharks.

a. Hemipristis elongatus (Klunzinger), foetus in advanced stages of development with placental cord and placenta of the 'entire' variety. *b. H. elongatus*, magnified view of a portion of placental cord showing the peculiarly plaited and frilled appendicula. *c. H. elongatus*, magnified view of nidamental gland. *d. Myrmillo mustelus* (Linnaeus), fertilized egg enclosed in shell membrane sac.
ab. albumen surrounding the zygote ; *g.d.*, germinal disc ; *zy*, zygote.

compartments, two with embryos, and the third being an undeveloped compartment containing an unfertilized egg enclosed in a spindle-shaped shell-membrane sac. The embryos were enclosed in shell membrane sacs containing a dirty yellow, opaque liquid, in which were distributed what looked like small bits of coagulated yolk-like matter. Probably this may be a nutritive fluid formed as a result of the mixing up

of the albuminous liquid secreted by the nidamental gland and the secretion of the glandular uterine mucosa, absorbed by the prominent appendicula on the placental cords of the embryos. The latter did not, however, lie freely in the compartments but were attached to the uterine wall through the medium of their well-developed yolk-sac placentae. Three out of the four embryos in the right uterus were males and one female, whereas in the left one was male and one female.

Embryo.

Total length	387 mm.
Length of caudal fin	115 mm.
Length of umbilical cord	300 mm.
Yolk-sac placenta	90×62 mm.
Appendiculum	12×10 mm.

The embryo was nearly completely developed at this stage, but differed from the adult form in some important respects. Faint brown pigmentation was apparent, though still very sparse. The length of the preoral snout was slightly greater than the width of the mouth. The teeth were not yet visible externally. The most singular feature in the embryo was, however, its possession of a very prominent and peculiarly appendiculated placental cord and a very well-developed yolk-sac placenta.

Yolk-sac placenta.– The foetal placenta was formed by the original yolk-sac which had now become completely devoid of any yolk. Its walls were excessively folded over its entire surface so as to give rise to a mass of highly wrinkled, crimson-coloured vascular frills and folds, lined very intimately by folds of the shell-membrane. This placenta was very firmly interdigitated with the vascular villi on the maternal trophonema, the villous ridges of which are arranged in more or less circular rows, so that the entire maternal placenta presented a flower-like appearance. A certain amount of force was necessary to pull apart the foetal from the maternal tissues and in this attempt, the foetal tissue withdraws along with it the shell-membrane folds that rub in intimate contact with it. The foetal placenta is of the ' entire ' placental variety.

Placental cord and appendicula (Text-fig. 2*b*).—The appendicula were of a unique type, consisting of highly vascular, semi-transparent and sinuously-contoured, broad frills or flaps. These extended in dense clusters almost throughout the entire length of the cord, imparting to it an uncommon anatomical feature, rarely met with in other Elasmobranchs. These appendicula represented undoubtedly a stage of development more pronounced than that of the appendicula in *Scoliodon acutus*, in which the appendicular frills were not so prominently developed. The two types of appendicula appear, however, to be of the same morphological variety and hence comparable. The well-developed appendicula in the present case were, apparently, capable of absorbing the composite nutritive liquid in the shell-membrane sacs.

The placental vessels in the cord had their usual connections within the embryonic body and the atrophied yolk-duct was not seen to be related to an internal yolk-sac.

Myrmillo mustelus (Linnaeus).

Fertilized eggs (Text-fig. 2*d*).—(parent ♀: Total length 32″; App. wt. 4 lb.; November 2, 1942.) In this specimen only the left ovary was present as a small flattened organ beset with small, pale ova, only a few being as large as peas. The ova were rather flattened and had yellow yolk. The characteristic epigonal organ was merged anteriorly into the substance of the ovary. Each nidamental gland consisted of two coiled horns. The cavity of each of the two uteri was divided into three oblique compartments but these were not yet shut off from one another as the intervening partitions had not yet been completely formed. Each compartment contained a *zygote* enclosed in a spindle-shaped sac of the shell-membrane similar to that described by Sarangdhar (1943) for *Galeocerdo tigrinus*. The zygote was an oval mass of scarlet-yellow yolk having at one of its poles a round dark, opaque speck surrounded by a light halo—the germ disc. The germinal disc was the biggest in the zygote nearest to the cloacal end of the uterus.

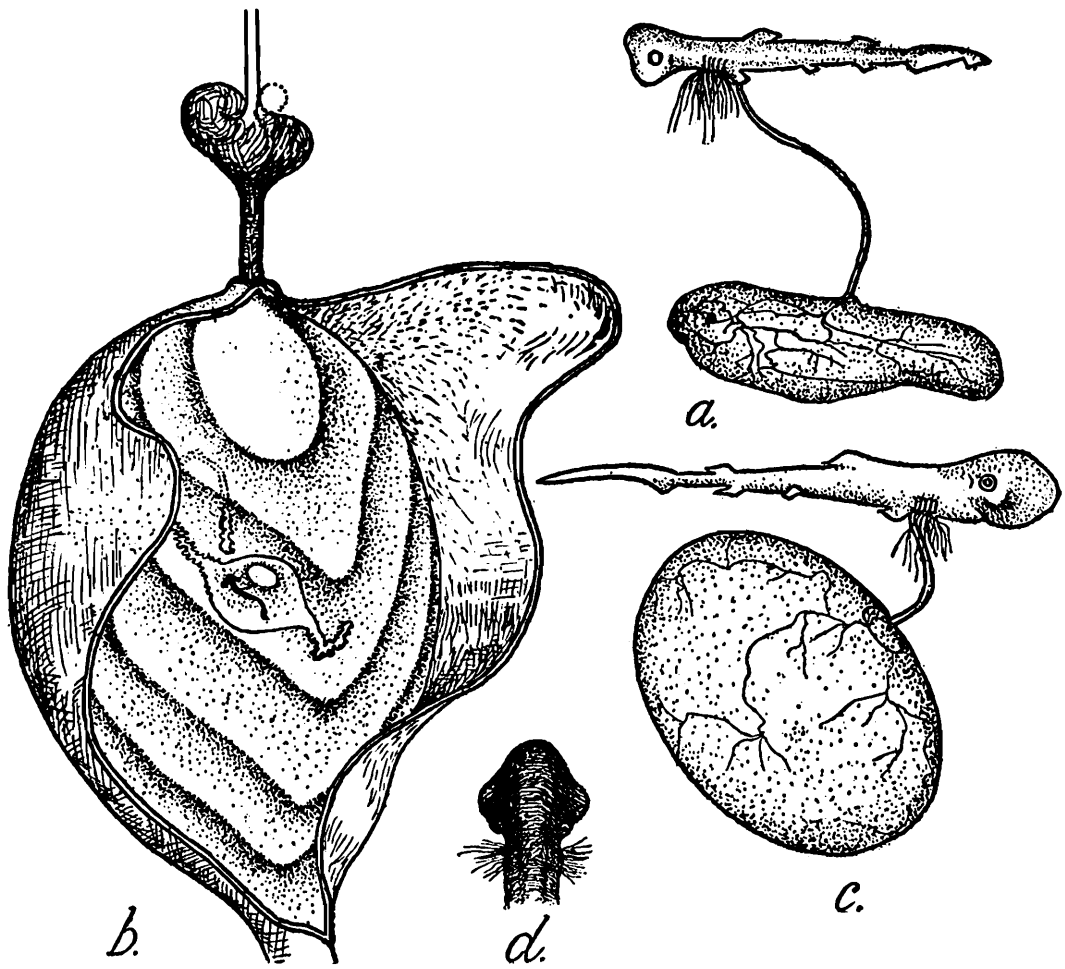
38 mm.—stage.—(Parent ♀: Total length-32″; App. wt. 4 lb.; December 20, 1943). The reproductive organs of this female were quite similar to those described in the previous stage. The uterine compartments were, however, complete at this stage, the right uterus having five compartments but only four embryos and an empty shell-membrane sac, and the left, five compartments and five embryos. The embryos, together with their yolk-sacs and umbilical cords were enclosed in shelly sacs containing thin films of gelatinous albumen which had not yet been liquified. As none of the embryos displayed clasper buds, it is possible that either all the embryos were female or that the sexes had not yet been differentiated externally.

Embryo (Text-fig.3*a*).

Total length	38 mm.
Length of caudal fin	7 mm.
Yolk-sac	47×18 mm.
Length of umbilical cord	40 mm.
Maximum length of branchial filament	3 mm.

The embryo was cream-coloured suffused with crimson in the region of high vascular activity and the process of pigmentation had not yet commenced. The head region was rounded and swollen and merged almost vertically downwards into a soft broadly-rounded snout. Very minute slit-like nostrils were distinguishable on the ventral surface of the snout. The mouth formed a fairly large pit hardly bounded by jaws but the characteristic prominent labial folds were discernible at the angles of the mouth. The eyes were rounded and prominent with bulging lenses, pigment stripes being noticeable in front of and behind each lens. Small, nearly vertical spiracular slits devoid of filaments were present behind the orbits. Bunches of short vascular, branchial filaments emerged through the gill-slits, which region was rather more inflated than the rest of the body. All the fins had developed in their respective adult positions, but they were more semicircular flaps without the characteristic adult shapes and fin rays.

Yolk-sac and umbilical cord.—The yolk-sac was horizontally ovoid in shape and filled with scarlet-coloured yolk. The blood capillaries interspersed in its walls gave rise to the umbilical vessels, which, together with the yolk duct passed up into the umbilical cord through a gelatinous disc. The umbilical cord was devoid of any appendicula.



TEXT-FIG. 3.—Embryonic stages of Bombay sharks.

a. Myrmillo mustelus (Linnaeus), embryo in early stages of development (38 mm.—stage). *b. Sphyrna blochii* (Cuvier), gravid uterus in early stages of pregnancy opened to show the V—shaped disposition of the compartments. One of the compartments with an embryo enclosed in shell-membrane sac. *c. S. blochii*, Profile of 43 mm.—stage embryo. Note the rudimentary lateral expansion in front of the eye. *d. S. blochii*, dorsal aspect of head of a 43 mm. embryo showing rudimentary lateral expansions and the orbits just behind them.

Sphyrna blochii (Cuvier).

43 mm.—stage.—(Parent ♀: Total length 4′-4″; App. wt. 25 lb.; September 28, 1942.) Only the right ovary was present which was studded with pale ova not bigger than peas. Two or three eggs were about 8 mm. in diameter and contained pale yellow yolk. The cavity of each of the uteri was divided into five compartments, each roughly V-shaped. The greater arm of the V, representing the major portion of the compartment (Text-fig. 3 *b*), occupied an obliquely transverse position, while the smaller inclined upwards at an angle, lay in a more or less vertical narrow corner of the compartment. In each uterus only three compartments contained embryos while the other two contained

unfertilised eggs. The embryos, together with their appended structures, lay enclosed in shell-membrane sacs, the ends of the membranes being folded into compact tufts. The tufts near the cranial end were invariably more folded than at the caudal extremity. The sacs containing the embryos contained a small quantity of watery albuminous liquid similar to that in other Elasmobranchs. The unfertilised eggs, too, were enclosed in spindle-shaped sacs of shell-membranes. The mucous membrane of each compartment was highly vascular, almost crimson in colour, but did not at this stage, show any modification into trophonematous ridging.

Embryo (Text-figs. 3*b* and *c*.)

Total length		43 mm.
Length of caudal fin		12 mm.
Length of umbilical cord		25 mm.
Yolk-sac	62	×75 mm.
Length of branchial filament		3 mm.

The embryo was nearly completely formed externally but the head region had not yet assumed the characteristic hammer-shaped form (*Sphyrnidae*). Rudiments of the 'hammer' had, however, been formed as very small lateral projections on the lateral borders of the head, immediately in front of the eyes. Due to their presence, the head presented in the dorsal aspect, a rounded outline terminally, with two slight lateral bulges in the ocular region (Text-fig. 3 *d*). The head region was soft and swollen, as were also the lateral expansions. Chondrification had not set in at this stage. Each lateral rudiment bore on its ventral aspect a slit-like nostril. The eyes were fully formed and situated immediately behind the lateral rudiments, though on a slightly more dorsal aspect. Their position was exactly similar to that in the corresponding stages of other sharks (*Carcharhinidae*) and did not give any indication that they would subsequently move away from the head and migrate to the tips of the 'hammer' in the fully-formed condition. V-shaped, oblique spiracular slits were discernible immediately behind the orbits. They were however, devoid of any spiracular filaments. The gill-slits had bunches of branchial filaments protruding from them. All the fins had appeared in their respective adult positions but were in a rudimentary state of development, the delicate fin rays not being quite enclosed by the fin-membranes. Also, the caudal fin was not at this stage, quite one-third the total length as in the adult condition. The V-shaped myotomes were visible through the semi-transparent skin. In the caudal region they had not yet assumed the V-shaped character but were in the form of vertical muscle plates only.

Yolk-sac and umbilical cord.—The yolk-sac was a thin-walled oval sac containing thin cream-coloured yolk. Its walls were interspersed with a network of prominent capillaries which joined to form the umbilical vessels. At its upper pole was a transparent gelatinous oval disc through which the umbilical vessels and the yolk-duct passed into the umbilical cord. The umbilical sheath was quite plain and smooth and the characteristic locular appendicula described by Alcock (1890) had not yet made their appearance. Squarish markings on the sheath, in all probability, forerunners of the appendicula, could, however, be distinguished at this stage.

Mobula diabolus (Shaw).

Parturition stage.—Several gravid females measuring 3'-9" to 4' across the disc were landed throughout May, 1943. Their examination revealed the following interesting reproductive features :—

Only the left ovary, left oviduct and the left uterus were developed, these structures being altogether absent on the right side. During pregnancy the uterine mucous membrane was beset uniformly over its entire surface with crowded, thin short, flattened but highly vascular villi—the trophonemata—which secrete a thin yellowish nutritive liquid with which the embryo is bathed. A single embryo was borne at a time and at full term was seen to lie in a supine position (mother lying on her back) with its ' wings ' folded backwards and its cephalic horns directed medially so as to meet in the middle line. At term its dimensions are :—

Width across disc	400 mm.
Length of disc	200 mm.
Length of tail	175 mm.
Approximate weight	3 lb.

The foetus was light purple in colour dorsally and white ventrally. It was a perfect replica of its parent. Even the yolk-stalk and sac were completely absorbed at this stage so that even the umbilical scar was no longer visible. There was no caudal spine in the tail but a darkish thickened marking behind the dorsal fin indicated its position of suppression The foetus was completely formed and ready to be born.

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