DESCRIPTION, BIONOMICS AND DEVELOPMENT OF *SCOLIODON SORRAKOWAH* (CUVIER).

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INTRODUCTION.

As a result of serious food shortages during the war and stoppages of imports from abroad, fishery of the Sharks and Rays became very popular, principally for the production of rich vitamin bearing liver oils but also as a valuable source of protein food. In consequence, the catches of these fishes increased manyfold and even immature specimens are not spared. The fishery officers began to realise that such an indiscriminate fishing and injudicious exploitation, particularly of gravid females and immature forms, may, in course of time, lead to a depletion of the Selachiam fauna and the need for working out the life-histories of commercially important species became evident, for at any stage it may become necessary to control the fishery by legislative measures. The present communication is the result of investigations conducted in Bombay waters over a period of three years since 1942.

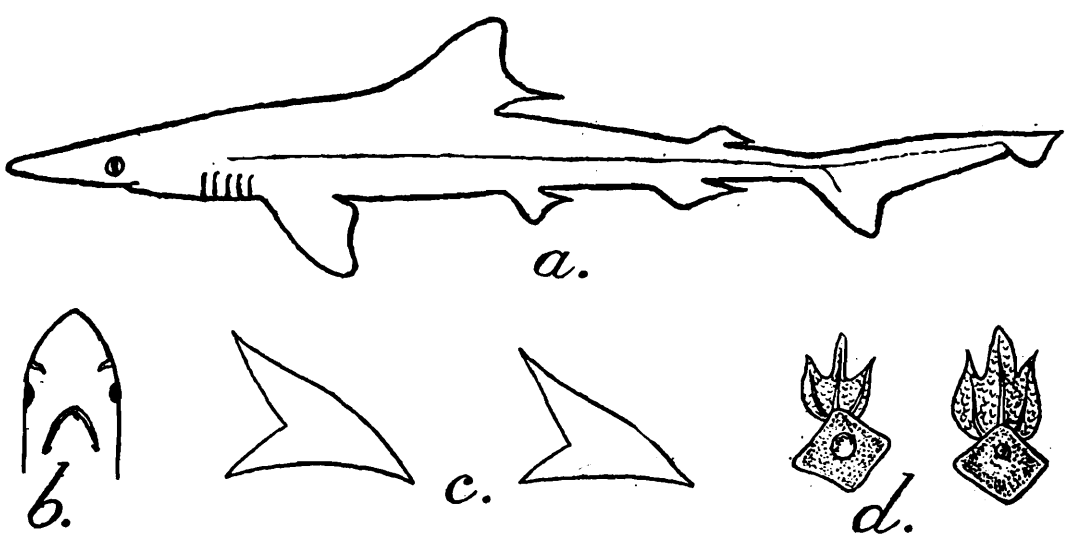
The Shark *Scoliodon sorrakowah*, locally known as "Son Mushi", is in great demand with a section of the Bombay Public as a table delicacy. The species is found in Bombay waters throughout the year in fair abundance and is perhaps the smallest among the present-day viviparous Elasmobranchs. Some of its placental features were described by Mahadevan (1940) and next year Choodamani (1941) described its eggs.

As will be shown below, this shark is remarkable for its mode of foetal nurture and the adaptive structural modifications it has undergone for this purpose. The histology of the placental features described here is perhaps unique among Elasmobranchs, in so far as it approaches the highly evolved placentation among the mammals.

A set of specimens representing various phases in the development of the species is deposited in the collections of the Zoological Survey of India for convenience of reference in future.

DESCRIPTION.

The snout (Text-fig. 1*a*) is rather thin, elongated and pointed; its sides are not quite straight. The length of its preoral portion (Text-fig. 1*b*) exceeds the width of the mouth by one-fourth and is slightly more than the distance between the eye and the first gill-opening. The groove at the angle of the mouth extends a short distance along the lower jaw but not along the upper. The nostrils, with triangular flaps, are nearer the mouth than the end of the snout. The teeth (15.1.15/14-15.0.14-15) are thin and flat, with deep external notches and without swollen bases (Text-fig. 1*c*) ; their borders are entire. The teeth on both jaws are obliquely situated, but more so near the symphysis, where they are arranged in a close-set bunch. Scales (Text-fig. 1*d*) are small in size and thickly set all over the body. The basal plate is quadrangular in outline with rounded angles. The spines are trident with three keels and each spine is about twice as long as abroad. The central cusp is the highest. *Fins;* The pectoral fin originates below the last gill slit and does not extend to below the first dorsal. Its posterior border



TEXT-FIG. 1.—*S. sorrakowah* (Cuvier)

a. Lateral view; *b*. Under surface of head; *c*. Teeth; *d*. Dermal denticle.

is nearly straight. The first dorsal fin is situated almost in the middle of the trunk and its posterior tip extends above the pelvic fins. The latter are about one-third the size of the pectorals. The second dorsal fin originates above the posterior fourth of the base of the anal and is much smaller than it. The anal fin is an unnotched, triangular, flap-like structure about three to four times as long as low. Its basal

length exceeds twice that of the second dorsal. The caudal fin is contained four times in the total length. It is a broad blade-like structure with a deep notch posteriorly. The sub-caudal lobe is not sharply marked off from the caudal blade and extends but slightly below the caudal fin. The colour is pale greyish bronze above, dull white at sides and beneath. The maximum length of this species in Bombay waters is 26″, while that from Madras observed by Mahadevan (1940) is 29″ Females attain maturity when about 17″ long and the smallest male possessing long and well-developed fusiform claspers measured 18″ in length, indicating that maturity in both sexes is attained when they are of about the same size.

BIONOMICS.

The species is generally an inhabitant of the rocky regions close to the shore and is obtainable in Bombay waters within a radius of two to three miles off the coast. Its seclusion in a rocky abode makes its catching with nets difficult, and thus hooks and lines are commonly employed for its capture. The presence of some specimens in fishermen's nets is probably due to their having strayed away from their habitat to prey on fish already trapped in the nets.

The fish generally swim in shoals in quest of food. The individuals are either all males or all females. This characteristic may be noted at the landing sites where the fish caught will be found to be exclusively males or females.

The species feeds voraciously on prawns, shrimps, cuttlefishes, etc., and such small shoaling fish as '*Mandela*' (*Coilia dussumieri*), '*Kaleti*' (*Trypauchen vagina*), '*Khada*' (*Bregmaceros maclellandi*) '*Bombil*' (*Harpodon nehereus*), etc. These varieties figure regularly among their stomach contents.

Fishermen assert that the flesh and entrails of *S. sorrakowah* make excellent bait for '*Shingala*' (*Arius* sp), '*Wam*' (*Muraenesox talabonoides*) and larger sharks, probably because of a peculiar strong odour that emanates from them even in the fresh condition.

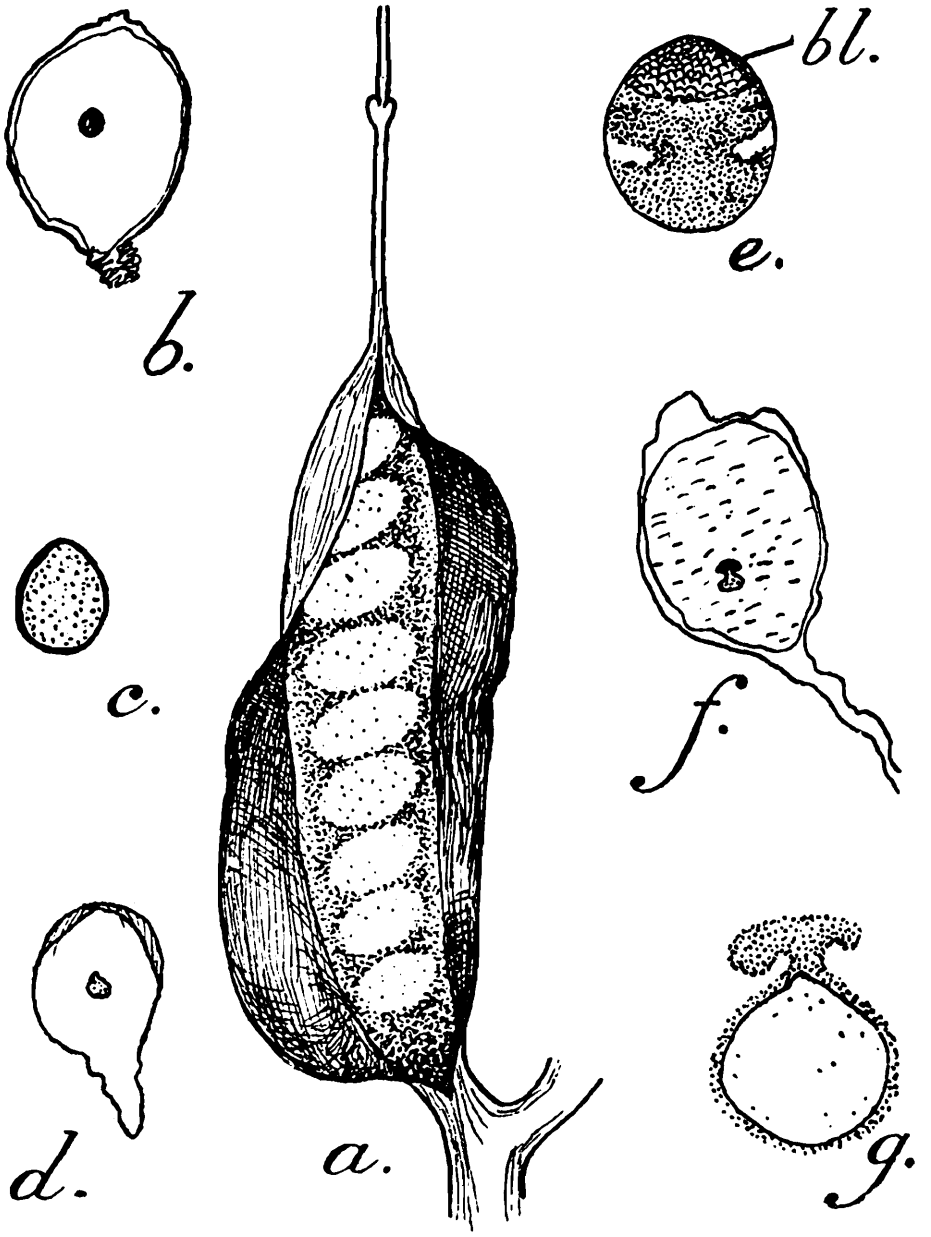
DEVELOPMENT.

Early Pregnancy.—Under this heading are included those stages of pregnancy which display the growth and subsequent full-fledged morphological structure of trophonemata.

Intra-capsular eggs.

Examination of the reproductive organs of a female measuring 23″ in total length and landed on 5th January, 1943 showed that both the ovaries were present and contained small, rounded, whitish opaque ova about the size of pin heads, and sometimes even smaller, the largest measuring a millimetre in diameter. There was no trace of yellow yolk in them, Epigonal organs were present as long, thin strips of pinkish crimson hue, merging anteriorly in the substance of the ovaries. Both the uteri were equal in development, each being 5·2 cms. long and a centimetre broad and did not appear to be gravid. Dissection showed,

however, that each uterus was divided into nine obliquely transverse compartments (Text-fig. 2*a*), each containing an egg enclosed in a very thin, colourless and transparent sac of the shell-membrane. The entire egg-case looked like a pear-shaped or ovoid, turgid ball, having at its



TEXT-FIG. 2.—*S. sorrakowah* (Cuvier)

a. Uterus in very early stages of pregnancy opened to show more or less horizontal disposition of compartments ; *b*. Egg-case with zygote embedded in albuminous mass. Note the end with folded tuft; *c*. Magnified view of the egg within the egg-case ; *d*. Egg-case with tufted end extended (naturally) as embryonic growth proceeds ; *e*. Egg with blastodermic cap above & partially consumed yolk below; *f*. Egg-case with nutritive liquid in which the embryo floats, *g*. 0·8 mm. embryos with yolk-stalk & yolk-sac *bl*, blastoderm.

narrower pole a somewhat elongated, folded tuft of the shell-membrane. There was no such tuft at the other pole, though an irregular and rather inconspicuous folding of the shell-membrane was discernible. In the present case, the end with the tuft was always directed posteriorly in the compartment. Later examination of a number of other females bearing intrauterine eggs showed, that this end would be directed even anteriorly. The egg-cases (Text-fig. 2*b*) were from 5-6 mm. long and from 2-2·5 mm. in width. The entire case stretched to about 8-9 mm. when its tufted end was gradually pulled.

Dissection and microscopic examination of an egg-case showed that the extremely thin and delicate but elastic shell-membrane formed within it an avoid sac enclosing a small quantity of clear, transparent liquid[1], with the whitish opaque, oval egg suspended in it (Text-fig. 2*c*). The eggs measured on an average 1 mm. ×0·75 mm. They did not, however, reveal any embryonic differentiation at this stage, though the white yolk appeared to have been already used up slightly.

A female 25″ in total length and landed on 1st February, 1944 revealed a further stage in the developmental condition of the egg-cases and the eggs contained in them. There was no longer a folded tuft at the end of the egg-case, which had now stretched so much that it looked like the elongated tubular end of the major, bulbous sac (Text-fig. 2*d*). The egg-cases measured, on an average, 12 mm. in total length. Their bulbs contained even now a quantity of clear, transparent albumimous liquid noted previously and the eggs remained suspended in them.

The eggs revealed, at this stage, conspicuous embryonic development. (Text-fig. 2*e*). Each was typically oval in outline, with opaque masses of granular yolk contents. At the narrower end, there was a white cap of blastodermic cells in contact with a narrow band of yolk. A little lower down, there was another big band of yolk, the two bands being connected by a narrow junctional zone. The yolk had evidently been consumed partially. The blastodermic area did not yet occupy a third of the egg, but in certain cases it already appeared to be separating from the yolk mass beneath.

Choodamani in his description of "The smallest (ξ) elasmobranch egg" (1941) refers to that of *Scoliodon sorrakowah*, but does not mention the presence of an albuminous mass or liquid surrounding the eggs in the egg-cases. Prasad (1942) states that both the mucous and albumen secreting tubules in the nidamental glands of this form have disappeared, implying that mucous and albumen are not secreted by them at all. Our observations on the presence of the albuminous liquid in the shell-sacs do not thus conform with the view of the aforesaid authors regarding the total functional activity of the nidamental glands in this form. This disparity may perhaps be explained by the possibility that some cells at least in the glands, scattered among the shell-secreting tubules, have retained the albumen (and/or mucous) secreting activity. Thus alone can the presence of the albuminous liquid in the shell-sacs be accounted for. The nidamental glands in *S. sorrakowah* appear to be functionally quite similar to those of the allied viviparous species though, as pointed out by Prasad, they may have undergone a certain amount of structural midification.

Embryonic 0·8 mm. Stage.

Parent ♀ : Total length —23″ ; App. wt.—1·5 lb. ; 6th January 1944.

Each uterus of this female was divided into six oval compartments, each of which contained an intact shell-membrane sac enclosing a rudimentary embryo. The uterine compartments lay one below the other

[1]Other cases, however, had a small quantity of a rather firm opaque albuminous mass surrounding the egg, instead of the clear transparent liquid.

at this stage and each contained a quantity of rather sticky, cream-coloured, nutritive secretion with which the shell-membrane sac was besmeared. The mucous membrane of each compartment was moderately vascular, quite plain and smooth at this stage and there was not the slightest indication of a trophonema formation.

Each shell membrane sac is, at this stage, an irregularly ovoid or oblong pouch of the extremely thin, colourless, transparent shell membrane, having its narrower end well stretched out (Text-fig. 2*f*). Obviously, this latter represents the folded elastic tufts in the egg-cases described previously. The sac itself measures, on an average, 7 mm. × 4 mm. and the extended portion about 5 mm. It is now filled with a quantity of yellowish opaque, nutritive liquid in which the contained embryo is bathed freely. The secretions in the compartment referred to above have, in all probability, diffused through the shell-membrane sac and serve as a source of nourishment to the developing embryo.

From a microscopic examination of the embryonic mass, it is at once apparent that the rudimentary embryo has definitely lifted itself above the general surface of the yolk-sac, with which it remains connected by a short, thick umbilical stalk (Text-fig. 2*g*). The embryo measures hardly 0·8 millimetre in length and under low power magnification appears to be a rather elongated and flattened structure with a broad head end and a narrower, rounded tail end. Beyond this, not a trace of external morphological differentiation is yet noticeable. The umbilical stalk, which is nothing but the short upper pole of the yolk-sac, joins the embryo at a point near its mid-length ventrally. The yolk-sac itself measures about 1·1 mm. × 1 mm. and its walls are seen to be coated externally with a thick layer of blastoderm, which is continuous, round the umbilical stalk and the umbilicus with the ventral body wall. The umbilical stalk is devoid of appendicula at this stage.

Embryonic 1 mm. stage.

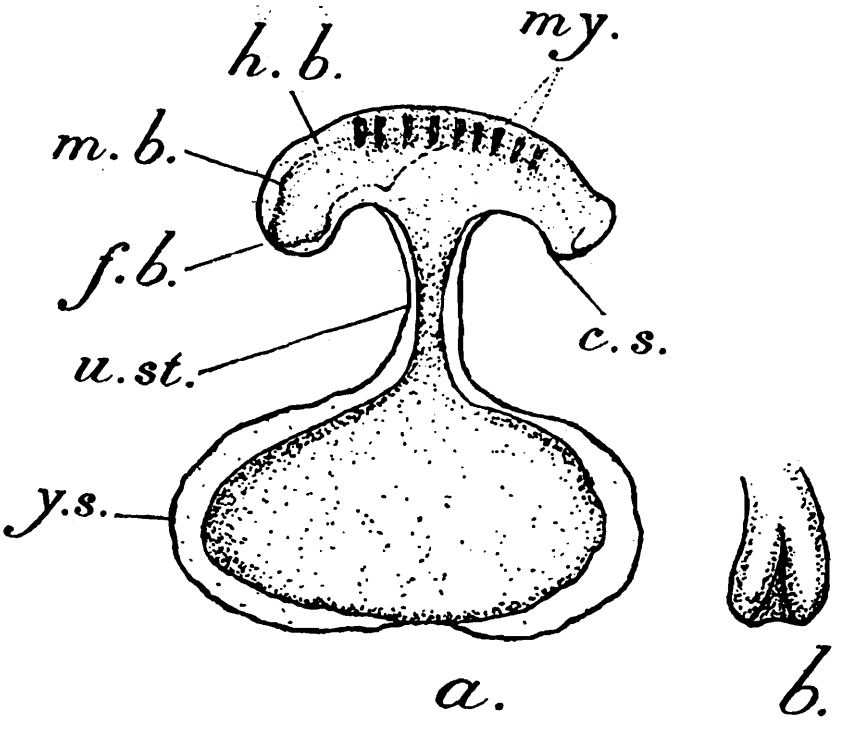
Parent ♀ : Total length—17·5″ ; App. wt.—1·5 lb. ; 18th May, 1944. Each uterus was divided into six obliquely transverse compartments, each lodging a tiny embryo. Except for one embryo lying in the most anterior compartment of the right uterus, all the other embryos lay naked in the compartments, unenclosed in any shell-membrane sacs of the previous stage. Neither was there any trace of the disintegrated shell-membrane sacs in these compartments. The exceptional embryo was, however, enclosed in an outstretched shell membrane sac similar to that of the previous stage. The sac contained a quantity of translucent liquid in which the embryo was bathed. It was evident that the development of this embryo had not progressed to the same extent as that of the others and its egg was, thus, obviously the last to be fertilised and received into the uterus. The other embryos were smeared with a quantity of cream-coloured, pasty secretion of the uterine mucous membrane and the compartments were not yet filled with the thin and opaque nutritive liquid characteristic of later stages. The mucous membrane of each compartment was fairly vascular, but particularly so over a small patch lying in the postero-lateral corner where the future trophonema would arise.

It was evident that just at this stage of embryonic development the shell-membrane sacs disintegrated, liberating the embroys in the compartments.

The following are the measurements of the embryo at this stage :—

Total length	1 mm.
Length of umbilical stalk	0·6 mm.
Thickness of umbilical stalk	0·2 mm.
Yolk-sac (widest diameter)	1·2 mm.

The embryo (Text-fig. 3*a*) is an arched, laterally compressed structure, white in colour. Both its cephalic and caudal flexures are pronounced, its cranial end being a little more swollen than the caudal. A certain amount of organic differentiation is apparent at this stage. The three primary divisions of the brain, *viz.*, forbrain, mid-brain and hind-brain, are distinguishable. About eight to nine pairs of mesoblastic somites can be counted in the middle third of the embryonic body and there is an unsegmented mass on either side of the tail. A peculiarity



TEXT-FIG. 3.—*S. sorrakowah* (Cuvier), 1 mm. stage (× 36).

a. Embryo with yolk-sac and umbilical stalk ; *b*. Dorsal view of the ununited caudal region.

c.s., caudal swelling ; *f.b.*, forebrain ; *h.b.*, hind brain ; *m.b.*, mid brain ; *my.*, myotomes ; *u.st.*, umbilical stalk ; *y.s.*, yolk-sac.

of the stage is that near the posterior tip of the caudal region the lateral body walls have not yet fused with one another, there being an open space, between two thickened lips—the caudal swellings (Text-figs. 3*b*). A portion of the notochordal tissue is visible through the aforesaid space. The embryonic vascular structures are not easily distinguishable.

The umbilical stalk is a fairly elongated structure, opening with a wide, funnel-like opening in the mid-ventral region of the embryo. The stalk conveys the yolk-duct which is the prolongation of the upper

pole of the yolk-sac. Appendicula have not yet developed. The yolk-sac is an ivory-coloured, horizontally ovoid sac of a firm consistency. Its external surface is quite smooth at this stage and it is, in all likelihood, filled with the cream-coloured secretion of the uterine mucosa, which replaces the meagre quantity of the initial yolk. There is no trace yet of the formation of spongy, vascular tissue in the sac.

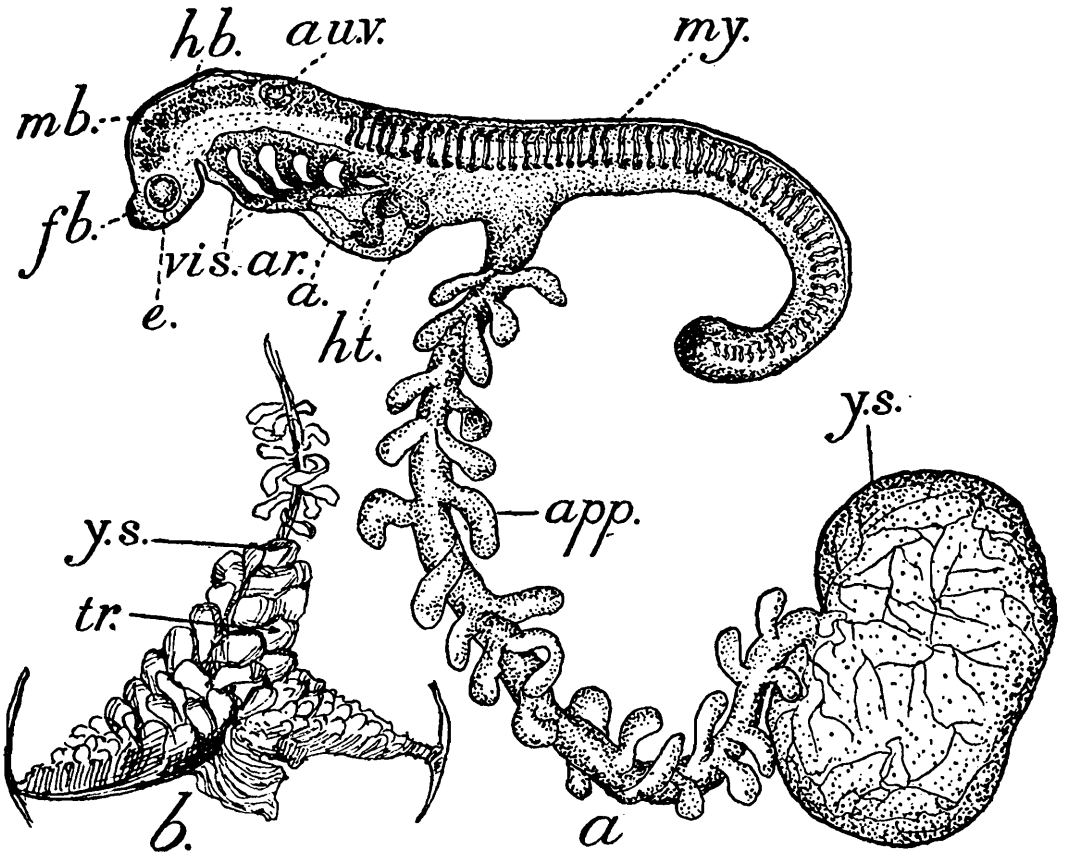
Embryonic 3-4 mm. stage.

Parent ♀ : Total length—19″ ; App. wt.—1·5 lb ; 20th January, 1944. Each uterus of the above female measured 55 mm. × 10 mm. and was divided into five obliquely longitudinal compartments containing very tiny embryos. Each compartment was filled with a quantity of yellowish opaque liquid under which the embryo, with its appended structures lay completely submerged. The embryos which were 3 mm. to 4·5 mm. in total length were no longer enclosed in shell-membrane sacs (egg-cases) and their tiny yolk-sacs were already connected with the uterine trophonemata to form rudimentary placental connections. Their extremely delicate placental cords already possessed very minute appendicula. The uterine mucous membrane on the dorsal face of each compartment was highly vascular and very finely folded to form a pinnate, central ridge, which, at the posterior end of the compartment, was involuted, together with a portion of the underlying sub-mucous tissue, to form a small rudimentary trophonema. The latter was in the form of an extremely wrinkled, more or less solid, conical bulge, the top of which afforded a deep seat for the tiny yolk-sac (Text-fig.4*b*). The structures referred to later on as 'trophonematous cord' and 'trophonematous bulb' as the various morphological components of a full-fledged trophonema were not clearly distinguished at this stage of pregnancy. This shows that, even after the formation of a rudimentary placental connection, the uterine trophonema continues to grow and develop till its various components are distinctly differentiated morphologically. The earliest stage recorded at which these were discernible, was the 10-12 mm. stage referred to later.

The following are the measurements of the embryo at this stage :—

Total length	3-4 mm.
Length of umbilical cord	4-5 mm.
Yolk-sac	1 mm. × 0·75 mm.
Length of trophonema	1·5 mm.

The embryo (Text-fig. 4*a*) is perfectly white in colour and its tissues are fairly transparent. In the fresh condition the heart and the capillary-like blood vessels are easily distinguishable by the red blood conveyed through them. The cephalic flexure is well marked, the long axis of the front part of the head making, at this stage, almost a right angle with the long axis of the body. The brain consists of the usual three divisions, the fore, mid and hind brain, the midbrain region constituting the anterior termination of the long axis of the embryo. Optic vesicles are clearly visible in the forebrain region, and a round, transluscent lens appears in each vesicle. In the region of the hind-brain the auditory vesicles are seen as prominent but shallow, cup-shaped structures in the external skin. The mouth is discernible as a median longitudinal



TEXT-FIG. 4.—*S. sorrakowah* (Cuvier), 3 mm. stage (×27).

a. Embryo with appendiculated placental cord & yolk-sac ; *b*. Yolk-sac placenta (×9) *a*., conus arteriosus ; *app*., appendicula ; *au v*., auditory vesicle ; *e*., eye ; *fb*., fore-brain ; *hb*., hind brain ; *ht*., heart ; *mb*., mid brain ; *my*. myotomes ; *tr*., trophonema ; *vis. ar*., visceral arches ; *y.s*., yolk-sac.

pit, the hind borders of which are constituted by the first pair of viscecal arches, the mandibular. Behind the oral region, four pairs of branchial clefts and five pairs of visceral arches are easily made out though the fifth pair of the latter is yet rudimentary. The heart is quite prominent, but still an elongated and twisted, tubular organ not yet possessing the characteristic compacted form of the adult condition. The elongated ventral aorta runs beneath the visceral region, and very fine capillary like vessels, emerging dorsally from the arches are seen to join into a single dorsal aorta which extends posteriorly only up to a point corresponding to the entrance of the placental cord in the body of the embryo. The liver bud is not yet formed, nor is the position of the anus yet indicated. There is no fin differentiation yet. About 40 pairs of mesoblastic somites can easily be counted and they extend right up to the tail end of the embryo. The tail end is rather swollen and like the cranial end, it too, is flexed ventrally and not in a line with the long axis of the trunk.

The placental cord joins the embryonic intestine nearly midway between its total length. It already bears very tiny, blunt-tipped appendicula some of which are forked near their tips. The cord contains, at this stage, only a single blood-vessel, in all probability an artery which s a branch of the dorsal aorta. It sends off delicate off shoots to the ppendicula. There is no definite yolk duct, nor is there a trace of a econd blood-vessel.

The yolk-sac is an extremely small, pale coloured more or less rounded sax with hardly any traces of yolk, but already possessing a small quantity of spongy vascular tissue. Its basal, as also its side walls, are fairly vascular. As already pointed out, the trophonema is an excessively wrinkled but highly glandular conical mass of the uterine mucosa which is not yet vascularised externally. Its apex affords a deep seat for the tiny yolk-sac which is more or less completely embedded there, thus completing the rudimentary placental arrangement (Text-fig. 4*b*).

Embryonic 15 mm. stage.

Parent ♀ ; Total length—22″ ; App. wt.—1 lb. ; 20th December, 1943.

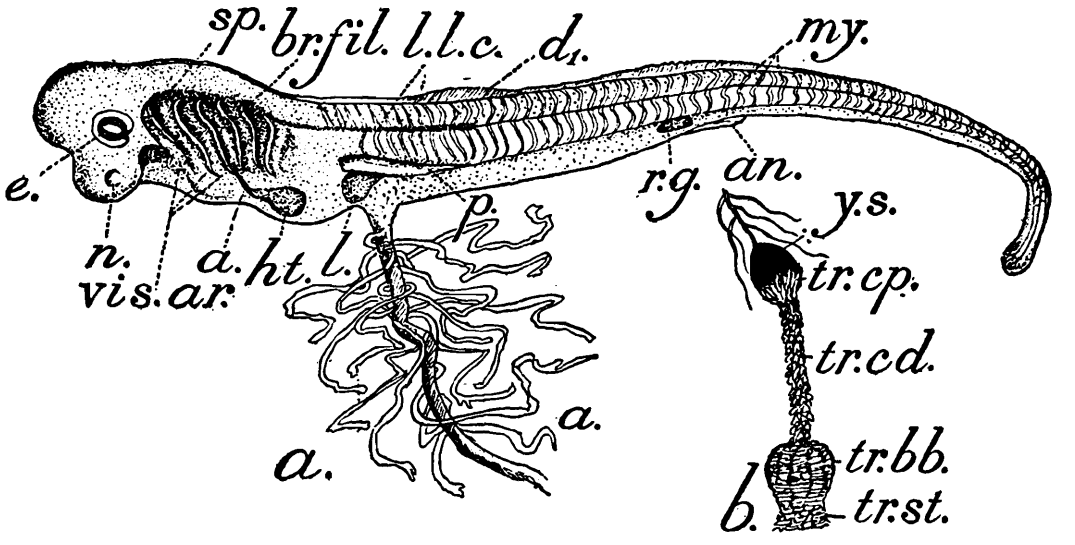
The right uterus of this female contained seven conpartments and seven embryos and the left six, the yellow liquid in the compartments referred to in the previous stage being present in this case also. The uterine mucous membrane of each compartment had, at hits stage, given rise to a full-fledged trophonema consisting of four distinct morphological components and the trophonema occupied at this stage a major portion of the compartment cavity.

The sexes of the embryos could not be distinguished externally.

The following are the measurements of the enbryo at this stage :—

Total length	14-15 mm.
Length of placental cord	15-17 mm.
Diameter of yolk-sac	3 mm.
Length of the entire trophonema	11-13 mm.
Thickness of the trophonematous cord	2 mm.
Length of an appendiculum	6-7 mm.

The embryo (Text-fig. 5*a*) is still in a rudimentary stage of development and the various external morphological features, especially most of the fins, have not yet made their appearance. It has semi-transparent body walls through which the various internal organs such as the heart, the liver, the intestine, the rectal gland, the lateral line canals, the myotomes, etc., are easily discernible. In profile, the head region resembles a soft, rounded, swollen bulge anteriorly and a slight flattening antero-dorsally. The head merges below, at an angle,



Text-Fig. 5.—*S. sorrakowah* (Cuvier), 15 mm. stage (× 16).

a. Embryo ; *b*. Yolk-sac placenta. na., anus ; *br. fil.*, branchial filaments ; d^1., rudinent of first dorsal fin ; *l.*, liver bud ; *l.l.c.*, lateral line canal ; *n.*, nostril ; *p.* pectoral fin ; *r.g.*, rectal gland ; *sp.*, spiracle ; *tr. cp.*, trophonematous cup ; *tr., cd.* trophonematous cord ; *tr. bb.*, trophonematous bulb ; *tr. st.*, trophonematous stalk.

into the snout, which, too, is thick, soft and broadly rounded at this stage. Ventrally two very prominent nostrils are conspicuous on the margins of the snout. The eyes are prominent, rounded in outline, with ovoid lenses, but no ocular pigment has yet appeared. Also the orbital rims have not yet closed completely. Behind the wide buccal opening the inflated pharyngeal region is perforated laterally by prominent gill clefts, the first three of which are markedly oblique and much larger than the last two, which are also much smaller than the former. Rudiments of branchial filaments in the form of soft, knob-like papillae are visible on the front wall of each one of them. Above the mouth and only slightly ahead of the first gill opening but at an angle with it, is situated the spiracular cleft which, too, shows very faint (hardly distinguishable superficially) rudiments of spiracular filaments. The spiracular clefts are about half the size of the first gill openings. Beneath the gill region, the pinkish bulb-like heart and the conus arteriosus are easily discernible, the latter giving off epibranchial vessels to the gills. Behind the snout, ventrally, the mouth extends as a wide, more or less diamond-shaped opening not yet definitely bounded by jaws. The various flaps of the oral mucous membrane have, however, distinctly developed.

Only the pectoral fins are definitely formed at this stage, while some others are indicated only faintly. These former are situated on the ventro-lateral body walls, some distance behind the hindmost gill openings and this situation of theirs in relation to the gill region is in marked contrast with the adult condition, in which the pectorals move further forwards and eventually lie below the hindmost gill slits. The pectorals are mere crescent-shaped flaps at this stage, with wide bases and very small free posterior projections. The dorsal and the ventral median fin membranes are nothing but mere demarcations, in corresponding situations, of the general epidermal sheath of the embryonic body. The dorsal is distinguished at a point slightly posterior to the second gill cleft and the ventral behind the cloacal aperture, both being continuous round the tail end. The position of the first dorsal fin may roughly be said to be indicated by the elevation of the dorsal skin fold, a short distance behind the pectorals. The positions of the other median fins are not, however, even faintly marked out at this stage. Ventrally, the cloacal aperture is located at a point corresponding to a dorsal point situated slightly behind the posterior termination of the first dorsal rudiment, and two slight epidermal bulges, one on either side of the cloaca probably indicate the positions of the pelvic rudiments. The tubular intestine is seen to terminate into the cloaca posteriorly. The pinkish rectal gland is situated on the dorsal aspect of the intestine, slightly anterior to the cloacal aperture, and is easily distinguished superficially in profile. A number of V-shaped myotomes extend posteriorly from behind the gill region, but in the caudal region, they have lost their V-shaped character and become more or less vertical.

The placental cord is seen to pierce the ventral body wall midway between the pectoral fins and one of its vessels, the vein is easily seen to enter the whitish opaque liver, which is located internally in a position somewhat anterior to the origin of the pectorals and

immediately behind the bulb-like heart. Finally, also distinguished superficially, in profile, is the tubular lateral line sensory canal located beneath the epidermal sheath. It begins immediately above the orbit and extends, at this stage, posteriorly along the dorso-lateral surface of the body, to a point midway between the posterior end of the pectoral fin and the rectal gland.

Yolk-sac placenta.—Both the foetal and the maternal tissues enter into the formation of the yolk-sac placenta (Text-fig. 5*b*). The foetal placenta is contributed by the original yolk-sac (y.s.) which is by now a soft rounded structure, full of spongy vascular tissue. Its basal wall does not present a smooth and entire surface, but appears to be rather rough, fissured or perforated, the perforations leading inside the sac. The yolk-sac is received into a flask-shaped structure of the uterine trophonema, the maternal portion of the placenta, thus forming a composite placental arrangement. The trophonema itself presents a peculiar macroscopic structure. As seen in text-fig. 5 *b*, each trophonema, is seen to consist, from the maternal to the foetal end, of the following four distinct morphological components, *viz.*, (1) trophonematous stalk (*tr. st.*), a short, thick, pillar-like structure formed as a result of the toughened involutions of the uterine mucous membrane and the underlying submucous part of the compartmental wall, (2) trophonematous bulb (*tr. bb.*), the trophonematous stalk dilates at its foetal end to form a prominent, almost rounded, more or less solid bulge, which bears a striking resemblance to a bit of cauliflower, and (3) and (4) trophonematous cord and trophonematous cup (*tr. cd.* & *tr. cp.*), from the summit of the trophonematous bulb, there rises an elongated cord filled with a certain amount of spongy vascular tissue and free maternal blood ; at its foetal end the cord dilates into a thin walled, shallow cup which receives the basal portion of the yolk-sac. The attachment between the two is in the nature of apposition and there is no firm interdigitating arrangement as between folds and villi. In slightly advanced stages of pregnancy, the cup is not quite entire, but disintegrated into a crown of processes which then hold the yolk-sac in a manner akin to that in which gems are gripped in rings.

The outer walls of the structures described above are not plain and smooth, but present an extremely wrinkled and uneven surface, which presents under the low power of the microscope, scaly and rugose appearance. The trophonema as a whole is not loose and lax, but is firm, with a definite tone. On gently detaching the yolk-sac from the cup, free maternal blood oozes from the distal end of the trophonematous cord.

The placental cord consists of a small artery and a fairly prominent vein enclosed in a connective tissue sheath there being no trace of a yolk-duct even at this stage. It is quite possible that the yolk-duct might have atrophied much earlier. The cord bears numerous, long appendicula almost throughout its length. They are rather flat, strap-shaped structures, some of them being forked near their distal extremities. Each possesses, even at this stage, a very fine arterial and a venous capillary running marginally and a vascular loop at its tip. At its

distal end the cord is attached to the yolk-sac which connects with the trophonema to form the placenta.

The 10-12 mm. stage, examined on the 28th February, 1944 almost completely resembled the one described above, except in two respects. Firstly, there was not the slightest indication of any fin differentiation but for the formation of rudimentary pectoral fins. Secondly, the lateral line canal extended at this stage only up to the roots of the pectoral fins. A full-fledged placenta was, however, formed and resembled ' in toto ' that of the 15 mm. stage.

Embryonic 20 mm. stage.

Parent ♀ : Total length—23·5" ; App. wt.—2 lb. ; 20th October, 1943.

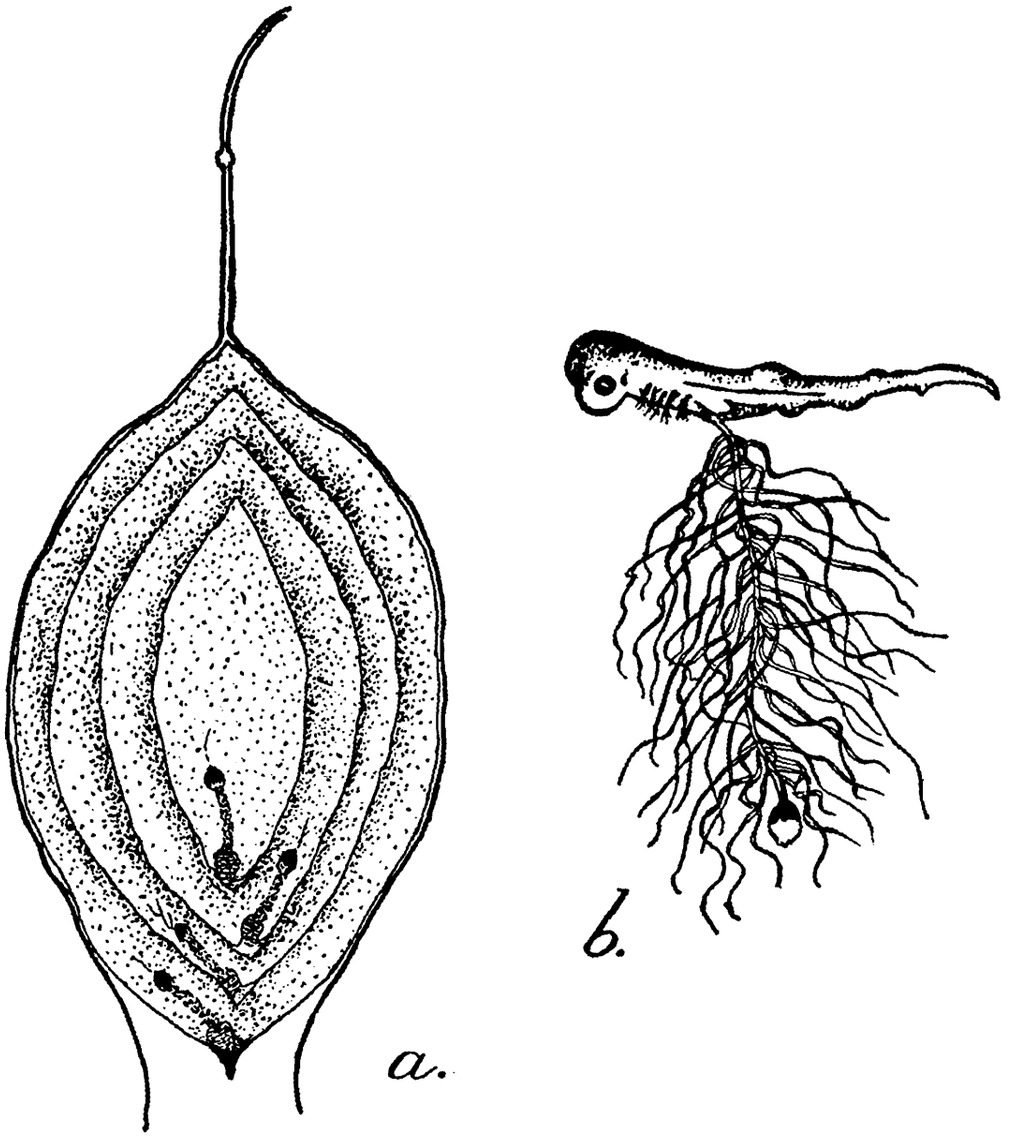
The compartments in the uteri of the above female, were disposed antero-posteriorly (Text-fig. 6*a*), there being five in the right uterus and four in the left. There were, however, only two embryos in the former and three in the latter, and the trophenemata of only these were well-developed, those of the abortive compartments being comparatively much reduced in size, though definitely formed on a similar plan. All the embryos, except one in the left uterus, lay with the heads directed towards the cranial end of the mother, while the exceptional embryo lay with its head towards her caudal end. Sexes were not yet differentiated externally.

The following are the measurements of one of the embryos at this stage :—

Total length	20 mm.
Length of caudal fin	5 mm.
Length of placental cord	32-35 mm.
Diameter of the yolk-sac and that of the trophonematous cup	2·8 mm. and 3 mm. resp.
Total length of the entire trophonema	14 mm.
Thickness of trophonematous cord	2 mm.
Maximum length of an appendiculum	23 mm.

The embryo (Text-fig. 6*a*,*b*) is completely formed externally at this stage and almost reddish crimson in colour, the process of general pigmentation not having yet started. The head region is a soft and swollen bulge, merging below, at an angle, into the beak-like snout, which too, is short and bluntly rounded and not flattened dorso-ventrally. The head and the snout regions thus contrast markedly with the adult condition of these regions. The eyes are prominent, and rather oval in outline with a round whitish opaque lens. The iris is represented at this stage by two narrow strips of dark pigment, an anterior and a posterior, which just overlap small segments of the lens in front and behind. Some distance behind the orbit and immediately above the angle of the mouth, the spiracular slit is discernible as a distinctly reduced crescent-shaped, oblique slit with short papillae-like spiracular filaments. The gill region

is very conspicuous on account of the presence of bunches of crowded and vascular branchial filaments which are now in the form of very short, club-shaped threads slightly protruding out of the gill-slits. The fins, excepting the pectorals, have all appeared in their respective adult positions. The pectorals, are, however, located well behind the last gill-slit and in this respect; the condition is still primitive. Nor have any of the fins yet assumed their respective characteristic adult forms, most of them being mere curved flaps, supported internally by delicate fin rays. The subcaudal lobe, too, is not yet clearly marked out and thus the heterocercal character of the selachian tail is indistinguishable at this stage.



Text-Fig. 6.—*S. sorrakowah* (Cuvier), 20 mm. stage

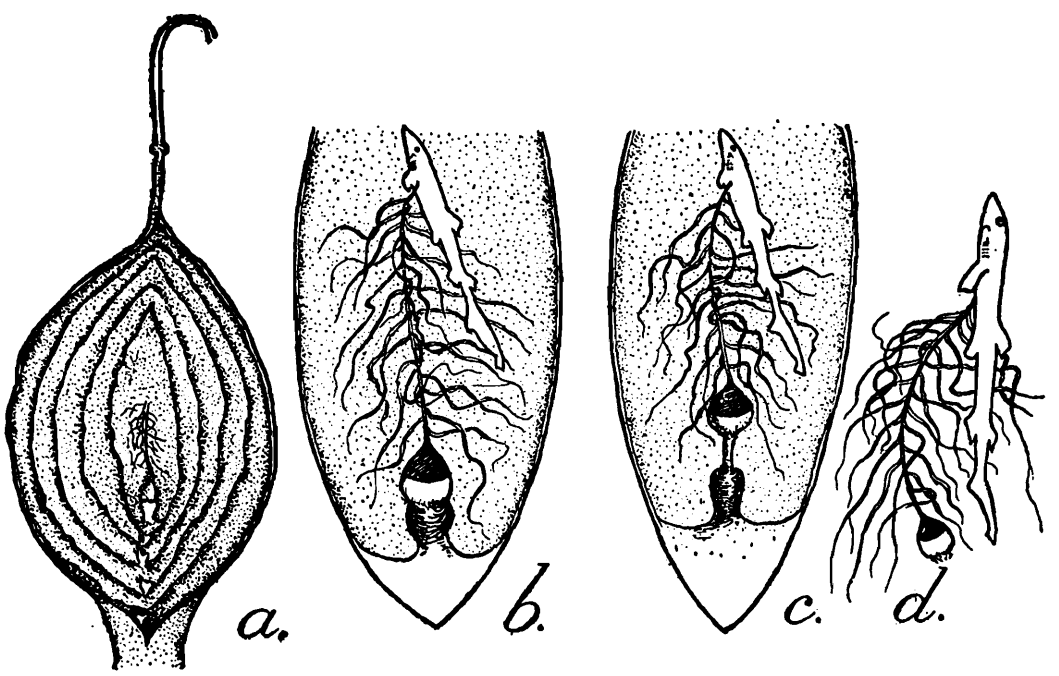
a. Dissection of uterus showing arrangement of compartments and trophonomata; *b*. Embroy with appendiculated placental cord and foetal placenta.

The placental cord pierces the abdominal wall of the embryo at a point midway between the pectoral fins. It presents the same anatomical features as described in the previous stage and is similarly attached to the rounded yolk-sac which forms a placenta in conjunction with the full-fledged maternal trophonema of its own compartment.

Except for the actual number of young ones borne by the uteri, exactly identical conditions of pregnancy and embryonic development were encountered in 25 mm. to 33 mm. stages.

Intermediate stages of pregnancy:—Under this heading are described such stages of pregnancy in which trophonemata display structural degeneration in varying degrees.

Each uterus of a female 17·5 inches in length (App. wt. 1·5 lb. ; Aug. 29, 1942) was divided into five compartments, each containing an embryo and a trophonema. The embryos now resembled the adult in every respect (Text-fig. 7*d*), though the general dorsal pigmentation had not yet advanced to any appreciable degree. The rudiments of



TEXT-FIG. 7.—*S. sorrakowah* (Cuvier), (Intermediate stages of pregnancy).

a. Dissection of uterus showing compartments and trophonemata ; *b*. A portion of compartment magnified showing embryo with its placenta 'in situ.' Note the complete reduction of trophonematous cord ; *c*. Placental condition in which trophonematous cord is still present though definitely reduced in length ; *d*. Embryo with appendiculated placental cord & yolk-sac.

branchial filaments could also be seen projecting through gill-silts though they were definitely undergoing degeneration. Sexes were distinguishable at this stage, three of the five embryos in each uterus being male

and two female. The embryos presented the following range of dimensions :—

Total length	56-61 mm.
Yolk-sac	6 mm. × 4 mm.
Length of placental cord	78-81 mm.
Maximum length of an appendiculum	55 mm.
Length of trophonematous cord (where present)	5 mm.
Length of barrel-shaped trophonema	5-6 mm.
Diameter of summit of trophonema	3-4 mm.

The existence of two different conditions in the anatomical character of the maternal placentae was striking. In three of the five compartments of the right uterus each trophonema was seen to consist of the four distinct components described in the 15 mm. stage and the basal portion of the yolk-sac was still attached to the crown of processes, (remnants of the original trophonematous cup) at the foetal end of the cord. The latter, however, showed a conspicuous reduction in its length, suggesting structural degeneration (Text-fig. 7*c*). In the remaining two compartments of the right uterus and in all compartments of the left, the trophonematous cords were, however, entirely absent and the foetal yolk-sacs rested directly on the summits of the barrel-shaped or pillar-like trophonemata which now consisted of the modified trophonematous bulbs and stalks only. The trophonemata were no longer tough and solid as their components were before, but were rather lax and hollow and filled with loose, spongy tissue having blood capillaries entering them basally. Their apices afforded seats for the yolk-sacs which were slenderly held in position by strands of tissue arising from the rims of the trophonemata and representing the remnants of the original trophonematous cups (Text-fig. 7*b*). The outer surface of the trophonemata was now smooth and not wrinkled as before and was highly vascular. Mere touch dislodged the yolk-sac from their seats, and maternal blood was noted exuding freely through the apices of the hollow trophonemata.

Such trophonemata which show a partial reduction of their constituent components with the synchronic growth of the embryos represent a case of gradual structural and functional degeneration of the specially developed structures, when the conditions that necessitate their growth gradually alter on the negative side.

Parent ♀ : Total length—25″ : App. wt.—3 lb., October 1, 1942.

The right uterus of this fish was divided into seven compartments containing seven embryos, out of which two were males and five females. The left uterus contained, however, eight compartments and eight embryos, all of which were females. The embryos presented the following range of dimensions :—

Total length	55-64 mm.
Yolk-sac	6 mm. × 5 mm.
Length of placental cord	60-74 mm.
Length of trophonema	3 mm.
Diameter of trophonematous cup	5 -7 mm.

The trophonemata in this particular instance presented a slight variation from the condition recorded in the latter instance of the

preceding case. As in that condition the trophonematous cords were entirely absent, but unlike it, the residual trophonemata still bore on their summits entire trophonematous cups which had not yet disintegrated into crowns of processes, in spite of a more or less equal advancement in pregnancy. On the other hand, the cups showed a slight increase in size in keeping with the larger size of the yolk-sacs and it could easily be discerned that this increase was at the cost of the foetal ends of the trophonematous cords, which had themselves undergone complete morphological reduction. Further, the trophonemata still retained the highly wrinkled superficial consistency noted in the earlier stages of pregnancy though not possessing the same firm tone as before. A gentle pull dislodged the yolk-sac from the cup and as before, free maternal blood oozed from the apex of the more or less hollow trophonema.

The comparative observations described above clearly show that gravid females in similar conditions of pregnancy (complete morphological reduction of the trophonematous cords and bearing nearly equal-sized embryos) do not necessarily exhibit the same degenerative changes in the trophonemata and this appears to be in keeping with the fact that all gravid females do not necessarily bring forth young ones of identical sizes.

Advanced Pregnancy.—Under this heading are recorded the stages in which the trophonemata have undergone a more or less complete degeneration and are reduced to mere scars.

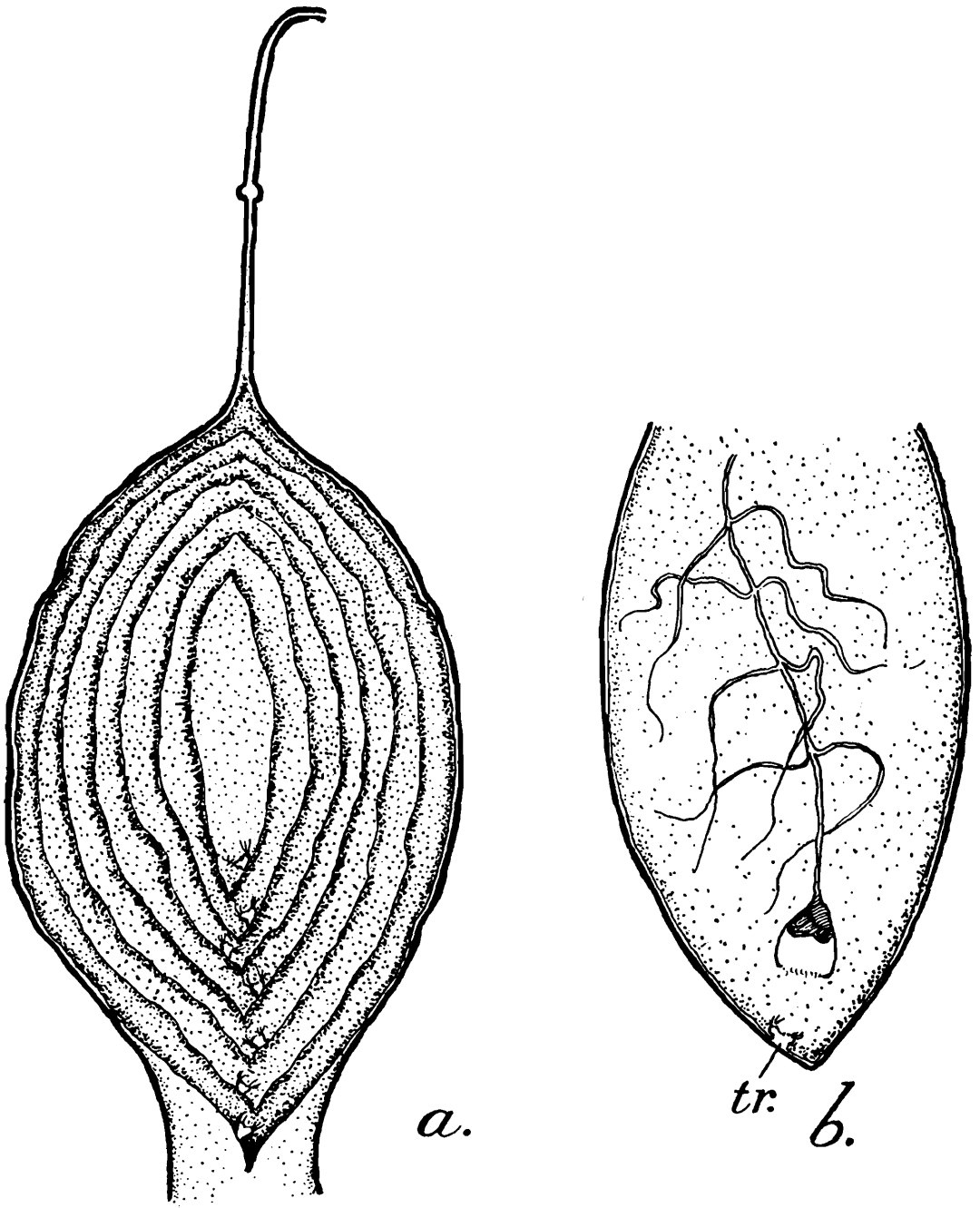
Parent ♀ : Total length-20·5″ ; App. wt.-2 lb. ; May 22, 1942.

Examination of the above female showed that her right uterus contained seven embryos, of which five were males and two females, while the left uterus contained six embryos, of which three were male and three female. A slight difference was noticeable in the size of the male and female embryos at this stage, the females being bigger than males. The embryos of the two sexes presented the following dimensions :—

Total length	117 mm.	125 mm.
Length of placental cord	125 mm.	105 mm.
Maximum length of an appendiculum	80 mm.	70 mm.
Yolk-sac	7·5 mm. × 7·5 mm.	10 mm. × 10 mm.
Length of trophonema	3 mm.	2 mm.

The advanced embryos of *S. sorrakowah* measuring 135 mm. in total length have been described by Southwell and Prashad (1919) and the descriptive features of the embryos referred to by us above closely resemble those of the embryos examined by the aforesaid authors. The embryos are, at these advanced stages of development, perfect replicas of the parent fish. Their placentae are described below :

The trophonemata, at this stage, are extremely reduced in size and appear as mere hollow, vascular stubs or thick elevations in the posterior parts of the uterine compartments (Text-fig. 8*a-b*). Their rims still bear remnants of the disintegrated cups and some of the yolk-sacs are still held in contact with the reduced trophonemata. The contact is however, slight and a mere touch dislodges the sac from the trophonema. It is at once apparent that the structural degeneration of the trophonema noted in the intermediate stages of pregnancy has by now progressed considerably and a corresponding increase in the size of the embryos indicates that the parent female is fast nearing the delivery period



TEXT-FIG. 8.—*S. sorrakowah* (Cuvier) (Advanced pregnancy).

a. Dissection of uterus showing arrangement of compartments with reduced trophonemata ; *b*. A single compartment magnified to show structural degeneration undergone by trophonema (tr.).

Histology of the yolk-sac placenta.

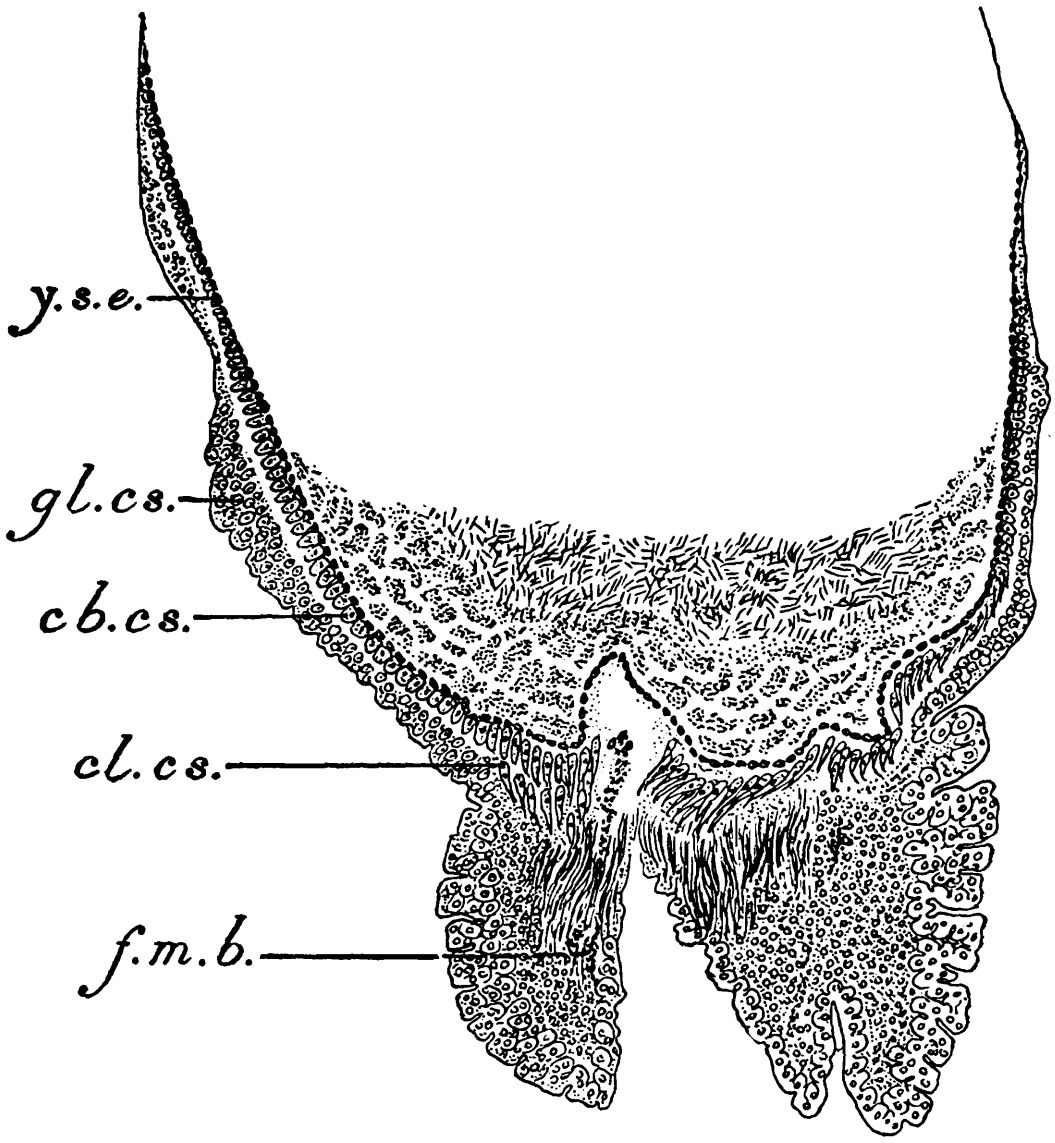
In order to be able to understand the structure of the placenta and the mode of transference of nourishment from the mother to the foetus the yolk-sac placentae in various stages of gestation, *viz.*, 10 mm. stage, 15 mm.—stage, 25 mm.—stage, 6 cm.—stage and 12 cm.—stage were cut into longitudinal sections. In the first three stages, the sections clearly display the four morphological constituents already described, and the doublewalled trophonematous cup is seen to embrace the tiny yolk-sac almost completely. In the 6 cm.-stage, the trophonematous cord is no longer present and the yolk-sac rests on the cup, which now comes to lie over the residual, pillar-like trophonema. Due to an increase in the size of the yolk-sac the grip of the cup over the sac has slackened considerably, and the sac is now only half way embraced by

the cup. In the most advanced stages the greatly reduced trophonema and its cup display an extremely disintegrating structure and the yolk-sac which is then comparatively several times larger, is barely in contact with the trophonema.

The different sections, while revealing a histological structure which, for the most part, substantiates Mahadevan's (1940) observations on the structure of the trophonematous cup and the mode of transference of nourishment suggested by her bring out a few additional very striking facts which are of special interest both histologically and physiologically.

The trophonematous cup is seen to be composed, throughout, of two distinct walls, an inner one formed as observed by Mahadevan as the result of invagination of the outer. The outer wall of the cup, as also the walls of the entire trophonema (including all its components), is seen to be made up of glandular epithelium (Text-fig. 9), mostly grouped together in the form of glands but simply layered occasionally. Except for the region of the cup, the glandular walls of the trophonema are seen to be arranged in the form of broad villi or papillae that impart to the trophonema, the uneven and rugose superficial consistency. The gland cells are more or less rounded or oval in outline with prominent central nuclei and granular protoplasm. This glandular tissue is also seen to extent within the lumen of the trophonema. In fact in the earlier stages of pregnancy the trophonematous cord is more or less solid, being made up of glandular tissue, with a sparse quantity of connective tissue interspersed between it. The glands of the trophonema must undoubtedly be secreting, in part at least, the nutritive liquid noted in the compartments and their secretions must also be thrown within the trophonema whence they must subsequently be transferred to the embryo.

The inner wall of the trophonematous cup is seen to be one cell trick, though occasionally it gives the effect of being pseudo-stratified. The cells of this layer present a peculiarity with respect to their histological nature in different regions and at different stages of pregnancy. In the very early stages the cells are more or less cuboidal throughout, tending to elongate and become columnar in the basal region of the cup, where the wall of the yolk-sac presents an undulating contour (Text-fig. 9, *cl. cs.*). By their basal ends these cells are in firm and intimate contact with the yolk-sac ectoderm, following it even through the undulations, while their narrow and tapering ends meet the glandular tissue of the outer wall of the cup and that of the core of the trophonematous cord, thus keeping themselves actively engaged in absorbing their nutritive secretions. As however, pregnancy advances, the cells in the basal and basilateral regions get detached from the glandular core of the trophonematous cord, elongate and become distinctly columnar. They then possess highly granular protoplasm and prominent, oval, binucleolated nuclei which appear to be in a high state of activity. The remaining cells of the invaginated layer continue, however, to retain their original cuboidal character. In these latter regions, the contact with the glandular tissue persists, with the result that their cells do not get an opportunity of changing their form and becoming



Text-Fig. 9.—*S. sorrakowah* (Cuvier).

Longitudinal section of placenta in intermediate stages of pregnancy.

cb. cs., Cuboid cells of inner layer of trophonematous cup ; *cl. cs.*, columnar cells of the same ; *f. m. b.*, free maternal blood ; *gl. cs.*, land cells of outer layer of trophonematoues cup *f. m. b.* ; *y.s.e.*—yolk-sac ectoderm.

columnar. Occasionally the columnar character of the cells may be defective and the original cuboidal persistent in certain sections of even the basal region of the invaginated layer, where the cells generally become columnar. As before, this defect may be traced to the persistence of attachment of the defective regions with the glandular tissue, with the result that the development of the cells is missed. Contact with the yolk-sac ectodern is maintained throughout, however, despite advancement in pregnancy and it is only in very highly advanced stages that this contact is lost as a result of the general disintegration which sets in then.

With the assumption of the columnar character by the cells of the inner invaginated layer of the cup and their subsequent detachment from the glandular tissue of the cord, a new additional mode of absorption of nutriment becomes apparent. The columnar cells are then

profusely bathed with free maternal blood (Text-fig. 9) rising up through the trophonematous cord. The latter is no longer a solid glandular cord, but develops a core of loose, spongy connective tissue engulfing free maternal blood. At the base of the trophonema the involuted blood-capillaries of the uterine mucosa may show definite capillary walls, but the capillaries as such are not extended throughout the cord. Free maternal blood is seen to pour forth through the involuted capillaries near the base of the cord, whence it is carried up its reticulated and spongy core either in regular channels or through irregular spaces. (Free blood rising up through the longitudinally running grooves and furrows, which are formed internally as a result of the excessive superficial folding and furrowing of the walls of the trophonematous cord, may produce the effect of capillary formation, but this is only an illusion and there are no true blood-capillaries in the cord). Two streaks of involuntary muscle fibres running through the entire length of the cord immediately inside the outer glandular walls appear to propel this channelled or engulfed blood towards the columnar cell layer of the cup, which is thus continuously bathed by free maternal blood. It is not clear how a disintegration of the blood-capillaries of the uterine mucosa occurs but the fact remains that they emit free blood within the trophonema. Since trophonema constitutes the maternal portion of the placenta a specialized organ of foetal nutrition-emission of free maternal blood for the more direct supply of nutriment to the developing embryo is not quite an inconceivable phenomenon.

The general histology of the yolk-sac conforms with the description of it given by Mahadevan (1940). The firm contact between the single-layered granulated cells of the yolk-sac ectoderm and the columnar cells of the invaginated layer of the trophonematous cup is, indeed, highly suggestive of a mutual exchange of food material and excretory products between the maternal and foetal tissues.

The development of prominent columnar cells in only the basal and basilateral regions of the cup and a nearly synchronous development of a new mode of food-supply, *viz.*, free blood bathing the columnar cells so as to supply them nourishment, point to two distinct possibilities *viz.*, (i) that these cells are, with the advancement in pregnancy, called upon to perform a function more complex than mere absorption of nutrition and its transference to the yolk-sac ectoderm and (ii) that the basal region of the yolk-sac which presents a deeply fissured and undulating surface is particularly absorptive in nature. With the advancement in pregnancy, two kinds of nutritive materials appear to be made available to the embryo through the trophonema. As in earlier stages, the ready-made, nutritive secretions elaborated by the glandular tissue of the trophonema and thrown into its lumen, whence they are, we might say, diffused, in all probability, unaltered through the invaginated layer and passed on to the embryo and secondly the nutritive materials in the free maternal blood which must exist chiefly in an elementary (digested and simplified) condition. It is highly probable that these undergo suitable elaboration and conversion within the then specially developed columnar cells before passing to the foetus. It is also possible

that some of the disintegrating gland cells (Histotrophe of ungulate mammals) and maternal blood corpuscles undergo nutritive degeneration and are absorbed by the trophic columnar cells. Such dynamic action of the columnar cells would well be regarded as an active trophoblastic action, and the layer a trophoblast in the true sense of the term, analogous to the ' true trophoblast ' of birds and mammals. A significant point of difference between the two trophoblasts would be that; whereas the latter is a foetal tissue, the former is a purely maternal one, representing a phenomenon of reversion of functions—a phenomenon that is only in keeping with the fact that the foetal tissue in such primary group of vertebrates as fishes is not endowed with the higher physiological faculties (*viz.*, phagocytosis, elaboration and synthesis, controlled supply of food materials etc.) of a true avian and mammalian trophoblast, thus rendering the intervention of an analogous maternal tissue a crucial necessity.

Embryonic history of the yolk-sac placenta, with remarks on its probable mode of function.

(Text-figs. 4, 6, 7, 8 & 9.)

The placenta in *Scoliodon sorrakowah* presents very unique structural peculiarities and is the only one of its kind amongst the placental elasmobranchs studied. The foetal placenta is constituted throughout by the almost yolkless yolk-sac of the embryo while the maternal portion consists of the trophonema, an organ formed from the specially modified uterine mucous membrane in the posterior part of the uterine compartment. The earliest placenta noted by us in this species is that formed at the 3 mm.-stage of embryonic development. At that stage the trophonema is very small, just a bit of the highly wrinkled, glandular tissue of the uterine mucosa. Nevertheless, it already enguifs the yolk-sac, thus completing the placentol arrangement. As growth proceeds both the yolk-sac and the trophonema grow in size and length till the latter develops the four distinct morphological components described by us, at the earliest, at the 10-12 mm. stage. These components are, from the foetal to the maternal end, (i) & (ii) the trophonematous cup and cord (iii) the trophonematous bulb and (iv) the trophonematous stalk. The foetal yolk-sac is simply fitted on the double-walled trophonematous cup there being no invasion of the maternal tissue by the foetal tissue and no firm interdigitating arrangement a between folds and villi. Such a condition persists for some time and then structural and functional degeneration of the trophonema sets in. The foetal yolk-sac is continuously increasing in size and the cup gradually loses its hold on the sac, becoming shallower and shallower. The trophonematous cord also goes on diminishing in length and finally disappears (55-60 mm.). The disappearance of the trophonematous cord marks, in our opinion, the commencement of the intermediate stages of pregnancy. The trophonematous bulb and stalk which were hitherto more or less tough and solid now become hollow and modified so as to form a barrel-shaped or pillar-like structure, the apex of which affords a seat for the yolk-sac. Remnants of the original trophonematous cup are even yet noticeable holding the yolk-sac in contact with the trophonema.

The trophenema is quite vascular at this stage. With further growth of the embryo, even this residual trophonema goes on diminishing in size, till finally, any trace of the original complex structure is completely lost and a mere stub-like vascular elevation is left behind, with the yolk-sac very nearly losing contact with it (110-130 mm.). It is apparent that simultaneously with the growth of the embryo structural and functional degeneration of the specialized maternal structure—the trophonema proceeds downwards from its foetal to the maternal end, till it finally disappears completely after the birth of the embryos (120-140 mm.).

As observed by Mahadevan (1940), the mature egg in this species is very small (1 mm. in diameter) and contains very little yolk which lasts the embryo a very short while indeed. The mother is, therefore, driven to the necessity of making a very early provision of nutriment for the developing embryo, and we find the uterine compartments containing nutritive secretions even as early as in the 0·8 mm. stage of embryonic development, when the embryo still lies enclosed in the egg-case. An actual placental connection is formed as early as 3-4 mm. stage. Judged from the histological structure of the placenta in very early stages, the alimentary condition of the embryo then appears to be principally histotrophic. The cuboidal cells of the inner invaginated layer of the cup lying in actual contact with the outer gland cells actively absorb their secretions and transfer them to the cells of the yolk-sac ectoderm with which they are in firm contact by their basal ends. With subsequent advance in pregnancy (as observed by us in 10 mm. stage and onwards), the placental condition becomes distinctly haemotrophic also. In addition to the former source of nutrition, nutriment from free maternal blood is then made available to the embryo *via* the trophoblastic columnar cells of the invaginated layer of the cup, which may thus be rightly described as a ' maternal trophoblast ' as distinguished from the foetal trophoblast of birds and mammals. The placental layers from the maternal to the foetal end are then seen to be (i) free maternal blood, (ii) ' maternal trophoblast ', & (iii) yolk-sac ectoderm. Using Grosser's terminology describing tissue relationship in the placentae of mammals, the above placenta in *S. sorrakowah* could be described as of Haemo-epithelio-chorialis variety, an altogether new category not met with in any of the placental forms studied so far.

In highly advanced stages of development, the placental structure is seen to be totally disorganised and very little nutrition, if at all, reaches the embryo through that organ. The embryonic development is almost completed by that time and the nutritive secretions in the compartments which continue to be secreted to the last, serve as nourishment to the foetus till the time of its birth.

In view of the fact that profuse quantities of uterine secretions are made available to the embryo almost throughout its intrauterine life, it appears that the alimentary conditions during the foetal life of *S. sorrakowah* are far more histotrophic than haemotrophic and that comparatively a very small quantity of nutrition is derived directly from the maternal blood vascular system. Further, the efficiency of the

maternal trophoblast, which is not inherently a 'true trophoblast', is bound to be of a limited nature and in view of this, as also the poor contact relations between the foetal and maternal tissues, we are inclined to believe that the placenta in *S. sorrakowah* is of a primitive nature, in spite of the fact that it is highly specialised structurally.

List of adult females in pregnant and post-pregnant stages collected from Bombay from April '42 to May '44.

Date of capture.	Length of parent female.	Total No. of embryos.	Average length of embryos.	Remarks.
28-4-1942	21″	7+7=14	10·6 cm.	Advanced pregnancy.
18-5-1942	17·5″	5+5=10	5·6 ,,	Intermediate pregnancy.
22-5-1942	20·5″	7+6=13	12·1 ,,	Advanced pregnancy.
14-8-1942	18″	4+4=8	3·2 ,,	Early pregnancy.
18-8-1942	21″	7+7=14	9·2 ,,	Advanced pregnancy.
29-8-1942	17·5″	5+5=10	5·8 ,,	Intermediate pregnancy.
8-9-1942	18″	3+3=6	4·7 ,,	Intermediate pregnancy.
29-9-1942	22″	7+7=14	11·5 ,,	Advanced pregnancy.
30-9-1941	21·5″	7+6=13	13 ,,	Parturition stage.
1-10-1942	23″	5+5=10	4·8 ,,	Intermediate pregnancy.
1-10-1942	25″	7+8=15	5·9 ,,	Intermediate pregnancy.
1-10-1942	22″	..	..	Post-pregnant condition.
14-11-1942	22″	6+5=11	13·75 cm.	Parturition stage.
15-11-1942	18″			Post-pregnant condition.
5-2-1943	23″	9+9=18	Intrauterine eggs.	Very early pregnancy.
9-3-1943	18″	7+7=14	0·5 cm.	Very early pregnancy.
11-4-1943	21″	7+7=14	5 ,,	Intermediate pregnancy.
12-5-1943	22″	6+5=11	4 ,,	Early pregnancy (Sexes differentiated externally).
17-5-1943	24″	5+5=10	Intrauterine eggs.	Very early pregnancy.
17-5-1943	23·5″	7+7=14	5·5 cm.	Intermediate pregnancy.
6-7-1943	23″	6+5=11	9·3 ,,	Advanced pregnancy.
11, 12, 13, 14-7-1943.				Young ones 6″-7″ in fishermen's baskets.
26-8-1943	22″	7+5=12	12·7 cm.	Advanced pregnancy.
26-8-1943	22·5″			Post-pregnant condition.

List of adult females in pregnant and post-pregnant stages collected from Bombay from April '42 to May '44—contd.

Date of capture.	Length of parent female.	Total No. of embryos.	Average length of embryos.	Remarks.
26-8-1943	21″	6+6=12	14 cm.	Parturition stage.
27-8-1943	22″	7+7=14	4·5 ,,	Intermediate pregnancy.
24-9-1943	20·5″			Post-pregnant condition.
28-9-1943	22″	6+6=12	12 cm.	Advanced pregnancy.
9-10-1943	20·5″	4+3=7	13 ,,	Parturition stage.
20-10-1943	23·5″	2+3=5	2 ,,	Early pregnancy. There were five compartments in each uterus but some were abortive and without embryos. Their trophonemata were present but in a very rudimentary condition.
21-10-1943	22·5″			Post-pregnant condition.
25-10-1943	21″	4+4=8	6 cm.	Intermediate pregnancy.
25-10-1943	23″	4+3=7	12 ,,	Advanced pregnancy.
26-10-1943	21·5″	4+4=8	8·1 ,,	Intermediate pregnancy.
26-10-1943	22″	4+4=8	2·5 ,,	Early pregnancy.
15-12-1943	25·5″	4+4=8	13·5 ,,	Parturition stage.
15-12-1943	24″	6+2=8	9·3 ,,	Advanced pregnancy. The abortive compartments of the left uterus were infected with a species of flat-worms.
20-12-1943	18″			Pre-pregnant condition. Ovaries full of ripe ova.
20-12-1943	22·5″	7+7=14	9·6 cm.	Advanced pregnancy.
20-12-1943	22″	7+6=13	1·5 ,,	Very early pregnancy.
30-12-1943	26″	6+3=9	13·5 ,,	Parturition stage. Three compartments in the left uterus were abortive though showing a complete trophonema formation.
31-12-1943	20″			Post-pregnant condition.
1-1-1944	25·75″	6+6=12	11·8 cm.	Advanced pregnancy.
6-1-1944	23·5″			Post-pregnant condition.
6-1-1944	21·5″	6+2=8	Intrauterine eggs.	Very early pregnancy.
6-1-1944	23″	6+6=12	0·08 cm.	Very early pregnancy.

List of adult females in pregnant and post-pregnant stages collected from Bombay from April '42 to May '44—contd.

Date of capture.	Length of parent female.	Total No. of embryos.	Average length of embryos.	Remarks.
20-1-1944	21·5″	6+6=12	2·5 cm.	Early pregnancy. The right uterus had seven compartments but one of them was abortive. It contained, however, a complete trophonema.
20-1-1944	20″	4+4=8	2·3 ,	Early pregnancy.
20-1-1944	22″	6+6=12	Intrauterine eggs.	Very early pregnancy.
20-1-1944	19″	5+5=10	0·4 cm.	Very early pregnancy.
27-1-1944	22·5″			Post-pregnant condition.
28-1-1944	19″			Post-pregnant condition.
1-2-1944	25″			Post-pregnant condition.
1-2-1944	25″	6+6=12	Intrauterine eggs.	Very early pregnancy.
1-2-1944	25·5″	5+4=9	14 cm.	Parturition stage.
28-2-1944	22″			Post-pregnant condition.
28-2-1944	23″	7+7=14	Intrauterine eggs	Very early pregnancy.
28-2-1944	25″	6+6=12	1·1 cm.	Very early pregnancy.
28-2-1944	23″	7+7=14	Intrauterine eggs.	Very early pregnancy.
28-2-1944	22″	8+8=16	,,	Very early pregnancy.
28-2-1944	25″	0+5=5	2·5 cm.	Early pregnancy. The right uterus was in an unhealthy state. It nevertheless contained five compartments three of which contained empty shell-sacs and two abortive ova.
29-2-1944	25″			Post-pregnant condition.
1-3-1944	21″			Post-pregnant condition.
2-3-1944	22″	2+3=5	2·8 cm.	Early pregnancy.
2-3-1944	19″	7+7=14	Intrauterine eggs.	Very early pregnancy.
2-3-1944	21″	1+1=2	17·5 cm.	Advanced pregnancy. Abnormally big foetuses.
6-3-1944	22·5″	7+7=14	Intrauterine eggs.	Very early pregnancy.
6-3-1944	22″	4+4=8	6·1 cm.	Intermediate pregnancy.
6-3-1944	23″	6+6=12	2·8 ,,	Early pregnancy.
11-4-1944	21″	4+4=8	7·5 ,,	Intermediate pregnancy.

List of adult females in pregnant and post-pregnant stages collected from Bombay from April '42 to May '44—concld.

Date of capture.	Length of parent female.	Total No. of embryos.	Average length of embryos.	Remarks.
11-4-1944	23·5″	8+8=16	9 cm.	Advanced pregnancy.
13-4-1944	25″	9+9=18	12 ,,	Advanced pregnancy.
13-4-1944	19″	8+8=16	5·1 ,,	Intermediate pregnancy.
13-4-1944	23″	12+10=22	4 ,,	Early pregnancy.
11-5-1944	21·5″	5+0=5	16 ,,	Parturition stage. The left uterus was empty and had been evacuated sometime back. The placental cords of the young ones in the right uterus were shed in the compartments and the umbilical scars were fresh.
15-5-1944	20·5″	5+5=10	12 cm.	Advanced pregnancy.
17-5-1944	21·5″	6+0=6	Intrauterine eggs.	Very early pregnancy.
17-5-1944	23″	6+6=12	,,	Very early pregnancy.
17-5-1944	22·5″			Post-pregnant condition.
18-5-1944	17·5″	6+6=12	0·1 cm.	Very early pregnancy. It is just at this stage that the shell membrane sacs are disintegrated and embryos lie naked in the uterine compartments. There is no formation of a trophonema yet.
18-5-1944	19″	4+4=8	4·8 cm.	Intermediate pregnancy.

SUMMARY.

A scrutiny of the foregoing account and table brings out the following points about the breeding season and breeding habits of the species:—

(i) The species breeds throughout the year. The peak period of parturition appears, however, to be in November, December and January, for, in the early months of the year, females are in early stages of pregnancy,

(ii) Females mature when they are about 17″ long. The maximum length of the species in the Bombay waters appears to be about 26″.

(iii) Both the ovaries are present and functional. The mature egg is extremely small in size, about a millimetre in diameter and contains very little, colourless, granular yolk.

(iv) Fertilized eggs descend into the uterus enclosed in delicate shell-membrane sacs. These sacs disintegrate at a very early stage of embryonic development (1 mm-stage) and for the most part of the existence, the embryos lie naked in the compartments, but profusely covered with nutritive uterine secretions.

(v) As a rule the number of embryos born is 14, 7 from each uterus. The maximum number of embryos borne by a single uterus is twelve. The sexes are distinguished externally when the embryos are about 40 mm. long.

(vi) The young ones measure from 130 mm. to 150 mm. in total length at birth. Their placental cords are shed shortly before birth.

(vii) All the compartments of a uterus do not necessarily contain developing embryos, some of them being found to contain abortive trophonemata only. It is possible that either the embryos of these compartments have undergone very early abortive degeneration or that the actual presence of embryos is not necessary for the formation of trophonemata, the pregnancy (fertilization) stimulus being enough to cause their formation even in the maiden compartments (hormonic action ?)

(viii) The conditions of embryonic alimentation are highly histotrophic and only slightly haemotrophic. The placenta formed is of the *Haemo-epithelio-chorial* variety.

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* These references have been quoted in the text.