OBSERVATIONS ON THE REPRODUCTIVE SYSTEM, EGG-CASE, EMBRYOS AND BREEDING HABITS OF CHILOSCYLLIUM GRISEUM MULL. AND HENLE.

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Introduction.

Several Elasmobranchs have been recorded from the Indian Coasts. Many of these are viviparous forms and just a few, oviparous. Our knowledge of the life-history of these fishes is confined to descriptions of embryos of some of these forms by Alcock (1890, 1892), Southwell (1910), Wood Mason and Alcock (1891, 1892), Southwell and Prashad (1919). In regard to the oviparous form Chiloscyllium griseum the egg-case was described by Sundara Raj (1914), Southwell and Prashad (1919) and that of C. indicum by Smedley (1926) and Deraniyagala (1934). Embryos of C. indicum were described by Smedley (1926) and Deraniyagala (1934). Their descriptions are incomplete in several respects. We are not aware of any record of the embryos of C. griseum nor is there any definite information regarding the duration of incubation and breeding. The following is the first connected account of the life-history of an Elasmobranch from the Indian Coast.

More than 2 dozen specimens of C. griseum were obtained during the years 1936–38. Of these six alone were fully mature, while the rest were mostly immature with the ovaries yet undeveloped. Of the mature specimens, the first was captured on 5–2–1937, the second on 8–2–1937, the third on 11–2–1937, the fourth on 25–3–1937, the fifth on 31–1–1938 and the sixth on 15–3–1938. That obtained at the end of January last is the largest and measures 29" long and 4·5" broad. The remaining five are about equal and measure 26·5" by 3·5" approximately. All the six specimens had the abdomen distended.

1 We are indebted to Dr. S. L. Hora of the Zoological Survey of India for sending us the necessary references relating to identification of the form.

2 The length was taken from tip of snout to end of caudal fin and the width just in front of the pectoral fins.

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Reproductive System.

For the purpose of this description the reproductive organs of the specimen obtained on 5-2-1937 has been taken. The single ovary (Pl. XXV, Fig. 1) which had a measurement of 125 mm. in length and 50 mm. in breadth and 18 mm. in thickness in the fresh condition contained 33 huge bluish green eggs and a large number of smaller light yellow ova. The other organs were almost completely hidden away from view by the huge ovary. The attachment of the epigonal organ to the ovary is very slender and the organ itself is thin and strap-shaped. There is a common median wide oviducal opening with thin-walled soft extensible lips (Pl. XXV, Fig. 2). The cranial part of the oviduct measures 62 mm. in length and 8 mm. in width. When slit open it is found to be traversed by longitudinal folds which are not single and continuous, but made up of tiny folds, each of which is cut up into leaf-like bits, free at the tips but continuous below, so that the crests of the long folds give rise to an undulating appearance (Text-Figs. 1 and 2).

Both the shell-glands are equally developed and each measures 50 mm. in length and 37 mm. in breadth at the swollen portion. When cut open, the inner surface of the gland shows three zones (Text-Fig. 3). The first zone is composed of alternating shallow grooves and low ridges, the second
or the middle (the broadest) consists of very delicate lamellæ with slightly wavy tops, the third is formed of a dense glandular zone with a comparatively smooth inner surface. On the ventral side there is a very prominent groove starting from the middle of the gland and extending down an inch and a half below the swollen portion and continuous with the lumen of the caudal part of the oviduct below. A shallow groove occurs also on the dorsal surface but it is not so conspicuous as the ventral one. Into the grooves open densely packed very fine filamentous tubules running horizontally towards them. Both the glands were rather flaccid in the fresh condition having apparently just then disgorged the egg-case into the uteri.

The caudal portion of the oviduct measures 45 mm. in length and 33 mm. in width. Internally it is lined with longitudinal ridges which are smooth and entire but wavy. Between the caudal oviduct and the entrance into the uterus is a powerful sphincter (Text-Fig. 4). Here the longitudinal ridges crowd and become closely pressed against each other. The uterus measures 75 mm. in length and 40 mm. in width. On opening the uterus which was tensely stretched it was found to contain one boat-shaped egg-
Observations on Chiloscyllium griseum Mull. and Henle.

The egg-case, which was smooth, hard and chitinous. Between the uterus and the egg-case there was a little uterine fluid. The inner surface of the uterus is traversed by a large number of transverse folds. The above description would apply to all the remaining five specimens except that in two of them each uterus contained two egg-cases instead of one and in a third there were three egg-cases on each side. In the last specimen the capsules of the first pair were symmetrically placed opposite each other whereas one of the fellows of the third pair had slipped partly down into the cloaca.

Some of the egg-cases were removed and suspended in sea-water which was kept aerated and renewed at frequent intervals. The capsules had the benefit of direct sunlight entering the sea-water room in the mornings. The temperature of the water was near 25°C. Developing eggs were taken out at definite intervals and examined. Three of the eggs did not develop properly. This can only be explained by the probable rough handling of the fish before they were brought to the laboratory and the consequent 'jar' that the eggs would have received.

Egg-Case.

The 20 capsules found in the six specimens are of about the same size. They range from 75–80 mm. in length and 35–40 mm. in width, with an average thickness of 16 mm. They are of a yellowish brown colour, with the thickened edges of a deeper brown.

The capsule is more or less quadrangular but slightly asymmetrical (Text-Fig. 5). One of the two long sides is more curved and therefore

Fig. 5.
longer and this side has two short tufts of filaments. Along the opposite long edge is the characteristic broad band composed of silky fibres which gradually twist into a long cord, measuring 6·8 inches intended for attachment of the capsule to sea-weeds or other similar objects. The two long edges come closer together at the posterior end than at the anterior. The more curved side is the dorsal side considering its orientation inside the uterus. But actually, however, the capsules turn over with the uterus and present the more convex side directed away from the mid-line of the body-cavity. There is an oval slightly transparent area at the posterior end which is presented first during oviposition; into this the cavity of the capsule does not extend. At the anterior end also the two surfaces are pressed against each other, an intervening cavity being absent. When the egg-cases were gently removed from the uteri, the twisted cord formed by the tapering broad band was found lying in the lumen of the caudal part of the oviduct with the terminal part of the cord lodged in the posterior portion of the ventral nidamental gland groove. The whole twisted cord lay freely in the lumen so that when the capsule was removed it came off easily. It seems highly probable that this portion (cord) is formed last. Deraniyagala says that only half the long edge was covered with elongate anchoring filaments in his egg-cases of C. indicum. But the specimens in our possession show that practically the entire edge is covered with these silky filaments though it is not so prominent or concentrated at the two ends as towards the middle. Besides the two short tufts and the large band mentioned, there are slender silky threads fringing the edges as observed by Sundara Raj though Deraniyagala does not mention this for C. indicum. Sundara Raj did not find any prolongation into tendrils at the four corners. Nor do we find any in the egg-cases with us. But Southwell and Prashad (1919) describe a pair of poorly developed filaments (tendrils) at one end and a shorter pair at the other. They also mention and figure two short tufts of filaments at two places along the longer side. It seems to us that the filaments from the corners may or may not be formed and they constitute a variable character. Clark's (1922) researches on the Rays have shown that the egg-cases of the same fish may show slight variation in size and in other minor details.

In the case of one of the specimens with two egg-cases in each uterus, the twisted silky filaments of the anteriorly situated egg-cases had the tips lodged freely in the gland-grooves, while the filaments of the posterior egg-cases were curled up and lay freely in the uteri between the two egg-cases. The uteri of the specimen with the three egg-cases in each uterus were absolutely packed from end to end. This shows that the secretion of the egg-case together with the accessory appendages is very rapid, and probably
3 pairs form the maximum number that could be accommodated in the uteri at a time. There is no doubt that the eggs are fertilized in the upper parts of the oviduct. Dean (1895) and Lo Bianco have clearly stated this as their opinion. As gravid females confined in aquaria in which no males were present, have laid several pairs of eggs it can only be as the result of the eggs getting fertilized by sperms retained in the reproductive system of the female for a long time in a living condition.

The egg-case has 4 slits, one situated at each of the four corners. In a side view of the egg-case only two are seen as the other two are placed along the opposite long edge but are visible on the other side only. They are plugged with a gelatinous substance and when this is removed carefully the slits are found to lead into the cavity of the capsule. Sundara Raj (1914), Southwell and Prashad (1919) do not mention the slits in their description of the egg-case. Deraniyagala (1934) speaks of an "opening at the edge of one corner" permitting the water to enter. He thought that the opening is used for the intake of water while Beard (1890) believed that a current is non-existent, and that the slits are intended to counteract pressure. We believe that these slits are for the entrance of water, for, when after a time the albumen is exhausted probably by the trophonematic activity of the branchial filaments, the plug gets dissolved and the water enters freely. This is helped by the movements of the embryo inside, allowing a free interchange of water between the outside and inside. Clark (1922) also believes that the slits are for the interchange of respiratory water. When the capsules are lifted out, the water inside rapidly drains off and the capsule floats on the surface. Care must be taken to immerse the capsule and to fill its inside once more with water by gently pressing it between the fingers and releasing the pressure once or twice. Otherwise the embryo will perish.

Development during the First Week.

The blastoderm of an egg taken from a capsule about to be laid is yellowish in colour and is in the form of a circular halo and measures 3-4 mm. in diameter. After three days of development the blastoderm has the appearance shown in Text-Fig. 6. It is circular in outline and has a diameter
of 0.5 mm. One side of the edge of the blastoderm is thickened and here the medullary groove has commenced to form and has extended to one-fifth of the distance across the blastoderm. During the fourth and fifth days, growth is rapid and the medullary folds grow rapidly forwards. The medullary groove gets deepened behind, but remains wide and shallow in front. The sides of the folds in the front region get so much flattened that they give rise to a plate-like structure, the cephalic plate of some authors. The head end and the sides of the developing embryo get raised and folded off from the blastoderm. Blood-islands have formed during the third and fourth days, giving rise to a network-like peripheral ring. Five pairs of vertebral somites could be counted on the completion of the fourth day of development. During the next two days quick transformation of the embryo takes place. The medullary groove closes and the tail end gradually projects beyond the hind edge of the blastoderm. Mesoblastic thickenings on either side of the tail now manifest themselves clearly.

*Embryo One Week Old.*

The blastodermic area measures 25 mm. in diameter, the rim of the area being very thick. The embryo is clearly visible and has lifted itself out of the yolk and measures 5 mm., is perfectly white in colour, and shows active movements (Pl. XXV, Fig. 3). The separation of the embryo has so far progressed that one can already speak of a definite broad but short yolk-stalk. The embryo now corresponds to stage H of Balfour (1878). The brain clearly consists of the usual three divisions—the fore, middle and the hind-brain. The tail is long and slightly broadened. The primary optic vesicles have become clear. The auditory vesicles are just visible as translucent circles. The heart has developed. The tail is slightly dilated and the usual cranial flexure has commenced. As many as 26–28 vertebral somites could be counted at the commencement of the second week of development in healthy embryos and there is an unsegmented region on either side of the tail.

*Embryo Two Weeks Old.*

This is very nearly equivalent to stage K of Balfour (Text-Fig. 7 and Pl. XXV, Fig. 4). The embryo now measures 10 mm. The blastodermic area
has extended almost half round the yolk-mass. The yolk-stalk has become narrow but slightly longer. The cranial flexure has become very pronounced. The position of the anus is now clear. The mid-brain is conspicuous and now forms the front end. The optic vesicles have closed but the lens could not be made out. The mouth has commenced to form as a median slit. The alimentary canal has extended forwards and backwards. Four pairs of visceral slits could now be made out with faint indications of a fifth pair. The branchial filaments have begun to appear as faint projections. The auditory vesicles are now clear. Fin differentiation has progressed rapidly. There is a dorsal median and a ventral median fold. In addition there are two delicate lateral thickenings but the boundaries of the paired fins cannot be made out.

*Embryo Three Weeks Old.*

<table>
<thead>
<tr>
<th>Description</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>40 mm</td>
</tr>
<tr>
<td>Yolk-sac</td>
<td>22</td>
</tr>
<tr>
<td>Tip of head to hind end of pelvic fins</td>
<td>14</td>
</tr>
<tr>
<td>Yolk-stalk</td>
<td>12</td>
</tr>
</tbody>
</table>

The stage corresponds to stage O of Balfour (Pl. XXVI, Figs. 5 and 6). The albumen has been completely absorbed. The vitelline arteries and veins are fully developed. The tail has lengthened out considerably. Pectoral fins, pelvic fins and the two dorsal and caudal have assumed their respective positions. The ventral median fin-fold is almost continuous from behind the pelvies to the tip of the caudal fin. Two minute indentations already mark the end of the anal and the commencement of the caudal. All the six pairs of visceral clefts are fully formed. The spiracles are situated midway in the interval between the eyes and the gill-slits.

The eye vesicles are fully formed and the lens is clear and pigmented. The nasal depressions are distinct but not confluent with the now squarish mouth. All the gill-slits are now clear and projecting from the outer tips of the internal gill-lamellae are a number of vascular branchial filaments provided with vascular loops. The filaments of the spiracular clefts are only half the length of the filaments from the other gill-slits. The filaments from the posterior gill-slits are very much shorter than those shown for *C. indicum* by Deraniyagala and reach only the hind edges of the pectoral fins. These filaments are not only respiratory but also serve probably for the absorption of the albumen. In this respect the respiratory function may be said to commence after the albumen has been absorbed. The mouth-cavity has widened and has become deep. The animal is very active. The gelatinous plugs of the slits on the capsules have not yet been dissolved away.
Embryo One Month Old.

Length ........ 45 mm.
Tip of head to hind edge of pelvic fins .... 16 mm.
Yolk-sac ........ 20 mm.
Yolk-cord ........ 5 mm.

This stage is very much like the previous stage. The embryo has grown longer (Pl. XXVI, Fig. 7). There has been a rather sudden shortening of the yolk-cord. The branchial filaments have become denser. The buccal opening has become transverse. Nasal depressions are conspicuous in front of the mouth. The nasal tentacles have sprouted out and the mouth has become connected with the nasal depressions. The interval between spiracles and the eyes is very much less than in the previous stage. There is a ring of pigment round the lens. The surface of the body is not pigmented. The pectoral, the pelvic, the first dorsal and the second dorsal are distinct. The caudal fin extends along the median ventral line some distance beyond the commencement of the second dorsal and now shows two dents, the first of which will later on separate off the anal from the caudal. On either side of the caudal there are two rows of serrated denticles 11 in the upper row and 7 in the lower (Text-Figs. 8 and 9). Deraniyagala mentions 16 and 13 denticles from an embryo of 53 mm. of C. indicum. The surface of the yolk-sac is highly vascular. With the disappearance of the albumen rapid absorption of the yolk has commenced.

Embryo Two Months Old.

On the completion of the second month of development one of the capsules was taken and long slit-like windows were cut on one side to observe the movements of the enclosed embryo.
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Length ........................................ 100 mm.
Width of embryo in front of pectorals ........ 18 „
Tip of head to hind edge of pelvic fins ......... 40 „
Diameter of yolk-sac ................................ 18 „
Length of yolk-cord ................................ 15 „

The embryo was found coiled round the yolk-sac with its head pointing towards the posterior end of the capsule (Text-Fig. 10). All the fins have assumed the adult character and the characteristic colouration which is described in connection with the next stage has become fully established. The part of the median ventral fin-fold (the anal membrane) in front of the anal has become absorbed. The nasal tentacles (barbels) are prominent and now reach the margin of mouth. The embryo is a male and the claspers are well formed. Teeth have broken through. All traces of the branchial filaments have disappeared. Vigorous respiratory movements of the gill region were noticeable causing rhythmic lateral movements of the embryo as a whole. In the position in which it was found the back of the embryo was directed towards the right side of the capsule. Now and then the embryo revolves round, in a circle. In the limited space no other movements seemed possible.

FIG. 10.

Embryo 70 Days Old.

Length of space inside capsule .......... 45 mm.
Breadth of space inside capsule ........ 20 „
Length of the embryo ..................... 110 „
Diameter of yolk-sac ...................... 6 „
Breadth at the broadest part .......... 16 „
Yolk-cord ................................ 5 „
Tip of head to hind edge of pelvic fins .. 45 „
The embryos are found curled up and are incapable of any movement in the limited space available; when one was taken out and placed in a jar of sea-water it swam in circles with energetic movements of the tail. After two days the yolk-sac had become further reduced after which the embryo was fixed. Colouration has become fully established (Text-Fig. 11 and Pl. XXVI, Figs. 8 and 9).

![Fig. 11.](image)

Looked at from the dorsal side, there are twelve white bands. The first is immediately in front of the eye, the second passes across the broadest part of the head of the animal, *i.e.*, just behind the spiracle, the third and fourth behind the level of the pectoral and in front of the ventral fins respectively. The fifth crosses the body just in front of the first dorsal fin. The next one divides the interval between the first and second dorsal into two. The seventh band occupies a position in respect of the second dorsal which the fifth does to the first dorsal. The remaining five bands divide the part of the body behind the tail into six equal spaces. The tip of the tail is white.

All the twelve bands are peculiar in that their outer ends are swollen into large white spots decreasing in size from before backwards. The number of caudal denticles in the specimen has increased (Text-Fig. 12). There are 19 in the upper and 13 in the lower row. Deraniyagala

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3 Young specimens slightly larger in size were caught on 20-4-1937 and in these the white bands showed signs of fading.
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Thinks that these denticles have the function of fixing the embryo to some part of the inside of the egg-case to prevent too violent movements and a premature exit from the egg-case.

FIG. 12.

There does not appear to be any justification for this belief. Active movements of the embryo could easily be seen through the egg-case and the authors believe that it is these movements which bring about renewal of water in the egg-case especially in the earlier stages. Clark attributes a similar function to the elongated caudal fin of Raja naevus. An egg-case removed from the fish and allowed to develop on 31st January 1938, hatched out on 21st April 1938, exactly after eighty days' incubation. The embryo was seen wriggling out, forcing its way through the anterior end of the egg-case. The yolk-sac was found to have been completely absorbed, leaving just a scar at its point of attachment on the ventral side of the body.

Clark (1926) from a consideration of the measurements of the total length of embryos and the distance from tip of snout to origin of the first dorsal, came to the conclusion that there is a differential growth of the parts pre-dorsal and post-dorsal. After a certain length has been reached the length of the post-dorsal remains practically stationary while the pre-dorsal length shows progressive growth.

The following table gives the measurements of Chiloscyllium griseum of different ages.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Age</th>
<th>Total length</th>
<th>To end of pelvic fin</th>
<th>Rest of body</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21 days</td>
<td>mm. 40</td>
<td>mm. 14</td>
<td>mm. 26</td>
</tr>
<tr>
<td>2</td>
<td>30 ,,</td>
<td>mm. 45</td>
<td>mm. 16</td>
<td>mm. 29</td>
</tr>
<tr>
<td>3</td>
<td>60 ,,</td>
<td>mm. 100</td>
<td>mm. 40</td>
<td>mm. 60</td>
</tr>
<tr>
<td>4</td>
<td>70 ,,</td>
<td>mm. 108</td>
<td>mm. 45</td>
<td>mm. 63</td>
</tr>
<tr>
<td>5</td>
<td>80 ,,</td>
<td>mm. 130</td>
<td>mm. 55</td>
<td>mm. 75</td>
</tr>
<tr>
<td>6</td>
<td>Adult of unknown age</td>
<td>mm. 620</td>
<td>mm. 290</td>
<td>mm. 330</td>
</tr>
</tbody>
</table>
An analysis of the figures given in the table above indicates the rates of growth of the anterior part (from the snout to hind edge of pelvic fins) and of the posterior part (from the pelvic fins to the tip of the tail) of the growing embryo are different. For example, the head and trunk region has elongated from 14 mm. to 45 mm. during an increase of age from 21 to 70 days, while the tail region has recorded a growth from 26 mm. to 63 mm. Thus it is fairly clear that the anterior end develops at a slightly higher rate than the posterior. This is as it should be for, the length of the tail is proportionately greater in the earlier stages than in the adult.

**Breeding Period and Duration of Development.**

In deciding this question the following facts may be taken into consideration:—

Sundara Raj collected his egg-case of *C. griseum* from the Madras Aquarium on the 27th January 1913. Southwell and Prashad obtained their two egg-cases of the same species from the Gangetic delta in March 1918. Deraniyagala obtained his egg-cases of *C. indicum* in March 1933. Smedley’s record of his egg-cases of *C. indicum* unfortunately does not give the date of collection. The egg-cases obtained by us were from females captured during January–March period. Very young *C. griseum* measuring 130 mm. have also been obtained in the month of March from the fisherman’s catches. Judging from these facts and bearing in mind that the incubation period is about two months and a half, one might be led to conclude that the period of spawning is restricted to the months of January, February and March along the Madras Coast. But the fact that it was possible to obtain embryos measuring 100–125 mm. now and again throughout the year seems to point to a different conclusion. This would mean that early in the year the gravid females seek sheltered situations near the Coast for purposes of egg-laying and that as the year advances they seek deeper waters with the result that they escape the fishermen’s net. No other explanation seems to be possible for the capture of very young specimens in small numbers during the year. Similar observations of a fairly prolonged breeding period have been recorded by Beard for the Skate *R. batis* and the Ray, *R. navus* in the North Sea; and for *R. punctata* in the Naples Bay by Lo Bianco. It is highly probable that the capsules are deposited in favourite spawning grounds.

Madras gets a fair proportion of its supply of sharks by trains during certain months of the year from Malabar. An examination of a small heap of *C. griseum* in one of the fish markets of Madras early in December 1937 revealed two specimens with egg-cases. One was 21.5” long and was in the gravid condition, with an egg-case in each uterus. The nidamental glands
were in a high state of activity and the ova were of the maximum size. The second specimen measuring 22.5" was also mature, with the ovary containing large-sized bluish green ova, but these were fewer than in the first specimen. The nidamental glands were fully active, but no egg-case was found in the uteri which were flaccid and represented a condition probably just after the release of the egg-capsules into the sea. The fact that fewer ova occurred in the ovary of this fish is itself sufficient to prove that some of them had already descended into the uteri surrounded with the capsular covering and had been liberated into the sea by the fish.

Comparing the sizes of the mature forms of Malabar and Madras it seems that the Malabar specimens attain maturity when they are relatively smaller than the Madras forms. It would mean either that the maximum size that the fish is capable of attaining in the Malabar Coast is less or that if the maximum size is taken as about equal, then the reproductive maturity sets in earlier on the Malabar Coast than on the East Coast. In the absence of more detailed data on this question nothing definite could be stated. The egg-capsules of the Malabar form are also smaller than those of Madras specimens. Those of the former measure 60 mm. in length and 25 mm. in width; while the latter 70–80 mm. in length and 40 mm. in width. The difference in size is in accordance with the statement of Clark (1912) that considerable variation is apparent in the Mediterranean capsules compared with the Plymouth ones of the same species. He makes a suggestion that the mature fish of the same species are smaller in size in the Mediterranean and Lo Bianco's (1908–09) observations are in conformity with this. Variation in individuals of the same species has led several workers like Jordan and Evermann (1896) and Garman (1913) to adopt a classification according to distribution.

Regarding the period of incubation (i.e., the period of development inside the egg-case) it is now clear, from the facts available, that for this Indian form it is not at all so long as in the case of the European Elasmobranchs. Clark gives, for instance, for Raia marginata 14½ months. He also records other cases with the incubation ranging from 4½ to 8 months. Kerr mentions 20 months for Raja batis and says that for this form the effect of temperature is so great that the December eggs of this form are overtaken in their development by the April eggs. This may be so for several of the European forms, but for the species under consideration this period cannot be much more than 2½ months. Sundara Raj's statement that "the period of gestation is probably very long in dog-fish" is clearly an error as he seems to use the term "gestation" to mean period of development inside the parent, which we know to be very short in oviparous forms. It would
otherwise be impossible for oviparous forms to produce and liberate as many as 25 capsules in a short time. In our specimens the blastoderm had just commenced to divide and there were other eggs coming down.

Smedley suggests a "lengthy period" of incubation judging from the presence of hydroid organisms. Work done in this Laboratory has clearly shown that in the tropics hydroids grow very rapidly. For instance, *Laomedea spinulosa* becomes mature sexually in nine days and further these are constantly being browsed down by small animals. Consequently, we cannot judge the period of incubation from the size and nature of hydroid growth on the egg-capsule.

It seems to us that the comparatively short period of development is in accordance with the general shortening of development that seems to exist in a number of tropical forms as has been shown in this Laboratory by work on several organisms (Paul, 1937), *Salmacis* (Aiyar, 1935) and *Acentrogobius* (Aiyar, 1935).

*Egg-Liberation.*

In all the six gravid specimens examined by us the ovary was in a state of full development. There were in each case more than 30 full-sized eggs, each as big as those enclosed in the egg-capsules. Southwell and Prashad mention an egg-case in each uterus. It is only when the cloaca is almost reached that one of the egg-cases takes a slight precedence over the other and is presented first. Further, the observation of those who have watched the behaviour of some of the Elasmobranchs in aquaria goes to show that the eggs are deposited in pairs, the two capsules of a pair coming out one after the other in quick succession. Clark mentions that in the case of *Raia brachyura* as many as 25 were laid during the course of 20 days between the 12th April and 31st of May of 1922. He says that one capsule would be followed immediately by another. Then there would be a pause for a day which would be followed by another pair. This appearance of eggs spawned in pairs, he thought, was in keeping with the maturation of a single ovum from each ovary, there being two in *Raia brachyura*. The fact that in one of our specimens there were three pairs of capsules (3 in each uterus) closely packed one behind the other and that the ovary still had several fully-developed eggs can only mean that the eggs are liberated at very short intervals.

Our observations are in accordance with the facts recorded by Fr. Kopsch who studied the egg-laying of *Scyllium canicula* in the aquarium at Rovigno. Two eggs were laid almost at the same time. He further states that between the temperature 11° and 16° C. "The stage reached is a function
of time and temperature; thus if a stage x be reached in six days at 10° C.,
the same will be reached in four days at 15° C."

In C. griseum there is only a single ovary and the evidence available
goes to show that the egg liberation is very similar. Sundara Raj observed
rapid laying of eggs in C. griseum in the Madras Aquarium tanks though
unfortunately no details are given.

Smedley mentions a cluster of three eggs of C. indicum attached by con-
tinuous strands and he suggests the possibility of the eggs being laid in threes.
This does not seem probable. The eggs have been seen by us in the uteri
of the Madras form placed opposite to each other and since in the specimens
which contained more than a pair, the capsules were one behind the other
the probability is that they are laid in pairs, one egg-case being fol-
lowed rapidly by another. The presence of a single ovary only need not offer any
difficulty. The ovary matures two eggs in rapid succession which one after the
other find their way into the oviduct. Widakowich (1908) has pointed out
how the congestion of blood in the posterior cardinals at the time of egg
liberation helps in the process of rapidly pushing the egg into the median
oviducal opening. Hobson (1930) points out that in Raia radiata which
has two ovaries, the pairs of eggs may be formed alternately in each ovary.
Dean (1906) believes that a very similar occurrence takes place in Chima-
eroids and suggests an alternate liberation of eggs from the ovary. He
thinks that the fluidity of the eggs at this stage unquestionably aids easy
entry into and smooth passage through the narrow oviduct. The condition
of C. griseum is very similar and may be taken as a step in advance de-
veloped in correlation with the complete suppression of one of the ovaries.
The eggs are fertilized as they come down the upper reaches of the oviducts;
they get a coating of albumen and shell substance in the nidamental glands
and finally pass rapidly down the oviducts to be extruded from the cloaca.

Summary.

The complete life-history of Chiloscyllium griseum from Madras is
described in detail.

A description of the reproductive system and the egg-case is given.
There is a single ovary and a common oviducal opening. The nidamental
glands are well developed.

An account of the different stages of development is given.

The breeding period commences probably in January and extends over
several months.

Eggs are probably liberated in pairs, the two eggs of every pair escape-
ing in quick succession.
The time taken for development of the egg into a full-grown embryo before it is liberated is very short being $2\frac{1}{2}$ to 3 months unlike the very much longer periods taken in colder regions by allied forms.

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Explanations of Text-Figures.

Text-Fig. 1.—The nidamental gland cut open to show the general appearance of the inside of the gland. d.gr. dorsal groove; v.gr. ventral groove; cr.ov. cranial oviduct; cd.ov. caudal oviduct.

Text-Fig. 2.—Diagram of transverse section of cranial part of oviduct showing the projecting folds.

Text-Fig. 3.—Diagram of longitudinal section of nidamental gland showing three definite gland zones. al.s.z. albumen secreting zone; cr.sh.s.z. cranial shell secreting zone; cd.sh.s.z. caudal shell secreting zone.

Text-Fig. 4.—Diagram of inside view of caudal part of oviduct and the commencement of the uterus with the sphincter in between.

Text-Fig. 5.—Egg-capsule as seen from the right side.

Text-Fig. 6.—Blastoderm. Three days old.

Text-Fig. 7.—Embryo. Two weeks old.

Text-Fig. 8.—Caudal fin of thirty days old embryo.

Text-Fig. 9.—Two denticles enlarged.

Text-Fig. 10.—Embryo sixty days old exposed from the left side of capsule.

Text-Fig. 11.—Embryo seventy days old.

Text-Fig. 12.—Caudal fin of embryo seventy days old.

Explanations of Photographs.

Plate XXV.

Fig. 1.—A gravid female with the abdominal cavity cut open. Note huge ovary and an egg case lying to one side.

Fig. 2.—Reproductive system. Showing median oviducal opening, enlarged nidamental glands and uteri distended with egg-capsules.

Fig. 3.—Embryo one week old.

Fig. 4.—Embryo two weeks old.

Plate XXVI.

Fig. 5.—Embryo three weeks old. Ventral view.

Fig. 6.—Embryo three weeks old. Side view.

Fig. 7.—Embryo one month old.

Fig. 8.—Embryo seventy days old. Ventral view.

Fig. 9.—Embryo seventy days old. Dorsal view.

Fig. 10.—Embryo normally hatched out. Eight days old.