

OBSERVATIONS ON THE DEVELOPMENTAL STAGES OF THE
SMOOTH DOGFISH, *ERIDACNIS RADCLIFFEI* SMITH FROM
GULF OF MANNAR.

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ABSTRACT

The structure of mature reproductive organs of fifteen adult females of *Eridacnis radcliffei*, ranging in total length from 150 to 218 mm collected from the trawl catches off Mandapam in Gulf of Mannar during February, 1972 at a depth ranging from 100 to 150 fathoms were studied and the various stages of intra-uterine embryos are described and discussed. A close examination of different stages of embryos revealed that this species exhibits ovoviviparous type of development. The intra-uterine egg is enclosed in a thin shell membrane which disappears when the embryo develops inside the uterus. The embryos are seen free inside the uterus and no placental connection has been observed in any stage of development.

INTRODUCTION

The family Triakidae includes a number of small species of sharks found in the tropical and warm temperate waters of all the oceans of the world. These sharks usually inhabit the sea bottom. Literature on the development of members of this family is very meagre. However it is known that they exhibit heterogenous type of development viz; oviparity, viviparity and ovoviviparity. Smith (1913) established the genus *Eridacnis* for *E. radcliffei* a new shark from Philippines and the known species of this genus are *E. radcliffei* (Smith), *E. barbouri* (Bigelow and Schroeder) and *E. sinuans* (Smith). Fowler (1941) attributed viviparity for *Eridacnis* while Compagno (1970) suggested ovoviviparity.

Misra (1950) described *Proscyllium alcocki* from Andaman Sea and this is now treated as a synonym of *E. radcliffei* (Compagno, 1970). Except for the taxonomic details (Misra, 1950; Nair and Lal Mohan, 1973) there is practically no information on the development of *E. radcliffei* from Indian waters. Apart from the stray accounts on the late embryonic stages of *E. radcliffei* (Smith, 1913) and *E. barbouri* (Bigelow and Schroeder, 1948) very little is known about the developmental stages of any of the three species of *Eridacnis*. In the present paper descriptions of the reproductive organs of females with mature yolk

laden eggs in the ovary, females with the intra-uterine eggs, early stages of embryos of total length 17 mm and 22 mm and late stages of embryos ranging from 101 to 107 mm of *E. radcliffei* are given with a view to elucidate the developmental process of this species. Development in *E. radcliffei* is of ovoviviparous type. The intra-uterine egg is enclosed in a thin shell membrane which disintegrates when the embryo is formed. Embryos lie free inside the uterus and placental connection is not present at any stage of development.

MATERIAL

Material for the present study was collected from the trawl catches in Gulf of Mannar off Mandapam (08° 80' N and 70° 05' E) at a depth ranging from 100 to 150 fathoms during February, 1972. Fifteen females with total length of 151 to 218 mm were utilised for the present study. Out of these, six were with mature yolk laden eggs in the right ovary, two had intra-uterine eggs, two with early stages of intra-uterine embryos and the rest with advanced stage of embryos. The details relating to the total length and the number of developed eggs and intra-uterine embryos present in each specimen are given in Table 1.

DESCRIPTION OF FEMALES WITH MATURE OVARIAN EGGS

Examination of the reproductive organs of six females measuring 151 - 218 mm in total length showed that the right ovary alone was functional, the left one being either atrophied or absent. The right ovary contained well developed mature yolk laden eggs, the number of which varied from one to two (Fig. 1A). These yolk laden eggs were round and yellowish in colour and the diameter varied from 7 mm to 11 mm. Apart from these mature eggs there were a number of small, rounded, whitish opaque immature eggs of the size of pin heads in the right ovary of all the specimens. Nidamental glands were present on both the sides as well developed structures, their length ranged from 3 mm to 4 mm. In the 151 mm specimen alone the nidamental gland was poorly developed. The uteri of all these females were slender and did not contain egg or embryo. On dissection it was found that the wall of the uterus was tough and there were a number of raised longitudinal ridges running throughout its length.

In the present study it is interesting to note that the number of mature yolk laden eggs in each specimen was one or two and examination of gravid females showed that only one or two intra-uterine embryos are developed at a time in all the females. This observation agrees with that of Compagno (personal communication), who has found that the adult females of *E. radcliffei* collected from Philippines have only one embryo in each uterus.

DESCRIPTION OF FEMALES WITH INTRA-UTERINE EGGS

Two females of total length 161 mm and 165 mm revealed further stage in the developmental condition with developed eggs measuring 13 mm and 14

TABLE 1. *Size of pregnant females, number and diameter of developed intra-uterine eggs and number and size of intra-uterine embryos of E. radcliffei recorded in February, 1972.*

| Sl. No. | Total length of adult (mm) | Number of developed eggs in ovary and their diameter | Number of intra-uterine embryos | Total length of embryos | | Remarks |
|---------|----------------------------|--|---------------------------------|-------------------------|-----------------|---|
| | | | | In left uterus | In right uterus | |
| 1. | 151 | 1 (7 mm) | — | — | — | No shell membrane observed inside both the uterus. |
| 2. | 180 | 2 (9, 9 mm) | — | — | — | Nidamental glands developed. |
| 3. | 185 | 2 (9, 9 mm) | — | — | — | Right uterus bulged in the central portion. |
| 4. | 191 | 2 (9, 9 mm) | — | — | — | Uterine tube slender with longitudinal ridges on the inner wall. |
| 5. | 194 | 2 (10, 10 mm) | — | — | — | — |
| 6. | 218 | 2 (11, 10 mm) | — | — | — | Nidamental glands 4 mm in width. |
| 7. | 161 | — | — | — | — | One intra-uterine egg is seen inside the right uterus. 13 mm in length. |
| 8. | 165 | — | — | — | — | One intra-uterine egg inside the right uterus. 14 mm in length. Egg covered with shell membrane. Left uterus empty. |
| 9. | 166 | 1 (8 mm) | 1 | — | 17 mm | Early stage of development. |
| 10. | 168 | — | 1 | — | 22 mm | — |
| 11. | 188 | 2 (8, 9 mm) | 1 | — | 103 mm | Left uterus empty. |
| 12. | 189 | 1 (9 mm) | 1 | — | 106 mm | Left uterus empty. |
| 13. | 198 | 2 (8, 8 mm) | 2 | 101 mm | 105 mm | — |
| 14. | 203 | 2 (9, 9 mm) | 2 | 105 mm | 106 mm | Uterine wall thin and without longitudinal ridges. |
| 15. | 205 | 2 (9, 9 mm) | 2 | 105 mm | 107 mm | Embryos free inside the uterus, no placental connection with the mother. |

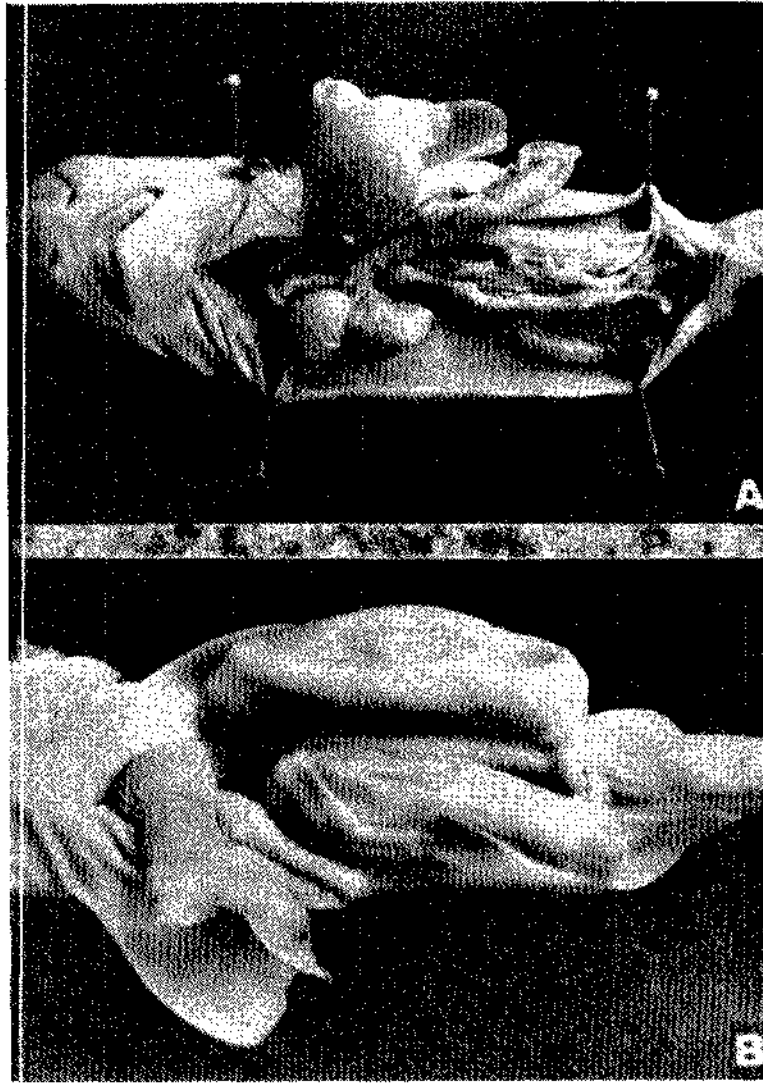


FIG. 1. A. Female showing mature yolk-laden eggs in the right ovary.
B. Gravid female with advanced stage of intra-uterine embryos, one in each uterus.

mm in length respectively inside the right uterus of each specimen. The right ovary of both the specimens had only small, rounded, whitish, opaque immature eggs. The nidamental glands of both the sides were well developed measuring 4 mm in length. On dissection of the uterus it was found that the intra-uterine egg is enclosed in a very thin, light yellowish, transparent shell membrane. The

egg was somewhat elongated and at the posterior end the shell membrane formed a corner tendril. Development of the egg has not yet started inside the uterus as evidenced by the absence of any embryonic stages. The left uterus was thin, slender and there were tough raised longitudinal ridges on its inner wall. Inside the left uterus, a thin transparent membrane corresponding to that found in the right uterus was present.

DESCRIPTION OF 17 MM INTRA-UTERINE EMBRYO

The 17 mm intra-uterine embryo was found in the right uterus of a female with total length of 166 mm.

One yolk laden egg, 8 mm in diameter was present in the right ovary. The left ovary was non-functional and atrophied. Nidamental glands were well developed. Inside the right uterus the embryo was free and it was connected to the yolk sac by a yolk-stalk (Fig. 2A). The embryo was not enclosed by any shell membrane at this stage. The right uterus which contained the embryo was slightly inflated in the middle portion and the left one was slender and undifferentiated. Both the uteri had longitudinal ridges running throughout its length, the ridges being more prominent in the left one. A transparent, yellowish membrane was present inside the left uterus which was devoid of embryo.

The embryo is in the rudimentary stage of development and the body is perfectly white in colour and semitransparent. The cephalic flexure is well marked, the long axis of the front part of the head making almost a right angle with the long axis of the body. Head region soft, swollen, bulged anteriorly and slightly flattened antero-dorsally. The snout is thick, soft and rounded at this stage. Optical vesicles are clearly visible in the head region. The eyes situated laterally in the head are prominent, rounded in outline and with traces of orbital rim developed. Lenses are round but no trace of pigmentation has appeared around the eye. Mouth can be seen on the ventral side of the head as crescent shaped slit. Behind the mouth, the pharyngeal region is perforated laterally by five well developed gill-openings, the first three are longer and slightly oblique than the last two which are smaller. Long and slender branchial filaments issue out from the angle of each gill-opening at this stage. The branchial filaments are mere outpushings of the wall of the gill-openings. Above the mouth and slightly in advance of the first gill-opening is situated the spiracular cleft, which is devoid of any spiracular filament.

All the fins have made their appearance in their respective adult position, but are poorly developed and are mere outpushings from the body. The pectoral fins are crescent-shaped flaps and the origin is not clearly visible. The dorsal and ventral median fins are mere membranous demarcations in the body of the embryo. The first dorsal fin is distinguished slightly posterior to the pectoral fin and the anal fin originates behind the cloacal opening. The caudal fin

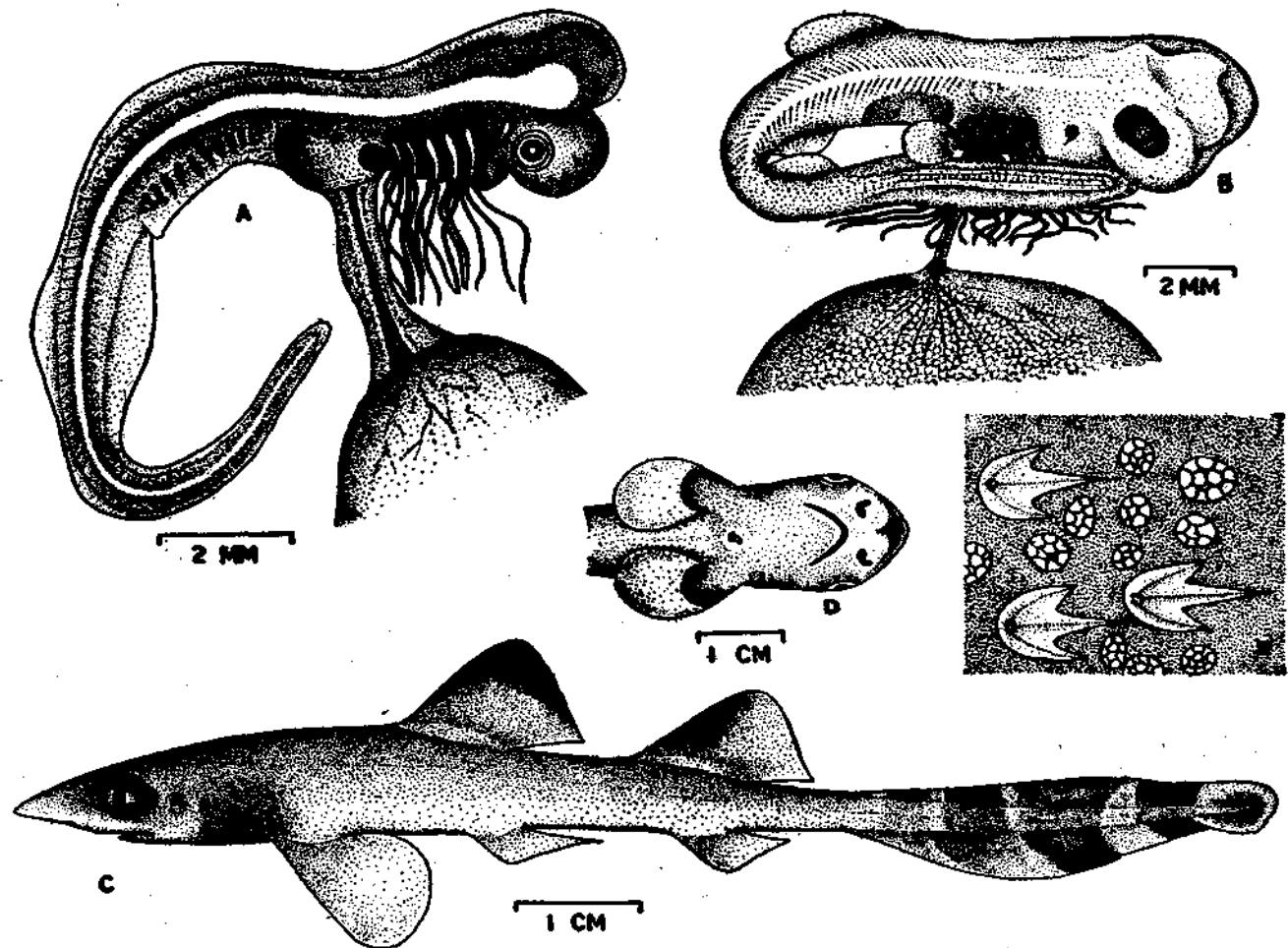


FIG. 2. A. Lateral view of 17 mm intra-uterine embryo. B. Lateral view of 22 mm intra-uterine embryo. C. Lateral view of 107 mm intra-uterine embryo. D. Ventral side of the embryo showing the remnant of yolk in between the pectorals. E. Diagram of tridentate dermal denticles of embryo.

is narrow and rounded and the subcaudal lobe has not yet developed. All fins are transparent and fin rays have not appeared. The sex of the embryo is not distinguishable at this stage.

A number of 'V' shaped myotomes extend posteriorly behind the gill region up to the tail end, but in the tail region they have lost their 'V' shape and are more or less vertical.

The yolk sac is ovoid and full of viscous yellow yolk. The yolk-stalk is connected to the embryo at a point below the last gill-opening and it is devoid of any appendicula at this stage. The yolk-stalk contains an artery and a vein. The yolk sac wall is vascularised in the region where the yolk stalk is attached to the yolk sac and there is neither any placental connection established by the embryo nor any trace of trophonemata formed in the uterine wall of the mother.

DESCRIPTION OF 22 MM INTRA-UTERINE EMBRYO

An embryo of 22 mm (Fig. 2B) was observed in the right uterus of a female of total length of 168 mm.

The right uterus contained the embryo and the middle of the uterus was slightly inflated. The left uterus was slender and empty. There were no yolk laden eggs in the right ovary. On dissection of the right uterus it was found that the embryo was free inside the uterus and a long yolk-stalk connected the embryo with the spherical yolk sac. There was no shell membrane covering the embryo at this stage and no trace of it was noticed inside the uterus. The uterus was filled with an yellowish fluid which might provide additional nutrition to the growing embryo, apart from the yolk already present in the yolk sac. On the inner wall of the uterus a number of less prominent ridges running throughout the length were still present. On dissection of the left uterus it was found that a thin transparent shell membrane was present inside.

The cephalic flexure is still retained and there is no trace of pigmentation over the body of the embryo. The skin is light yellowish and soft. The head region is soft and swollen and the snout is short and bluntly rounded and not flattened dorso-ventrally. The nostrils are prominent and located ventrally in the anterior part of the head. The mouth is visible as a small triangular slit on the ventral side of the head. The eyes are prominent, round and stud-like. The eye has a round whitish lens and the iris is represented by a ring of dark pigments thickened towards the anterior and posterior margins. Behind the eye a distinctly reduced crescent shaped spiracle is present. The pharyngeal region is perforated latero-ventrally by gill-openings and bunches of long blunt-tipped branchial filaments issue out from their angles.

All the fins appear in their corresponding adult position, though differing considerably from their respective adult shape. The anterior margin of the pectoral fin is rounded and its origin is behind the last gill-opening. Traces of

fin rays are visible in the basal part of the pectoral fin in this stage. The first dorsal fin arises as a delicate curved flap from the middorsal region supported by thin fin rays at its base. Second dorsal originates behind the first dorsal and is situated a short distance behind the posterior margin of pelvic fin. Anal fin has made its appearance at this stage but is feebly developed. In the caudal fin the subcaudal lobe has not yet developed and thus the heterocercal nature of the selachian tail is not attained at this stage.

A number of 'V' shaped myotomes are still present from behind the gill region and extend up to the tail end. In the caudal region they are more or less vertical.

Yolk in the yolk sac is viscous and the latter persists as a spherical ball connected to the embryo, at a position behind the last gill-opening by yolk-stalk, which is traversed by blood vessels. There is no appendicula in the yolk-stalk. The wall of the yolk sac is highly vascularised in the region where the yolk-stalk is attached. There is no placental connection with the mother at this stage and a close examination of the wall of the uterus revealed that trophonemata have not been formed.

DESCRIPTION OF 101 TO 107 MM INTRA-UTERINE EMBRYOS

The total length of the mother and the length of embryos are given in Table 1.

Five adult females examined contained advanced stages of embryos of length ranging from 101 to 107 mm. In all the five specimens the right ovary alone was functional and there were one or two yolk laden eggs in the ovary. The uterine walls of these females were thin and transparent when they contained developed embryos inside. The number of embryos in each uterus was always one (Fig. 1B). The embryos were fully developed at this stage and they resembled the adult in most of the morphological details (Fig. 2C). Yolk sac and the yolk-stalk noticed in the previous stages have disappeared and the body pigmentation is complete. The colouration of the body is more or less similar to the adult except that it is prominent in the embryo. The major differences compared with the adult at this stage are the presence of remnants of yolk-stalk as a small stub in between the pectoral fins on the ventral side (Fig. 2D) and a much elongated caudal fin. At this advanced stage of development the embryos are not covered by any shell membrane. No placental connection is established with the mother and the wall of the uterus do not show any trace of development of trophonemata at this stage. This stage of embryo which very much resembles the adult, can be regarded as one slightly prior to the condition at parturition and the embryo corresponds to that of 90 - 100 mm stage of *E. barbouri* described by Bigelow and Schroeder (1948). The sex of the embryo was distinguishable at this stage. Out of the eight embryos five were females and the rest males.

The body proportions in per cent of total length of embryos and adults (mean for 8 embryos followed by that for 5 mothers in parenthesis) are given as follows:

Snout length in front of: nostril 4.6 (3.9); mouth 6.4 (5.1); anterior margin of eye 3.7 (4.5).

Eye: horizontal diameter 5.5 (4.7); vertical diameter 2.5 (2.3).

Mouth: length 3.0 (3.1); width 7.2 (8.0).

Internarial distance: 2.9 (2.9).

First dorsal fin: height 10.8 (8.9); basal length 8.4 (7.7).

Second dorsal fin: height 12.9 (9.3); basal length 9.7 (7.5).

Caudal fin length; 29.1 (22.8).

Distance from snout tip to: first dorsal fin 30.3 (31.7); Second dorsal fin 49.4 (53.3); pectoral origin 20.3 (20.4); pelvic origin 37.3 (42.9); first gill opening (head length) 16.5 (15.9).

Interdorsal distance: 13.4 (16.2).

Distance between the hind margin of the pectoral to pelvic origin. 11.8 (18.0).

Body of the embryo is slender, elongate and the head dorsoventrally flattened. Snout short and pointed. Eyes are oblong with nictitating membrane. Mouth is angular and labial folds are not well developed in its corners. Teeth have not appeared in both the jaws at this stage. Well developed spiracles are present below the posterior margin of the eye. Gill-openings are well developed and they exactly resemble the adult in its position; there are no traces of any external branchial filaments. Body pigmentation is complete and a microscopic examination of the skin shows that tridentate dermal denticles are present scattered over the body of the embryo (Fig. 2E).

All the fins of the embryo are completely formed and they resemble those of the adult in shape and position. Pectoral originates behind the third gill-opening; first dorsal origin far ahead of pelvic origin and second dorsal origin in between the pelvic and anal, positively nearer to the anal origin. Anal originates below the middle of the second dorsal. Caudal fin closely resemble the adult in shape and it has attained the characteristic heterocercal nature at this stage. There is no distinct caudal pit but the three dark bands present in the caudal region are more prominent in the embryos. Except for the prominent and distinct colouration in the embryos the colour pattern is more or less similar in both adult and embryo.

The uterus of gravid females was distended and there were no longitudinal ridges in the uterine wall. In two specimens the left uterus was empty

and slender, the walls were thick and there were longitudinal ridges running throughout the length of it. The nidamental glands of all the five gravid females were well developed.

GENERAL REMARKS

From the present observations it can be inferred that in *E. radcliffei* a shell membrane is secreted by the nidamental gland, and the egg when it enters the uterus is enclosed within this yellowish and transparent membrane. The shell membrane is absorbed in due course of the development as evidenced by the absence of the membrane in 17 mm and 22 mm embryonic stages. In all the specimens where the left uterus is empty, it is found that a thin shell membrane is present inside the uterus, which indicates that the shell membrane is secreted by the nidamental gland before the entry of mature eggs into the uterus for development. Setna and Sarangdhar (1948) have observed that in *Scoliodon sorrakowah* (Cuvier) an egg case is formed in an early state, which is thin and delicate. The egg case is retained till 0.8 mm stage while in 1 mm stage there is no shell membrane covering the embryo thus indicating that the shell membrane disintegrates liberating the embryo into the uterus. Nalini (1940) states that even in viviparous forms the embryos are sometimes covered by a thin shell membrane secreted by the nidamental gland which get ruptured in the uterus itself before the embryos are liberated. *Scoliodon sorrakowah* which exhibits viviparity have a small yolk sac (1.1 mm) and hence establishes a placental connection with the mother even at an early stage (3-4 mm embryonic stage) for its nutrition (Setna and Sarangdhar, 1948). In *E. radcliffei* the nutrition of the embryo is mainly from the yolk sac which is fairly large (13 mm) and is supplemented with the yellow fluid present in the uterus as noticed in 22 mm stage.

A close study of the mothers and the embryos shows that there is relation between the total length of the mother and the embryo. In 161 mm and 165 mm specimens, one uterine egg each 13 mm and 14 mm in length respectively was noticed while in 166 mm mother there was an embryo of 17 mm length. In 168 mm specimen the embryo had attained a length of 22 mm. All the advanced stages of embryos ranging from 101 to 107 mm were collected from females with a total length from 188 to 205 mm. The largest embryo was obtained from 205 mm specimen. Thus a progression of length of embryo with the length of mother is noticed in the present study. Compagno (Personal communication) has also noted such size differences while examining specimens of *E. radcliffei* from Philippines and Gulf of Aden and suggests that if the gestation period is very long the differences in the size between the mothers might indicate growth during the time they were carrying young ones. However examination of more materials from different parts of the world is necessary to prove this point beyond doubt.

The present observation clearly shows that *E. radcliffei* exhibits ovoviviparity, an intermediate stage between oviparity and viviparity. Though a shell membrane is formed in the early stage of development, the embryo is found free inside the uterus connected to a fairly big yolk sac. The embryo does not establish any placental connection with the maternal tissue during the course of development and there is no trace of trophonemata formation in the uterine wall of the mother. Since the pregnant females were all collected during February, 1972 it would appear that *E. radcliffei* may breed during this period. However more information on the breeding season and gestation period of this species is desirable.

REFERENCES

- BIGELOW, H. B. AND W. C. SCHROEDER. 1948. Fishes of the Western North Atlantic. I. Lancelets, Cyclostomes and Sharks. *Mem. Sears. Fdn. mar. Res., New Haven*, (1):59-575.
- COMPAGNO, J. L. V. 1970. Systematics of the genus *Hemirhamphus* (Selachii: Carcharhinidae) and related genera. *Proc. Calif. Acad. Sci.*, 38 (4):69-98.
- FOWLER, H. B. 1941. Contribution to the biology of the Philippine Archipelago and adjacent regions. *Bull. U.S. Nat. Mus.* No. 100, (13):1-879.
- MISRA, K. S. 1950. On a new species of Scyliorhinid fish from Andaman Sea, Bay of Bengal. *J. Zool. Soc. India*, 2 (2):87-90.
- NAIR, R. V. AND R. S. LAL MOHAN. 1973. On a new deep sea skate *Rhinobatos variegatus* with notes on the deep sea sharks *Halaaelurus hispidus*, *Eridacnis radcliffei* and *Eugaleus omanensis* from the Gulf of Mannar. *Senck. biol. Frankfurt*, 54 (1|3): 71-80.
- NALINI, K. P. 1940. Structure and function of the nidamental glands of *Chiloscyllium griseum* (Muller and Henle). *Proc. Indian Acad. Sci., Sect. B*, 12 (5):189-214.
- SETNA, S. B. AND P. N. SARANGDHAR. 1948. Description, bionomics and development of *Scoliodon sorrakowah* (Cuvier). *Rec. Indian Mus.*, 46:25-53.
- SMITH, H. M. 1913. Description of a new carcharoid shark from the Sulu Archipelago. *Proc. U.S. Nat. Mus.*, 45:599-600.