The Journal of the Shimonoseki University of Fisheries 25(1) 41 — 45 (1976)

Studies on Sharks—IX*.

Ovary and Oogenesis in Selachians*

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The female reproductive system in the selachian is different from that in the teleost (Fig. 1). In most teleosts, the mature eggs are ovulated in the ovary itself, and are discharged. In ovoviviparous teleosts such as *Sebastiscus marmoratus* (CUVIER et VALENCIENNES)[1] and *Sebastes inermis* CUVIER et VALENCIENNES[1], the mature eggs are ovulated, fertilized, and developed in the ovary from which they are immediately discharged. In the viviparous teleost such as *Ditrema temmincki* BLEEKER[2], the embryos grow to some length in the ovary and are discharged. In the selachian, as the shark reaches the maturity, the ovary is formed at the anterior end of the right epigonal organ on the ventral wall. The left epigonal organ of female is rudimentary in many species. Therefore, only the right ovary is functional, and the left is not formed in most species, though both ovaries are functional, e.g., *Squalus acanthias* LINNÉ[3], *S. brevirostris* TANAKA[4][5], *Scoliodon sorrakowah* (CUVIER)[6], *S. palasorrah* (CUVIER)[6], *S. walbeehmi* (BLEEKER)[6], *Dasyatis akajei* (MÜLLER et HENLE)[7] and *Raja kenojei* MÜLLER et HENLE[7]. The eggs ovulated are received through the common ostium, and fertilized in the nidamental gland. The fertilized eggs develop into the embryos in the uterus. In viviparous sharks, it has been reported that the embryos are born after ten months gestation period, e.g., *Mustelus manazo* BLEEKER[8][9][10], *M. griseus* PIETSCHMANN[8][9][10] and *Galeorhinus japonicus* (MÜLLER et HENLE)[11]. Moreover, many viviparous sharks develop placentae in the middle stage of gestation. In oviparous sharks, the gestation period is relatively short; an embryo at early development is discharged enclosed in an egg capsule, e.g., *Heterodontus japonicus* (DUMÉRIL)[12], or an embryo enclosed in an egg capsule is deposited after six to eight months period in the uterus, e.g., *Halaelurus buergeri* (MÜLLER et HENLE)[13].

As was mentioned here, the selachian has a peculiar reproductive system compared with that of the teleost. The present report comprises the observation on the ovary and oogenesis of the selachian.

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*Contribution from the Shimonoseki University of Fisheries, No. 768.
Received July 8, 1976.

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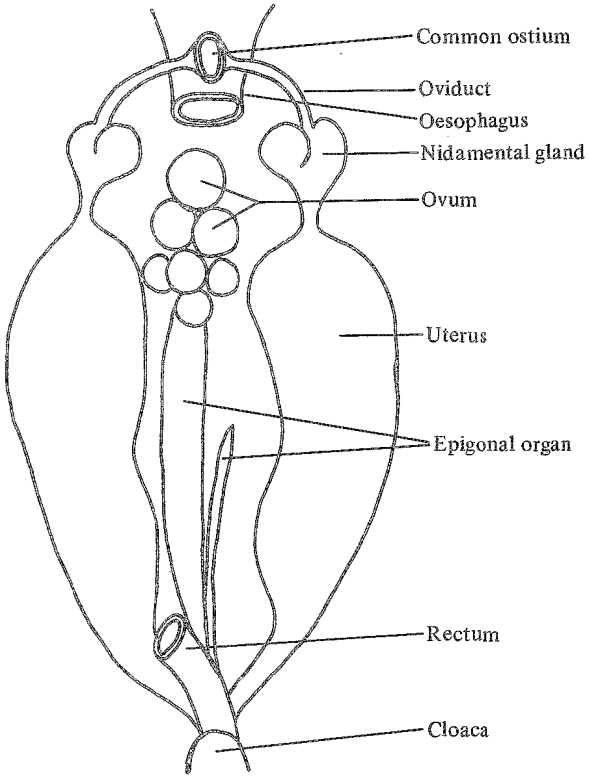

Fig. 1. Female reproductive organs in the selachian

Material and Method

Nine species of sharks were used for the present study: *Mustelus manazo, M. griseus Galeorhinus japonicus, Squalus mitsukurii, Carcharhinus dussumieri,* (MÜLLER et HENLE) *C. longimanus* (POEY), *Scoliodon palasorrah, S. walbeehmi,* and *Prionace glauca* (LINNÉ). Of these, the former four species were obtained monthly from the fish markets in Shimonoseki and Nagasaki, Japan, and remaining five were collected from the catch by T.S. Nagasaki Maru of Nagasaki University that carried out the long line operation in the eastern Indian Ocean and trawl in the South China Sea.

Specimens were measured and external characteristics observed. The ovaries and uteri were removed from the female specimens. In order to investigate the seasonal change of the development and degeneration of ova in the ovary, the diameter of each ovum was measured. Histological sections were made of the ovaries to examine the development of ova, and these stained with Hanzen's haematoxylin and eosin.

Result

1. Oogenesis

As the shark reaches the maturity, the ovarian cortex is formed at the anterior end of the epigonal organ. The reproductive cells appeared in the epithelial cells of the ovary sink into the ovarian cortex (Fig. 1 in Plate I). Each of reproductive cells in the ovarian cortex is covered with a single and thin layer of follicular epithelial cells to become an oocyte, and a nucleolus is observed in a cell nucleus. As the reproductive cell develops, the follicular epithelium changes from a simple to a stratified epithlium (Fig. 2 in Plate I). The nucleolus is divided and again scattered in the nucleus along the nuclear membrane (Fig. 3 in Plate I). At this stage, the cytoplasm of an oocyte is filled with the yolk granules (Fig. 3 in Plate I). As an oocyte develops, the yolk granules grow to become the yolk globules, and they fill the ooplasm (Fig. 4 in Plate I, Fig. 1 in Plate II). Ovulation occurs when the oocyte has reached about 20 mm in diameter in *Carcharhinus dussumieri,* 20 mm in *Mustelus manazo,* 15 mm in *M. griseus,* 35 mm in *Galeorhinus japonicus* and 60 mm in *Squalus mitsukurii.*

2. Degeneration and absorption of ova in the ovary

Although relatively many oocytes appear in the ovary of the selachian, a very small number of eggs are ovulated, e.g., only two eggs are ovulated in *Carcharhinus dussumieri* in an ovulating season, Most oocytes appeared in the ovary do not reach the maturity, and they degenerate to be absorbed during the course of the development.

The degeneration and absorption of oocytes are divided into two stages; 1) the oocyte at its early developmental stage is absorbed, and 2) the relatively developed oocyte is absorbed. A very large number of oocytes are absorbed at their early developmental stage. The follicular epithelium invades the cytoplasm, and an oocyte is rapidly disintegrated and absorbed (Fig. 2 in Plate II). The oocytes survived after the first disintegration and absorption continue to develop up to the stage when the yolk globules are formed. Then, the second disintegration and absorption are undergone (Fig. 3 in Plate II, Fig. 4 in Plate II), and the oocytes necessary for ovulation are remained.

Discussion

In the teleost, the ova develop in order through the chromation-nucleolus, peripheral nucleolus, yolk vesicle and yolk globule stage[1)2)]. In sharks of the present investigation, the development of ova appears not to include some stages as observed in the teleost, and the ova increase their size to grow gradually. The development of oocytes and follicular epithelial cells in the selachian is relatively similar to that from primordial to primary and secondary follicles in the mammalia. In the oocyte of the selachian, however, the follicular antrum is not formed, and no follicular liquid exists.

Of viviparous sharks in the present investigation, the oocyte of the placental species appears to be small in diameter compared with that of the non-placental when it is ovulated.

MATTHEWS[14] has reported on corpora lutea in his study on *Cetorhinus maximus* (GUNNER), but the corpus luteum defined by him appears to be a degenerating oocyte as shown in Fig. 4 in Plate II of the present paper. In the ovaries of the present specimens, the tissues like corpora lutea and the cells like lutein cells were not found. In the selachian 1) it is not necessary to restrain the following ovulation because only the oocytes necessary for ovulation are developed, and no mature eggs exist in the ovary after ovulation, and 2) it is not advisable to restrain the following ovulation because the small-sized oocytes begin to develop immediately after ovulation[10)11)15)]. Owing to these two points, it may be said that the tissue like the corpus luteum as found in mammalia should not exist in the selachian.

In the selachian, a group of eggs expected to be ovulated equally develops, and the mature eggs are ovulated at the same time. Ovulation never occurs successively throughout the year, and new eggs begin to develop and prepare for the succeeding ovulation immediately after ovulation[10)11)15)]. It is, hence, considered that an organ exists in secreting a hormone, unlike the corpus luteum hormone, which performs the above mentioned function.

Summary

The ovary and oogenesis in the selachian were investigated, and the following results obtained:

1) The ovarian cortex is formed beneath a layer of epithelial cells of the epigonal organ.

2) The reproductive cells appeared in the epithelial cells of the ovary sink into the ovarian cortex where each of them is covered with a simple epithelium of follicular cells to become an oocyte.

3) As the oocyte develops, the follicular epithelium changes from a simple to a stratified epithelium. The developed oocyte is filled with the yolk globules.

4) The follicular antrum is not formed, and no follicular liquid exists.

5) A small number of eggs are ovulated. Although relatively many oocytes appear in the ovary, all other oocytes except those expected to be ovulated degenerate and are absorbed during the course of development.

6) The tissue like the corpus luteum was not found.

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PLATE

PLATE I

Plate 1. (All the sections are stained with Hanzen's haematoxylin and eosin)

Fig. 1. Oogonia in *Carcharhinus dussumieri.* Ovarian cortex is formed beneath the epithelium of epigonal organ. Oogonia appeared in the epithelial cells of the ovary sink into the ovarian cortex, x150.

Fig. 2. A group of young eggs appeared in young ovary in *Galeorhinus japonicus,* x200.

Fig. 3. An oocyte at its early developmental stage in *Galeorhinus japonicus.* Nucleoli are scattered along nuclear membrane. Cytoplasm is filled with yolk granules, x300.

Fig. 4. An oocyte at its late developmental stage in *Galeorhinus japonicus.* An oocyte is filled with yolk globules, and is covered with a stratified epithelium of follicular cells, x300.

Abbreviation

eo:	epigonal organ
fe:	follicular epithelium
n:	nucleus
nl:	nucleolus
o:	oocyte
oe:	ovarian epithelium
og:	oogonium
om:	ovarian medulla
yg:	yolk globule
ygr:	yolk granule

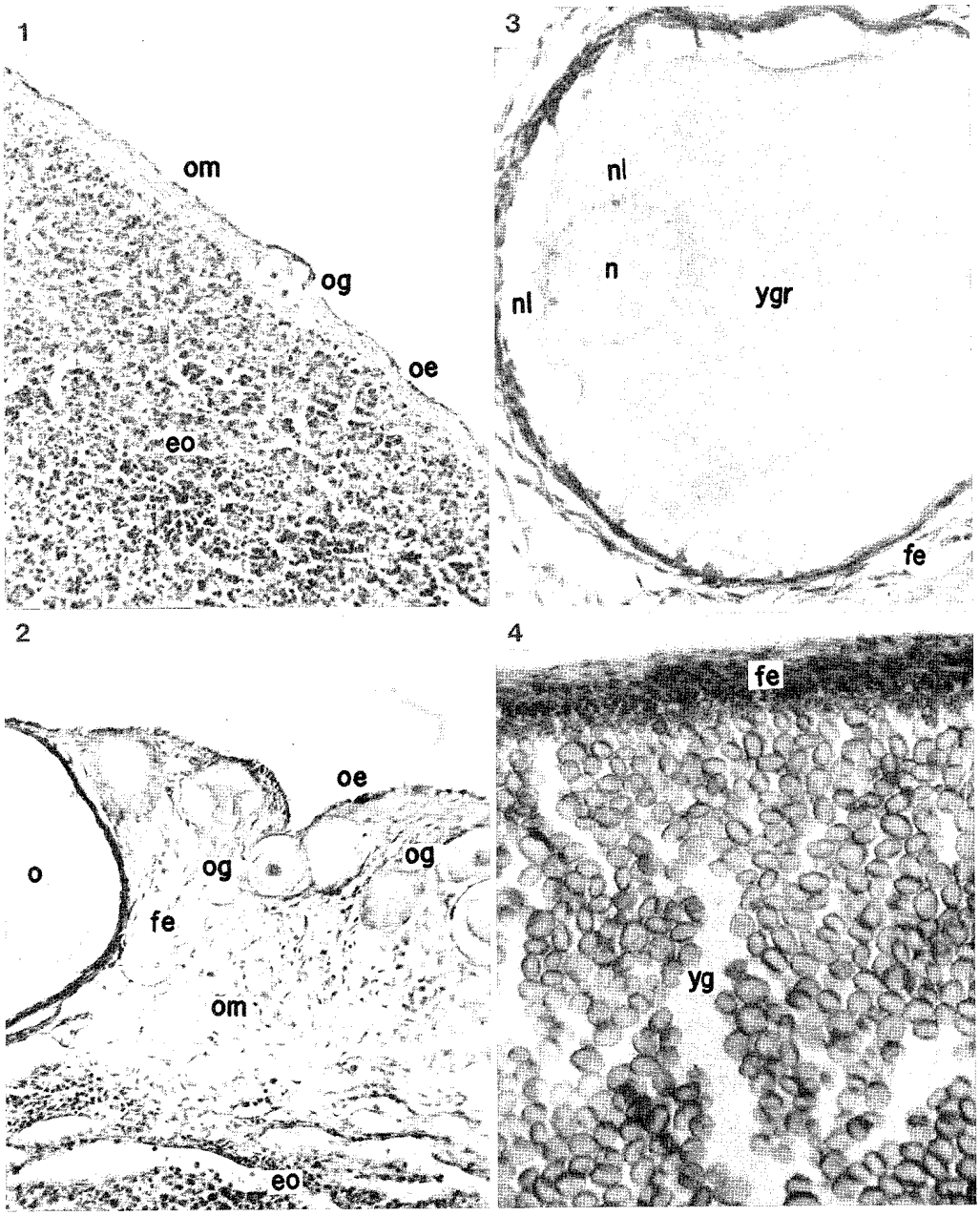
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PLATE II

Plate 2. (All the sections are stained with Hanzen's haematoxylin and eosin)

Fig. 1. An oocyte at its late developmental stage in *Mustelus manazo*. An oocyte is lined by a stratified epithelium. A internal layer of follicular cells consists of tall columnar cells, x600.

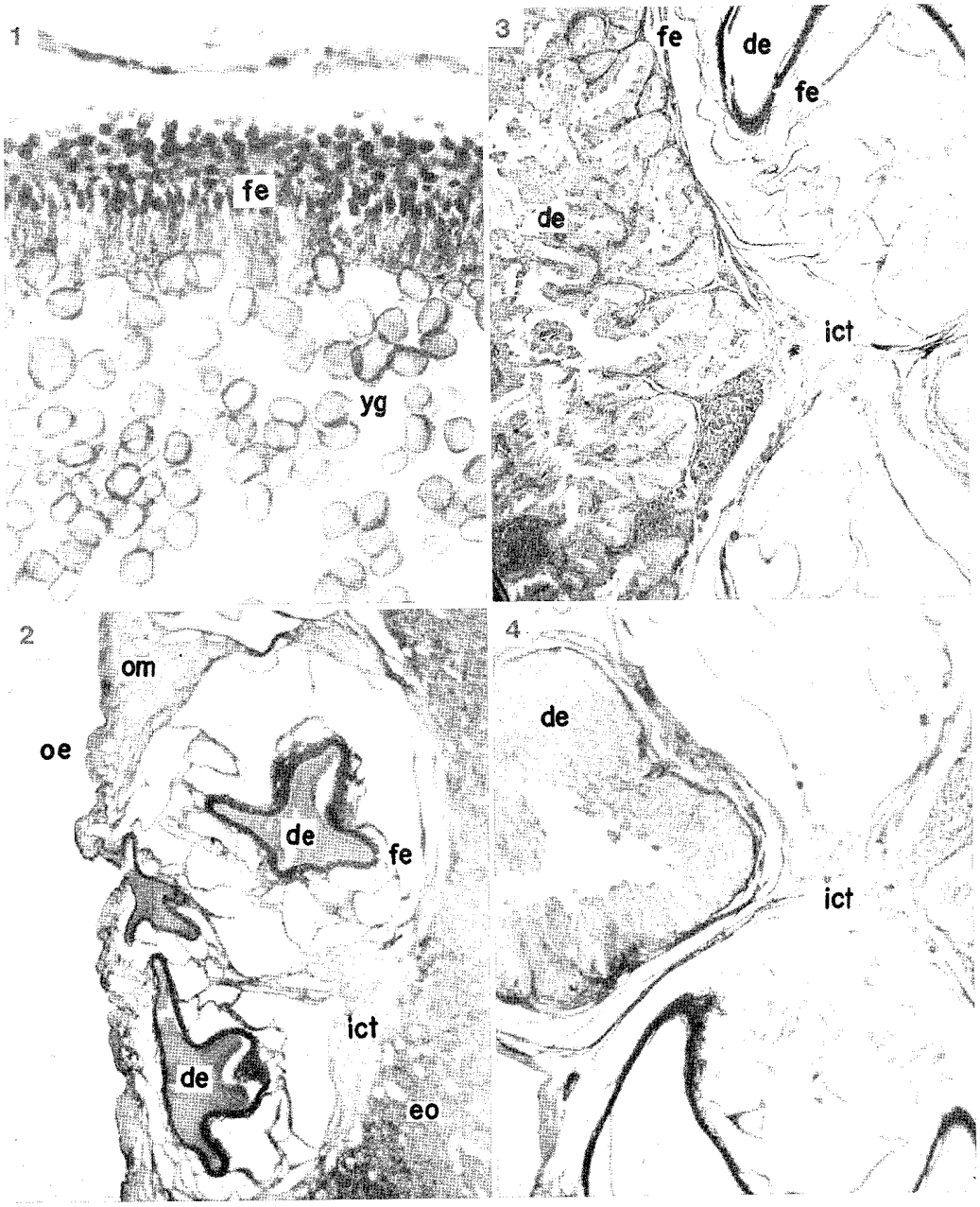
Fig. 2. Degenerating oocytes at their early developmental stage in *Mustelus manazo*, x150.

Fig. 3. An degenerating oocyte at its late developmental stage in *Galeorhinus japonicus*. Follicular epithelium deeply invades the oocyte, x60.

Fig. 4. The same histological section as Fig. 3. in Plate II in *Galeorhinus japonicus*. Disintegration and absorption advance in the left oocyte. Degeneration commences in the lower oocyte. The right oocyte is the same as that in Fig. 3. in Plate II, x60.

Abbreviation

eo:	epigonal organ
de:	degenerating egg
fe:	follicular epithelium
ict:	interstitial connective tissue
oe:	ovarian epithelium
om:	ovarian medulla
yg:	yolk globule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