Studies on the Sharks — II

On the Reproduction of Japanese Dogfish

*Mustelus manazo* BLEEKER

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The sexual cycle of Japanese dogfish, *Mustelus manazo*, landed at Nagasaki fish market was studied in the present study. Study on *Mustelus manazo* distributed in the waters off eastern coast of Kyushu has been done to some extent, lacking, however, very important portions in the sexual cycle, i.e., observation upon collection during the period from May to August. Investigation including the above-mentioned period was carried out on the materials caught in the waters off western coast of Kyushu. This species belongs to viviparous non-placental type, and does not develop the uterine compartments during gestation. The left ovary of this species is rudimentary throughout the life, and only the anterior portion of the right ovary is functional. During the ovulating period (June to August), of the developing ova, 8-10 mature eggs are ovulated in the peritoneal cavity, and are, one by one, received at a common ostium where they are distributed to the both oviducts and moved to the nidamental glands. The eggs fertilized in the nidamental gland are enclosed in the embryonic membrane and descend into the uterus to develop as embryos. The uterus of this species is a semi-transparent thin membrane, and the placenta is not developed at all stages. The posterior end of the uterus is not closed even when large-sized embryos being contained. The embryo, being small, is nourished by the yolk stored in the yolk sac through the yolk stalk. However, when yolk is completely utilized, the yolk stalk disappears. In these waters, the parturition season is April through May and the embryo at birth is approximately 30 cm in total length. This species appears to have two months’ resting period after parturition, and after this period, starts another mating, ovulation, fertilization and pregnancy. This species reaches maturity when it becomes about 60 cm in total length. The number of embryos contained in the both uteri is 2 to 8, increasing proportionally with the body length of the female parent. Gestation period is about 10 months.

Introduction

The biological studies on sharks lag behind those of teleosts, and knowledges
of them are relatively little. In the previous paper\textsuperscript{1)}, the authors presented the reproductive classification of sharks as follows:

\begin{center}
\begin{tikzpicture}
\node (root) {Selachians};
\node [left of=root, anchor=west] {Oviparity};
\node [left of=root, anchor=west] {Viviparity};
\node [below of=root, anchor=south] {Non-placental type};
\node [below of=nonplacental, anchor=south] {Uterine compartments not formed};
\node [below of=nonplacental, anchor=south] {Uterine compartments formed};
\node [below of=nonplacental, anchor=south] {Multiple pregnancy};
\node [below of=nonplacental, anchor=south] {Simple pregnancy};
\node [below of=nonplacental, anchor=south] {Placental type};
\end{tikzpicture}
\end{center}

On these, mostly placental species were discussed in the previous paper. However, this report deals with non-placental species. Non-placental selachians have heretofore been considered as ovoviviparous species. Although the relation between the uteri and embryos in \textit{Squalus} species whose both ovaries are functional has not been clarified, a few specimens on hand of the authors suggest that these species appear not to develop the placenta during gestation. Non-placental species appear to be relatively many among selachians. Of the selachians caught in the waters around Nagasaki, \textit{Mustelus manazo}, \textit{M. griseus} and \textit{M. kanekonis} belong to non-placental type. According to SCHLERNITZAUER and GILBERT\textsuperscript{2)}, \textit{Mustelus vulgaris} and \textit{Galeus canis} are also of this type. Moreover non-placental type is divided into two according to the structure of the uterus during gestation. In one of them, the uterine compartments are developed according to the number of embryos, and in another such compartments are not developed in the uterus. Although the former will be described later, \textit{Mustelus manazo}, a material in this study, belongs to the latter. Selachians such as \textit{Mustelus manazo} appear to be small in number, and this is the first case in Japan. On Japanese dogfish, \textit{Mustelus manazo}, KUDO\textsuperscript{3)} studied the growth of embryos and sexual cycle of this species captured by the medium danish seiners in the waters off eastern coast of Kyushu. In the study by KUDO\textsuperscript{3)}, data on very important season in the sexual cycle is not provided, and the conditions in the uterus are not described either. This was due to the impossibility of securing materials during the period from May to August when trawling is forbidden in the area. In the waters off Nagasaki, it is possible to get materials during this period, because they are captured not by trawl but by line. Hence, priority was given to the collection of materials during this season and the sexual cycle of this species was completed by supplementing the lacking portion in the sexual cycle by KUDO\textsuperscript{3)}. Also the conditions in the uterus and the relation between the embryos and the uterus were studied in this report.
The long line fisheries are operated throughout the year in the western waters off Goto Islands, Nagasaki Pref. Although the primary objects of these long liners are grouper, red sea bream and yellow sea bream, sharks are sometimes captured among them. These are *Mustelus manazo*, *M. griseus*, and *M. kanekonis*. Of these, the authors' attention was paid on *Mustelus manazo*, because this dogfish with many white small star marks on its body is the most popular species distributed in the coastal waters of Japan, and also has much commercial value among sharks in Nagasaki region.

![Fig. 1. Japanese dogfish *Mustelus manazo*.](image)

<table>
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<th>Month</th>
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<th>Female</th>
<th>Total</th>
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<td>20</td>
<td>28</td>
</tr>
<tr>
<td>May</td>
<td>18</td>
<td>10</td>
<td>28</td>
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<tr>
<td>Jun.</td>
<td>15</td>
<td>7</td>
<td>22</td>
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<tr>
<td>Jul.</td>
<td>13</td>
<td>–</td>
<td>13</td>
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<tr>
<td>Aug.</td>
<td>–</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Sep.</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Nov.</td>
<td>–</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>56</td>
<td>42</td>
<td>97</td>
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</table>

During half a year, from April to November, 1971, some individuals of *Mustelus manazo* were bought every month at the fish market and brought to laboratory for analyses as shown in Table 1. *Mustelus manazo* landed at the fish market is very sound, because it is captured by long liners. The materials were measured and anatomized for gross observations of their gonads.
Observations and Discussions

1. Female reproductive organs

In selachians there are species whose both ovaries are functional as in teleosts. These examples are Squalus⁴,⁵ and Scoliodon⁶ species. However, in most selachians, not the both ovary reaches maturity and becomes functional. Mustelus manazo is also the same case as this.

During the ovulating period 8-10 mature eggs are ovulated in the peritoneal cavity from the anterior portion of the right ovary. The mature eggs are received at a common ostium and distributed to the both oviducts. The anterior portions of both oviducts surrounding the oesophagus from both sides on the falciform ligament are connected at the ventral side of the oesophagus, and the protruding portion as a trampet from the connected part towards the ventral side of the peritoneal cavity forms a common ostium. The protruding portion of this species is longer than that of sumitsuki shark, Carcharhinus dussumieri¹). The mature eggs received through the common ostium are moved towards the nidamental gland where they appear to be fertilized, and then enclosed in an embryonic membrane. After this, fertilized eggs enclosed in the embryonic membrane descend into the uterus. Above matters are demonstrated by the followings. As shown in Fig. 6, two cases found in the uteri of the specimens were that the fertilized eggs were enclosed in the embryonic membranes, and both ends of the embryonic membrane were closed from this stage to the birth. These
observations are the same as those of sumitsuki shark\textsuperscript{13}. Each fertilized egg is developed while enclosed in an embryonic membrane of the uterus, and grows into an embryo.

The uterus of this species does not have a thick uterine wall as found in sumitsuki shark\textsuperscript{13} and other species, and the embryo in the uterus can be seen through the semi-transparent uterine wall. This species is of multiple pregnancy. Although it sometimes occurs that one embryo is found in a uterus, as will be described later, the number of embryos contained in both uteri increases with adult body length.

![Diagram of reproductive organs](image)

Fig. 3 Reproductive organs of female *Mustelus manazo*.

Fig. 3 shows the location of female reproductive organs which are in the process of development.

Although in sumitsuki shark\textsuperscript{13} the posterior end of the uterus is closed when the pregnancy is started, the uterus of this species does not close its posterior end throughout gestation.

2. Reproductive season

*Mustelus manazo* landed at Nagasaki fish market appears to have a certain reproductive season. This species does not show every developmental stage of embryos throughout the year as found in sumitski shark\textsuperscript{13} distributed in the South China Sea. The embryos were found in the uteri of materials collected until May. The materials collected from June did not possess embryos at all. Parturition may occur in April and May as estimated by the monthly variation of length frequency distribution of embryos by Kudo\textsuperscript{32} supplemented by the authors with the materials collected from April to November. The fullest grown embryo found in the uterus of females collected was 32 cm in total length (12 embryos).
and according to KUDO\textsuperscript{3)}, the smallest shark captured was 28 cm in total length. These facts suggest that embryos at birth are approximately 30 cm in total length.

Although most of the females collected in June and July were immature, specimens collected in August contained small sized embryos or fertilized eggs in their uteri. The size of the embryos in the uteri suggests that ovulation, mating and fertilization occur during the period from June to July, and gestation period of this species appears to be about 10 months. These estimations are the same as those of KUDO\textsuperscript{3)}.

The ova develop for the succeeding ovulation as embryos grow up to parturition, reaching about 15 mm in diameter by the parturition season in April or May. During the period from parturition to ovulation, the ova continue to develop to be about 18 mm in diameter when they are ovulated in June or July. This finding is different from the study by KUDO\textsuperscript{3)}. The ova remaining in the ovary after ovulation are reabsorbed rapidly.

3. The sexual maturity

YOKOTA\textsuperscript{8)} and KIBESAKI\textsuperscript{5, 6)} estimated age and length at sexual maturity of male elasmobranchs by the length of clasper. Also, in this study, the sexual maturity of male \textit{Mustelus manazo} is estimated by the relation between body length and clasper length. The relation between total length of male and

![Fig. 4. Relation between clasper length and total length.](image-url)
clasper length is shown in Fig. 4. Fig. 4 shows that clasper length increases with total length and it continues to do until the shark reaches about 60 cm in total length. The shark more than 60 cm does not show this increasing tendency of clasper length. Although the histological observations on testis are needed to determine the exact length at sexual maturity, the male of this species appears to reach sexual maturity when it is about 60 cm in total length from this figure.

It is relatively easy to determine the length of female at the sexual maturity, which is indicated by the first ovulation. Of the specimens, females more than 65 cm in total length (26 specimens) were all pregnant, however, females less than 64 cm showed variation in pregnancy. These facts demonstrate that the female of this species reaches the sexual maturity at the total length between 62 and 64 cm.

4. Relation between number of embryos and adult body length

In multiple pregnant selachians, the number of embryos contained in both uteri appears to increase with adult body length\(^3\)\(^-\)\(^4\). This is also true with this species. Fig. 5 shows the relation between the number of embryos contained and adult body length. This figure tells that the number of embryos contained in the uteri of adult increases with adult body length. The shark which has just undergone the first pregnancy shows that it contains one embryo in each uterus. The number of embryos contained increases with adult body length, accounting for 8 in females more than 90 cm in total length. This tendency is considered due to the facts that small-sized adults ovulate a small number of eggs and that the activity of ovary in adults with less experience of pregnancy is not so vigorous.

![Chart](chart.png)

Fig. 5. Relation between number of embryos contained and adult total length.
5. Conditions in the uterus

Viviparous non-placental type includes two kinds of species, one of which develops the uterine compartments during gestation, has been studied to some extent. Mustelus manazo does not develop such compartments according to the number of embryos throughout gestation. The fertilized eggs enclosed in the embryonic membrane in the uterus are shown in Fig. 6.

Fig. 6. Conditions of the uterus in the earliest gestation
Above - Fertilized eggs in uterus
Below - Fertilized eggs

As the uterus of this species has a thin uterine wall, and is semi-transparent, the fertilized eggs can be seen through the uterine wall. Fig. 6 (below) shows the fertilized eggs enclosed in the embryonic membranes. As obvious in this figure, the uterus of this species does not develop an embryonic membrane-store chamber as found in sumitsuki shark\(^1\) and every portion of membrane exists in the uterus. The membrane extending from both sides expands as the embryo grows, enclosing the embryo until birth. When parturition occurs, the embryonic membrane remains in the uterus and later it is discharged with contraction of the uterus. The posterior end of the uterus of this species is open towards the
vagina even in gestation, unlike placental species such as sumitsuki shark, shiro shark and others whose uterus is closed in gestation.

During early gestation embryos are nourished with yolk through the yolk stalk. However, yolk is completely consumed at early developmental stage of embryo, and it disappears with the yolk stalk.

Although the uterine wall of placental species is thick and possesses many uterine epithelial folds, that of this species is thin and has smooth surface. Placenta is not established, and there exists no connection between the embryonic membrane and the uterine wall throughout gestation. Nutrition needed for development of embryo during the period from disappearance of yolk stalk to birth is a very significant problem which remains to be studied further.

**Summary**

Study on Japanese dogfish, *Mustelus manazo*, caught by the bottom long liners in the waters off Goto Islands is summarized as follows:

1. This species belongs to the viviparous non-placental type, and neither the uterine compartments nor the placenta are developed in the uterus throughout gestation.

2. The left ovary of this species is rudimentary throughout the life, and only the anterior portion of the right ovary is functional.

3. Parturition of this species occurs during the period from April to May and the embryo at birth is approximately 30 cm in total length.

4. This species has two months' resting period after parturition, and then undergoes ovulation, mating and fertilization in June to July. This means that gestation period is about 10 months.

5. Females of this species reach sexual maturity at the total length between 62 and 64 cm, and males at the length of about 60 cm.

6. During ovulating period, 8-10 mature eggs of about 18 mm in diameter are ovulated in the peritoneal cavity from the right ovary. The ovulated eggs are received at a common ostium where they are distributed to the both oviducts and moved to the nidamental gland. The fertilization appears to occur in the nidamental gland.

7. Each fertilized egg is enclosed in an embryonic membrane in the nidamental gland, and descends into the uterus to develop as an embryo. The embryo is enclosed by the embryonic membrane until birth, and no connections exist between this membrane and the uterine wall.

8. This species does not possess any embryonic membrane-store chamber.

9. Although the embryo is nourished with yolk through the yolk stalk during early gestation, the yolk stalk disappears upon consumption of yolk when the embryo grows up to some developmental stage.
10. The uterine wall of this species is thin and semi-transparent. The posterior end of the uterus is open towards the vagina throughout gestation.

11. The number of embryos in a gestation is relative to the adult body length. The adult being 60-90 cm in total length, the embryos contained in both uteri numbered within the range of 2-8, accordingly.

References


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