Studies on Holocephali — II

On the Reproduction of *Chimaera phantasma* JORDAN et SNYDER Caught in the Coastal Waters of Nagasaki

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The internal sexual organs and reproduction of *Chimaera phantasma* caught in the coastal waters of Nagasaki were investigated. The testes of *C. phantasma* is that of seminiferous follicle type. The seminiferous follicles develop more in the region near the outer pole of the testis. Both ovaries are functional and each gonopores open separately without the cloaca. Some ova were covered in the capsule one by one at the nidamental gland, as in most Elasmobranchii, and the ova were spawned in succession in the same breeding season. Sexual maturity in females was apparently reached at a body length of about 63cm, while in males it was attained at about 51cm. The reproductive season of *C. phantasma* appears to last about a half year, with the peak activity during winter.

As mentioned in the previous paper (1), the some descriptions (2~9) of Holocephali are mainly on classification and morphology, because the commercial value of those fishes are not so high that the specimens are sarcely landed at fish market. It has become important, however, to know about Holocephali because of a resurgence in interest in this unused resource that is frequently caught but is usually thrown away into the sea. Acknowledgement of the ecological position of those fishes is required to understand this resource.

The external morphology and the sexual organs of the males of *Chimaera phantasma* were described in the previous paper, and the internal sexual organs and reproduction are discussed in this paper.

Materials and Methods

The total of 408 specimens (164 males and 244 females) were collected from the catches landed at Nagasaki Fish Market and from those caught by the bottom long line by the authors themselves in the coastal waters of Nagasaki during the period from September of 1975 to May of 1980. Some of them were also collected at our request from the catches of the coastal bottom long line fishermen based at Mogi in the suburbs of Nagasaki. This species was usually abandoned, even though the catch was not so large. The fishing ground was the same area and the body length was given in terms of the length between the tip of the snout and the posterior base margin of

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the anal fin as mentioned in the previous paper. After measurement of external proportions in the laboratory, the internal sexual organs were observed, measured and taken out. Optical microscopic and electromicroscopic preparations were made from those organs by means of staining with Hanzen's haematoxylin and eosin and with lead acetate and uranyl acetate, respectively. The electromicroscopic results will be discussed in a separate paper.

Results and Discussion

1 Internal sexual organs

MALE: Elasmobranchii can be easily differentiated sexually by their distinctive claspers but it is difficult to differentiate by the gonads before the individual attains maturity. On the other hand, in Holocephali, even in the smallest specimen (B. L. 44cm) collected during the present study frontal, anterior and posterior claspers were conspicously visible, and testes and ovaries were easily recognized by visual observation, even though the testes had a weight of only 0.20g, and the ovaries had a weight of only 0.25g.

The male internal sexual organs of *C. phantasma* are shown in Fig. 1-A. Unlike

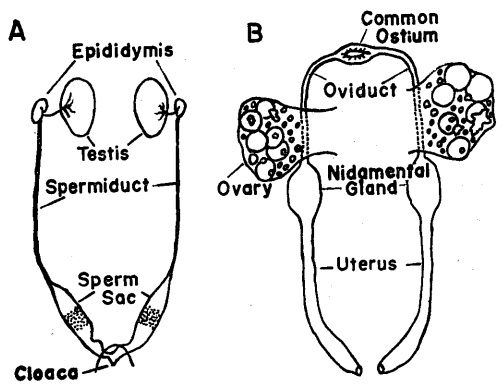
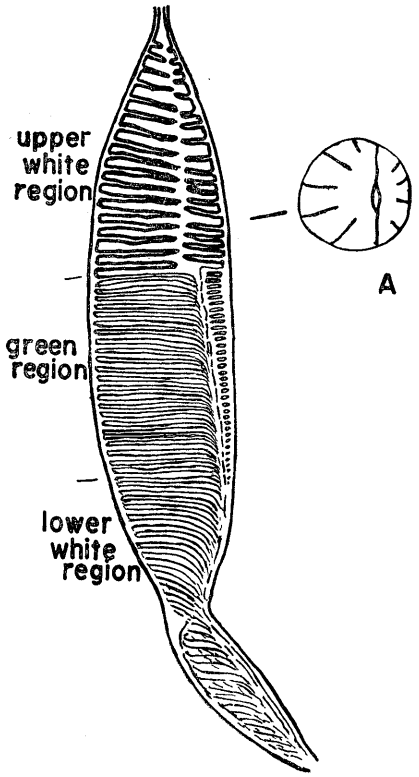


Fig. 1. Internal sexual organs.
A; male, B; female

Elasmobranchii which have large elongated testes, *C. phantasma* has relatively small rounded testes, slightly compressed at both poles. They lie separately, half embedded in the right and left parts of the liver. Unlike most Elasmobranchii (10), the testes of *C. phantasma* are of the seminiferous follicle type and spermatogenesis occurs throughout the year. The seminiferous follicles near the outer poles of the testis develop completely, but those in the region away from the poles are in early development stages. Each testis is closely connected to tho epididymis by a thin duct and the epididymis is formed by a slender winding duct with an approximate weight of one-tenth of the testis. The epididymis windings continue for two or three centimeters to form the spermiduct. The spermiduct is attached to the dorsal side of the body peritoneal cavity, and it continues then to straight thin duct of about 1 mm in width which expands before the its opening to form the sperm sac.

The sperm sac was thick-walled, cigar-shaped with an average length and diameter of 6.5 cm and 1.0 cm, respectively. The color of the anterior- and posterior-third in mature male is white, while the central-third of it is green. Both sperm sacs continue in short and thick ducts that fuse together into a single duct shortly before opening.

The sperm sac, illustrated by longitudinal and traverse sections in Fig. 2, consists of many wide and irregularly sharped cavities in the region near the spermiduct, but these cavities become smaller and dense as they approach the region near the opening. In the white region near the spermiduct, 30～40 parallel membranes expand from the both sides of inner surface and fuse alternately to each other at the center.



Eig. 2. Longitudinal section of sperm sac.
A: traverse section

There are small holes at a side of the line of fused membranes and these holes shift the position to the center of the fused line in proportion to the lower part of this region. The membranes of one side are parallel with each other and each membranes fuses with the nearest two membranes of the opposite side. Moreover, the membranes combining the parallel membranes also expand toward the hole and increase in number in the lower part of this region. In the green region, the membranes are more dense and form a small eddy-like shape with the hole at the center. This center shifts the position toward the wall of the sperm sac in proportion to the descent and is by the wall in the white region near the opening. This white region is compressed and leads to the opening. The wall of this region is most thick through the area of the sperm sac. The inner surface of the sperm sac and mambranes secrete fluid and numerous sperms are observed in the secretion of the white region near the spermiduct in the breeding season. Some sperms are observed in the center of the eddy part of the green and, sometime, lower white region.

FEMALE: Fig. 1-B shows the female reproductive organs of *C. phantasma*. Unlike most Elasmobranchii, in which only the right ovary is functional and the other is vestigial, *C. phantasma* has both ovaries functional. Almost always, ovaries of a mature female have a large number of ova with a wide range of diameter. The range noted was from 1 mm to a maximum of about 40 mm. Most of the ova were below the size of 10 mm, and only some of them, about 2～8 ova, were in the range of 10～40 mm. Few individuals had mature ova bigger than 40 mm. Ova of immature females rarely exceeded 10 mm. Atrophied ova were usually found in both ovaries, but their number was small and they did not cover the whole range of diameters that normal ova did. It is considered that atrophied ova were those ova which did not present the characteristic turgid texture of maturing or mature ova. Normally one or two atrophied ova had a diameter of 20 to 60 mm, the rest, numbering two to ten, being much smaller had a diameter of 3 to 8 mm.

The mature ova pass through a common ostium which is a little rigid and very small compared with the ova. Immature specimens have no opening or only a small opening. In mature females, the common ostium is very flexible and the opening can have a diameter up to 30 mm or more, but

in most specimens it was around 13 mm. No relationship has been found between the diameter of mature ova and the diameter of the common ostium.

From the common ostium, the mature ova go to the nidamental gland passing through the oviduct which has an average diameter of 8 mm and a length of 15~20 cm, depending on the size of specimens. The nidamental gland, where the mature ovum is covered by a capsule, is elongated with an average size of 45 mm in length and 30 mm of diameter. As in Elasmobranchii, the nidamental gland is well developed, and in the matured individual, many villi grow thickly on its inner surface. The nidamental gland opens into the uterus which is wider than the oviduct (about 13 mm), and with thicker wall. The cloaca is not formed, and the uteri open externally and separately, through it opens into the cloaca in Elasmobranchii.

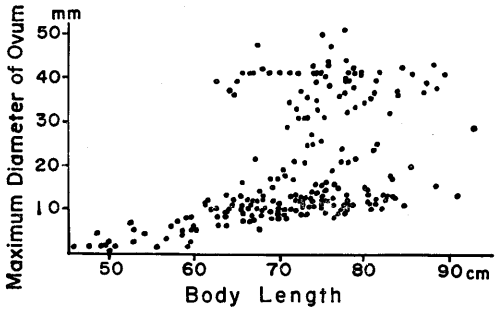


Fig. 3. Relationship between body length and maximum diameter of ovum.

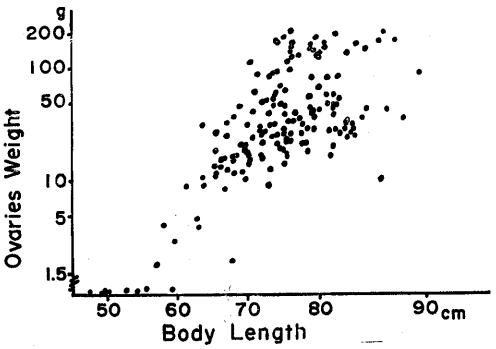


Fig. 4. Relationship between body length and ovaries wecght.

2 Sexual maturity

As was mentioned in the previous paper, it seems that sexual maturity in males was reached at a body length of about 51 cm, considering the relationship between body length and clasper length or testes weight. And in females, the maximum diameter of ova from the 244 females collected during the present study increased slowly, from individuals with body length less than 50 cm to 63 cm (Fig. 3). After specimens attained a body length of more than about 63 cm, ovaries could be found with mature ova having a diameter of 40 mm or larger. Forty mm was the maximum diameter ova generally attain even in larger specimens with capsules found in one specimen of approximately the same diameter. Therefore it can be said that the size at which a mature ovum is fertilized was about 40 mm.

At the same time, if we compare the weight of the ovaries with body length (Fig. 4), we can see that ovarian weight started to increase after a body length of 63 cm. Although this increment had a wide range, from 10 to 200 g, it was highly significant compared to the increment in smaller specimens.

From the results of the parameters mentioned above, it appears that the females of *C. phantasma* reached sexual maturity at about 63 cm in body length.

3 Reproductive season

To assess the reproductive season, several parameters were measured. In the following figures only mature specimens were taken into account, that is, females with a body length of more than 63 cm and males

with a body length of more than 63 cm and males with body length of more than 51 cm.

In males, seasonal changes of testes weight (Fig. 5) showed that the number of individuals with high weight values increases from autumn to early winter, and decreases afterward; individuals with higher values are scarce until summer. Because testes weight increases with body length, it is difficult from this graph to find a clear correlation of the seasonal changes of testes weight. However, the maturity factor (Fig. 6) and gonad index (Fig. 7) of the males shows a similar seasonal pattern, with high values during autumn that slowly decrease to their minimum during the late winter and early spring.

On the other hand, the volume of the sperm sac (Fig. 8) shows a clear tendency to increase from autumn to late winter with the highest values obtained in February. No data exists for March and April, but probably the sperm sac volume starts to decrease during these months to reach the low values of summer. A histological study of the sperm sac showed no presence of sperm in October. In January it was present in great amounts, and it was diminished in May. In July once again, no sperm was present in the sperm sac.

In famales the maximum diameter of ova starts to augment steadily from mid-summer to early winter (Fig. 9). Most specimens during winter had ova with a diameter of more than 30 mm, with a peak in February when almost all specimens had mature ova.

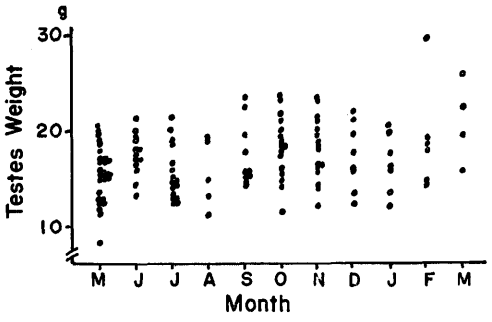


Fig. 5. Monthly variations of testes weight.

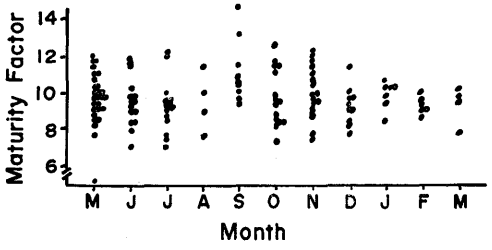


Fig. 6. Monthly variation of maturity factor in male.

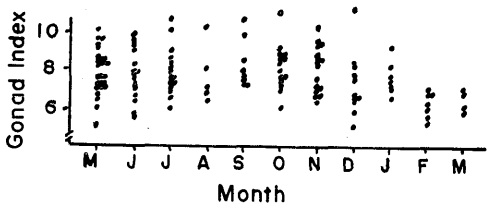


Fig. 7. Monthly variation of gonad index in male.

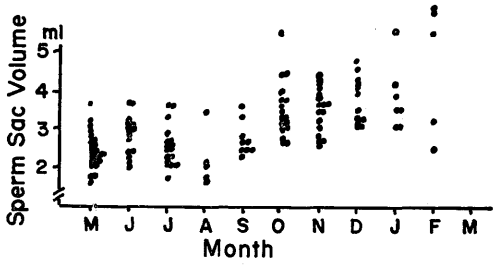


Fig. 8. Monthly variation of sperm sac volume.

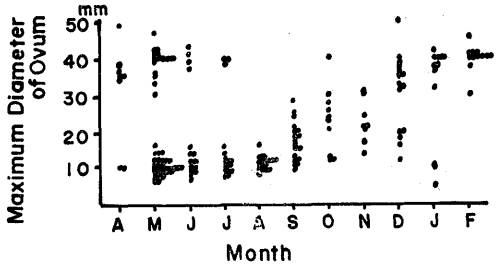


Fig. 9. Monthly variation of maximum diameter of ovum.

In early February of 1977 only one female among 238 specimens was found with egg capsules in advanced stage of formation. From December on, the changes in the maximum diameter of ova follows a peculiar pattern : they had a diameter either less than 20 mm or more than 30 mm. This gap in the frequency of the maximum diameter of ova was probably due to differences in their spawning time and development speed. It seems that the growth of small ova slows down after the specimens release their egg capsules.

The variation of ovaries weight (Fig. 10) and gonad index (Fig. 11) throughout the year closely follows the pattern of maximum diameter of ova, with high values during winter and low values in summer.

As noted before, ovaries almost always contained atrophied ova in small numbers. The diameters of atrophied ova were small from mid-autumn to mid-winter, remaining large during the rest of the year (Fig. 12). The specimen found with egg capsules had

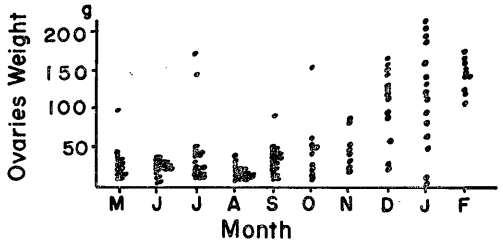


Fig. 10. Monthly variation of ovaries weight.

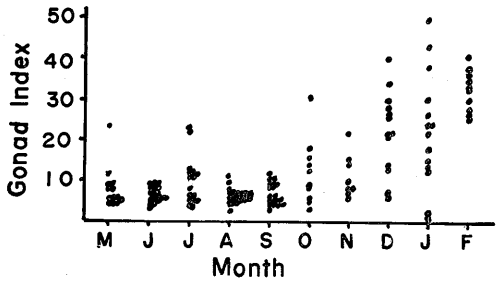


Fig. 11. Monthly variation of gonad index in female.

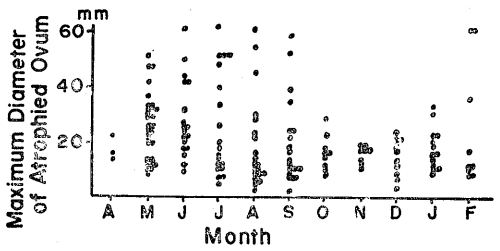


Fig. 12. Monthly variation of maximum diameter of atrophied ovum.

several large atrophied ova, indicating that they had been mature but degenerated for lack of the possibility of ovulation. Those atrophied ova had a maximum diameter of 65 mm, the largest measurement of all the specimens. Another specimen, collected the same day, probably had laid egg capsules shortly before capture because it also showed an atrophied ovum of about 65 mm. The long presence of atrophied ova is probably due to a low speed in their absorption.

Taking into account the variation in sperm sac cavity, testes weight, and the maximum diameter of mature and artophied ova throughout the year, we can see that *C. phantasma* has a long reproductive season of about 6 to 7 months, from early winter to early summer. Testes weight increases before the reproductive season starts, to produce sperm which is stored in the sperm sac. The seasonal variation of sperm sac volumes closely resembles the variation in mature ova. On the other hand, there are few atrophied ova when the reproductive season starts, and their number rapidly increase shortly afterward.

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全頭類の研究－Ⅱ

長崎県沿岸域で捕獲されたギンザメ *Chimaera phantasma* JORDAN et SNYDER の生殖について

ジョバニ・マラグリノ・竹村　暘・水江　一弘

1975年から1980年まで長崎沿岸域より採集された408個体（雄・164，雌・244）のギンザメ *Chimaera phantasma* の生殖器官の調査を行った．本種の生殖腺の発達過程は板鰓類のそれとは全く異なるが，生殖器官の形態・様式及び精子形式の過程等は極めてよく似ている．そこで，ギンザメの生殖について板鰓類と比較しながら述べた．本種の生殖腺は多くの板鰓類と異なり，雌雄とも又左右いずれも機能的である．雄は体長約51cm，雌は約63cm で性的成熟体長に達すると考えられる．産卵直前の卵は直径40mm 以上にもなり，連続していくつかの卵をカプセルにつつんで産出する．産卵期は冬期を中心にして半年近くの長期にわたるものと考えられる．