

## Studies on Holocephali-I

### On the morphology and ecology of *Chimaera phantasma*, and male reproductive organs.\*<sup>1</sup>

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The morphological characters and ecology of *Chimaera phantasma* and male's reproductive organs were investigated. Specimens (115 males, 191 females) were collected at the Nagasaki Fish Market or caught by the authors themselves from September 1975 to October 1976. The variation of proportion percentages compared with body length is not remarkable and the growth curves of the male and female are indicated by the following formula:

$$\text{Male : } W = 0.1913L^{2.2269}$$

$$\text{Female : } W = 0.0376L^{2.6349}$$

It was observed that the male's condition factor increases with the increment of body length, but no seasonal variation of this factor could be observed. In females no variations of any kind were observed. The diet is basically formed by Crustacea, especially crabs, and teeth consist of three pairs of dental plates.

The posterior clasper is trifurcated and has no remarkable appendices. External radii are rigid and the anterior clasper bears 8 serrations in a line. The pelvic girdle consists of right and left cartilages. Sexual maturity in males can be considered to be reached at a body length of 45 to 50cm.

There are many publications concerning the different fields of study of fishes, but few of them refer to Elasmobranchs and even fewer to Holocephali. Only recently has research on Elasmobranchs become larger, providing new knowledge about their morphological, histological, and ecological characters. However, this recent interest in Elasmobranchs has not been extended to Holocephali which is equally important in marine animal classification, ecology, histology, undeveloped fishery resources, etc.

It is the purpose of the authors to contribute to the enhancement of the range of

information of these seemingly primitive animals by carrying out research on the morphology and ecology, and on the male reproductive organs of one Holocephali species, namely *Chimaera phantasma*.

The morphological and ecological characters of other Holocephali collected in other countries have been described; *Harriotta raleighana* by GARRICK (1971, 1975), *Chimaera monstrosa*, *C. colliciei*, *C. mirabilis*, and *Callorhynchus antarcticus* by LEIGH-SHARPE (1922a, 1922b), *Neoharriotta carrii* by BULLIS et al (1966), *Harriotta raleighana* and *H. chaetirhamphus* by BEAN et al (1910), *Callorhynchus callorhynchus* and *Harriotta curtis-jamesi* by

\*1. A part of this study was supported by scientific research fund from the Ministry of Education.

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BEEBE et al (1941).

As for the Holocephali species in Japanese coastal waters, brief morphological and ecological studies have been made on *Chimaera phantasma*, *C. (Phasmichtys) mitsukurii*, and *Rhinochimaera pacifica* by DEAN (1904a, 1904b), and on Holocephali in general by TANAKA (1905).

According to MATSUBARA (1955), only nine species of Holocephali are known to be in Japanese coastal waters. Among them, two species, *Chimaera phantasma* and *Phasmichtys mitsukurii*, are frequently found while the others are rarely caught.

At the Nagasaki Fish Market, Chimaeroids are seldom landed except for *C. phantasma*, which can be collected throughout the year together with the sub-deep sea shark, *Heptranchias perlo*. Nevertheless, the number of specimens is usually not large, specially during the winter season and August. According to our own catches, approximately the same number of this

species could be caught every month in the same waters. At the same time, it seems that the number of *C. phantasma* landed at the fish market depends on the state of commercial fishery. This species does not appear to be so important economically; it is caught only accidentally by the fishermen whose real aim is to catch sea bream and other expensive fishes. *C. phantasma* is utilized in the same way as sharks. It is eaten mainly as boiled fish paste or parboiled.

In the present paper, the specimens were collected and examined in order to investigate their morphological and reproductive characters, and to compare them with those of other Holocephali already described and of Elasmobranches.

#### Materials and Methods

Many individuals of *C. phantasma* (Fig. 1) are landed at the Nagasaki Fish Market

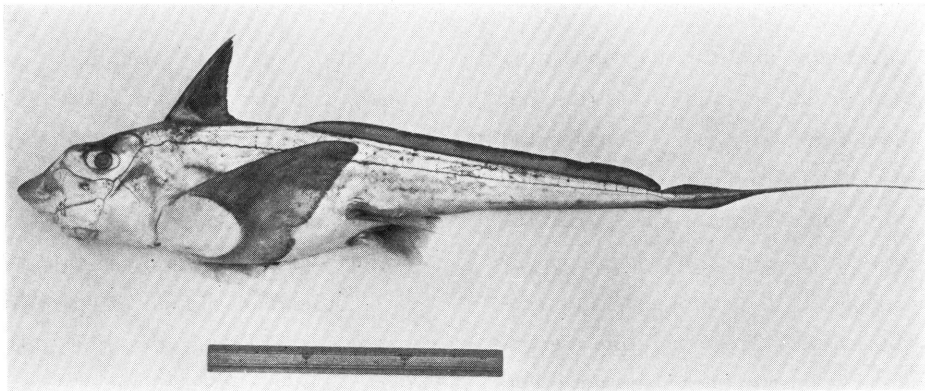


Fig. 1. *Chimaera phantasma*

together with *Heptranchias perlo* throughout the year, especially from April to July and from September to October. The amount varies according to the fishing activities which decrease during August and are switched to different fishing grounds in winter.

Materials were collected either at Naga-

saki Fish Market or by the authors themselves in coastal waters off Nagasaki Prefecture from September 1975 to October 1976. According to the fishermen, *C. phantasma* is caught in waters 200-300m deep, along the continental shelf of the East China Sea. The fishing ground is shown by the dark area in Fig. 2.

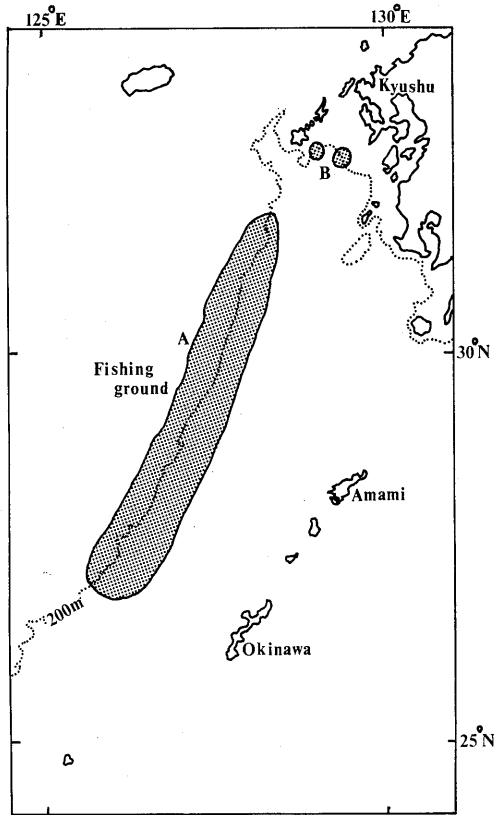


Fig. 2. Fishing ground

The authors' operations were carried out on the research boat "Kakusui", of Nagasaki University, in the same area at depths ranging from 100m to 600m (Fig. 2-B). Angling by means of bottom long line or vertical long line was generally used, because this species lives at depths greater than the usual fishing grounds of commercial bull trawling. This species is rarely found in gill nets of fishermen. Table 1 shows the number of specimens collected in each month. The specimens were measured and dissected in the laboratory. Morphological characters were investigated, and reproductive organs, content of digestive organ, liver, dorsal spine and teeth were taken out for examination. Since the long and flexible tail was often found broken, the body length is given in terms of the length between the tip of the snout and

Table 1. Number of specimens of *C. phantasma* in each month

Month	Female	Male	Total
Sep.'75	1	3	4
Oct.	1	0	1
Nov.	0	0	0
Dec.	4	1	5
Jan.'76	0	0	0
Feb.	2	2	4
Mar.	0	4	4
Apr.	8	0	8
May.	71	35	106
Jun.	25	18	43
Jul.	22	17	39
Aug.	24	5	29
Sep.	22	12	34
Oct.	11	18	29
Total	191	115	306

the posterior base margin of the anal fin (Fig. 3, No. 14).

### Results and Discussions

#### 1. Growth

Proportional dimensions of 30 parameters were measured, as shown in Fig. 3. Table 2

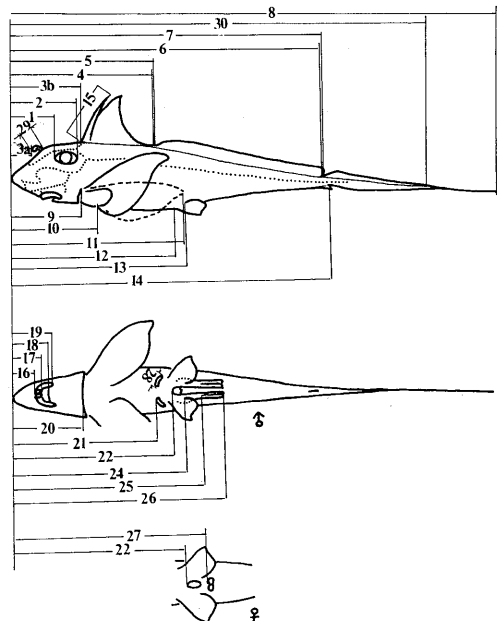


Fig. 3. Proportions of external measurements

1.	From snout tip to anterior margin of eye;	18.	" " " "	anterior margin of labium mandibulare;
2.	" " " " posterior margin of eye;			
3A.	" " " " tip of frontal clasper;	19.	" " " "	posterior margin of labium mandibulare;
3B.	" " " " origin of first dorsal fin;	20.	" " " "	anterior margin of gill opening;
4.	" " " " base of first dorsal fin end;	21.	" " " "	anterior margin of anterior clasper;
5.	" " " " origin of second dorsal fin;	22.	" " " "	anterior margin of anus;
6.	" " " " base of second dorsal fin end;	24.	" " " "	origin of posterior clasper;
7.	" " " " origin of upper caudal fin;	25.	" " " "	diverging point of posterior clasper;
8.	Total length;	26.	" " " "	posterior margin of posterior clasper;
9.	From snout tip to origin of pectoral fin;	27.	" " " "	anterior margin of gonopore;
10.	" " " " base of pectoral fin end;	28.	Width of pouch of anterior clasper;	
11.	" " " " posterior margin of pectoral fin;	29.	Length of frontal clasper;	
12.	" " " " origin of pelvic fin;	30.	Tip of snout to base of caudal fin end;	
13.	" " " " base of pelvic fin end;			
14.	" " " " base of anal fin end;			
15.	Length of dorsal spine;			
16.	From snout tip to anterior margin of nostrils;			
17.	" " " " posterior margin of nostrils;			

Table 2. Proportional measurements of *C. phantasma* at intervals of 10cm body length

No.	proportional dimensions in percent of body length (No. 14)							
	male (cm)			female (cm)				
	0-49	50-59	60-69	0-49	50-59	60-69	70-79	80-89
1	11.3	10.9	10.7	10.0	10.7	10.6	10.7	11.9
2	16.7	16.8	16.2	15.7	14.3	15.9	15.9	16.7
3A	6.8	6.0	6.0	-	-	-	-	-
3B	23.5	23.1	22.3	22.0	22.1	22.4	22.1	25.6
4&5	42.0	44.3	40.5	41.3	41.2	40.4	41.2	42.3
6&7	99.8	98.6	97.7	99.6	100.0	99.8	98.5	99.7
8	159.4	147.1	126.9	159.9	138.4	143.8	135.1	125.1
9	22.6	22.6	22.7	25.6	23.0	23.8	23.0	23.6
10	28.4	28.0	26.5	26.6	27.0	27.2	27.2	28.2
11	57.1	47.8	53.1	55.5	55.5	53.9	53.7	55.0
12	49.9	48.6	47.5	47.9	49.2	49.8	49.1	50.4
13	53.1	52.2	49.8	60.4	52.4	53.1	51.5	53.2
14	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
15	19.9	19.3	16.9	22.8	19.2	17.9	16.4	15.8
16	6.8	7.4	7.0	7.8	7.6	7.1	7.6	7.7
17	7.2	8.1	7.6	9.1	8.8	7.9	7.8	8.4
18	9.3	10.0	9.6	11.2	10.4	9.8	9.9	10.4
19	12.0	12.3	11.4	13.1	12.6	11.7	11.8	12.7
20	20.5	21.4	20.3	23.7	20.9	20.6	20.3	21.3
21	48.1	48.2	44.9	-	-	-	-	-
22	50.6	51.1	47.2	55.9	49.4	49.7	49.2	50.0
24	53.3	53.6	50.8	51.5	51.9	52.6	51.8	52.7
25	54.9	59.8	56.1	-	-	-	-	-
26	57.1	73.2	66.9	-	-	-	-	-
27	-	-	-	58.0	51.4	54.2	53.0	52.9
28	2.0	2.8	2.5	-	-	-	-	-
29	1.8	3.0	2.7	-	-	-	-	-
30	-	118.0	104.7	-	-	115.7	105.2	111.2

shows the ratio between proportion measurements and body length expressed in percentage for individuals grouped at intervals of 10cm.

As for the number of specimens observed, 5 females were of the body length less than 50cm, 54 in the range of 60–70cm, 77 in the range of 70 to 80cm, and 36 in the range of 80 to 90cm. In the male, 1 was less than 50cm, 62 in the range of 50 to 60cm, and 48 in the range of 60 to 70cm,

Data on specimens of both sexes less than 50cm in body length is scarce and therefore, for information, not valid, however this data is indicated only because all of these specimens were found to be still immature.

The tail and the dorsal spine were often found broken so data on both shows some discrepancies among individuals of similar body length.

It may be observed from Table 2 that the increment of body length in males is accompanied by a proportional increment of pelvic and anal fin, while the thorax and trunk region proportion remains almost unchanged. The head, by contrast, shows a slight decrease.

In the case of females less marked changes in the proportions are observed for each region.

The relation between body length (L cm) and body weight (W gr) is indicated by the following formulas.

$$\text{Male : } W = 0.1913L^{2.2269}$$

$$\text{Female : } W = 0.0376L^{2.6349}$$

In the male, the condition factor  $\frac{\text{body weight}}{\text{body length}^3} \times 10^3$  shows a tendency of decreasing with the increase of body length; it is about 9 for individuals of 50cm in body length, and it decreases to about 7 for individuals of 70cm. Moreover, a small

seasonal variation can be observed, the value being larger in summer and smaller in winter. However, the variation of the condition factor with the season is smaller than that with the body length. In the female, this factor remains almost constant for both season and body length.

In both sexes, the hepatosomatic index  $\frac{\text{liver weight}}{\text{body weight}} \times 100$  shows no difference by body length or season.

## 2. Teeth

In Elasmobranches teeth are usually present in large number in both jaws, with the characteristic of being renewable, and they play an important role in their classification.

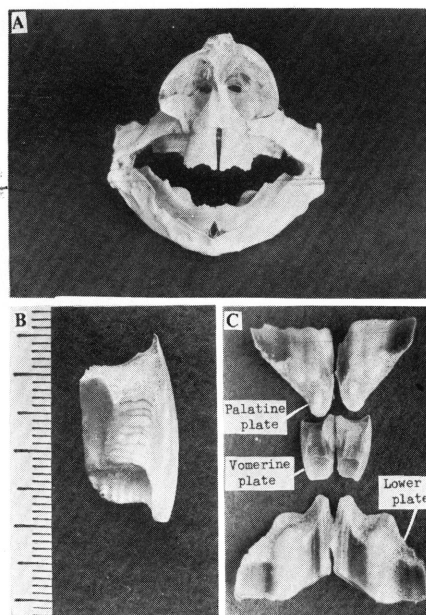


Fig. 4. Teeth, A: Frontal view of tooth, B: Ridges of vomerine plate, C: Three pairs of dental plate

The teeth of *Holocephali* (Fig. 4) are entirely different, being larger in size and not numerous but equally sharp and strong, with knobs and ridges embedded in them.

The function of the teeth of *C. phantasma* is quite similar to that of globefish, well

adapted to crush strong bodies like crustaceans or bivalves. Because of this strength, we sometimes found the nylon gut of our bottom long line cut and we had to use wire as gut.

As described by TANAKA (1905), they consist of three pairs of dental plates: the vomerine plates and palatine plates in the upper jaw and the lower plates in the lower jaw. These plates are thick at the base and thin at the top, specially the vomerine and lower pairs, and are supported by cartilage. With the mouth closed, the lower plates fit the gap between vomerine and palatine plates. As a consequence of repeated bitings, the tip of the inner surface of those plates is defaced.

On the inner surface of each vomerine plate there are ridges as shown in Fig. 4-B, whose number is usually the same for both plates.

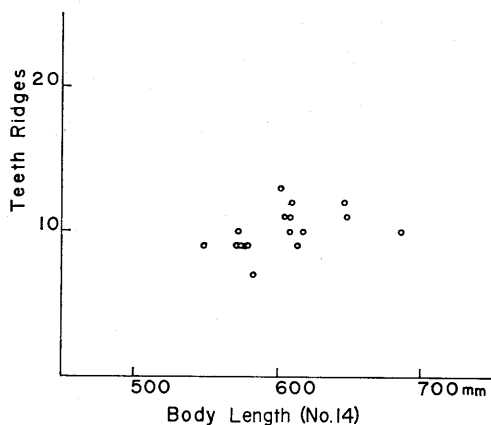


Fig. 5. Relationship between body length and teeth ridges

It seems that these layers could be related to growth (Fig. 5) but not to age. At the same time, the above mentioned defacement prevented us from a reliable counting of ridges. Other body dimensions like skeleton length, number of dorsal spine serrations, and eyeball diameter were examined to look for a clue to determining

age, but so far they seem to have failed to serve the purpose.

### 3. Content of digestive organ

The content of the spiral intestine was examined in 101 males and 171 females.

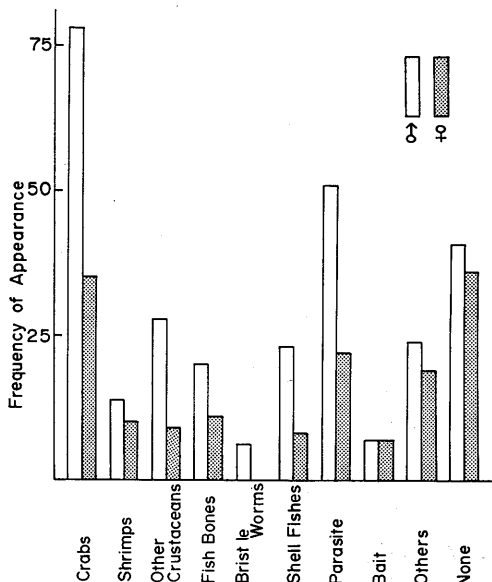


Fig. 6. Frequency of appearance of intestinal content of *C. phantasma*

The frequency of appearance of intestinal content by kind is shown in Fig. 6. The "Parasite" is *Gyrocotyle* sp. Sometimes four or five individuals can be found in one specimen of *C. phantasma*. Included in "Others" are occasional remains of squids, starfish, seaweeds, and sea anemones. It was difficult to define the species because the content almost always was found in an advanced stage of digestion.

From Fig. 6 it is clear that *C. phantasma* of both sexes feeds mainly on crustaceans, specially crabs with a carapace length of about 3-4cm. Other kinds of content were also of similar size. They were mostly benthic animals, like crabs, shrimps, amphipods, shellfish, starfish, sea anemones, with no or rather limited swimming ability. This fact strongly suggests that *C. phantasma*

mainly lives at the Sea bottom. According to DEAN (1904a), movements are sluggish when kept in shallow water. But the presence of small-fish bone indicates *C. phantasma* could actively swim in his natural habitat in search of food.

#### 4. External clasper

Males of Elasmobranchs have as external sexual organs a pair of characteristic claspers. Holocephali have, in addition to this, a pair of anterior claspers and a frontal clasper (Fig. 7).

The posterior clasper (Fig. 8) quite resembles externally that of Elasmobranchs, and so are its skeleton and the skeleton of pelvic fin. As described on *Chimaera* spp., *Callorynchus* sp. and *Harriotta* sp. by GARRICK (1971, 1975), DEAN (1904a, 1904b) and LEIGH-SHARPE (1921, 1922), many differences can be accounted between the clasper of Holocephali and that of Elasmobranchs.

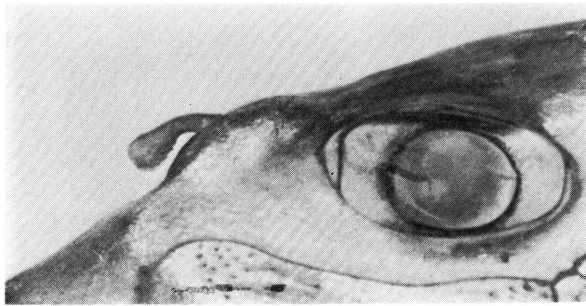


Fig. 7. Frontal clasper

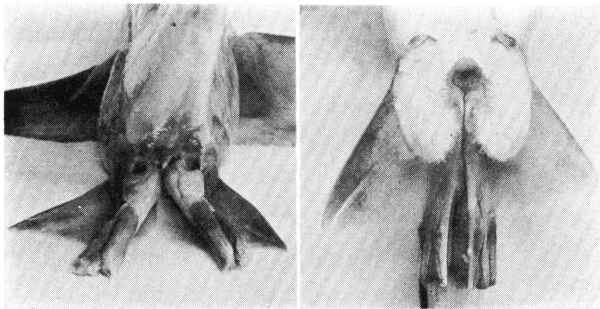


Fig. 8. Posterior clasper, Right: ventral view, Left: posterior view

In general it can be said that though Holocephali have far less species than

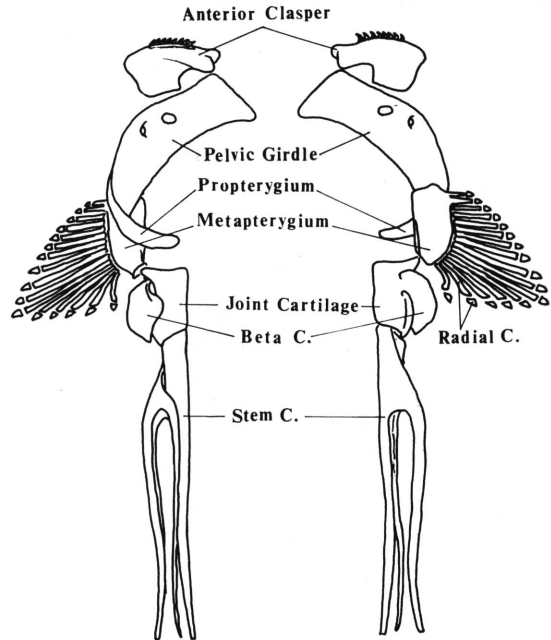


Fig. 9. Right skeleton of pelvic fin and posterior clasper, Right: ventral view, Left: dorsal view

Elasmobranchs, they present a greater variety in the morphology of their clasper.

The clasper of Elasmobranchs is not divided but in some species of Holocephali it is divided into two or three. In *C. phantasma*, the posterior clasper bifurcates into external and internal radii. The external radius, in its turn, bifurcates into two (Fig. 9). Unlike those of *C. monstrosa*, radii of *C. phantasma* are not flexible. The tips of these radii have no dermal hooklets or accessory organs as Elasmobranchs do.

The dorsal basement of each posterior clasper is covered by muscle and is fleshy. Near each base there is a small pouch. On *C. monstrosa*, LEIGH-SHARPE (1922a) describes a

clasper cavity in this dorsal swelling that opens at the diverging point of the posterior clasper. No presence of clasper cavity can be found in *C. phantasma*.

The tip of the outer border of the anterior part of the clasper is covered by loose and dented skin. Many capillary vessels are present in this body.

The anterior clasper of *C. phantasma* has no conspicuous differences from other Chimeroids. They bear 8 spines in line on its inner border. The pouches are widely open in a transverse axis with the body.

The frontal clasper nearly resembles that of other Holocephali and is usually kept in a small depression of the skin as shown in Fig. 7. It is strongly dented on its inferior surface, as described by LEIGH-SHARPE in *C. monstrosa* and *Callorhynchus antarcticus*.

##### 5. Skeleton of Pelvic Fin and Clasper

There are not so many differences in general structure of pelvic fin and clasper between Holocephali and Elasmobranches.

The skeleton of the pelvic fin and clasper consists of pelvic girdle, propterygium, metapterygium, radial cartilages, joint cartilage, beta cartilage and stem cartilage (Fig. 9).

The pelvic girdle is connected to the anterior clasper at its anterior margin by a ligament. The biggest difference from Elasmobranches is found in the pelvic girdle which consists of left and right cartilages in *C. phantasma* but only one cartilage in most sharks. A complex system of small bones is at the tip of the stem cartilage in many kinds of sharks; there is none in *C. phantasma*. LEIGH-SHARP (1922) described dermal hooklets at the tip of the stem cartilage of *Rhinochimaera atlantica*.

Moreover, stem cartilage is trifurcated

at the basement region, each radius looking like a scroll. The radial cartilage of this species is formed by 15 cartilages.

##### 6. Relationship of body length with testes weight and with clasper length

Almost all 115 males, collected at the Nagasaki Fish Market and caught by ourselves, were more than 50cm in body length, with the exception of one individual measuring 44.3cm caught in June.

The smallest specimen in the range of 50 to 60cm, had a body length of 51.4cm, the difference between these two individuals being not so large. However a striking difference can be appreciated in clasper length. We considered as clasper length of the outer clasper only.

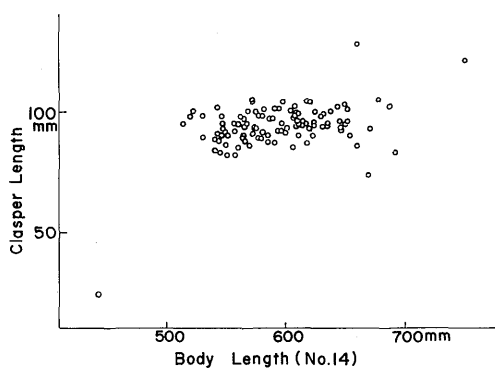


Fig. 10. Relationship between body length and posterior clasper length

While the clasper length in the smallest specimen is 1.7cm, it is around the average (9.5cm) for all other specimens (Fig. 10).

On the other hand, the difference between the testes weight of the small individual and that of specimens in the range of 50 to 60, is not so remarkable as the one observed in clasper length (Fig. 11). Nevertheless, it can be easily appreciated that, though in large individuals increment of testes weight with body length is slow, it does increase rapidly from the small individual to the small ones in the large group.



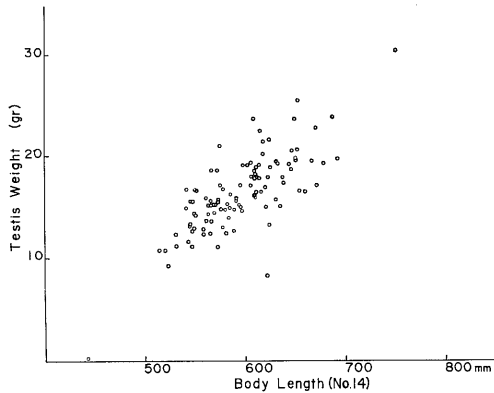


Fig. 11. Relationship between body length and testes weight

From the above mentioned results, and from the fact that all the other 18 specimens caught in July had bigger testis weight, we can observe a conspicuous contrast in the sexual maturity. Accordingly, we can fairly consider that *C. phantasma* reaches sexual maturity at a body length between 45 and 50cm.

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#### 全頭類の研究—I

##### ギンザメ *Chimaera phantasma* の形態と雄の生殖器官について

ジョバニ・マラグリーノ・竹村 暁・水江一弘

1975年9月から1976年10月にかけて長崎魚市に水揚げされたり、著者らが長崎県沿岸で採捕したギンザメ 306 個体 (雄 115 個体, 雌 191 個体) について、形態学的に、雄については生殖生態についても調査した。成長に伴う各部の外形プロポーシヨンの割合はほぼ一様である。また、雌雄の成長式は次式で示された。

$$\text{雄: } W(g) = 0.1913L(\text{cm})^{2.2269}$$

$$\text{雌: } W(g) = 0.0376L(\text{cm})^{2.6349}$$

雄の肥満度は成長に伴い減少するのが観察された。歯は非常に強固な三対の歯板よりなり、主として底棲動物を捕食し、中でも小型のカニを最も多く捕食している。Posterior clasper は三叉し、先端は顕著な附属物はなく、external radii は屈曲しない。Anterior clasper の内縁には一列に並んだ8個の棘があり、Pelvic girdle は左右二つに分離している。本種の雄は体長 (No. 14) 45cmから50cmで成熟に達する。