

Studies on Sharks—X

Morphological and Ecological Study on the Reproductive Organs in Male *Heptranchias perlo* *

Sho TANAKA, Kazuyuki TESHIMA ** and Kazuhiro MIZUE ***

The present report is to compare the clasper and its constituent skeleton of *Heptranchias perlo* (BONNATERRE) with those of other sharks. Moreover, the relationship of total length with testes weight and clasper length of *H. perlo* is discussed respectively, and the total length at the maturity of male is estimated. Then comparison is made between the clasper cavity of *H. perlo* and the siphon sac of other sharks.

Introduction

Most selachians possess five gill openings. However, sharks in families of Hexanchidae, Chlamydoselachidae and Pristiophoridae have six or seven gill openings: six-gill sharks are *Hexanchus griseus* (BONNATERRE), *Chlamydoselachus anguineus* GARMAN and *Pliotrema* sp.¹⁾, and seven-gill sharks are *Heptranchias perlo* and *Notorhynchus platycephalus* (TENORE). As compared with sharks of five gill openings, the members of the families Hexanchidae and Chlamydoselachidae have some different characters except the number of gill openings and only one dorsal fin, and these sharks appear to be primitive. Authors' attention was paid to sharks having six or seven gill openings. However, *C. anguineus* is not found at the fish markets in Nagasaki region. (There has been no report nor news that *C. anguineus* was caught in Nagasaki region.) Although *H. griseus* and *N. platycephalus* are sometimes found at the fish market in Nagasaki, collection is restricted to very short period of the year, i.e., April to June. Moreover, these two species are not suitable for study owing to their large size. Contrary to three species, *H. perlo* is landed at the fish market in Nagasaki almost all the year round. In addition to this, as the fishing ground is not far from Nagasaki, it is possible to capture *H. perlo* by authors themselves. Moreover, the size of *H. perlo* is suitable to treat.

According to the fishermen and the workers of the fish market, *H. perlo* is very fierce and is given the nickname of "Ohkami" (sea wolf) or "Tobitsuki" (leaper). Teeth of *H. perlo* are very sharp. The stomach contents reveal that *H. perlo* is polyphagous and ferocious as compared with other bottom sharks. Regarding foreign

* The outline of the present study was presented at the annual meeting of the Japanese Society of Scientific Fisheries held in Nagasaki, autumn, 1975.

**Shimonoseki University of Fisheries, Yoshimi, Shimonoseki, Japan.

***Ocean Research Institute, University of Tokyo, Nakano, Tokyo, Japan.

H. perlo, BIGELOW and SCHROEDER²⁾ have reported classification and morphology of specimens collected mainly from Nice and Cuba.

The body of *H. perlo* is very flexible and the calcification in the skeleton such as vertebrae is scarcely advanced. Therefore, in order to compare the reproduction in *H. perlo* with that in five-gill sharks, the present specimens were collected and examined. In the present report, reproduction and its associated aspects in male *H. perlo* are mainly discussed. Investigation of the female of *H. perlo* will be described elsewhere. Moreover, *H. perlo* is a deep-sea shark and is caught in Nagasaki region only by the bottom long line.

Material

Many individuals of *Heptranchias perlo* (Fig. 1) are landed at the fish market

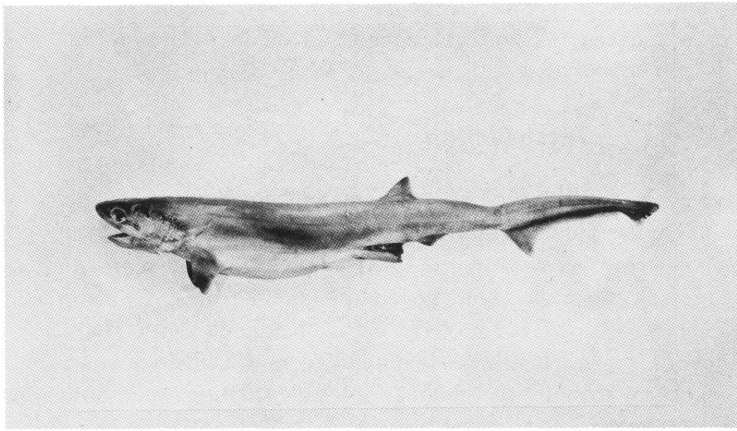


Fig. 1 Male *Heptranchias perlo*.

in Nagasaki, Japan throughout the year, excluding August. No landing in August does not mean that *H. perlo* leaves the fishing ground, but commercial fishing is forbidden in this season. The specimens were collected every two days at the fish market during the period from April to October, 1975. The authors themselves captured some specimens by the bottom long line during summer. The operation was carried out by the "Kakusui", a small research vessel of Nagasaki University, in the waters of 150-250m. deep (Fig. 2). It seems that the specimens landed at the fish market were caught in the northern waters along the continental shelf in the East China Sea (Fig. 2).

The specimens were measured and dissected in the laboratory. The gonads of both sexes and stomach contents were taken out for examination, and as occasion demanded, photographs were taken. The specimens investigated were 63 males and 128 females.

in Nagasaki, Japan throughout the year, excluding August. No landing in August does not mean that *H. perlo* leaves the fishing ground, but commercial fishing is forbidden in this season.

The specimens were collected every two days at the fish market during the period from April to October,

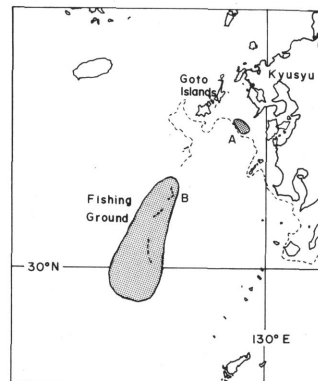


Fig. 2. Fishing ground (shaded area).
A: The long line operation was carried out by the authors.
B: The commercial long line is engaged.

Results and Discussion

1. Teeth

The dental formula of *Heptranchias perlo* is $\frac{7-9\text{toll}9\text{toll}7}{9\text{toll}5-15-9\text{toll}}$. The shape of anteriors of the upper jaw is different from that of the lower jaw. However, the shape of posteriors of both jaws is almost the same.

The number of anteriors of the right and left upper jaws is nine to 11 respectively. Each of anteriors is strongly oblique, and possesses a sharp, fang-like cusp. The first and second anteriors are formed by three to four rows of teeth (Fig. 3), and the subsequent anteriors form a line along the jaw. The fourth to last anteriors possess inside one to two small cusps, and the sixth to the last ones possess outside two small cusps (Fig. 3).

In the center of the lower jaw, there is a symmetrical tooth having a large cusp and two smaller ones on either side. Subsequent to a median tooth, the right and left lower jaws have five anteriors respectively (Fig. 3). Each of anteriors possesses seven to ten obliquely triangular cusps. The first and second cusps appear to be accessory ones, but the third one is the longest and appears to be functional.

The number of posteriors of the right and left upper jaws is seven, and that of each lower jaw is nine to 11 respectively. Each of posteriors is very small and round, and possesses no cusps. Posteriors are also found in such species as *Hexanchus griseus* and *Notorhynchus platycephalus*. Posteriors do not appear to be functional.

According to BIGELOW and SCHROEDER²⁾, the number of anteriors of the upper jaw in an immature *H. perlo* specimen (257mm. in body length) in the Atlantic is ten and it changes to 12 in mature specimens. The last anterior does not possess any definitive cusps. So far as examined, irrespective of immature and mature specimens, the number of anteriors of the upper jaw was nine to 11 with a mode of ten in most cases.

2. Reproductive season

It has been reported that bottom sharks in the western waters of Kyushu and in the East China Sea have the definitive reproductive season. These sharks are *Galeorhinus japonicus* (MÜLLER et HENLE)³⁾, *Mustelus manazo* BLEEKER⁴⁾⁵⁾, *M. griseus* PIETSCHEMANN⁶⁾, *Carcharhinus milberti* (MÜLLER et HENLE)⁷⁾, *Squalus brevirostris* TANAKA⁸⁾, *S. suckleyi* (GIRARD)⁹⁾ and *Halaelurus bürgeri* (MÜLLER et HENLE)¹⁰⁾. The reproductive season in these species is relatively short

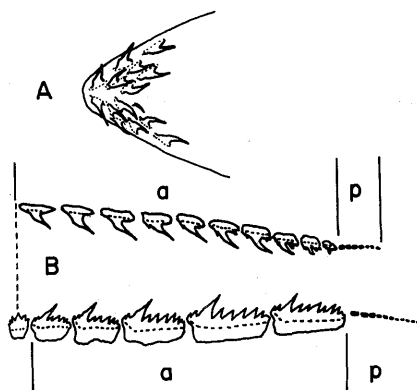


Fig. 3. Teeth of *Heptranchias perlo*.
A: Ventral view of the anterior part of upper jaw.
B: Upper and lower teeth.
a: anteriors, p: posteriors.

extending from spring through summer. Contrary to the above species, in the southern waters (the South China Sea), bottom sharks caught by trawl net appear to have no definitive reproductive season probably because the sea conditions are almost the same throughout the year. *Carcharhinus dussumieri* (MÜLLER et HENLE)¹¹⁾ sets a good example.

However, *Heptranchias perlo* in the western waters of Kyushu does not appear to have the definitive reproductive season in view of the maturity of male and female gonads as a result of the dissection and examination up to the present. Among specimens of *H. perlo* which were collected during seven months from April to October, 1975, females containing the mature eggs in their ovaries were always found, and the eggs appeared to be ovulated soon. Moreover, throughout the period collected, male specimens having the large-sized testes and the expanded sperm sacs filled with spermatozoa were always found. Generally in sharks, there is a difference of some months between the mature time of testes and the time when the sperm sacs are filled with spermatozoa, the latter coming late. These facts in both sexes suggest that *H. perlo* in the area investigated should successively mate during the period examined.

3. Relationship of total length with testes weight and clasper length

Since a conclusion that *Heptranchias perlo* does not appear to have the definitive reproductive season was reached in the preceding chapter, it is not necessary to choose any specific period for the purpose of discussing the relationship between testes weight and total length.

The testes weight rapidly increases with the increment of the total length when *H. perlo* is between 70 and 85cm. When the shark grows to more than 85cm. in

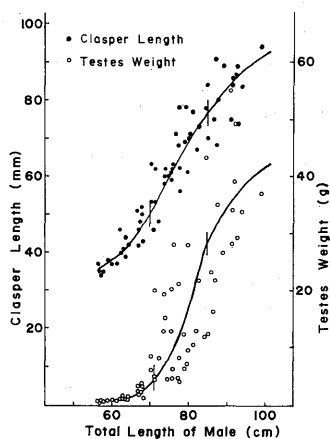


Fig. 4. The relationship of the total length with the testes weight and the clasper length.

total length, the testes weight increases slowly (Fig. 4). This may indicate that male *H. perlo* reaches the maturity when the shark is between 70 and 85cm. in total length. Moreover, the relationship between the clasper length (inner part) and the total length is similar to that between the testes weight and the total length (Fig. 4). A rapid increment in clasper length is remarkable at the total length between 70 and 85cm. This fact makes more clear that male *H. perlo* reaches the maturity when it is between 70 and 85cm. in total length. According to BIGELOW and SCHROEDER²⁾, male *H. perlo* in the Atlantic reaches the maturity at its total length between 60 and 75cm. There is a difference by 10cm. between the shark in the East China Sea and one in the Atlantic. In order to compare *H. perlo* with other species, the relationship between the clasper length and the total length is shown in Fig. 5; *Squalus brevirostris*⁸⁾ (A), *Mustelus manazo*⁴⁾ (B), *Galeorhinus japonicus*³⁾ (C), *M. canis*¹⁵⁾ (D), *S. acanthias*¹⁵⁾ (E) and *H. perlo* (F). Of these, *H. perlo* shows about the same tendency as others, but the clasper length in *Squalus* species is relatively short.

4. External characters of clasper

Naturally the clasper is a copulatory appendage and is originally formed by the elongated posterior of the pelvic fin. This is obvious at a glance of the skeleton of pelvic fin and clasper. In most male sharks, the clasper is externally distinguished from the pelvic fin (Fig. 6).

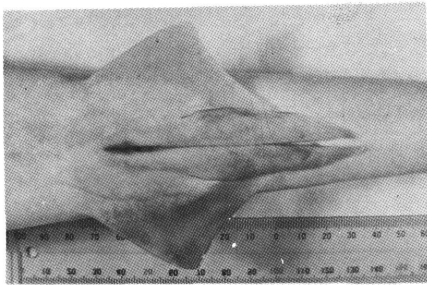


Fig. 6. The ventral view of the pelvic fin and the clasper in *Mustelus manazo*.

However, in *Heptranchias perlo*, the posterior part of the pelvic fin extends to form the clasper sheath which wraps up and protects the clasper, and the clasper is hardly visible from its ventral side (Fig. 7).

The internal surface of the clasper sheath secretes a large quantity of highly viscous substances and the clasper is shielded by them. The clasper sheath of the present species is similar in its external characters to that of *Hexanchus griseus* described by LEIGH-SHARPE¹²⁾. In *Notorhynchus platycephalus* landed at the fish market in Nagasaki, the clasper sheath was also found and it wrapped up the clasper.

Unlike most male sharks, *H. perlo* possesses no siphon sac. However, *H. perlo* has a clasper cavity on its ventral surface of each clasper. The cavity is also observed in *H. griseus*¹²⁾ and *Chlamydoselachus anguineus*^{13) 14)}. The cavity, according to LEIGH-SHARPE¹²⁾, is used for "pumping spermatozoa", the sea water contained in the cavity is pushed out into the clasper groove and the spermatozoa are conveyed together with the sea water into the oviducts of the

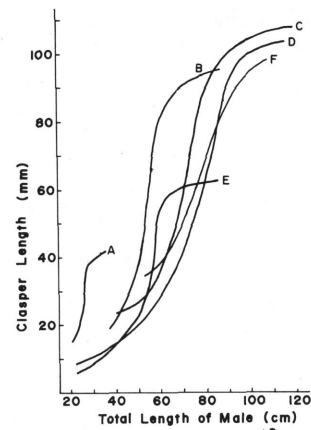


Fig. 5. The relationship between the clasper length and the total length in six species. (A): *Squalus brevirostris*, (B): *Mustelus manazo*, (C): *Galeorhinus japonicus* (D): *M. canis*, (E): *S. acanthias*, (F): *Heptranchias perlo*.

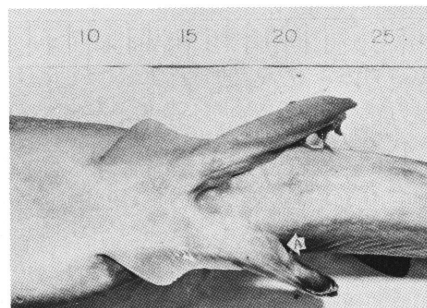


Fig. 7. The ventral view of the pelvic fin and the clasper in *Heptranchias perlo*. A: Clasper cavity.

female during copulation. The cavity was also found in *N. platycephalus* collected from the fish market in Nagasaki.

5. Skeleton of pelvic fin and clasper

The skeleton of the pelvic fin and clasper in *Heptranchias perlo* and *Mustelus manazo* are shown in Fig. 8 (in dorsal view). The morphological characters of



Fig. 8. The dorsal view of the skeleton of the pelvic fin and the clasper in *Mustelus manazo* and *Heptranchias perlo*.
Right : *M. manazo*, Left : *H. perlo*.

the pelvic fin in *M. manazo* are similar to those in other species such as *M. griseus*, *Galeorhinus japonicus*, *Centrophorus atromarginatus* GARMAN, *Squalus mitsukurii* JORDAN et FOWLER and *S. brevirostris*. However, the skeleton of the pelvic fin in *H. perlo* has some different characters compared with others; the pelvic girdle is longitudinally longer and transversely shorter. The central portion of the upper margin of the girdle is convexed, but that of the lower margin is concaved.

The metapterygium is attached to each side of the pelvic girdle, and the radial cartilages are formed posteriorly along the metapterygium from the side of the pelvic girdle. The radial cartilages are different in their shape from others (Fig. 8).

The clasper skeleton in *H. perlo* is very simple compared with that in the others. In *Squalus acanthias*¹⁵⁾, the clasper is made up of the main stem cartilage, to which two marginal cartilages are fused, and four terminal cartilages, namely, the claw, the rhipidion, the distal basal and the spur. No great differences may be found in the clasper skeleton between *S. acanthias* and the others. In *H. perlo*, however, the stem cartilage only extends tapering posteriorly, and no accessory cartilages are attached.

The skeleton of the pelvic fin and the clasper is hardly calcified. However, only the internal part of the anterior end of the metapterygium is calcified.

Summary

1. The male reproductive organs in *Heptranchias perlo* with seven gill openings were morphologically and ecologically investigated.
2. Teeth of *H. perlo* are peculiar in their shape, especially in the lower teeth.
3. The present species does not appear to have any definitive reproductive season, as a result of examination of testes and sperm sacs of males and

4. Male reaches the maturity at its total length between 70 and 85cm. according to testes weight and clasper length.
5. The posterior part of the pelvic fin extends to form the clasper sheath.
6. Unlike most male sharks, *H. perlo* has no siphon sac.
Instead of the siphon sac, *H. perlo* possesses the clasper cavity.
7. The skeleton of the pelvic fin is different in its shape from other species, especially in the pelvic girdle.
8. No accessory cartilages are attached to the stem cartilages.
9. The skeleton of the pelvic fin and the clasper is hardly calcified.

References

- 1) ASAHI NEWS PAPER Co.: Asahi-Larousse Sekai Dobutsu Hyakka (World Animal Encyclopedia), 160, Squaliformes, Asahi Shimbun, Tokyo, P. 8 (1974) (Jap.)
- 2) BIGELOW, H.B. and W.C. SCHROEDER: Fishes of the Western North Atlantic (Pt. 1), Sharks, *Mem. Sears Fdn. Mar. Res.*, 1, 77-93 (1948)
- 3) CHEN, C.T. and K. MIZUE: Studies on Sharks - VI, Reproduction of *Galeorhinus japonicus*, *This Bull.*, 36, 37-51 (1973)
- 4) TESHIMA, K., H. YOSHIMURA and K. MIZUE: Studies on the Sharks - II, On the Reproduction of Japanese Dogfish *Mustelus manazo* BLEEKER, *This Bull.*, 32, 41-50 (1971)
- 5) KUDO, S.: Studies on the Sexual Maturation of Female and Embryos of Japanese Dogfish *Mustelus manazo* (BLEEKER), *Rep. Nankai Reg. Fish. Res. Lab.*, 9, 60-62 (1958) (Jap., Engl. abstr.)
- 6) TESHIMA, K. and S. KOGA: Studies on Sharks - V, Taxonomic Characteristics of Reproductive Organs in Japanese *Mustelus*, *Mar. Biol.*, 23(4), 337-341 (1973)
- 7) TANIUCHI, T.: Reproduction of the Sandbar Shark, *Carcharhinus milberti*, in the East China Sea, *Jpn. J. Ichthyol.*, 18(2), 94 - 98 (1971)
- 8) KIBESAKI, O.: Studies on the Sharks from the East China and Yellow Seas. (II), Maturity of the *Squalus brevirostris*, *Bull. Seikai Reg. Fish. Res. Lab.*, 5, 36-46 (1954) (Jap., Engl. abstr.)
- 9) YAMAMOTO, T. and O. KIBESAKI: Studies on the Spiny Dogfish *Squalus suckleyi*. (I), On the Development and Maturity of the Genital Glands with Growth, *Bull. Jap. Soc. Sci. Fish.*, 15(10), 531-538 (1949) (Jap., Engl. abstr.)
- 10) KUDO, S.: Studies on the Sexual Maturation of Female and on the Embryo of Japanese Dogfish *Halaelurus burgeri* (MÜLLER et HENLE), *Rep. Nankai Reg. Fish. Res. Lab.*, 11, 41-45 (1959) (Jap., Engl. abstr.)
- 11) TESHIMA, K. and K. MIZUE: Studies on Sharks - I, Reproduction in the Female Sumitsuki Shark *Carcharhinus dussumieri*, *Mar. Biol.*, 14(3), 222-231 (1972)
- 12) LEIGH-SHARPE, W.E.: The Comparative Morphology of the Secondary Sexual Characters of Holocephali and Elasmobranch Fishes; The Clasper, Clasper Siphons and Clasper Glands, *Mem. V, J. Morph.*, 36, 221-225 (1922)
- 13) GILBERT, P.W.: The Morphology of the Male Urogenital System of the Frilled Shark, *Chlamydoselachus anguineus*, *J. Morph.*, 73, 507-528 (1943)

- 14) GOODEY, T.: A Contribution to the Skeletal Anatomy of the Frilled Shark, *Chlamydoselachus anguineus* GAR., *Proc. Zool. Soc. Lond., Pt. 1*, 540-571 (1910)
- 15) GILBERT, P.W. and G.W. HEATH: The Clasper-Siphon Sac Mechanism in *Squalus acanthias* and *Mustelus canis*, *Comp. Biochem. Physiol.*, **42A**, 97-119 (1972)