Japanese Journal of Ichthyology
Vol. 31, No. 2 1984

魚類学雑誌
31巻2号 1984年

Sexual Dimorphism in a River Sculpin *Cottus hangiongensis*

Akira Goto

(Received January 21, 1984)

Abstract The river sculpin, *Cottus hangiongensis*, is characterized as a nest spawner. In general, a male spawns successively with several females and defends the eggs. Sexual dimorphism in body size and some morphological characteristics were recognized in this species; males were larger in size, and had a larger mouth and longer anal fin than females. Females may mate preferentially with large males. Larger males could be superior in nest defense and fanning of eggs to smaller ones, thus resulting in higher survival of eggs. Similarly, the larger mouth in males could be advantageous in acquiring and defending their nests. Such sexual dimorphism in this species may reflect the outcome of sexual selection.

The amphidromous cottid fish, *Cottus hangiongensis*, spawns in the lower course of rivers during early spring (Sato and Kobayashi, 1953; Goto, 1981). It is characterized as a nest spawner and deposites the eggs on the under side of stones. The egg cluster generally consists of several egg masses which are different from each other in color, shape and developmental stages. In many cases, the male remains at a nest to defend the eggs. Evidence suggests that *C. hangiongensis* is polygynous, as observed in the mottled sculpin, *Cottus bairdi* (Downhower et al., 1983).

In the present study, sexual dimorphism in the river sculpin, *C. hangiongensis*, is described in terms of morphological characteristics and in body size. The significance of sexual dimorphism is discussed on the basis of the mating system of this species.

Materials and methods

Samples of male and female river sculpins were collected from late March to early April, 1981 and 1982, in the Hekiriji River, and in October, 1982 in the Daitobetsu River. These two rivers flow through the southernmost part of Hokkaido, draining into Hakodate Bay. Fish were captured with a dip net, and preserved in 10% formalin. A total of 593 sculpins was collected for this study; 290 sculpins from the Hekiriji River, 73 males (30.0–109.4 mm in body length) and 89 females (28.2–111.5 mm) in 1981, and 52 males (29.6–104.1 mm) and 76 females (27.4–96.4 mm) in 1982. The remaining 303 sculpins, 71 males (58.1–149.0 mm) and 232 females (53.6–109.8 mm), were collected from the Daitobetsu River.

Standard length, head length, width of mouth, and length of the longest rays of pectoral, pelvic and anal fins were measured to the nearest millimeter. Sex and maturity of fish were determined by direct examination of the gonads. Otoliths were removed 2 days after fixation and stored in glycerine. Fish were aged by counting annuli on the otoliths.

Results

Sexual dimorphism in body size. The length frequency distributions in male and female river sculpin collected from the Hekiriji River in early spring just prior to beginning of their spawning season are shown in Fig. 1. Between sexes, distinct differences were recognized in length mode and in the minimum body length at the first maturity. In 1981, body length of females fell within modes 30–34, 55–59, 75–79 and 90–94 mm, whereas corresponding modes for males were 30–34, 65–74, 80–84 and 90–94 mm, which would represent age groups I through IV, respectively. The minimum body lengths at the first maturity were 49.6 mm in female and 59.4 mm in male. These facts indicate that males mature at larger size than females and are also larger at age groups II and III, respectively. Similar differences between sexes were also recognized in 1982 samples.

In order to determine if such differences between sexes result from differences in growth or age, the length frequency distributions of fish

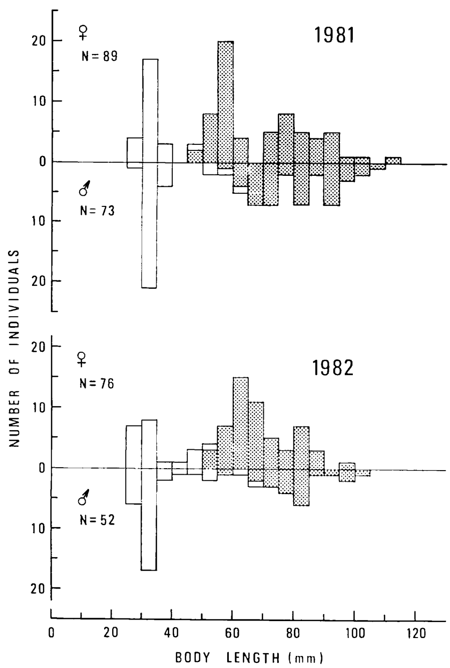

Fig. 1. Length frequency distribution of male and female river sculpin, *Cottus hangiongensis* collected from the Hekiriji River in 1981 and 1982. Open bars represent inmature fish and dotted bars represent mature fish.

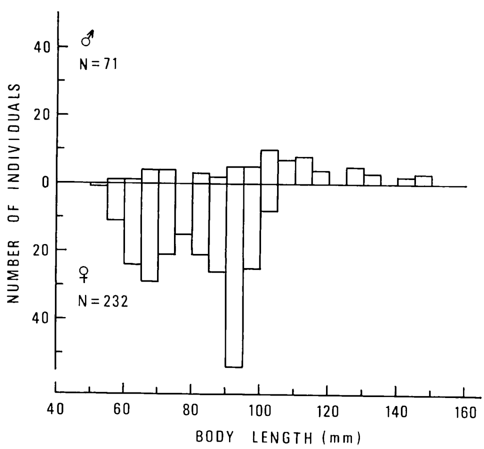

Fig. 3. Length frequency distribution of male and female river sculpin, *Cottus hangiongensis* collected from the Daitobetsu River in October, 1983.

aged by the otolith method are shown for samples collected in 1981 (Fig. 2). Five age groups were established and designated as I, II, III, IV and V

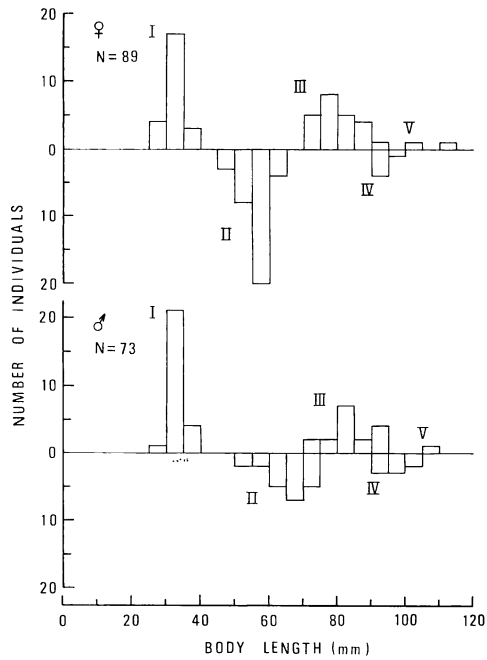

Fig. 2. Length frequency distribution for each age group of male and female river sculpin, *Cottus hangiongensis* collected from the Hekiriji River in 1981.

in both sexes. In age I fish, there were no differences in length mode; 30–34 mm in both sexes. In fish older than age II, however, each mode at the same age was biased at larger size in males than in females, except age V fish, where almost no differences in body length between sexes were observed; females showed modes at 55–59, 75–79 and 90–94 mm in age groups II through IV, respectively, whereas males at 65–69, 80–84 and 90–99 mm. Such differences were most pronounced at age II groups and gradually decreased according to their ages. It is apparent, therefore, that the differences in size between sexes are due to differences of growth rate during the period from age I to age II.

On the other hand, more distinct sexual dimorphism in body size was found in the Daitobetsu River (Fig. 3). The largest male was 149.0 mm in body length and estimated as VI^+ aged fish by the otolith, whereas the largest female was 109.8 mm at IV^+. In this river, the apparent greater size attained by males is mainly due to increased survivorship of males allowing them to live longer.

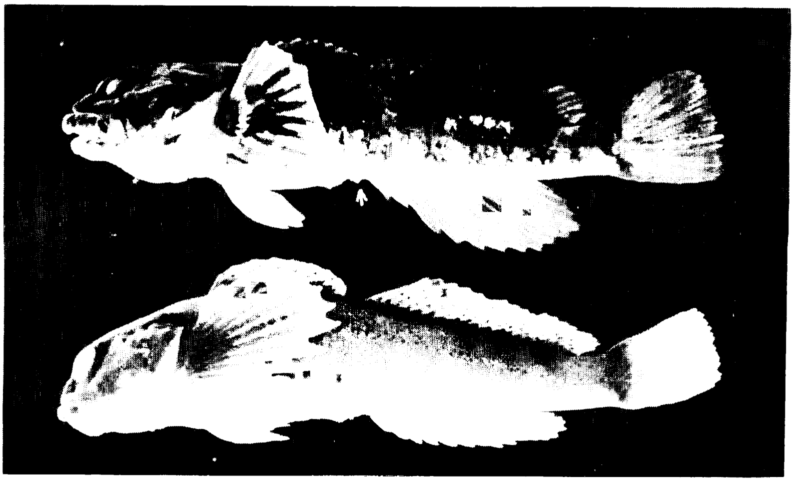

Fig. 4. Male and female adult specimens of river sculpin, *Cottus hangiongensis* collected from the Hekiriji River. Top, male, 101.4 mm SL. Bottom, female, 101.9 mm SL. Arrow indicates a genital papilla.

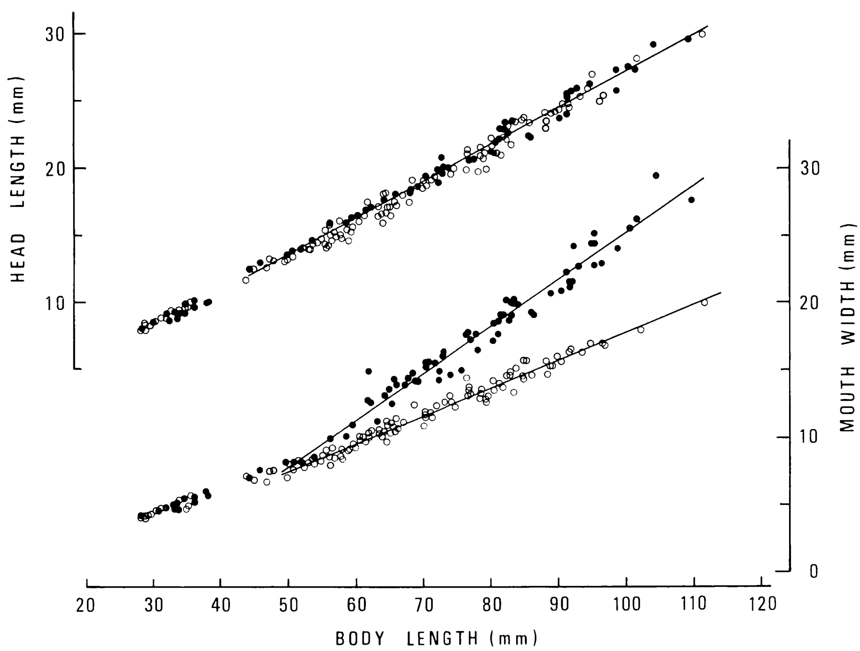

Fig. 5. Relationships between head length and width of mouth versus body length of river sculpin, *Cottus hangiongensis* in the Hekiriji River. Solid circles represent males and open circles represent females.

Sexual dimorphism in morphological characteristics. In adult sculpins, it was possible to discriminate males from females based on external morphological characteristics; males have a genital papilla, whereas females do not. Comparing males and females of similar body length, it was apparent that males had a larger mouth, and several rays in the posterior end of anal fin in males were longer than those in females (Fig. 4).

The relationships between head length and width of mouth versus body length of river sculpins are shown in Fig. 5. No significant differences were recognized between sexes in rela-

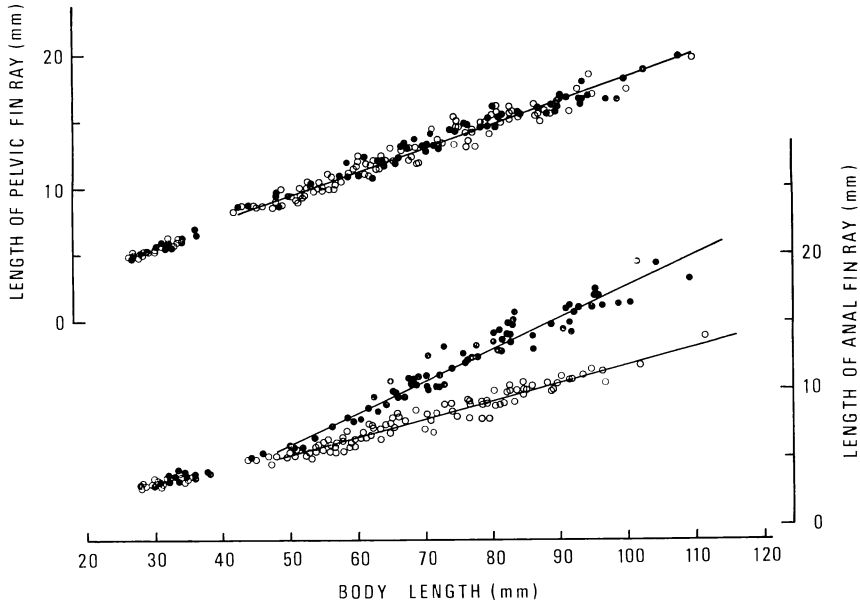

Fig. 6. Relationships between the length of the longest pelvic fin ray and the longest anal fin ray versus body length of river sculpin, *Cottus hangiongensis* in the Hekiriji River. Solid circles represent males and open circles represent females.

tive head length ($P<0.01$). In fish larger than 40 mm, there was a linear relationship between head length (HL) and body length (BL), formulated as follows: HL=0.276 BL−0.538 (r=0.991). On the other hand, significant differences between sexes were apparent in relative mouth width. Males larger than 40 mm had significantly larger mouths ($P<0.01$), though fish smaller than 40 mm showed no differences between sexes. For fish larger than 40 mm, different linear relationships between mouth width (MW) and body length were observed between sexes: MW=0.351 BL−9.87 (r=0.984) in males and MW=0.205 BL−2.77 (r=0.987) in females.

The relationships between the length of the longest pelvic fin ray and the longest anal fin ray versus body length are shown in Fig. 6. There was no differences in the length of pelvic fins between sexes ($P<0.01$), and a linear relationship was recognized between length of the longest pelvic fin ray (PL) and body length, PL=0.178 BL+0.234 (r=0.978), in fish larger than 40 mm in body length. Significant differences between sexes were observed in the length of anal fin rays ($P<0.01$). Males larger than 40 mm in body length had longer fin rays than females. Linear relationships between length of the longest anal fin ray (AL) and body length were found both in males, AL=0.232 BL−5.49 (r=0.970), and in females, AL=0.132 BL−1.36 (r=0.968).

There were no significant differences in the length of pectoral fins between sexes ($P<0.01$).

Discussion

The river sculpin, *C. hangiongensis* is sexually dimorphic in body size, males being larger than females. The differences in body length between sexes reflect differences in growth rate and/or longevity. Males grow faster than females during the period from age I to age II, though no differences were found in size between sexes before age I. Furthermore males sometimes live longer than females as indicated in the Daitobetsu River sample; the longevity is estimated as 6 or 7 years in males, and 4 or 5 years in females.

Adults of this species showed sexual dimorphism in mouth size and length of anal fin rays. Males have larger mouths and longer anal fin rays. These characteristics develop before the time of sexual maturity and become progressively pronounced with age. It is evident that the large mouth in males did not result from the increase of their head size when compared with females, because no differences between sexes were recognized in relative head length. Namely, the increase of mouth size in males developed independently from the allometry of their head size. It has been reported that pelvic fins in adult males of some cottid fishes, such as *Gymnocanthus intermedius*, *Argyrocottus zanderi* (Watanabe, 1960), *Cottus amblystomopsis* (Berg, 1932) and *Cottus nozawae* (Nakamura, 1963), are distinctly longer than those in adult females. In *C. hangiongensis*, however, there were no differences in the length of pelvic fins between sexes, though males have a longer anal fin than females.

In this species, a male generally mates successively with several females and remains at the nest even after spawning (Sato and Kobayashi, 1953; Goto, 1981). Important aspects of a male's parental care include the apparent defense of the nest and fanning of the eggs with its pectoral fins. It is reasonable to presume that larger males can better defend the nest and fan the eggs than smaller ones, thereby allowing higher survival of their developing eggs to hatch. Thus females mating with larger males may have increased reproductive success, as pointed out in the Jamaican lizard, *Anolis garmani* by Trivers (1976). These reproductive habits may be one of the reasons why this species has a polygynous mating system. As a consequence, preferential selection for large sized males may be an important function of females in this mating system.

In the similar way, it is possible to speculate why males have a larger mouth relative to females. When a male competes with other males for a suitable nest site and defends against intruders attempting to prey on eggs in the nest, he threatens them by mouth-opening display and bites their heads. Therefore, a large mouth in males should be advantageous in acquiring and defending their nests, and presumably a male with a larger mouth would have a better chance of winning the encounters. There are two aspects to sexual selection (Darwin, 1888; Wilson, 1975); one is the intra-sexual selection focused on the consequence of competition between members of one sex, and the other is epigamic selection focused on the consequences of mate preferences of one sex with regard to the other sex. The underlying selective pressures resulting in larger size of the mouth in males could thus be mainly associated with intra-sexual selection. At this time it is not possible to explain why males have a longer anal fin relative to females, because it is not clear what the functional role of the anal fin is in their reproductive habits.

Acknowledgments

The author is indebted to Dr. Keikichi Hamada, Faculty of Fisheries, Hokkaido University, for his critical reading of this manuscript, and Dr. Fumio Yamazaki of the same University and Mr. Tom Kron, Alaska Dep. Fish and Game, for their valuable advice and correcting of the manuscript. This work was partly supported by a Grant-in-Aid (57340035), and for Special Project Research on Biological Aspects of Optimal Strategy and Social Structure (58121004) from the Ministry of Education, Culture and Welfare, Japan.

Literature cited

Berg, L. S. 1932. A review of the freshwater cottoid fishes of Pacific slope of Asia. Copeia, 1932: 17–20.

Darwin, C. 1888. The descent of man and selection in relation to sex. 2 Vols. 2nd ed. John Murray, London, 1035 pp.

Downhower, J. F., L. Brown, P. Pederson and G. Staples. 1983. Sexual selection and sexual dimorphism in mottled sculpins. Evolution, 37: 96–103.

Goto, A. 1981. Life history and distribution of a river sculpin, *Cottus hangiongensis*. Bull. Fac. Fish. Hokkaido Univ., 32: 10–21. (In Japanese with English summary).

Nakamura, M. 1963. Keys to the freshwater fishes of Japan fully illustrated in colors. Hokuryukan, Tokyo, 260 pp. (In Japanese).

Sato, S. and K. Kobayashi. 1953. Ecological studies on the fresh water cottoid fishes. I. Breeding habits of *Cottus hangiongensis* Mori. Bull. Fac. Fish. Hokkaido Univ., 3: 233–239. (In Japanese with English summary).

Trivers, R. L. 1976. Sexual selection and resource-accruing abilities in *Anolis garmani*. Evolution, 30: 253–269.

Watanabe, M. 1960. Fauna Japonica, Cottidae (Pisces). Biogeograph. Soc. Japan, vii+218 pp.

Wilson, E. O. 1975. Sociobiology: the New synthesis. Harvard Univ. Press, Cambridge, 697 pp.

(Laboratory of Embryology and Genetics, Faculty of Fisheries, Hokkaido University, Hakodate 041, Japan)

カンキョウカジカの性的二型

後藤　晃

カンキョウカジカは nest spawner であり，雄はふつう数尾の雌と次々に産卵し，産着卵を保護する習性をもつ．こうした一夫多妻の繁殖システム，卵保護との関りから，本種の成魚には，体サイズおよび口のサイズ，臀鰭軟条の長さに明瞭な性的二型が認められた．雄は雌より体サイズが大型で，大きい口，臀鰭後部に長い軟条をもつ．大型の雄は小型の雄よりも，より好適な産卵巣の位置を獲得し，捕食魚から産着卵を守るうえで有利であろう．また，口のサイズについても同様の理由で，大きい口をもつ雄の方が有利であるだろうと予想される．従って，これらの性的二型は性選択によって発達した，と考えられる．

(041 函館市港町 3-1-1　北海道大学水産学部発生学・遺伝学講座)