

Duration of Male Mating Activity and Male Mate Choice in the River Sculpin, *Cottus hangiongensis*

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The river sculpin, *Cottus hangiongensis*, which has an amphidromous life-cycle, is a bottom-dwelling fish widely distributed in Hokkaido, Japan (Goto, 1981). The species is polygynous and sexually dimorphic, the male being larger than the female at all ages (Goto, 1984). The male takes care of developing eggs (Goto, 1987a, 1988). Male mating success, the number of females with which a male mates during one breeding season, is positively correlated to male body size, and which has been interpreted as a result of female preference for larger males (Goto, 1987a). Similar male mating tactic tendencies have been reported in the congeneric species, *C. bairdi* (Downhower and Brown, 1980; Brown, 1982), *C. gobio* (Marconato and Rasotto, 1983; Marconato and Bisazza, 1988) and *C. cognatus* (Mousseau et al., 1987).

To estimate male reproductive success, however, the size of the females with which a male mated must be known, as the female size and clutch size are usually correlated (Bagenal and Braum, 1978; Goto, 1981). In the river bullhead, *C. gobio*, Marconato and Bisazza (1988) observed assortative mating in which females mated with males larger than themselves, with smaller females preferring to mate with males smaller than those chosen by larger females.

The objectives of this study on *C. hangiongensis* were, 1) to estimate the reproductive success of males, represented as the total number of eggs guarded by a male; 2) to find the actual duration of male mating activity, i.e., the period between the first and last matings; and 3) to assess male preference for larger females.

Materials and Methods

A field survey was carried out in the Daitobetsu River, southern Hokkaido, Japan. This is a small,

steeply graded river about 17 km long. Its detailed physical and biological characteristics have been described elsewhere (Goto, 1986). The breeding season of *Cottus hangiongensis* in the Daitobetsu River generally occurs from mid-April to mid-May (Goto, 1981).

On May 11-13, 1989, just after the spawning period, nests of *C. hangiongensis* were sought in the lower course of the river at Sts. 1 and 2 (see Goto, 1986, 1987b, 1988). At that time no gravid females were found and newly hatched larvae were rarely observed; i.e., almost all of the eggs spawned during that breeding season seemed to still be guarded by parent males. Rocks, which were thought to be suitable as nest sites, were isolated with a "capture trap cage" (Goto, 1987a) and examined. When a nest was found, both the egg-cluster adhering to the underside of the rock and the resident male guarding the eggs were collected. The captured males were anesthetized and standard length (SL) measured to the nearest 0.1 mm. When the egg-cluster consisted of several egg masses, these were separated from each other according to differences in egg size, color and developmental stage, and fixed with 10% formalin. Subsequently, eggs of each mass were separated and counted in a shallow petri dish. Because the clutch sizes are positively correlated with the body length of the parent females (Goto, 1977, 1981) and have resulted from single spawning periods (Goto, 1988), the body lengths of the females could be backcalculated from the following formula,

$$E = 34.0L - 1,673,$$

where E is the clutch size and L is the standard length (mm) of the female.

The developmental stages of the eggs were determined for each mass by observation under a dissecting microscope, and the time elapsed following fertilization for each stage, estimated from previous observations of early egg development under seminatural conditions in the Daitobetsu River (Goto, 1977). The duration of actual male mating activity (abbreviated as AMA hereafter) was defined as the time discrepancy between the earliest and latest developmental stages of the eggs.

Results and Discussion

Fourteen nest sites located were suitable for the

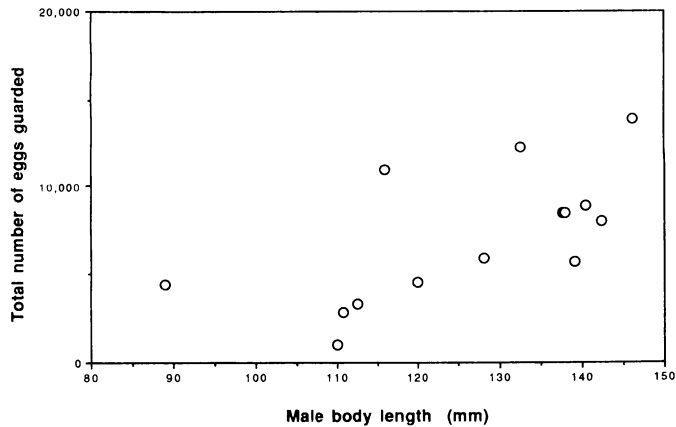


Fig. 1. Relationship between body length of nesting males and total number of eggs guarded.

analysis of AMA duration and determination of the reproductive success of resident males and the body size of females with which they mated. The number of egg masses guarded by a male ranged from 2 to 12 (Table 1). The estimated duration of AMA varied from 1–2 to 13–15 days. This is much shorter than the period during which males are physiologically reproductively capable (1–2 months; Goto, unpublished data).

Male mating success (the number of egg masses guarded by the male) was positively correlated with the size of the male ($r_{xy}=0.701$, $n=14$, $p<0.01$) (Table 1), but the duration of AMA was not ($r_{xz}=$

0.436 , $n=14$, $p>0.05$). Although a positive correlation was found between the duration of AMA and mating success ($r_{yz}=0.636$, $n=14$, $p<0.05$), it was spurious (partial correlation coefficient, $r_{yz..x}=0.515$, $t=1.992$, $p>0.05$). These results suggest that during the short period of AMA, large males had higher mating success than small ones, probably because of the female preference for mating with larger males (Goto, 1987a). However, the timing of female visits to the male's nest was random, having no relation with male size.

Both mating success and male reproductive success were significantly correlated with male size,

Table 1. The number of egg masses guarded by each male and the duration of male mating activity (AMA)

SL of male (mm)	Number of egg masses guarded	Stage number of eggs*		Duration of AMA (days)
		Earliest	Latest	
89.0	4	17	17	1–3
100.1	2	13	13	1–2
110.8	3	7	8	1–2
112.6	4	14	16	7–9
116.0	9	11	14	10–12
119.1	5	16	17	3–5
128.1	6	16	17	3–5
132.5	9	7	13	7–9
137.6	6	14	15	1–3
137.9	7	8	13	6–8
139.1	8	10	14	13–15
140.4	6	9	12	5–7
142.3	7	9	12	5–7
146.1	12	13	15	6–8

* Stage 7, blastula; Stage 8, early gastrula; Stage 9, late gastrula; Stage 10, appearance of embryonic body; Stage 11, optic vesicle; Stage 12, auditory vesicle; Stage 13, tail bud; Stage 14, pigmentation of retina; Stage 15, rudiment of pectoral fins; Stage 16, invagination of mouth; Stage 17, formation of jaw.

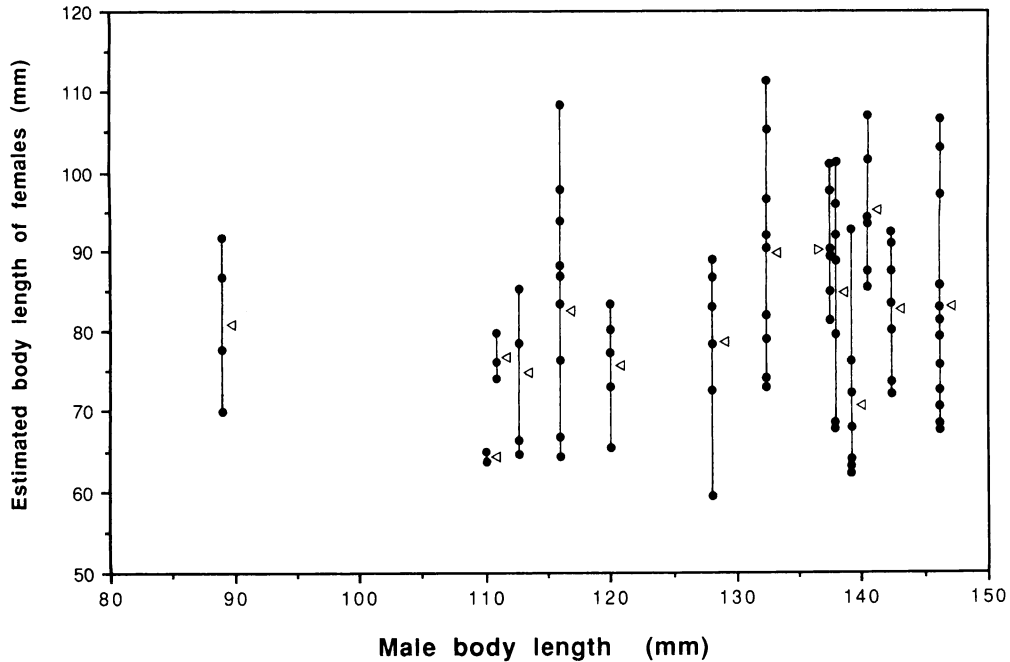


Fig. 2. Relationship between body length of nesting males and estimated body length of females mated; estimated body length of each female (●) and mean of estimated body lengths of all females which mated with each male (◁).

larger males having guarded a greater number of eggs ($r=0.472$, $n=14$, $p<0.05$) (Fig. 1).

The size of nesting males was not significantly correlated with the estimated size of all of the females which mated with them ($r=0.154$, $n=88$, $p>0.05$), nor with the estimated mean size of females which mated with each male ($r=0.472$, $n=14$, $p>0.05$) (Fig. 2). This suggests that there is no size-assortative mating in *Cottus hangiongensis*, unlike the congeneric sculpin, *C. gobio* (Bisazza and Marconato, 1988; Marconato and Bisazza, 1988). Assortative mating in *C. gobio* has been explained by the timing of male reproduction, large males breeding early in the season when large females lay their eggs (Marconato and Bisazza, 1988). Large *C. hangiongensis* males do not necessarily spawn early in the season (Goto, unpublished data), although large females tend to do so (Goto, 1987a). In this species, the males appear to mate randomly with any gravid females which visit their nests, while females prefer to mate with larger males, probably due to their greater ability to take care of developing eggs (Goto, 1987a).

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カンキョウカジカにおける雄の繁殖期間と配偶者選択

後藤 晃

一夫多妻で雄が卵保護をするカンキョウカジカにおいて、自然河川個体群での雄の繁殖期間（実効繁殖期間）、雄の体長とその繁殖成功（一繁殖期に得る受精卵の総数）、および雄に雌の体長に応じた番い選好性があるか否かについて調査した。その結果、生理的繁殖可能期間（1-2カ月間）に比べて、雄の実効繁殖期間は最長でも13-15日間で、多くの場合は1週間以内と短かった。雄は大型の個体ほど高い繁殖成功を得ていたが、それはその実効繁殖期間が長いからではなく、雌が大型雄を選好するためであると考えられた。一方、雄の体長とその雄が番った雌の体長との間には相関が認められなかった。この結果から、本種には体長に依存した同類交配はなく、雄は出会った雌とほぼ無選択に交配すると推察された。

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