ドンコの音響生態

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Acoustical Behavior of the Freshwater Goby *Odontobutis obscura*[*1]

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The calls of the fresh water goby *Odontobutis obscura* consisted of a train of about eight pulse sounds, with each lasting for about 9 msec and followed by a silent period of 30–40 msec. Each pulse sound was made of a frequency component of less than 1 kHz. They emitted vigorous calls during the reproductive season, May to July, while the calls were seldom heard in other seasons. No remarkable diurnal variation in the frequency of sound emitting was observed. The calls which are mainly used for threatening invaders, are made by the rubbing of the upper and lower pharyngeal teeth, and amplified by the swim-bladder. The power and the frequency range of a call are limited by the size of swim-bladder, namely the fish size.

The freshwater goby *Odontobutis obscura* is found in Korea, China, Taiwan, the Phillippines and the western part of Japan.[1] Although this fish had been one of the common species in most rivers of Kyushu, it has recently been descreasing due to the river enhancement and various agricultural medicines. There are some reports on the life history or behavior of this species,[2-8] but few reports on its acoustical behavior. The studies on the acoustical behavior of freshwater fishes are few compared with those of marine fishes. In spite of its specific name, *obscura,* which implies silence, this species vigrously emits calls.

As a link in a series of studies on the underwater sound of marine animals, the sound producing mechanism, acoustical behavior and emitted sounds of this fish are described in this paper.

Materials and Methods

This species is a nocturnal fish. During the daytime, they usually hide in a hole of the stone walls or under any shelters like rocks, and only sometimes go out from the shelter to threaten invaders or to search for food. The specimens for the present study were mainly collected from Lake Ezu in Kumamoto City, the Kumasaki River in Usuki City, the Tsuetate River in Hita City and the Nagayo River in Nagasaki Prefecture from April to August, 1981. A hook with bait was inserted into the shelters and the fish were caught one by one. The fish collected were carried to an experimental tank ($1 \times 1 \times 0.5$ m) in the laboratory. The specimens were quite robust and none of them died during the long trip of up to four days. Out of 60 fish collected, 25 were kept in the experimental tank to observe their behavior. For their shelters, 20 plastic tubes (20 cm in length and 6 cm in diameter) were placed in the tank. The movements were observed by means of the hydrophone (ST-6502, OKI) suspended in the center of the tank and a video-camera set in front of the tank. A recording was for more than 24 hours once every month made on the sounds emitted and the movements of the fish.

The remaining 35 specimens were divided into five groups by total lengths and used for the measurements of the power and frequency range of the emitted calls, and the volume of swim-bladder and for the study on the sound producing mechanism. Two or three specimens from a total length group were kept in a small cage net with one shelter set in the center of a large tank. Their sounds were recorded by using the hydrophone (#8103, B & K), amplifier (#2650, B & K) and measuring amplifier (#2607, B & K).

After anesthetizing, the gas of the swim-bladder was collected from each fish in the water to determine its volume.

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Results and Discussions

Calls of the Freshwater Goby

As shown in Fig. 1, a call of this species consisted of a train of about eight (varying from five to thirty-five) pluse sounds with each lasting for about 9 msec and followed by a silent period of 30–40 msec. The interval of each pulse sound had almost no relation with the number of pulse sounds that a call consisted of. Each pulse sound consisted of a frequency component of less than 1 kHz. Depending on the size of the fish, the power, the peak frequency and the frequency range were different.

As the volume of the swim-bladder increases proportionately with the fish size (Fig. 2), the call emitted also changes by the sizes of the specimens as mentioned below. In Fig. 3, the power and the frequency range of emitted calls are plotted against the sizes of fish. According to the growth, the power of the calls increased, but their frequency range decreased conversely. This tendency was remarkable in the specimens of more than 15 cm TL.

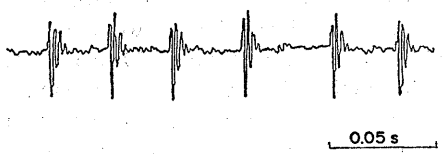

Fig. 1. A train of pulse sounds emitted by the freshwater goby.

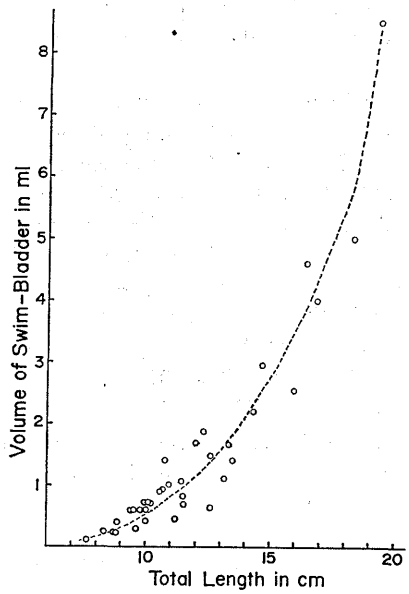

Fig. 2. Relationship between total length and volume of swimbladder.

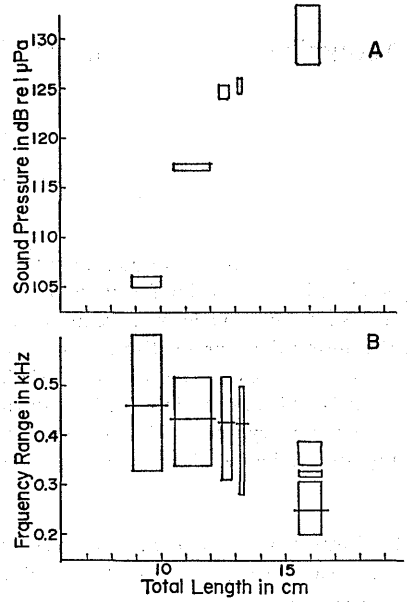

Fig. 3. Relationships between sound pressure (A) or frequency range (B) of emitted calls and total length, transverse line shows the peak frequency.

Depending on the dominance-subordinance hierarchy, larger fish emitted calls more frequently than the smaller ones. When the specimens of different sizes were kept together, the calls emitted by a small fish were hardly heard. The calls usually heard in natural condition were lower than the calls emitted in captivity by these specimens, less than 300 Hz.

Seasonal Variation of Calls

The spawing period of this species in a water pass in Yanagawa, Fukuoka Prefecture extends from April to May.[2] During this study, the fish laid eggs onto the upper part of the inner surface of some of the shelters in the experimental tank from the end of May to late June. Except for one batch, all the egg masses disappeared within a week, because the male parent had eaten them up due to any incentive for him.

As shown in Fig. 4, the spawning period coincided with the time when the calls were emitted most frequently and it is clear that these calls were related to the reproductive behavior. The frequency of these calls continued at the same level for about one month and then the amount of calls emitted rapidly decreased. After August, calls were rare. In this experiment, only three of the hatched larvae were observed to survive to juveniles, probably because they were neither

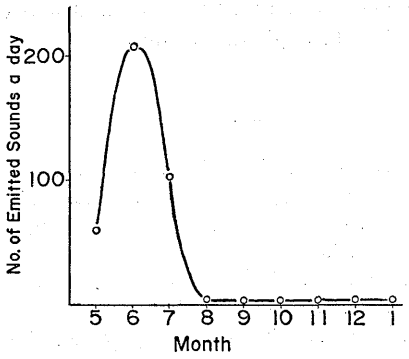

Fig. 4. Seasonal variation of call emitting.

fed nor separated from the adult fish. Then, it seems that at least one batch went through from spawning to hatching. It was considered that the call emitting lasted until the hatching of the eggs, because Dotsu mentioned that it takes one month from spawning to hatching.[2]

As mentioned above, the frequency of call emitting became low after the reproductive period, but the frequency was high when they were kept in a crowed condition. A high frequency of call emitting was observed with two adult specimens kept in a small cage net ($15 \times 20 \times 30$ cm) in October and November.

Diurnal Variation of Calls

In the reproductive period, the frequency of call emitting rose during the day and no remarkable diurnal variation was noticed. Save for the reproductive period, the call emitting had an imperceptible tendency to raise its frequency around sunrise or sunset as shown in Fig. 5. However, no remarkable diurnal variations were observed in this period, too. The frequency of call emitting in the reproductive period is more than 100 times that of in the nonreproductive period.

Behavior and Sound Producing

As far as the nonreproductive season is concerned, they seldom emitted calls except when the shelter (territory) was invaded by other fish. In the reproductive period, however, they became quite nervous and often emitted the sound even against an out-of-sight or distant fish, not to mention against nearby invader. Then, the frequency of call emitting was most frequent during the reproductive season. When these calls were emitted, the escape movements of the invaders were observed in many cases. But, when

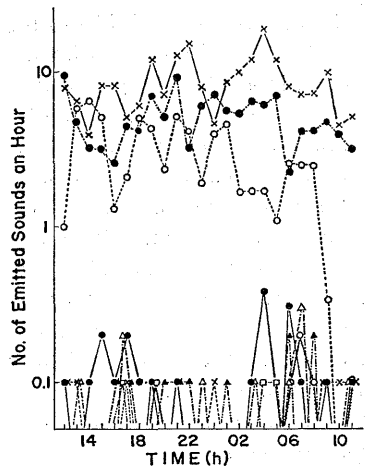

Fig. 5. Diurnal variation of call emitting.

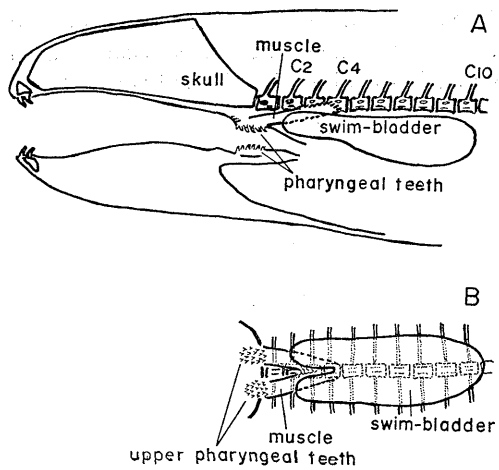

Fig. 6. Sound producing mechanism. A; lateral view, B; ventral view.

the individuals were apart from each other, the escape movements were not observed in almost all cases. The threat was usually executed with the call alone, but, sometimes accompanied by a mouth opening or by biting the invader.

Sound Producing Mechanism

The membrane of the swim-bladder of the fish is very thin and muscle connected directly with the swim-bladder was not observed, unlike e.g. a scorpaenid fish *Sebastiscus marmoratus*.[9] As shown in Fig. 6, the swim-bladder is Y shaped, occupying the dorsal part of the body cavity from below the 10th vertebra forward, and forks into two branches at the fourth vertebra to reach to the anterior end of the cavity. A pair of muscles

extending from each of the upper pharyngeal teeth connects with the ventri-lateral sides of the second to fourth vertebrae and covered with the forked branches of swim-bladder. By touching a part of the pharynx while calls were emitted, some weak vibration was recognized. The same call was heard by means of an electric stimulation to the muscle. When the swim-bladder was destroyed, the call became very weak. From the above-mentioned, it is clear that the call of this species is produced by rubbing of the upper and lower pharyngeal teeth, amplified by the swim-bladder, and then emitted. The velocity of the rubbing movement of pharyngeal teeth seems to be constant, because the interval between each pulse sound is almost constant.

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