Nest site selection by males of the tide pool goby, *Bathygobius fuscus* (Gobiidae)

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**SUMMARY:** Males of the goby occupy the nests with a small entrance and brood periodically in semi-lunar cycles. We investigated the preference of males to the shape of nests using the brooding periodicity and experimental nests with various sizes of body and various sizes of entrance. Brooding in semi-lunar cycle and sharper hatching peaks indicate that the timing of releasing of larvae must be precise for their reproduction. Males appear to select the nests by means of not nest size, but entrance size, even though large nests have a larger capacity of eggs than small ones. The analyses using the selection order index, SOI, showed the same results. Our observations show that one of the reasons why they need the nest with small entrance should be intrusion of sneakers.

**KEY WORDS:** goby, reproduction, semi-lunar cycle, nest site selection, sneaker

**INTRODUCTION**

Most gobies lay eggs on the inner surface of closed spaces, so-called 'nests'. A male parent takes care of his eggs in a nest alone. The nest protects not only eggs but also the parent against predators while he takes care of his eggs. For example, a Mediterranean blenny male selects a nest with an entrance size similar to his head width.

The goby *Bathygobius fuscus* is a small bottom-dwelling goby in southern Japan. It is found in rocky shallow areas in bays or tide pools facing the open sea. In the spawning season of the goby, males defend nests, such as holes or crevices in rocks. This goby is a periodic brooding species.

Making use of artificial nests and brooding periodicity, we studied nest site selection by males of the goby, *B. fuscus*.

**MATERIALS AND METHODS**

We studied the goby on the rocky shore near the Marine Science Station of Miyazaki University. The station is located on the east coast of Kyushu Island (30°15', N, 131°41', E). There were three different levels of tide pools in our study area. Since the density of the gobies was highest in the highest pools within the intertidal zone, our field experiments were mainly carried out in the highest pools.

There were natural spawning sites in the tide pools, but it was difficult to observe breeding. In order to make observations easier, we used the experimental nests made from vinyl chloride tube and cement (Fig.1). Removable transparent films covered the inner surface of nests. Eggs were laid on these films.

We monitored the occupant of each nest from 26

![Fig. 1 A nest used in the field experiment.](image-url)

**Table 1** Sizes of nests used in field experiments.

<table>
<thead>
<tr>
<th>Diameter of nests (mm)</th>
<th>Diameter of entrance (mm)</th>
<th>Length (mm)</th>
<th>No. of nest sizes</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>56</td>
<td>20</td>
<td>120</td>
<td>1</td>
<td>1997</td>
</tr>
<tr>
<td>31, 44, 56, 71, 83</td>
<td>10, 15, 20, 25, 30</td>
<td>120</td>
<td>25</td>
<td>1999</td>
</tr>
<tr>
<td>44</td>
<td>10, 12, 14, 16, 18</td>
<td>120</td>
<td>5</td>
<td>2000</td>
</tr>
</tbody>
</table>
June to 11 September in 1997. In 1999 and 2000, we checked each nest every 2 or 3 days throughout the breeding season, if the weather permitted.

If there was an occupant goby in a nest, we checked the color paint marks of each fish to identify them individually, measured body length (standard length) and confirmed the presence of eggs in the nest. Eggs attached to the transparent films were traced onto waterproof paper. When we found a new male without the marks, we injected color paint subcutaneously. 4)

In 1997, the location of each nest was fixed throughout the breeding season. In 1999 and 2000, the location of each nest was changed at random during days when most of the nests were vacant. In rare cases, where there were eggs not released yet, we replaced the transparent plastic film with a new one. The sizes of nests used are shown in Table 1. We define the diameter of nests as "nest size", and the diameter of the nest entrance as "entrance size".

We also investigated the occurrence of sneaking with a video camera in 2000. Nests with different entrance sizes were observed for 45 to 90 min.

RESULTS AND DISCUSSIONS

This goby is a periodic brooding species and the cycle is semi-lunar. The goby kept the cycle strictly, but was disturbed by stormy weather such as typhoons.

Five utilization peaks were clearly recognizable in 1997 (Fig. 2). Most experimental nests were used during each brooding cycle. Eggs hatched 4 to 6 days after spawning. Hatching peaks were sharper than spawning peaks (Fig. 3). It seems that the timing of releasing of larvae is more precise than that of spawning. We observed that the releasing larvae took place at dusk when seawater flooded the tide pool. After hatching, males left their nests and most nests were vacant during the several days prior to the onset of the next spawning event. Each brooding cycle was, thus, clearly divided by a non-active period. It was not clear whether a male occupied the same nest in successive brooding cycles.

We found that 124 males, ranging from 45 to 80 mm in body length, occupied the nests in 1999. Nests of less than 56 mm were generally selected by more males while it was found that males preferred nests with smaller size of the entrance (Fig. 4).

The relationship between entrance size and body length of males occupying the nest is shown in Fig. 5. Five males found in the nests with 10 mm entrance were undoubtedly smaller than those in the other nests. The mean body lengths of 31 males found in
Fig. 5 Relationship between entrance size and body length (standard length) of male occupying the nest. The entrance size 10 and 15 mm restricted the usage by bigger sizes of gobies. All the gobies were able to use the nests with more than 20 mm entrance size.

nests with 15 mm entrance size were significantly smaller than those with larger entrance sizes (p<0.01, t-test).

We focused on the relationship between the entrance size and the head width of the occupant. The line in Fig. 6 shows the regression between body length and head width of males. The squares show body length of males occupying nests with 10 and 15 mm entrances. The squares below the line indicate that males occupy the nest with smaller entrances than their head width. They had to squeeze their gill openings when they went in and out through the entrance.

Most males were unable to use the nests with 10 mm entrances, and males over 73 mm in body length were unable to use the nests with 15 mm entrances. The largest male was 80 mm with an estimated head width of 18.9 mm. All males can use nests with more than 20 mm entrance size.

Except for the nest with a 10 mm entrance, the results of an analysis of variance suggest that the size of the entrance affects male selection of the nest (p<0.05, ANOVAR).

The selection order index, SOI, was calculated by the order of occupation in each brooding cycle. Each nest size or entrance size was provided with a SOI. For example, the first nest occupied by a male in a brooding cycle was allocated 1 point, and the nest occupied fifth was allocated 5 points, and so on. If there were more than two nests occupied on the same day, those were provided the mean point. The smaller SOI value expresses that the nest was occupied earlier in brooding cycles.

Although there was no relationship between SOI and nest size, the entrance size significantly affected SOI (Fig. 8). The results indicated that the nests with 20 and 25 mm in entrance size were occupied by males earlier than those with smaller or larger entrances (p<0.05, ANOVAR).

There was a significant relationship between male size and the number of eggs estimated (p<0.01, t-test). There was a tendency for males in larger nests to have

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Fig. 8 Comparison of selection order index in each size of nest (left) and in each size of entrance (right). Selection order index (SOI) shows the sum of the order of selection by males in each brooding cycle. The smaller index means that nests are occupied earlier in each brooding cycle.

Fig. 9 Body length and the gonadosomatic index (GSI) of males in the major reproductive season (June and July).

GSI=100×GW/BW

Fig. 10 Entrance size, frequency of sneaking and occupant size. Circles show frequency of sneaking, squares occupant size by body length.

more eggs than those in smaller nests, though values varied widely.

Males appear to select their nests by means of the entrance size, even though large nests have a larger capacity of eggs than small nests.

When a pair was spawning in a nest, we usually found several males around the entrance of the nest. Once they had a chance, they rushed into the nest. Gonadosomatic indices, GSI, of small males were higher than those of large males (Fig. 9), it is probable that they are sneakers.

Our results show that although large males were able to prohibit sneakers from intruding into the nest regardless of entrance size (Fig. 10), occupant males ranging from 45 to 65 mm in body length were frequently intruded on by sneakers. That seems to be one of the reasons why they need the nest with small entrance.

The major functions of the nest are to provide eggs and their parent male protection against predators. When the tide pool is isolated from the sea, there are not so many predators in the highest pools, except for several kinds of herons.

Large males, over 65 mm in body length, selected nests with 20 or 25 mm entrance size earlier in the reproductive season than smaller males. Males less than 65 mm selected nests with smaller entrances than their head width probably because of defense against sneakers.

REFERENCES