Characteristics of Spawning Sites in the Natural Environment of the Korean Endemic Species, *Liobagrus somjinensis* (Siluriformes: Amblycipitidae) in the Yocheon (stream), Seomjingang (river), Korea

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**ABSTRACT**  The characteristics of 11 spawning sites in the natural environment of the Korean endemic species, *Liobagrus somjinensis* were investigated in the Yocheon (stream) of Seomjingang (river), located in Sikjeong-dong, Namwon-si, Jeollabuk-do, Korea from May to June 2015. The spawning sites had largely two parts, the upper region close to the surface of the waters and under region at bottom: the upper part was covered with a large and flat boulder over about 256 mm in size, whereas the under part consisted mainly of pebbles and sand. The large boulder put on the upper region may be seen as a bulwark for guarding eggs laid at the under (bottom) region. All the sites under the boulder showed a similar structure having a small hollow filled with an egg mass and an individual (male). The spawning bottoms left clean having no any benthic invertebrates and detritus. The egg shape was spherical, yellow and covered with a transparent membrane and the egg size was $3.31 \pm 0.15$ mm ($n=30$) in diameter. The development stage of each egg mass under the boulder was almost same from morula stage to formation stage of eye lens. The average number of eggs in 11 spawning sites was $121 \pm 35.5$ ($84 \sim 176$) and the average number of female fecundity in ovary was $143 \pm 31.3$ ($110 \sim 232$).

*Key words:* *Liobagrus somjinensis*, spawning site, Yocheon

**INTRODUCTION**

Fishes of the family Amblycipitidae are distributed in Southern and Eastern Asia, ranging from Pakistan across Northern India to Malaysis, Korea, and Southern Japan and can be mainly found in swift freshwater river and streams (Chen and Lundberg, 1995; Ng and Kottelat, 2000; Kim and Park, 2002; Nelson, 2006; Wright and Ng, 2008). The family includes four genera and appears to have distinct distribution ranges having many endemic species in the world (Wright and Ng, 2008).

Only one genus, *Liobagrus* Hilgendorf, 1878, and five species, *L. andersoni* Regan, 1908, *L. mediadiposalis* Mori, 1936, *L. obesus* Son, Kim and Choo, 1987, *L. somjinensis* Park and Kim, 2010, and *L. hyeongsanensis* Kim, Kim and Park, 2015, are known to distribute in the Korea peninsula (Kim, 1997; Kim et al., 2015). These species exhibit a specific reproductive ecology, called parental care that is any form of parental behavior following fertilization. This strategy helps increase offspring fitness and has two main functions: to protect offspring and to promote their development (Smith and Wootton, 1995).

*L. somjinensis* is distributed mainly in the middle to upper stream of Seomjingang, Yeongsangang, Dongjingga, Tamjingang (river), and Geogeum Island (Park and Kim, 2010). This species usually inhabits the gravel and cobble bottoms with riffle of high flow velocity. Recently it has resulted in a rapid decline of its natural habits because of man-made causes such as stream improvement,
characteristics of Spawning Sites of Liobagrus somjinensis. Amid accelerated destruction of habits, however, few studies have focused on the ecology even in amblycipitidae species, with biological studies that mostly limited to works on alpha taxonomy studies (Uchida, 1939; Son and Choo, 1988; Kim, 2007). Therefore, the aim of the present study is to understand characteristics of the spawning sites of L. somjinensis as part of protection and preservation of this species.

MATERIALS AND METHODS

Study area. Our study area were investigated at the Yocheon (stream) of the Seomjingang (river), located in Sikjeong-dong, Namwon-si, Jeollabuk-do, Korea (35°26’ 50.76”N, 127°25’59.68”E; Fig. 1). The stream surrounded by fields for rice was about 200 m in length and 30 to 50 m in width, consisting of riffle, run and pool.

Characteristics of spawning sites. The investigation was conducted in May and June 2015, known as spawning season (Kim, 2007; Choi, 2008; Park and Kim, 2010). Analysis of the spawning sites was collected from 15 transect lines, which a transect line is positioned across the stream. To avoid disturbance such as impeding fish distribution caused by researchers that may affect fish distribution, the distance of the next point to observe was at interval of 3 m. We searched for the eggs of L. somjinensis during daylight hours by snorkeling slowly to the upstream. When the eggs and L. somjinensis were observed, we collected and preserved in 10% formalin solution both. Sex of the captured fish was confirmed by direct observation of the gonads and the mass eggs are counted at the laboratory. Additionally, the number of the female fecundity was investigated from 13 females collected in March to June, 2006, deposited at Chonbuk National University, Jeonju, Korea.

Data on characteristics of spawning sites. The data was recorded at each point observed: water depth (m), average water velocity (60% of depth, m/s), bottom water velocity (2 cm above substrate, m/s) and percent substrate composition. Water depth was measured to the nearest 1 cm with a meter stick. Water velocity was measured to the nearest 0.01 m/s with a flow meter (Swoffer model 2100, USA). To measure substrate composition, we centered a grid of twenty-five 50×50-cm cells on each point and it was analyzed. The substrate was divided into five size classes by Cummins (1962): sand (<2 mm); gravel (2~16 mm); pebble (16~64 mm); cobble (64~256 mm); and boulder (>256 mm). The upper region having a flat boulder of the spawning site, close to the surface of the waters was measured to the nearest 1 cm in long and short axis.

![Fig. 1. A map showing the study area of spawning sites of Liobagrus somjinensis in the Yocheon (stream) of Seomjingang (river), Jeollabuk-do, Korea. A black arrow indicates water flow from upstream to downstream.](image-url)
RESULTS AND DISCUSSION

1. Characteristics of the spawning sites

During the survey, a total of 11 spawning sites that eggs are laid with *L. somjinensis* were found (Table 1). Air and water temperature were 23~25°C and 18~20°C, respectively. The 11 spawning sites had largely two parts based on a kind of substrate, the upper region close to the surface of the waters and under region at bottom: the upper part is covered with a large and flat boulder over about 256 mm in size, whereas the under part consists mainly of pebbles and sand. There was a small hollow which consisted of an egg mass and one individual on each site. The bottoms of the spawning sites remained clean without having any benthic invertebrates and detritus (Fig. 2). This structure was similar to its congener such as *L. obesus* (Kim et al., 2012), *L. andersoni* and *L. mediadiposalis* (Uchida, 1939) and *L. reini* (Watanabe, 1994). It is possible that the large boulder put on the upper region and cleaning bottom may reduce predation and the problems of oxygen supply and siltation (Wootton, 1998).

The sex of four individuals of *L. somjinensis* captured among the 11 sites was identified as males by direct observation of the gonads (86.2~95.4 mm TL). The results of the present study correspond well with those found of Kim et al. (2012) and Watanabe (1994) that the parental individuals of *L. obesus* and *L. reini* observed in spawning sites with eggs were males. Meanwhile, Choi (2008) reported such spawning behavior in the Seomjingang (river) population of *L. mediadiposalis* by hormone-induced experiment in the aquarium. He stated that the female and male together guard their eggs after the female build a spawning nest and release her eggs. Also Uchida (1939) reported that at spawning sites of *L. andersoni* and *L. mediadiposalis*, under the boulder, a female parent was observed with an egg mass. These two results were very different from our present study that the eggs in the spawning sites are protected by males. Unfortunately, present study should be needed more research in the future because the sample size was small.

The eggs in the spawning sites were spherical, yellow and covered with a transparent membrane. The egg size (mean ± SD, 3.31 ± 0.15 mm, n = 30) and the number of spawned eggs (121 ± 35.5, n = 11) of *L. somjinensis* were

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**Table 1.** The characteristics of spawning sites of *Liobagrus somjinensis* in the Yocheon (stream) of Seomjingang (river), Jeollabuk-do, Korea from May to June 2015. Water velocity was measured at 0.6 of the water depth (average) and 2 cm above the substrate (50-cm cells).

<table>
<thead>
<tr>
<th>No. Data</th>
<th>Water depth (cm)</th>
<th>Water velocity (m/s)</th>
<th>Substrate structure</th>
<th>Boulder structure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average Bottom</td>
<td>Average Short</td>
<td>Boulder girth (cm)</td>
<td>Boulder height (cm)</td>
</tr>
<tr>
<td>1</td>
<td>May 28</td>
<td>48 ± 0.02</td>
<td>0.01 ± 0.00</td>
<td>41 ± 0.01</td>
</tr>
<tr>
<td>2</td>
<td>May 28</td>
<td>45 ± 0.04</td>
<td>0.01 ± 0.00</td>
<td>31 ± 0.01</td>
</tr>
<tr>
<td>3</td>
<td>June 3</td>
<td>47 ± 0.04</td>
<td>0.02 ± 0.00</td>
<td>21 ± 0.01</td>
</tr>
<tr>
<td>4</td>
<td>June 4</td>
<td>40 ± 0.03</td>
<td>0.01 ± 0.00</td>
<td>31 ± 0.01</td>
</tr>
<tr>
<td>5</td>
<td>June 4</td>
<td>45 ± 0.03</td>
<td>0.01 ± 0.00</td>
<td>31 ± 0.01</td>
</tr>
<tr>
<td>6</td>
<td>June 4</td>
<td>43 ± 0.03</td>
<td>0.01 ± 0.00</td>
<td>31 ± 0.01</td>
</tr>
<tr>
<td>7</td>
<td>June 4</td>
<td>43 ± 0.03</td>
<td>0.01 ± 0.00</td>
<td>31 ± 0.01</td>
</tr>
<tr>
<td>8</td>
<td>June 4</td>
<td>46 ± 0.03</td>
<td>0.01 ± 0.00</td>
<td>31 ± 0.01</td>
</tr>
<tr>
<td>9</td>
<td>June 4</td>
<td>50 ± 0.03</td>
<td>0.01 ± 0.00</td>
<td>31 ± 0.01</td>
</tr>
<tr>
<td>10</td>
<td>June 6</td>
<td>48 ± 0.03</td>
<td>0.01 ± 0.00</td>
<td>31 ± 0.01</td>
</tr>
<tr>
<td>11</td>
<td>June 6</td>
<td>48 ± 0.03</td>
<td>0.01 ± 0.00</td>
<td>31 ± 0.01</td>
</tr>
</tbody>
</table>

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Characteristics of Spawning Sites of *Liobagrus somjinensis*

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similar to *L. obesus* (3.40 ± 0.08 mm, 99 ± 12.9), *L. ander­soni* (3.0 mm, 100 ~ 120) and *L. mediadiposalis* (3.27 mm, 132) in the Seomjingang (river) (Uchida, 1939; Choi, 2008; Kim et al., 2012). Generally the *Liobagrus* fishes have bigger eggs and the less number of eggs than other freshwater fishes. Presumably low fecundity has evolved due to the tradeoff with larger egg size (Smith and Fret­well, 1974). The average number of eggs released from 11 spawning sites was 121 ± 35.5 (84 ~ 176). The average number of female fecundity in a mature ovary was 143 ± 31.3 (110 ~ 232, n = 13). The results may suggest that this species seems to be a single spawner: the number of female fecundity is very similar to that of spawned eggs and the development stage was almost same.

2. Data on characteristics of spawning sites

The spawning sites of *L. somjinensis* were 46.1 ± 2.91 (40 ~ 50) cm in water depth, 0.04 ± 0.02 (0.02 ~ 0.09) m/sec in average water velocity, 0.01 ± 0.01 (0 ~ 0.02) m/sec. The boulder width was 35.2 ± 5.27 (29 ~ 44) cm in long axis, 27.9 ± 5.75 (17 ~ 39) cm in short axis and 8.8 ± 1.25 (8 ~ 12) cm in height. The boulder girth was 76.3 ± 11.00 (63 ~ 95) cm in long axis and 66.9 ± 12.08 (49 ~ 91) cm in short axis. The hollow size under the boulder was 9.8 ± 1.78 (8 ~ 14) cm in long axis, 7.6 ± 1.36 (6 ~ 10) cm in short axis and 1.4 ± 0.50 (1 ~ 2) cm in depth. Substrate composition of spawning sites is as follows: % sand (22.9 ± 16.21), % gravel (7.3 ± 6.65), % pebble (26.5 ± 12.43), % cobble (6.2 ± 6.78) and % boulder (37.1 ± 8.41).

Although there was no report of *Liobagrus* fishes about moving to another sites for spawning, the present investi­gation revealed that for the spawning, *L. somjinensis* use a wide range of area, slower water velocity than its main habit (Table 1). Unfortunately, this study has a limitation stemming from its small sample size and so we need to expand the site in the future. The hollow size under the boulder was enough to keep their eggs, larvae and parents.
of *L. somjinensis*. This result has the similarity to the report of *L. obesus* (Kim *et al.*, 2012).

In case that the boulder was lifted up from the spawning sites, both a parent and larvae disappeared on the following day. It hints that this species is very sensitive to environmental impacts. Based on this result, the spawning site is very important as incubation. Consequently, for this species, an active protection and preservation should be needed. During the spawning season from April to June, in particular, the spawning area in the wild must be protected in terms of pre-spawning, spawning period, keeping period of eggs and larvae as part of conservation strategies for this species.

**REFERENCES**


섬진강 수계 요천에 서식하는 한국고유종 섬진자가사리
*Liobagrus somjinensis* (Siluriformes: Amblycipitidae)의 자연산란장 특징

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요 약 : 2015년 5~6월에 전라북도 남원시 식정동 섬진강 수계 요천에서 한국고유종 섬진자가사리 *Liobagrus somjinensis*의 자연산란장 11개 지점에 대한 특징을 조사하였다. 자연산란장은 하상기질에 따라 256 mm 이상의 큰 돌(boulder)이 놓여진 상부와 자갈(pebble)과 모래(sand)로 이루어진 하부로 구분되었다. 큰돌 아래의 자연산란장은 작은 구멍 안에 난과(egg mass)를 형성한 알 덩어리와 섬진자가사리 1개체(수컷)가 위치하였고 어떠한 저서성 무척추동물이나 유기물이 없는 깨끗한 상태였다. 알은 구형의 노란색으로 투명한 막으로 둘러싸여 있었고 알 크기 3.31±0.15 mm (n=30)로 나타났다. 큰돌 아래 자연산란장에서 확인된 각 알 덩어리는 유사한 발생단계였고 각 각은 상실기에서 안구 형성기까지 나타났다. 11개의 자연산란장에서 확인된 알수는 평균 121±35.5 (84~176)개였고 암컷의 난소에서 확인된 포란수는 143±31.3 (110~232)개였다.

 찾아보기 낱말: *Liobagrus somjinensis*, spawning site, Yocheon, 섬진자가사리, 자연산란장, 요천