

Functional Anatomy of the Olfactory Organ in the Torrent Catfish, *Liobagrus somjinensis* (Siluriformes, Amblycipitidae)

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ABSTRACT The anatomical study of the olfactory organ in *Liobagrus somjinensis*, being related to the habitat environment and ecological habit, was carried out using a stereomicroscopy and digital camera. The paired olfactory organs are situated at the dorsal part of the snout, and consisted of two opening (anterior and posterior nostrils) and the olfactory chamber. The tubular anterior nostril is located between the tip of upper lip and the nasal barbel. The posterior nostril flat to the surface is adjacent entirely to the basement of the nasal barbel. The olfactory chamber has a rosette structure with 22~24 lamellae of linguiform, arranged transversely and radially from the medium raphe. These results may prove that *L. somjinensis* is dependent on olfaction, related to the hiding, the feeding and the nocturnal lifestyle in rapids.

Key words: *Liobagrus somjinensis*, olfactory organ, anatomy, tubular nostril, lamellae

INTRODUCTION

Various chemical mixtures such as amino acids, sex hormones and vital signal stimulants, are dissolved together in the aquatic environment (Yambe *et al.*, 2006). To perceive and sense such components important for survival, teleost fish generally has paired olfactory organs as a major sensory system with the receptor neuron at the snout (Hara, 1986). This organ is affected consistently by a water condition with diverse chemicals and physical factors in a surrounding environment, and is optimized for its smooth olfactory role (Yamamoto, 1982). In particular, bottom-dwelling fishes, which are inactive and hide, are known to get a unique olfactory structure and nasal sac (Kapoor and Ojha, 1972; Kasumyan, 2004; Zielinski and Hara, 2006).

The genus *Liobagrus*, which has currently five species in South Korea, prefers the rapids of fast flowing current with the bottoms of gravel, stones and sand (Kim *et al.*, 2015). Among them, the torrent catfish *L. somjinensis*, as restricted in Somjin, Yeongsan, Dongin, and Tamjin

Rivers, is the Korean endemic species belonging to the family Amblycipitidae (Park and Kim, 2010). Therefore, the olfactory system for this catfish is predicted to own a distinct structure adapted to the turbulent environment, where water is rushing through the gravel or stones and flows so fast. In the catfishes with well-developed olfaction, the olfactory structure and morphology has been researched by some previous workers (Yamamoto, 1982; Theisen *et al.*, 1991). Also, the olfactory characters can be a significant proof to account for a correlation between morphology and ecology (Waryani *et al.*, 2013; Kim *et al.*, 2014). However, a research on the olfactory organ of the Korean endemic species, including *L. somjinensis*, has not yet been investigated. Therefore, the present study of *L. somjinensis* is aimed to describe the structure and analyze a relationship to its habitat environment.

MATERIALS AND METHODS

Adult males and females (total 20 specimens) of *Liobagrus somjinensis* (72.5 to 94.4 mm standard length) (Fig. 1A) were caught between May and Jun 2017 in the rapids of Sikjeong-dong, Namwan-si, Jeollabuk-do, South

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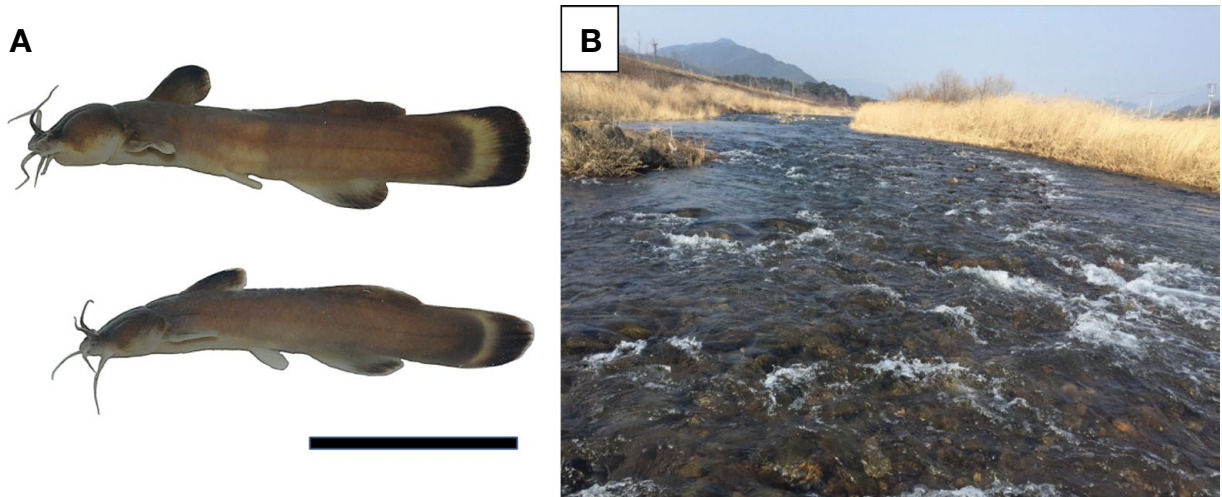


Fig. 1. The photograph (A) (above, male; below, female) and habitat (B) of *Liobagrus somjinensis* in Sikjeong-dong, Namwan-si, Jeollabuk-do, South Korea. The bar indicates 5 cm.

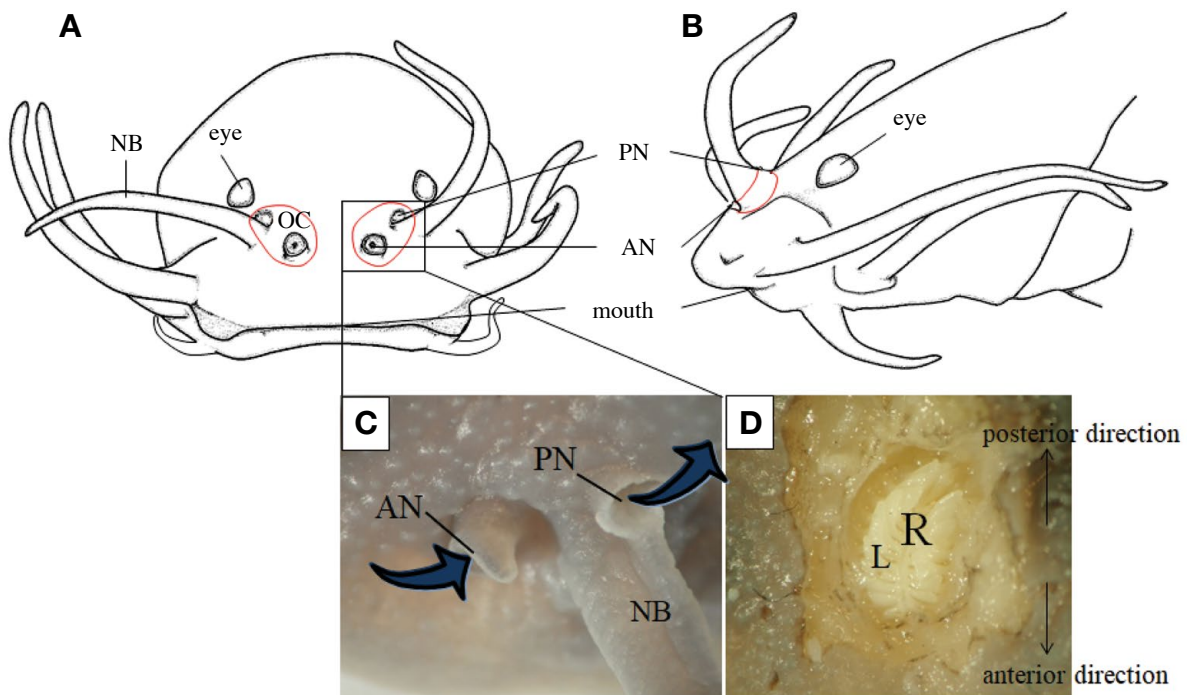


Fig. 2. Schematic diagrams (front, A; side, B) of the head and photographs (external structure, C; internal structure, D) of the olfactory organ in *Liobagrus somjinensis*. The red line indicates the outline of the olfactory chamber. Bent arrows in the above photograph mean the flow of the water through the olfactory chamber. AN, anterior nostril; L, lamellae; NB, nasal barbel; OC, olfactory chamber; PN, posterior nostril; R, rosette structure.

Korea, 35°26'55"N, 126°26'01"E (Fig. 1B) and Byeong-am-ri, Gwanchon-myeon, Imsil-gun, Jeollabuk-do, South Korea, 35°39'40"N, 127°16'28"E. 20 specimens collected by a kick net were immediately fixed in neutral buffered 10 % formalin solution. To check a detailed internal structure, the olfactory organ were anatomized using a

blade (Feather Safety Razor Co., LTD, Japan) under a stereo microscopy (SM; Stemi DV4; Carl Zeiss, Germany), and photographed with a digital camera (TG-3, Olympus, Japan). Morphometric characteristics of the olfactory organ were measured using a 0.1 mm digital caliper. The use of terms followed Hara (1975) and Yamamoto (1982).

RESULTS AND DISCUSSION

The paired olfactory organ of Korean torrent catfish *Liobagrus somjinensis* is situated at the dorsal snout, and consists of two openings (anterior and posterior nostrils) and an olfactory chamber (Fig. 2). The tube-like anterior nostril (0.63 to 1.12 mm major axis diameter) is located between the tip of the upper lip and the nasal barbel, whereas the posterior nostril (0.41 to 0.83 mm major axis diameter) is just at the basement of the nasal barbel. The anterior nostril is similar to the eye size, and also projected from the skin (Fig. 2A, C). The olfactory chamber contains a rosette structure, which is built of lamellae arranged transversely and radially on the basis of middle-elongated raphe. Each well-developed lamella (linguiform) is curved proximally and the posterior lamella is larger in size than the anterior one (Fig. 2B, D).

As a result of anatomy, the tubular anterior nostril and the rosette structure are general characters, known in many of freshwater catfishes with occasionally nasal sac (Ojha and Kapoor, 1972; Goel, 1978; Jakubowski and Kunysz, 1978). For *L. somjinensis*, however, the absence of the nasal sac and a lamella number are different from other catfishes.

The striped eel catfish *Plotosus lineatus*, however, has accessory nasal sac as expanded from olfactory chamber to ventilate inflowing and outflowing water (Theisen *et al.*, 1991). Unlike the freshwater bottom-dweller *L. somjinensis*, *P. lineatus* is a coastal benthic fish, which live in coral reef, sometimes estuaries, tide pools and open coast with probably slow-flowing water (Carpenter *et al.*, 1997). So, the presence of nasal sac may be related to the water flow (flowing current) in where fishes live, based on the study that enables the fish to change a total volume of the olfactory chamber by its contraction and relaxation (Døving *et al.*, 1986).

In the number of lamellae, *L. somjinensis* has a range of 22~24 units (Table 1) unlike other catfishes: the wels

catfish *Silurus glanis* (about 150 units) living in large, warm lakes and deep, slow-flowing rivers; the amur catfish *Parasilurus asotus* (mean 68 units) in slow-flowing river or pond; and *P. lineatus* (mean 5 units) in a shallow coastal area (Yamamoto, 1982). They all are nocturnal species to hide beneath a rock, stone, ledge or any organic substances during the day. However, although almost all of catfishes have similar dwelling styles of hiding, their microhabitat may differ physically and chemically in the following conditions by species: 1) the type and amount of suspended particles, 2) the flow velocity and depth of water, 3) the levels of transmitted light 4) salinity (Helfman *et al.*, 2009). The number of the lamellar is generally much more in catfish, unlike other benthic fishes (Yamamoto, 1982). Having more lamellae can be mean fishes that inhabit turbid and dark conditions (Branson, 1979; Waryani *et al.*, 2013). Until now, in the catfishes, the exact cause on the difference of the number of the lamella is still unclear whether it reflects their microhabitats. Nevertheless, the number is exactly different by species, which may play an important role for classifying catfishes. Based on the result, the well-developed lamellae of *L. somjinensis* may prove dependent on the olfactory organ evolved for an adaptation of the nocturnal fishes' habitat.

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Table 1. Measurement of the olfactory organ in *Liobagrus somjinensis*

	Standard length (mm, SL)	Diameter of the anterior nostril (mm)	No. of lamellae
Male	90.1 ± 7.2 (78.7~101.1)	0.8 ± 0.1 (0.6~0.9)	23 (22~23)
Female	78.4 ± 5.5 (72.5~88.9)	0.8 ± 0.2 (0.6~1.1)	23 (22~24)
% to SL			
Male		0.9 ± 0.1 (0.8~1.0)	
Female		1.0 ± 0.2 (0.8~1.3)	

Mean ± SD (Min~Max)

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섬진자가사리 *Liobagrus somjinensis* (Siluriformes, Adrianichthyidae) 후각기관의 기능 해부학적 구조

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요 약 : 섬진자가사리 *Liobagrus somjinensis* 후각기관과 서식처 환경 및 생태적 습성의 연관성을 규명하기 위해 실체현미경과 디지털카메라를 이용하여 해부학적 특징을 묘사하였다. 후각기관은 주둥이 위에 좌우 한 쌍으로 존재하였으며, 전비공, 후비공, 비강으로 크게 구성되어 있었다. 전비공은 튜브형의 형태로 코수염과 윗입술 끝 사이에 위치하였다. 후비공은 표면과 평평한 유출공으로써 코수염의 기부 바로 아래에 위치해 있었다. 비강은 가로와 방사형으로 배열된 혀 모양의 22~24개의 판으로 구성된 로제트 구조를 보유하고 있었다. 결과적으로 섬진자가사리의 후각기관의 기능 해부학적 구조는 여울에서의 은신, 섭식, 야행성의 생활패턴에 연관된 높은 후각의존도를 반영하는 것으로 생각된다.

찾아보기 낱말 : *Liobagrus somjinensis*, 후각기관, 로제트 구조, 서식처, 생태적 습성