Otolith Microstructure and Ecology of the Conger Eel (*Conger myriaster*) Larvae Collected in the Seto Inland Sea, Japan

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Otolith microstructure of the conger eel (*Conger myriaster*) larvae was observed using the scanning electron microscope with reference to the ecology in the Seto Inland Sea, Japan. The radii and the number of rings of the otoliths from the developing stage larvae were 104-145 µm and 123-172, respectively, while those from the metamorphic stage larvae were 140-496 µm and 159-212, respectively. The number of rings correlated highly with the radius of otoliths (r=0.905). The growth of radius and increase of number of rings were recognized for the first time in the otolith of the conger eel larvae in relation to growth of the head during the metamorphic stage. It was assumed that narrow and clear rings in the range from the first to about the 140th-150th ring correspond to the period from hatching to developing stage of leptocephalus, while wide rings in the range from about the 150th ring to the otolith margin corresponded to the period from the latest developing stage to the metamorphic stage. The daily growth rhythm in the otolith could not be proved from reared larvae due to the disturbance of ring arrangement in the marginal region.

The leptocephalus larvae of *Conger myriaster* (Brevoort) appear commonly in the coastal waters from Kagoshima Prefecture to Hakodate, Hokkaido, between November to July.1–3 The larvae are one of the main constituents of ichthyoplankton in the coastal waters around Japan. All larvae so far collected, however, were more than 84 mm in body length and belonged to the latest developing stage of leptocephalus or the metamorphic stage. The spawning ground, spawning season, and ecology of the leptocephali in the ocean remain unknown at present.

Recently, the daily growth rings on the otolith have been observed in many species of larval fishes, and ageing by counting the daily growth rings has been shown to be useful for the ecological studies of the larvae.4–9 The otoliths of leptocephalus larvae of the conger eel have rings similar to the daily growth rings observed in other fish larvae. The authors observed the microstructure of the otoliths of the conger eel larvae using a scanning electron microscope with reference to the ecology in the Seto Inland Sea.

Materials and Method

Larvae of the conger eel were collected with a bag net for the sand-eel fisheries off Onomichi, Hiroshima Prefecture, the Seto Inland Sea, on April 28, 1980, and on May 23, 1981 (Table 1). Eight specimens of the latter collection were reared in an aquarium until May 24–30, 1981, to examine the growth rhythm in the otoliths.

After measuring the body parts and counting sectionally the myomeres, the sagittal otoliths were removed from the larvae under a dissecting microscope, embedded in a few drops of epoxy resin, and placed on a glass microscope slide. A longitudinal section of the otolith was ground with a whetstone and etched with a 0.5% HCl solution. The samples were examined and photographed with a scanning electron microscope. Measurements and counts of the samples were made on the scanning electron microscopic photographs. The radii, total number of rings and distance between neighboring rings of otolith were determined with both right and left otoliths, and the average was calculated for each. The

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maximum radius of the ground otoliths was defined as the otolith radius.

Results

Developmental Stage of the Larvae

It is difficult to define the developmental stages of the conger eel larvae from the body proportion and external morphology, because the larvae show a great variety in body length and pigmentation at the beginning of the metamorphosis under both natural and rearing conditions. The number of preanal myomeres of the conger eels is known to keep on almost constant value in the developing leptocephalus stage and to change drastically in the course of metamorphosis. The authors adopted the ratio of preanal myomeres to total myomeres (PAM/TM) as a criterion for the developmental stages. According to the value of PAM/TM, the specimens of Nos. 5–10 in Table 1 belong to the developing leptocephalus stage, and those of Nos. 11–28 to the metamorphic stage. Sectional counts of myomeres of the April specimens (Nos. 1–4 in Table 1) were not made. Larvae collected together with the specimens of Nos. 1–4 were referable to the developing leptocephalus stage, and the April specimens were considered to be in the same stage as their fellow larvae.

General Description of the Microstructure of the Otolith

The ground and etched otolith took a longioval form, and showed a concentric ring pattern with the core region delimited by the innermost discontinuous zone (Figs. 1 and 2). All the otoliths showed the same pattern of ring arrangement and other characteristics, except for the marginal region. Marginal rings of the otoliths of the April specimens were narrow and countable (Fig. 1),
Fig. 1. Otolith microstructure of No. 1 specimen (Table 1) of Conger myriaster. Left, profile of the ground and etched otolith; right, high magnification of the otolith, showing the arrangement of the concentric rings. Scales 10 μm.
Fig. 2. Otolith microstructure of No. 8 specimen (Table 1) of *C. myriaster*. Left, high magnification of the left otolith, 173 rings; right, high magnification of the right otolith, 168 rings. Arrow indicates the 150th ring. Scale 10 μm.
while those of the May specimens were wide and unclear (Fig. 2). The total number of rings could be determined in the ten specimens, which occupied about one third of the total larvae examined. The daily growth rhythm in the otolith could not be proved by examining the reared larvae, since all of them had unclear rings in the marginal region (Fig. 3).

Radius and Number of Rings of the Otolith, and Relationship Between Radius and PAM/TM

Radius and number of rings of otoliths from the larvae in the developing leptcephalus stage were 104–145 μm and 123–172, respectively, while those of the otoliths in the metamorphic stage were 140–496 μm and 159–212, respectively (Table 1). A positive correlation was observed between the radius of otoliths and the number of rings (Fig. 4, $r=0.905$). Relationship between PAM/TM and radius of otoliths showed that the radius was almost constant in the developing stage (more than 0.750 of the PAM/TM value in Fig. 5), and was a gradual and then rapid increase as the PAM/TM value decreased in the metamorphic stage (less than 0.750). This indicates a prominent growth of otolith with an increase of rings during the metamorphic stage which is characterized by a remarkable shrinkage of the body as well as the decrease of the value of PAM/TM (Table 1). The head grew constantly in the metamorphic stage (Fig. 6, $r=-0.839$), forming a contrast to the shrinkage of the body. The head length highly correlated with the radius of otolith during the metamorphic stage (Fig. 7, $r=0.909$).

Distance Between Neighboring Rings of the Otolith

The distances between the neighboring rings of the otoliths were narrow from the core region...
to about the 140th–150th ring range, though they were comparatively wide and clear at around the 10th–40th ring range. Beyond about the 150th ring, the distances became abruptly wide and the rings became clear at a certain range and then unclear again. Clear marks appeared sometimes in the marginal region (Fig. 3). Fig. 8 shows the relationship between ring number and mean width of each ten increments in the otoliths of the representative specimens. Lack of unclear rings or wide rings in the marginal region of otoliths of the April specimens (Nos. 1 and 4) is in striking contrast to the marginal ring pattern in the otoliths of the May specimens (Nos. 5, 7, 14 and 19).

Discussion

The growth rhythm of otoliths could not be proved by examining of the present reared larvae on account of disturbance of ring arrangement in the marginal region (Fig. 3). If each ring of the otoliths was formed under the same conditions as in the cases of other fish larvae, the larvae collected on May 23, 1981, may have consisted of various groups of recruitments from the ocean (Table 1).

This paper is the first report that the growth of radius and increase of number of rings were recognized in the otoliths of the conger eel larvae in relation to growth of the head during the metamorphic stage.

Leptocephalus larvae of the conger eel are usually observed in the waters of Hiroshima Prefecture from March to May.10) The authors made unsuccessful efforts to collect the larvae in the neighboring area off Onomichi on April 16, 1980. The larvae collected on April 28 appeared to be the first migrating group to the waters from the ocean or offshore. Judging from the body length frequency distribution, the April larvae (Nos. 1–4 in Table 1) were considered to be younger than the larvae belonging to the developing stage (Nos. 5–10) in the May group. A remarkable difference was observed in the ring arrangement in the marginal region of the otoliths between the April and the May larvae. It was assumed that the narrow and clear ring range from the first to about the 140th–150th ring corresponds to the period from hatching to developing stage of leptocephalus, while the following wide and clear ring range and the further wide and unclear ring range to the otolith margin correspond to the period from the latest developing stage to the metamorphic stage. Further studies are needed to confirm daily ring formation on the otoliths.

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Fig. 8. Relationship between ring number and mean width of each ten increments in the otoliths of the larvae. Numerals in parentheses after the specimen number (Table 1) show the number of rings. Mean width at 10th ring, for example, was calculated from the widths from 10th to 20th rings.

References