

Leptocephalus of *Anguilla japonica* Found in the Waters South of Taiwan

Osame Tabeta and Toru Takai
(Received January 21, 1975)

Leptocephali of the Japanese eel *Anguilla japonica* Temminck and Schlegel have been reported by Matsui et al. (1968), Tanaka (1975) and Tabeta and Takai (1975) from the waters south of Taiwan and of the Okinawa Islands. Recently, Yamamoto et al. (1974; 1975; 1975) described the spawned eggs and yolk-sac larvae of the Japanese eel obtained by artificial insemination.

At the beginning of March 1973, an anguillid leptocephalus, measuring 52.0 mm in total length, was collected in the waters south of Taiwan by the R/V Hakuho-maru, Ocean Research Institute, University of Tokyo, in the course of the first research cruise for the biological study of larval stages of the Japanese eel. At that time, the specimen could not be positively identified as *Anguilla japonica*. In the second research cruise for the study, during November and December, 1973, 52 leptocephali referred to *Anguilla japonica* were collected in the waters south of the Okinawa Islands (Tanaka, 1975; Tabeta and Takai, 1975), and a detailed knowledge of the morphological characters of the larva of the Japanese eel in or shortly before metamorphosis has become available. Reexamination of the present larva revealed that it also belongs to *Anguilla japonica*. The present larva is the smallest of the leptocephali of the Japanese eel undergoing metamorphosis. The authors give here collection data and description of the present larva.

The specimen was preserved in 10% neutralized formalin, and measured and counted under binocular microscope following the methods adopted by Jespersen (1942), Castle (1963), and Tabeta and Takai (1975). Ossification of the specimen was examined on X-ray photograph.

Description

Specimen: ORI KH-73-2 (Ocean Research Institute, University of Tokyo) No. 30-8-1 (Fig. 1). One specimen, 52.0 mm in total

length, collected at 21°01.4'N, 121°00.8'E (KH-73-2, Station 30-8, ca. 2200 m in depth, Fig. 2) on March 7, 1973 (21:07~21:40) by horizontal tow of the larva net, 4 m in diameter, in 75 m wire length and 69° wire angle at ship speed 1.5 knots. Towing depth 30 m or less.

Water temperatures recorded with BT are shown in Fig. 3. The present larva was found together with the leptocephali of Congridae (12 specimens), Nettastomidae (2) and Nemichthyidae (1). In this station, 9 tows were made by the same larva net, 2 tows by the larva net of 1.5 m in diameter and 1 tow by the net of 1.6 m in diameter at the surface and middle layer, but no other specimens of anguillid leptocephali or elvers were obtained.

Measurements in mm: Total length 52.0, standard length 51.0, head 4.8, snout 1.0, eye 1.0, upper jaw 1.8, postorbital 2.8, pectoral 1.4, preanal 22.8, predorsal 20.3, ano-dorsal 2.5, depth just before eye 1.9, depth at pectoral base 3.2, depth at posterior margin of opisthonephros (maximum depth) 8.4.

Branchiostegals 12. Total myomeres 114, predorsal 40, preanal 45, ano-dorsal 5. First vertical blood vessel at 15th myomere, 2nd at 38th, 3rd (last) at 45—46th. Anterior margin of gall-bladder at 18th myomere. Each fin obvious; dorsal rays 258, anal rays ca. 215, pectoral rays 17, caudal rays 1+2+2+2+2+1=10. Teeth absent.

Body elongate, compressed and rather high, about 1/6 of the total length, deepest just before the mid point of the body. Head sub-cylindrical, relatively short, about 1/11 of the total length, with gently sloping dorsal profile, indented at the throat. Snout short, a little longer than 1/5 of head, the dorsal profile slightly concave; nasal organ oval, tubular anterior nostril opens just before the mid point between tip of snout and anterior margin of eye, posterior nostril as a single aperture located before eye. Eye oval, moderate in size, a little longer than 1/5 of head with its greatest diameter vertical, equal to snout length in horizontal diameter. Brain differentiated clearly into fore-, mid- and hind-brain. Upper jaw shorter than lower jaw; gape oblique, reaching below middle of pupil. Tongue well-developed. No larval

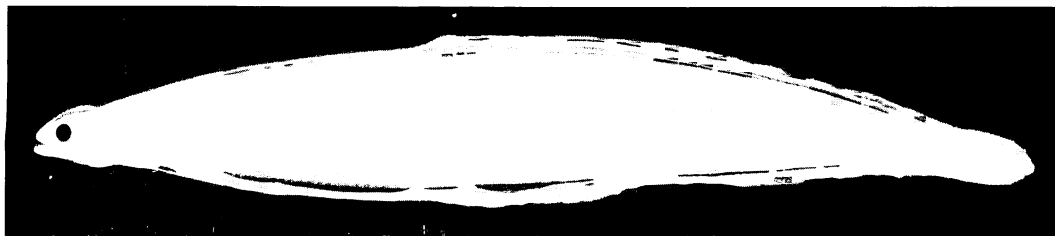


Fig. 1. *Anguilla japonica* Temminck et Schlegel, Cat. ORI KH-73-2, No. 30-8-1, 52.0 mm in total length.

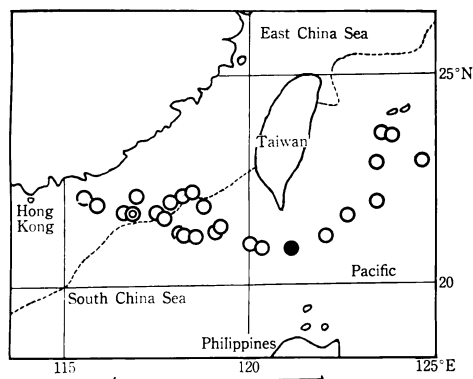


Fig. 2. Station location of the R/V Hakuho-maru in the South China Sea and its adjacent waters. Solid circle, the present leptocephalus station; double circle, the elver station; open circle, negative station.



Fig. 4. X-ray photograph of the leptocephalus. a, otolith; b, parasphenoid; c, vertebral column.

teeth. Branchiostegals recognizable externally. Gill opening very small, locating at pectoral base; 4 gill-arches visible externally. Pectoral fin long, rounded at tip, a little shorter than 1/3 of head, fleshy basally with distinct rays. Dorsal fin low, originating slightly before posterior 3/5 of total length, with 22 rays before level of vent. Anal fin higher than the dorsal, originating slightly posterior to anterior 3/7 of total length. Vertical fins becoming higher posteriorly, confluent with caudal fin. A series of pterygiophores visible along the bases of

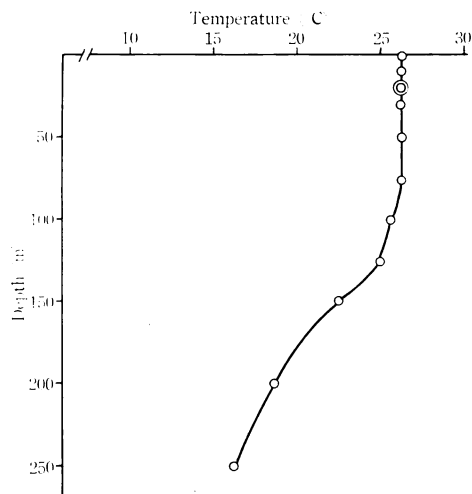


Fig. 3. Water temperature at the sampling station (KH-73-2, St. 30-8). Double circle indicates the approximate layer where the leptocephalus was obtained.

vertical fins. Two hypurals. Parasphenoid and most of vertebrae slightly ossified. Otoliths easily recognizable on X-ray photograph (Fig. 4).

The intestine has no swellings nor festoons, but a flexion at about 23rd myomere (about 1/4 of total length) and two elongate tubercles (0.7 mm in length) just before the flexion which forms blind sacs. Intestinal contents, possibly the residues of food taken, clearly visible externally from the flexed portion to the vent. No gas-bladder. Liver extending from the level of 11th myomere (about 1/7 of total length) to the flexed portion. Gall-bladder is located before the flexion and seen from the right side. The vent just below posterior margin of opisthonephros. The submarginal spaces between the end of myomeres and dorsal and ventral edges of the body and tail are very narrow so that the nerves from each segment

are not obvious.

Body in formalin translucent, with black pigment on the chorioid of the eye. Several traces of minute chromatophores were said to be observed on the inner wall of the intestine of the larva when alive. These chromatophores might have originated from the food taken, and disappeared completely in formalin.

Discussion

The present specimen is referable to the genus *Anguilla* in having 114 total myomeres, 5 ano-dorsal myomeres, no swellings nor festoons in the intestine, 3 major vertical blood vessels, developed pectoral fin with 17 rays, 258 dorsal rays, ca. 215 anal rays, and 10 caudal rays (Schmidt, 1909, 1916; Jespersen, 1942; Castle, 1963; Tabeta and Takai, 1975). Nineteen species and subspecies of eels around the world are divided into two forms: 14 long finned and 5 short finned forms (Ege, 1939). According to Jespersen (1942), the anguillid leptocephali in the waters of Eastern Indo-Malaya and north of New Guinea have 8~13 ano-dorsal myomeres in the long finned eels and 2~6 in the short finned eels, whereas in the waters of Western Indian Ocean, there are 8.5~13 ano-dorsal myomeres in the long finned eels and 3~7.5 in the short finned eels in the developing stage. Castle (1963) reported also that the leptocephali in the Southwest Pacific have less than 6 ano-dorsal segments in the short finned eels in the developing stage. It is said that an alteration takes place during metamorphosis in the ano-dorsal space of the leptocephalus, this being a sign of the beginning of metamorphosis (Jespersen, 1942). The body shape and structure of the present specimen seem to correspond to Stage III of the metamorphic stage, or semilarva III of *A. anguilla* (Jespersen, 1942; Bertin, 1956). The developing larva of the Japanese eel described by Matsui et al. (1968) has 8 ano-dorsal myomeres, whereas the elvers have 7~10 (mode 9) vertebrae in the ano-dorsal space (Tabeta and Takai, 1975). In the Japanese eel, however, the number of ano-dorsal myomeres in metamorphic stage had not been ascertained before the present larva was found. The specimen was tentatively classified into a short finned eel on the basis of the number of ano-dorsal segment (5 myomeres), and then identified

as *A. bicolor pacifica* from the geographical distribution (Ege, 1939; Jespersen, 1942; Castle, 1963), although there was a disagreement in the number of body segment between the specimen (114 myomeres) and the known adult (103~111 vertebrae, Ege, 1939). On the other hand, the 52 leptocephali of the Japanese eel obtained in the second research cruise in November and December, 1973, had 7~13 myomeres in the developing stage (49 specimens) and 6~8 myomeres in the metamorphic stage (3 specimens) in the ano-dorsal space (Tabeta and Takai, 1975). This fact revealed that too much reliance must not be placed on the number of ano-dorsal myomeres in identifying the anguillid leptocephali throughout the developing and metamorphic stages, because the range of segment number in ano-dorsal space considerably overlaps in several species of the long and short finned eels (Tabeta and Takai, 1975). Consequently, we must take into account the following short and long finned eels which possibly migrate into the waters south of Taiwan: *A. bicolor pacifica* (short finned eel), *A. marmorata*, *A. celebesensis*, *A. japonica* and *A. anguilla** (long finned eels) (Ege, 1939; Tabeta and Takai, 1975). Of these eels, the first three species have the vertebral counts less than 111, and *A. anguilla* has the extensive nerve-cord pigmentation and cutaneous pigmentation at caudal part in Stage III of the metamorphic stage or semilarva III (Ege, 1939; Jespersen, 1942; Bertin, 1956). As stated before, the present metamorphic specimen has 114 total myomeres and no pigmentation except for the chorioid of the eye. The authors therefore identified the larva as *A. japonica*. Its metamorphic stage is the same as that of Cat. ORI KH-73-5, No. 10-15-1 obtained in the second research cruise, and is the most developed stage among the specimens. It shows the lower size limit of the stage under metamorphosis of the eel (ranging from 52.0 mm in the present specimen to 60.2 mm of Cat. ORI KH-73-5, No. 10-29 in the second research cruise, Tabeta and Takai, 1975). It is noteworthy that the water temperature of the station was more than 25°C at the surface, which coincides with the temperature conditions under which the leptocephali

* The elvers of *A. anguilla* have been imported in large quantities and cultured in Japan and its neighbouring countries since 1968.

of the Japanese eel have been found (Matsui et al., 1968; Tanaka, 1975). An elver of just after metamorphosis was also obtained in the cruise in the mid point between the southernmost tip of Taiwan and Hong Kong in the South China Sea on March 10, 1973 (Fig. 2; Tabeta and Takai, 1973). The anadromous elvers are found from October to April in the rivers of Taiwan and South Mainland China (Guo-Huo, 1971; Tabeta and Takai, 1973). The present specimen may be a member of the last anadromous population in Taiwan, South Mainland China, etc.

Acknowledgments

The authors are deeply grateful to Professor Masa Shiwaki, Director of the Ocean Research Institute, University of Tokyo and chief scientist of the cruise, for the invaluable opportunity to participate in the cruise and study the material, all members of the cooperative work of Biological Study of Larval Stages of the Japanese Eel, and the officers and crew of the R/V Hakuho-maru, for their suggestions and help which were necessary in preparing this paper. The authors also express their sincere gratitude to Mr. Seirō Kimura of Kyushu University for preparing the photograph of the leptocephalus. Dr. Tetsushi Senta and Miss June Low, Marine Fisheries Research Department, SEAFDEC, Singapore, kindly read and improved the manuscript.

Literature cited

- Bertin, L. 1956. Eels. A biological study. Cleaver-Hume Press, London, vi+192 pp., figs. 1~55, tabs. 1~9, pls. 1~8.
- Castle, P. H. J. 1963. Anguillid leptocephali in the Southwest Pacific. Zool. Publ. Victoria Univ. Wellington, 33: 1~14, figs. 1~3.
- Ege, V. 1939. A revision of the genus *Anguilla* Shaw. A systematic, phylogenetic and geographical study. Dana-Rep., 16: 1~256, figs. 1~53, tabs. 1~208, pls. 1~6.
- Guo-Huo. 1971. Approach of eel elvers to the land in Taiwan. Fish Culture (Yoshoku), 1971, 1: 52~56, figs. 1~2 (in Japanese).
- Jespersen, P. 1942. Indo-Pacific leptocephalids of the genus *Anguilla*. Systematic and biological studies. Dana-Rep., 22: 1~128, figs. 1~83, tabs. 1~51, App. tabs. 1~4, pls. 1~4.
- Matsui, I., T. Takai and A. Kataoka. 1968. Anguillid leptocephalus found in the Japan Current and its adjacent waters. J. Shimonoseki Univ. Fish., 17 (1): 17~23, figs. 1~3, tabs. 1~2, pl. 1.
- Schmidt, J. 1909. Remarks on the metamorphosis and distribution of the larvae of the eel (*Anguilla vulgaris*, Turt.). Medd. Komm. Hav. Fisk., 3 (3): 1~17, tabs. 1~5, pls. 1~2.
- Schmidt, J. 1916. On the early larval stages of the fresh-water eels (*Anguilla*) and some other north Atlantic muraenoids. Medd. Komm. Hav. Fisk., 5 (4): 1~20, figs. 1~14, pls. 1~4.
- Tabeta, O. and T. Takai. 1973. An elver of *Anguilla japonica* found in the northern part of the South China Sea. J. Shimonoseki Univ. Fish., 22 (2): 49~53, figs. 1~3, tab. 1.
- Tabeta, O. and T. Takai. 1975. Leptocephali of *Anguilla japonica* found in the waters south of the Okinawa Islands. Bull. Japan. Soc. Sci. Fish., 41 (2): 137~145, fig. 1, tabs. 1~2, pl. 1.
- Tanaka, S. 1975. Collection of leptocephali of the Japanese eel in waters south of the Okinawa Islands. Bull. Japan. Soc. Sci. Fish., 41 (2): 129~136, figs. 1~3, tabs. 1~3.
- Yamamoto, K. and K. Yamauchi. 1974. Sexual maturation of Japanese eel and production of eel larvae in the aquarium. Nature, 251 (5472): 220~222, figs. 1~2, tab. 1.
- Yamamoto, K., K. Yamauchi and S. Kasuga. 1975. On the development of the Japanese eel, *Anguilla japonica*. Bull. Japan. Soc. Sci. Fish., 41 (1): 21~28, tab. 1, pls. 1~2 (in Japanese).
- Yamamoto, K., K. Yamauchi and T. Morioka. 1975. Pre-leptocephalic larvae of the Japanese eel. Bull. Japan. Soc. Sci. Fish., 41 (1): 29~34, pl. 1 (in Japanese).
- (Department of Aquiculture and Biology, Shimonoseki University of Fisheries, Yoshimi, Shimonoseki, 759—65 Japan)

台湾の南方海域から採集されたウナギの葉形幼生

多部田 修・高井 徹

1973年3月7日に台湾南方海域から、東大海洋研究所の白鳳丸によって、1個体の変態期の葉形幼生が採集された。この幼生は全長52.0mmで、筋節の総数は114、肛門-背鰭起部間数は5であった。腸管には特殊な構造はなく、主要垂直血管は3本、胸鰭は発達し、17条をそなえ、眼以外に色素胞はなかった。以上の特徴からこの幼生を *Anguilla japonica* と同定した。この幼生はこれまで知られた変態期幼生では最も小さい。採集場所の表層水温はこれまで幼生が得られた場所と同じく25°C以上を示した。

(759-65 下関市吉見永田本町 1944 水産大学校増殖学科水産動物学研究室)