

1988年ルソン島東方北西太平洋で得られたウナギ属葉形仔魚

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Anguillid Leptocephali from the Western North Pacific East of Luzon, in 1988

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A total of eight specimens of the anguillid leptocephali were collected by TV Keiten Maru, Faculty of Fisheries, Kagoshima University, in the waters east of Luzon in June and July 1988. They were identified as seven *Anguilla japonica* Temminck et Schlegel, and one *A. marmorata* Quoy et Gaimard or *A. celebesensis* Kaup based on the segmental characters. The present *A. japonica* leptocephali were 24.0–31.8 (mean 27.4) mm TL, and were smaller than those of the previous collections. The location and month of the capture extended spatially and temporally the distribution of the Japanese eel leptocephali in the western North Pacific. The smallest specimen in the present *A. japonica* leptocephali, the youngest larva hitherto known from the field, was collected at a station east of Luzon (15°46.1'N, 138°42.4'E).

The early life of the Japanese eel *Anguilla japonica* Temminck et Schlegel in the field has long been studied by many scientists,¹⁻⁹⁾ but the total number of leptocephali of the eel ever obtained is only 78 specimens, and the biological information has remained insufficient to locate the spawning ground. Kajihara and others⁷⁻⁹⁾ collected the 21 specimens of the Japanese eel larvae, 33.9–47.0 (mean 43.1) mm TL, mainly from the waters east of Luzon, Philippines, in September 1986, and suggested the possibility of determining their breeding place if a survey was carried out in June or July.⁷⁾

In June–July 1988, TV Keiten Maru (860 t), Faculty of Fisheries, Kagoshima University, conducted a survey cruise for exploring the spawning and early life of the Japanese eel in the western North Pacific from southern Kyushu, Japan, to east of Luzon, Philippines. A total of eight anguillid leptocephali were caught in the waters east of Luzon. They were identified as seven *A. japonica* and one *A. marmorata* or *A. celebesensis* from the segmental characters. The smallest specimen of the Japanese eel larvae, 24.0 mm TL, in the present collection was the youngest larva hitherto known from the field. The location and month of the capture of the larvae extended spatially and temporally the distribution range of the Japanese eel larvae in the sea. In this paper, the

authors report the collection data, description, and diurnal occurrence of the Keiten Maru specimens. Other aspects of the survey will be reported by other scientists.

Materials and Method

The present sampling stations were located at an area of 12°32.9'–27°38.0'N and 131°11.5'–138°42.4'E (Fig. 1). Sampling was conducted with a larva net (SRFRL*⁴ larva net, mouth diameter 1.6 m, mouth opening 2 m², net length 7.35 m, mesh aperture 0.53 mm) during day and night on June 11–17 and July 14 and 15, 1988. Day sampling was planned to conduct at noon (about 12:00–12:30), and night samplings were planned to conduct after evening (about 20:00–20:30), at midnight (about 00:00–00:30), and before dawn (about 04:00–04:30). The net was towed horizontally at three depth layers (step tow) of wire lengths of 50, 100 and 150 m for ten min each. At the same time, another net of the same type was towed horizontally at the surface (surface tow) for 20 min. Ship speed was about 2.0 kt.

The leptocephali of Anguilliformes were examined alive on board by binocular microscopy. They were measured and counted following the methods adopted by Jespersen¹⁰⁾ and Castle¹¹⁾ after fixation in 10% sea water formalin.

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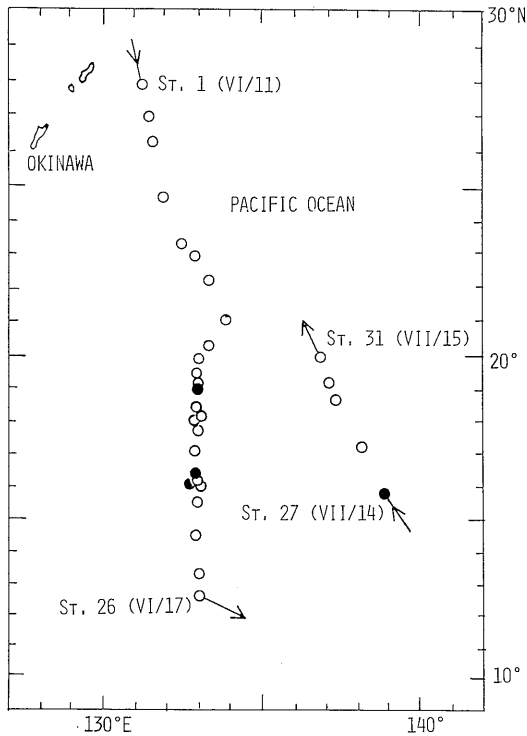


Fig. 1. Cruise track and sampling stations of TV Keiten Maru, June-July 1988. Black circles indicate the stations where *Anguilla leptocephali* were collected (see Table 1). Arrows indicate the direction of cruise.

Results

Description of the Anguillid Larvae

The catalogue number and the data of collection are shown in Table 1.

Anguilla japonica Temminck et Schlegel (Fig. 2, A)

Specimen. Seven specimens, 24.0–31.8 mm in total length (Table 1). The description given below is mainly based on a specimen of 31.8 mm in total length (Cat. KU KT-88, No. 27M-4). The other specimens were utilized to show the range of characters. Measurements related to dorsal origin were limited to the two largest specimens in Table 1, because the others were too young to develop discernible dorsal origin.

Description. Measurements in mm: total length 31.8 (24.0–31.8, mean 27.4), standard length 31.2 (23.6–31.2, 27.1), head 3.4 (2.7–3.4, 2.9), snout 0.8 (0.7–0.9, 0.8), eye 1.0 (0.8–1.0, 0.9), upper jaw 1.6 (1.3–1.6, 1.4), postorbital 1.5 (1.1–1.5, 1.3), pectoral 1.0 (0.5–1.0, 0.7), preanal 24.4 (19.0–25.5, 22.2), predorsal 22.0 (19.0, 22.0), ano-dorsal 2.4 (2.2, 2.4), depth just before eye 1.5 (1.2–1.5, 1.4), at pectoral base 2.7 (2.2–2.7, 2.4), at midpoint between pectoral and vent 5.9 (4.2–5.9, 4.9), at vent 4.9 (4.0–5.0, 4.4). Branchiostegals not obvious. Total myomeres 117 (112–117, mean 115.3), predorsal 70 (68, 70), preanal 81 (77–81, 79), ano-dorsal 10 (10, –), 1st vertical blood

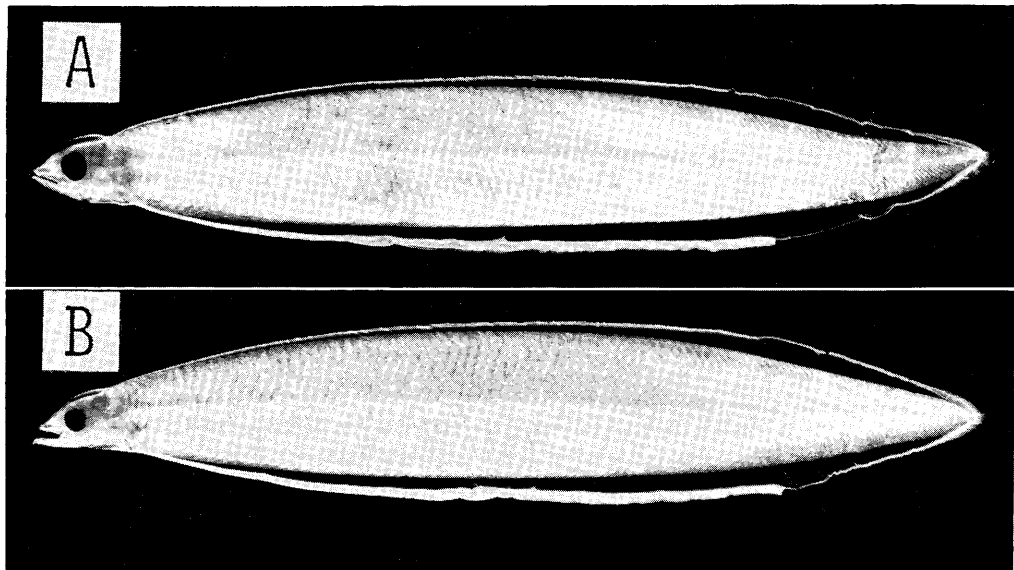


Fig. 2. Anguillid leptocephali from the waters east of Luzon.

A. *Anguilla japonica* Temminck et Schlegel, Cat. KU KT-88, No. 27M-4, 31.8 mm TL.

B. *Anguilla marmorata* Quoy et Gaimard or *Anguilla celebesensis* Kaup, Cat. KU KT-88, No. 13M, 33.5 mm TL.

Table 1. Catalogue number and collection data of *Anguilla leptocephali*

Fish No.	Cat. No.	TL (mm)	Date	Time	Stn. No.	Locality	
						Lat.	Long.
<i>Anguilla japonica</i>							
Cat. KU KT-88*							
1	19M-1	25.3	June 16, 1988	0356-0428	19M	16°21.8'N	132°59.8'E
2	19M-2	27.6	June 16, 1988	0356-0428	19M	16°21.8'N	132°59.8'E
3	22M	27.3	June 17, 1988	0021-0053	22M	16°11.9'N	132°59.9'E
4	27M-1	24.0	July 14, 1988	0359-0431	27M	15°46.1'N	138°42.4'E
5	27M-2	24.8	July 14, 1988	0359-0431	27M	15°46.1'N	138°42.4'E
6	27M-3	31.3	July 14, 1988	0359-0431	27M	15°46.1'N	138°42.4'E
7	27M-4	31.8	July 14, 1988	0359-0431	27M	15°46.1'N	138°42.4'E
<i>Anguilla marmorata</i> or <i>Anguilla celebesensis</i>							
Cat. KU KT-88*							
1	13M	33.5	July 14, 1988	1959-2029	13M	19°02.2'N	132°54.1'E

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vessel at 19th myomere (16th-20th, mode 18th), 2nd at 41st (33rd-42nd, 40th), 3rd (last) at 48th (44th-48th, 46th). Anterior margin of gall bladder at 30th (29th-34th, 31st). Caudal fin rays $1+2+2+2+3+1=11$ (9-11, 10). Other fin rays not obvious. Teeth $1+1+6+5/1+6+4$ ($1+1+3-6+3-5/1+3-6+3-4$, $1+1+4+4/1+4+4$).

Body much compressed, not very deep, with the greatest depth contained about 5.4 times in total length. Head short, about one-ninth of total length, indented at throat so that it is well differentiated from trunk; snout short, about one-fourth of head length, its dorsal profile convex; anterior and posterior nostrils well separated; eye little larger than snout length, oval; mouth gape oblique, extending almost to level of posterior margin of pupil; teeth conspicuous, very acute, 13 in the upper jaw and 11 in the lower jaw, distributed as follows: first tooth of upper jaw small, needle-like directed anteriorly and placed immediately above the second much larger, grasping tooth; these two are followed by a series of six large teeth and final series of five smaller teeth; lower teeth similar to those of upper jaw with the absence of needle-like anterior teeth. Dorsal fin slightly developed, originating at about seven-tenths of total length; anal fin also slightly developed, its origin at about three-fourths of total length; both fin rays obvious only posteriorly. Pectoral fin large, about one-third of head length, rounded, fleshy. Caudal fin clearly differentiated from other median fins. Intestine is straight, not festooned or swollen. Gall bladder clearly visible in front of stomach portion, oval.

Color in preservative translucent with black pigment restricted to the choroid of the eye.

Remarks. The present anguillid leptocephali are characterized in having 112-117 total myomere, 10 ano-dorsal myomere and last vertical blood vessel usually lying at about 46th myomeres. These characteristics fit only *Anguilla japonica* Temminck et Schlegel in the western North Pacific.^{9,8,10,11}

Anguilla marmorata Quoy et Gaimard or *Anguilla celebesensis* Kaup (Fig. 2, B)

Specimen. One specimen, 33.5 mm in total length (KU KT-88, No. 13M) (Table 1).

Description. Measurements in mm: total length 33.5, standard length 33.0, head 3.4, snout 0.8, eye 0.9, upper jaw 1.6, postorbital 1.5, pectoral 1.0, preanal 26.1, predorsal 24.8, ano-dorsal 1.3, depth just before eye 1.6, at pectoral base 2.6, at mid-point between pectoral and vent 6.4, at vent 5.6. Branchiostegals not obvious. Total myomeres 105, predorsal 64, preanal 74, ano-dorsal 9, 1st vertical blood vessel at 17th, 2nd at 38th, 3rd (last) at 44th. Anterior margin of gall bladder at 28th. Caudal fin rays $1+3+2+2+2+1=11$. Other fin rays not obvious. Teeth $1+1+5+7/1+7+3$.

Body much compressed, not excessively elongate, rather deep, with the greatest depth contained about five times in total length. Head short, about one-tenth of total length, slightly convex so that it is well differentiated from trunk; snout short, one-fourth of head length, its dorsal profile convex; anterior and posterior nostrils well separated; eye subequal to snout length, oval; mouth gape oblique, extending almost to level of posterior margin of pupil; teeth conspicuous, very acute, 14 in the upper jaw and 11 in the lower jaw, distributed as in *A. japonica* described before. Dorsal

Table 2. Number of surface and step tows in day and night, and *Anguilla japonica* larvae collected

Towing method	Time	Number of tows	<i>A. japonica</i> larvae collected
June 11-17, 1988			
Surface	Day	6	0
	Night	20	0
Step	Day	6	0
	Night	20	4*
July 14 and 15, 1988			
Surface	Day	1	0
Step	Night	4	4

* One of them was *A. marmorata* or *A. celebesensis*.

fin slightly developed, its origin at about seven-tenths of total length; anal also slightly developed, its origin about three-fifths of total length; both fin rays obvious only posteriorly. Pectoral fin large, about one-third of head length, rounded, fleshy. Caudal fin clearly differentiated from dorsal and anal fins. Intestine is straight. Gall bladder visible in front of stomach portion, elongated oval.

Color in preservative translucent with pigment restricted to the choroid of the eye.

Remarks. The leptocephalus has 105 total myomeres and nine ano-dorsal myomeres. This indicates that the larva belongs to the long finned eel.¹⁰⁾ This character together with its locality restricts the identification to either *A. marmorata* Quoy et Gaimard or *A. celebesensis* Kaup.^{10,12-14)} However, it is difficult to identify further this larva, since the segmental characters of the two species overlap much each other.^{12,14)}

Diurnal Occurrence

Table 2 shows the number of surface and step tows which were conducted during day and night, and the number of anguillid larvae collected. The present anguillid larvae were collected only with the step tows in night. All the *A. japonica* larvae were collected before dawn (six specimens) and at midnight (one specimen) (Table 1). The present larvae were not distributed in the surface of the sea during the survey period, since the surface tows yielded no anguillid larvae in both day and night. Depth recorder attached to the net of wire length 150 m indicated 26-45 m depth in the survey on July 14 and 15.

Discussion

Jespersen,¹⁰⁾ Castle,¹¹⁾ Tabeta and Takai,^{2,3)} and Tabeta and Mochioka⁸⁾ described the features of

Anguilla leptocephali from the Pacific. These features are applicable in identifying the present leptocephali. For further identification of *A. marmorata* or *A. celebesensis*, it is necessary to examine a series of larvae of various body lengths.

The present larvae were exclusively collected from the subsurface waters shallower than 40 m depth during night. This was the same trend as those already reported.¹⁻⁹⁾

The highest number of the Japanese eel larvae ever collected with one tow, seven specimens, was recorded with IKMT (8.7 m² mouth opening, 0.5 mm mesh, W-shaped oblique towing with a maximum wire length of 156 m for 40 min at ship speed of 1.5-3.0 kt) at a station (C-15) of 18°58.5'N, 129°15.2'E on September 23-24 (23:41-00:31), 1986.⁷⁻⁹⁾ On the present cruise, the highest number of the eel larvae collected with one tow (towing for 30 min) was four specimens at Stn. 27M (Table 1). If the present SRFRL larva net and the above-mentioned IKMT have the same filtering rate, the IKMT should filter a water column of 5.4 times that of the SRFRL larva net. This means that the same volume of water column as that the IKMT passes at Stn. 27M would contain 21.6 specimens of the eel larva (5.4 × 4 specimens). This suggests that eel larvae were three times more numerous at Stn. 27M of the present cruise than observed at Stn. C-15 in September 1986.

The present leptocephali of *A. japonica* were characterized in having small body size in comparison with those of the previous collection (Fig. 3).^{1-6,8)} The segmental characters of dorsal origin and positions of anus and vertical blood vessels, and the number of teeth on both jaws of the present *A. japonica* larvae were within the ranges of those of the larvae reported previously.^{1-6,8)} The more eastern location and earlier month of collection than those of the previous leptocephali which were found in the waters west

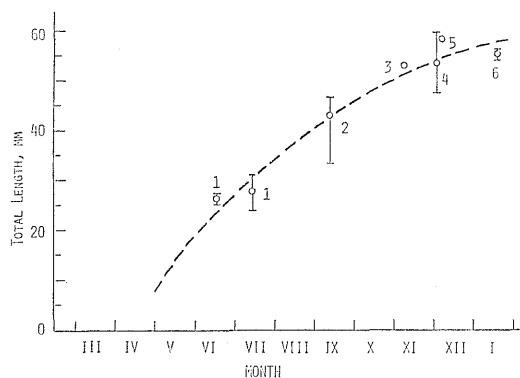


Fig. 3. Averages (circles) and ranges (vertical bars) of total length of all known specimens of *A. japonica* leptocephali, and estimated growth (broken line). Sampling dates are set on the middle of the duration of the leptocephali collection. Numbers indicate: 1, present study; 2, Tabeta and Mochioka;⁸⁾ 3, Matsui *et al.*;¹⁾ 4, Tanaka;⁴⁾ 5, Tabeta and Konishi;⁶⁾ and 6, Tabeta.⁵⁾

of 130°E from September to March¹⁻³⁾ give an importance to the present leptocephali. This extended spatially and temporally the distribution range of *A. japonica* leptocephali in the sea.

Tsukamoto *et al.*¹⁾ concluded from otolith observation of the Japanese eel leptocephali (14 specimens, 40.5–47.0 mm TL) that the age of leptocephali was 72±3 days (means±SD), and their birth date ranged from June to July. Number of rings on the otoliths of the elvers migrating to the Japanese coast showed that the estimated spawning season of the Japanese eel ranged from April to November.²⁾ Although we could not observe the otolith microstructure of the present larvae because of inadequate fixation, these eel larvae were considered to be spawned in April and May 1988 from the trend of the total length of all larvae ever collected (Fig. 3).

A total of 85 known leptocephalus larvae of *A. japonica*¹⁻³⁾ contrast strongly with the richness of collection of the anguillid larvae in the Atlantic and east Indian Ocean.^{10, 15-17)} Our research areas should be at some distance from the spawning ground of the eel. Latitudinally, the spawning ground seems located between the westward North Equatorial Current at about 10°N and the eastward Subtropical Countercurrent at about 20°N¹⁸⁾ according to the collection localities of this study

and those except one (22°02'N, 122°25'E) of Kajihara.⁷⁾ The latter author states that, according to the prevailing westward water flow observed, the spawning area of *A. japonica* seems more eastern waters than the study area, though not denying the possibility of spawning in waters just east of Luzon. In this study, surface current was examined with data of ship drift¹⁹⁾ along 133°E meridian²⁰⁾: it was westward between 20°–18°N, and gradually changing southward, became eastward between 16° and 15°N; to the southern limit, 12°N, of observation beyond 15°N, surface current was exclusively westward, suggesting the influence of the North Equatorial Current.

Therefore, surface currents were not uni-directional between 20° and 10° or 15°N, which means it is difficult to estimate the direction of transport of the present leptocephali during such a long period as about two months after spawning suggested above.

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