Malays. Appl. Biol. (2011) 40(1): 51-54

Research Note

AGE AT MATURATION OF A TROPICAL EEL *Anguilla bicolor bicolor* IN PENINSULAR MALAYSIA, MALAYSIA

ARAI, T.[1]*, CHINO, N.[2], ZULKIFLI, S.Z.[1] and ISMAIL, A.[1]

[1]*Department of Biology, Faculty of Science, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia*
[2]*International Coastal Research Center, Atmosphere and Ocean Research Institute, The University of Tokyo, 2-106-1 Akahama, Otsuchi, Iwate 028-1102, Japan*
**E-mail: arai@science.upm.edu.my*

Anguillid eel species are widely distributed throughout the world. The eels have catadromous life history, migrate between freshwater growth habitats and offshore spawning areas. Fifteen species of *Anguilla* have been reported worldwide, ten of which occur in tropical regions (Ege 1939). Of the latter, seven species/subspecies occur in the western Pacific around Indonesia and Malaysia, i.e. *A. celebesensis*, *A. interioris*, *A. nebulosa nebulosa*, *A. marmorata*, *A. borneensis*, *A. bicolor bicolor* and *A. bicolor pacifica* (Ege, 1939; Castle & Williamson, 1974; Arai *et al*., 1999). The tropical species is thought to be more closely related to the ancestral (primitive) form than their temperate counterparts. Studying the distribution and life history of tropical eels may provide some clues to understanding the nature of primitive forms in anguillid eels and how the distribution of the genus became established.

The recent decline of glass eel (juvenile) catches in East Asia has caused serious problems in eel aquaculture in Japan and Taiwan. Eighteen percent of the eel consumed in Japan is produced in the country (23, 211 tons, aquaculture; and 817 tons, wild in 1999), and the remainder is imported from China, Taiwan, and Malaysia (Kato & Kobayashi, 2003). Therefore, the tropical eels are considered to be a major target species for the eel trading recently. However, little attention has been given to natural populations and the resource management of eel in Malaysia.

Therefore, the objective of this study was to gain the biological information of a tropical eel *Anguilla bicolor bicolor* collected in the Peninsular Malaysia. In the present study, we found maturing stage of the eel in Malaysian waters. There is no information available regarding the maturation in the tropical eel species. We reported the first eel biology study in Malaysia.

A total of 10 specimens were collected by local fishermen mainly in Kurau River in Bukit Merah and Penang River in Peneng Island of the northwestern peninsular (4°59'-5°23 N, 100°12-100°40'E) during November 2008 and August 2010. The eels were collected by angling and bamboo trap at night. The total length (TL), predorsal length (PDL), preanal length (PAL) (Fig. 1), body weight (BW) and gonad weight were measured. The gonad and body weights were measured to determine the gonado somatic index (GSI) of each eel. The GSI value was calculated as follows:

GSI % = gonad weight (g) /body weight (g) x 100

The sex was determined by visual observation of gonad characters by Tesch (1977). The fin difference index (FDI %) (Ege 1939) was calculated based on Ege 1939 method showed as follows:

FDI % = (PAL-PDL)/TL x 100

To distinguish developmental stage of female eels, each individual was classified as either a yellow (immature) (<1.0) or a silver (mature) stage (≥1.0) using GSI, following Utoh et al. (2004). These indexes and visual observation indicated that eight specimens were sexually immature, and two specimens had reached the migratory silver phase. Overall, we found seven females in yellow stage, two females in silver stage and the one unknown sex in yellow stage due to the less developed gonad.

After the measurement of the morphological characteristics in each specimen, sagittal otoliths were extracted from each fish, embedded in epoxy resin (Struers, Epofix) and mounted on glass slides. The otoliths were then ground and polished, as

* To whom correspondence should be addressed.

described by Arai et al. (2004, 2006). Otoliths were then aged by counting the number of transparent zones, as reported in Chino & Arai (2010a, b).

Differences between data were analyzed using the Mann-Whitney *U*-test (Sokal & Rohlf, 1995).

The FDI % measured by the distance between the verticals from the beginning of the dorsal fin to the anus (ano-dorsal length) relative to the total length (Fig. 1), ranged from -1.93 % to 2.63 %, with a mean ± SD of 1.06 ± 1.20 % (Table 1). The value was in the range of that of the previous study (range; -3 – 3.9 %, mean 0.7 %) in *Anguilla bicolor bicolor* by Ege (1939). Thus, these eels could be easily identified morphologically as the short-finned eel *Anguilla bicolor bicolor*.

The TL of *Anguilla bicolor bicolor* eels ranged from 462 to 687 mm in yellow stage and from 497 to 636 mm in silver stage (Table1). The BW of yellow stage and silver stage was ranged from 185 to 645 g and from 205 to 497 g, respectively. The GSI was ranged from 0.11 to 1.79 (mean ± SD; 0.71 ± 0.54). The annuli in the otoliths of *A. bicolor bicolor* were ranged from 3 to 6 yr in the yellow stage and from 4 to 6 yr in the silver stage.

This is the first description on the biological characters of an anguillid eel in silver stage from tropical area. In the present study, age at maturation of female *A. bicolor bicolor* was ranged from 4 to 6 with body length ranging 50 to 64 cm and body weight ranging 205 to 497 g. Furthermore, two specimens, namely ML-8 and ML-10 have GSI values around 1.0 indicating readiness for downstream migration. Thus, we roughly included those specimens as the silver stage to compare the biological characters for those of yellow stage. There were no significant differences for TL, BW and age between the silver stage and the yellow stage (Mann Whitney U-test, $p > 0.5$). These results suggest that the timing of maturation of the eel might be induced not to reach the age and the growth but to be ready for the physiological condition.

In the European eel *A. anguilla*, the size of female silver eels was estimated to be 54-61 cm and the age of silver eels ranged from 8-12 years (Tesch, 1977). In the Japanese eel *A. japonica*, they reached silver stage at the length range of 48-85 cm and the age ranged from 4 - 16 years (Arai *et al*., 2003; Chino *et al*., 2008; Chino & Arai, 2009). In the American eel *A. rostrata*, the size and age of silver eels were 40-94 cm and 19.3 years for females (Jessop, 1987). The body length at maturation in a tropical eel *A. bicolor bicolor* is almost as same as those of temperate eels, while the age at maturation in the species is younger than those of temperate eels. These results suggest that maturation of the tropical eels is faster than that of temperate eels. The higher growth rate associated with higher temperature might induce the earlier maturation in the tropical eels.

The temperate anguillid species make their spawning migration as silver eels during the fall and winter. All species descend freshwater rivers and streams in fall and enter saltwater, where they begin their marine migration to the open ocean spawning areas. In tropical anguillid species, there is no information available on the timing of downstream migrations of reproductively maturing sliver stage. Arai et al. (2001) found that the spawning seasons of the tropical eels including *A. bicolor* extended throughout the year. However, in temperate species, spawning occurs over a limited period. The difference in spawning season duration and timing between tropical and temperate species could be due to differences in the seaward migration seasons of maturing adult eels. In tropical species, which spawn year round (Arai *et al*., 2001), and thus spawning

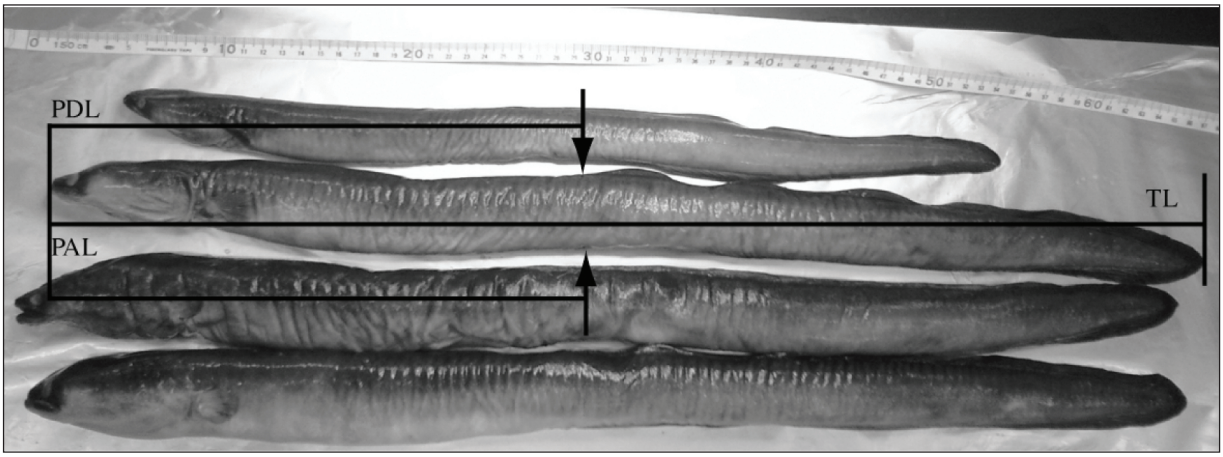

Fig. 1. Photographs of the short-finned eel *Anguilla bicolor bicolor* collected from Peninsular Malaysia. Arrows indicate the beginning of the dorsal fin (up) and anus (bottom). TL, PDL and PAL indicate the total length, predorsal length and preanal length, respectively.

Table 1. Biological data of *Anguilla bicolor bicolor* collected in Peninsular Malaysia

Sample number	Sampling date	Sampling location	Body weight (g)	Total length (mm)	Preanal length (mm)	Predorsal length (mm)	Fin difference index (%)	Sex	Gonadosomatic index (%)	Age (years)
ML-1	November 2008	Kurau River	476	618	262	260	0.32	Female	0.34	5
ML-2	November 2008	Kurau River	497	636	269	260	1.42	Female	1.37	4
ML-3	November 2008	Kurau River	497	637	275	267	1.26	Female	0.56	6
ML-4	November 2008	Kurau River	203	489	206	200	1.23	Female	0.11	4
ML-5	July 2010	Kurau River	245	524	218	210	1.53	Female	0.51	5
ML-6	July 2010	Kurau River	200	466	186	195	-1.93	unknown	0.15	3
ML-7	July 2010	Kurau River	185	462	197	192	1.08	Female	0.46	5
ML-8	August 2010	Kurau River	645	684	295	277	2.63	Female	0.91	5
ML-9	August 2010	Penang River	205	497	205	198	1.41	Female	1.79	6
ML-10	August 2010	Penang River	205	479	218	210	1.67	Female	0.94	5

migration may occur throughout the year. Further studies on the anguillid eels in tropical areas including Malaysia are needed to provide basic information about their biology that can help initiate management efforts of this important fishery resources in the world.

REFERENCES

Arai, T., Aoyama, J., Limbong, D. & Tsukamoto, K. 1999. Species composition and inshore migration of the tropical eels *Anguilla* spp. recruiting to the estuary of the Poigar River, Sulawesi Island. *Mar. Ecol. Prog. Ser.*, **188**: 299-303.

Arai, T., Limbong, D., Otake, T. & Tsukamoto, K. 2001. Recruitment mechanisms of tropical eels, *Anguilla* spp., and implications for the evolution of oceanic migration in the genus *Anguilla*. *Mar. Ecol. Prog. Ser.*, **216**: 253-264.

Arai, T., Kotake, A., Ohji, M., Miller, M.J., Tsukamoto, K. & Miyazaki, N. 2003. Occurrence of sea eels of *Anguilla japonica* along the Sanriku Coast of Japan. *Ichthyol. Res.*, **50:** 78-81.

Arai, T., Kotake, A., Lokman, P.M., Miller, M.J. & Tsukamoto, K. 2004. Evidence of different habitat use by New Zealand freshwater eels, *Anguilla australis* and *A. dieffenbachii*, as revealed by otolith microchemistry. *Mar. Ecol. Prog. Ser.*, **266**: 213-225.

Arai, T., Kotake, A. & McCarthy, T.K. 2006. Habitat use by the European eel *Anguilla auguilla* in Irish waters. *Estuar. Coast. Shelf Sci.*, **67**: 569-578.

Castle, P.H.J. & Williamson, G.R. 1974. On the validity of the freshwater eel species *Anguilla ancestralis* Ege from Celebes. Copeia **2**: 569-570.

Chino, N., Yoshinaga, T., Hirai, A. & Arai, T. 2008. Life history patterns of silver eels *Anguilla japonica* collected in the Sanriku Coast of Japan. *Coast. Mar. Sci.*, **32**: 54-56.

Chino, N. & Arai, T. 2009. Relative contribution of migratory type on the reproduction of migrating silver eels, *Anguilla japonic*a, collected off Shikoku Island, Japan. *Mar. Biol.*, **156**: 661-668.

Chino, N. & Arai, T. 2010a. Occurrence of marine resident tropical eel *Anguilla bicolor bicolor* in Indonesia. *Mar. Biol*. **157**: 1075-1081.

Chino, N. & Arai, T. 2010b. Habitat use and habitat transitions in the tropical eel, *Anguilla bicolor bicolor. Environ. Biol. Fish.*, **89**: 571-578.

Ege, V. 1939. A revision of the Genus *Anguilla* Shaw. Dana. Rep., **16**: 8-256.

Jessop, B.M. 1987. Migrating American eels in Nova Scotia. *Trans. Am. Fish. Soc*., **116**: 161-170.

Kato, M. & Kobayashi, M. 2003. Aquaculture and genetic structure in the Japanese eel *Anguilla japonica*. UJNR Technical Report **30:** 87-92.

Sokal, R.R. & Rohlf, F.J. 1995. Biometry, 3rd edn. WH Freeman and Company, New York

Tesch, F.W. 1977. The Eel. Biology and management of anguillid eels. Chapman and Hall, London

Utoh, T., Mikawa, N., Okamura, A., Yamada, Y., Tanaka, S., Horie, N., Akazawa, A. & Oka, H. P. 2004. Ovarian morphology of the Japanese eel in Mikawa Bay. *J. Fish Biol*. **64**: 502–513.