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

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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 Penang 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:

\[ \text{GSI \%} = \frac{\text{gonad weight (g)}}{\text{body weight (g)}} \times 100 \]

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:

\[ \text{FDI \%} = \frac{\text{PAL-PDL}}{\text{TL}} \times 100 \]

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

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


