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A Preliminary Report of Ecological Researches on a Stocked Population of Eel *Anguilla japonica* in the River Monobe, Kochi Prefecture, Japan

Abstract

This is a preliminary report of ecological researches on a stocked population of eel *Anguilla japonica* in the river to get fundamental information on eel population processes.

We marked 7977 eels by clipping the right pectoral fin and released them in the River Monobe, Kochi Prefecture, Japan, at 19th May 2000. The distance of the river for the ecological research was about 7 km from the mouth of the river to the sluice. We used both wooden box traps (5.2 x 6.5 x 70 cm) and stone mound traps (about 2 m in diameter) as fishing gears. Number of recaptured eels was 92 in total until the end of September. The ratio of recaptured eels within 1 km upper or lower from the release site was 58% of the total. The total body length in average after four months from May was mostly same the as the size at the release day.

The fatness condition of stocked eels in a relationship between total body length and body weight was lower than that of natural living eels. Recaptured eel of about 70% changed into the yellowing body (that is a body color of natural living eel) from the bluish black body (that is a body color of cultured eel) for only two months after being released.

We could get some important pieces of information on distribution and growth of released eels in the river. These eels grew slowly and got much thinner as compared with natural eels. We may have to try to estimate other population parameters of stocked eels and to find new strategies of effective stocking to the eel population by continuing ecological researches in the river in a long term.

Key words: *Anguilla japonica,* Japanese eel, Pectoral fin clipped eel, Stocked eel population, Fatness condition

The Japanese eel *Anguilla japonica* is one of the most important stock of inland water fisheries in Japan. The catch of both yellow eels and silver eels was 817 ton in 1999. Millions of cultured eels are stocked in both rivers and lakes every year. However, some of fisheries scientists are concerned about the present state of eel population, because of a decreasing tendency in the catch[(1)]. Unfortunately, we have very few ecological studies and also few research reports on this eel population in inland waters. Therefore, we only have a poor idea to make

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up eel population dynamics models and also eel fisheries management strategies.

Then, we planned to estimate eel population parameters on both survival processes and growth processes of stocked eel population in a river. But, we have not enough data, because we started just to study on this population from May 2000. We can present only some preliminary results of our research.

This study is one part in the research project for the Japanese eel population dynamics that was worked out in 1999 by the Fisheries Agency of Japan.

Materials and Methods

Cultured juvenile eels as materials to stock in a river were arranged by the Fisheries Cooperative Association of Kochi prefecture. First, these eels were given an anesthetic in a dilute solution of 4-Allyll-2-methoxyphenol (FA 100) with ice.

An eel in the anesthetized condition had the a right pectoral fin clipped off by scissors. These fin-clipped eels were put in a medicated water bath of sodium nifurstyrenate overnight.

Both wooden box traps (5.2x6.5x70 cm) and stone mound traps (about 2 m in diameter) were used to catch eels in a river. One set of five wooden traps with earthworms as bait was set each at three sites in a river every two weeks to catch eels. We asked mainly two river fishermen to recapture eels. But, we could not standardize fishing efforts on both fishing gears as data to assess eel densities during our research period.

Both recaptured eels and natural living eels which were caught independently by fishermen were measured (Total body length and weight), and were identified body color.

The River Monobe (133° 42´E, 33° 32´N) is located in Kochi prefecture on the southwestern part of Japan. The research water area is from the mouth of the river to the Machida sluice which is about 7 km upriver. We released 7,977 fin-clipped eels under the bridge 3 km from the mouth of the river.

We set four temperature loggers, Stow Away "Tidbit" (By the Onset company), in the research water area to get time series data of water temperatures every 30 minutes.

Results and Discussion

Daily changes of water temperatures in the research water area:

One of four water temperature data is shown in Fig. 1. The temperature was about 17℃ during several days after the eels were released in the river. Then the temperature raised rapidly and reached about 24℃ of maximum in May.

However it dropped down momentarily to about 18℃ during rainy days in June. After that, the temperature continued to rise and reached at about 28℃ maximum in July. And the temperature fell down quickly to about 19℃ during heavy rainy days again and recovered the maximum degree of 28℃ in August after three weeks. The temperature fluctuated from 19℃ to 21℃ in September and had low values of about 16℃ in October.

The water temperature in July was very low for long days, because much water was drained off from the dam gate after heavy rain. These low temperatures might produce harmful effects on both growth and maturity processes of stocked eels.

Releasing marked eels by a fin clipping method:

We released 7,977 marked eels at the release site about 3 km upper from the mouth of the River Monobe, on 19 th May 2000 (Table 1). The eel of 295.5 kg in total weight was stocked in the river. The average total length of individual eel was 34 cm and the average body weight was 37 g. After released, eels dug themselves into the muddy bottom or sneaked into gaps between stones or rocks and hid in them.

Number of recaptured eels and its ratio to catch of natural living eels:

The catch number of both marked eels and natural living eels was 1,053 in total from 19th May, the release day, to 30th September, 2000, by adding our

records to fishermen's reports. The catch number of both eels increased every month and reached a maximum number of 329 eels in August (Fig. 2). After then, the catch dropped to 130 eels in September. These catches may correspond to monthly water temperature changes. The number of recaptured eels was 92 in total. The recapture rate in total was 1.15% within our research period, because of 7,977 stocked eels. The ratio between the number of recaptured eels and the total number of catch was 8.7% in total. This ratio varied monthly from 6.1% in August to 13.4% in June. However, this ratio did not show seasonal changes. We thought that water temperatures might not produce different effects on feeding behavior or movement of both stocked eels and natural living eels.

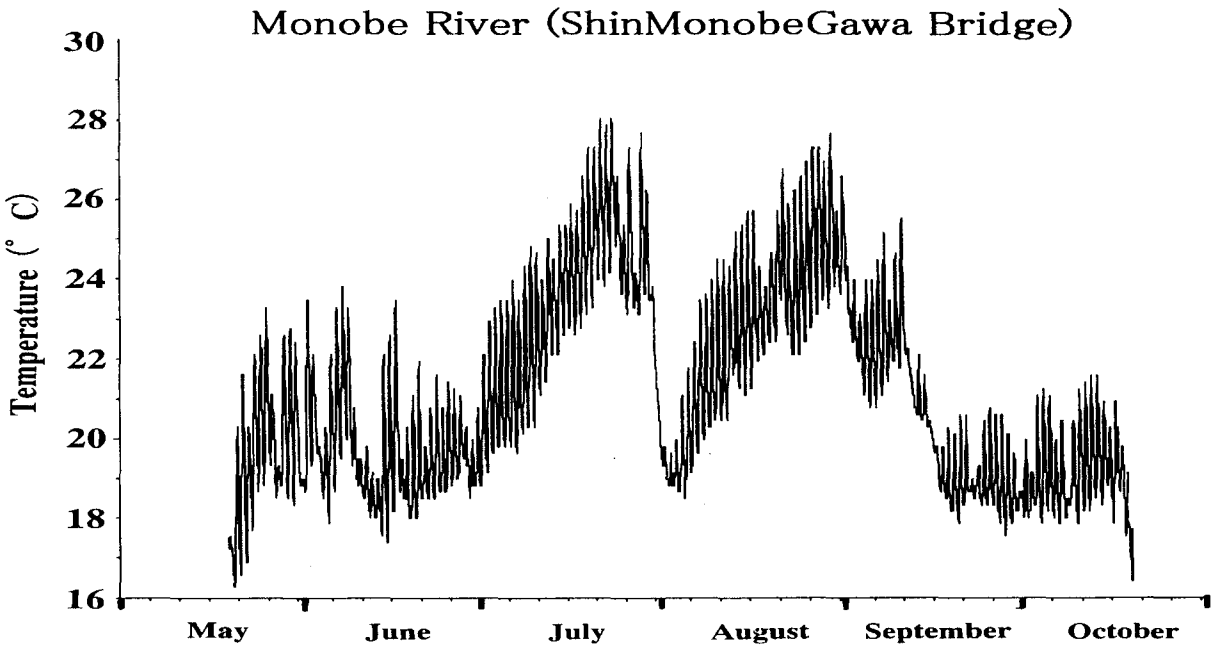

Fig. 1. Water temperatures (℃) in the River Monobe near the bridge ShinMonobe. The water temperature about 1 m from the surface of the river was measured every 30 minutes by a data logger of the StowAway "Tidbit" of the Onset company.

Table 1. Stocked juvenile eels in the River Monobe, Kochi Prefecture, Japan, on 19th May 2000. 50p means 50 eels per 1 kg of total weight. 30p means 30 eels per 1 kg of total weight.

Size	*Total body length (cm)*	*Body weight (g)*	*Total weight (kg)*	*Number*
50 p	29.56±2.80	18.44±5.06	34.58	1,875
30 p	34.87±1.77	42.76±7.54	260.92	6,102
total	34.25	37.04	295.50	7,977

Distribution of marked eels in the research water area:

Number of recaptured eels in month is shown in parenthesis within every a 1-km radius from the release site on the map of research water area (Fig. 3). Three eels were recaptured within both one km downstream and up stream from the release site in May (Fig. 3 - a). One eel was recaptured at the water area between 3 - km spot and 4 - km spot near the Machida Sluice, and also one eel at the water area between 2 - km spot and 3 - km spot near the mouth of river, respectively. We may guess that marked eels were distributed in all parts of research water area soon after being released. Twenty-one eels were recaptured within a 1 - km of radius from the release site in June (Fig. 3 - b). Although many eels were recaptured near the release site in July, the number of recaptured eels increased at both places between 3 - km spot and 4 - km spot near the Machida sluice and between 1 - km spot and 2 - km spot below the release site than before (Fig. 3 - c).

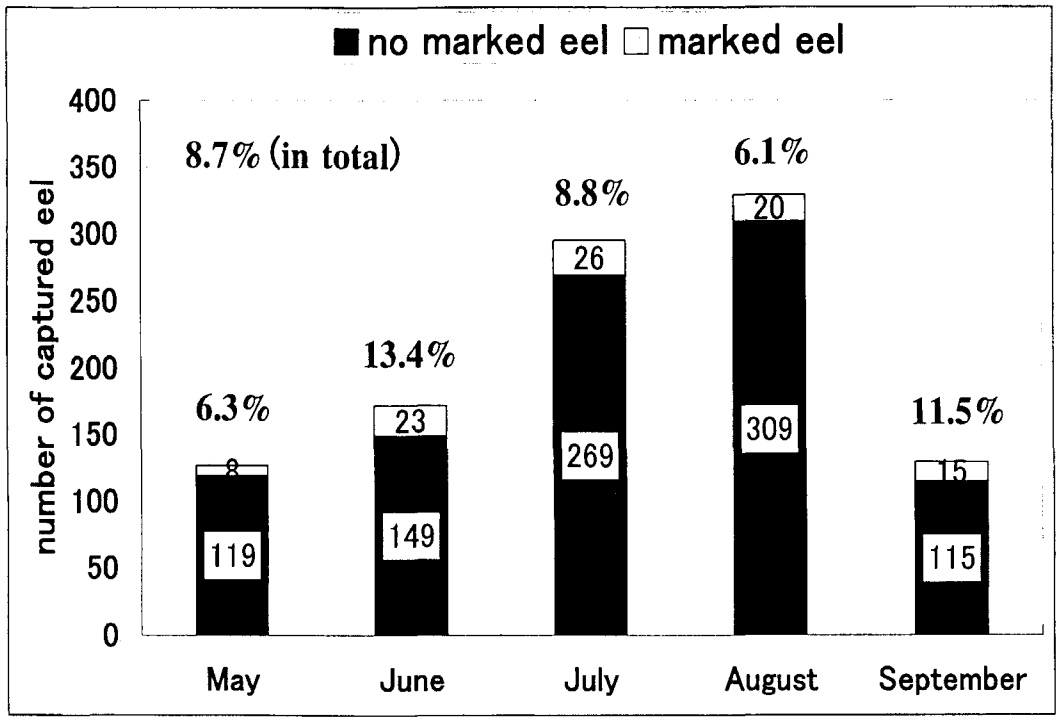

Fig. 2. The number of eels captured by both wooden box traps and stone mound traps in each month. Black bar graph indicates the number of non-marked eels. White bar graph indicates the number of marked eels. The ratio of the number of marked eels to a total number of eels is showed in percent.

After July, number of recaptured eels increased at the downstream from the release site as compared with that at the upper stream (Fig.3-d & e). Percent ratios of number of recaptured eels in each 1-km unit area to a total recapture number from May to September were shown in Fig.3-f. There was no fishing report of marked eels in the upper stream than the Machida sluice. The ratio of recaptured eels within 1-km from the release site was 58% of total catches. As a whole, most of stocked eels may stay in

a water area near the release site during these months, in spite of only 7 km river distance to the sluice.

Growth process of stocked eels:

We could measure 34 recaptured eels in total body length during a research period. The average total length in month was shown in Fig. 4. These average values were 38.0 cm in May, 35.6 cm in June, 35.9 in July, 37.1 cm in August and 35.6 cm in September, respectively. But, only one eel was measured it each in both May and June. The total body length in average after about four months was mostly same as 34.2 cm of the size at the release day in May (in a parenthesis). We could not discuss a growth rate of stocked eel with some living environmental conditions such as amount of food, eel density and so on, because of lack of data about them. It is so difficult to get some conclusions on growth of stocked eels, because of poor data. Even so, we thought that stocked eels might have only a little increment of body length during these months.

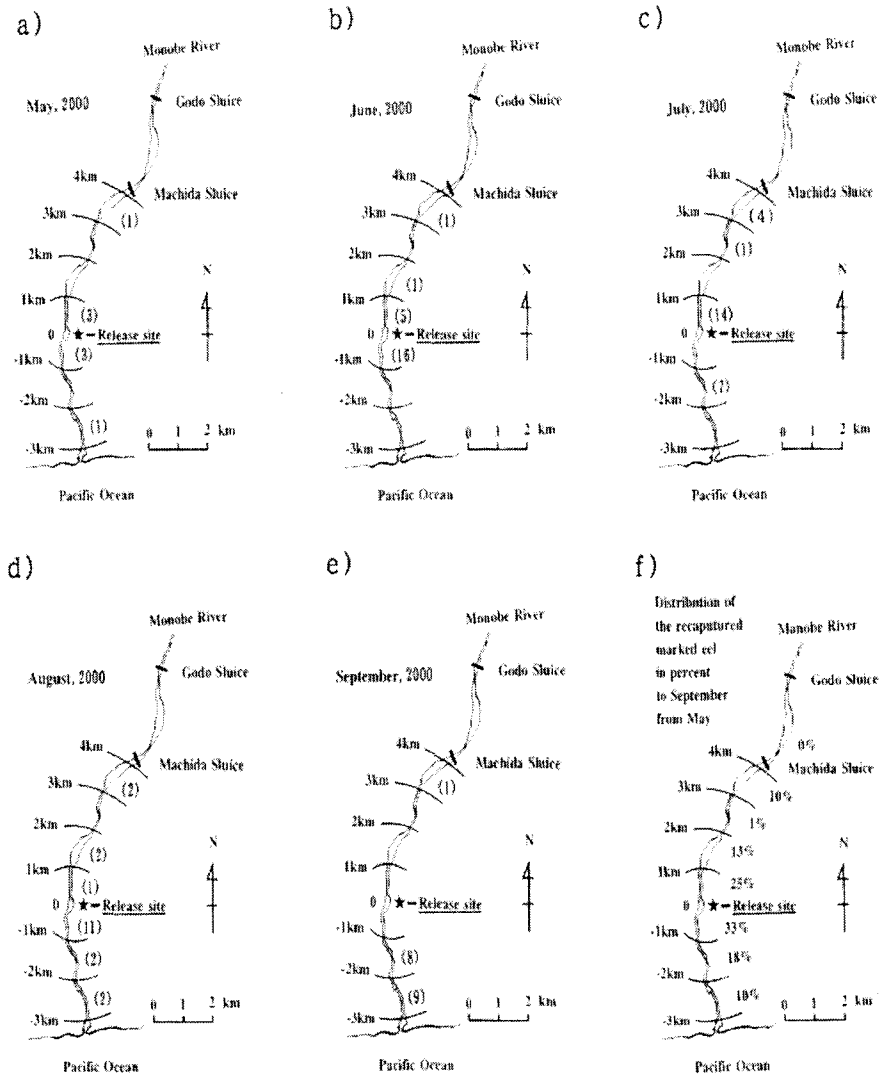

Fig. 3. Distribution of recaptured marked eels on the map of river in each month.
A small letter of the alphabet from a to e indicates from May to September. A number in parenthesis shows a number of recaptured eels. The ratio of a number of recaptured eels in each 1 km unit water area to a total number of recaptured eels from May to September is shown on the figure 3-f.

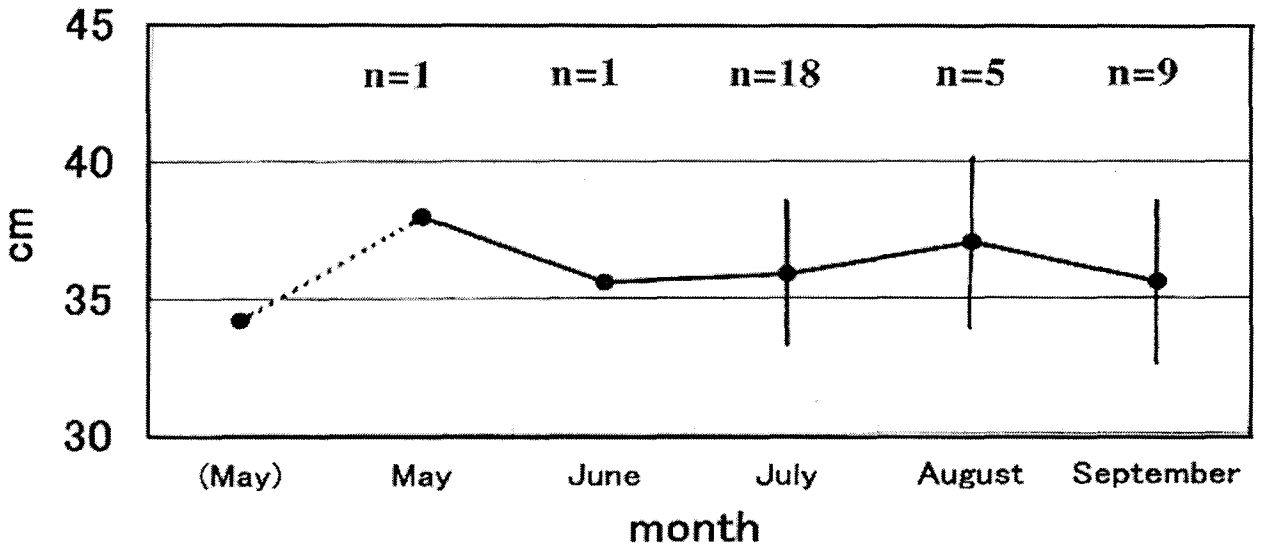

Fig. 4. Average total body length (cm) of marked eels in each month.
May in parenthesis means the month when marked eels were released in the river.

Fatness condition of stocked eels:

Relationships between total body length and body weight on both stocked eels and natural living eels from July to September are shown in Fig. 5. In this figure, we used a range from 25 cm of the length to 45 cm. We used an allometric growth function (logarithmic function) to make a comparison between their fatness condition. In the case of marked eels (y2), the constant of slope was 2.72. This constant, namely a coefficient of fatness, was smaller than 3.63 in the case of non marked eels (y1). This means that marked eels have lost their weight as compared with that of non marked eels. The total coefficient of determination for y2-variables ($R2^2$) was 0.626. This coefficient was smaller than 0.890 of $R1^2$. This means that the difference in fatness condition among individuals of stocked eels was larger than that of non marked eels.

Body color changes of stocked eels:

The ratio of the number of yellowing body to total number of recaptured eels is shown monthly in Fig. 6. No yellowing body eel was recaptured in May. In June, the ratio was only 4.5%. However, this ratio increased suddenly to 69.2% in July and 70% in August. And also it was 53.3% in September. The marked eel of 49% has changed into yellowing body until September. The body color of stocked eel was blue black, because it was a cultured eel. On the contrary, this yellowing body was almost similar to the body color as a natural living eel. This means that a half of stocked eels have adapted to new habitats in this river for two months after released. This was very important observation If cultured eels become similar to the body color of natural living eel for several months and live in a same life style, it would be very effective to stock juvenile eels in a river. If so, we have to find out new strategies of stocking to be effective in practice for both fishery production and reproduction.

The summary is as follows. We could examine some parts of both distribution and growth processes on a stocked eel population in the River Monobe at least. Marked eels distributed widely in a water area of 7 km from the mouth of the river for about one month after release, but most of eels may live near the site of release. Most of the stocked eels became

lean as compared with natural living eels. About half of the number of recaptured eels has changed into yellowing body which is similar to the body color of natural living eel.

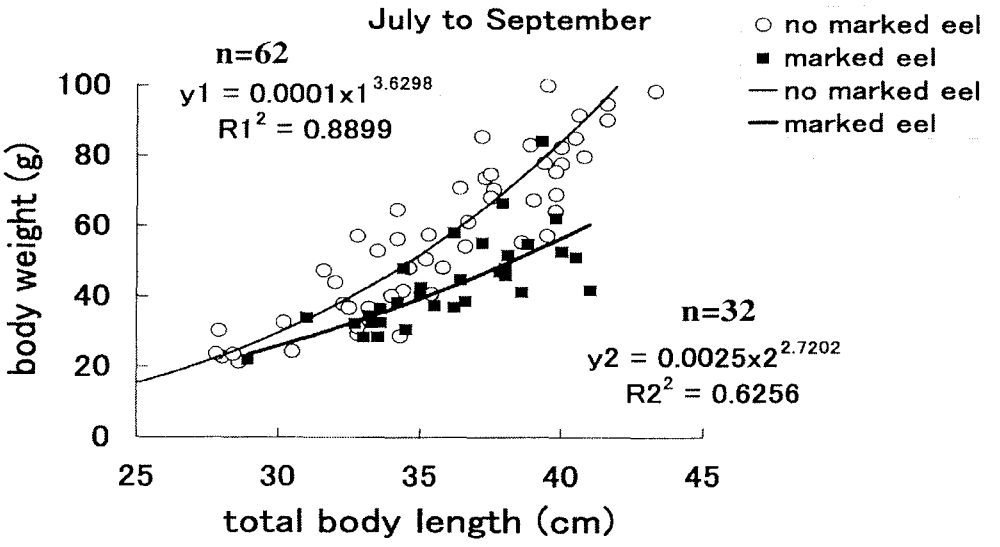

Fig. 5. Relationships between total body length and body weight of eels.
A nomarked eel is indicated by a white circle and a marked eel by a black square. The formula is an allometric function on growth. y1 is a body weight of non marked eel (by a regular line), x1; total body length, $R1^2$; total coefficient of determination for y1-variables, and also y2, x2 and $R2^2$ for marked eels (by a thick line). n is a number of eels.

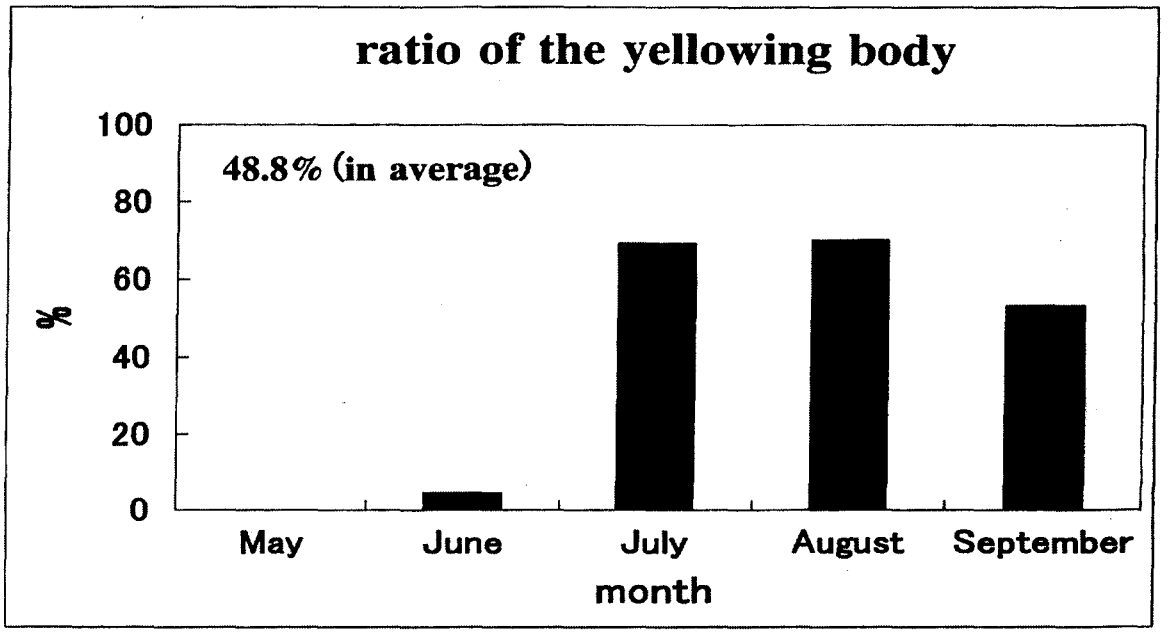

Fig. 6. The percent ratio of the number of yellowing body eels to the total number of recaptured eels in each month.

In the future, we may be able to estimate other population parameters of marked eels and to find new strategies of effective stocking of the eel population by continuing long term ecological researches in this river.

References

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