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The Growth of the Freshwater Crayfish (*Astacus leptodactylus* Eschscholtz, 1823) Juveniles Until the First Sexual Maturity Age in Concrete Fish Ponds

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Abstract: In this study, freshwater crayfish (*Astacus leptodactylus*, Eschscholtz,1823) juveniles reared until the first sexual maturity age in the concrete fish ponds and growth and survival rates were investigated. The juvenile crayfish with initial weights of 67±3.48 mg and total lengths 10.1±0.4 mm (2130 pieces) was put into two concrete ponds, 400×140×75 cm in sizes and fed with trout food and fresh trout meat 3 times a week. The juvenile crayfish hatched until the 1st week of June, reached 1.038±0.23 g weight and 4.82±0.02 cm total length in the 1st year, 6.320±0.43 g weight and 6.34±0.80 cm total length in the 2nd year and 21.97±4.21 g weight and 9.81±1.93 cm total length in the 3rd year. At the end of the third year it was observed that 62 crayfish out of 97 laid eggs and the rate of survivals were 10.44% (97 female, 137 male).

Key words: *Astacus leptodactylus*, freshwater crayfish, growth, maturity, juvenile, concrete pond

INTRODUCTION

The only native crayfish species in Turkey, *Astacus leptodactylus* is widely distributed in lakes and ponds in many parts of the country. It is also known as Turkish, Galicia, swamp or pond crayfish (Harlioglu, 2004). *A. leptodactylus* lives in deep and shallow lakes, small streams, large rivers, ponds, dams and has become adapted to living in estuarine conditions (Koksal, 1988). Artificial culture of *A. leptodactylus* is still not operation in Turkey. All harvests are obtained from the wild (Harlioglu and Harlioglu, 2004). Harvest of *A. leptodactylus* from nature in Turkey varied from 3885-7936 tons between 1977 and 1984 (Koksal, 1988). The production of *A. leptodactylus* after 1985 decreased dramatically in most Turkish lakes as a result of crayfish plague (Baran *et al*., 1987; Rahe and Soylu, 1989; Harlioglu and Harlioglu, 2004). The harvest was 551 tons in 1995, 850 tons in 1996, 1.100 tons in 1997, 1.500 tons in 1998, 1.372 tons in 1999, 1.681 tons in 2000, 1.634 tons in 2001, 1.894 tons in 2002, 2.183 tons in 2003 and the harvest increased to 2.317 tons in 2004. But after 2004, the harvest went down to the level of 809 tons in 2005 and 797 tons in 2006 (Anonymous, 1995).

In terms of their growth, there are two contrasting life-history strategies in crayfish; fast growing and short lived (warm water species) and slow growing and long-lived (cool water species). Cool water species such as *A. leptodactylus* grow slowly. Most of astacid crayfish mature in 2-4 years (Harlioglu, 1999). In *A. leptodactylus*, breeding season begins with the decrease in water temperature. In the lake district in Turkey mating occurs in November at 7-8°C and spawning commences in early December at 4-6°C (Koksal, 1988; Harlioglu, 1999). The eggs hatch during the late May when the water temperature is 21-23°C and last until the third week of June. After hatching, the young remain with their mother for about 20-25 days. During this period, the juveniles molt once and then leave their mothers to begin to live independently in shallow waters (Aydin and Dilek, 2004).

The purpose of this study is to investigate the growth and maturity of *A. leptodactylus* juveniles in the concrete fish ponds. Recently, as a research topic freshwater crayfish farming gained momentum in Turkey which primarily focused on egg incubation and nutrition Koksal, 1988; Koksal *et al*., 1992; Aydin and Dilek, 2004; Harlioglu, 1999, 2000, 2009; Mazlum and Uzun, 2008).

However, there are no studies which documented the growth and maturity process of *A. leptodactylus* in concrete fish ponds. As a respond to fill this gap, this study investigated freshwater crayfish (*Astacus leptodactylus* Eschscholtz, 1823) juveniles rearing experiment until the first sexual maturity age in the concrete fish ponds.

MATERIALS AND METHODS

The brood stocks of freshwater crayfish used in this study were obtained from Iznik Lake, Bursa. In the beginning November 2007, crayfish were collected using fyke nets (pinters) and transported to the trout farm in Karamursel, Kocaeli. About 100 crayfish with an average

Table 1: Water quality analysis parameters

Parameters (mean)	October-March	May-August
Dissolved Oxygen (DO) (mg L^{-1})	7.500	7.20
Water temperature (°C)	8.900	17.30
Total hardness (mg L^{-1})	118.000	121.00
Calcium (Ca^{2+}) (mg L^{-1})	47.380	49.13
Magnesium (Mg^{2+}) (mg L^{-1})	8.330	8.11
pH	7.710	8.13
Chlorine (Cl^{-}) (mg L^{-1})	2.660	2.34
Aluminum (Al^{3+}) (mg L^{-1})	0.059	0.07
Carbon dioxide (CO_2) (mg L^{-1})	5.300	5.20

weight of 54.34±3.44 g and 112.4±8.5 mm total length (50 female, 50 male) were stocked into two concrete ponds (400×140×70 cm) with 50 cm water depth (1750 L) for mating and spawning. As hiding places for the crayfish, perforated bricks and plastic pipes were installed. The major water quality parameters are shown in the Table 1.

Mating started on November 21, 2007 in these concrete ponds and 87% of the crayfish deposited their eggs by January 16, 2008. After the males mated, they were removed and transported to other ponds. Gravid females were kept in these ponds by hatching time and fed fresh trout meat twice a week *ad libutum*. The juveniles that hatched and left their mothers were fed with *Artemia* sp. and *Daphnia* sp. for 3 weeks later, the juveniles were fed with crunched fresh trout meat and trout food in turn. In order to count the juveniles during the study, the ponds were cleaned (i.e., after lowering the water level) twice a year. The juveniles the carapace, total lengths and weights were measured, disregarding their gender.

RESULTS AND DISCUSSION

Regarding the mating, the crayfish continued breeding and began to mating in the last week of December 2004 and that all the female crayfish laid eggs by January 15, 2005. When measured, the diameters of the eggs were found to be 2.68±0.094 mm. The embryonic development of the eggs beneath the abdomens of the female crayfish lasted about 4.5-5 months. The 1st young larva was observed on May 17, 2005 and by June 15, 2005, all the other larvae hatched. Although, the water temperature inside the ponds differed depending on the air temperature during egg incubation, it stayed between the values shown in Table 1. During the egg incubation period which lasted about 5 months and 18 female crayfish out of 100 died. The eggs of some crayfish were found dead either partially or completely Fig. 1.

Regarding their physical features, the average weight of the newly hatched crayfish which got adult from was determined as 0.67±0.03 g, carapace length 0.66±0.03 cm and total length 1.01±0.04 cm. It was observed that new crayfish left their mothers after staying on or around them for a while changing their second shells. After this period, female crayfish were also removed from ponds in order not to disturb the juveniles Fig. 2.

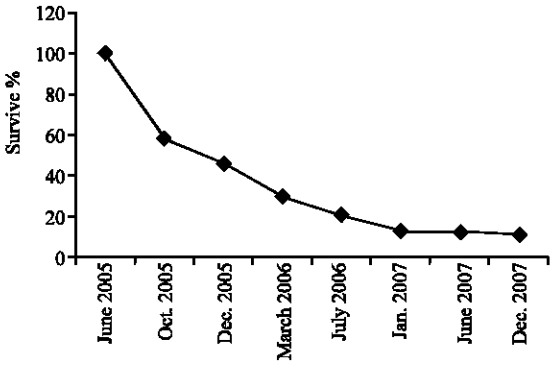

Fig. 1: Survival rate of *A. leptodactylus* juveniles for 3 years

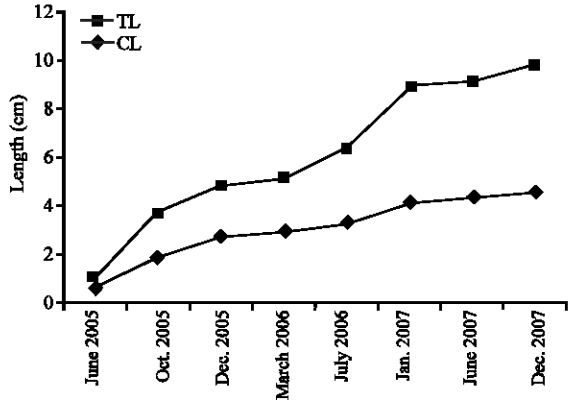

Fig. 2: Carapace and total length growth of *A. leptodactylus* juveniles

During the weighing and measuring on June 25, 2005, the number of the crayfish was counted and 2130 pieces of juvenile crayfish were put equally into two concrete ponds (190 pieces m^{-2}). The rise of alive weight, carapace and total length of the juveniles, grown in fish ponds were measured twice a year.

The alive weight of the juveniles was found in the 1st year (2005) in December as 1.038±0.23 g, 2nd year (2006) in June 6.320±0.43 g and at the end of the 3rd year (2007) 21.97±4.21 g. And the average carapace length was found in the same dates in turn, 2.81±0.03, 3.35±0.08 and 4.61±0.89 cm, average total length was in turn, 4.82±0.02, 6.34±0,80 and 9.81±1.93 cm (Table 2 and Fig. 3).

On June 25, 2005, the 2130 pieces of juveniles put into two concrete ponds equally (190 m^{-2}) and were 986 pieces in December 2005, 441 pieces in June 2006 and 234 pieces in December 2007 (i.e., 97 of them were female, 137 of them were male). The total death rate recorded as 89% (1896 pieces) from June 2005-December 2007. The crayfish used in the study started to mate in the last week of December 2007 under 8.2°C water temperature

Table 2: *Astacus leptodactylus* juveniles alive weight, carapace and total length growth

Date	Weight (g)	C.L (cm)	T.L (cm)	Crayfish number
25 June 2005	0.067±0.03	0.66±0.03	1.01±0.04	2130
October 2005	0.648±0.65	1.93±0.02	3.66±0.03	1239
December 2005	1.038±0.23	2.81±0.03	4.82±0.02	986
March 2006	3.910±0.75	2.94±0.05	5.10±0.08	656
June 2006	6.320±0.43	3.35±0.08	6.34±0.80	441
January 2007	12.220±3.11	4.15±0.55	8.87±1.34	283
June 2007	15.540±3.81	4.41±0.58	9.12±1.49	265
December 2007	21.970±4.21	4.61±0.89	9.81±1.93	234

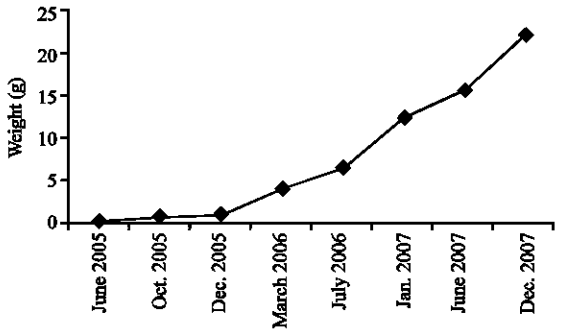

Fig. 3: Increase of the live weight *A. leptodactylus* juveniles

and 62 crayfish out of 97 laid eggs on January 12, 2008. The development and growth of freshwater crayfish differ depending on the temperature, chemical structure and the nutrition facts of the water they in. Since the moulting occurs more in those waters that have the optimum standards, the growth is also faster (Celikkale, 1994). Alderman and Wickins (1990) have stated that the water temperature should be over 16°C for a quality development of crayfish in their natural habitat and that the water temperature ought to be below 14°C at least during three months a year in order to get a good breeding. The chemical and physical specifications of the water we used in our study have been found close to those of these researchers.

Alpbaz (1993), Celikkale (1994) and Kumlu (2001) have found that *A. leptodactylus* reached the sexual maturity with an 8-9.5 cm length after 3 or 4 years and that mating was seen at the end of October in November or in December, changeable to the regions. Balik *et al.* (2005) have calculated the first sexual maturity length as 97.9 mm for the female *A. leptodactylus*.

Ackefors (1993) has stated that the Pacifastacus and Astacus types reached their sexual maturity with 60-125 mm length in 2 or 6 years and that climate, sex and nutrition facts affected the situation. In the study, the *Astacus leptodactylus* juveniles reached a total length of 9.81±1.93 cm and 21.97±4.21 g weight at the end of the 3rd year. Researchers have found that the water temperature, stock intensity and feeding are the main factors which affect the growth and living rate of juveniles in crayfish growing (Arringnon, 1981; Koksal *et al.*, 1992). Koksal *et al.* (1992) stocked the *Astacus leptodactylus* juveniles that have an average weight of 70 mg into the concrete ponds in intensity of 100 pieces m^{-2} and after feeding with four different foods during four months they obtained a living rate between 66.31 and 76.67% and 560-1220 mg alive weights. In the study, the juveniles with average weight of 67 mg were stocked into concrete ponds in a rate of 190 pieces m^{-2} and after 5 month feeding (15 June 2005-15 December 2005), the living rate was 46.2% and average living weight 1.038±0.23 g. The living rate we obtained in our study is lower than to those of Koksal *et al.* (1992). The reason is the high stock intensity at the beginning and long term (2 months) feeding period.

Arringnon (1981) reported that the *Astacus astacus* reached the total length of 30-40 mm in the 1st year, 59-63 mm 2nd year and 73-81 mm in the 3rd year. Kalma informed that the freshwater crayfish juveniles grew by 2-8 cm in one year in the natural environment depending on the water temperature and nutrition facts of their habitat. It was seen that the crayfish juveniles that used in the study, reached the total length of 4.82±0.02 cm in the 1st year, 8.87±1.34 cm 2nd year and 19.81±1.93 cm 3rd year.

Researchers stated that the freshwater crayfish enjoyed consuming the vegetative and animal nutritions (Arringnon, 1981; Koksal *et al.*, 1992; Koksal, 1988) had the *A. leptodactylus* juveniles grown by 198.64-221.66 mg feeding with trout food and fibrous green algae in 45 days. Also in this study, the crayfish juveniles were fed with trout food, fresh trout meat and the natural food in the ponds until the end of study. The growth rates were shown in Table 1.

CONCLUSION

As a result, reared in the fish concrete fish ponds at the end of the 3rd year *A. leptodactylus* juveniles reached 21.97±4.21 g weight, 4.61±0.89 cm carapace length, 9.81±1.93 cm total length and 62 out of 97 pieces of female crayfish reached the first sexual maturity and laid eggs.

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