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Adaptation of Crayfish (*Astacus leptodactylus* Eschscholtz, 1823) to aquaculture environment in Bafra fish lakes (Samsun-Turkey)

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Abstract
In this study, it was aimed to adapt the crayfish obtained from Bafra Fish Lakes (Samsun-Turkey) to the aquaculture environment. Weight gain (%), specific growth rate (%g/day) and daily live weight gain (g/day) were determined during the adaptation period. At the initial and final of the study, the average length of crayfish was 11.06±0.14-13.04±0.17cm, carapace length 50.98±0.77-60.82±1.25mm, carapace width 28.23±0.43-33.36±1.12mm, abdomen length 53.89±0.76-64.55±1.24mm, abdomen width 25.92±0.52-30.69±0.67mm, claw length 39.08±1.59-46.25±5.13mm, claw width 15.71±0.47-18.52±1.58mm, weight 42.45±1.90-57.37±2.22g. The average weight gain of crayfish was 35.14±3.21%, the average specific growth rate was 0.30±0.01% and the average daily live weight gain was 0.04±0.03%. As a result, it was determined that the growth values of the adapted crayfish were low due to feeding, and the mortality rate was high during the stressful periods when the water temperature started to rise and the shell change occurred.

Keywords: *Astacus leptodactylus*, crayfish, aquaculture, adaptation, growth

1. Introduction
Crayfish are cultivated shellfish found in rivers, lakes and reservoirs in many countries around the world. Crayfish are represented by 737 species and subspecies in the world and approximately 15 of these species are of economic importance [1]. Although there are many species, Parastacidae, Cambaridae and Astacidae are known as the economically important families in hunting and aquaculture.
The natural habitat of crayfish in the Astacidae family is the inland waters of the northern hemisphere. The species known as narrow-clawed crayfish (*Astacus leptodactylus* Eschscholtz, 1823) is the only species in the inland waters of Turkey. There are two subspecies of this species (*Astacus leptodactylus* Eschscholtz, 1823 and *Astacus leptodactylus salinus* Nordmann, 1842) [2].
The food sources of crayfish, which have omnivorous diets, are based on detritus, which are rich in microbial properties. Some of the food may be animal (worms, insects, molluscs and zooplankton) or plant-based [3]. Until 1984, Turkey was one of the countries that had a say in the crayfish market in Europe, but the introduction of the crayfish plague (*Aphanomyces astaci*) disease into our waters caused the production from natural crayfish stocks to decline to low levels. For this reason, in order to support crayfish populations and to create new crayfish production areas, it is of great importance to conduct research on the production and breeding of these creatures [4-14].
In the study, it was aimed to ensure the adaptation of crayfish obtained through hunting by feeding in the aquaculture environment.

2. Material and Method
The crayfish used in the study were obtained from Bafra Fish Lakes (Samsun-Turkey) by fishing 48 crayfish (31 females, 17 males). A pinter was used to catch the crayfish. The captured crayfish were brought to Sinop University, Faculty of Fisheries, Research and Application Unit live in moistened styrofoam boxes.

Crayfish were stocked in 200×100×50cm tanks with a water height of 40cm. Water temperature, dissolved oxygen and pH values were measured daily with YSI multi-parameter meter. In-tank water change was 10% daily and continuous ventilation was provided with a central system. Plastic pipes with a diameter of 70mm and a length of 150mm were placed inside the tanks to prevent cannibalism. At the initial of the study, crayfish were subjected to adaptation and those with unsuitable morphological and nutritional performance were separated. Crayfish were fed for 12 months in the study. Feeding was done twice a day in the morning (09.00) and evening (16.00) and commercial feed (trout feed) with 48% crude protein and 18% crude fat was used. Morphometric measurements of crayfish were made every 2 months. The length measurements of the crayfish were made using a length measuring board with a precision of 0.1mm and weights were made using a scale with a precision of 0.01g. Total length, abdominal length, abdominal width, carapace length, carapace width, cheliped length and cheliped width of crayfish were measured using a digital caliper with a precision of 0.01 mm according to Rhodes and Holdich [15].

Weight gain (%), specific growth rate (%g/day) and daily body weight gain (g/day) were calculated using the following formulas [10].

Weight gain (%) = $(W_t - W_0 / W_0) \times 100$

Specific growth rate (%g/day) = $((\ln W_t - W_0) / t) \times 100$

Daily live weight gai n (g/day) = $(W_t - W_0) / t$

Survival Rate (%) = (Number of crayfish at the end of the period / number of crayfish at the initial) x 100

W_t: Weight at end of period (g)

W_0: Weight per period (g)

t: day

3. Results

In the study, the average water temperature was 16.29±0.15 ℃, the dissolved oxygen value was 6.02±0.29mg/lt and the pH was 8.40±0.05. Determined morphometric measurements of crayfish are given in Table 1 and Figure 1.

Table 1. Morphometric measurements

	TL (cm)	CL (mm)	CW (mm)	AL (mm)	AW (mm)	CLL (mm)	CLW (mm)
Initial	11.06±0.14	50.98±0.77	28.23±0.43	53.89±0.76	25.92±0.52	39.08±1.59	15.71±0.47
Period 1	11.12±0.14	51.44±0.77	28.40±0.44	54.20±0.71	26.08±0.47	39.19±1.52	15.82±0.47
Period 2	11.19±0.18	51.79±1.07	28.57±0.51	54.55±0.91	26.24±0.50	39.44±2.28	15.86±0.65
Period 3	11.46±0.11	52.99±0.52	29.25±0.36	55.85±0.69	26.87±0.56	40.38±1.52	16.28±0.45
Period 4	12.02±0.16	55.65±0.83	30.69±0.39	58.60±1.71	28.19±0.86	42.87±2.46	17.08±0.84
Period 5	12.75±0.10	59.96±0.84	32.54±0.48	63.14±0.61	29.89±0.97	44.98±3.83	18.11±1.31
Final	13.04±0.17	60.82±1.25	33.36±1.12	64.55±1.24	30.69±0.67	46.25±5.13	18.52±1.58

TL: Total Length, CL: Carapace Length, CW: Carapace Width, AL: Abdomen Length, AW: Abdomen Width, CLL: Claw Length, CLW: Claw Width

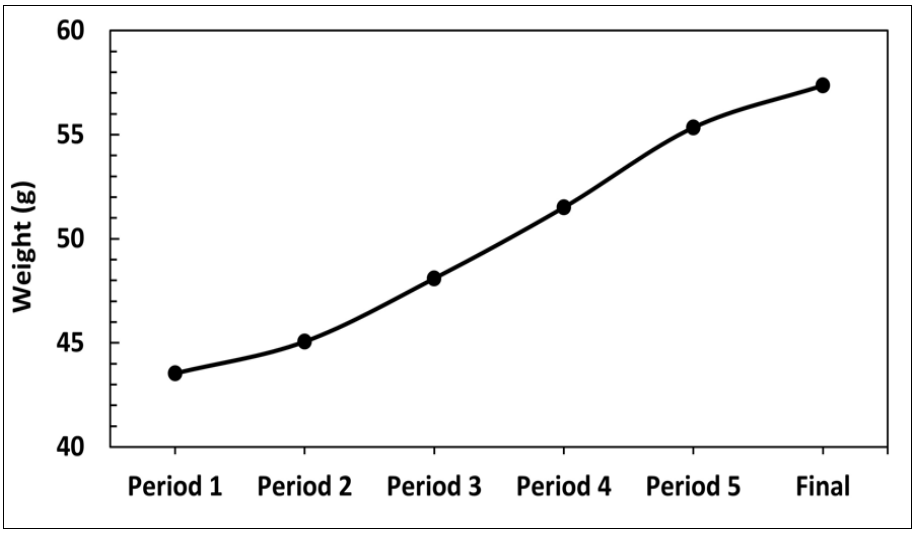

Fig 1: Weight values

The initial weight of the crayfish was 42.45±1.90g and the final weight was 57.37±2.22g. In the study, the average inter-period weight growth rate was 5.17±0.88% and the average weight growth rate between the initial and the end was 35.14±3.21%. The average specific growth rate of crayfish was 0.30±0.01% and the average daily live weight gain was 0.04±0.03% (Figure 2).

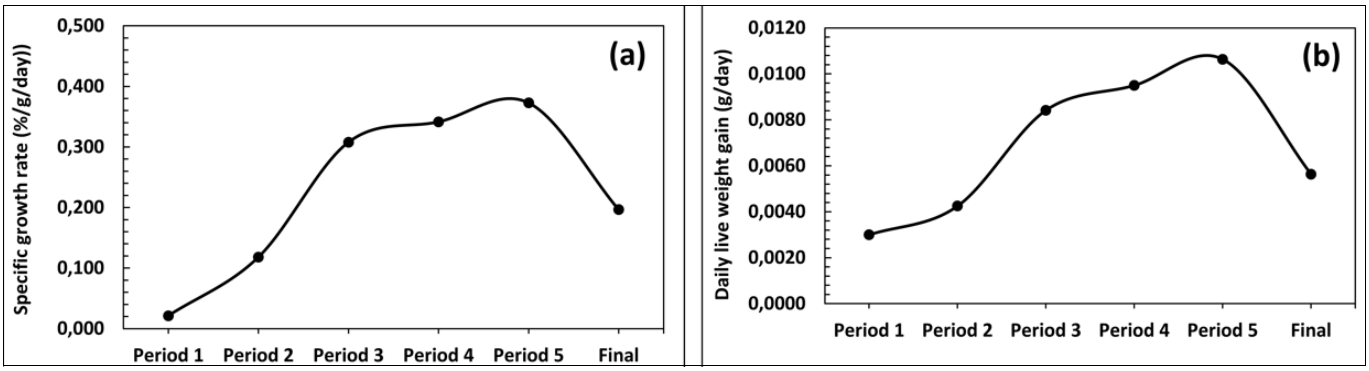

Fig 2: (a) Specific growth rate (b) Daily body weight gain values

Crayfish survival rate and water temperature values are given in Figure 3.

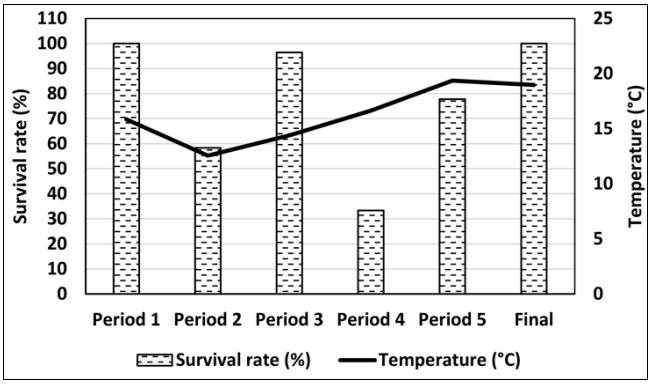

Fig 3: Survival rate and water temperature values

In the study, water temperature values were determined between 10.3-22.9 ℃ with an average of 16.29±0.15 ℃. During the adaptation period at the initial of the study (period 1-2), mortality rates increased with the decrease in water temperature. Stress-induced mortality rate was highest (67%) between the 2nd-5th period when the water temperature started to increase and in the 4th period when shell change was observed.

4. Discussion and Conclusion

In the study, it was aimed to ensure the adaptation of the crayfish obtained by fishing by feeding them in the aquaculture environment. The average initial length of the crayfish was 11.06±0.14cm, carapace length 50.98±0.77mm, carapace width 28.23±0.43mm, abdomen length 53.89±0.76mm, abdomen width 25.92±0.52mm, claw length 39.08±1.59mm, claw width 15.71±0.47mm. At the end of the experiment, the average length of the crayfish was 13.04±0.17cm, carapace length 60.82±1.25mm, carapace width 33.36±1.12mm, abdomen length 64.55±1.24mm, abdomen width 30.69±0.67mm, claw length 46.25±5.13mm, claw width 18.52±1.58mm.

The initial weight of the crayfish was 42.45±1.90g and the final weight was 57.37±2.22g. The mean weight gain was 35.14±3.21%, and the specific growth rate was 0.30±0.01% on average. In the studies performed, Valipour *et al.* [10] weight gain 44.17±6.96%, specific growth rate 0.37±0.05, Nedaeia *et al.* [11], weight gain as 38.24±3.12%, specific growth rate as 0.33±0.08, Rezaei *et al.* [13] reported weight gain as 13.09±0.15g and specific growth rate as 0.68±0.01. It is thought that the differences in other studies are due to the fact that the adaptation to the environment is not fully achieved, and that the feed intake remains low and the growth values are affected. Nutrition is one of the most important conditions for living things to survive. It is necessary for this to be sufficient and balanced in order for the creature to undergo healthy changes in the life process. One of the most important features of the crustacea group is that they have periods of shell change during the life process, unlike other living things. This period is a fundamental part of the organisms existence such as survival, growth and reproduction [16, 17]. Organisms that are expected to adapt to different environments are expected to provide good nutritional and reproductive performance. It is especially important to know the nutritional characteristics of the organisms that are taken from the natural environment and to feed them with feed that can meet their needs. It is thought that the adaptation of crayfish, whose natural habitats are the ground areas of water resources and known to show omnivorous feeding characteristics, to both aquaculture environment and culture feed is a very long and difficult process, and at the same time, it is thought to show low survival rate under different stress conditions.

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