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Determination of meat productivity and biochemical composition of freshwater lobster (*Astacus leptodactylus* Eschscholtz, 1823) in Lake Tatlı and Lake Gici from Bafra Fish Lakes

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Abstract
In this study, it was aimed to determine the meat productivity and biochemical compositions of freshwater lobster (*Astacus leptodactylus* Eschscholtz, 1823) in Tatlı and Gıcı Lakes from Bafra Fish Lakes. The research was carried out by monthly fishing of freshwater lobsters using Pinters at the stations determined between November 2018 and October 2019. While 105 of the 242 freshwater lobsters caught in Tatlı Lake were female and 137 male, 87 of the 216 freshwater lobsters obtained in Gıcı Lake were found to be female and 129 as male. In the study, the average total length and an average weight of freshwater lobsters in Tatlı Lake were determined as 10.27±0.09 cm and 33.76±0.88 g, respectively. In Lake Gıcı, the mean total length was 10.44±0.41 cm and the average weight was 37.15±1.91 g. While the total meat yield of female and male lobsters obtained from Tatlı Lake was 15.27±0.51% and 15.13±0.64%, respectively, the total meat yield of female and male lobsters obtained from Gıcı Lake was 15.18±0.59% and 15.51± 0.69.%, respectively. Crude protein, crude oil, crude ash and moisture values were determined as 16.10±0.23, 0.59±0.39%, 1.60±0.24% and 81.60±0.26%, respectively, in lobsters obtained from Lake Tatlı. In lobsters, it was determined as 15.49±0.13%, 0.61%±0.06%, 1.57±0.36% and 82.24±0.19%, respectively.

Keywords: Tatlı Lake, Gıcı Lake, Bafra, freshwater lobster, *Astacus leptodactylus*, meat yield, biochemical composition

Introduction
There are more than 640 freshwater lobster species worldwide, mostly in the Americas and Australia. In our country, freshwater lobsters are only represented by the species *Astacus leptodactylus* (Eschscholtz, 1823) [1]. Among the animal products obtained in inland waters, freshwater lobsters take the second place after fish [2]. Although freshwater lobster consumption is low in Turkey, freshwater lobster is a valuable food in many European countries [3]. 76% of its dry weight is protein, besides being an important protein source, it is also rich in vitamins E and K [4]. Body composition analyzes of an organism (moisture, crude protein, crude oil, and crude ash) are indicators of determining physiological conditions. High protein and fat content represents high energy density [5]. In addition, chemical composition analyzes are considered as an appropriate method to obtain information about the nutritional requirements of crustaceans [6]. Many researchers conduct such studies to understand how nutrient intake and preservation of nutrients in different organs occur in order to support physiological events such as growth and reproduction. In crustaceans, these analyzes also provide information on how they can adapt their metabolism to environmental factors such as living environment, nutrient availability and season [6].
In this study, which is the first scientific study on the freshwater lobster population in Tatlı and Gıcı Lakes from Bafra Fish Lakes, it was aimed to determine the meat yield and biochemical composition characteristics of the freshwater lobster population.

Materials and Methods
The study was carried out in Tatlı Lake (41°34′23.20″N, 36°03′43.77″E) and Gıcı Lake (41°, 35′16.29″N, 36°03′50.48″E), which have lagoon characteristics, located in the east of Bafra town of Samsun province in the Central Black Sea Region, was carried out.

20 km away from the town center. The research material was carried out over a 12-month period in order to determine the meat yield and biochemical composition of freshwater lobster (*Astacus leptodactylus*) in Tatlı Lake and Gıcı Lake from Bafra Fish Lakes. Pinters used in commercial freshwater lobster fishing in the region were used in the study. 150 pinters were thrown into each lake, and a total of 300 pinters and 458 freshwater lobsters were caught. The freshwater lobsters caught were brought to the Sinop University Fisheries Faculty laboratory by placing them in Styrofoam boxes containing a sufficient number of ice trays and moistened inside. The lengths of the lobsters were measured using a height measuring board with a precision of 0.1 mm and a scale with a precision of 0.01 g. In order to determine the meat yield of freshwater lobsters, the abdomen and claws were cut with the help of scissors, the meat was removed with forceps and the weight of the meats was determined by weighing them separately on a 0.01 g precision scale. [7, 8]. Condition factor is expressed as the ratio of average weight to the cube of average total length [9]. Microsoft Office 2010, MINITAB 17 programs were used in the statistical analysis of the obtained data and the Excel program was used in the drawing of the graphs obtained from the data.

Morphometric parameters, meat yield, biochemical parameters in Tatlı and Gıcı Lakes were tested with One Way Anova, and the differences between values were tested with Tukey. The package program determines the differences between the values by automatically lettering them. In addition, all of the data on morphometric and biochemical parameters were evaluated by correlation analysis.

Results

In this study, it was aimed to determine the meat productivity and biochemical composition of freshwater lobster (*Astacus leptodactylus* Eschscholtz, 1823) in Tatlı and Gıcı Lakes from Bafra Fish Lakes.

While 105 of the 242 freshwater lobsters caught in Tatlı Lake were female and 137 male, 87 of the 216 freshwater lobsters obtained in Gıcı Lake were found to be female and 129 as male, and the difference between the sexes was determined to be insignificant ($p>0.05$). The values calculated in the freshwater lobsters examined in Tatlı Lake and Gıcı Lakes are respectively; mean total length 10.27±0.09 cm; 10.44±0.41 cm, 10.38±0.13 cm in females; 10.75±0.17 cm, and 10.19±0.12 cm in male freshwater lobsters, It was found to be 10.24±0.11 cm. The average weight of freshwater lobsters was 33.76±0.88 g; 37.15±1.91 g, 30.38±1.05 g in females; 35.60±1.58 g, and 36.35±1.29 g in male freshwater lobsters; ıt was determined as 38.20±1.41 g.

During the research, the condition factor of freshwater lobsters caught monthly from Tatlı and Gıcı Lakes was calculated. Condition factors calculated for all female+male individuals in freshwater lobsters caught from Tatlı Lake are given in Table 1.

In Tatlı Lake, the month with the lowest average condition factor for all male+female individuals was determined as January with a value of 2.71 and the month with the highest condition factor was determined as February with a value of 3.24 (Table 1). It was determined that the average condition factor in female individuals was the lowest in February with 2.45 and the highest value in September with 2.93, for male the lowest value was found in January with 2.77 and the highest value in October with 3.71.

In addition, while there was a statistically significant difference in condition factors between male and female individuals in Tatlı Lake ($p<0.05$), the difference between lakes was insignificant ($p>0.05$).

Table 1: Condition factors of freshwater lobsters calculated according to months in all female+male individuals in Tatlı Lake

Months	W±sh	L±sh	L^3	K
November	45.45±2.61	11.42±0.16	1489.36	**3.05**
December	37.27±1.97	10.61±0.16	1194.39	**3.12**
January	37.88±1.70	11.18±0.27	1397.42	**2.71**
February	31.63±4.80	9.92±0.49	976.19	**3.24**
March	36.91±2.55	10.96±0.23	1316.53	**2.80**
April	34.32±3.61	10.69±0.41	1221.61	**2.81**
May	28.80±3.89	9.93±0.49	979.15	**2.94**
June	20.36±3.26	8.85±0.43	693.15	**2.94**
July	26.26±2.12	9.53±0.24	865.52	**3.03**
August	30.64±2.56	9.97±0.25	991.03	**3.09**
September	33.78±2.15	10.09±0.19	1027.24	**3.29**
October	40.68±2.39	10.80±0.17	1259.71	**3.23**

It was found that the average condition factor for all female+male individuals in Lake Gıcı was the lowest in June with a value of 2.80 and the highest in September with a value of 3.51 (Table 2). The average condition factor was found to be the lowest in January with 2.42 in females, in September with the highest value of 3.06, in June with the lowest value of 2.96 in males, and in October with the highest value of 3.86. There was a statistically significant difference in condition factors between male and female individuals in Gıcı Lake ($p<0.05$).

Table 2: Condition factors of freshwater lobsters calculated according to months in all female+male individuals in Lake Gıcı

Months	W±sh	L±sh	L^3	K
November	47.95±2.15	11.35±0.26	1462.14	**3.28**
December	50.23±2.11	11.71±0.14	1605.72	**3.13**
January	33.47±2.61	10.40±0.39	1124.86	**2.98**
February	45.19±9.44	11.14±0.86	1382.47	**3.27**
March	44.83±4.09	11.31±0.37	1446.73	**3.10**
April	37.96±3.25	11.00±0.26	1331.00	**2.85**
May	26.97±3.48	9.72±0.51	918.33	**2.94**
June	23.57±3.24	9.44±0.54	841.23	**2.80**
July	28.84±2.52	9.85±0.20	955.67	**3.02**
August	26.59±2.04	9.38±0.21	825.29	**3.22**
September	35.61±2.34	10.05±0.20	1015.08	**3.51**
October	49.79±3.01	11.46±0.24	1505.06	**3.31**

Meat yields of freshwater lobsters caught from both lakes were calculated monthly. In the freshwater lobsters in Lake Tatlı, the lowest meat yield in all female+male individuals was found in November (13.24%), and the highest meat yield was in April (17.03%) (Figure 1). The month with the lowest meat yield of female individuals was determined as November (10.56%), and the highest month as July (17.33%). In males, the lowest meat yield was found in February (13.14%) and the highest meat yield in April (17.52%). There was a statistically significant difference in all female+male individuals, abdomen and total meat yield in female individuals according to the months in Tatlı Lake ($p<0.05$). In male lobsters, a statistically significant difference was found in abdomen meat yield ($p<0.05$).

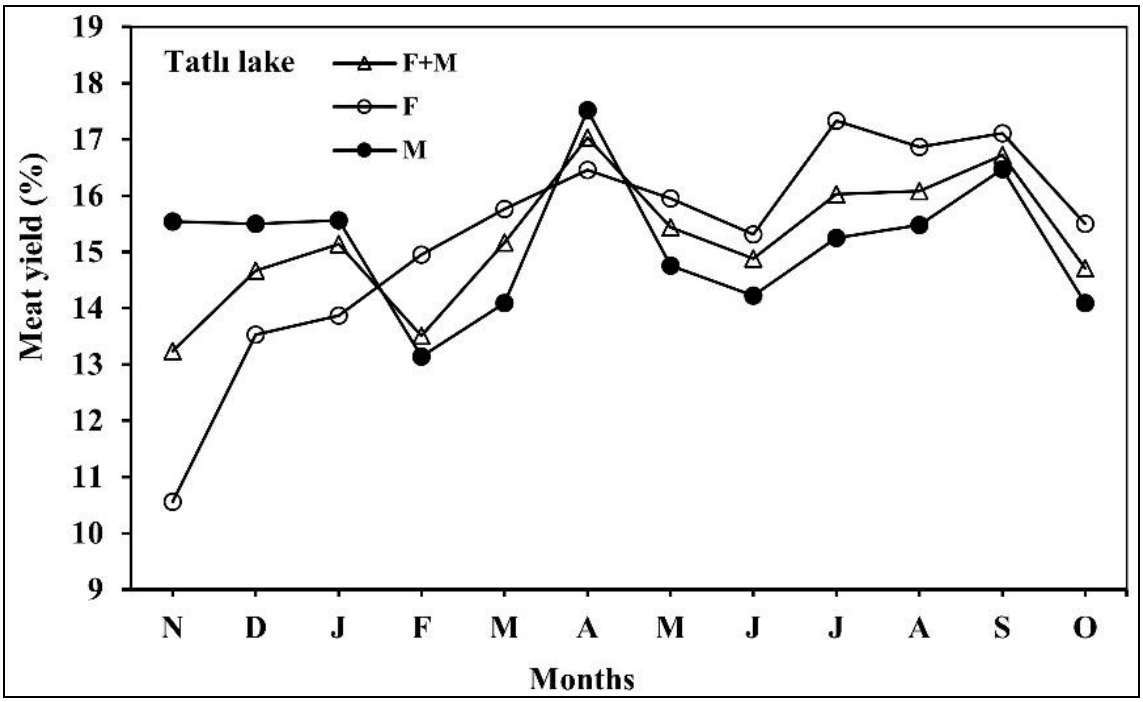

Fig 1: The variation of the average meat yield in all female+male individuals, females and male lobsters in Tatlı Lake by months

In Lake Gıcı, on the other hand, the lowest meat yield was determined in November (12.64%) and the highest meat yield in April (17.43%) in all female+male individuals (Figure 2). It was determined that the meat yield of the females was the lowest in January (13.03%) and the highest in March (17.39%). In males, the lowest meat yield was in November (11.87%) and the highest meat yield was in April (19.14%). A statistically significant difference was found in the abdomen and total meat yield between months in Gıcı Lake in all female+male individuals (p<0.05). In female individuals, it was found statistically similar in the abdomen and total meat yield (p>0.05). A statistical difference was found in the abdomen and total meat yield in male lobsters (p<0.05). There was no statistical difference between the lakes in abdomen meat yield, pincer meat yield and total meat yield (p>0.05).

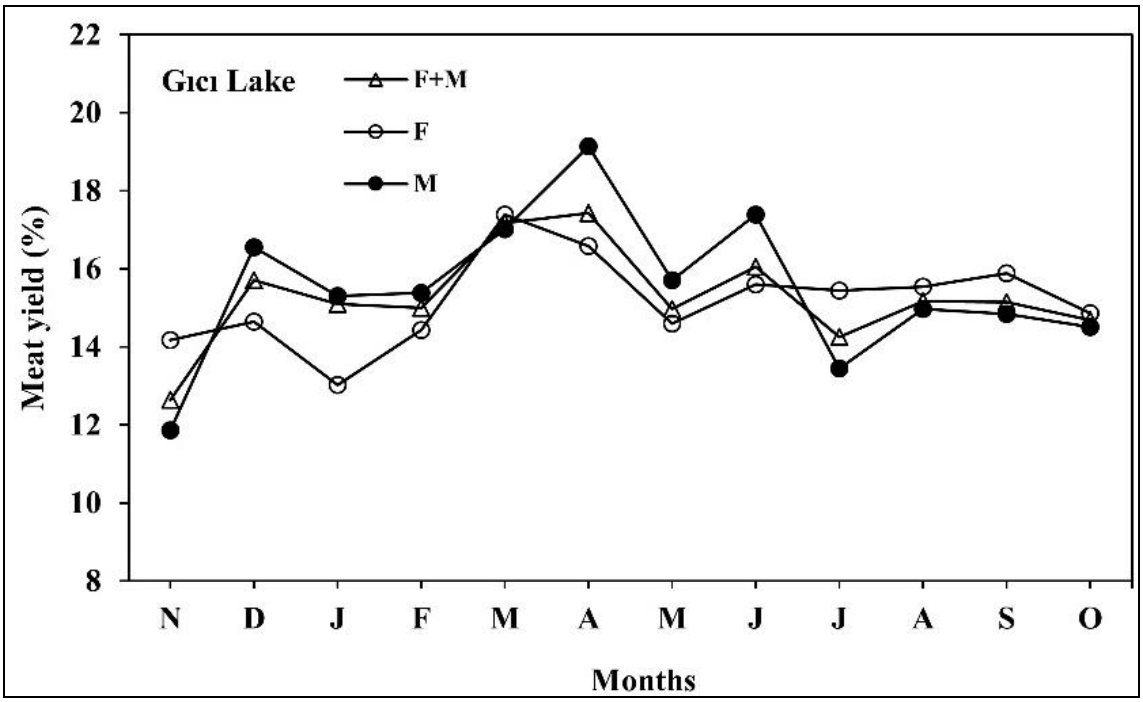

Fig 2: According to months variation of average meat yield in Gıcı Lake in all female+male individuals, females and male lobsters

In the study, protein, oil, moisture and ash values of freshwater lobsters caught monthly from Tatlı Lake and Gıcı Lake were determined monthly according to the lakes, and the collective results and statistical evaluations are given in Table 3.

Table 3: Average protein, fat, ash and moisture values calculated monthly in freshwater lobsters in Lake Tatlı and Gıcı

	Tatlı Lake				Gıcı Lake			
Months	**Protein (%)**	**Oil (%)**	**Ash(%)**	**Moisture(%)**	**Protein (%)**	**Oil (%)**	**Ash (%)**	**Moisture(%)**
November	13.72±0.01^{h}	0.57±0.00^{e}	1.22±0.00^{e}	84.40±0.01^{a}	14.30±0.02^{c}	0.32±0.01^{de}	1.51±0.01^{cd}	83.84±0.04^{ab}
December	15.15±0.05^{f}	0.96±0.01^{b}	1.60±0.00^{cd}	82.22±0.07^{cd}	14.44±0.01^{c}	0.25±0.01^{e}	1.16±0.08^{f}	84.05±0.08^{a}
January	17.74±0.03^{b}	0.50±0.00^{fg}	1.52±0.00^{d}	80.15±0.04^{ef}	14.49±0.04^{c}	0.36±0.00^{d}	1.30±0.05^{ef}	83.76±0.01^{ab}
February	17.67±0.02^{b}	0.72±0.01^{c}	1.59±0.00^{cd}	79.98±0.02^{fg}	15.96±0.02^{b}	0.47±0.01^{c}	1.59±0.01^{bc}	81.88±0.00^{cd}
March	15.73±0.02^{d}	0.54±0.01^{ef}	1.55±0.01^{d}	82.09±0.02^{d}	16.41±0.04^{a}	0.38±0.02^{cd}	1.46±0.04^{cde}	81.67±0.02^{d}
April	17.31±0.03^{c}	0.46±0.01^{g}	1.73±0.01^{ab}	80.36±0.06^{e}	16.67±0.11^{a}	0.88±0.04^{b}	1.52±0.02^{cd}	80.84±0.02^{f}
May	18.14±0.03^{a}	0.30±0.01^{i}	1.85±0.03^{a}	79.55±0.01^{h}	15.74±0.06^{b}	1.25±0.02^{a}	1.76±0.07^{ab}	81.22±0.14^{e}
June	17.22±0.05^{c}	1.10±0.01^{a}	1.60±0.00^{cd}	79.94±0.07^{g}	15.74±0.15^{b}	1.15±0.03^{a}	1.75±0.01^{ab}	81.25±0.11^{e}
July	15.50±0.01^{e}	0.65±0.01^{d}	1.60±0.01^{cd}	82.14±0.01^{cd}	15.98±0.02^{b}	1.17±0.02^{a}	1.78±0.02^{ab}	81.01±0.00^{ef}
August	15.70±0.00^{d}	0.32±0.01^{i}	1.69±0.04^{bc}	82.19±0.05^{cd}	15.88±0.05^{b}	0.39±0.01^{cd}	1.85±0.01^{a}	81.80±0.07^{cd}
September	15.29±0.02^{f}	0.65±0.02^{d}	1.61±0.03^{cd}	82.33±0.03^{c}	15.83±0.05^{b}	0.34±0.02^{de}	1.74±0.03^{ab}	82.04±0.02^{c}
October	14.05±0.06^{g}	0.39±0.01^{h}	1.61±0.06^{cd}	83.90±0.02^{b}	14.46±0.05^{c}	0.40±0.01^{cd}	1.38±0.01^{de}	83.67±0.05^{b}
Average	**16.10±0.23**	**0.59±0.39**	**1.60±0.24**	**81.60±0.26**	**15.49±0.13**	**0.61±0.06**	**1.57±0.36**	**82.24±0.19**

Not: Aynı sütunda farklı üssel harflerle ifade edilen değerler istatistiksel olarak birbirinden farklıdır (p<0.05).

The highest protein amount in Tatlı Lake was determined as 18.14% (May), the lowest amount was 13.72% (November), and the average protein amount in freshwater lobster meat was 16.10%. In Lake Gıcı, the highest amount of protein was determined as 16.67% (April) and the lowest amount was determined as 14.30% (November). In Figure 3, the variation of average protein values according to months in lobsters from Tatlı and Gıcı Lakes is given. While the difference between monthly protein values in both lakes was significant (p<0.05), there was no statistical difference between the lakes (p>0.05).

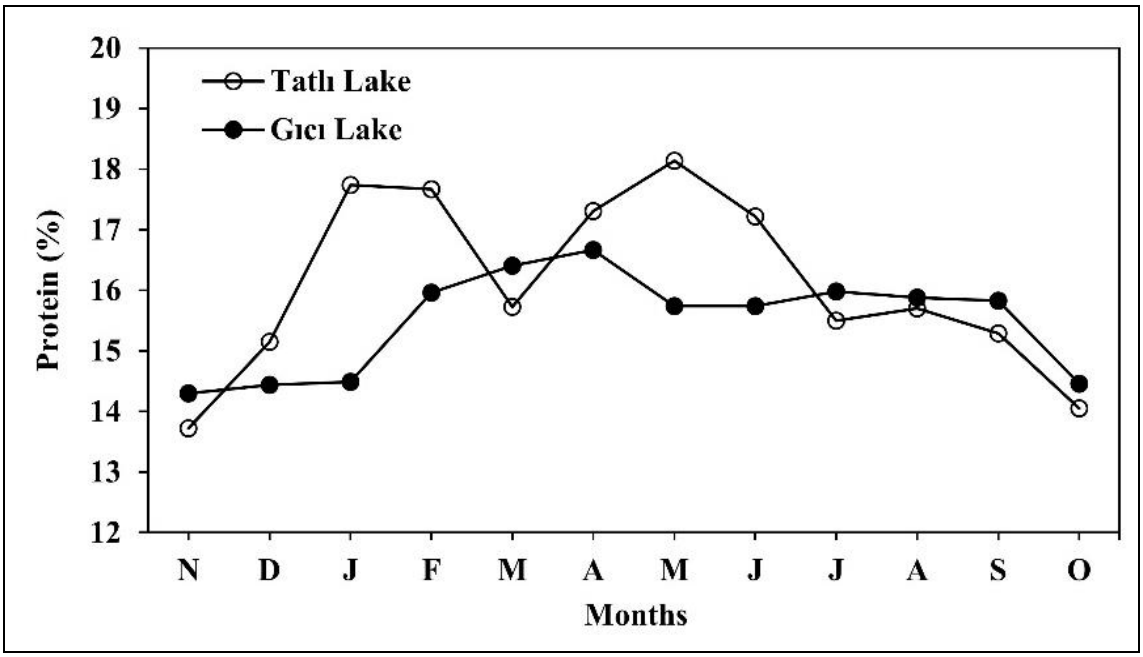

Fig 3: According to months variation of average protein values of freshwater lobsters in Tatlı and Gıcı Lakes

The highest amount of oil was found to be 1.10% (June) and the lowest amount was 0.32% (August) in Tatlı Lake freshwater lobsters, and the average amount of oil was determined as 0.59% throughout the experiment. In Lake Gıcı, the highest amount of fat was found as 1.25% (May), the lowest amount was determined as 0.25% (December), and the average amount of fat in lobster meat was determined as 0.61%. In figure 4, the variation of the average fat values of the lobsters in Tatlı and Gıcı Lakes according to months is given. While the difference between monthly oil values in both lakes was significant (p<0.05), the difference between lakes was insignificant (p>0.05).

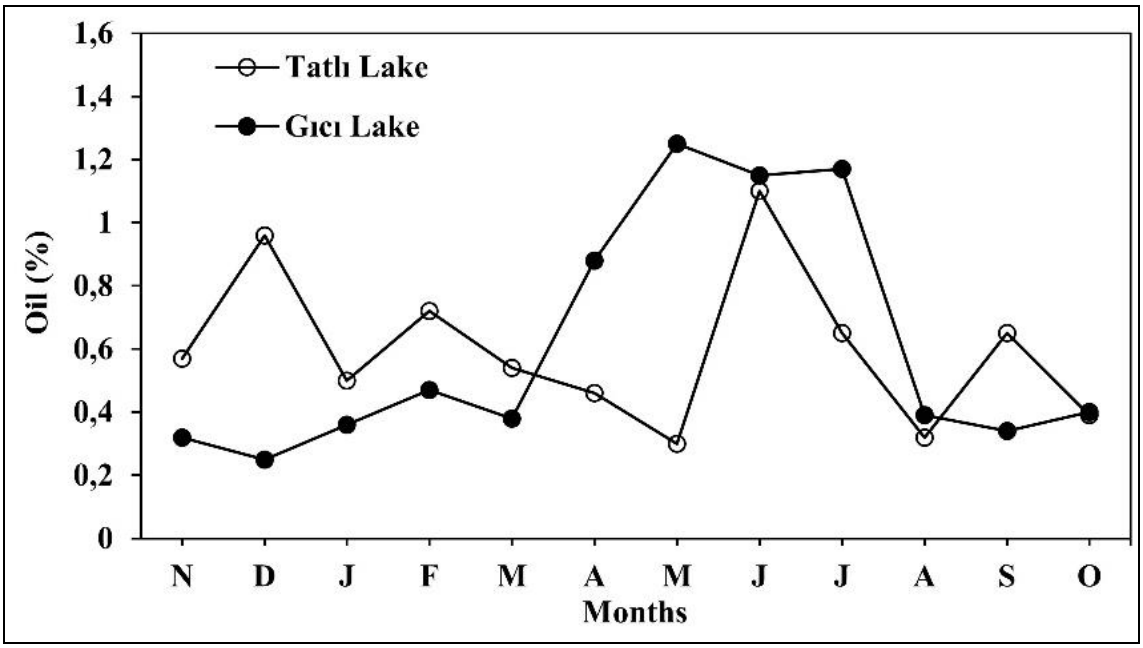

Fig 4: According to months variation of average oil values of freshwater lobsters in Tatlı and Gıcı Lakes

The amount of ash in Tatlı Lake freshwater lobster meat varied between 1.22% and 1.85%, and the average ash amount was determined as 1.60%. While it is found between 1.16% and 1.85% in Lake Gıcı, the average amount of ash was determined as 1.57%. The variation of the average ash values of lobsters in Tatlı and Gıcı Lakes according to months is given (Figure 5). While the difference between monthly ash values in both lakes was significant (p<0.05), the difference between lakes was insignificant (p>0.05).

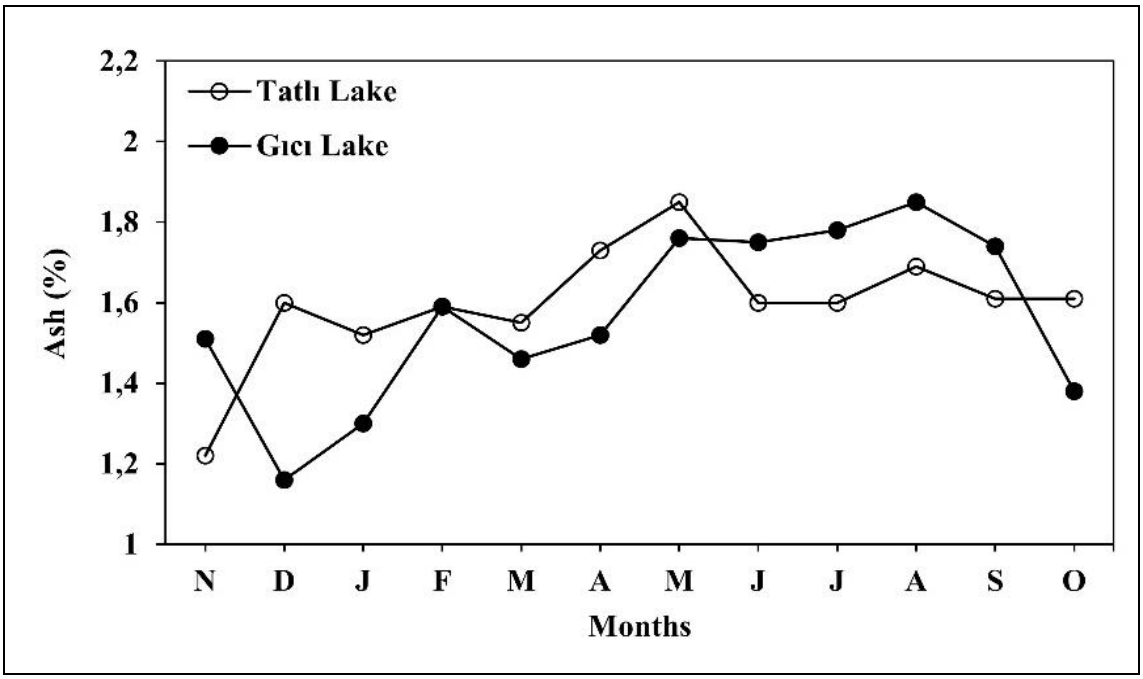

Fig 5: According to months variation of average ash values of freshwater lobsters in Tatlı and Gıcı Lakes

The highest moisture content was found to be 84.40% (November) and the lowest amount was 79.55% (May) in Tatlı Lake freshwater lobster meat, and the average moisture value was determined as 81.60%. In Lake Gıcı, the highest humidity was determined as 84.05% (November), the lowest amount was 80.84% (April), and the average humidity value was determined as 82.24%. The variation of average humidity values in lobsters in Tatlı and Gıcı Lakes according to months is given (Figure 6). While the difference between monthly humidity values in both lakes was significant (p<0.05), the difference between lakes was insignificant (p>0.05).

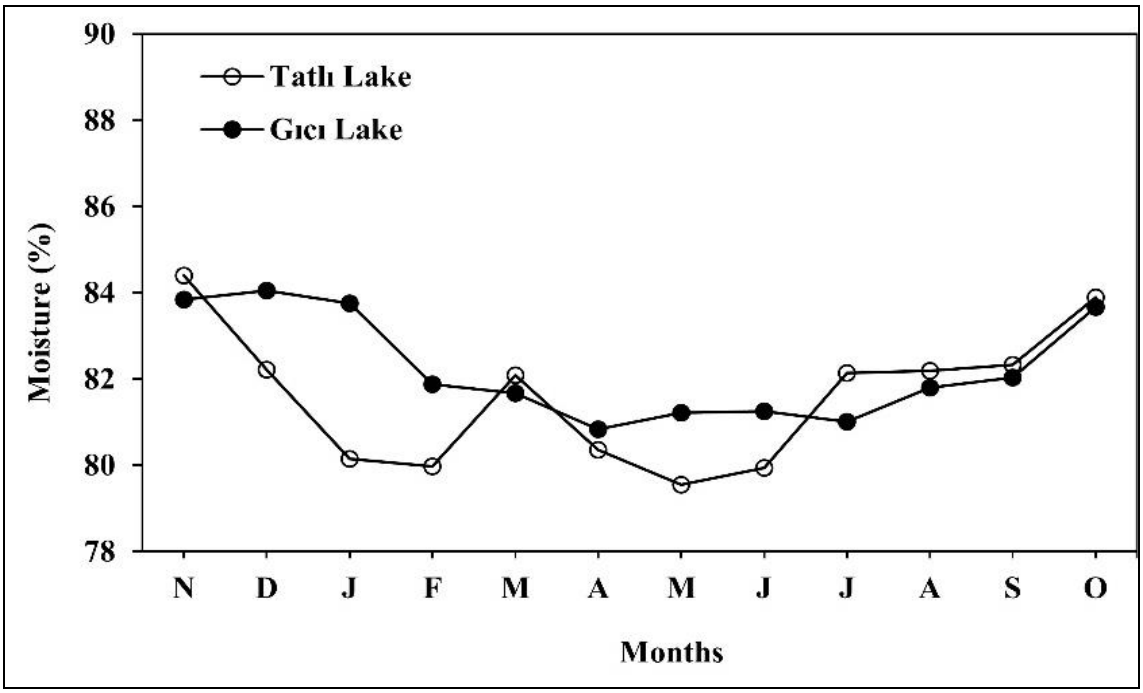

Fig 6: According to months variation of average humidity values of freshwater lobsters in Tatlı and Gıcı Lakes

Dıscussıon and Conclusıon

In this study, meat productivity and biochemical compositions of freshwater lobster (*Astacus leptodactylus* Eschscholtz, 1823) in Tatlı and Gıcı Lakes from Bafra Fish Lakes were determined monthly between November 2018 and October 2019.

In the study, the abdominal meat yield of female lobsters in Tatlı Lake was 13.26±0.48%, chela meat yield was 2.09±0.41% and total meat yield was 15.27±0.51%. In male lobsters, abdomen meat yield, chela meat yield and total meat yield were determined, respectively. It was found to be 10.14±0.46%, 5.02±0.64%, 15.13±0.64%. In Gıcı Lake, abdominal meat yield in female lobsters was 13.01±0.48%, chela meat yield was 2.21±0.34%, total meat yield was 15.18±0.59%, in male lobsters abdomen meat yield, chela meat yield and total meat yield were respectively %. It was found to be 10.14±0.78, 5.41±0.91, 15.51±0.69%.

Aksu and Kurt Kaya[10] found that the abdomen meat yield, chela meat yield and total meat yield were 10.03%, 4.60% and 14.63% respectively in male lobsters in Aktaş Lake. They found that 11.59%, 2.73% and 14.32%. In Keban Dam Lake Çemişgezek Region by Barım [11], the total meat yield is 15.16% in male individuals and 16.25% in female individuals. Berber and Balık [12], this rate was determined as 15.86% for males and 17.36% for females in Lake Apolyont. Yılmaz *et al*. [13] reported 19.70% in male lobsters and 15.68% in females in Lake Gaga. As can be understood from the literature, the results were different in some regions in meat yield studies. The reasons for this difference are thought to be due to changes in meat yields according to populations, seasonal differences in hunting times and the way the samples were taken.

In the study, the condition factor was found to be 3.02 in all individuals, 2.65 in female lobsters, and 3.31 in male individuals in Tatlı Lake. In Lake Gıcı, it was determined as 3.11 in all individuals, 2.75 in females and 3.36 in males. Aydın *et al*. [14] found the condition factor to be 2.6 in freshwater lobsters, 3.33 in male lobsters, 3.15 in females and 3.23 in all individuals.

Condition factor is defined as one of the nutrition and development criteria in which the morphological structure is best controlled in lobsters by Kaya [15]. Condition factor may vary according to sex, gonad development, age, seasonal changes in growth, hunting place and time.

Weya *et al*. [16] is interpreted the larger the condition factor is 1, the better the freshwater lobster population.

Duman *et al*. [17] was determined that crude protein 16.27%, crude oil 2.97%, crude ash 1.51%, and moisture 79.18%. Berber *et al*. [18] determined that crude protein amount was 11.78-15.68% in male lobsters and 13.09-17.59% in female lobsters. Harlıoğlu *et al*. [19] reported that in Yenice Lake in male lobsters moisture is 81.90%, protein 15.30%, fat 0.57%, ash 1.55%, while in female lobsters moisture is 81.70%, protein 15.20%, fat 0.50%, ash 1.45%. Öksüz and Mazlum [20] reported that protein, moisture, lipid and ash values of 17.25%, 80.36%, 1.62% and 0.97% in Lake İznik, respectively and protein, moisture, lipid and ash values of 17.46%, 81.33%, respectively, in Keban Dam Lake, 1.09%, 0.80%, protein, moisture, lipid and ash values in Lake Eğirdir 15.41%, 81.76%, 1.25%, 0.95%, respectively, protein, moisture, lipid and ash values in Hirfanlı Dam Lake 15.51%, respectively. 82.06, 1.36%, 0.64%.

In the study, the biochemical compositions of freshwater lobsters in Tatlı Lake were found as crude protein 16.10±0.23, crude oil 0.59±0.39%, crude ash 1.60±0.24%, moisture value 81.60±0.26%. In Lake Gıcı, crude protein was 15.49±0.13%, crude oil was 0.61±0.06%, crude ash was 1.57±0.36%, and moisture value was 82.24±0.19%. When the study is compared with the literature, it is similar to the majority. Differences in protein values may be due to the fact that female lobsters contain more protein than male freshwater lobsters and need more protein for gonad development.

As a result, in this study, it was observed that there is a very strong linear relationship between the height and weight of *Astacus leptodactylus* species in Tatlı and Gıcı Lakes, and the average weight of males is higher than females. It was determined that meat yields and biochemical compositions of freshwater lobsters were close to the average values of other freshwater lobsters living in Turkey. It can be said that the freshwater lobster species in Tatlı and Gıcı Lakes have a

healthy population of fishable size and it is important to evaluate them economically. This is the first study on freshwater lobsters in Lake Tatlı and Gıcı and it is thought to lead to further studies.

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