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Some Biological Characteristics of Crayfish (*Astacus leptodactylus* Eschscholtz, 1823) in Lake Eğirdir

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Abstract: This study was conducted in Lake Eğirdir in 2001 and 2002, to investigate some biological characteristics, i.e. sex and length compositions, length-weight relationship and reproduction, of the crayfish (*Astacus leptodactylus* Eschscholtz, 1823) population. Sex ratios of crayfish caught with fykenets of 34 - mm mesh size (stretched mesh) were 65.2% male and 34.8% female. The total body lengths of both sexes ranged from 40 to 150 mm and the majority were in the 110 mm length class. Although the average lengths of both sexes were nearly the same, the average weight of male crayfish was higher than that of females. The length (L) - weight (W) relationships for males, females and combined sexes were $\text{Log } W = -10.007 + 2.922 \text{ Log } L$ ($R^2 = 0.960$), $\text{Log } W = -9.206 + 2.724 \text{ Log } L$ ($R^2 = 0.977$) and $\text{Log } W = -9.714 + 2.850 \text{ Log } L$ ($R^2 = 0.958$), respectively. Mating and spawning of crayfish started in mid- December and mid- January, respectively. Embryonic development of eggs lasted until the beginning of June, and young larvae hatched from the eggs left their mothers by the middle of June. First maturity length (L_m) was estimated as 97.9 mm for female individuals. The fecundity (F) – length and the fecundity – weight relationships were $F = -359.3 + 56.6 L$ ($R^2 = 0.670$) and $F = 151.4 + 3.09 W$ ($R^2 = 0.779$), respectively. On the other hand, in 27.9% of females with cement glands no eggs were seen.

Key Words: Lake Eğirdir, crayfish, *Astacus leptodactylus*, population structure, reproduction

Eğirdir Gölü'ndeki Tatlısu İstakozu (*Astacus leptodactylus* Eschscholtz, 1823)'nun Bazı Biyolojik Özellikleri

Özet: Bu çalışma, Eğirdir Gölü'ndeki tatlısu istakozu (*Astacus leptodactylus* Eschscholtz, 1823) popülasyonunun eşey ve boy kompozisyonları, boy-ağırlık ilişkisi ve üreme gibi bazı biyolojik özelliklerini incelemek için 2001 ve 2002 yılları arasında yürütülmüştür. Göz genişliği 34 mm (gerilmiş ağ gözü) olan pinterlerde yakalanan tatlısu istakozlarının eşey oranları % 65,2 erkek ve % 34,8 diştir. Her iki eşeyin de total vücut boylarının 40 ile 150 mm arasında değiştiği ve çoğunluğunun 110 mm boy sınıfında olduğu tespit edilmiştir. Erkek ve dişi bireylerin ortalama boyları hemen hemen eşit olduğu halde, erkek bireylerin ortalama ağırlıkları dişilere göre daha yüksek bulunmuştur. Erkek, dişi ve her iki eşeyin ortak boy (L) - ağırlık (W) ilişkileri sırasıyla $\text{Log } W = -10,007 + 2,922 \text{ Log } L$ ($R^2 = 0,960$), $\text{Log } W = -9,206 + 2,724 \text{ Log } L$ ($R^2 = 0,977$) ve $\text{Log } W = -9,714 + 2,850 \text{ Log } L$ ($R^2 = 0,958$) şeklinde tespit edilmiştir. Çiftleşme Aralık, yumurtlama ise Ocak ayının ortalarında başlamaktadır. Yumurtaların embriyonik gelişimi Haziran ayı başlarına kadar sürmekte, yumurtadan çıkan larvalar Haziran ayı ortalarına kadar anaçları terk etmektedirler. Dişi bireyler için ilk eşeyel olgunluk boyu (L_m) 97,9 mm olarak hesaplanmıştır. Fekondite (F) – boy ve fekondite – ağırlık ilişkileri $F = -359,3 + 56,6 L$ ($R^2 = 0,670$) and $F = 151,4 + 3,09 W$ ($R^2 = 0,779$) olarak saptanmıştır. Diğer taraftan, spermatoforlu bireylerin % 27,9' unda hiç yumurta görülmemiştir.

Anahtar Sözcükler: Eğirdir Gölü, tatlısu istakozu, *Astacus leptodactylus*, popülasyon yapısı, üreme

Introduction

From the end of the 1960s to 1986, crayfish (*Astacus leptodactylus* Eschscholtz, 1823) was the most important fisheries product in Lake Eğirdir. Total crayfish production in Turkey was about 3000 t in the 1970s, and 75% of this yield was obtained from Lake Eğirdir (Erdemli, 1982). Unfortunately, the yield of crayfish from 1984 to 1986 decreased from 2014 t to 12 t in the

lake (Bayrak et al., 1991), and catching crayfish was prohibited in 1986. The reason was determined to be an acute outbreak of crayfish plague, *Aphanomyces astaci* Schikora (Furst, 1988). After about 15 years, the crayfish population considerably increased in the lake, and fishing was allowed again in autumn 1999. Since that time, crayfish have been caught between 15 June and 24 December. In 2001, yearly yield was 602 t. It is clearly

shown that the crayfish population has significantly increased in the lake in recent years. The crayfish population should therefore be observed carefully to determine maximum sustainable yield. In particular, population features should be well known. Thus, the aim of this study was to determine the population structure and reproduction features, i.e. the sex and length composition, the length-weight relationship, maturity size, fecundity, and mating, spawning and hatching time.

Materials and Methods

Lake Eğirdir is located in the Lakes Region of Turkey. The total surface area of the lake is 46,800 ha, its mean depth is 8-9 m, and the altitude is 918 m. The major fish species in the lake are the carp (*Cyprinus carpio*), pikeperch (*Sander lucioperca*), silver crucian carp (*Carassius gibelio*), and vimba (*Vimba vimba*).

Samples were collected monthly with fykenets of 34 - mm mesh size (stretched mesh) at 3 different localities in the lake (Figure 1) from March 2001 to February 2002. Sixty fykenets were set before noon in each study area. After 2 days, the nets were hauled and the crayfish harvested. Each sample was measured [total body length (L) to the nearest mm] and weighed [(W) to the nearest

0.1 g]. Sex, maturity, mating, spawning and hatching statuses were recorded during the study. In addition, the surface water temperature of the lake was measured each month.

Sex and length composition, the average length and weight, and the length-weight relationship for each sex and combined sexes were determined from samples. The length-weight relationship was calculated using Le Cren's equation: $W = aL^b$ (Le Cren, 1951), where W is the weight (g) and L is the body length (mm) and a and b are parameters of regression.

For the estimation of the mean lengths at 50% maturity, a logistic function was fitted to the proportion of the mature individuals by length class using nonlinear regression. The function used is below (Skúladóttir, 1998; DeMartini et al., 2000):

$$P_L = 100/[1 + e^{(a-bL)}]$$

where P_L is percentage mature at length L, and a and b are regression parameters. The mean lengths at 50% maturity were calculated by $L_{50} = -a/b$.

Fecundity was determined by counting the pleopodal eggs. The relationships between fecundity-length and fecundity-weight were calculated by the least-squares method.

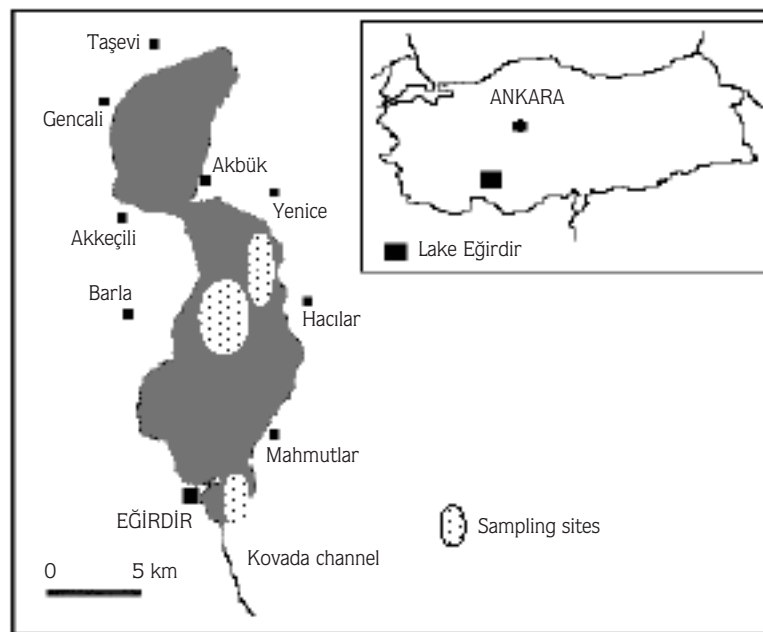


Figure 1. Map of Lake Eğirdir showing the study areas.

We tested differences between male and female crayfish for the average length and weight by Student's t-test, and the difference in the rates of male and female crayfish by χ^2 -test (Yurtsever, 1984; Elbek et al., 2002).

Results

Sex and length composition

In samplings 3630 crayfish were caught using fykenets. The ratio of males (2366) to females (1264) was 1.87:1, and the difference between the sexes was statistically significant ($\chi^2 = 4.621 > \chi^2_{1, 0.05} = 3.84$) in the samples observed above 40 mm length. Length distribution was from 40 to 150 mm, and the majority were 110 mm (Figure 2).

Length-weight relationship

The average length and weight of samples were 104.5 ± 0.5 mm and 40.6 ± 0.5 g for males, 104.7 ± 0.6 mm and 35.4 ± 0.5 g for females and 104.5 ± 0.4 mm and 38.8 ± 0.3 g for the combined sexes, respectively. There was no statistically significant difference between the average lengths of 2 sexes (d.f. = 3628, $t = 0.257$, $P > 0.05$), but a significant difference between their average weights (d.f. = 3628, $t = 7.325$, $P < 0.05$) was present.

The equations of length-weight relationships were calculated using the lengths and weights of the samples as follows:

For males $\text{Log } W = -10.007 + 2.922 \text{ Log } L$
 $(R^2 = 0.960, n = 2366)$

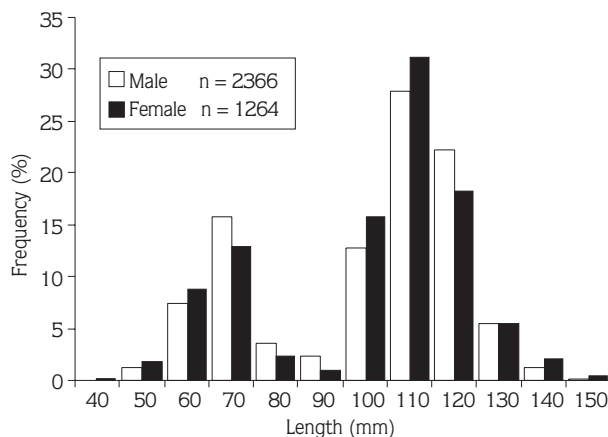


Figure 2. Length distributions of male and female crayfish in Lake Eğirdir.

For females $\text{Log } W = -9.206 + 2.724 \text{ Log } L$
 $(R^2 = 0.977, n = 1264)$

For combined sexes $\text{Log } W = -9.714 + 2.850 \text{ Log } L$
 $(R^2 = 0.958, n = 3630)$

Length at first maturity

Length at first maturity was estimated as 97.9 mm from the equation $L_{50} = (-9.3793/-0.0958)$. Percentages of mature crayfish for different lengths were calculated using the formula $PL = 100/[1 + e^{(9.3793 + 0.0958 L)}]$, and then the maturity ogive was drawn using these values (Figure 3).

Mating, spawning and hatching periods

It was determined that mating began the middle of December and the first crayfish with pleopodal eggs was seen in the middle of January, when water temperature was between 4 and 5 °C. During the study, cement glands were clearly visible across the ventral side of the abdomen. The embryonic development of eggs, under the abdomens of the female crayfish, lasted about 4-5 months. The first young crayfish was seen at the beginning of June, and all larvae had emerged by the middle of June, when the water temperature was between 22 and 24 °C.

Fecundity

The number of pleopodal eggs varied between 1 and 570 eggs/crayfish. It was determined that 27.9% of females with cement glands had no pleopodal eggs. The

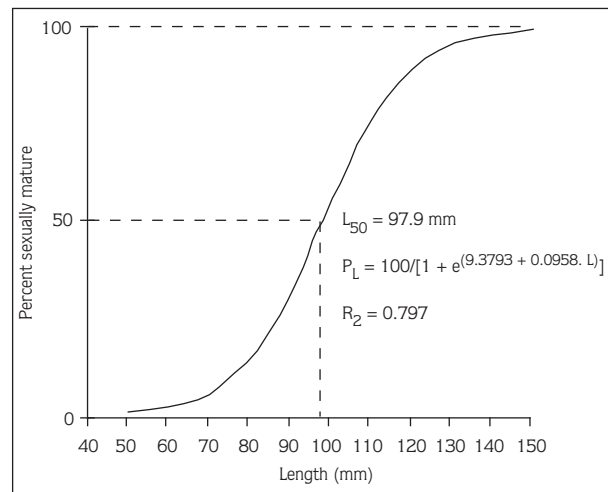


Figure 3. Ogive of first sexual maturity for female crayfish in Lake Eğirdir.

average fecundity for females with pleopodal eggs was 208.6 ± 18.6 eggs/crayfish and 6.30 ± 0.22 eggs g^{-1} . There was a linear increase both between fecundity and length, $F = -359.3 + 56.6 L$ ($R^2 = 0.670$), and between fecundity and weight, $F = 151.4 + 3.09 W$ ($R^2 = 0.779$).

Discussion

The proportion of male individuals in the crayfish population of Lake Eğirdir was higher than that of females. Erdemli (1982) stated that female crayfish were more abundant than males in this lake about 20 years ago. Similarly, the proportions of female individuals in the samples taken from Lakes Uluabat, Manyas, İznik, Eber, Akşehir and Terkos and Miliç River by Köksal (1980), Lakes Beyşehir, Akşehir and Eber and Apa Dam Lake by Erdemli (1982), Lake Mogan by Karabatak and Tüzün (1989), and Dikilitaş Reservoir by Köksal and Korkmaz (2000) were higher than those of males or were similar to them. In contrast, a high proportion of males was only determined in Keban Dam Lake (Duman and Gürel, 2000). In our opinion, the proportion of female crayfish in Lake Eğirdir gradually decreased from 1999 to 2002 because male crayfish caught were thrown back into the lake in November and December. Male crayfish caught by fishermen during this period were not bought by exporting firms. According to these firms, male crayfish caught in November and December (especially during the mating period) are not popular among consumers in the importing countries. To maintain the sex ratio of the crayfish population in the lake, this kind of fishing must be prohibited. Otherwise, the proportion of females will decrease further in the future. The sex ratio of a population clearly affects the potential reproductive rate and may affect social interactions in many vertebrates (Krebs, 1972).

Although the average lengths of both sexes were nearly the same, the average weight of males was higher than that of females. This difference is consistent with the slope (b) values [$b = 2.922 \pm 0.0012$ for males and $b = 2.724 \pm 0.0021$ (\pm SE) for females] of the length-weight relationships of male and female crayfish. In addition, the b value of females was significantly different from 3 (t-test, d.f. = 2364, $P < 0.05$), but was not (t-test, d.f. = 1262, $P > 0.05$) for males. The results suggested that the male crayfish in Lake Eğirdir grows isometrically, but the females grow allometrically. The b value of the

combined sexes was 2.850 ± 0.0007 (\pm SE) and it was significantly different from 3 (t-test, d.f. = 3628, $P < 0.05$). The b value was found to be about 3 in Lake Mogan by Karabatak and Tüzün (1989) and in Ayrancı Dam Lake by Erdem and Erdem (1994). However, the b values of both sexes ($b = 2.66$ for males and $b = 2.51$ for females) reported in the Ağin region of Keban Dam Lake by Harlıoğlu (1999) were smaller than the b values in Lake Eğirdir. The average length and weight of samples in Lake Eğirdir were higher than those in Lake Beyşehir (Erdemli, 1982), Lake Hotamış and Mamasın Dam Lake (Erdemli, 1987), Dikilitaş Reservoir (Köksal and Korkmaz, 2000), and Lake İznik (Balık et al., 2002), but lower than those in Lakes Akşehir and Eber and Apa Dam Lake (Erdemli, 1982), Ayrancı Dam Lake (Erdem and Erdem, 1994) and (in 1995 and 1996) Lake Eğirdir (Bolat, 2002). The reason for these differences may be factors such as the environmental, food, population density and the selectivity of the traps or fykenets used in the studies. In addition, male crayfish were heavier than females. This disparity is due primarily to the accelerated development of the male chelae with the onset of sexual maturity, while the chelae of the females remain isometric throughout their life (Romaine et al., 1977). Furthermore, males are rougher and more thick-set than females (Skurdal and Quvenild, 1986). Lengths of both male and female crayfish ranged from 40 to 150 mm. The catching of crayfish smaller than 90 mm in total length is prohibited in all Turkish lakes (TKB, 2002). However, in this study 27.3% of individuals caught in the fykenets were smaller than the legal catching size. Therefore, the mesh size of fykenets should be increased from 34 mm to at least 40 mm. The mesh size of nearly all fykenets used by fishermen in Lake Eğirdir is 34 mm.

Sexual maturity for female crayfish began at about 80 mm and 50% of them were mature at 97.9 mm total length. Length at first maturity for female crayfish in Lake Eğirdir was reported as 71 mm at the beginning of the 1980s by Erdemli (1982) and 74 mm in 1995 and 1996 by Bolat (2002). First maturity length for female crayfish in Lake Eğirdir was higher than the lengths reported in Lakes Beyşehir, Akşehir and Eber and Apa Dam Lake (Erdemli, 1982), Lake Mogan (Karabatak and Tüzün, 1989), Seyhan Dam Lake (Çevik and Tekelioğlu, 1997), Keban Dam Lake (Duman and Gürel, 2000) and Lake İznik (Erdem et al., 2001). In freshwater crayfish, size at maturity varies significantly within and between

populations. It is generally thought that factors such as food, temperature, water quality and density may contribute to the variation (Abrahamsson, 1972). Therefore, the maturity size of the crayfish population in Lake Eğirdir may have increased in recent years. Length at first maturity was higher than the legal catching size. Therefore, the minimum catch length for crayfish in Lake Eğirdir should be increased from 90 mm to 100 mm.

The crayfish population in Lake Eğirdir mated during the second half of December and spawned in January. The embryonic development of eggs lasted until the beginning of June, and the young crayfish left their mothers by the middle of June. Erdemli (1982) and Bolat (2002) reported that the first young crayfish in this lake were seen at the end of May or at the beginning of June. Mating, spawning and hatching times may vary from year to year, because these times are affected by environmental conditions; in particular, hatching requires temperatures above 15 °C (Abrahamsson, 1972). In Turkey, the catching of crayfish is prohibited between 25 December and 14 June (TKB, 2002). The results of this study showed that the legal closed season, considering their reproduction period, is suitable for crayfish in Lake Eğirdir.

It was determined in this study that 27.9% of females with cement glands had no pleopodal eggs. Furthermore, egg numbers in crayfish with pleopodal eggs were very high, varying between 1 and 570 eggs. It is clearly seen that some or all of the ovarian eggs in the crayfish population of Lake Eğirdir are lost for different reasons. Nevertheless, the average fecundity (209 eggs/crayfish) was higher than the value (148 eggs/crayfish) reported in the same lake by Erdemli (1982). According to Bolat (2002), the pleopodal egg number in this lake varied from 69 to 463 eggs/individual in 1996, but no information was given about females with cement glands but without eggs. Erdemli (1982, 1985) stated that the

average fecundity was 156, 149, 161, 163 and 153 eggs/individual in Lakes Beyşehir, Akşehir, Eber and Hotamış and in Apa Dam Lake, respectively. These fecundity values were lower than that in Lake Eğirdir. Similarly, the relative fecundity of crayfish in Lake Eğirdir was also higher than or similar to levels elsewhere. However, the average fecundity (306 eggs/crayfish) of crayfish in Keban Dam Lake (Harlıoğlu et al., 2004) and both the average fecundity (216 eggs/individual) and relative fecundity (6.5350 eggs/g) of crayfish in Lake Işıkli (Güner and Balık, 2002) were higher than those in Lake Eğirdir. Many crayfish lose a considerable number of eggs between the time of spawning and the time the young crayfish hatch (Abrahamsson, 1971). For example, the number of pleopodal eggs in Lake Steinsfjorden in Norway was determined to be 55%-60% that of the ovarian eggs by Skurdal and Qvenild (1986). Discrepancies between ovarian and pleopod counts prior to incubation are because of the failure of some eggs to attach and because some females do not extrude all their eggs at spawning (Penn, 1943). In addition, Taugbøl and Skurdal (1989) determined that some mature females reabsorbed their ovarian eggs, and some mature females lost all their eggs during laying.

In conclusion, the crayfish population destroyed by the plague in 1985 has increased significantly in Lake Eğirdir recently. It is now the most important product in the lake. The results of this study showed that the catching season for crayfish is suitable for mating, spawning and hatching times. However, the minimum catching length should be increased from 90 mm to 100 mm. Male crayfish caught in November and December must not be released back into the lake to avoid disturbing the sex ratio of the population. In addition, for sustainable economic yield, the crayfish population should be carefully monitored in the future as well.

References

- Abrahamsson, S. 1972. Fecundity and growth of some populations of *Astacus astacus* Linne in Sweden. Rep. Inst. Freshwater Res, Drottningholm 52: 23-27.
- Abrahamsson, S.A.A. 1971. Density, growth and reproduction in populations of *Astacus astacus* and *Pacifastacus lenisculus* in isolated pond. OIKOS 22: 373-380.
- Balık, İ., Özkök, E. and Özkök, R. Catch per unit effort and size composition of crayfish, *Astacus leptodactylus* Eschscholtz 1823, in Lake İznik. Asian and Australasian Journal of Animal Sci. 15: 884-889.
- Bayrak, M., Karakoyun, S., Menengiç, M. and Vatansever, H. 1991. Eğirdir Gölü Ekolojisi ve ekonomik su ürünlerinin incelenmesi projesi. TÜBİTAK DEB-ÇAĞ 51, Eğirdir Su Ürünleri Araştırma Enstitüsü, 44 pp.

- Bolat, Y. 2002. Eğirdir Gölü tatlısu istakozlarında (*Astacus leptodactylus* Esch. 1823) üreme. Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü Derg. 5: 49-56.
- Çevik, C. and Tekelioğlu, N. 1997. Seyhan Baraj Gölünde yaşayan tatlısu istakozu (*Astacus leptodactylus*, Esch., 1823)'nin bazı biyo-ekolojik, morfometrik özellikleri ile hastalık durumunun saptanması. In: IX. Ulusal Su Ürünleri Sempozyumu, Eğirdir, pp. 279.
- DeMartini, E.E., Uchiyama, J.H. and Williams, H.A. 2000. Sexual maturity, sex ratio, and size composition. *Xiphias gladius*, caught by the Hawaii-based pelagic longline fishery. Fish. Bull. 98: 489-506.
- Duman, E. and Gürel, A. 2000. Keban Baraj Gölü Ağin Bölgesi'nde yaşayan kerevitin (*Astacus leptodactylus salinus* Nordmann 1842) üreme özelliklerinin belirlenmesi. In: Su Ürünleri Sempozyumu, Erzurum, pp. 141-150.
- Elbek, A.G., Oktay, E. and Saygı, H. 2002. İstatistik. Ege Üniversitesi Su Ürünleri Fak. Yay. No:19, Ders Kitabı Dizin No:6, İzmir.
- Erdem, U. and Erdem, Ü. 1994. Ayrancı Baraj Gölündeki (Karaman) tatlısu istakozu (*Astacus leptodactylus* Esch. 1823)' nun bazı biyo-ekolojik ve morfolojik özelliklerinin incelenmesi. In: XII. Ulusal Biyoloji Kongresi, Edirne, pp. 358-361.
- Erdem, Ü., Cebeci, M., Selçuk, S., Tunç, N., Özbay, A. and Çiğdem, B. 2001. İznik Gölü'ndeki tatlısu istakozu (*Astacus leptodactylus* Esch., 1823)' nun bazı biyo-ekolojik özellikleri. In: XI. Ulusal Su Ürünleri Sempozyumu Bildirileri, Cilt I, Hatay, pp. 449-456.
- Erdemli, A.Ü. 1982. Beyşehir, Eğirdir, Akşehir, Eber gölleri ile Apa Baraj Gölünde tatlısu istakozu (*Astacus leptodactylus* Esch., 1823) popülasyonlarının bazı biyolojik ve morfolojik özellikleri üzerinde karşılaştırmalı bir araştırma. Türkiye Bilimsel ve Teknik Araştırma Kurumu, Veteriner Hayvancılık Araştırma Grubu, Proje No: VHAG-490, 84 pp.
- Erdemli, A.Ü. 1985. Hotamış Gölü ve Mamasın Baraj Gölünde tatlısu istakozu (*Astacus leptodactylus salinus* Nordmann, 1842) popülasyonlarının bazı biyolojik ve morfolojik özellikleri üzerine bir araştırma. Türkiye Bilimsel Araştırma Kurumu Matematik, Fizik ve Biyoloji Araştırma Grubu, Proje No: TBAG 594, 73 pp.
- Erdemli, A.Ü. 1987. Hotamış Gölü ile Mamasın Barajı tatlısu istakozu popülasyonlarının karşılaştırmalı incelenmesi. DOĞA TU Zooloji D. 11: 16-23.
- Furst, M. 1988. Future perspectives for Turkish crayfish fishery (Türkiye'de kerevit avcılığının geleceği). İstanbul Üniversitesi Su Ürünleri Y.O. Su Ürünleri Derg. 2: 139-147.
- Güner, U. and Balık, S. 2002. Işıklı Gölü (Çivril-Denizli) tatlısu kerevitlerinde (*Astacus leptodactylus* Eschscholtz, 1823) yumurta verimliliğinin boy ve ağırlık ilişkisi. Ege Üniversitesi Su Ürünleri Derg. 19: 109-113.
- Harlioğlu, M.M. 1999. Keban Baraj Gölü, Ağin Yöresi tatlı su istakozu, *Astacus leptodactylus*, Eschscholtz popülasyonunda ağırlık-uzunluk ilişkisi ve et verimi. Tr. J. of Zool. 23: 349-357.
- Harlioğlu, M.M., Barım, Ö., Türkgülü, İ. and Harlioğlu, A.G. 2004. Potential fecundity of an introduced population, Keban Dam Lake, Elazığ, Turkey, of freshwater crayfish, *Astacus leptodactylus leptodactylus* (Esch., 1852). Aquaculture 230: 189-195.
- Karabatak, M. and Tüzün, İ. 1989. Mogan Gölündeki kerevit (*Astacus leptodactylus*, Esch, 1823) popülasyonunun bazı özellikleri. Akdeniz Üniversitesi Su Ürün. Müh. Derg. 2: 1-34.
- Köksal, G. 1980. Biometric analysis on the freshwater crayfish (*Astacus leptodactylus* Esch. 1823) which is produced in Turkey—relationship between the major body components and meat yield. Ankara Üniversitesi Veteriner Fakültesi Derg. 26: 93-114.
- Köksal, G. and Korkmaz, Ş. 2000. Ankara-Dikilitaş Göleti tatlısu istakozlarının (*Astacus leptodactylus* Esch., 1823) popülasyon büyüklüğünün tahmini. Ankara Üniversitesi Ziraat Fakültesi Su Ürünleri Bölümü, Ankara, 28 pp.
- Krebs, C.J. 1972. Ecology: The Experimental Analysis of Distribution and Abundance, Ecology. Harper and Row, New York.
- Le Cren, E.D. 1951. The length-relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). J. Animal Ecology 20: 210-218.
- Penn, G.H. 1943. A study of the life history of the Louisiana red-crawfish, *Cambarus clarkii* Girard. Ecology 24: 1-18.
- Romaire, R.P., Forester, J.S. and Avault, J.W. 1977. Length-weight relationships of two commercially important crayfishes of the genus *Procambarus*. Freshwater Crayfish 3: 463-470.
- Skuladottir, U. 1998. Size at sexual maturity of female northern shrimp (*Pandalus borealis* Krøyer) in the Denmark Strait 1985-93 and a comparison with the nearest Icelandic shrimp populations. J. Northw. Atl. Fish. Sci. 24: 27-37.
- Skurdal, J. and Qvenild, T. 1986. Growth, maturity and fecundity of *Astacus astacus* in Lake Steinsfjorden, In: Freshwater Crayfish (Eds., J. Skurdal and T. Tougbøl), Norway, pp. 182-186.
- Taugbøl, T. and Skurdal, J. 1989. Effect of indoor culture conditions on maturation and fecundity of wild caught female noble crayfish *Astacus astacus* L. Aquaculture 81: 1-12.
- TKB. 2002. Denizlerde ve İçsularda Ticari Amaçlı Su Ürünleri Avcılığını Düzenleyen 2000-2002 Av Dönemine Ait 34/1 Numaralı Sirküler. TKB Koruma ve Kontrol Genel Müdürlüğü, Ankara.
- Yurtsever, N. 1984. Deneysel İstatistik Metodları. TOKB Genel Yayın No: 1212, Teknik Yayın No: 56, Ankara.