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Growth and Flesh Yield of the Swan Mussel [*Anodonta cygnea* (Linnaeus, 1758)] (Bivalvia: Unionidae) in Lake Çıldır (Kars, Turkey)

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Abstract

Swan mussel, *Anodonta cygnea* (Linnaeus, 1758), plays an important role in the food web of the lake as a primary consumer. However, there is very limited information about the biology, ecology and population structure of this species. Knowledge about the population characteristics of this mussel before the exploitation phase is very important for the management of this species in the future. On the other hand this study is the first record of the swan mussel from Lake Çıldır and determination of the growth and flesh yield of *Anodonta cygnea* in this lake will be the basic reference for further studies on fisheries and processing activities.

The mean shell length of the specimens was 104.2±0.52 mm (±SE of average) (range 49.8-136.8 mm) and mean live weight 94.8±1.42 g. The relationship between shell length and live weight was estimated as $W = 0.0001\ L^{2.88}$ (r = 0.96). Linear relationship was found between dry flesh weight and shell length (DFW = 0.052 L - 2.3721, r = 0.99). Condition index values based on dry flesh (CI1) and wet flesh weight (CI2) showed monthly fluctuations. The maximum value in July and minimum value in October should probably be attributed to an increase in the larval density in the brood chambers and abundant food at higher water temperature permitting faster growth in July.

Keywords: *Anodonta cygnea*, Lake Çıldır, growth, flesh yield, condition index.

Introduction

Species of the family Unionidae are considered to be the most characteristic and wide spread of the riverine biota; they are often the major primary filter feeders in many aquatic habitats. Swan mussels are located at the first links of the lake food web (Cumming and Mayer, 1992; Ravera and Sprocati, 1997).

Studies on freshwater mussels are very limited in Turkey. Çetinkaya (1996) noted that freshwater mussels of Anatolia may be divided into four groups: I. Dardanelles forms which come from Central Europe by Tuna river systems and distrubuted mainly in western Turkey (including 2 *Unio* and 1 *Anadonta* sp.), II. Eastern Mediterranean forms which come from the River Nile and Mediterranean costs and distrubuted in the southern region of Turkey from Antalya to Hatay provinces, especially in Orantes River and Lake Amik and Çukurova Plato (3 Potomida, 4 *Unio*, 2 *Leguminaia* and 1 *Gabillotia* sp.). III. Euphrate-Tigris forms migrating from South Asia and distributed in upper Euphrat and South-eastern Anotolia (2 *Unio*, 1 *Pseudodontoptsis*, 1 *Leguminaia* and 1 *Siannodonta* sp.) and IV. Pontic forms coming from southern Russia and Caucasus Region to the west bank of the River Sakarya and Eastern Turkey (3 *Unio*, 1 *Pseudoanodonta* and 4 *Anodonta* sp.). This species has geographicaly distributed to British Isles, Siberia, and northern Africa. (Zhadin, 1952; Watters, 2001). In Turkey, *Anodonta cygnea* has been reported from Meriç River, Lake Sapanca (Soylu, 1990), Karadere, Lake Manyas, Ulubat River, Lake Apolyont, and Lake Beyşehir (Bilgin, 1980). Kinzelbach (1989) has studied on the morphology distribution areas of five species (*A. anatina*, *A. cygnea*, *A. palustris, A. pseudodopsis* and *A. Vescoiana)* of the fresh water mussels in Anatolia. Pekkarinen and Englund (1995) reported the shell size of larvae of *Anodonta anatina*, *Pseudadonta complanata*, *Anodonta cygnea*, *Unio pictorum* and *Unio timudus*. The glochidium size of *A. anatina, A. cygnea*, *Unio pictorum* and *Unio timudus,* shows differences depending on year and geography. For *A. anatina, A. cygnea and P. complanata* they discovered that the size of glochidia does not depend on the host mussel. Ravera and Sprocati (1997), studied on population dynamics and production of Unio mancus and *Anodonta cygnea* in the Lagadone River.

This is the first study investigating growth and flesh yield of swan mussel in Lake Çıldır, Turkey. This is also first record of this species in Lake Çıldır. It has important implications on potential fisheries and related processing activities.

Materials and Methods

Lake Çıldır, a volcanic lake, is located on the Northeast part of Anatolia in Turkey; 41°00' N, 43°12' E within the city borders of Ardahan and Kars at the altitude of 1,959 m. Its surface area is 124 km^2, and it has 15 km width and 18 km length. Its maximum depth is 30 m and waters from melting snow, spring waters and small rivers discharged into the Lake. It has long freezing period starting from December to the end of April. Ice layers may reach up to 110 cm depending on the duration of the cold season.

Within the framework of this study, samples were collected from five different locations to ensure better representation of the population (Figure 1). 799 specimens were collected from the lake in total by SCUBA diving (Dunn, 2000) from one square meters in each sampling locations from May to October 2001.

The total length, height and convexity of each specimen were measured with Vernier calliper to the nearest 0.05 mm. The maximum distance between the posterior edge and anterior edge were recorded as length, between dorsal edge and ventral edge of shell length as height, and convexity was lateral form of shell (Zhadin, 1952; King, 1995; Bilgin, 1980). After the measurements, the samples were classified into 5 mm length groups and live (total) weight, flesh wet weight and shell weight, total volume, shell volume, edible flesh weight (food) and flesh dry weight of 10 specimens from each length group were also measured. Flesh samples were dried down to a constant weight for durations ranging from 44 to 48 hours (Akyıldız, 1984). The condition index (CI), was calculated from volume and dry wet weight as (Akyıldız, 1984);

CI1 = [Dry flesh weight / Dry shell weight] x 100

CI2=[Wet flesh weight/(Total volume–Shell volume)]x 100

One liter glass measures were used for volumetric analyses. After measuring the total volume, excess water was removed with the help of paper tissues. Then, the flesh was removed and the volume of the shells was measured. Wet flesh, shell and edible flesh were all weighed to the nearest mg. The fleshs were dried in the oven at 105°C to a constant weight, and weighed to the nearest 0.0001 g (Akyıldız, 1984).

Wet and dry flesh yield and edible flesh yield were calculated using the equations (Düzgüneş *et al*., 1992);

Wet flesh yield=[Total flesh weight/Live weight]x100

Dry flesh yield = [Dry flesh weight/Live weight]x100

Edible flesh yield = Total flesh weight-Internal organs

All statistical analysis and graphs were developed by using the software Minitab® (8.1) statistical software, Statsoft Statistica® 5.0. Descriptive statistical parameters such as means and standard errors were calculated for all parameters and one-way ANOVA was performed to test for differences between the sampling locations.

Results

Length – frequency distribution were given according to months and length classes (Table 1). Shell lengths varied between 49.8 to 136.8 mm and 85% of the samples ranged between 85-125 mm, 10% 45-85 mm and 5% 125-145 mm.

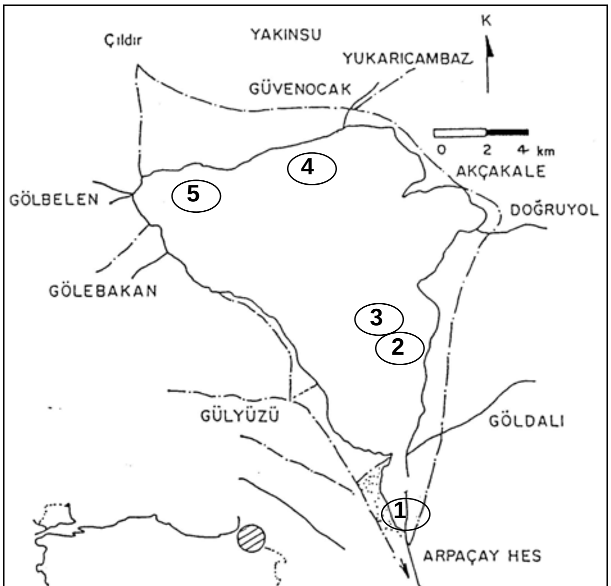

Figure 1. Sampling locations in Lake Çıldır.

Table 1. Mean values (of length, height, convexity, weight, wet flesh and dry flesh weight ± SE, N: number) for length group of *A. Cygnea*.

Length (mm)	N	Length (mm)	Height (mm)	Convexity (mm)	N*	Weight (g)	Wet Flesh weight (g)	Dry Flesh (g)
45 - 54.9	1	49.8	31.6	12.2	1	7.93	1.64	0.15
55 - 64.9	8	60.1±1.07	35.2±0.68	18.0±0.61	8	18.3±0.99	5.4±0.35	0.7±0.007
65 - 74.9	20	70.0±0.50	40.4±0.48	21.0±0.27	20	27.4±0.71	7.9±0.30	1±0.04
75 - 84.9	58	79.6±0.33	44.2±0.31	24.5±0.29	57	39.8±0.99	12.5±0.42	1.8±0.09
85 - 94.9	97	90.9±0.26	48.6±0.29	28.9±0.33	72	59.1±1.19	17.7±0.56	2.5±0.10
95 - 104.9	216	100.1±0.19	51.5±0.22	31.5±0.18	162	80.8±1.16	22.4±0.43	3.0±0.007
105 - 114.9	185	110.1±0.21	56.3±0.20	34.9±0.24	179	101.4±1.24	25.5±0.41	3.6±0.08
115 - 124.9	177	119.4±0.20	61.3±0.20	39.2±0.20	175	131.0±1.30	30.6±0.47	4.0±0.07
125 - 134.9	33	127.3±0.32	64.7±0.45	42.5±0.41	31	159.0±3.15	36.2±1.38	4.5±0.13
135 - 144.9	4	136.5±0.13	70.7±0.71	47.0±1.02	4	203.9±9.51	47.9±3.03	4.4±0.67
Mean±SE	799	104.2±0.52	54.1±0.24	33.3±0.21	709	94.8±1.42	24.1±0.33	3.3±0.05

Mean shell length, height and convexity were calculated as 104.2±0.52 mm, 54.1±0.24 mm, and 33.3 ± 0.21 mm, respectively. Mean live weight was 94.8±1.42 g.

Relationships between length-weight (Figure 2), height-weight, convexity-weight, length-height, length-convexity and height-convexity of *Anodonta cygnea* are shown in Table 2.

The highest wet flesh and dry flesh yield were calculated as 29.8% and 3.1% of total weight, respectively in the length group 85-95 mm. It has been found that the weight of dried flesh increased between May to October. The relationship between length and dry weight of *A. cygnea* is given in Figure 3 and the linear and exponential equations are derived as;

$DFW = 0.052\ L - 2.3721$, $r = 0.99$

$DFW = 0.000003\ L^{2.9917}$, $r= 0.95$, respectively.

Linear equation was fitted best to the actual growth pattern due to higher regression.

Condition index (CI) showed monthly variations reaching maximum in July (CI1 = 16.73±0.03 and CI2 = 5.08±0.01) and lowest in October (CI1 = 14.32±0.09 and CI2 = 5.45±0.00). CI has also changed with the size of the mussel. Maximum values were observed in the length groups of 75-85 mm and 85-95 mm as CI1=18.3±1.29 and 18.3±2.75, CI2=7.8±0.66 and 5.9±0.33, respectively, while minimum values were observed for the groups 55-65 mm for CI1 and 135-145 mm for CI2. Mean index values were calculated as 15.4±0.47 for CI1 and 5.49±0.11 CI2. Condition index and dried flesh weights showed a similar trend according to the months (Figure 4).

Discussion

This is a preliminary research on *A. cygnea* in Lake Cıldır in Turkey. The existence of this species had been reported by Kinzelbach (1989), Bilgin (1980) and Soylu (1990) in Turkey, but there is no available information about the population characteristics in their natural habitats. Being a first record in the Lake, there is also no historical information about swan mussel. There are several studies carried out on other species, mainly with *Unio* sp., which are the relatives of Anodonta; body measurements, flesh yield and biochemical composition (Akyurt and Erdoğan, 1993; Özdemir *et al.*, 1999), heavy metal accumulations (Şeker *et al.*, 1999).

Ravera and Sprocati (1997) have reported that the length of *Anodonta cygnea* varied between 42 to 137 mm at river Lagodane in North Italy in 1975-1977. In this study, the range of shell length of the samples changed between 49.8 - 136.8 mm which is slightly higher than that of the population in Italy. In case of the *Unio* sp., there are several studies on their growth and flesh yield which were carried out in the Karasu and Müceldi Rivers in the Marmara Region (Akyurt and Erdoğan, 1993). Height, length and convexity of the samples collected from the Müceldi River were found as 2.66±0.11 cm, 4.59±0.20 cm and 1.65±0.08 cm, respectively (Akyurt and Erdoğan, 1993). Same parameters were determined as 2.92±0.10 cm, 5.72±0.23 cm, 1.84±0.07 cm in the Karasu River (Akyurt and Erdoğan, 1993). Unios of Gölmarmara Lake were rather bigger in all sizes compared to the Karasu and Müceldi Rivers, with a mean height of 4.02 cm, length of 8.48 cm and convexity of 2.82 cm (Çetinkaya, 1996). Keban Dam in the South-eastern Anatolia Region is another habitat for the Unio sp. The length and height of freshwater mussels (*Unio pictorum*) in this reservoir ranged between 55.7-79.1 mm (mean 69.1 mm) and 29.2- 37.5 mm (mean 33.82 mm), respectively, while these values were 65.9-86.0 mm (mean 79.98 mm) and 31.6-40.7 mm (mean 36.18 mm) for *Unio elongatulus* in the same order (Bilgin, 1987).

The mean weight of the swan mussels in Lake Çıldır is 94.8 g (49.8 - 136.8 mm length group) and it is three times heavier than those *Unio elongatulus eucirrus* living in the Keban Dam (36.03±7.49 g

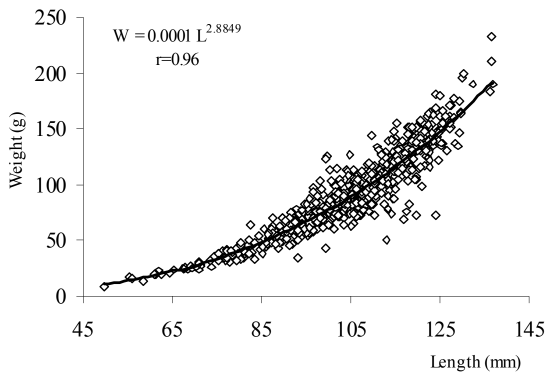

Figure 2. Length-weight relationship of *Anodonta cgynea* in Lake Çıldır.

Table 2. Relationships between L-W, H-W, C-W, L-H, L-C, and H-C values of *A. cygnea*

Relationships	a	b	r	n	F	P
$W = a L^b$	0.0001	28.849	0.96	709	7,338.34	<0.0001
$W = a H^b$	0.0002	32.236	0.90	709	180.25	<0.0001
W = a + b C	-90.794	55.661	0.92	709	3,929.37	<0.0001
H = a + b L	89.133	0.4339	0.93	798	5,252.45	<0.0001
C = a + b L	-47.954	0.3656	0.90	798	3,350.58	<0.0001
C = a + b H	-65.611	0.7363	0.84	799	1,915.86	<0.0001

L: Length,W: Weight, H: Height, C: Convexity, n: number, F: F-test, P: probability

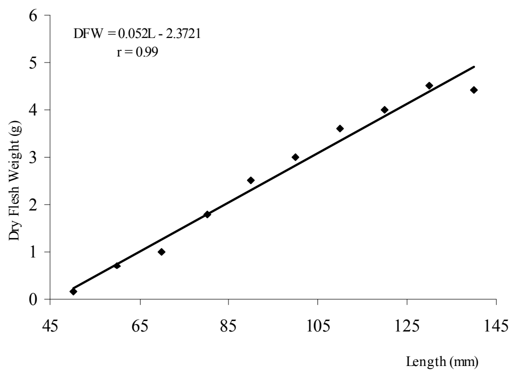

Figure 3. Relationship between length and dry flesh weight of *Anodonta cgynea* in Lake Çıldır.

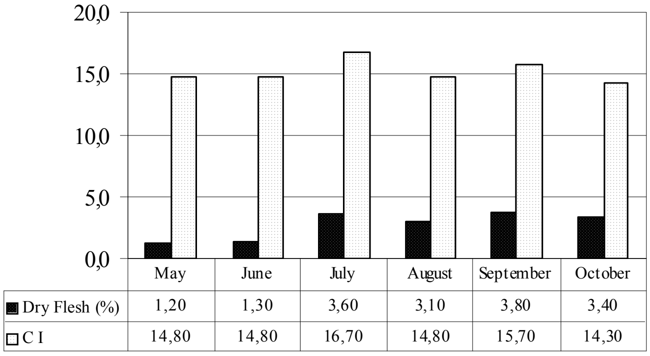

Figure 4. Monthly values of dried flesh weight and condition index (CI) for *Anodonta cygnea* in Lake Çıldır.

within the length range of 31 - 47 mm) (Özdemir *et al*., 1999).

Mean length and weight data from this research show that *Anodonta cygnea* in Lake Çıldır has higher values than the others.

David (1999) has reviewed the values of the regression equations (Equations are in the form y=a+bx) on the shell morphology for *Anodonta anatina* and *Anodonta cygnea* in the Fenland Waterway (Table 3). According to the results of both study regression coefficients show close similarity to populations living in the different localities mentioned above.

Relationship between length and dry flesh wasy=0.004 $e^{0.51x}$ for *Unio mancus* and y=0.12 $e^{0.31x}$ for *A. cygnea*. (Ravera and Sprocati, 1997). In the present study, flesh yield was calculated on dry flesh weight basis. Consequently, the relationship between length and dry flesh was DFW = 0.052 L - 2.3721 (r = 0.99) and DFW = 0.000003 $L^{2.9917}$ (r = 0.95) for *A. cygnea*. The main differences are for the equations derived by using different parameters in the two researches. *Anodonta cygnea* has a bigger body size than the above mentioned species.

Condition index and flesh yield were higher in the length groups of 75-85 mm and 85-95 mm. It can be concluded that, the differences between the two condition index values by months were due to larvae carried in the brood chambers along the whole year period, except for June.

Wet flesh and dry flesh yield for *A. cygnea* were found as 24.1±0.33% and 3.3±0.05% in this study. Although the live weight and the wet flesh weight of *A. cygnea* in Lake Çıldır were high, wet flesh yield of *Unio* sp. in Gölmarmara was higher than that of the present study (37.7%) (Çetinkaya, 1996). The wet flesh weights of *Unio* sp. as 3.67±0.30 g and 4.36±31.44 g for the Karasu and Müceldi rivers respectively were all less from our samples, as reported by Akyurt and Erdoğan (1993)

This preliminary research is very important for further studies as to create a reference point to make any possible comparisons. At present, fishing activities are limited only with common carp fishing even by drilling ice layer in winter period. The existence of swan mussel is well known by the inhabitans around the Lake, but there is no attempt to exploit mussel stocks. If any kind of intention will rise to catch and process swan mussel for a commercial purpose, these basic information will be more important both for the entrepreneurs and the nature conservators.

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Table 3. Values of the linear regression equations for the shell morphology of the species (*A. anatina* and *A. cygnea*) according to David (1999)

X	Y	Species	number	Slope (b)	Intercept (a)	r
Length	Convexity	*A. anatina*	299	0.383	-4.564	0.958
		A. cygnea	138	0.371	-7.398	0.977
		**A. cygnea*	798	0.366	-4.795	0.900
Length	Height	*A. anatina*	166	0.497	6.207	0.947
		A. cygnea	86	0.450	8.766	0.978
		**A. cygnea*	798	0.434	8.913	0.930
		A. anatina	166	0.719	-7.284	0.951
Height	Convexity	*A. cygnea*	86	0.740	-10.656	0.952
		**A. cygnea*	799	0.736	-6.561	0.840

(* present study)

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