Length-weight relationships of 12 fish species from the Köyceğiz Lagoon, Turkey

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ABSTRACT

This study provides the length-weight relationships of 12 fish species that belong to ten families from the Köyceğiz Lagoon, Turkey; *Dicentrarchus labrax* (Linnaeus, 1758); *Diplodus annularis* (Linnaeus, 1758); *Diplodus sargus* (Linnaeus, 1758); *Dassumieria elopsoides* Bleeker, 1849; *Engraulis encrasicolus* (Linnaeus, 1758); *Oreochromis niloticus* (Linnaeus, 1758); *Gobius niger* Linnaeus, 1758; *Mullus barbatus barbatus* Linnaeus, 1758; *Sparus aurata* Linnaeus, 1758; *Siganus rivulatus* Forsskål & Niebuhr, 1775; *Solea solea* (Linnaeus, 1758); *Trachinotus ovatus* (Linnaeus, 1758). A total of 720 fish samples were collected with fish barrier, trammel net, beach seine and cast-net. The growth type of *D. annularis* (*b*=3.148), *D. elopsoides* (*b*=3.089), *G. niger* (*b*=3.154), *S. solea* (*b*=3.124) was determined as positive allometry and *E. encrasicolus* (*b*=2.814), *D. labrax* (*b*=2.764), *T. ovatus* (*b*=2.901) was determined as negative allometry whereas *D. sargus* (*b*=2.995), *M. barbatus barbatus* (*b*=3.003), *O. niloticus* (*b*=3.088), *S. aurata* (*b*=3.009) and *S. rivulatus* (*b*=3.079) showed isometry. The results of this investigation will contribute to further fishery studies in the Köyceğiz Lagoon.

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Introduction

Lagoons and wetlands, which are of great ecological importance, are special ecosystems and undertake many functional tasks. The coastal lagoons located between the land and the sea are under the influence of both terrestrial and marine factors and are the transition zones between seawater and freshwater environments (Bianchi, 1988). Lagoons are also important for the economy due to providing a wide array of ecosystem services in addition to being the home of so many different species. Some of these services include fisheries, nutrient cycling and flood protection (Miththapala, 2013).
Lagoons play a positive role in increasing fish stocks as they are the places where the larvae of many fish species provide their nutrition, shelter and sustainability (Whitfield, 1999).

Length-weight relationships (LWRs) have an important role in fish stock management (Froese, 2006) and are also useful for comparing life history and morphological aspects of different populations from other regions (Goncalves et al., 1997). The LWRs provide predicting the weight corresponding to a given length and to allow for the comparison of fish growth in different habitats (Bagenal and Tesch, 1978; Morato et al., 2001; Tsoumani et al., 2006). LWRs may be useful to determine whether somatic growth is isometric or allometric (Ricker, 1975). Also the LWRs data provide the estimation of population size of a fish stock (Dulčić and Kraljević, 1996). Though there are some studies on length weight relationships in the Black Sea (Samsun et al., 2006; Kasapoğlu and Düzgüneş, 2013), the Sea of Marmara (Keskin and Gaygusuz, 2010; Bok et al., 2011) the Aegean Sea (İlkyaz et al., 2008; Bilge et al., 2014; Ates et al., 2017), the eastern Mediterranean Sea (Cicek et al., 2006; Sangun et al., 2007; Gökçe et al., 2010) and in the Turkish Lagoons few studies on LWRs of fish species in the Homa Lagoon (Acarli et al., 2014); in the Beymelek Lagoon (Sümer, 2012) have been conducted.

The aim of this study is to determine the LWRs of 12 fish species sampled from the Köyceğiz Lagoon, Southeastern Aegean Sea.

Material and Methods

The Köyceğiz Lagoon system covers 5400 hectares lake area, 1150 hectares marsh-looking delta area and is connected to sea via a 14 km long canal. The width of the canal varies between 5-70 meters and the depth between 1-6 meters (Buhan, 1998). A total of 720 fish samples were collected with fish barrier (40 mm mesh size), trammel net (32 mm mesh size), beach seine (10 mm mesh size) and cast-net (32 mm mesh size) between January 2017 and December 2017 in the Köyceğiz Lagoon, Turkey (Figure 1). Fish species were identified at the species level and validated by referencing FishBase (Froese and Pauly, 2017). Total length (TL) of fish species were recorded to the nearest centimetre (0.1 cm), and body weight (W) was measured with precision balance of (0.01 g accuracy).

The parameters a and b of relationships of the equation

\[ W = aL^b \]

(Ricker, 1975) were estimated through logarithmic transformation;

\[ \log W = \log a + b \log TL \]

where W is weight (g), TL is total length (cm), a is the intercept and b is the slope of the linear regression. Parameters a and b were calculated by least-squares regression, as was the coefficient of determination (r²). The significance of the b-values for each species was tested by Pauly’s t-test to confirm that it was significantly different from the predictions for isometric growth (b=3) (Pauly, 1984). Pauly’s t-test was calculated as:

\[ t = \left( \frac{SD_{\log TL}}{SD_{\log W}} \right) \times \frac{|b - 3|}{\sqrt{1-r^2}} \times \sqrt{(n-2)} \]

where SD_{\log TL} is the standard deviation of the logTL values, SD_{\log W} is the standard deviation of the logW values, n is the number of fish species used in the computation. The value of b is different from 3 if t value is greater than the tabled t values for n-2 degrees of freedom (Pauly, 1984).

Results

A total of 12 fish species from ten families namely Carangidae, Cichlidae, Dussumieriidae, Engraulidae, Gobiidae, Moronidae, Mullidae, Siganidae, Soleidae and Sparidae were sampled in this study. The sample size ranged from 29 individuals for D. elopsoides, to 196 individuals for E. encrasicolus. The b value of the LWRs ranged from 2.274 for D. labrax to 3.154 for G. niger. The curves of length-weight relationships for studied species are given in Figure 2. The growth type of D. annularis, D. elopsoides, G. niger, S. solea was determined as positive allometry (b>3) and E. encrasicolus, D.
labrax, *T. ovatus* was determined as negative allometry (*b*<3) whereas *D. sargus, M. barbatus barbatus, O. niloticus, S. aurata* and *S. rivulatus* showed isometry (*b*≈3). The determination coefficient (*r*²) ranged from 0.94 for *S. aurata* to 0.99 for *D. elopsoides*. The coefficient of determination (*r*²) was very high for all studied species. Length-weight relationship parameters *a* and *b*, standard deviation of *b* (SDₚ), 95% confidence interval (CI) for *b*, correlation coefficient (*r*²), number of sample (*n*), length range and weight range for each of the twelve species were presented in Table 1.

**Figure 2.** The curves of length-weight relationships for studied species from Köyceğiz Lagoon
Table 1. Parameters of length-weight relationship for twelve fish species from the Köyceğiz Lagoon

| Species               | n  | TL range (cm) | W range (g) | a    | b    | r²  | SDb | %95CI of b | Pauly’s t-test |
|-----------------------|----|---------------|-------------|------|------|-----|------|------------|----------------|
| D. labrax             | 39 | 18.3-40.8     | 69.76-805.32| 0.0253| 2.764 | 0.967| 0.049| 2.59-2.94 | t=2.8002, P<0.05|
| D. annularis          | 81 | 5.0-17.1      | 1.85-100.57 | 0.0123| 3.148 | 0.976| 0.061| 3.04-3.26 | t=2.6505, P<0.05|
| D. sargus             | 35 | 11.9-22.1     | 29.40-194.25| 0.0188| 2.995 | 0.983| 0.031| 2.86-3.13 | t=0.0685, P>0.05|
| D. elopsoides         | 29 | 7.0-24.1      | 2.41-99.50  | 0.006 | 3.089 | 0.994| 0.045| 2.99-3.19 | t=1.9158, P<0.05|
| E. encrasicolus       | 196| 6.5-11.8      | 2.09-10.61  | 0.0099| 2.814 | 0.956| 0.033| 2.72-2.90 | t=4.1570, P<0.05|
| G. niger              | 34 | 3.1-10.8      | 0.33-14.10  | 0.0076| 3.154 | 0.978| 0.070| 2.98-3.33 | t=1.8252, P<0.05|
| M. barbatus barbatus  | 53 | 5.8-10.8      | 2.25-14.10  | 0.0110| 3.003 | 0.964| 0.043| 2.84-3.17 | t=0.0387, P>0.05|
| O. niloticus          | 93 | 6.0-28.6      | 5.31-467.85 | 0.0168| 3.088 | 0.970| 0.093| 2.98-3.20 | t=1.5513, P<0.05|
| S. aurata             | 61 | 12.1-26.5     | 25.15-283.82| 0.0139| 3.009 | 0.938| 0.062| 2.81-3.21 | t=0.0916, P>0.05|
| S. rivulatus          | 37 | 8.2-19.9      | 8.42-117.51 | 0.0115| 3.079 | 0.979| 0.047| 2.93-3.23 | t=1.0623, P>0.05|
| S. solea              | 32 | 10.7-25.1     | 11.42-172.51| 0.0066| 3.124 | 0.972| 0.057| 2.92-3.32 | t=1.7488, P<0.05|
| T. ovatus             | 30 | 14.9-26.9     | 28.14-160.36| 0.0113| 2.901 | 0.971| 0.040| 2.70-3.09 | t=1.7198, P<0.05|

Note: n: sample size; TL: total length (cm); W: total weight (g); a: intercept; b: slope of the regression line; r²: coefficient of determination; SDb: standard deviation of b; CI: confidence intervals.

Discussion

The length-weight relationships in fish could be affected by many factors such as season, habitat, temperature, salinity, gonad maturity, sex, diet, food availability and length range (Tesch, 1971; Moutopoulos and Stergiou, 2002; Froese, 2006). The growth coefficient (b) values in LWR identify the growth type of the fish species. The value of b ≠ 3 shows allometric growth where the fish becomes thinner with increasing length, b = 3 shows isometric growth and fish transform into more robust with increase in length (Bagenal and Tesch, 1978). The b value is expected to range from 2.5 to 3.5 (Froese, 2006). The b values of studied species are in reported range by Froese (2006).

Growth types were found similar to present study for D. labrax (Crec’hriou et al., 2013; Mahé et al., 2018), D. annularis (Ilkyaz et al., 2008), D. sargus (Ceyhan et al., 2009), D. elopsoides (Erguden et al., 2009), E. encrasicolus (Aka et al., 2004; Samsun et al., 2015), G. niger (Cicek et al., 2006; Bilge et al., 2014), M. barbatus barbatus (Djabali et al., 1993; Giacalone et al., 2010), S. aurata (Stergiou and Moutopoulos, 2001), S. rivulatus (Gabr et al., 2018), S. solea (Cerim and Ateş, 2020) and T. ovatus (Abdallah, 2002; Moutopoulos et al., 2013). In contrast, there are different results of growth types for D. labrax (Dulčić, and Glamuzina, 2006), D. annularis (Sangun et al., 2007), D. sargus (Maci et al., 2009), E. encrasicolus (Veiga et al., 2009), O. niloticus (Mehak et al., 2017), G. niger (Bok et al., 2011; Kasapoğlu and Düzgüneş, 2013), M. barbatus barbatus (Maci et al., 2009; Gökçe et al., 2010), S. aurata (Ceyhan et al., 2009; Crec’hriou et al., 2013), S. rivulatus (Ates et al., 2017), S. solea (Türkmen, 2003) and T. ovatus (Santos et al., 2002). Length-weight relationships obtained in the present study are compared by different researches in other locations and some differences determined (Table 2). It can be think that the differences are about sampling method, fish condition, seasonality, length range, sex, gonadal maturity, sample size and stomach fullness.
Table 2. Comparison of length-weight relationships of studied species from different locations

| Species          | n   | TL range (cm) | a      | b    | r²   | Location                                      | References                           |
|------------------|-----|---------------|--------|------|------|-----------------------------------------------|--------------------------------------|
| **D. labrax**    | 422 | 24.5-88.0     | 0.0079 | 3.065| 0.976| Eastern Adriatic estuarine systems            | Dulčić and Glamuzina, 2006          |
|                  | 67  | 27.0-53.0     | 0.0150 | 2.880| 0.924| French Catalan coast                          | Crečhiou et al., 2013               |
|                  | 111 | 8.5-33.9      | 0.0150 | 2.947| 0.999| Homa Lagoon                                   | Acarli et al., 2014                 |
|                  | 417 | 16.0-83.0     | 0.0340 | 2.701|      | North-eastern Atlantic Ocean                  | Mahé et al., 2018                   |
|                  | 39  | 18.3-40.8     | 0.0253 | 2.764| 0.966| Köyceğiz Lagoon                               | Present study                       |
| **D. annularis** | 154 | 10.3-15.0     | 0.0370 | 2.677| 0.90 | North-Eastern Mediterranean Coast              | Sangun et al., 2007                 |
|                  | 161 | 9.8-16.0      | 0.0253 | 3.012| 0.95 | Gulf of Gabes, Central Mediterranean          | Ghailen et al., 2010                |
|                  | 15  | 7.0-16.7      | 0.0220 | 2.957| 0.994| Sea of Marmara                                | Bok et al., 2011                    |
|                  | 121 | 3.9-15.5      | 0.0100 | 3.190| 0.994| Homa Lagoon                                   | Acarli et al., 2014                 |
|                  | 81  | 5.0-17.1      | 0.0123 | 3.148| 0.976| Köyceğiz Lagoon                               | Present study                       |
| **D. sargus**    | 33  | 14.9-26.7     | 0.0342 | 2.808| 0.850| South coast of Iskenderun Bay                 | Can et al., 2002                    |
|                  | 33  | 16.0-32.3     | 0.0144 | 3.061| 0.980| Gökova Bay, Aegean Sea                        | Ceyhan et al., 2009                 |
|                  | 368 | 10.0-40.0     | 0.0170 | 3.000| 0.934| French Catalan Sea                            | Crečhiou et al., 2013               |
|                  | 124 | 11.0-38.5     | 0.0110 | 3.145| 0.975| Southern Ionian sea, Greece                   | Dimitriadi and Konstantinidou, 2018 |
|                  | 35  | 11.9-22.1     | 0.0188 | 2.995| 0.983| Köyceğiz Lagoon                               | Present study                       |
| **D. elopsoides**| 59  | 9.9-16.4      | 0.0055 | 3.123| 0.987| Iskenderun Bay, Mediterranean Sea              | Erguden et al., 2009                |
|                  | 29  | 7.0-24.1      | 0.006  | 3.089| 0.994| Köyceğiz Lagoon                               | Present study                       |
| **E. encrasica** | 212 | 5.8-14.0      | 0.0008 | 3.822| 0.950| North Aegean Sea, Greece                      | Karachte and Stergiou, 2008         |
|                  | 759 | 5.9-14.6      | 0.0124 | 2.711| 0.944| Black Sea                                     | Kasapoglu and Düzgün, 2013          |
|                  | 188 | 7.0-11.3      | 0.0070 | 2.917| 0.999| Homa Lagoon                                   | Acarli et al., 2014                 |
|                  | 196 | 6.5-11.8      | 0.0099 | 2.814| 0.956| Köyceğiz Lagoon                               | Present study                       |
| **G. niger**     | 272 | 2.1-12.2      | 0.0047 | 3.394| 0.946| Northeastern Mediterranean Sea                 | Çicek et al., 2003                  |
|                  | 112 | 6.8-15.8      | 0.0180 | 2.856| 0.953| Mediterranean Sea                              | Kasapoglu and Düzgün, 2013          |
|                  | 34  | 3.1-10.8      | 0.0076 | 3.154| 0.978| Köyceğiz Lagoon                               | Present study                       |
| **M. barbatus**  | 2693| 5.3-19.0      | 0.0074 | 3.123| 0.962| Black Sea                                     | Kasapoglu and Düzgün, 2013          |
| **barbatus**     | 1565| 8.7-21.5      | 0.0071 | 3.165| 0.894| Mediterranean Sea                              | Özvarol, 2014                      |
|                  | 53  | 5.8-10.8      | 0.0110 | 3.003| 0.964| Köyceğiz Lagoon                               | Present study                       |
| **O. niloticus** | 125 | 9.1-18.5      | 0.0393 | 2.720| 0.910| Indus River, Pakistan                         | Naem et al., 2010                   |
|                  | 261 | 11.5-47.0     | 0.310  | 3.250| 0.967| Eight floodplain lakes of Agusan Marsh        | Jumawan and Seronay, 2017           |
|                  | 93  | 6.0-28.6      | 0.0168 | 3.088| 0.970| Köyceğiz Lagoon                               | Present study                       |
| **S. aurata**    | 59  | 14.6-45.0     | 0.0266 | 2.736| 0.966| Gökova Bay, Aegean Sea                        | Ceyhan et al., 2009                 |
|                  | 105 | 13.5-18.3     | 0.0090 | 3.150| 0.999| Homa Lagoon                                   | Acarli et al., 2014                 |
|                  | 61  | 12.1-26.5     | 0.0139 | 3.009| 0.938| Köyceğiz Lagoon                               | Present study                       |
| **S. rivulatus** | 84  | 15.5-25.0     | 0.016  | 2.964| 0.97 | Beymelek Lagoon                               | Sümer, 2012                        |
|                  | 2004| 11.2-30.2     | 0.0114 | 3.061| 0.98 | Red Sea, Saudi Arabia                         | Gabr et al., 2018                   |
|                  | 37  | 8.2-19.9      | 0.0115 | 3.079| 0.979| Köyceğiz Lagoon                               | Present study                       |
| **S. solea**     | 21  | 11.0-22.1     | 0.0098 | 3.002| 0.988| Northern Aegean estuarine systems             | Koutrakis and Tsikliras, 2003       |
|                  | 73  | 8.7-20.5      | 0.0070 | 3.053| 0.999| Homa Lagoon                                   | Acarli et al., 2014                 |
|                  | 1136| 3.9-31.1      | 0.0079 | 3.064| 0.991| Southern Aegean Sea                           | Cerim and Ateş, 2020               |
|                  | 32  | 10.7-25.1     | 0.0066 | 3.124| 0.972| Köyceğiz Lagoon                               | Present study                       |
| **T. ovatus**    | 26  | 14.1-26.8     | 0.0120 | 2.897| 0.90 | Beymelek Lagoon                               | Sümer, 2012                        |
|                  | 33  | 15.7-44.0     | 0.0089 | 2.937| 0.994| Tropical north-eastern Atlantic                | Oliveira et al., 2015               |
|                  | 30  | 14.9-26.9     | 0.0113 | 2.901| 0.971| Köyceğiz Lagoon                               | Present study                       |

Note: n: sample size; TL: total length (cm); a: intercept; b: slope of the regression line; r²: coefficient of determination.
Conclusion

Consequently, growth parameters such as length-weight relationship provide some indication of resource utilization and the effectiveness of management strategies. Thus, fisheries management should be designed on biological data to understand the status and to manage of fish stocks. Köyceğiz Lagoon is important fishing area for local fishermen. This study provides the first basic information of the length-weight (LWRs) relationships of the studied species for the Köyceğiz Lagoon. These results will be useful for fisheries research, management and conservation in the Köyceğiz Lagoon.

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Compliance with Ethical Standards

Conflict of Interest

The author declares that there is no conflict of interest.

Ethical Approval

This study was conducted in accordance with ethics committee procedures of animal experiments.

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