Journal of Biological Sciences 8 (1): 155-160, 2008
ISSN 1727-3048
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# Age, Growth, Reproduction and Mortality of Tub Gurnard (*Chelidonichthys lucernus* (Linnaeus, 1758)) Inhabiting in Babadillimani Bight (Northeastern Mediterranean Coast of Turkey)

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**Abstract:** This study was carried out between May 1999 and April 2000 in Babadıllimanı Bight, located in the Western entrance of Mersin Bay. A total of 228 specimens were trawled by monthly sampling and they consisted of 49.56% females, 46.49% males and 3.95% juveniles. Age composition varied from 0 to V. The mean total length and weight for females, males and combined sexes were calculated as 15.12±4.36 cm-39.85±38.55 g, 15.11±4.51 cm to 40.71±38.69 g and 14.82±4.71 cm to 39.24±38.63 g, respectively. The length-weight relationships were $W = 0.0114*L^{2.9179}$ for females, $W = 0.0094*L^{2.9883}$ for males and $W = 0.0129*L^{2.8735}$ for combined sexes. The von Bertalanffy growth parameters were estimated as $L_\infty$ = 46.42 cm, $W_\infty$ = 832.13, K = 0.157 year$^{-1}$ and $t_0$ = -1.569 year for females, $L_\infty$ = 56.77 cm, $W_\infty$ = 1728.32, K = 0.121 year$^{-1}$ and $t_0$ = -1.646 year for males and $L_\infty$ = 42.25 cm, $W_\infty$ = 605.90, K = 0.196 year$^{-1}$ and $t_0$ = -1.351 year for combined sexes. According to monthly changes of mean Gonadosomatic Index values, spawning occurs between February and May. Mean fecundity was calculated as 77010±17622. In additionally, length-fecundity and weight-fecundity relationships were estimated as $F = 1898*L^{1.156}$ ($r^2 = 0.4077$) and $F = 242*W+43072$ ($r^2 = 0.4827$), respectively. Total mortality rate (Z) was estimated 1.19, fishing mortality (F) was calculated as 1.09 and exploitation rate (E) was estimated as 0.90 by using mortality rates.

**Key words:** *Chelidonichthys lucernus*, fecundity, length-weight relationships, Mersin Bay, tub gurnard

## INTRODUCTION

Tub gurnard *Chelidonichthys lucernus* is a demersal marine fish species distributed along the European and West African coast of Atlantic, from Norway to Cape Blanc and also inhabiting in the Mediterranean and Black seas. The species inhabits sandy and/or muddy bottoms at the depths between of 20 and 300 m (Hureau, 1996; Froese and Pauly, 2007). Tub gurnard exhibits migratory movement within its overall depth range during the year and it shows a pronounced concentration the shallow depths in spring and summer and then moves progressively to deeper waters in winter (İşmen *et al*., 2004). Its feeding depends on fish, crustacean and mollusks (Hureau, 1996; Froese and Pauly, 2007).

*C. lucernus* has a commercial importance and exploited in the northeastern Mediterranean coasts of Turkey with deep trawl and longlines and marketed as a fresh fish. A total of 316 t of *C. lucernus* were obtained from the Turkish seas in 1984. The annual landing sharply increased up to 3287 t in 1992 and then decreased year by year (FAO, 2000). In 2004, the yield was reported 241 t. In addition, over the 65% of total annual catch were obtained from Mediterranean coasts of Turkey especially in Mersin and Iskenderun bays (FishStat, 2007).

Age and growth of this species have been studied in the Mediterranean coasts (Papaconstantinou, 1984; Altun *et al*., 1996; Abdullah, 2002; Moutopoulos and Stergiou, 2002; Santos *et al*., 2002; Borges *et al*., 2003; İşmen *et al*., 2004; Mendes *et al*., 2004). In the Northeastern Mediterranean, Altun *et al*. (1996) and İşmen *et al*. (2004) studied the age, growth and spawning of tub gurnard. Both of these studies were carried out in the same region (Iskenderun Bay). However there was no study about *C. lucernus* inhabiting in Mersin Bay. Therefore, the main objective of the present study was to estimate the length, weight and age frequency distribution, length-weight relationship, von Bertalanffy growth equation, sex ratio, reproduction and fecundity of *C. lucernus* distributed in the western entrance of the Mersin Bay.

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## MATERIALS AND METHODS

This study was carried out in Babadıllimanı Bight (33°23′36′′-33°32′57′′N; 36°07′00′′-36°09′39′′E) located in the Cilician Basin, northeastern Mediterranean (Fig. 1) at monthly sampling interval using a commercial bottom trawl net from May 1999 to April 2000. Fishes were caught from 20 to 100 m depth ranges by using typical Mediterranean deep trawl net with 6 mm cod end mesh size and two duration was restricted with 1 h. A total of 36 hauls were analyzed during the sampling period. Samples were collected randomly from each haul as suggested by Holden and Raitt (1974) and preserved in 4% formaldehyde solution buffered by borax. In the laboratory, the Total Length (TL), Total Weight (TW) and Total Gonad Weight (TGW) measurements were made with the nearest 0.1 cm, 0.01 and 0.0001 g, respectively.

The sagittal otoliths were examined under the stereo binocular microscope for the age determination. The Length-Weight Relationship (LWR) was calculated by using the formula $W = a*L^b$ given by Ricker (1975) for females, males and the combined sexes since males and females may have different growth models (Dulcic and Kraljevic, 1996; Moutopoulos and Stergiou, 2002). In order to test the possible significant differences between sexes, t-test was used for the comparison of two slopes of their LWR curves. The parameters a (proportionality constant) and b (regression coefficient) of the LWR were estimated by the Least Square Regression Method (Sparre and Venema, 1992) and the growth type was identified by the employing t-test using the SPSS computer program. The growth parameters K, $L_\infty$ and $t_0$ were estimated using the Least Square Regression Method suggested by Sparre and Venema (1992).

In order to estimate the spawning season, monthly mean Gonadosomatic Index (GSI) values were calculated by using the formula given by Gibson and Ezzi (1978) The Condition Factor (CF) was calculated by using the formula $CF = W/L^3*100$ to assess the maturity and condition of the specimens.

Total mortality rate (Z) was estimated using the Beverton and Holt Z-equation based on length-at-first-capture method:

$$Z = \frac{(L_\infty - \bar{l})}{(\bar{l} - l_c)}$$ (Sparre and Venema, 1998)

$l_c$ = Length at which 50% of the fish entering the gear are retained

$\bar{l}$ = Average length of the entire catch

Natural mortality (M) was calculated by using the Pauly's Empirical formula $M = -0.0152-0.279*$ (In $L_\infty$) $+0.6543*$ (in K)$+0.463$(In T). In this formula, T is mean annual sea surface temperature. Fishing mortality (F) was calculated from the formula F = Z-M. Exploitation rate was calculated by using the formula:

$$E = \frac{F}{Z}$$ (Sparre and Venema, 1998).

## RESULTS

A total of 228 specimens were examined during the study period and obtained results were given as follows. Age-frequency distribution, mean total length and weight characteristics for each sex and combined sexes were shown in Table 1.

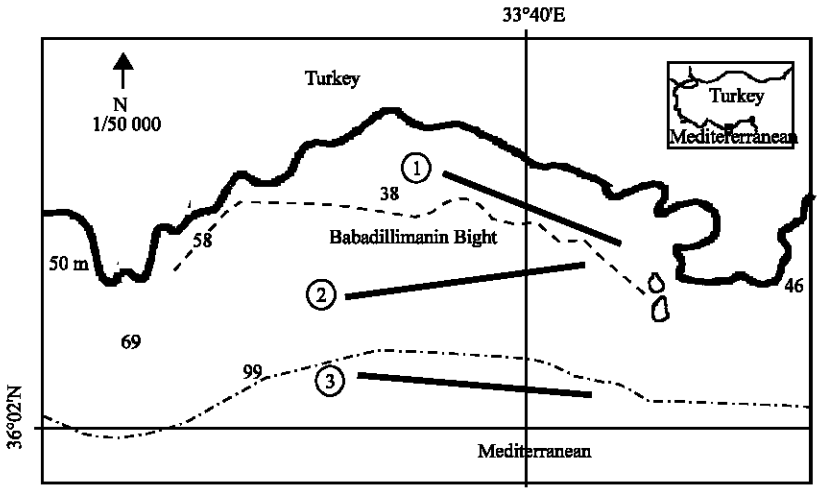



Fig. 1: Location of study area, Babadillimani Bight, Northeastern Mediterranean, Turkey

Table 1: Mean total length/weight and range of age groups for females, males and combined sexes

| Age groups | Females n | Mean TL | TL range | Mean TW | TW range | Males n | Mean TL | TL range | Mean TW | TW range | Combined sexes n | Mean TL | TL range | Mean TW | TW range |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 40 | 11.06±2.13 | 6.1-14.0 | 13.95±7.01 | 3.2-31.4 | 38 | 10.42±1.92 | 6.5-14.3 | 11.31±5.70 | 2.9-25.3 | 87 | 10.63±2.20 | 2.2-14.3 | 11.76±6.95 | 0.2-31.4 |
| I | 57 | 15.83±1.76 | 14.5-22.1 | 37.23±14.46 | 29.5-110.9 | 51 | 16.26±1.48 | 13.9-21.6 | 39.11±12.89 | 19.2-101.8 | 108 | 16.80±1.99 | 13.9-22.1 | 38.25±13.71 | 19.2-110.9 |
| II | 7 | 20.30±1.34 | 20.5-21.8 | 79.19±18.47 | 72.6-104.7 | 10 | 20.32±1.81 | 18.0-23.2 | 85.37±27.64 | 52.4-123.3 | 17 | 21.09±1.56 | 18.0-23.2 | 85.90±23.01 | 52.4-123.3 |
| III | 7 | 23.20±1.66 | 21.4-25.7 | 119.00±30.70 | 86.2-161.9 | 5 | 23.36±0.73 | 22.4-24.3 | 130.03±18.41 | 110.5-158.7 | 12 | 23.39±1.41 | 21.4-25.7 | 123.60±25.88 | 86.2-161.9 |
| IV | 1 | 28.9 | - | 213.77 | - | 2 | 28.25±1.48 | 27.2-29.3 | 193.23±4.57 | 190.0-196.5 | 3 | 28.47±1.29 | 27.2-29.3 | 205.41±14.65 | 190.0-213.8 |
| V | 1 | 30.3 | - | - | - | - | - | - | - | - | 1 | 30.30 | - | 221.41 | - |
| Total | 113 | 15.12±4.36 | 6.1-30.3 | 39.85±38.55 | 3.2-221.4 | 106 | 14.21±5.17 | 6.5-29.3 | 40.71±38.69 | 2.9-196.5 | 228 | 14.90±5.57 | 2.2-30.3 | 39.24±38.63 | 0.2-221.4 |

**Age-frequency distribution:** Age groups of *C. lucernus* varied from 0 to 5 for females and 0 to 6 for males age 1 was dominant for females, males and combined sexes (include 9 juvenile specimens). According to percentage occurrence, age group I was dominant for combined sexes and it was followed by the age groups 0, 2, 3, 4 and 5. However, it is highly possible that the percentage occurrence of 0th age group is higher than that of first age group, but due to the gear selectivity the percentage occurrence of this age group realized in the second order.

**Length-frequency distribution:** Total length of all individual varied from 2 to 30 cm (Table 1). In addition, 13.60% of total specimens consist of 15 cm individuals and total lengths of 68.42% of total specimens were between 11 and 18 cm.

As shown in Table 1, total length of female specimens varied from 6.1 to 30.3 cm and male specimens ranged from 6.5 to 29.3 cm. Mean total length was calculated as 15.63±5.93 cm for females, 14.21±5.17 cm for males and 14.90±5.57 cm for combined sexes. Mean annual growth rate in length between the first and second year was the highest followed by subsequent years. As can be shown from Table 2, fast growth rate in length decreased with the increasing age of fish.

**Weight-frequency distribution:** As summarized in Table 1, the total weight ranged from 3.2 to 221.4 g for females, 2.9 to 196.5 g for males and 0.2 to 221.4 g for combined sexes. The mean weight for females, males and combined sexes were calculated as 39.85±38.55 g, 40.71±38.69 and 39.24±38.63 g, respectively. The mean annual growth rate in weight between the first and second year was the highest and the growth rate decreased in the subsequent years.

**Length-weight relationship:** Length-weight relationship parameters for females, males and combined sexes were shown in Table 2 and Fig. 2. It is clearly shown from Table 2 and Fig. 2 parameter b values were estimated as 2.9179, 2.9883 and 2.8735 for females, males and combined sexes respectively. Although all of the values were under the 3, according to result of the t-test, estimated b values were significantly different from 3 for females and combined sexes and b values were not significantly different from 3 for males. This result implies that, while type of growth was negative allometry for females and combined sexes, it is isometry for males.

Table 2: Length-weight relationship parameters and von Bertalanffy growth parameters in length and weight for females, males and combined sexes (-A: negative allometry; I: Isometry)

| Parameters | Females | Males | Combinedsexes |
|---|---|---|---|
| N | 113.000 | 106.0000 | 228.000 |
| a | 0.0114 | 0.0094 | 0.0129 |
| b | 2.9178 | 2.9883 | 2.8735 |
| SE of b | 0.0320 | 0.0340 | 0.0210 |
| 95% Confidence intervals of b | 2.855-2.981 | 2.921-3.056 | 2.832-2.915 |
| $r^2$ | 0.9870 | 0.9870 | 0.988 |
| Type of Growth | -A | I | -A |
| $L_\infty$(cm) | 46.4200 | 56.770 | 42.250 |
| $W_\infty$ (g) | 832.1300 | 1728.320 | 605.900 |
| $t_o$ (year) | -1.5690 | -1.646 | -1.351 |
| K ($year^{-1}$) | 0.1570 | 0.121 | 0.196 |

**Growth:** The von Bertalanffy growth parameters in length and weight were shown in Table 2. The lowest asymptotic length was calculated for combined sexes ($L_\infty$ = 42.25 cm) and the values were also calculated as $L_\infty$ = 46.42 and $L_\infty$ = 56.77 cm for females and males, respectively. The estimated von Bertalanffy growth constants in length and weight were: $L_\infty$ = 46.42 cm, $W_\infty$ = 832.13, K = 0.157 $year^{-1}$ and $t_o$ = -1.569 year for females, $L_\infty$ = 56.77 cm, $W_\infty$ = 1728.32, K = 0.121 $year^{-1}$ and $t_o$ = -1.646 year for males and $L_\infty$ = 42.25 cm, $W_\infty$ = 605.90, K = 0.196 $year^{-1}$ and $t_o$ = -1.351 year for combined sexes. As can be seen from Table 4, the asymptotic length and weight for males were higher than that of females.

Calculated mean length and weight for each age group of each sexes using length-weight relationship were predicted. When measured values for each age group of each sex and their pooled data given in Table 1 and calculated values were taken in the considiration; there were very close correlations between measured and calculated length and weight (R = 0.99).

**Sex ratio, spawning season and fecundity:** A total of 228 specimens were sexed, among them 113 were females (49.56%), 106 were males (46.49%) and 9 were juvenile (3.95). The overall female:male ratio was 1.07:1.00 and $\chi^2$ analysis showed that there was no significant difference

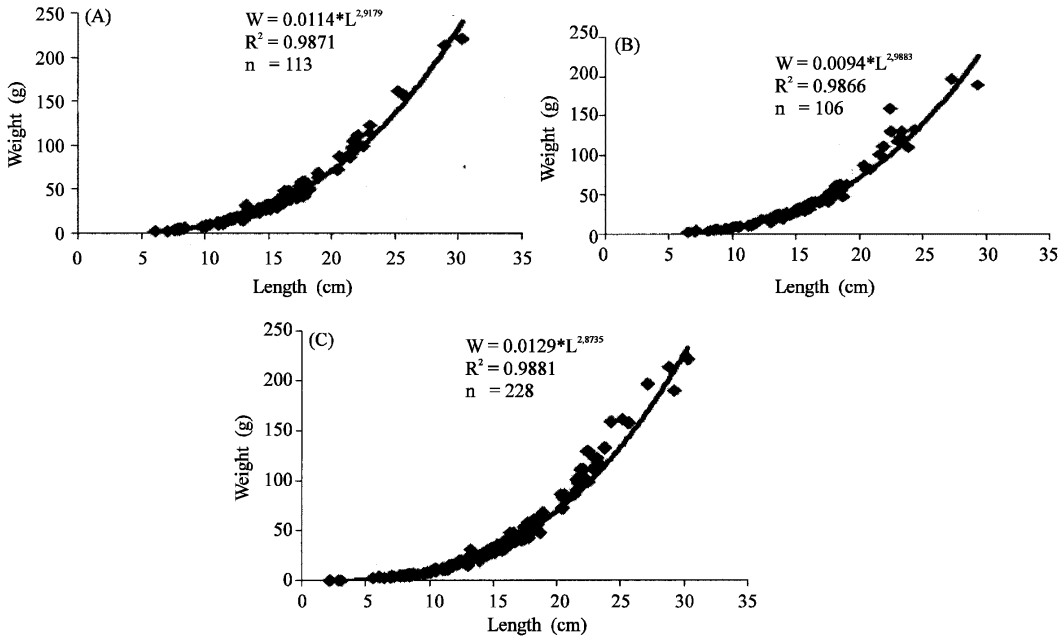



Fig. 2: Length-weight relationship parameters for females (A), males (B) and combined sexes (C)

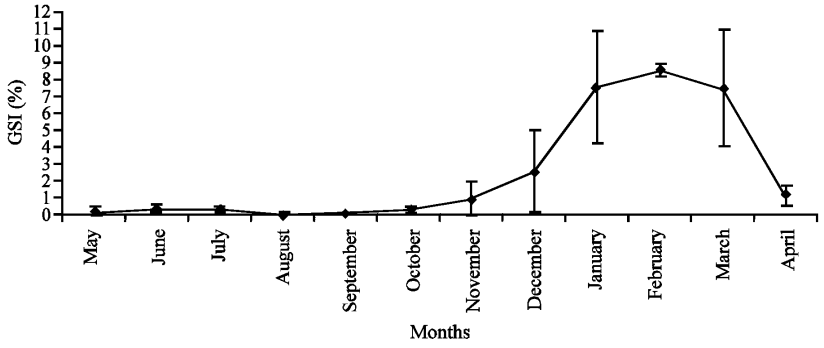



Fig. 3: Monthly changes of gonadosomatic index values

between 1:1 ratio and calculated one. Examination of the female ovaries indicated that the sexual maturation starts at age group I.

Monthly changes of the mean Gonadosomatic Index (GSI) values were shown in Fig. 3. As can be seen from the figure, spawning was occurred between of February and May in the northeastern Mediterranean population of *C. lucernus*. Indeed, GSI values started to increase in October with producing gonads and reach its highest value in February. Because of the starting spawning, GSI values decreased sharply until May.

Mean fecundity and mean fecundity per 1 g body weight were calculated as 77010±17622 and 587±177, respectively. In addition to this, length-fecundity and weight-fecundity relationships were estimated as $F = 1898*L^{1.156}$ ($r^2 = 0.4077$) and $F = 242*W+43072$ ($r^2 = 0.4827$), respectively.

**Mortality and exploitation:** Mortality rates and exploitation rate were given in Table 3. As listed in the table, total mortality (Z) rates for females, males and combined sexes were estimated 1.04, 1.24 and 1.19 and natural mortality (M) rate were 0.19, 0.32 and 0.10, respectively. In this case, fishing mortality rate is higher than the natural mortality rate.

Minimum exploitation rate (0.75) was estimated for males and maximum (0.90) was estimated for combined sexes.

## DISCUSSION

In this study, estimated b values were found to be 2.9179, 2.9883 and 2.8735 females, males and combined sexes respectively (Fig. 2, Table 2). On the other side, estimated b values of *C. lucernus* which is distributed

Table 3: Estimated length-weight relationships for *Chelidonichthys lucernus* distributed along the Mediterranean coasts (F: Female, M: Male, C: Combined sexes)

| n | Sex | a | b | $r^2$ | $L_\infty$(cm) | K ($year^{-1}$) | $t_0$(year) | Author |
|---|---|---|---|---|---|---|---|---|
| 153 | M | 0.000005 | 3.147 | 0.992 | - | - | - | Papaconstantinou (1984) |
| 122 | F | 0.000006 | 3.110 | 0.997 | - | - | - | Papaconstantinou (1984) |
| 210 | M | 0.000012 | 2.977 | 0.900 | - | - | - | Moutopoulos and Stergiou (2002) |
| 181 | F | 0.000004 | 3.187 | 0.950 | - | - | - | Moutopoulos and Stergiou (2002) |
| 563 | C | 0.000010 | 3.011 | 0.930 | 71.30 | - | 1.567 | Moutopoulos and Stergiou (2002) |
| 348 | C | 0.113000 | 3.089 | - | 40.90 | 0.138 | - | Altun *et al.* (1996) |
| 196 | C | 0.029000 | 2.630 | 0.947 | | - | - | Abdallah (2002) |
| 75 | C | 0.018000 | 2.978 | 0.968 | - | - | - | Santos *et al.* (2002) |
| 10 | C | 0.001290 | 2.956 | 0.990 | - | - | - | Borges *et al.* (2003) |
| 169 | C | 0.028000 | 2.668 | - | - | - | - | Mendes *et al.* (2004) |
| 143 | C | 0.008900 | 3.010 | 0.980 | 36.00 | 0.309 | - | İşmen *et al.* (2004) |
| 199 | C | 0.009500 | 2.990 | 0.990 | 45.60 | 0.223 | - | İşmen *et al.* (2004) |
| 342 | C | 0.009300 | 2.990 | 0.980 | 45.00 | 0.221 | - | İşmen *et al.* (2004) |
| - | C | 0.006500 | 3.110 | - | - | - | - | Froese and Pauly (2007) |
| - | C | - | - | - | 65.00 | 0.148 | - | Froese and Pauly (2007) |
| 106 | M | 0.009400 | 2.988 | 0.987 | 56.77 | 0.121 | - | Present study |
| 113 | F | 0.011400 | 2.918 | 0.987 | 46.42 | 0.157 | - | Present study |
| 228 | C | 0.012900 | 2.874 | 0.988 | 42.25 | 0.196 | - | Present study |

Table 4: Mortality and Exploitation rates of the *C. lucernus*

| Sexes | Z ($year^{-1}$) | M ($year^{-1}$) | F ($year^{-1}$) | E |
|---|---|---|---|---|
| Females | 1.04 | 0.19 | 0.86 | 0.82 |
| Males | 1.24 | 0.32 | 0.93 | 0.75 |
| Combines Sexes | 1.19 | 0.10 | 1.09 | 0.90 |

along the Mediterranean coast ranged from 2.630 for Egyptian coast (Abdullah, 2002) to 3.187 for Greek coast (Papaconstantinou, 1984) and median value were determined as 2.990. Therefore, it is reasonably proposed that, there was close similarity between median value and estimated value from the present study.

Estimated length-weight relationships and von Bertalanffy growth constants in length for *C. lucernus* distributed along the Mediterranean coasts were given in Table 4.

As can be shown from Table 3, the lowest estimated asymptotic length was calculated as 36.0 cm for Turkish coast (Ismen *et al.*, 2004) and the highest one is 71.3 cm for Greek coast (Moutopoulos and Stergiou, 2002; Papaconstantinou, 1984). In this study this value was calculated as 46.42 cm. In this case, there was close similarity among them however the value was highly lower than that of Greek waters.

Spawning season for *C. lucernus* inhabiting along the Mediterranean coasts were reported between January and May for Greek coasts (Papaconstantinou, 1984); December and May for Turkish coasts (Ismen *et al.*, 2004); December and May for Italian coasts (Papaconstantinou, 1984) January and April for French coasts (Papaconstantinou, 1984). While there were some differences in terms of spawning season from region to region; in all of the Mediterranean water system, spawning occurs between December and May. In this study, spawning season was estimated between February and May. This time period was to be timely in common spawning season which were reported for the Mediterranean coasts.

Mean annual fecundity for this species was reported as approximately 70000 for Iskenderun Bay (Turkey) by Ismen *et al.* (2004). In this study, mean annual fecundity was calculated as 73909. In this case, it is shown that there was close similarity between these two values. Length-fecundity relationship was expressed as $F = 0.0031*L^{5.58}$ ($r^2 = 0.94$) by Ismen *et al.* (2004). In this study, the relationship was estimated as $F = 1898*L^{1.156}$ ($r^2 = 0.4077$). Therefore, there was close similarity to estimate mean fecundity for a given length group. Nevertheless, it is determined that there was no significant relationship between fecundity and length.

The overall female:male ratio was observed 1.07:1.00. This value indicated that there were no significant differences between this value and expected one (1:1). Previous studies of female:male ratio was reported as 1.00:1.34 for Greece waters of Aegean Sea (Papaconstantinou, 1984) and 1.39:1.00 for northeastern Mediterranean coast of Turkey (Ismen *et al.*, 2004). Consequently, it could be reasonably stated that there were differences between the female to male ratio obtained in this study and the result given by Papaconstantinou (1984) and Ismen *et al.* (2004).

The length at first maturity for *C. lucernus* was reported as 18 cm for males and 20 cm for females by Ismen *et al.* (2004). When taken all determined values into consideration, 78.30% of males and 86.73% of females were under the length at first maturity, which was reported by Ismen *et al.* (2004). Therefore, it could be claimed that the population was under the over fishing. Anyway, exploitation rate ranged from 0.75 (for females) to 0.90 (for combined sexes). Even minimum exploitation rate indicates that there was fishing pressure on the *C. lucernus* population in Babadillimani Bight. It can be asserted that the population in the bight has not been managed properly.

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