Age, Growth and Reproduction of the Goldband Goatfish, *Upeneus moluccensis* (Bleeker, 1855), in İskenderun Bay, the Eastern Mediterranean

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Abstract: The age composition, growth parameters, spawning season, sex ratio, length at first sexual maturity and fecundity of the goldband goatfish (*Upeneus moluccensis*) caught in İskenderun Bay in the eastern Mediterranean Sea were investigated. Females and males made up 51.6% and 48.4%, respectively, of the particular population of the species. The total length of females ranged from 7.0 cm to 20.5 cm, and of males from 7.0 cm to 17.8 cm. The length (L) – weight (W) relationships for males and females were estimated as $W = 0.0118*L^{2.99}$ and $W = 0.0097*L^{3.00}$, respectively. The age data derived from otolith readings were used to estimate the growth parameters of the von Bertalanffy equation. The estimated parameters were $L_\infty = 25.19$ cm, $K = 0.197$ and $t_0 = -1.002$. The maximum age was 7 for females and 6 for males. The 2-year age group was dominant in the pooled data. Males and females matured at a total length of 11 cm. The monthly values of the gonadosomatic index indicated that spawning occurred mainly between June and September. The fecundity (F) - length relationship was $\log F = -1.732 + 5.39\log L$ (r = 0.82).

Key Words: İskenderun Bay, eastern Mediterranean, goldband goatfish, growth, reproduction.

İskenderun Körfezi'nde (Doğu Akdeniz) Paşa Barbunu Balığı (*Upeneus moluccensis* (Bleeker, 1855))' nın Yaş, Büyüme ve Üreme Özellikleri

Özet: İskenderun Körfezi'nden (Doğu Akdeniz) örneklenen Paşa Barbunu balığının (*Upeneus moluccensis*) yaş kompozisyonu, büyüme parametreleri, yumurtlama zamanı, cinsiyet oranları, ilk cinsi olgunluğa erişme boyları ve fekonditesi araştırılmıştır. Örneklerin % 51,6'sı dişiler, % 48,4'ünü erkekler oluşturmuştur. Dişilerin total boyu 7,0 ile 20,5 cm arasında, erkeklerin ise 7,0 ile 17,8 cm arasında değişim göstermektedir. Erkek ve dişilerin boy (L) ve ağırlık (W) ilişkisi sırasıyla $W = 0,0118*L^{2.99}$ ve $W = 0,0097*L^{3,00}$ olarak saptanmıştır. Otolitlerden elde edilen yaş verileri von Bertalanffy büyüme parametrelerinin tahmininde kullanılmıştır. Hesaplanan parametreler; $L_\infty = 25,19$ cm, $K = 0,197$, $t_0 = -1,002$ dir. En büyük yaş, dişiler için 7, erkekler için 6 olarak belirlenmiştir. Erkek ve dişilerde 2 yaş grubu baskın bulunmuştur. İlk cinsi olgunluğa, erkekler ve dişiler 11 cm total boyda ulaşmaktadır. Aylık gonadosomatik indeks değerleri, yumurtlama zamanının yoğun olarak Haziran ve Eylül ayları arasında olduğunu göstermiştir. Fekondite (F) - boy ilişkisi, $\log F = -1,732 + 5,39\log L$ (r = 0.82) olarak saptanmıştır.

Anahtar Sözcükler: İskenderun Körfezi, Doğu Akdeniz, Paşa Barbunu, yaş, büyüme, üreme.

Introduction

The goldband goatfish (*Upeneus moluccensis*) is a Lessepsian migrant species which penetrates into the Mediterranean Sea through the Suez Canal (Golani and Ben-Tuvia, 1995). The por's goatfish is a commercially important demersal species, living mostly in sand, muddy sand or gravel bottoms at depths ranging from 10 to 120 m (Golani, 1994). It is a subtropical species, distributed along the western Indian Ocean from the Red Sea to southern Oman (Ben-Tuvia and Golani, 1989).

İskenderun Bay is situated in southern Turkey and is characterised by shallow depths (up to 90 m) and high salinity (0.39%). The general circulation characteristics of the bay are affected by the prevailing currents in the open sea (north-eastern Mediterranean), because of its outlet through a wide opening, and by the regional and local winds (Yılmaz et al., 1992). The bay is overfished (trawlers, purse seines etc.) (Bingel et al., 1993).

Published information on the comprehensive biology and ecology of this species along the Turkish coast of the

eastern Mediterranean Sea is scarce. However, the goldband goatfish in other regions of the Mediterranenan were studied satisfactorily by many researchers in recent years. Most of the available information on the distribution of the species, except for a few studies (Golani, 1990; Golani and Galil, 1991; Golani 1994; Torcu, 1995; Kaya et al., 1999; Taskavak and Bilecenoglu, 2001) was provided by Hureau (1979), Ben-Tuvia and Golani (1994), Galil (1993), Gucu et al. (1994), Golani and Ben-Tuvia (1995), Mater et al. (1995), Golani (1996), Basusta (1997), and Golani (1998a). Golani (1990), and Golani and Galil (1991) provided some information on the feeding habits of the species. Golani (1994) dealt with niche separation between colonising and indigenous goatfishes of the Mediterranean coast of Israel. Torcu (1995) reported population parameters and bioecological features of the goldband goatfish inhabiting in the Mediterranean and south Aegean Sea coasts of Turkey. Taskavak and Bilecenoglu (2001) studied length-weight relationships for 18 Lessepsian immigrant fish species in the eastern Mediterranean coast of Turkey. Kaya et al. (1999) studied growth, reproduction and food of the goldband goatfish inhabiting in the Mediterranean and south Aegean Sea coasts of Turkey.

The present study provides information concerning the age and length distribution, growth, sex ratio and reproduction of the goldband goatfish in İskenderun Bay, in the eastern Mediterranean, as a contribution to the management of the fishery exploiting these stocks.

Materials and Methods

A total of 418 goldband goatfish specimens were collected from the R/V Mustafa Kemal-1 between May 1999 and April 2000 at 2 stations in the Bay of İskenderun (Figure 1). Monthly trawl surveys were carried out during daytime at depths ranging from 0 to 50 m. The trawl was equipped with an 18 mm mesh size net at the cod-end. Hauling lasted about 2.5 h at a speed of 1.5 knots.

Total length was measured to the nearest millimetre, and whole body and gonad weights were measured to the nearest gram, all in the laboratory. Age was determined from otolith rings following the procedure described by Holden and Raitt (1974). Otoliths removed from the fish were stored dry in paper envelopes, and were later cleaned and made transparent. The otoliths were read in glycerin under a stereozoom microscope with reflected light.

The length-weight relationships were determined according to the allometric equation (1989):

$$W = aL^b,$$

where W is the total body weight (g), L the total length (cm), and a and b are constants.

Growth was expressed in terms of the von Bertalanffy equation (1957):

$$L_t = L_\infty (1-e^{-K(t-t_0)}),$$

where L_∞ is the asymptotic total length, L_t the total length at age t, K the growth curvature parameter and t_0 the theoretical age when fish would have been at zero total length. Growth parameters were estimated according to the non-linear method by using the software FiSAT (1989).

The sex and maturity stage of each specimen were determined by visual and microscopic examination of the gonads. The stages of maturation were classified according to Holden and Raitt's (1974) scale. The gonadosomatic index (GSI) was calculated monthly by the equation:

$$GSI = (gonad\ weight/fish\ weight\ without\ gonad)*100$$

The ovaries for fecundity estimation were cut longitudinally and stored in Gilson's fluid, which broke down the connective tissue. The egg numbers were estimated using the gravimetric method described by Bagenal (1978). The data were analysed by least squares regression using log10 transformations (Ismen, 1995).

Results

Of the 418 specimens measured, 216 were female (51.6%) and 202 male (48.4%). The total length of females in the Bay of İskenderun ranged from 7.0 to 20.5 cm. The range was smaller for males, from 7.0 cm to 17.8 cm (Figure 2). The overall mean total length of females was greater than that of males (P < 0.01).

The length-weight relationships were separately evaluated for females and males, and are presented in Figure 3. The exponent b demonstrated isometric growth. Comparing the length-weight relationships of the sexes using covariance analysis, no significant
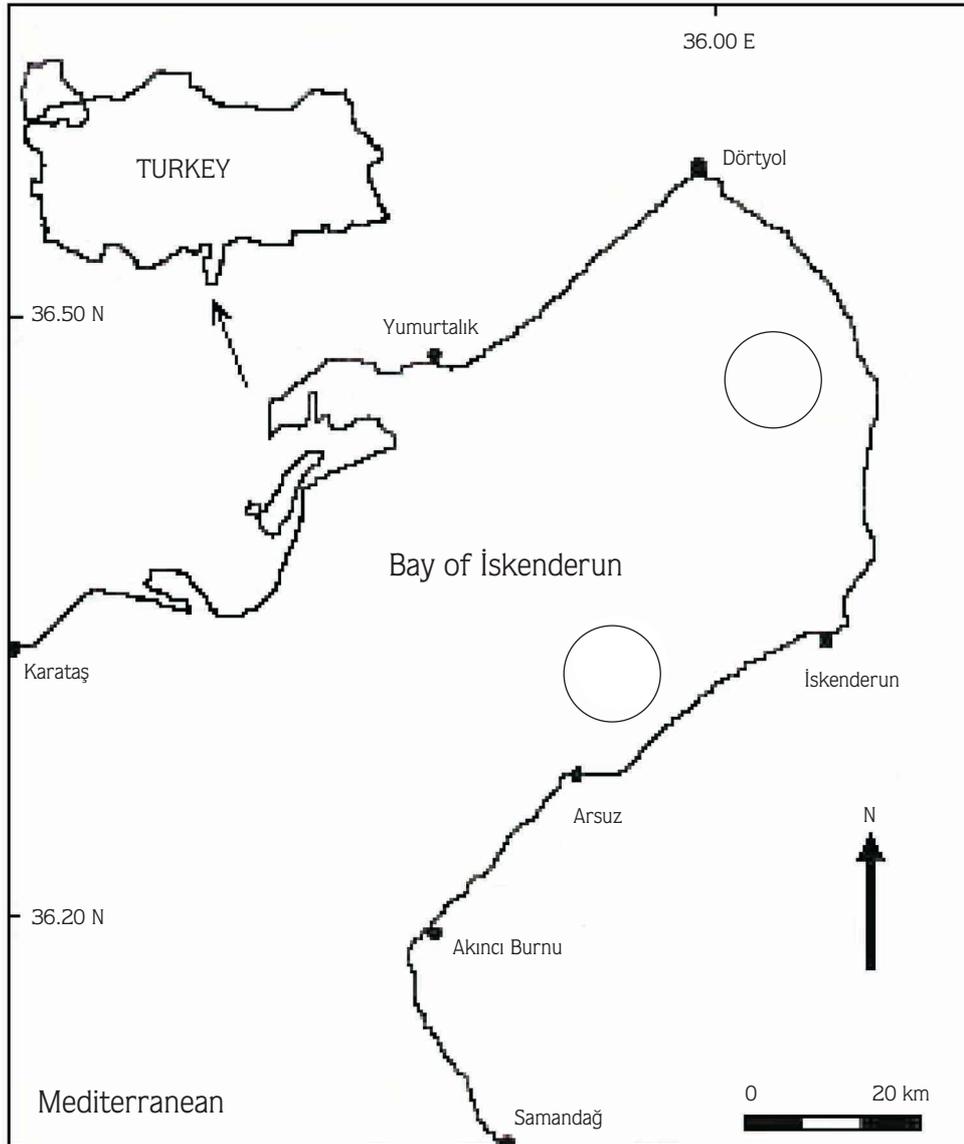
Figure 1. Location of the sampling stations in the Bay of İskenderun (O: sampling station).

difference was found. The equation for the relationship was $W = 0.0117*L^{3.00}$ (r = 0.99) for females, and $W = 0.0118*L^{2.99}$ (r = 0.99) for males.

The estimated von Bertalanffy growth parameters for the goldband goatfish were as follows:

L_∞ = 25.2 cm, K = 0.197 and t_o = -1.002 for both sexes combined, L_∞ = 24.3 cm, K = 0.218 and t_o = -0.922 for females, and L_∞ = 22.5 cm, K = 0.236 and t_o = -0.920 for males. The calculated and observed total length at age data are presented in Table 1. The observed lengths and growth increments of the sexes were similar at ages 1-5. The goldband goatfish attained approximately 33% of its calculated maximum size during the first year of life. After the completion of the first year, the annual growth rate ranged between 1 and 3 cm.

The maximum age was 7 for females and 6 for males. Age group 2 was dominant in females (34.7%). In males,
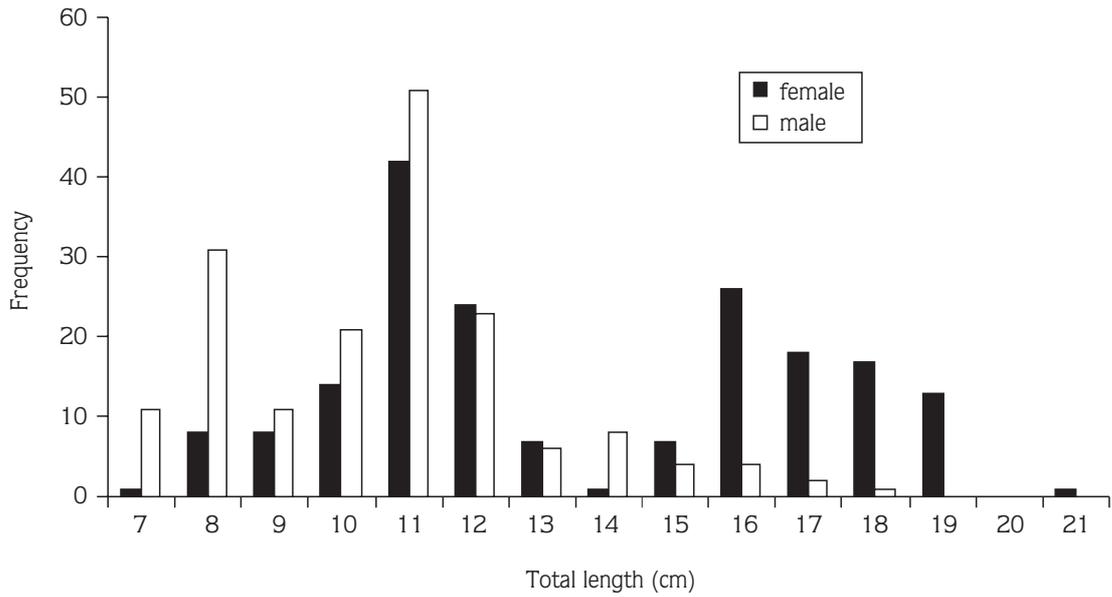
Figure 2.   Length-frequency distribution of male and female goldband goatfish.
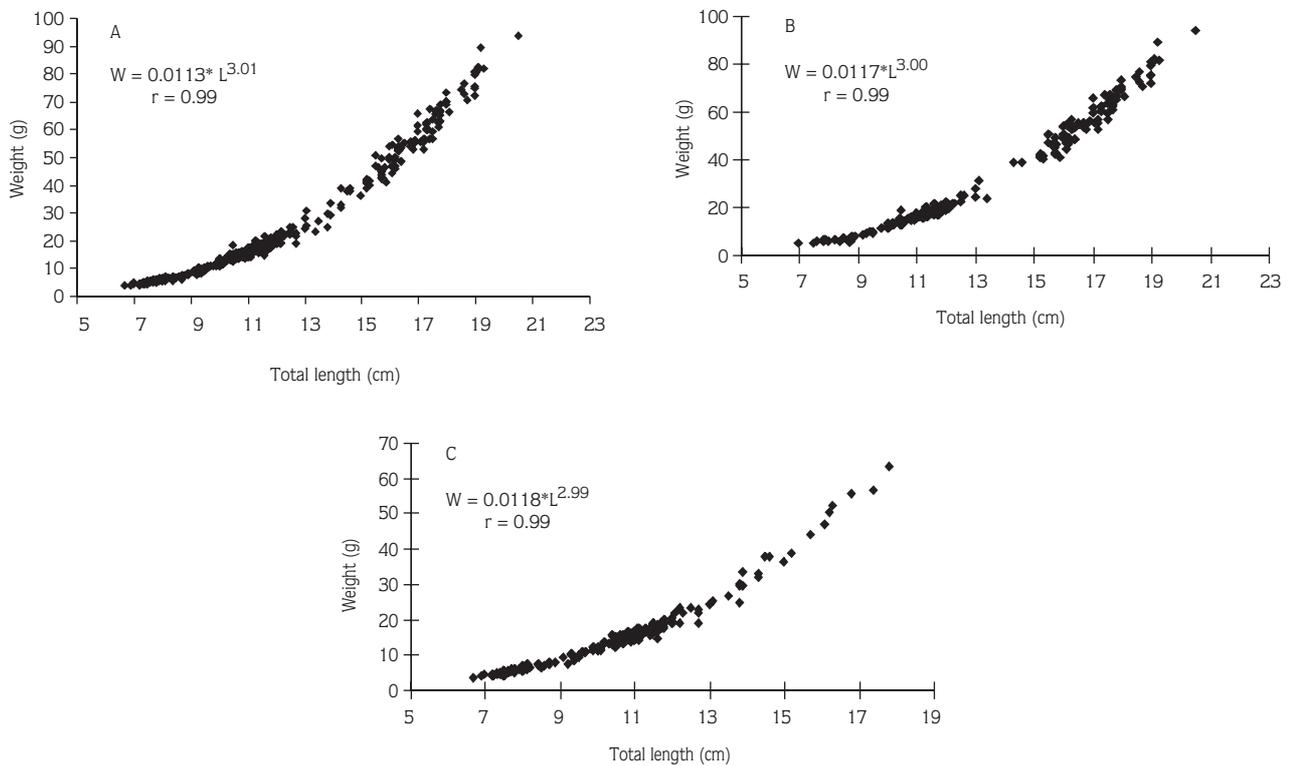

Figure 3.   Length-weight relationships (A) pooled, (B) female, (C) male.

Table 1. Total length at age values (cm) of the goldband goatfish from İskenderun Bay

Age groups	Observed			Calculated		
	Female (min-max)	Male (min-max)	Pooled (min-max)	Female	Male	Pooled
I	8.4 ± 1.06 (6.9-10.4)	8.1 ± 0.95 (6.0-10.4)	8.3 ± 0.99 (6.0-10.4)	8.3	8.2	8.2
II	11.3 ± 0.61 (10.2-12.5)	11.2 ± 0.63 (9.6-12.7)	11.2 ± 0.62 (9.6-13.0)	11.4	11.2	11.2
III	14.1 ± 0.90 (13.1-15.3)	13.6 ± 0.5 (12.7-14.3)	13.8 ± 0.69 (12.7-15.3)	14	13.6	13.7
IV	15.9 ± 0.43 (15.2-16.8)	15.3 ± 0.85 (13.9-16,3)	15.8 ± 0.60 (13.9-16.8)	16	15.5	15.8
V	17.4 ± 0.40 (16.7-18.1)	17.1 ± 0.42 (16.8-17.4)	17.4 ± 0.40 (16.7-18,1)	17.6	17	17.5
VI	18.9 ± 0.25 (18.5-19.3)	17.8 ± 0.00 (17.8-)	18.9 ± 0.39 (17.8-19.3)	18.9	18.1	18.8
VII	20.5 ± 0.00 (20.5-)	-	20.5 ± 0.00 (20.5-)	20	19.1	20

age group 1 represented 47.0% of the total. In females, age group 2 was followed by age groups 1 (25.5%), 3 (2.3%), 4 (15.3%), 5 (15.7%), 6 (6%), and 7 (0.5%). In males, age group 1 was followed by age groups 2 (42.1%), 3 (5%), 4 (4.5%), 5 (1%), and 6 (0.5%).

The overall female to male ratio was determined to be 1.07:1.0. The female to male ratios for each month are presented in Table 2. All the monthly samples contained more females than males, excluding August, September and November.

Examination of the male and female maturity stages indicated that males and females of *U. moluccensis* matured at about 11 cm total length (2 years old) (Figure 4). The GSI results revealed that spawning occurred after June, when the GSI for both sexes reached its highest level (Figure 5). However, the presence of mature individuals in September showed that reproduction may continue at a reduced rate during summer.

For the Bay of İskenderun, data analysis indicated that fecundity is significantly related to length by the relationship

LogF = -1.732+ 5.39logL (r = 0.82),

Table 2. Number of female and male goldband goatfish by sampling months.

Month	Female	Male	Female/Male ratio
February	15	8	1.90
April	41	10	4.10
June	6	4	1.50
July	1	1	1.00
August	12	15	0.80
September	89	110	0.80
October	6	4	1.50
November	19	28	0.68
December	27	23	1.17
Total	216	202	1.07

where F is fecundity and L is the fish length (cm). Plots of fecundity-length data and the arithmetical form of the relationship are shown in Figure 6. The correlation coefficient (r) is significantly different from zero (P < 0.01).
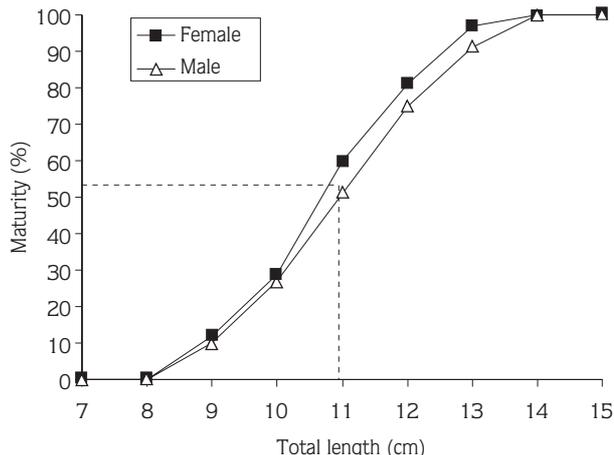
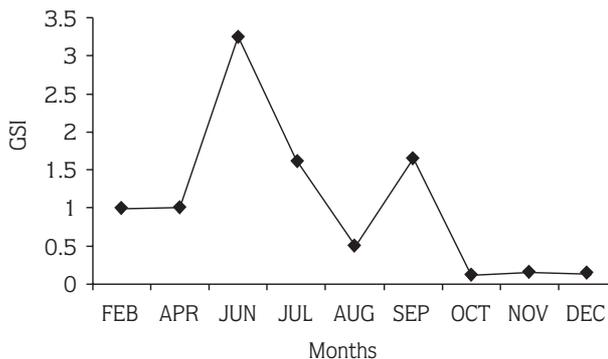Figure 4. Length at first maturity of males and females of goldband goatfish.

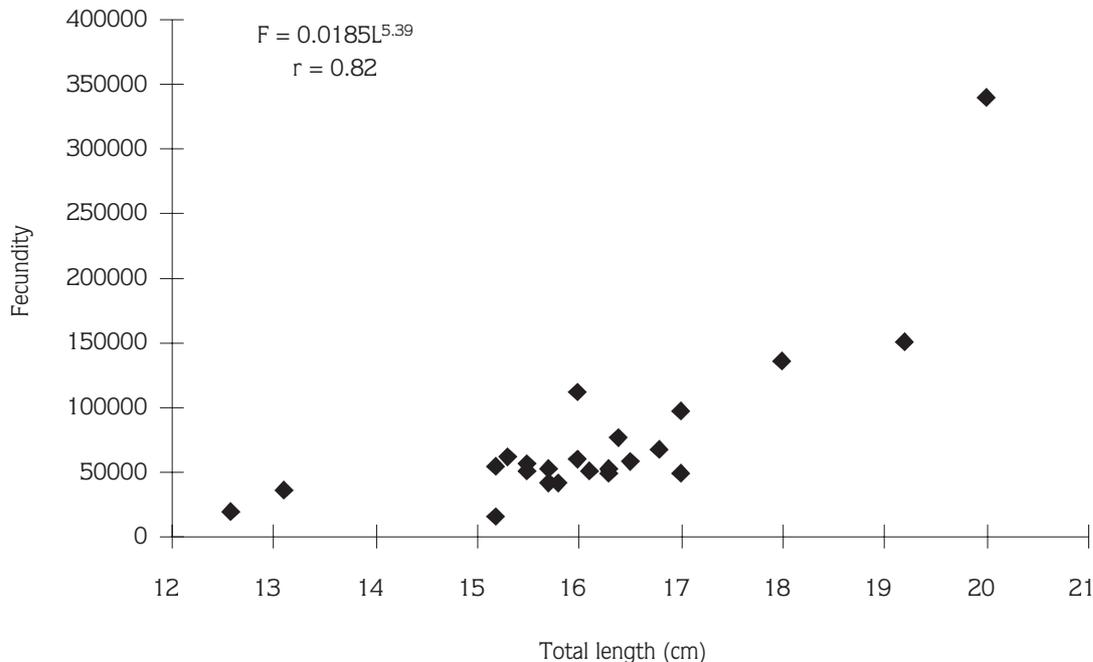Figure 5. Gonadosomatic index (GSI) values of both sexes of goldband goatfish.

$$F = 0.0185L^{5.39}$$
$$r = 0.82$$

Figure 6. Relationship of fecundity to length for goldband goatfish.

Discussion

The goldband goatfish is commercially important for the Mediterranean fisheries in Turkey. However, there are no precise data for the annual catch of goldband goatfish because the catches of all mullet without separation to species level are recorded in Turkish Fisheries Statistics. Bingel et al. (1993) reported that the goldband goatfish constitutes about 3% of the main catch for a depth range of 0-50 m along the north-eastern Mediterranean coast of Turkey and the stocks are highly overexploited.

The results of the growth rate in the first year of the goldband goatfish reported in the present paper are in agreement with those reported by Torcu (1995) and

Kaya et al. (1999). In the north-eastern Mediterranean and south Aegean Sea it was found that the first annulus is formed at a length of 10.3 cm and 10.3-11.2, respectively. In İskenderun Bay, the north-eastern Mediterranean it is formed at a length of 8.2 cm. Torcu (1995) reported that the largest specimen caught in the north-eastern Mediterranean (Fethiye and Mersin Bay) during the survey was 17.0 cm and that the maximum length was 17.8 cm in the Mediterranean and south Aegean Sea (Kaya et al., 1999). The largest individual caught in the Bay of İskenderun was 20.5 cm.

The mean annual growth rate for 1-7-year-old fish ranged between 1.2 and 2.5 cm in this study (Table 1). Growth was rapid in both sexes for the first year and declined gradually over subsequent years. Torcu (1995) reported the mean annual growth rate for 1-5-year-old fish as about 1.9 cm, 1.7 cm, 1.3 cm and 1.4 cm, respectively. Kaya et al. (1999) stated that the mean annual growth rate for 1-6-year-old fish was about 1.9 cm, 1.7 cm, 1.3 cm and 1.4 cm, respectively. The differences in growth rates might be attributed to different bio-ecological conditions.

Comparison of the length growth parameters obtained for Mediterranean goldband goatfish applying Munro's phi prime test showed that there is no significant difference (P > 0.05) between the overall growth performances of the goldband goatfish sampled from the different regions in the north-eastern Mediterranean (Table 3). The calculated value of the growth coefficient K in this study lies in the mid-range of the value calculated by Bingel et al. (1993) and Kaya et al. (1999) for goldband goatfish stocks inhabiting the north-eastern Mediterranean Sea. No statistically significant differences have been detected among the growth performances of goldband goatfish from the different areas of the north-eastern Mediterranean, possibly due to spatial and temporal changes in their different nutritional conditions.

The absence of a 0 age group in the samples was probably due to the selectivity of the cod-end used in the trawl nets. However, the low levels of the older age groups after the age of 2 cannot be related to selectivity, and are more likely to be the result of extremely intensive fishing activities. The maximum depth at which goldband goatfish were caught during this study was 50 m. Golani (1994) showed that niche partitioning of the eastern Mediterranean mullets is achieved on the bathymetrical axis; Lessepsian mullets occupy shallow waters (40-50 m) while indigeneous species dominate in greater depths.

Torcu (1995) and Kaya et al. (1999) found the female to male ratio in the north-eastern Mediterranean to be 2.7 and 3.04, which differ from that determined in the present study. In this study, a sex ratio of around 1:1 and a significant increase in the number of females compared to males in spring were found. Seasonal variations in the sex ratio may be due to the difference in the length (or age) of sexual maturity and the difference in length distribution in relation to depth.

Torcu (1995) and Kaya et al. (1999) reported that the spawning of the goldband goatfish in the north-eastern Mediterranenan extends from August to September and the GSI values reached their maximum level in August. These are similar to the present observations. The GSI results revealed that spawning occurred after June, when the GSI reached its highest level. However, the presence of mature individuals in September showed that reproduction may continue at a reduced rate during summer. Golani (1990) stated that the species spawns between June and September in the eastern Mediterranean Sea. Males and females of *U. moluccensis* mature at about 11 cm total length (2 years old). Lee (1974) stated that in Hong Kong (17°-21°N, 107°-115°E), the sexual maturation of *U. moluccensis* was reached at about 14 cm total length and the specimens spawn between March and September.

Table 3. Von Bertalanffy length-growth constants and ϕ' values of the goldband goatfish.

Author	Location	L_∞	K	t_o	ϕ'
Bingel et al. (1993)	Mediterranean	25.6	0.621	-0,270	6,01
Kaya et al. (1999)	Mediterranean	26.0	0.110	-3.770	4,31
Present study	Mediterranean	25.2	0.197	-1.002	4,83

Age and back-calculated growth were determined from annual rings in the otoliths. Increase in length is rapid during the first year and slow thereafter. Females have a slightly faster rate of growth than males and live longer. The oldest male was 6 years old and the oldest female found was 7 years old. Kaya et al. (1999) reported that the maximum age group determined was 6 for females and 5 for males.

The length-weight relationship is the same for both sexes (analysis covariance), but the final age attained suggested a different relationship for each sex. The functional regression b values (3.00 for females and 2.99 for males) of the goldband goatfish differ from these given by Torcu (1995) and Kaya et al. (1999). Torcu (1995) stated that the b values of the length-weight relationship for pooled data was 3.21. Kaya et al. (1999) reported that the b values estimated for males and females were 3.15 and 3.35, respectively. The functional regression b value is directly related to the weight affected by ecological factors such as temperature, food supply, spawning conditions and habitat characteristics within a year.

Individuals of both sexes mature for the first time after the second year of life. Fecundity is significantly related to length by the relationship $F = 0.0185L^{5.39}$ (r = 0.82). Torcu (1995) showed that the fecundity of *U. moluccensis* varies between 19.714 and 64.452, and the amount of eggs increases with age.

In conclusion, the control of fishing activity is achieved by the enforcement of the current system and covers restrictions on species, fish sizes, mesh sizes, locations, breeding seasons, etc. The available data suggest that the minimum fishing size should be limited to 11 cm for the Mediterranean goldband goatfish, and that the fishing season should be restricted from June to September. This extended period covers fishing seasons closed to the use of deep trawls (breeding seasons of the main catch in the Mediterranean). However, Mediterranean fisheries have features of both typical tropical fisheries, and the number of species encountered in the trawl catches is rather high compared to the other temperate areas. Therefore, stock assessment investigations should probably consider the multispecies situation in cases where single species assessments do not give suitable objectives in the eastern Mediterranean Sea.

Acknowledgements

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