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Age, Growth and Reproduction of Goldband Goatfish (*Upeneus moluccensis* Bleeker (1855)) from the Gulf of Antalya (Turkey)

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Abstract: We investigated the age and sex composition, growth parameters, sexual maturity, spawning season and fecundity of goldband goatfish (*Upeneus moluccensis*) n = 464 caught in Gulf of Antalya in the western Mediterranean Sea sampling, monthly between February 2002-August 2003. Age groups ranged between 0 and V, with the second year-classes dominating. Females made up 73.92% and males 26.08% of the specimens. The total length and weight of combined sexes ranged from 8.0-21.1 cm and 5.1-108.2 g, respectively. The von Bertalanffy growth parameters were estimated for combined sexes as: $L\infty = 25.56$, $K = 0.136$ and $t_0 = -3.8289$. Males and females matured at a total length of 11 cm and I year old. The spawning period occurred between July and October.

Key words: Goldband goatfish, *Upeneus moluccensis*, growth, reproduction, Gulf of Antalya, Western Mediterranean

INTRODUCTION

Goldband goatfish (*Upeneus moluccensis*) is a Lessepsian migrant species, which was distributed into the Mediterranean Sea through the Suez Channel, first reported in Turkish Seas by Ben-Tuvia (1953). *U. moluccensis* is a commercially important demersal species, living in shoals in sandy-muddy or muddy habitats at depths between 20 and 130 m. Since the Mediterranean continental shelf is relatively wide and its topographic structure is suitable for trawl fisheries, the Mediterranean is heavily fished. Moreover, the region's ichthyofauna is quite rich in terms of species diversity and several fishing techniques are utilized. We shall provide important contributions to both region and fishery. Although, there have been several scientific studies on *U. moluccensis* from Turkey, research from the Gulf of Antalya, where production of *U. moluccensis* is considerable and basic life history information needed for effective fishery management and stock utilization is limited. Published information on the biology and ecology of this species is scarce. In the Eastern Mediterranean Sea, except for a few studies on the aspects of its reproduction (Golani, 1990; Zeidane and Lakkis, 1995) and food intake (Ben-Eliahu and Golani, 1990; Golani and Galil, 1991; Golani, 1993), most of the research deals primarily with its distribution and biology. Most studies from Turkish Seas are limited to the distribution of the species (Aksiray, 1987; Gucu and Bingel, 1994; Mater *et al*., 1995; Basusta, 1997). Although, Torcu (1995), Kaya *et al*. (1999), Taskavak and Bilecenoglu (2001) and Ismen (2005) included observations on its age and size distribution, food and reproduction. The aim of this study was to determine length weight distributions, growth rate and some reproductive properties such as age and length at first sexual maturity, spawning period and fecundity of the population *U. moluccensis*, in Gulf of Antalya, as a contribution to the management of the fishery exploiting these stocks.

MATERIALS AND METHODS

We collected *U. moluccensis* specimens (n = 464) monthly between February 2002 and September 2003 at three stations in the Gulf of Antalya (Fig. 1). Specimens were collected using three pieces of multifilament trammel nets having 100 m of equipped length with mesh size nets of no 210 days/2, 20 mm and no 210 days/2, 22 mm; we also obtained samples from trawlers in some months.

The Total Length (TL, cm) and Weight (W, g) of each specimen were recorded. Scales were removed from each fish and cleaned in a 4% KOH and 70% alcohol, respectively, for age analyses according to Chugunova (1963), Nikolsky (1963), Quignard and Farrugio (1981) and Ricker (1971). The length-weight relationship was determined according to the allometric equation given by Sparre and Venema (1992):

$$W = aL^b$$

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Where:
W = The total body weight (g)
L = The fork length (cm)
a and b = Constants

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

$$Lt = L\infty\ (1-e^{-k(t-to)})$$

Where:
L_t = The total length at age
t and $L\infty$ = The asymptotic total length
$W\infty$ = The asymptotic total weight
K = The growth curvature parameter
t_o = The theoretical age when fish would have been at zero total length

These parameters were estimated by means of the Von Bertalanffy plot (Sparre and Venema, 1992).

Age and size sexual maturity form the basic data necessary to determine effects of fishing pressure on fish stocks; fecundity data are necessary to estimate new recruitment to the stock.

Sex and stage of maturity of *U. moluccensis* specimens were determined by the macroscopic and microscopic examinations of gonads. Spawning period was determined by examining monthly variations of the Gonadosomatic Index (GSI). GSI was calculated by the equation:

$$GSI = \frac{GW}{(W-GW)} \times 100$$

Where:
GW and W = Gonad weight and total weight in gram of fish, respectively (Ntiba and Jaccarini, 1990)

Fecundity was estimated using gravimetric method described by Bagenal and Braum (1971). Twenty ova selected at random from each ovary were measured by means of a micrometer eyepiece and the mean egg diameter was then computed for the entire sample (Ricker, 1971).

RESULTS AND DISCUSSION

Age and growth: The age and sex distributions of the 464 *U. molucensis* specimens from the Gulf of Antalya are shown in Fig. 2. Age of captured fish ranged between age group 0 to V. The dominant age was group II (40.75%), followed by age group III (27.42%) and then group I (21.58%).

The samples consisted of 74% females and 26% males and differences between sexes by age were significant ($p<0.05$). The total length of *U. moluccensis* ranged from 8-21.1 cm. Among the specimen caught 74.03% were 12.9-14.9 cm (Fig. 3). Weight of individuals investigated varied between 5.1-108.1 g.

The distribution of weight among the specimens was as follows: 80.34% were between 20 and 40 g and 18.32% were between 50 and 110 g (Fig. 4). When the specimens we collected from trawler fishermen during the last half of the research were evaluated, individuals with different weights were obtained.

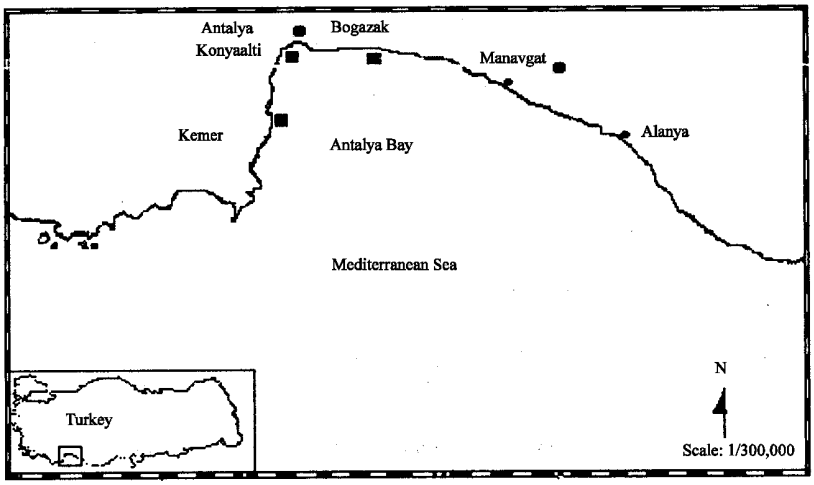

Fig. 1: Location of the sampling stataions in the Gulf of Antalya (■): sampling station

The total length and weight for female, male and combined sexes of each age group are given in Table 1. The maximum age was V for females and IV for males. Age group II was dominant in both sexes. Length based on the Von Bertalanffy (1957) growth equations for combined sexes were estimated as $Lt = 25.56\times[1-e^{-0.136*(t+3.8289)}]$. No significant differences were found among observed and calculated length for combined sexes ($p>0.05$, Table 2).

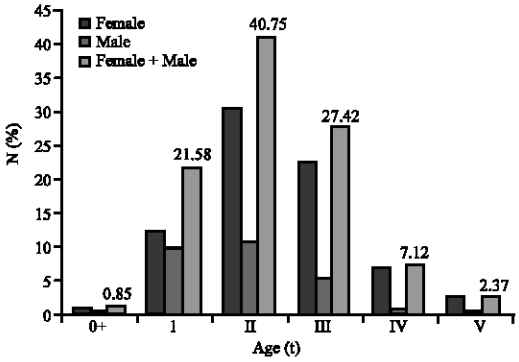

Fig. 2: Age and sex composition of *U. moluccensis*

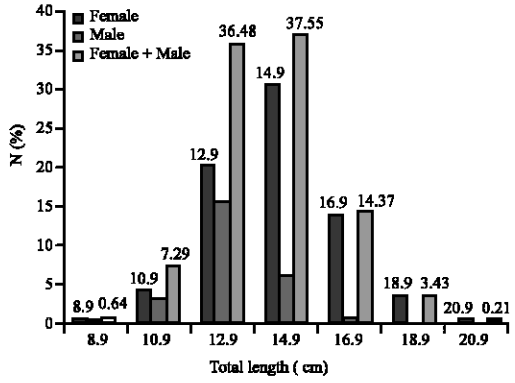

Fig. 3: Length- frequency distribution of *U. moluccensis*

Age-length relationships of combined sexes are plotted in Fig. 5. Weight based on the Von Bertalanffy growth equations for combined sexes were estimated as: $Wt = 190.76\times[1-e^{-0.136(t+3.8289)}]^{3.076}$.

Differences between observed and calculated weight weren not statistically significant except for age groups 0 and V for combined sexes (Table 3). Age-weight relationships of combined sexes are plotted in Fig. 6.

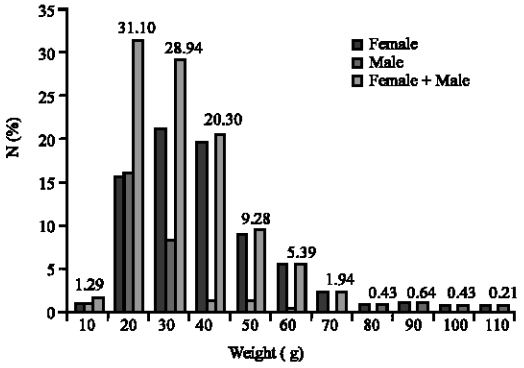

Fig. 4: Weight-frequency distribution of *U. moluccensis*

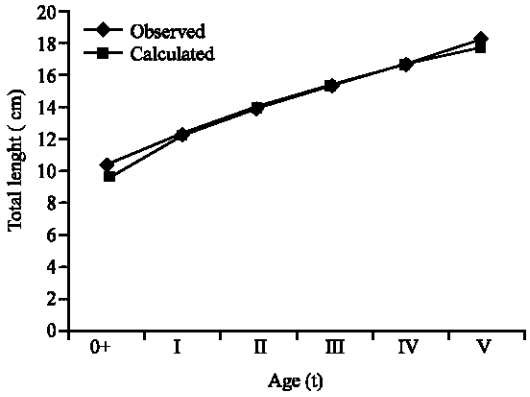

Fig. 5: Age-length relationship in *U. moluccensis*

Table 1: The mean length and weight of the different age group of *U. moluccensis* from Gulf of Antalya

	Female			Male			Pooled		
Age	N	TL±SD (Min.-Max.)	W±SD (Min.-Max.)	N	TL±SD (Min.-Max.)	W±SD (Min.-Max.)	N	TL ± SD (Min.-Max.)	W±SD (Min.-Max.)
0+	3	9.43±2.31 (8-12.1)	9.63±7.25 (5.19-18)	1	9.90	9	4	9.55±1.90 (8-12.1)	9.47±5.93 (5.19-18)
I	55	12.39±0.86 (10.9-14.6)	21.47±4.49 (14.8-37.2)	45	12.20±0.70 (10.5-13.6)	19.31±3.32 (12.7-31.2)	100	12.30±0.79 (12.30-10.5)	20.50±4.13 (12.7-37.2)
II	140	14.29±0.95 (12-16.5)	32.27±7.09 (17.8-50)	49	13.22±0.75 (11.8-14.9)	24.36±4.42 (17.9-35.8)	189	14.02±1.02 (11.8-16.5)	30.22±7.37 (17.8-50)
III	103	15.68±1.23 (12.7-18.4)	44.43±11.32 (23.9-86.9)	24	14.33±0.97 (12.7-16.5)	32.96±7.91 (22-54.1)	127	15.42±1.30 (12.7-18.4)	42.27±11.64 (22-86.9)
IV	31	16.81±1.35 (14.4-19.7)	54.83±14.26 (32-86.7)	2	15.70±0.98 (15-16.4)	48±7.21 (42.9-53.1)	33	16.75±1.35 (14.4-19.7)	54.42±13.96 (32-86.7)
V	11	18.30±1.33 (16.5-21.1)	73.88±19.21 (49.6-108.1)	-	-	-	11	18.30±1.33 (16.5-21.1)	73.88±19.21 (49.6-108.1)

Table 2: Total length at age values (cm) of *U. moluccensis* from Gulf of Antalya

	Pooled			
Age	Observed TL (cm)	Calculated TL	Differences	RTL (%)
0+	9.55±1.90	10.37	0.82*	18.70
I	12.30±0.79	12.31	1.01*	13.72
II	14.02±1.02	14.00	1.02*	10.42
III	15.42±1.30	15.46	1.04*	8.27
IV	16.75±1.35	16.74	1.01*	6.75
V	18.30±1.33	17.87	0.43*	-

*p>0.05

Table 3: Weight at age values (cm) of *U. moluccensis* from Gulf of Antalya

	Pooled			
Age	Observed W (g)	Calculated W	Differences	RW(%)
0+	9.47±5.93	11.91	2.44**	69.10
I	20.50±4.13	20.14	0.36**	48.41
II	30.22±7.37	29.89	0.33**	35.96
III	42.27±11.64	40.64	1.63**	27.82
IV	54.42±13.96	51.95	2.47**	22.05
V	73.88±19.21	63.41	10.47*	-

*p<0.05, **p>0.05

The equation of the length (TL)-weight (W) relationship were calculated using least squares regression on log (TL) and log (W) and gave the following results:

For females:

$$\text{Log } W = -1.984 + 3.025 \text{Log TL},$$
$$W = 0.010 * TL^{3.025} \ (r = 0.963)$$

For males:

$$\text{Log } W = -1.965 + 2.991 \times \text{Log TL},$$
$$W = 0.010 \times TL^{2.969} \ (r = 0.930)$$

For pooled:

$$\text{Log } W = -2.049 + 3.076 \times \text{Log TL},$$
$$W = 0.009 \times TL^{3.076} \ (r = 0.964)$$

The length-weight relationship curves for combined sexes are given in Fig. 7.

Reproduction: Size of initial sexual maturity for *U. moluccensis* in Gulf of Antalya began at about 11 cm TL and I year old (Table 4). The smallest mature female was 11 cm TL and 19.4 g in weight, while the smallest mature male was 10.5 cm in total length and 12.7 g in weight.

The GSI results revealed that peak spawning occurred in July, when the GSI for both sexes reached its highest level (Fig. 8). However, the data seem to suggest spawning is protracted continuing into September/ October. This conclusion is supported by the presence in the samples of mature individuals from October.

Fecundity was estimated in 71 females captured just prior to spawning. Mean length, weight, gonad weight and fecundity by age group is shown in Table 5.

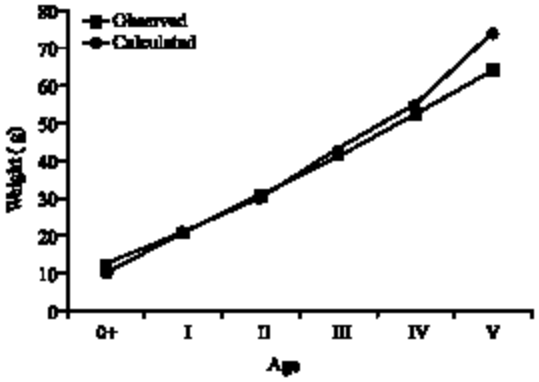

Fig. 6: Age-weight relationship in *U. moluccensis*

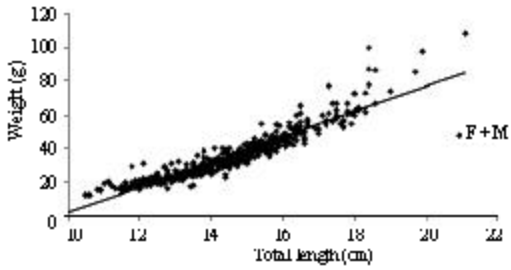

Fig. 7: Length-weight relationship in pooled of *U. moluccensis*

Table 4: Length and age at first maturity of males and females of *U. moluccensis*

	Female		Male	
Parameters	No.	%	No.	%
Age (t)				
I	35	94	10	60
II	34	79	14	85
III	43	100	9	89
IV	11	100	0	0
V	5	100	0	0
Total length (cm)				
9	0	0	0	0
11	16	94	4	100
13	42	86	13	53
15	39	95	16	93
17	25	100	0	0
19	5	100	0	0
21	1	100	0	0

Fecundity ranged from 2231-139065 in the samples. One female 13.1 cm in age group I had a fecundity value of 14854 eggs, while another (18.5 cm, age group V) had a fecundity value of 47984 eggs. Egg diameters of mature female *U. moluccensis*, which were obtained in the Gulf of Antalya between May 2003 to July 2003 were measured. Egg diameters ranged 0.25-0.62 mm and reached its maximum size in July with 0.62 mm diameter as in GSI values. *U. moluccensis* is a commercially important species in the Gulf of Antalya. During the study, 464 *U. moluccensis* were caught in Gulf of Antalya. However, as a result of trammel nets fishing in certain months, limited

Table 5: Fecundity of *U. moluccensis* by age groups

Age	N	TL±SD (Min.-Max.)	W±SD (Min.-Max.)	GW±SD (Min.-Max.)	F±SD (Min.-Max.)
I	7	13.1±2.10 (11.4-17.2)	28.24±14.74 (16.1-54)	1.26±0.66 (0.54-2.16)	14854.52±12382.01 (2231-33233)
II	14	14.3±1.22 (12-15.8)	35.807±8.40 (20-46.5)	1.40±0.54 (0.63-2.84)	18838.54±13130.03 (5874-36236)
III	27	16.0±1.09 (12.7-18.4)	49.51±12.22 (28.9-86.9)	2.06±1.05 (0.63-5.13)	26273.43±15797.84 (7205-71297)
IV	15	16.9±1.16 (15.2-18.6)	57.47±0.6 (37.5-86.7)	2.22±0.95 (1.03-3.60)	28053.11±21447.02 (7792-93986)
V	7	18.5±1.51 (16.5-21.1)	75.61±19.25 (60.9-108.1)	3.68±2.05 (2.12-7.24)	47984.01±41937.9 (16055-139065)

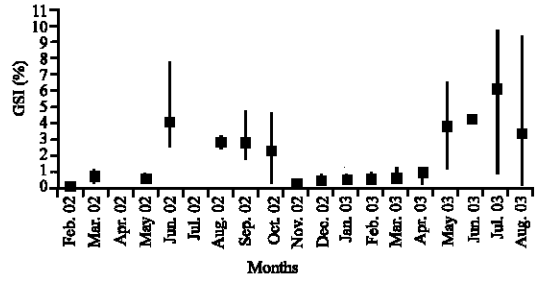

Fig. 8: Gonadosomatic Index (GSI) values of both sexes of *U. moluccensis*

number of fish specimens were collected. Therefore, in the last half of the study period, we obtained fish specimens from trawlers. Age distribution of sampled *U. moluccensis* ranges from age-groups 0 to V. This compares with Kaya *et al.* (1999), who found Goldband Goatfish ages ranging from I to VI with females age group III and age group II males dominant in their study in the South Aegean and Mediterranean. Sex ratio of *U. moluccensis* in the study was 74% (343) female and 26% (121) male individual.

The difference between sexes was significant according to χ^2-test. This result was similar Kaya *et al.* (1999), who determined the sex ratio as 75.25% female and 24.75% male in their South Aegean Mediterranean study. Torcu and Mater (2000) in their *U. moluccensis* biology study, found the sex ratio as 69% female-31% male and 77% female 23% male in Fethiye and Mersin Gulf, respectively. Females are the dominant gender in both Gulfs.

U. moluccensis specimens ranged from 8-21.1 cm. Seventy four percent of individuals were between 12.9 and 14.9 cm. Torcu and Mater (2000) determined that 13.5 cm FL and 11 cm FL were the modal length groups in the Mersin Gulf and the Fethiye Gulf, respectively. Kaya *et al.* (1999) determined the size distribution of Goldband Goatfish for females ranging from 8.6-17.8 cm FL and for males as 8.5-16.1 cm FL in South Aegean and Mediterranean. Ismen (2005) reported that the largest specimen caught in Bay of Iskenderun was 20.5 cm. Weights of *U. moluccensis* caught in the study ranged from 5.1-108.1 g, with 83.46% of individuals weighing between 20-40 g and 13.70% of the specimens weighing between 50-100 g. Torcu and Mater (2000) found the *U. moluccensis* ranged from 14.77-87.14 g in Fethiye Gulf and in Mersin Gulf from 24.40-73.90 g. The overall growth rates, indicated by the Von Bertalanffy (1957) growth coefficient were within the range of results from previous growth parameters in females were found as $L\infty = 25.56$ cm, $K = 0.136$ and $t_0 = -3.8289$ for both sexes combined. However, Ismen (2005) found L-25.2 cm, $K = 0.197$ and $t_0 = -1.002$ for both sexes combined. Kaya *et al.* (1999) determined the *U. moluccensis* Von Bertalanffy (1957) growth parameters in both sexes combined as $L\infty = 26.0$ cm, $K = 0.110$, $t_0 = -3.770$ in South Aegean and Mediterranean.

Clearly, we have been detected that the different among the growth coefficient of *U. moluccensis* from different areas, possibly due to spatial and temporal changes in their different nutritional, hydrographical and climatic conditions. The length-weight relationship of *U. moluccensis* was evaluated and the b value for females was found as 3.025 and for males as 2.991. During the study of *U. moluccensis* in South Aegean and Mediterranean shores, b value for females and males was found as 3.15 and 3.35, respectively. Kaya *et al.* (1999) and Torcu (1995) stated that the b values of the length-weight relationship for pooled data was 3.21.

Ismen (2005) estimated the functional regression b values of goldband goatfish as 3.00 for females and 2.99 for males. 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.

Sexual maturity age for both sexes of *U. moluccensis* was determined as I. age-group in Gulf of Antalya. This is similar to the finding of Kaya *et al.* (1999), who reported the sexual maturity age as I age-group in South Aegean and Mediterranean. Ismen (2005) reported individuals of both sexes mature for the first time after the second year of life.

In the study, sexual maturity length has found as 11 cm for both sexes. Kaya *et al.* (1999) determined the spawning season of Goldband Goatfish between August and October during their study in South Aegean and Mediterranean. Torcu and Mater (2000) reported the spawning season of Goldband

Goatfish begins in March and ends in November in Fethiye Gulf and in Mersin Gulf, starts in April-May and continues to November. These are similar to the present observations. In this study, the GSI results revealed that spawning occurred after July, when the GSI reached its highest level.

CONCLUSION

In this study, 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 Western Mediterranean goldband goatfish and that the fishing season should be closed from July to October. This extended period covers fishing seasons closed to the use of deep trawls spawning seasons of the main catch in the Gulf of Antalya and will afford protection to reproductively active Goldband Goatfish. 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 Western Mediterranean Sea.

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