

Age, growth and reproduction of the gold band goatfish, *Upeneus moluccensis* off the Elkhoms coast of Libya

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ABSTRACT

The age, growth parameters, spawning season, sex ratio, length at first sexual maturity and fecundity of the goldband goatfish, *Upeneus moluccensis* (Bleeker, 1855) caught in Elkhoms coasts of the Mediterranean Sea were investigated. It was found that, males constitute about 47.7% its population. Length-weight relationship of both sexes was illustrated as:

$$W = 0.01017 L^{3.01} \quad \text{for males and}$$

$$W = 0.00822 L^{3.09} \quad \text{for females}$$

The age data derived from scale readings were used to estimate the growth parameters of the von Bertalanffy equation and the calculated parameters were:

$$L_{\infty} = 233.6 \text{ mm, } K = 0.2274 \text{ and } t_0 = -1.872 \text{ for males and}$$

$$L_{\infty} = 234.4 \text{ mm, } K = 0.2120 \text{ and } t_0 = -1.983 \text{ for females}$$

It was found that the maximum age of males and females attained five years only. The second year age group was dominated the population. Otherwise, maturation of males and females occurred at a total length of about 11 cm. The monthly values of the gonado-somatic index indicated that spawning of the studied fish take place mainly between May and July. The fecundity-length relationship designated that the fecundity is highly correlated with the fish length and expressed by the equation:

$$\text{Log } F = 0.0268 + 3.8120 \text{ Log } L \quad (r = 0.995).$$

INTRODUCTION

The goldband goatfish is a commercially important demersal fish species, living mostly on sand, muddy sand or gravel bottoms at depths ranging from 10 to 120 m (Golani, 1994 and Ozvarol *et al.*, 2010). It is mainly a tropical and subtropical species, distributed along the western Indian Ocean and Red Sea (Ben-Tuvia and Golani, 1989 and Randall *et al.*, 1993). The goldband goatfish *Upeneus moluccensis* (Bleeker, 1855) is a Lessepsian migrant fish which penetrates from Red Sea into the Mediterranean Sea through the Suez Canal (Golani and Ben-Tuvia, 1995). Lessepsian fish species such as *Upeneus pori* and *Upeneus moluccensis*, have been reported to be important in commercial fishing along the Libyan Mediterranean coast, since the Mediterranean continental shelf is relatively wide and its topographical structure is suitable for trawl fisheries (Ozvarol *et al.*, 2010). The fishes inhabiting the Mediterranean Sea are well known on the global basis and are well documented (Whitehead *et al.*, 1986; Fischer *et al.*,

1987 and Ismen, 2006). However on the regional scale, there are discontinuities in the knowledge, especially on the Lessepsian species of the northeastern Mediterranean Sea (Ismen, 2006).

Published information on the comprehensive biology and ecology of goldband goatfish along the Libyan coast of the Mediterranean Sea is scarce. However, in other coasts of the Mediterranean this fish species was studied satisfactorily by many researchers in recent years. The *Upeneus moluccensis* is a small fish not exceeding 25 cm. in total length, but it is considered to be the most economic fish in Elkhoms coast due to its excellent quality of flesh and its moderate price in the local markets. In spite of this economic importance of this fish species, there is no information about its fisheries biology or its population dynamics in this region of Mediterranean Sea.

The present study provides information about the age, growth, sex ratio and reproduction of the goldband goatfish in Elkhoms coast of Libya, in the southern Mediterranean, as a contribution in the management of fishery exploiting stocks.

Materials and Methods

A total of 426 goldband goatfish specimens were collected from the Elkhoms coasts between June 2006 and May 2007. Total length of each fish specimens was measured to the nearest millimeter, and whole body and weights were measured to the nearest gram. Age was determined by counting the annual rings on the scales using the scale micrometer. The body length–scale radius relationship was determined using the least square method. The back calculated lengths at the end of each year of life were obtained by using Lee's equation:

$$L_n = (L - a) s_n / S + a$$

Whereas(L_n) is the calculated lengths at the end of n year, (L) is the fish length, (s_n) is the distance from the scale focus to the successive annuli, (S) is the total scale radius and (a) is the intercept of the regression line with the Y axis.

The length-weight relationships were determined according to the allometric equation (Sparre *et al.*, 1989): $W = aL^b$

Where W is the total body weight gram,(L) the total length in cm, and (a) and (b) are constants. Growth was expressed in terms of the von Bertalanffy equation (Beverton and Holt, 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) is the growth curvature parameter and (t_0) is the theoretical age when fish would have been at zero total length. These parameters were estimated by means of von Bertalanffy plot (Sparre and Venema, 1992).

For the description of the sexual cycle of the goldband goatfish the sequence of gonad maturation was monthly observed and the spawning period was determined. The sex and maturity stage of each specimen were determined by visual and microscopic examination of the gonads. The seasonal evolution of the gonado somatic index was analyzed according to the formula: $GSI = W_g / W \times 100$

Where (W_g) is the gonad weight to the nearest 0.1gram and (W) is the fish weight in gram. Length at first sexual maturity (L_{m50}) was estimated by King (1995) method.

The ovaries of 68 female goldband goatfish were cut longitudinally and stored in Gilson's fluid, which broke down the connective tissue for fecundity estimations. The egg numbers were estimated using the gravimetric method described by Bagenal (1978). The data were analyzed by least squares regression using log10 transformations (Ismen, 1995).

RESULTS

Growth in Length:

The relationship between the scale radii and the total fish lengths of *U. moluccensis* showed direct proportional one with high correlation presented in the following equations.

$$L = 12.0089 + 13.718 S \quad n = 426 \quad r^2 = 0.998$$

From this equation the calculated lengths at the end of every year of life are computed by back calculations according to Lee's formula (1920):

$$L_n = S_n / s (L - 12.0089) + 12.0089$$

The results indicated that the studied fish reached five years old. The observed and the calculated total lengths at age were nearly similar in the five age groups (Tables 1&2). *Upeneus moluccensis* attained approximately 54 % of its maximum size during the first year of life, (i.e. rapid growth occurs at the first year of life).

Table 1: Back calculated lengths at the end of each year of life of female *U. moluccensis* from the Elkhoms coasts

Age Group	Mean Number	observed Length	Back calculated lengths				
			1	2	3	4	5
I	42	110	88.5				
II	76	134	99.7	128.1			
III	44	152	98.6	130.6	149.6		
IV	36	169	98.8	132.0	149.9	166.5	
V	25	181	98.5	131.8	150.4	169.0	179.7
Increment			96.9	34.0	19.4	17.9	11.9
% increment			53.9	18.9	10.8	10.0	6.6

Table 2: Back calculated lengths at the end of each year of

Age Group	Mean Number	observed Length	Back calculated lengths				
			1	2	3	4	5
I	35	112	90.8				
II	70	138	96.0	133.1			
III	40	155	99.3	130.8	150.2		
IV	35	172	101.6	131.0	151.5	168.2	
V	23	185	104.6	127.8	148.2	168.7	182
Increment			98.4	32.3	19.2	18.6	13.8
% increment			53.9	17.7	10.5	10.2	7.6

of male *U. moluccensis* from the Elkhoms coasts of

Length – Weight relationship:

The total length of *Upeneus moluccensis* ranged from 9 to 19 cm. while the total weight ranged from 8.7 gm to 69.3 gm. The length-weight relationships were separately calculated for females and males, and are presented in figures (1&2). The exponent (b) demonstrates an isometric growth as illustrated in the equations:

$$W = 0.0082 \times L^{3.09} \quad (r = 0.99) \text{ for females and}$$

$$W = 0.01017 \times L^{3.01} \quad (r = 0.99) \text{ for female.}$$

Von Bertalanffy growth equation was applied to estimate the growth parameters (K, L_∞ and t_0) of the studied species. The estimated von Bertalanffy growth parameters were

$$L_\infty = 234.4 \text{ mm, } K = 0.2120 \text{ and } t_0 = -1.983 \text{ for females}$$

$$L_\infty = 233.6 \text{ mm, } K = 0.2274 \text{ and } t_0 = -1.8715 \text{ for males.}$$

The *U. moluccensis* attained approximately 54% of its calculated maximum size during the first year of life. After completion of the first year, the annual growth rate ranged between 1 and 3 cm. The maximum determined age was 5 for

both sexes. Age group two was dominant in females (34%) and males (34.5%). In females, age group two was followed by age groups three (19.7%), one (18.8%), four (16.1%) and five (11.2%). In males, age group two was followed by age group three (19.7%), one (17.2%) and five (11.3%).

Table (3) showing sex ratio of *Upeneus moluccensis* month wise.

Months	No. of Fish		Male		Female		Ratio	
	No.	%	No.	%	No.	%	male	female
January	38	18	8.87	20	8.97		1	1.11
February	35	17	8.37	18	8.07		1	1.05
March	40	19	4.36	21	9.42		1	1.10
April	37	17	8.37	20	8.97		1	1.18
May	39	18	8.87	21	9.42		1	1.17
Jun	34	16	7.88	18	8.07		1	1.13
July	38	18	8.87	20	8.97		1	1.11
August	37	17	8.37	20	8.97		1	1.17
September	32	15	7.39	17	7.62		1	1.13
October	31	17	8.37	14	6.28		1	0.82
November	34	15	7.39	19	8.52		1	1.26
December	31	16	7.88	15	6.73		1	0.93
Total	426	203	99.99	223	100.0		1	1.096

The mean sex ratio around all the studied period of female to male was 1.00:1.096. The number of female to male was given monthly and presented in table (3). All the monthly samples contained more females than males, except October and December. Examination of the male and female maturity stages indicated that males and females of *U. moluccensis* matured at about 11 cm total lengths, one year old (Fig. 3). The GSI results revealed that fish spawning occurred at July in this region of the Mediterranean Sea, when the GSI for both sexes reached its highest level (Fig. 4). However, the presence of mature individuals in August indicates that reproduction may continue at a reduced rate during summer.

Fecundity of *Upeneus moluccensis* was ranged from 11395 eggs for 11.5 cm to 64940 eggs for 18 cm. It was tightly correlated with the female as expressed in the following equation of fecundity-length relationship:

$$\text{Log } F = 0.0268 + 8.8120 \text{ where } r = 0.995$$

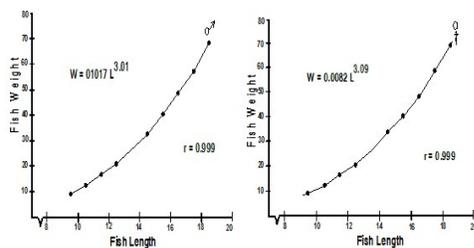


Fig.(1) length weight relationship of male *Upeneus moluccensis*

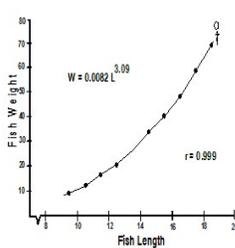


Fig.(2) length weight relationship of female *Upeneus moluccensis*

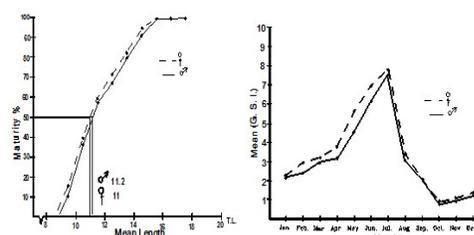


Fig (3) Length at first maturity of both sexes of *Upeneus moluccensis*

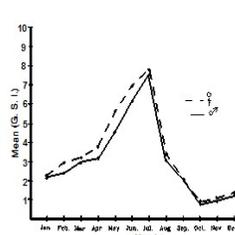


Fig (4) Gonadosomatic index of both sexes of *Upeneus moluccensis*

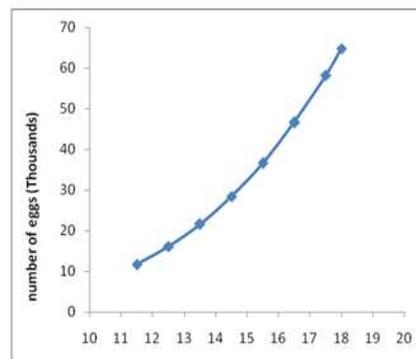


Fig. (5) Relationship between absolute fecundity and total length of *Upeneus moluccensis*

Discussion

The passage of Lessepsian fish species to the Mediterranean has affected on the ecosystem balance of the species in the Mediterranean. Even though there are not sufficient studies conducted, it was observed that the Lessepsian species which entered and rapidly colonized the Mediterranean competed with the indigenous species in terms of sharing the food and the habitat (Ismen, 2006).

The goldband goatfish is commercially important for the Mediterranean fisheries in Libya. The results of the growth rate in the first year of the goldband goatfish caught in Elkhoms coast of Libya reported in the present study are in agreement with those reported by Kaya *et al* (1999) in south Aegean coasts of Turkey, Ismen (2005) in Iskenderun Bay, the Eastern Mediterranean and Ozvarol *et al* (2010) in the gulf of Antalya (Turkey). It was found that the first annulus is formed at a length of 11.2 cm; 11 cm and 11 cm respectively. However, Torcu (1995) in Iskenderun Bay, stated that the first annulus of this fish species was formed at 8.2 cm. The mean annual growth rate in the present study for 1-5-years old ranged between 1.2 - 3.4cm and 1.4 - 3.2cm for females and males respectively (Tables 1&2). Growth was rapid in both sexes for the first year and declined gradually over subsequent years. Torcu (1995) reported that the mean annual growth rate for 1-5 years old of the same fish was about 1.9 cm, 1.7 cm, 1.3 cm and 1.4 cm, respectively. Mean while Kaya *et al*. (1999) stated that this mean annual growth rate for 1-6-years old fish was about 1.9 cm, 1.7 cm, 1.3 cm and 1.4 cm, for females and males respectively.

Table (4): The von Bertalanffy growth parameters of the goldband goatfish *Upeneus moluccensis* from different localities.

Author	Location	L_{∞}	K	t_0	ϕ
Bingel <i>et al.</i> (1993)	Mediterranean	25.6	0.621	-0.270	6.01
El-Drawany (1995)	Red sea	24.3	0.228	-1.523	4.15
Kaya <i>et al.</i> (1999)	Mediterranean	26.0	0.110	-3.770	4.31
Ismen (2005)	Mediterranean	25.2	0.197	-1.002	4.83
Ozvarol <i>et al.</i> (2010)	Mediterranean	25.6	0.136	-3.828	----
Present study for ♂	Mediterranean	23.4	0.227	-1.872	4.05
Present study for ♀	Mediterranean	23.4	0.212	-1.983	4.07

These differences in growth rates might be attributed to different bio-ecological 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.

From the given data in the table (4) it was found that there are no significant difference between the overall growth performances of the goldband goat fish sampled from the different regions in the north and eastern Mediterranean. The values of these parameters are $L_{\infty} = 24.3$ $k = 0.228$ $t_0 = -1.532$ for the Gulf of Suez Red sea (El-drawany, 1995) and $L_{\infty} = 25.2$ $k = 0.197$ $t_0 = -1.002$ for Iskenderun Bay, the north-eastern Mediterranean (Ismen, 2005). Goncalves *et al.* (2003) reported that the estimated von Bertalanffy growth parameters may vary according region, and year. Recently, Cicek and Aysar (2011) decided that, the major driving force in population fluctuation is recruitment variability year by year. The female to male ratio of the goat fish in the present study was 1: 1.096 is similar to that derived by Ismen (2005) for same species but was differed from that in the north-eastern Mediterranean (2.7 and 3.4) (Torcu, 1995 and Kaya *et al.*, 1999). Seasonal variations in the sex ratio may be due to the differences in the length (or age) of sexual maturity (Ismen, 2006).

In the present investigation it was found that length-weight relationship is nearly the same for both sexes, the functional regression b values (3.09) for female and (3.01) for males of the goldband goatfish was differed from those given by Anonymous (1993), Torcu (1995) and Kaya *et al.* (1999). Anonymous (1993) indicated that the value of exponent b of the length weight relationship for combined sexes was 3.30 while Torcu (1995) stated that the b value of the length weight relationship for pooled data was 3.21. Also Kaya *et al.* (1999) reported that the b value estimated for males and females were 3.15 and 3.35, respectively. This is because the functional regression b value is directly related to the weight affected by different ecological factors such as temperature, food supply, spawning conditions and habitat characteristics.

The GSI data revealed that, the spawning of goldband goatfish fish occurred at July, when the GSI for both sexes reached its highest level (Fig. 4). However Ismen (2005) stated that this fish species spawns at June. However, the presence of mature individuals in September indicated that the reproduction may continue at a lesser rate during summer. While Kaya *et al.* (1999) reported that the spawning season of goldband goatfish was between August and October during their study in south Aegean and Mediterranean.

Table 5: Length weight relationships of *U. moluccensis* recorded by some authors in different regions

Authors	Regions	Sex	a	b
Anonymous (1993)	Marmara Aegean sea	combined	0.000004	3.30
Torcu (1995)	Nor. East. Mediterr.	combined	1.0554	3.21
El-Drawany (1995)	Red Sea	Male	0.01130	3.009
		Female	0.10700	3.028
Kaya <i>et al.</i> (1999)	Mediterranean	Male	0.01501	3.150
		Female	0.00607	3.352
Taskavak & Bileceoglu (2001)	East Mediterranean	combined	0.000013	3.021
Ismen (2005)	Northern east Mediterranean	Male	0.0118	2.99
		Female	0.0117	3.00
Ozvarol <i>et al.</i> (2010)	Gulf of Anatalya Turkey	Male	0.010	2.99
		Female	0.010	3.025
Present study	Northern Mediterranean	Male	0.1017	3.01
		Female	0.0082	3.09

Sexual maturity of both sexes of *U. moluccensis* in Elkhoms coasts of Libya was with the first age group. This is similar to the findings of Kaya *et al.* (1999) and Ozvarol *et al.* (2010) whose reported that the sexual maturity of the fish was also in the first age group in south Aegean and Mediterranean. Nonetheless, Ismen (2005) found that the individual of both sexes mature for the first time after the second year of life.

The number of eggs (fecundity) of the present studied fish is ranged between 11.395 and 64.940 for lengths of 11.5 and 18 cm. It is tightly related to the fish length where (r) is equal to 0.995. However, Torcu (1995) showed that the fecundity of *U. moluccensis* varies between 19.714 and 64.452, and the amount of eggs increases with age.

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المخلص العربي

المصيدة من *Upeneus moluccensis* بدراسة معدلات النمو لأسماك البريونى مياه البحر المتوسط بمنطقة الخمس بالمياه اللبية وذلك بواسطة القشور تبين ان أطوال الأسماك المقدرة للأعمار المختلفة من معادلة فون برتلانفي (معادلة النمو العضوي) مطابقة لنظائرها المحسوبة بالحساب الرجعي وكلاهما كان مطابقاً للأطوال الحقيقية كما وجد أن معايير النمو العضوي (فون برتلانفي) كانت علي الوجه التالي :

الطول الأنهائي = 233,6 مم بالنسبة للذكور و = 234,4 مم بالنسبة للإناث والعمر الافتراضي عندما كان طول السمكة صفر للذكور والإناث هو - 1,8715 و- 1,983

والثابت k وهو ثلث معامل الهدم 2274, بالنسبة للذكور و 2120, بالنسبة للإناث وبناء علي ذلك وتطبيق معادلة النمو العضوي قدرت أطوال الأسماك للأعمار المختلفة وكانت علي النحو التالي:

137 , 156 , 172 , 186 مم بالنسبة للذكور و 109 , 133 , 153 , 168 , 181 مم بالنسبة للإناث من عمر عام إلي خمسة أعوام علي التوالي.

أما بالنسبة لدراسة معامل الانحصار في علاقة الطول بالوزن لأسماك البريونى من منطقة الخمس بلبيبا وجد انه عند القيمة التكعيبية تقريبا بالنسبة للجنسين وعليه

فان هذا النوع من الأسماك متمائل النمو أي انه لا يوجد أي تغير في الشكل كلما ازدادت الأسماك طولاً .

ومن الدراسة الحالية أيضا وجد أن نسبة الأجناس لهذا النوع من أسماك البربوني متساوية تقريبا غير أن الطول المقدر عند أول نضوج جنسي بالنسبة للذكور هو 11 سم والنسبة للإناث هو 11,2 سم .

سنوية التكاثر حيث تتكاثر في *Upeneus moluccensis* واسماك البربوني الفترة من مايو وحتى نهاية شهر يوليو مع ملاحظة أن قمة موسم التكاثر في شهر يوليو .

كما تم دراسة خصوبة هذا النوع من اسماك البربوني وتبين أن الخصوبة المطلقة لإناثها تتراوح بين 11395 و 64940 للأطوال من 11,5 سم إلى 18 سم .
وبدراسة علاقة الخصوبة المطلقة بالمتغيرات الطول والوزن والعمر وجد أن علاقة الخصوبة بالطول هي اقوي العلاقات وعلية يجب أن تؤخذ في الاعتبار عند دراسة إنتاجية وخصوبة هذا النوع من الأسماك في المياه الليبية بالبحر المتوسط.