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Aspects of growth of the lessepsian goldband goatfish [*Upeneus moluccensis* (Bleeker, 1855)] population living in İskenderun Bay, Türkiye

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Abstract

Background and purpose: Upeneus moluccensis *has become one of the most abundant lessepsian species which penetrated into the eastern Mediterranean since 1950's. It is considered one of the important species of commercial trawl fisheries, in abundance (approximately 60% of the catch per unit effort) from İskenderun Bay. Despite its economically importance in this region, there is a lack of biological information available for this species since 2005 and its growth and stock managament studies are limited. The present study deals with growth patterns of* U. moluccensis.

Materials and methods: *A total of 663, approximately 70 specimens per month were caught by trawl surveys during a 1 years' period from İskenderun Bay between 2017 and 2018. Age determination was based on indirect ageing through length –frequency data using the Bhattacharya method. Length-weight relationships, and von Bertalanffy equation were used to estimate the growth. Sexes were determined by macroscopic observation of gonads. Spawning period of this species was determined according to gonado-somatic index (%).*

Results: *Total length was measured between 7.0-17.9 cm and 7.0-18.9 cm in female and male, respectively. There was no significant difference in number of females and males from the expected 1:1 ratio ($p>0.05$). The population reached a maximum age groups of III. The von Bertalanffy growth equation (in length) was found as $Lt=20.75\ [1-e-0.33(t+0.56)]$, for all individuals. b values were estimated as 3.36 and 3.37 in female and male, respectively ($b>3.0$). Mortality and exploitation rates were derived as $Z=0.94$, $M=0.33$, $F=0.63$ and $E=0.67$, respectively*

Conclusions: *The calculated exploitation rate (≈0.67) of the goldband goatfish stock in eastern Mediterranean Sea is above the optimum value, indicating a high fishing pressure on the population. This confirms the need to enforce some regulations on commercial fisheries for* U. moluccensis.

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INTRODUCTION

In 1869, Suez Canal connected the Red Sea to the Mediterranean and allowed the penetration of numerous Indo-Pacific and Red Sea fish species including *Upeneus moluccensis* into the Mediterranean *(1). U. moluccensis* is often found among the commercial catch of many fisheries within the Mediterranean Sea *(2, 3)*. It lives in mostly sand, muddy sand or gravel bottoms, at depths of 20-130 m as schools (4) and distributes along the western Indian Ocean stretching from the Red Sea to

southern Oman and Turkish Seas (2, 5). As a native mullid, *Mullus barbatus* which entered a competition for food and habitat with the lessepsian species, *U. moluccensis,* had to move to deeper waters *(6)*, *U. moluccensis* has became an important fish of İskenderun and Mersin trawl fisheries since 1955 (7). Of the 374.725 tons of sea fish caught in Turkish Seas in 2019, 1.756 tons are belonging to the Mullidae including *U. moluccensis* (8). Studies on biology of fish are important to plan a better conservation and management strategies of fishery resources. There are some studies on distribution *(9)*, reproduction *(10)*, feeding and trophic level *(11),)*, growth *(2, 3, 12, 13, 14, 15, 16)* in the Mediterranean Sea.

There is an increase in the number of lessepsian species in eastern Mediterranean Sea . It is very important to observe non-indigenous species in these waters for better understanding of population dynamics in these environment and sustainability of native biodiversity and habitats. In this contest, Iskenderun Bay is a hot spot which may be used as a pilot region for monitoring of the non-native species. The purpose of this study is to evaluate the recent 10 years' stock structure of *U. moluccensis* population in İskenderun Bay, with some biological parameters.

MATERIALS AND METHODS

Study area and sample collection

Iskenderun Bay is located in the northeastern region of the Eastern Mediterranean Sea, about 70 km long and 35 km wide and maximum depth is approximately 100 m in the entrance to the Mediterranean Sea (36°37'23"N 35°53'17"E)**.** The average depth is 55-90 m, and it is known to have the largest continental shelf area after the Nile Delta in the Eastern Mediterranean Sea *(17)*.

A total of 663 specimens were caught by commercial trawl vessel İdrisoğulları between September 2017 and May 2018 in the Bay of İskenderun. Because of technical difficulties, sampling could not be carried out during summer. With approximately 70 specimens per month, trawl surveys were carried out during daytime at depths ranging from 0 to 60 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. After catching, specimens were transported in iced styrofoam boxes to the Hydrobiology Laboratory of Faculty of Science and Arts, Balikesir University.

Laboratory and data analysis

For each fish, total length was measured to the nearest 0.1 centimeter by a digital calliper and whole body and gonad weights were measured to the nearest 0.1 and 0.01 gram, by a digital balance all in the laboratory. Length – weight relationships were derived as $W=a \times TL^b$, in which the parameters of 'a' and 'b' were calculated by the least squares method *(6)*. The length and weight relationships were estimated for each sex along with the total length. The b value, which indicates growth tendency, was tested to verify whether it differs from the isometry at a 0.05 significance level.

The ages of specimens were determined using length frequency data analyses (ELEFAN) (Electronic length frequency analysis) using the Bhattacharya method in FISAT Software *(18)*.

The growths in length and weight were computed using the von Bertalanffy equation (VBGF) *(19)*: $Lt = L\infty [1 - e^{(-k(t-t_0))}]$ and b where Lt is the total length at age t, L∞ is asymptotic length (cm), k is the growth rate ($year^{-1}$), t is the age (year), and t_0 is the hypothetical age at zero length (year) (20). The growth performance in length, (Φ) was estimated using the equations given by Moreau *et al. (21)*: $(\Phi) = \log k + 2\log L\infty$.

The sexes of all specimens were determined by visual and microscopic examination of the gonads. The principal hypothesis supposes that there is equality in sex ratio which was evaluated with a chi-square test (χ^2) *(22)*.

To quantify the changes in gonad weight during the annual sexual cycle and to determine the spawning season, the gonad-somatic index (GSI) was calculated by the following formula: GSI = (GW / SW) x 100, GW: gonad weight (g) and SW: somatic weight (g) (body weight minus gonad weight) *(6)*.

Condition factor (CF) was calculated as $CF=[(W/L^3)*100]$ for each sex to assess the maturity, condition of specimens and an overall measurement of robustness of the fish *(6)*.

The instantaneous total mortality rate (Z) was estimated by length converted catch curve method using the FISAT II program *(18)*.The natural mortality (M) was also determined using the empirical equation of Pauly & Munro *(21)*: $\log M = -0.0066 - 0.279\log L\infty + 0.6543\log K + \log T$ where T is the water temperature (18.5 C°). Fishing mortality (F) was deduced from the formula F= Z–M. The exploitation rate indicated whether the stock is underexploited (E=0.5), based on the assumption that the stock is optimally exploited when F = M or E = 0.5 *(20)*.

RESULTS

The total length ranged from 7.0 to 18.9 cm, with lengths of 9.5-9.9 cm being the most dominant in the samples of females (n=321) (Figure 1) while the ranges between 7.0-18.9 cm were determined with the most individuals in 10.0-10.4 cm in males (n=342) (Figure 2).

The total weight also ranged from 3.5 to 65.9 g, with lengths of 11.5-11.9 g being the most dominant in the samples of females (n=321) (Figure 3) while the ranges

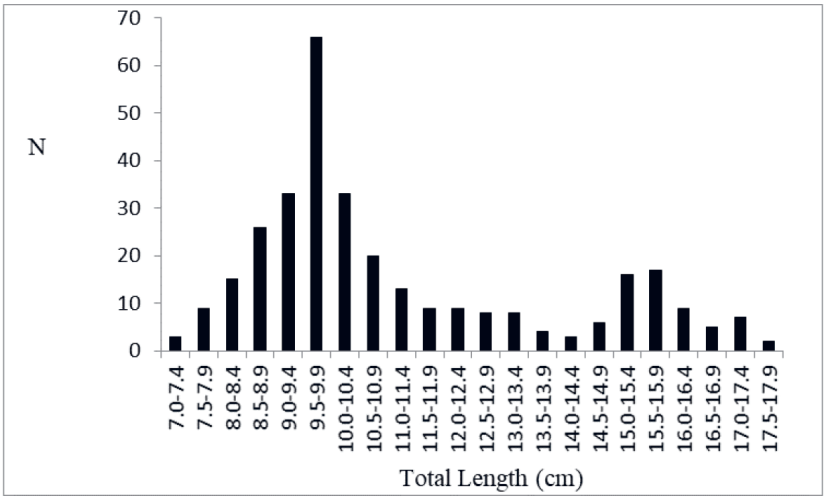

Figure 1. *Total length distributions in female Upeneus moluccensis.*

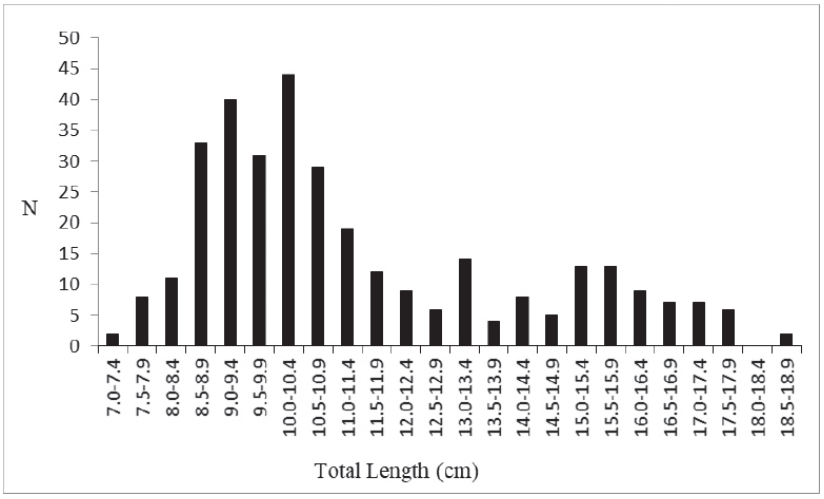

Figure 2. *Total length distributions in male Upeneus moluccensis.*

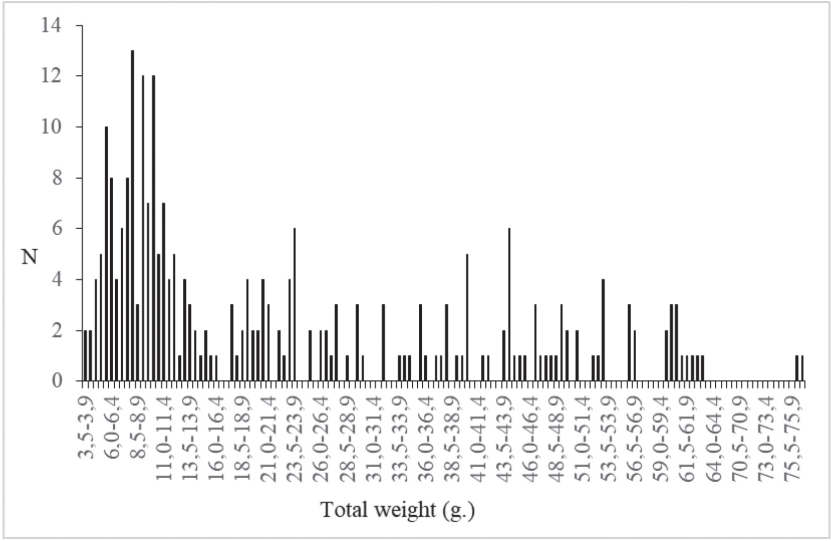

Figure 3. *Total weight distributions in male Upeneus moluccensis.*

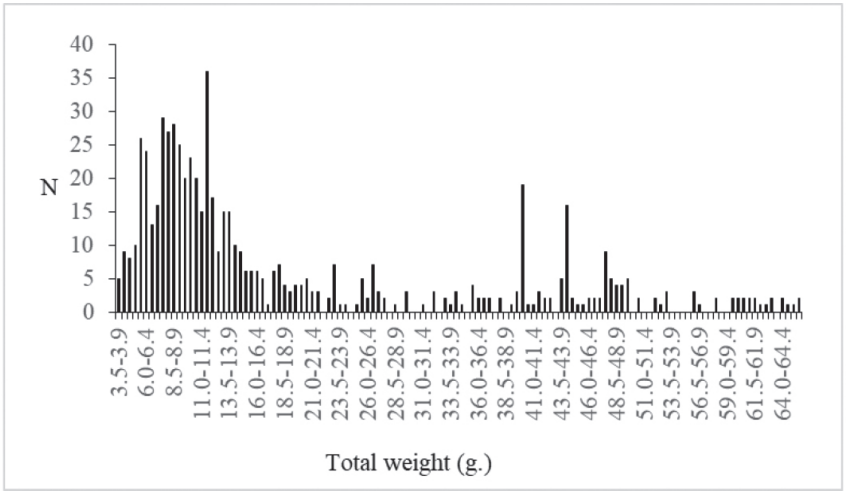

Figure 4. *Total weight distributions in female Upeneus moluccensis.*

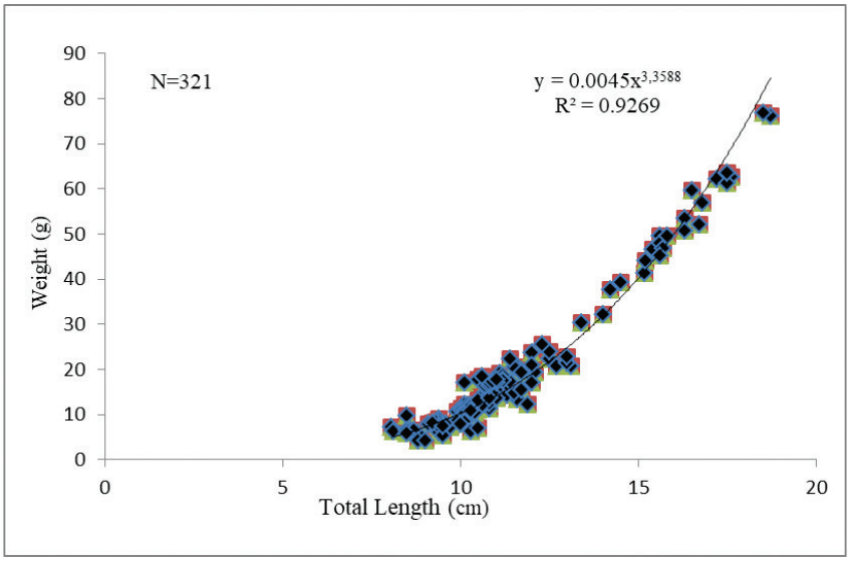

Figure 5. *Length–weight relationship in female of Upeneus moluccensis.*

between 3.5-76.9 g were determined with the most individuals in 8.0-8.4 g in males (n=342) (Figure 4)

A total of 663 specimens of *U. moluccensis* included 342 (52.0%) males and 321 (48.0%) females. The overall sex ratio was not significantly different from the expected value of 1:1 (F: M=0.94: 1, λ^2= 220.5, p>0.05).

Length–weight relationships were calculated by using the data of 321 and 342 *U. moluccensis* female and male specimens as $W=0.0045L^{3.35}$ (R^2=0.93), and $W=0.0045L^{3.37}$ (R^2=0.93), respectively. The relationships were allometrically positive, showing a statistically significant difference from the value 3.0 (t-test, P<0.05) in Figures 5, 6.

Estimation of age and growth were obtained using Bhattacharya's length frequency distribution assessment method with determination of the von Bertalanfy growth parameters. The length frequency distribution of *U. moluccensis* and age groups is presented in Figure7. Age of captured golden banded goatfishs ranged between 1 and 3. The one year class was found as dominant and it can be expressed that the population consisted of younger individuals. The mean total lengths for different age groups are shown in Table 1 and Figure 7.

The predictive von Bertalanffy growth parameter for *U. moluccensis* was seen as L_t=20.75 $[1-e^{-0.33(t+0.56)}]$, while the growth performance index (Φ) was 4.95.

As shown in Figure 8, the mean GSI started to increase from March and reached its highest value in September. After September, the GSI continued to decrease during October, November, December, January. In February, most of gonads may be considered to spent.

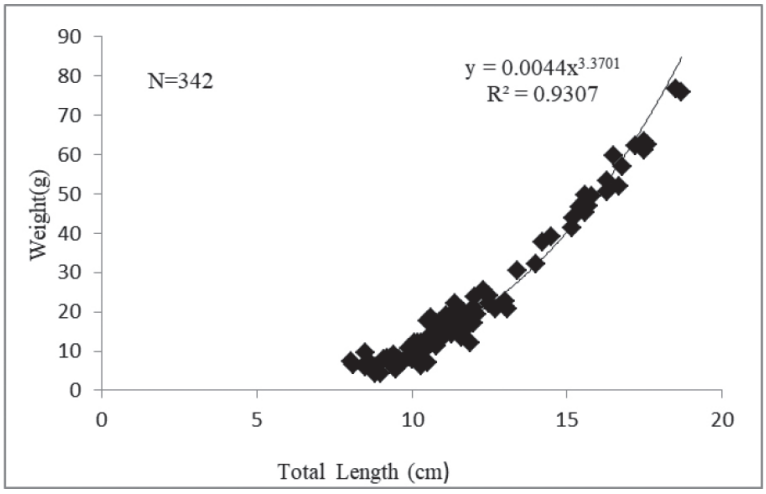

Figure 6. *Length–weight relationship in male of Upeneus moluccensis.*

Table 1. *Mean lengths at age (year) of Upeneus moluccensis determined from Bhattacharya's method of separating length frequencies distribution.*

Fish Species	Ages	Mean Total length (cm)	population	Separation index
Upeneus moluccensis	1	9.51	420	n.a
	2	13.06	86	2.31
	3	16.08	143	2.18

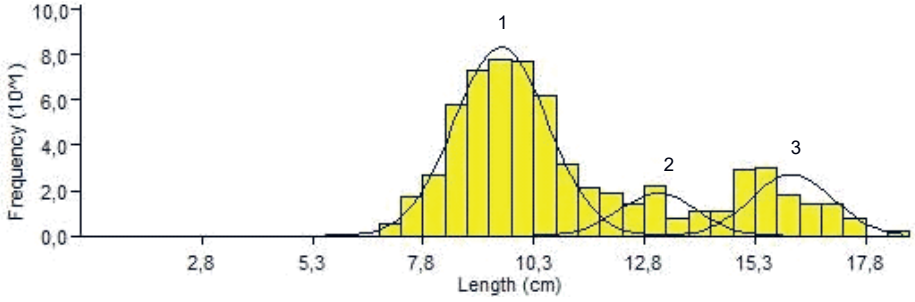

Figure 7. *Age group composition of Upeneus moluccensis from İskenderun Bay using total length frequencies (Bhattacharya Method).*

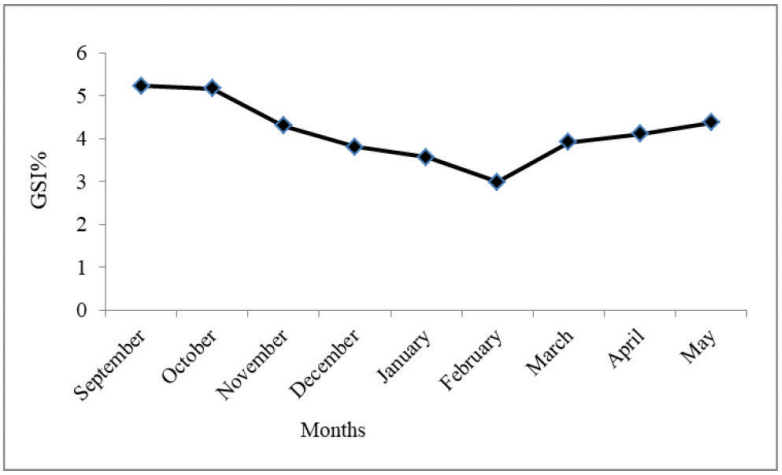

Figure 8. *Gonadosomatic Index values of Upeneus moluccensis in İskenderun Bay.*

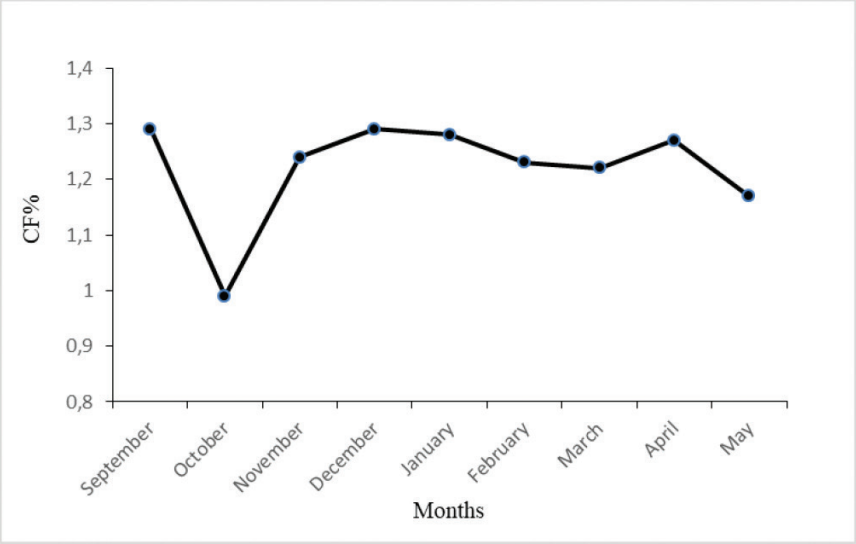

Figure 9. *Condition factor values of Upeneus moluccensis in İskenderun Bay.*

The minimum and maximum CF values for all individuals were found to be 0.98 in October, and 1.32 in September,respectively (Figure 9). In the *U. moluccensis* population, there was a tendency for the condition factor to increase little from the end of autumn to the mid of spring as in Figure 8.

The instantaneous natural mortality (Z), the natural mortality (M), the instantaneous fishing mortality (F) were computed as 0.9/year, 4, 0.31/year, and 0.63/year, respectively. The exploitation rate (E) was estimated as 0.67.

DISCUSSION

The length distribution were recorded in all individuals as 7.0-18.9 cm (Table 1.) The findings were in a harmony with those by İşmen *(2),* except for those by Kaya *et al. (13)* and Bengil *(3)*. As to weight distribution, geographic location and some environmental conditions such as temperature, organic matter, quality of food, time of capture, stomach fullness, disease, parasitic loads *(19)*, temperature, organic matter, quality of food and the water system in which the fish live *(23)* can also affect weight at-age estimates.

In this study, although males are found slightly more than females, there was not a significant difference between two genders as in Table 2. This is similar to the data which was estimated by İşmen *(4)*, opposite to other regions (Table 2). Sex ratio studies provide information on the proportion of male to female fish in a population and are expected to be 1:1 in nature *(22)*. This may vary from species to species, differing from one population to another of the same species, and may vary year after year within the same population *(33)*. The fact that the males are dominance in *U. moluccensis* population may be attributed to an easier catch of one sex, various fishing methods and equipments, gear selectivity, different fishing factors related to season and schooling and migration in feeding and spawning ground and spatio-temporal segregation of the sexes

Table 2. *Sex ratios of Upeneus moluccensis populations in relevant literature.*

Researcher	Locality	Female%	Male%	Sex Ratio
Torcu *(24)*	Fethiye Bay	69	31	F:M=2.23:1
Torcu *(24)*	Mersin Bay	77	23	F:M=3.35:1
Kaya *et al.*(13)	İskenderun B.	75.25	24.75	F:M=3.04:1
Kökçü *(25)*	İskenderun B.	62.0	38.0	F:M =1.65:1
İşmen *(2)*	İskenderun B.	51.6	48.4	F:M =1.07:1
Becer Ozvarol *et al. (14)*	Antalya Bay	75.25	24.75	F:M =2.83:1
Bengil *(3)*	Cyprus	70.0	30.0	F:M=2.32:1
This study	İskenderun	48.0	52.0	F:M =0.94:1

Table 3. *Parameters of the length-weight relationship (a, b) of Upeneus moluccensis in this study and previous studies (-indicates absence of data).*

Investigators	a	b	Min-max.	Length	N	R^2	Locality
El-Drawany *(12)*	0.0130	3.0	–	TL	–	–	Red Sea
Pauly *et al. (28)*	0.04510	2.636	–	FL	–	0.96	Endonesia
Torcu *(24)*	0.0554	3.21	–	FL	1040	–	İskenderun Bay
Kaya *et al. (13)*	0.00607	3.35		FL	535	0.92	Mediterranean
Taşkavak and Bilecenoğlu *(29)*	0.000013	3.021	–	TB	–	0.97	Mediterranean
Kökçü *(25)*	0.0092	3.08		TB	356	0.91	Mediterranean
İşmen *(2)*	0.0117	3.0		TB	216	0.99	E.Mediterranean
Ceyhan *et al.* (30)	0.0046	3.11	–	TB	51	0.93	Gökova Bay
Becer Özvarol *et al. (22)*	0.0110	2.99		–	–	–	Antalya Bay
Mehanna *(15)*	0.0119	3.04	–	TB	–	0.98	Alexandria Harbour
Bengil (3)	0.0068	3.32	–	TB	219	0.96	Northern Cyprus
Heneish *et al. (10)*	0.0056	3.19		-	45	9.98	Egypt
Karuppasamy *et al. (16)*	0.0118	3.223	–	TB	197	0.955	India
Özdemir *et al. (31)*	0.0079	3.002	–	TB	425	–	Mediterranean
This study	0.004	3.38	7.0–18.9	TB	690	0.85	İskenderun Bay

Length-weight relationships are important components of fisheries biology and when properly calculated they can be very useful to fisheries management *(26)*. The same equations are useful for the application of stock assessment models and for the comparison among geographical regions *(26, 27)*. In fishes, b values differ from 2.0 to 4.0 *(19)*. As seen, the analyses of the length-weigth relationship values given by several authors in the Mediterranean Sea showed some differences with b value in our study (Table 3). This variation may be caused by the lack of sampling in summer season. According to Froese *et al. (26)*, the value b in fish differs according to species, sex, age, sampling size, seasons and feeding, time of year, stage of maturity, growth increment or break in growth, fishing time and vessels.

In the Bhattacharya analysis, 1–3 age groups were determined. The increase in length was rapid during the first year and slow thereafter in golden bandad goatfish population. As seen, age 1 was represented with the most individuals (Table 1, Figure 7). The absence of zero age in the samples was probably due to the net mesh size selectivity. However, the low levels of the older age groups after the age 1 cannot be related to selectivity, and are more likely to be the result of the extremely intensive fishing activities and sampling techniques. The growth rate for this species is found to be rapid at the first years of life and declined gradually over subsequent years. It is thought that the differences in growth rates might be attributed to the bio-ecological conditions. According to İşmen *(2)*, the oldest male was 6 years old and the oldest female found was 7 years old. While Kaya *et al. (13)* reported that the maximum age group determined was 6 for females and 5 for males, Heneish *et al. (10)* estimated the maximum age groups as 5. We must take into account here that different techniques (scales, otoliths, Bhattacharya's method) were used in different studies, so some discrepancies could arise

The von Bertalanffy growth equation (age-length relationship) was calculated as $Lt = 20.75\ (1^{-e-0.33(t+0.56)})$ for all individuals and compared with the other investigations in Table 4. The theoretical maximum length was close to those estimated for Mediterranean, Samsun, and Mersin by El-Drawany *et al. (12)* and Özdemir *et al. (31)*. (Table 4). Differences between the theoretical maximum lengths may attribute exploitation pressures and different water environmental conditions. The fact that the growth parameters of *U. moluccensis* in sampling area is lower than the other regions has been shown that geographical conditions of İskenderun Bay may not strongly support the growth and development of golden banded goatfish species. Besides, the growth performance index (Φ) value for *U. moluccensis* showed variations in different regions (Table 4). Geographic location and some environmental conditions such as temperature, organic matter, quality of food, time of capture, *(23)* can also affect growth index.

As to mortality, total mortality ratios were found as 2.89, 0.98, 1.91 $year^{-1}$ in Adriatic Sea, coasts of Scily, and Egypt, respectively *(15, 35, 36)*. Mehanna *(15)* determined natural mortality, fishing mortality, and exploitation rates as 0.46, 1.45, and 0.76 in Port Said Region, Egypt . In our investigation, the estimated exploitation rate was 0.67, which is higher than the optimum exploitation rate (Eopt) of 0.5 according to Pauly and Munro *(37)*. The high values of the exploitation rates of the golden

Table 4. *Values of the von Bertalanffy of Upeneus moluccensis in this study and previous studies (-indicates absence of data.*

Investigators	Sex	Lmin-max	L∞	K	t_0	Φ	Locality
Bingel *et al. (32)*	–	–	25.6	0.6	–0.27	6.01	Mediterranean
El-Drawany *(12)*	–	–	24.3	0.23	–1.52	4.15	Adriatic Sea
Kaya *et al. (13)*	M	8.5-16.1	23.86	0.12	–3.69	–	Mediterranean
Kaya *et al. (13)*	F	8.6-17.8	26.20	0.11	–4.08		Mediterranean
Işmen *(2)*	C	7.0-20.5	25.2	0.19	–1.0	4.83	İskenderun Bay
Becer Ozvarol *et al.(14)*	C	8,0-21,1	25.6	0.14	–3.83		Antalya Bay
El-Drawany *(33)*	F	–	23.4	0.21	–1.98	4.07	Mediterranean
Gündoğdu and Bayhan *(34)*	C	–	24.7	0.13	–3.76	4.05	Mediterranean and Black Sea
Özdemir *et al.(31)*	C	–	23.49	0.61	–1.05	–	Samsun and Mersin
This study	C	–	20.75	0.33	–0.56	4.95	İskenderun Bay

banded goatfishes of Egypt and İskenderun Bay indicated that these fish stocks were exploited. The same species may show different mortality rates in different regions due to factors such as predators, competitors and fishing pressure *(38)*. Golani *(11)* suggested that niche partitioning of eastern Mediterranean mullets is achieved on the bathymetric axis: lessepsian mullets occupy shallow waters (20-30 m) whereas indigenous species dominate greater depths. As *U. moluccensis* has also penetrated into the Mediterranean Sea and colonised sucsessfully in shallow waters, easier catchability has made it one of commercial component of trawl fishery. In addition, the other reason for the over exploitation of *U. moluccensis* may be due to the fact that the fishers tend to reduce the mesh size of nets as well as double their efforts to catch more. Thus, it is thought that the population may be under fishing pressure in İskenderun Bay.

The gonad development was followed using the GSI% and monthly changes are plotted in Figure 8. Because of the different ecological and climatical conditions, the starting and finishing time of reproduction may include different months. Spawning started in September with a peak and continued to decrease. Ben-Tuvia *(39)* stated that the spawning season of golden banded goatfish was between June and September. While Torcu *(24)* reported that the spawning period of golden banded goatfish started in March and ended in November with a peak in September, Kaya *et al. (13)* determined the GSI between August and September with the highest level. According to Becer Özvarol *et al. (14)* and El-Drawany *(12)*, spawning period occured between July and October in Gulf of Antalya and Libya. It may be stated that our result in GSI is a harmony with the relevant studies. However, spawning periods of fish vary with respect to their species; the ecological characteristics of fish are determined by such ecological differences as stagnant or running water, as well as altitude, temperature and quality of food *(22)*.

In the *U. moluccensis* population, there was a tendency for the condition factor from to increase little from end of autumn to mid of spring, The "CF" value of the fish has been reported to be influenced by many factors such as feeding intensity, availability of food, fish size, age, sex, season, stage of maturation, fullness of the gut *(19)*.

The spread of non-native species into Turkish marine waters and their impacts on the native environment is of much concern for ecologists and fishery managers. According to Zenetos *et al. (40)*, a total of 92 lessepsian fishes penetrated into the eastern Mediterranean Sea. There is no doubt that some of non-indigenous species which successfully established in a new area have some adverse effects and threat native biological diversity and the ecological stability of ecosystems. Thus, they cause an economic loss in some fisheries and a negative influence on human welfare. However, some non-native species can also have desirable effects on a habitat., contributing to regional biodiversity (species richness and biotic interactions) and ecosystem. Besides, they have also been valued in the market as well as the native species such as *U. moluccensis*. It is said that non-indigenious species may be integral to the economies of most countries including Türkiye.

CONCLUSION

Penetrating of non-native species such as *U. moluccensis* into the eastern Mediterranean Sea has been going on. The impact of the non-indigenous species in Turkish marine waters should be constantly monitored, and strategies and dynamic management plans should be developed. The ecosystem based management concerning non-indigenous species should also be placed in the fishery policies.

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