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Short Communication

Assessment of Age and Growth Parameters of the Nakedband Gaper *Champsodon nudivittis* (Ogilby, 1895) with Different Models in the Eastern Mediterranean

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Authors' Contributions
SD designed the study. SD and ES collected the samples and performed laboratory work. SD and AD analyzed the data and wrote the article

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A B S T R A C T

This study was aimed to determine the age and the growth parameters of the nakedband gaper *Champsodon nudivittis* (Ogilby, 1895). A total of 329 samples were collected from the eastern Mediterranean Coast of Turkey between October 2011 and April 2012. Lengths and weights of sampled fish ranged from 6 to 14 cm and from 1.05 and 25.08 g, respectively. Sex ratio (1: 1.12) was biased toward males ($P < 0.05$) and positive allometric growth was determined in the sampled data. Length-weight relationship for all individuals was described by parameters; a = 0.0149 and b = 3.09, with $r^2 = 0.99$. The population consisted of five age-classes (0–4 years). Four growth models were used to identify the growth characteristics. Von Bertalanffy, Richards and Gompertz. Among these, the Richards model was the one best fitted to the data.

Champsodon Günther, 1867 has 13 valid species in the Indo-Pacific region (Nemeth, 1994). Nakedband gaper, *Champsodon nudivittis* (Ogilby, 1895) is common in the Indo-West Pacific, and has been recorded from Indonesia, Madagascar, Papua New Guinea, Philippines and Australia (Nemeth 1994; Yearsley *et al.*, 2006; Froese and Pauly, 2011). Çiçek and Bilecenoğlu (2009) first reported the nakedband gaper, from a trawl at 50 m depth in the northeastern Mediterranean Sea. It is thought that the entrance to the northeastern Mediterranean Sea of this species is ship-mediated (Bariche, 2010). The absence of the nakedband gaper from the north-western Indian Ocean and the Red Sea suggests that Lessepsian migration through Suez Canal is unlikely. Champsodontids were stated as bottom dwellers in as much as they appeared commonly in trawls. Thus, it is likely that champsodontids are vertical migrators, shuttling between the seabed and near surface. The maximum capture depth of nakedband gaper was 335 m (Nemeth, 1994). The occurrence of the nakedband gaper was in the Levantine basin of the Mediterranean far away from its native habitat. Considering the absence of the nakedband gaper at either the north-western Indian Ocean or the Red Sea, a natural range expansion of the species via Suez Canal does not seem plausible. The occurrence of the nakedband gaper in the Levantine basin of the Mediterranean, far off its native range, raised questions as to its mode of arrival.

Although the nakedband gaper has small size, a recent observation in the eastern Mediterranean suggested that there was a very important fishery biomass (Goren *et al*., 2011). Therefore, the population dynamics of the species is very important for fisheries management in the area. In this study, age-length relationship was studied using different growth models. Sex distribution and the length to weight relationship have also been determined.

Materials and methods

Nakedband gapers were caught between October 2011 and April 2012 in Iskenderun Bay (Eastern Mediterranean). A total of 329 specimens were captured by trawl (44 mm mesh size) at depths of 30-70m. Trawl operations were carried out for 180 minutes at average speed of 2.7 knots.

The samples were placed in iceboxes for transport to the laboratory. Lengths (to nearest mm) and wet weights (nearest 0.01 g) were measured. Sagittal otoliths were evaluated for age determination (Williams and Bedford, 1974; Turkmen *et al.*, 2005; Demirhan and Akbulut, 2015). Otolith readings were repeated by two different readers. Length and weight relationships of nakedband gaper were calculated with $W = aL^b$, where W is the fish weight (g) and L is the total length (cm).

In this study, different growth models were compared to the age and length parameters of the nakedband gaper. Growth curves were fitted with least squares method for each case using four growth models, the von Bertalanffy growth equation, the logistic growth equation, the Gompertz model and Richards equation

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(Haddon, 2010). This estimating technique was used for all specimens; all ages and their corresponding lengths were applied to estimate growth parameters except the classical methods that use age with their mean lengths. The solver routines in Microsoft Excel were used to determine length growth curves:

The von Bertalanffy growth equation (VBGE):

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

Here L_t is the total length at age t, L_∞ is the maximum theoretical total length, K is the growth coefficient, t_0 is the theoretical age at zero length.

The logistic growth equation

$$L_t = {L_\infty}/{\left(1 + e^{-K(t-t^*)}\right)}$$

Here, t* stands for age of the growth inflexion.

The Gompertz growth equation:

$$L_t = L_\infty * e^{-e^{(-K(t-t^*))}}$$

The Richards growth equation:

$$L_t = L_\infty \left(1 + {1}/{D} * e^{-K(t-t^*)}\right)^{-D}$$

Here, D stands for the determined shape of the curve (Tian *et al*., 1993).

Selection of the best model describing the age–length relationship was performed using both the residual sum of squares (RSS) and inspection of the L_∞ parameter.

Results

When 329 naked band gaper, all of which were caught with commercial trawls, were examined it was found out that their total length and total weight changed respectively 6 to 14 cm and 1.05 to 25.08 g. Of these, 155 were females while 174 were males. Overall ratio of females to males was 1: 1.12 (P<0.05). Length–weight relationship (95%) for all the samples was W= 0.0149 $L^{3.09}$, with r^2= 0.99. Confidence limit of the b coefficient in the length–weight relationship was 3.09. Thus, a positive allometric growth turned out to be different than 3, namely 3.09 as the determined in the sample (P<0.05) (Fig.1).

Age classes ranged from 0 to 4 years and age 2 was the dominant one with 42.9% (Table I).

Confidence limits of the four growth models appeared to be close to each other. However, there were differences in L_∞ and K values of those growth models. These values for von Bertalanffy, Gompertz, Logistic and Richards models were respectively 16.22 cm - 0.22^{-1}, 18.59 cm - 0.25^{-1}, 16.83 cm - 0.36^{-1} and 15.48 cm - 0.35^{-1} (Fig. 2, Table II).

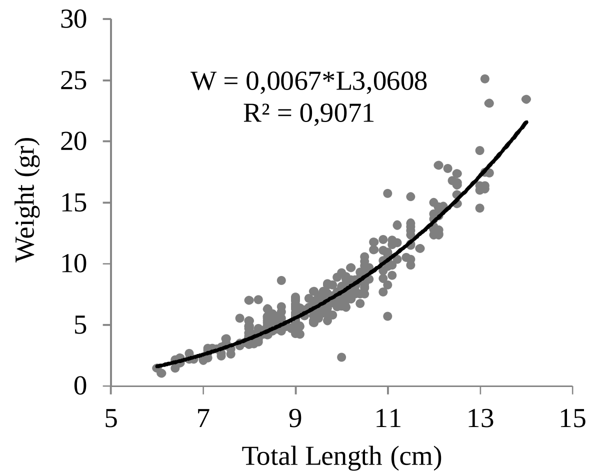

Fig. 1. Weight-length key for the nakedband gaper collected from Eastern Mediterranean Sea from October 2011- April 2012.

Table I.- Age-length key for the nakedband gaper collected from Eastern Mediterranean Sea from October 2011 to April 2012

TL (cm)	Age groups 0	1	2	3	4	Total
6	6					6
7	14	8				22
8	7	32	17			56
9		59	31			90
10		18	57	6		81
11		7	17	15		39
12			2	8	14	24
13				1	9	9
14					1	1
Total	27	108	141	36	17	329
%	8.2	32.8	42.9	10.9	5.2	100
L	7.3± 0.7	8.9 ± 1.1	9.7± 1.0	11.3 ± 0.8	12.8 ± 0.5	10± 0.1
W	3.33± 1.6	5.9 ± 2.3	7.1 ± 2.5	11.6 ± 3.1	16.9 ± 4.6	9± 1.1

Discussion

In the study, the observed length distribution was similar in from the Fethiye Bay (Filiz *et al*., 2014) and the same area (Yaglioglu *et al*,, 2014). The average estimated length was 10.1 cm less than those reported as

11.22 cm from the area by Yaglioglu *et al.* (2014). The fish body length and weight relationship is important in fisheries studies. It is usually recognized that b value, but not 3 indicates that the shape of fish changes with growth, while a value of 3 characterizes an isometric one (Le Cren, 1951; Ricker, 1975; Begenal and Tesch, 1978; Anderson and Neumann, 1996). In current study, the b value for the nakedband gaper (3.09) was smaller than those from the Aegean Sea (3.28) by Filiz *et al*. (2014) and those from the Iskenderun Bay (3.19) by Yaglioglu *et al*. (2014).

Table II.- Growth parameters of models for the nakedband gaper collected from Eastern Mediterranean Sea from October 2011 to April 2012.

	Von-Bertalanffy	Gompertz	Logistic	Richards
L_∞	16.22	18.59	16.83	15.48
K^{-1}	0.22	0.25	0.36	0.35
t_0	-2.49		0.86	
t^*		0.004		0.007
D				2.471
Sum of $(S-S')^2$	166.35	162.66	162.91	161.67
R^2	0.78	0.78	0.78	0.79

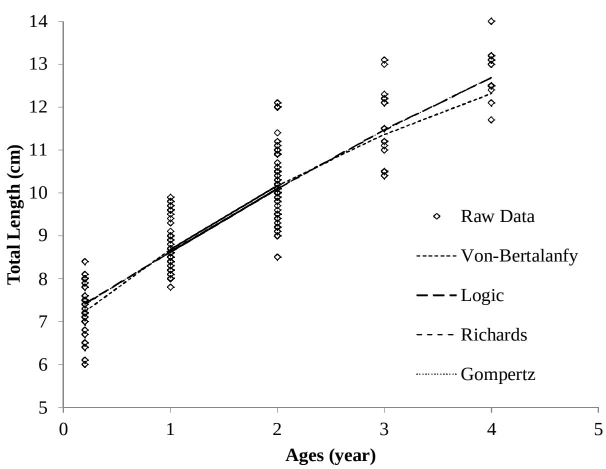

Fig. 2. Length at age for the nakedband gaper collected from Eastern Mediterranean Sea from October 2011- April 2012.

In the fishery management, the age-length relationship of fish as mathematical knowledge is of importance for temporal fish stock estimates. Any (t) time fish length (L_t) is a small part of the asymptotic length of the fish. Different nonlinear models have been proposed to estimate the mean growth of individual fish in a population (Katsanevakis, 2006). According to Haddon (2010) with the wide range of alternative growth equations available, the von Bertalanffy function (VBGF) to indicate fish growth has been criticized by several scientists. The estimation of L_∞ poses a problem particularly with fish species that do not exhibit an asymptotic maximum length. In this connection, Haddon (2001) mentioned about the problems in using the VBGF and advised that other functions should be used. However, the L_∞ estimates of Jardas and Pallaoro (1992) and Koca (2002) seemed sensible. Now a question arose concerning the reason why the previous results weren't in comply with the present study. The answer was that the methodologies used in former studies were different. Other studies used mean length at age, but the present study used all data (Demirhan and Can, 2009). Additionally, using the classic methodology (mean length), a reasonable L_∞ value would be obtained. With Haddon's (2010) suggestions, the classic method could lead to some errors (Sahinler and Can, 2003).

With a different growth model, L_∞ value (15.48-18.59 cm) proved that these models were appropriate for describing the growth of the nakedband gaper in this region. From the same area for the nakedband gaper reported L_∞ value was (20.41) by Yaglioglu *et al.* (2014). The reported value was higher than all of the current study values. It is believed that the present study should be regarded as L_∞ value because confidence intervals have given significant results. In addition, the maximum length of the nakedband gaper does provide a reliable approximation of asymptotic length, which varied from L_{max} / 0.95-0.82 (Mathews and Samuel, 1990). According to the results of present study Richards growth model is more reliable compared to others for stock estimation of for nakedband gaper.

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