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Some Fishery Aspects on the Brushtooth Lizardfish *Saurida undosquamis* (Richardson, 1848), Inhabiting Two Different Egyptian Water Environments

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ABSTRACT

The fishery aspects of the lizardfish *Saurida undosquamis were* studied in the northern Gulf of Suez and the southeastern Mediterranean. Samples were monthly collected from March 2018 to February 2019. A sum of 1110 samples were obtained from both sites. The length-weight relationships for the whole population were $W= 0.0045L^{3.10}$ and $W= 0.0032L^{3.23}$, respectively, while the life span was six years for the Gulf of Suez population and five years for the Mediterranean Sea one. The theoretical length ($L\infty$) was 45.49cm (about 1.49ft) for the Gulf of Suez population and 42.88cm (about 1.41ft) for that of the Mediterranean Sea. The growth performance indices (Φ) were 2.488 and 2.397 for the studied sites, respectively. The demographic structure for both populations was estimated. The mortality coefficients (Z, F, and M) were calculated in addition to the exploitation rate (E). Our results suggest that the Gulf of Suez population is exploited higher than that of the Mediterranean Sea.

INTRODUCTION

The presence of *Saurida undosquamis* (Richardson, 1848) as one of the most prosperous Lessepsian migrant species along Egypt's eastern Mediterranean coast highlights its significance as a prevalent target in coastal demersal fisheries with commercial potential **(Roshdy *et al.*, 2021)**. The brushtooth lizardfish is usually caught by trawlers from very shallow water to approximately 200m (about 656.17ft) in depth **(El-Ganainy, 2003)**.

The length-weight relationship is a vital biological tool, which plays an essential role in fishery management and has many applications in numerous fields, including fish biology, ecology, physiology, and fisheries assessment **(King, 2007)**. Moreover, the coefficient of condition (K) expresses the fish's conditions regarding the degree of well-being, fatness, or relative robustness in numerical terms **(Schneider *et al.*, 2000)**. Furthermore, the growth is the determination of the body size as a function of age. It is essential to determine the age of fish to estimate the growth rate as a fundamental input to understand the fishery aspects of the species **(Sparre & Venema, 1992)**.

The mortality rates are important to fishery experts in terms of expressing the fish population dynamics **(Edmond *et al.*, 2017)**. In addition to the significance of this aspect, the analytical fisheries management **(El-Haweet *et al.* 2005)** is also important since extreme exploitation of any population can change the size composition of individuals **(Ehrhardt & Deleveaux, 2007)**.

The rising fishing rate of economic species in Egypt is inevitable since the need for fish protein is increasing and the establishment of fishery management is therefore crucial and constantly required.

A detailed study of the fishery biology of this exploited fish stock would provide crucial information for its proper management. This study provides essential population data on *S. undosquamis* along the Egyptian coasts at the Gulf of Suez and the Mediterranean Sea. The results would assist in the proper management of *S. undosquamis* in both study areas and in the attainment of its optimum sustainable yield.

MATERIALS AND METHODS

1. Samples collection and measurements

Samples were randomly collected monthly from March 2018 to February 2019 from the Attaka harbor in the Suez Gulf and Port Said port in the southeastern Mediterranean by fishers using trawling nets. Specimens were kept frozen in an icebox until transferred to the laboratory. Different measurements were recorded. The total length (TL) is the length from the tip of the snout to the longest portion of the caudal fin, taken to the nearest 0.01mm using a ruler. Furthermore, the total weight is the weight of the body, recorded to the nearest 0.01gm using a digital balance. Specimens were dissected to inspect sex visually through gonad examination.

2. Length- weight relationship

The relationship between length and weight was calculated according to the equation of **Ricker (1975)**, as follows:

$$W = a L^{b}$$

3. Length- frequency distribution

The total length of the obtained specimens was measured in cm and allocated to length classes of 2cm (about 0.79in) size intervals, then the frequency of samples in each class was determined.

4. Age determination

The length frequency data were analyzed using the appreciate routines and subroutines of the FAO- ICLARM Stock Assessment Tools (FISAT) program following the method of **Gayanilo *et al.* (1997)**. The method of **Bhattacharya (1967)** was developed for the splitting of the composition distribution into its individual normal distributions, each corresponding to an age group. This method was used to estimate the component distribution's mean, standard deviations, separation index and population index, and population number.

5. Theoretical growth in length and weight

The growth of the Brushtooth Lizardfish, *Saurida undosquamis* (Richardson, 1848), was modeled using the Von Bertalanffy Growth Formula (VBGF) **(Bertalanffy, 1938)**. The growth equation is expressed as follows:

$$L_t= L_\infty [1- \exp^{\{-K (t- t_0)\}}].$$

The calculation of the growth in weight was obtained by applying the length- weight relationship formula ($W= aL^b$) to the Von Bertalanffy Growth Formula as follows:

$$W_t= W_\infty [1- \exp^{\{-K (t- t_0)\}}]^{b.}$$

6. Growth performance index (ϕ)

The growth performance index (ϕ) was estimated according to the formula of **Pauly and Munro (1984)**, as follows:

$$\phi = \log K +2 \log L_\infty$$

7. Mortality coefficients

The total mortality (Z) coefficient and its instantaneous rate were estimated by the length converted catch curve method described by **Pauly (1983)** and incorporated in FISAT software. A commonly used indirect method of estimating natural mortality (M) was described by **Pauly (1980)**. The fishing mortality coefficient (F) was determined by using the formula of **Beverton and Holt (1957)** and **Pauly (1984)**, as follows:

$$F= Z-M$$

8. Exploitation rate (E)

Exploitation rate (E) was attained by using the formula of **Beverton and Holt (1957)** and **Pauly (1984)**, as follows:

$$E = F/Z$$

RESULTS

1. Population structure

The study collected a total of 1110 specimens, with 492 obtained from the Gulf of Suez. Their total length varied between 9.9 & 32cm, with an average of 18.17cm (about 7.15in), while the total weight ranged from 5.87 to 207.91gm, with an average of 44.74gm.

The total length of the 618 specimens from the Mediterranean Sea varied between 8.5 and 32cm, with an average of 17.74cm (about 6.98in), while the total weight ranged between 2.77 and 227.1gm, with an average of 42.36gm.

2. Length- weight relationship

2.1. Entire population

The regressions of the relationships in the two study sites for the whole populations illustrated that *Saurida Undosquamis* at both study sites exhibited a positive allometric function of growth (Fig. 1). The two parameters (length and weight) were highly correlated ($R^2 > 0.95$).

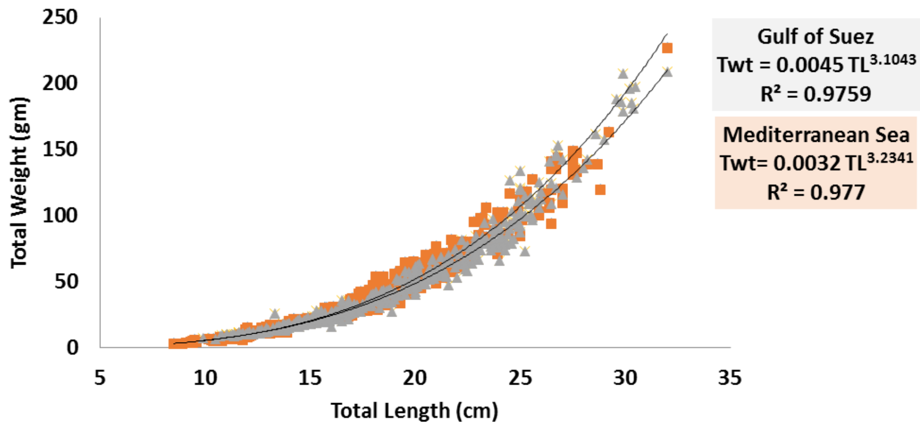

Fig. 1. Length- weight relationships for the entire population of *Saurida undosquamis* at both study sites

2.2. Separate sexes

The exponent values b for the separate sexes at both study sites showed that growth coefficients for females were higher than those of males.

For the Gulf of Suez population, a total of 447 specimens (250 males and 198 females) were used for length- weight relationship studies. The smallest lengths of males and females were 12.8 and 11.5cm, while the highest were 30.5 and 32cm, respectively. The minimum weights of males and females were 10.64 and 9.31gm, while the maximum was 196.48 and 207.91gm, respectively.

In the Mediterranean Sea population, a total of 488 specimens (316 males and 172 females) had 8.5 and 9cm as the smallest lengths of males and females, while the highest were 28.8 and 32cm, respectively. The minimum weights of males and females were 3.77 and 4.59gm, while the maximum was 148.6 and 227.1gm, respectively.

The regressions of the relationships at the two study sites for separate sexes took the same trend as that of the entire population where growth coefficients showed positive an allometric growth (b> 3). Females' growth coefficients were higher than males, and in Mediterranean Sea separate sexes, the b values were higher than those recorded in the two sexes inhabiting the Gulf of Suez (Fig. 2).

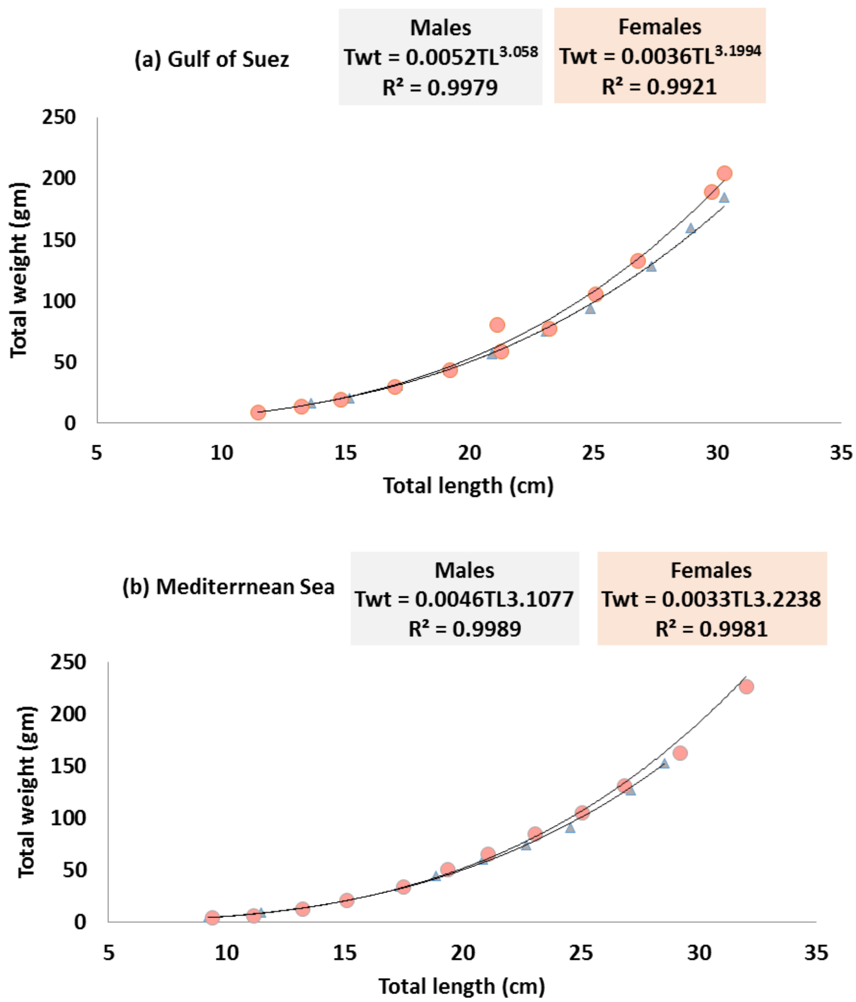

Fig. 2. Length- weight relationships for the separate sex of *Saurida undosquamis* from **(a)** The Gulf of Suez and **(b)** The Mediterranean Sea

3. Length frequency distribution

The bulk of the population of the Gulf of Suez was presented by individuals ranging between 18 and 24cm (55.38%). The Mediterranean Sea population was dominated by individuals ranging between 16 and 22cm (54.78%) (Fig.3).

4. Age determination

The Gulf of Suez population had six distinct age groups, with the highest mean length of 30.49± 1.140 for age group VI. The length composition of the Mediterranean population was separated into five age groups, with the maximum mean length value of 30.75± 1.840 for age group V. The age groups mean assigned lengths, their standard deviation and separation indices are given in Table (1). Age groups I and II represented over 60.5 and 69.6% of the populations from the Gulf of Suez and the Mediterranean, respectively (Fig. 4).

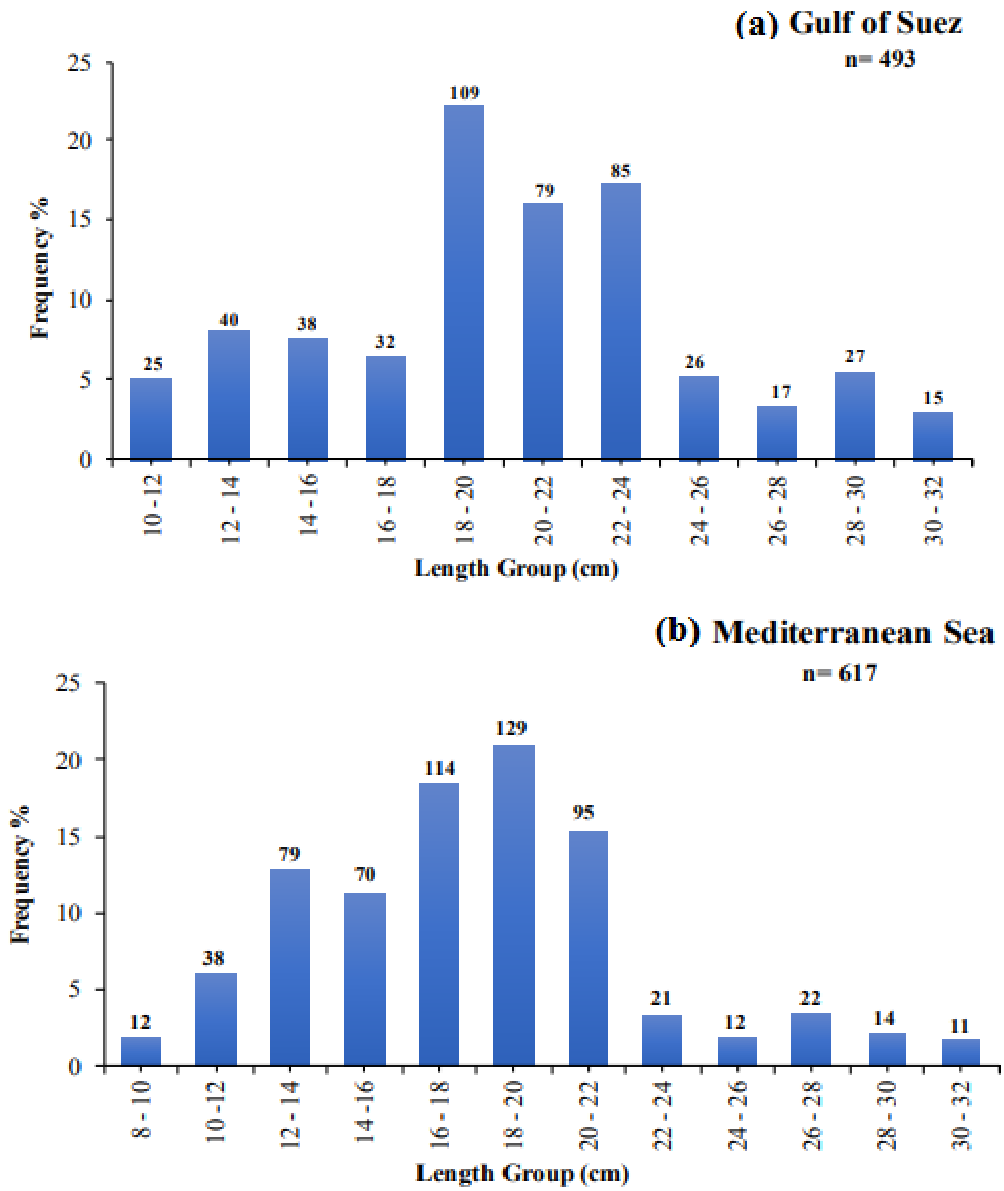

Fig. 3. Length frequency distribution of *Saurida undosquamis* from **(a)** The Gulf of Suez and **(b)** The Mediterranean Sea

Table 1. Mean length at age groups for populations of *Saurida undosquamis* at both study sites

Age group	Gulf of Suez			Mediterranean Sea		
	Computed mean length ± STDEV	No. of population	S.I.	Computed mean length ± STDEV	No. of population	S.I.
I	11.93± 1.670	147.7	n.a	11.5± 1.570	188.17	n.a
II	16.67± 1.580	161.89	2.22	16.22± 1.880	194.07	2.19
III	20.16± 1.010	58.51	2.10	20.46± 1.120	106.23	2.14
IV	23.64± 1.730	91.86	2.07	26.28± 1.440	37.42	2.30
V	27.97± 1.240	27.93	2.11	30.75± 1.840	23.14	2.09
VI	30.49± 1.140	23.83	2.01			

STDEV= standard deviation; S.I.= separation index.

5. Theoretical growth in length

The theoretical growth in length of the whole populations was expressed as follows:

$$L_t = 45.494\ [1 - \exp^{(-0.1489\ (t+1.095))}]\ \text{(Gulf of Suez population)}$$

$$L_t = 42.881\ [1 - \exp^{(-0.1358\ (t+1.846))}]\ \text{(Mediterranean Sea population)}$$

Individuals attained their highest increment in size at the end of the first year of life. Afterward, the annual increment in length decreased gradually with the increase in age to reach its lowest values at the end of the 6th and 5th years of life for the Gulf of Suez population and the Mediterranean population, respectively (Fig. 4a, b).

6. Growth performance index (Φ)

Growth performance indices of *S. undosquamis* for the Gulf of Suez population is higher than that calculated for the Mediterranean ones.

$$\phi = 2.488\ \text{(Gulf of Suez population)}$$

$$\phi = 2.397\ \text{(Mediterranean Sea population)}$$

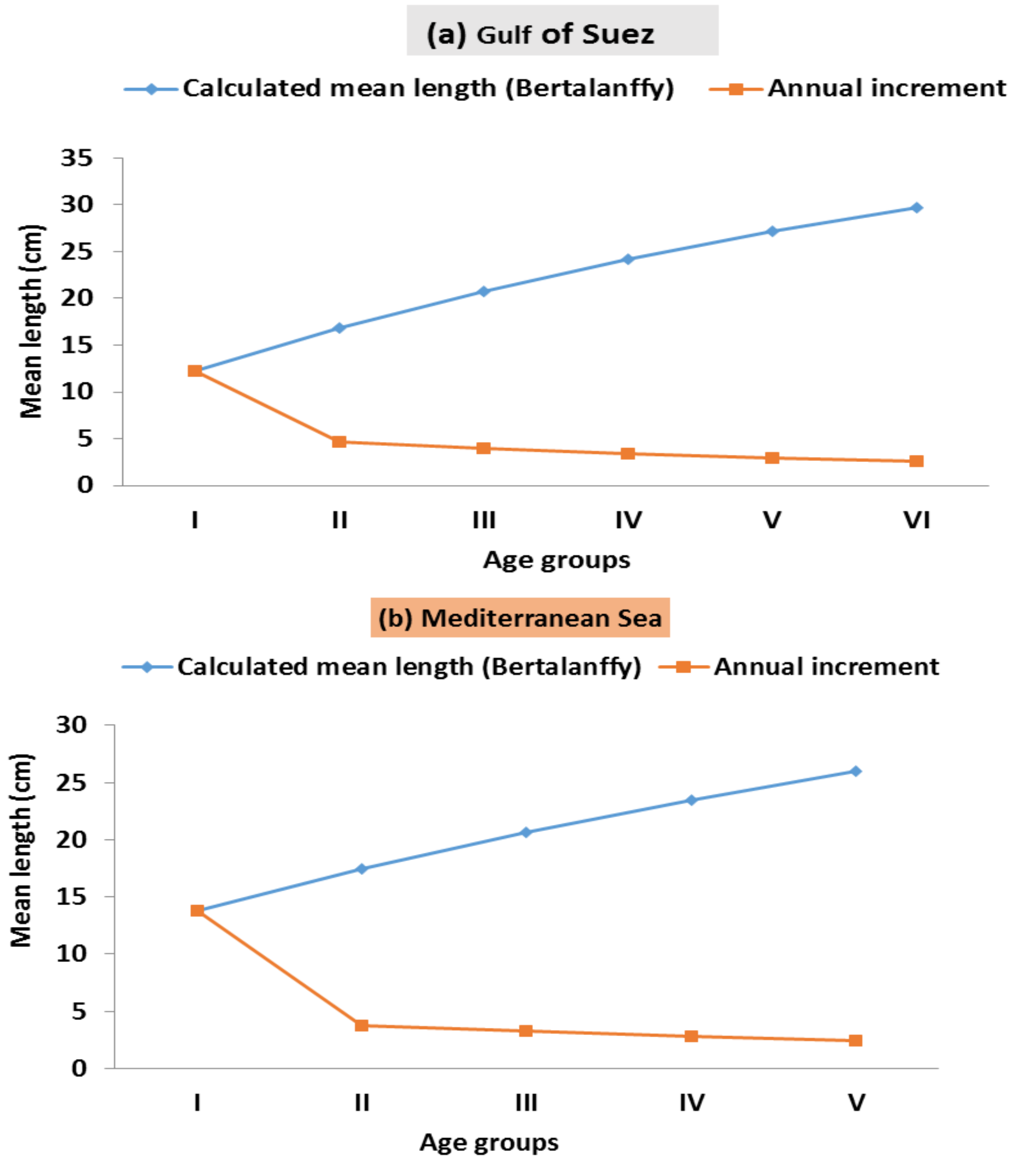

Fig. 4. Theoretical growth in length for combined sexes of *Saurida undosquamis* collected from **(a)** Gulf of Suez and **(b)** Mediterranean Sea.

7. Mortality coefficients (Z, M and F)

The total mortality coefficients (Z) of the Gulf of Suez and the Mediterranean populations were 1.19 Y^{-1} and 1.03 Y^{-1}, respectively (Fig. 5). Natural mortality (M) value was 0.42 for the Gulf of Suez population, while the value for the Mediterranean population was 0.39. The fishing mortality (F) value was 0.77 for the Gulf of Suez population, whereas it was 0.64 for the Mediterranean Sea population.

Exploitation rate for the population of Gulf of Suez was 0.65, while it was 0.62 in the Mediterranean Sea.

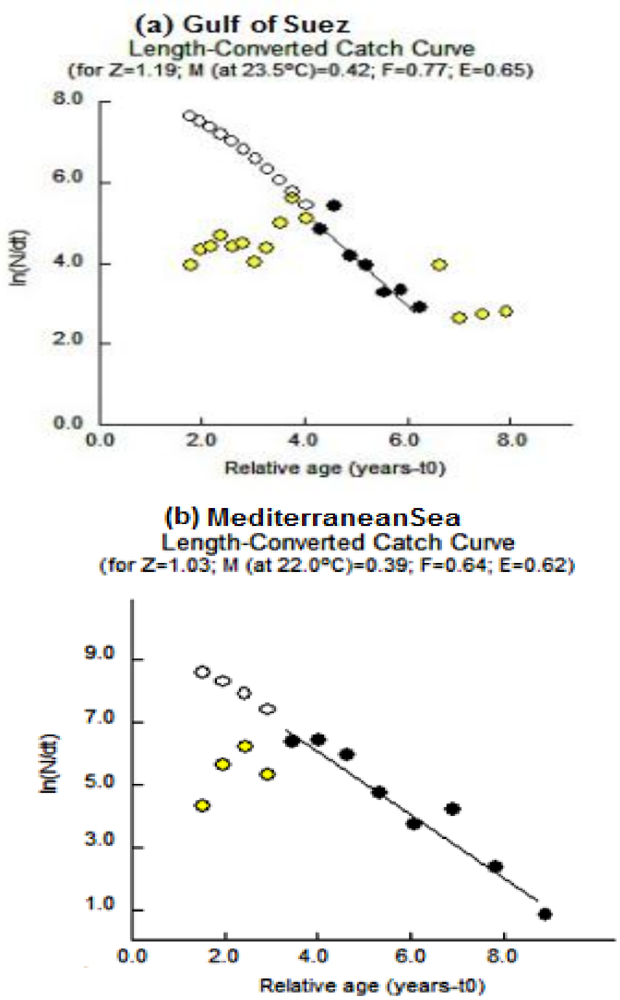

Fig. 5. The length converted catch curve of total mortality of *Saurida undosquamis* from **(a)** Gulf of Suez and **(b)** Mediterranean Sea.

DISCUSSION

1. Length- weight relationships

The findings of the length- weight relationships for the entire population, as well as separate sexes are in accordance with those previously obtained from numerous studies in different geographic localities (Table 2). However, **Gökçe *et al.* (2007)**, **Cicek and Avsar (2011)** and **Mahmoud *et al.* (2014)** reported the coefficient (b) to be negatively allometric. **Froese (2006)** stated that the differences in growth coefficient within the same species are due to several abiotic factors, such as temperature, which varies with geographical distribution habitats, food availability, season, and fishing vessels; or biotic factors, such as recorded lengths, age, stomach fullness and sex and gonad maturity.

2. Length- frequency distribution

Analysis of length- frequency data showed that the species is a relatively fast-growing fish, which agrees with the results of **Ismen (2002)** and **Gökçe *et al.* (2007)** on *Saurida undosquamis* in the Eastern Mediterranean Sea, as well as those of **Abdul-Razek *et al.* (2010)** who studied the same species from the Sudanese Red Sea and **Mahmoud *et al.* (2014)** from the Egyptian Mediterranean Sea.

3. Age determination and composition

The results about the aging of the Gulf of Suez population revealed that the longevity of *S. undosquamis* was six years. This agrees with other studies in different localities, including **EL-Ganainy, 2004** and **EL- Halafawy *et al*., 2007** in the Gulf of Suez, as well as **Cicek and Avsar (2011)** who studied the same species in İskenderun Bay.

The observation that the Mediterranean population has longevity of five years differ from the findings of **Manasirli *et al.* (2011)** who studied *S. undosquamis* from the northeastern Mediterranean Coast of Turkey and reported that longevity was up to eight years. Conversely, **Mahmoud *et al.* (2014)** stated that this species can reach over twelve years of age in the Mediterranean waters in Egypt.

4. Theoretical growth in length

The values of the theoretical maximum length were far to the size of the largest fish examined, and the values of the growth coefficient suggested a relatively slow growth rate. Those factors varied amongst different geographic areas, as shown in Table (3). Such differences are related to the different aging or the variance of the observed total length at each site in addition to the epigenetic responses of the species to the fluctuations of the environmental conditions in the different regions and times, such as temperature, food availability and salinity **(Bruton, 1990; Golani, 1993; El-Ganainy & Ahmed, 2002)**. After the first year of life, there may be a decline in length growth rate that is related to the beginning of maturity, which frequently results in a discontinuity in the growth curve **(Beverton & Holt, 1957)**.

5. Mortality

The estimations of mortality and exploitation rates are essential to detect whether the fish stock suffers from overfishing or not at different sites **(Zhang *et al.*, 2017)**. Generally, rates of mortality for *S. undosquamis* population (Gulf of Suez) were higher than the Mediterranean ones. The contribution of natural mortality (M) was more negligible to the total mortality (Z) compared to the role of fishing mortality (F) in both studied sites, and this indicates the impact of fishing activities on the stock. However, the high natural mortality in the Gulf of Suez may imply a wide range of competition in the native habitats (Table 4).

Table 2. Length- weight relationship parameters of *Saurida undosquamis* from different locations

Area of Study		a	b	R^2	Sex	Allometry	Author
Red Sea	Red Sea	0.0017 0.0044	3.319 3.109		Males Females	positive	El-Ganainy (2004)
	Gulf of Suez	0.0042	3.131	0.985	Males	positive	Amin *et al.* (2007)
	Gulf of Suez	0.0038	3.167	0.987	Females	positive	El-Halfawy *et al.* (2007)
	Southern Sudanese Red Sea	0.0037	3.259	0.997	Population	positive	Abdul-Razek *et al.* (2010)
	Gulf of Suez	0.004	3.107	0.965	population	positive	El-Etreby *et al. (2013)*
Mediterranean Sea	Egyptian Mediterranean Sea	0.003	3.3	0.953	population	positive	Abd Allah (2002)
	Mediterranean Sea, Turkey	0.0039	3.165	0.968	population	positive	Cicek (2006)
	Mediterranean Sea, Turkey	0.0105	2.801	0.94	population	Negative	Gökçe *et al.* (2007)
	Mediterranean Sea, Turkey	0.0047	3.095	0.988	population	positive	Manasirli *et al.* (2011)
	Mediterranean Sea, Turkey	0.0083	2.879	0.956	population	Negative	Cicek and Avsar (2011)
	Egyptian Mediterranean Sea	0.0094	2.899	0.95	population	Negative	Mahmoud *et al.* (2014)
	Eastern Mediterranean Sea, Turkey	0.002	3.366	0.976	population	positive	Yedier *et al.* (2019)
Suez, Gulf of Suez, Egypt		**0.0052**	**3.058**	**0.9979**	**Males**	**positive**	**Present study**
		0.0036	**3.1994**	**0.9921**	**Females**	**positive**	
		0.0045	**3.1043**	**0.9759**	**population**	**positive**	
Port Said, Mediterranean Sea, Egypt		**0.0046**	**3.1077**	**0.9989**	**Males**	**positive**	**Present study**
		0.0033	**3.2238**	**0.9981**	**Females**	**positive**	
		0.0032	**3.2341**	**0.977**	**population**	**positive**	

a= intercept; b= an exponent (coefficient equilibrium); R^2= correlation coefficient

6. Exploitation rate

Exploitation rates for the two populations indicate that the stock is overexploited at the study sites. Regarding the (E) value of the Mediterranean Sea population, *S. undosquamis* is not a targeted species in the fish market of Port Said. However, according to local fishers, the catch of this species is constantly shipped to other cities since it is required in fish cuisines, which explains the high exploitation rate. The result for Port Said population agrees with those of **Amin *et al.* (2007)**, **El- Halfawy *et al.* (2007)**, **Cicek and Avsar (2011)** and **Mahmoud *et al.* (2014)** who stated that *S. undosquamis* populations suffered from overexploitation.

Finally, studies on the brushtooth lizardfish in the southeastern Mediterranean Sea are limited compared to the same species inhabiting the Red Sea. This study is the first to provide a comparison between the Gulf of Suez population (native) and that of the Mediterranean (non-indigenous) in terms of the status of the population in this new habitat. Our results point to this migrant species being well established in the new habitat. Despite not being a targeted species in the fish market of Port Said as mentioned before, it is heavily exploited and is subjected to intensive fishing pressure. Further studies should be encouraged in other localities on the Mediterranean Sea and the Suez Canal.

Table 3. Growth parameters (L_∞, K and t_0) and growth performance index (ϕ) estimated for *Saurida undosquamis* from different locations

Area of study		L_∞	K	t_0	ϕ	Sex	Author
Red Sea	Red Sea	31.63 41.72	0.26 0.17	-1.38 -1.53	-	Males Females	El-Ganainy (2004)
	Gulf of Suez	31.03	0.44	-1.06	-	Males	Amin *et al.* (2007)
	Gulf of Suez	35.56	0.26	-1.059	2.602	Females	El-Halfawy *et al.* (2007)
	Southern Sudanese Red Sea	35.8	0.4	-0.035	2.71	Population	Abdul-Razek *et al.* (2010)
	Gulf of Suez	51.25	0.131	-1.45	-	population	El-Etreby *et al.* (2013)

Mediterranean Sea	Mediterranean Sea, Turkey	42	0.178	-1.229	2.5	population	Ismen (2002)
	Mediterranean Sea, Turkey	42	0.51	-0.029	2.95	population	Gökçe *et al.* (2007)
	Mediterranean Sea, Turkey	41.57	0.118	-1.895	-	population	Manasirli *et al.* (2011)
	Mediterranean Sea, Turkey	38.05	0.124	-1.68	-	population	Cicek and Avsar (2011)
	Egyptian Mediterranean Sea	41.77	0.232	-	2.61	population	Mahmoud *et al.* (2014)
Suez, Gulf of Suez, Egypt		**45.494**	**0.1489**	**-1.095**	**2.488**	**population**	**Present study**
Port Said, Mediterranean Sea, Egypt		**42.881**	**0.1358**	**-1.846**	**2.397**	**population**	**Present study**

L_∞= asymptotic length; K= growth coefficient; t_0= age of fish at length zero; ϕ= growth performance index.

Table 4. Different values of total mortality (Z), natural mortality (M), fishing mortality (F) and exploitation rate (E) for *Saurida undosquamis* from different locations

Area of study		Z	M	F	E	Sex	Author
Red Sea	Gulf of Suez	1.59	0.27	1.32	0.83	Males	Amin *et al*. (2007)
	Gulf of Suez	1.22	0.23	0.99	0.81	Females	El-Halfawy *et al*. (2007)
	Southern Sudanese Red Sea	1.1	0.72	0.38	0.35	Population	Abdul-Razek *et al.* (2010)
Mediterranean Sea	Mediterranean Sea, Turkey	1.79	0.87	0.92	0.51	population	Gökçe *et al*. (2007)
	Mediterranean Sea, Turkey	0.766	0.403	0.363	0.47	population	Manasirli *et al.* (2011)
	Mediterranean Sea, Turkey	1.77	0.35	1.42	0.80	population	Cicek and Avsar (2011)
	Egyptian Mediterranean Sea	0.938	0.363	0.575	0.613	population	Mahmoud *et al.* (2014)
Suez, Gulf of Suez, Egypt		**1.19**	**0.42**	**0.77**	**0.65**	**population**	**Present study**
Port Said, Mediterranean Sea, Egypt		**1.03**	**0.39**	**0.64**	**0.62**	**population**	**Present study**

Z= total mortality; M= natural mortality; F= fishing mortality; E= exploitation rate

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