Length-Weight Relationship and Condition Factor of white grouper *Epinephelus aeneus* (Geoffroy Saint Hilaire, 1817) in the Mediterranean coast of Sinai, Egypt

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ABSTRACT
This study describes the first documented length-weight relationship and condition factor of the white grouper *Epinephelus aeneus*in on the Mediterranean coast of Sinai, Egypt. A total of 697 specimens with an average length of 34.6 cm and weight 593.0 g were monthly sampled from January 2019 to December 2020. For each specimen, length (cm) and weight (g) were measured. The length-weight relationship was described by the equation: $W = a L^b$, while the condition factor was calculated using the equation: $K = 100 (W/ L^3)$. Condition factor was calculated monthly and according to the length group. The values of the regression coefficients obtained for the length-weight relationship were 2.9327, 2.8847 and 3.1141 having r² values of 0.9392, 0.9438 and 0.9616 for males, females and combined sexes of the studied species, respectively. Condition factor (K) of males, females and combined sexes of *E. aeneus* was fluctuated monthly and related to lengths groups. It was concluded that general well-being was observed for this species, since condition factor more than 1 (K= 1.20, 1.30 and 1.20 for males; females and combined sexes, respectively). The current study's findings can be used as baseline data for this species in the examined area.

INTRODUCTION

Groupers are bottom-associated fishes found in the tropical and subtropical waters of all oceans. Most species occur on coral reefs, but some live in estuaries or on rocky reefs. Adults of Groupers are generally associated with rocky bottoms, although juveniles are found in seagrass beds, and adults of a few species prefer sandy or silty areas. Some species occur in depths of 100 to 200 m (occasionally to 500 m); however, the majority inhabits depths less than 100 m, and juveniles are often found in tide- pools **(Heemstra and Randall, 1993)**

Turan *et al*., (2017) reported that the white grouper *Epinephelus aeneus* has remarkable economic importance in Epinephelus genus for the Mediterranean fisheries.

Epinephelus aeneus (Geoffroy Saint-Hilaire, 1817) can be found throughout the southern Mediterranean (up to 44°N in the Adriatic Sea) , along the Atlantic coasts of Portugal, Spain, and Africa, down to southern Angola (**Thierry *et al*., 2008 & Pollard *et al*., 2018)**.

E. aeneus is of considerable economic importance in fisheries and caught with hooks and lines and by trawls. The species is listed as Near Threatened both in the Mediterranean Regional Red List and Global Red List of IUCN (**Abdul Malak *et al*., 2011).**

A fish Length Weight Relationship is an important tool in fisheries biology and stock assessments since it allows for the determination of fish age, structure, and health by providing many details about its seasonal cycles and affecting components of biotic and abiotic parameters (**Ayoade and Ikulala, 2007**).

Length-weight relationship of fish is widely known as an important tool in fisheries science especially in ecology and population dynamic (**Abdoli and Rasooli, 2008).** This relation provides useful information on fish species within a given geographic region (**Morato *et al*., 2001; Aura *et al*., 2011**). In fish, size is generally more biologically relevant than age, mainly because several ecological and physiological factors are more size-dependent than they are age-dependent. Therefore, variability in size has important implications in fisheries science and population dynamics (**Erzini, 1994**), and is one of the most common measurements in fisheries data (**Mendes *et al*., 2004**).

Pauly (1983) reported the importance of length-weight relationship in the calculation of an equation of growth in length into an equation of growth in weight. Whereas **Arsalan *et al.* (2004)** stated that, it is usually easier to measure length than weight and weight can be predicated later on using the length-weight relationship which helps among other fish given its definite length. The study of length-weight relationship is of paramount importance in fishery science, as it assists in understanding the general well-being and growth patterns in a fish population. According to **Bashir *et al.* (1993),** the length-weight relationship of fish varies depending upon the condition of life in aquatic environment. Length-weight relationship is of great importance in fishery assessments **(Haimovici and Velasco, 2000**).

This relation can also be used for deriving comparisons between different stages in life history and between fish populations from regions or habitat groups (**Gonçalves *et al*. 1996),** and tracking seasonal variations in fish growth (**Richter ,2007**). Length-weight relationships can also be used to know the growth pattern of the fish in the culture system. It is also used to estimate fish biomass from length frequency distributions, infer fish condition (**Petrakis and Stergiou, 1995**).

Condition factor is required to fishery biologists to describe the condition plumpness, or well-being of fish (**Ogongo *et al.,* 2015**). It is used to express fish condition in numerical terms, such as degree of well-being, fatness, or relative robustness. Fish condition factor is a measure that is commonly used to understand fish

survival, reproduction, maturity, and health **(Le Cren, 1951),** and often, it can be utilized as a good indicator of water quality or the overall health of fish populations in a given area or ecosystem **(Tsoumani *et al*., 2006).** It was used to assess the degree of well-being of *E. aeneus* in the study area which provides information on the environmental quality and suitability (polluted or non-polluted of the ecosystem **(Le Cren 1951 and Guidelli *et al*. 2011).**

The length-weight relationships and condition factors are two of the most important biological aspects to assess the growth rate and fish condition (**Muchlisin, 2010**). Therefore, the information of length-weight relationships and condition factors are important to plan a better conservation strategy of the fishery resources (**Muchlisin *et al*., 2015**).

Grouper remains poorly studied in Egypt, despite their economic and ecological importance. The main objective of this work is to assess the growth pattern of the white grouper *Epinephelus aeneus* harvested from Mediterranean North Saini coast. This study describes the first documented data on length- weight relationship and condition factor of white grouper *E. aeneus* in the Mediterranean coast of Sinai, Egypt. Such data is crucial for the management of this fish species.

MATERIALS AND METHODS

Study area and data collection:

A total of 697 *E. aeneus* (Fig.1) was obtained from the fish market in Al-Arish. As the fish merchants bring the fish from fishing boats operating in the Mediterranean off the coast of Sinai, (Fig. 2), which exit at the Port Said seaport.

Fig. 1. White grouper *Epinephelus aeneus* from the Mediterranean coast of Sinai, Egypt

Fig. 2. Study area at Mediterranean coast of Sinai

The fish samples were collected monthly from January 2019 to December 2020. Samples were temporarily placed in cooling box filled with ice and transported to the laboratory. For each individual, the total length (TL, cm) and total weight (TW, g) were measured. The growth pattern was calculated using the formula based on **Le Cren (1951)** as follow: W= a L^b,   where, W is total body weight (g), L is total length (cm) and (a) is geometric coefficient, (b) is slope of the regression model.

Fulton's condition factor (K): Fulton's condition factor (K) was calculated according to **Hile (1936)** equation as per formula given below:

K = (W * 100) / L^3 Where, W= weight of fish (g), L= Length of fish (cm)

Condition factor (K) was calculated monthly and according to different length groups.

RESULTS

1. *Length – weight relationship:*

The length – weight relationship of 697 specimens (including 169 females and 100 males) of *E. aeneus* were presented graphically in Figs. 3, 4 and 5. It has been found that, the lengths of combined sexes varying between 20.4 to 61.0 cm (mean= 34.6 cm) and the weight from 94.1 to 2788.9 g with an average 593.0 g. and the length – weight relationship was: W = 0.0083 x $L^{3.1141}$.
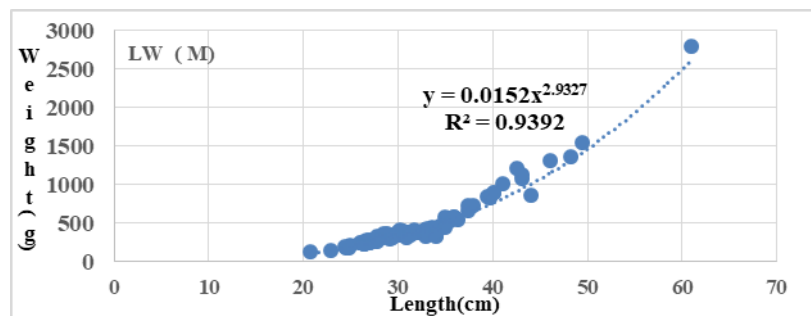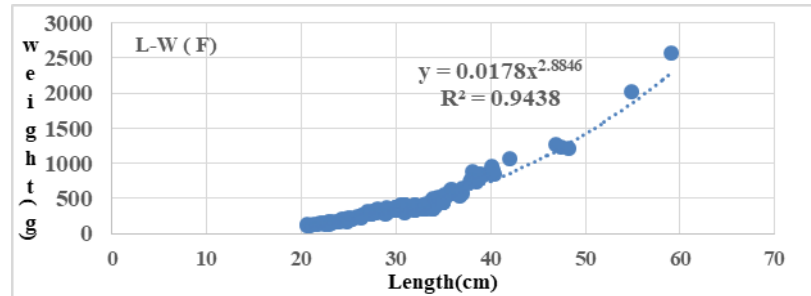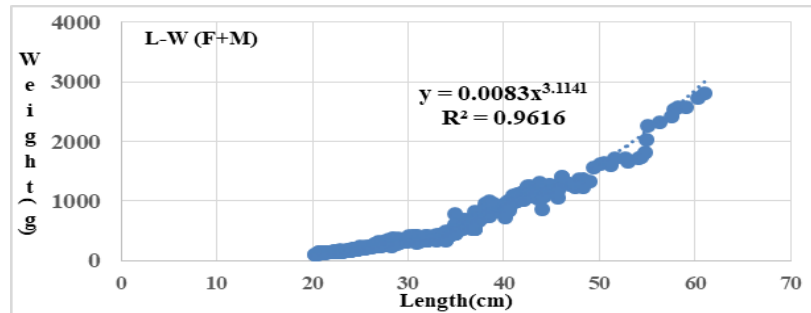

Fig. 3. Length-weight relationship of males of *Epinephelus aeneus*

Fig. 4. Length-weight relationship of females of *E. aeneus*

Fig. 5. Length-weight relationship of combined sexes of *E. aeneus*

1.   Condition factor (K):

2.1. According to different length group:

Condition factor (K) of males, females and combined sexes of *E. aeneus* related to lengths groups are represented graphically in figures (6, 7 and 8). Condition factor of males was observed to be less than females and sexes combined. The lowest value of (K) 34 for males was observed in size class 34-34.9 & 44- 44.9 cm and the highest one was recorded in size class of 42- 42.9cm(K= 1.6).
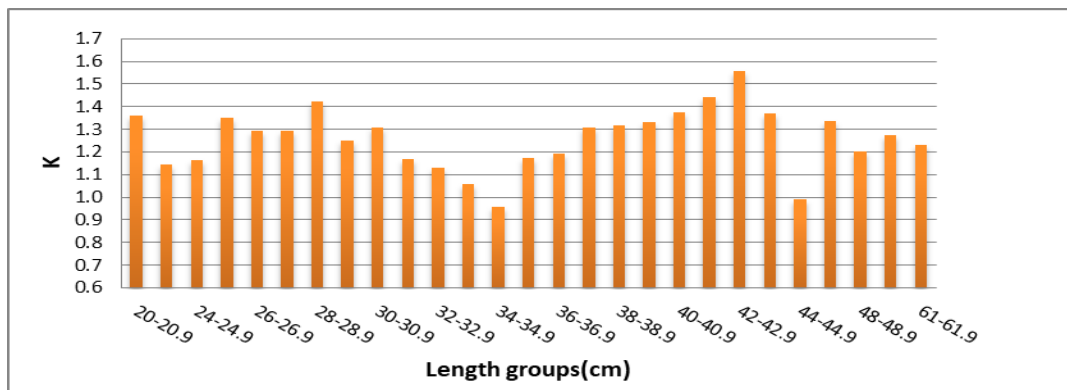
Fig. 6. Condition factor (K) of males of *E. aeneus* at different length groups
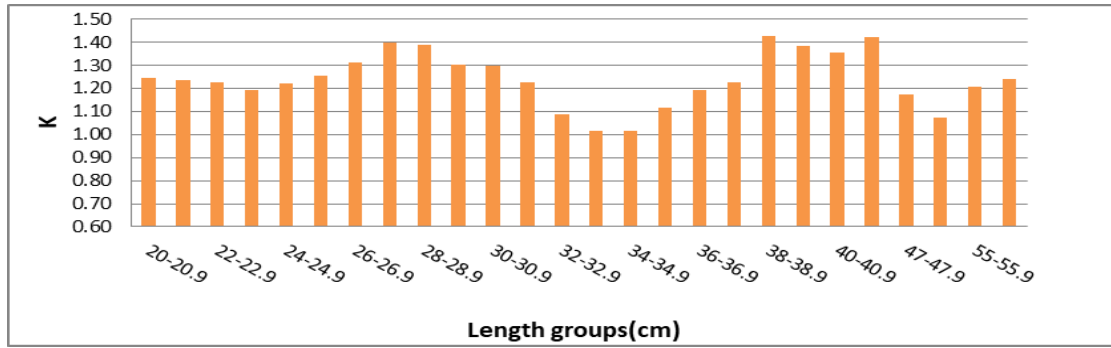
Fig. 7. Condition factor (K) of females of *E. aeneus* at different length groups
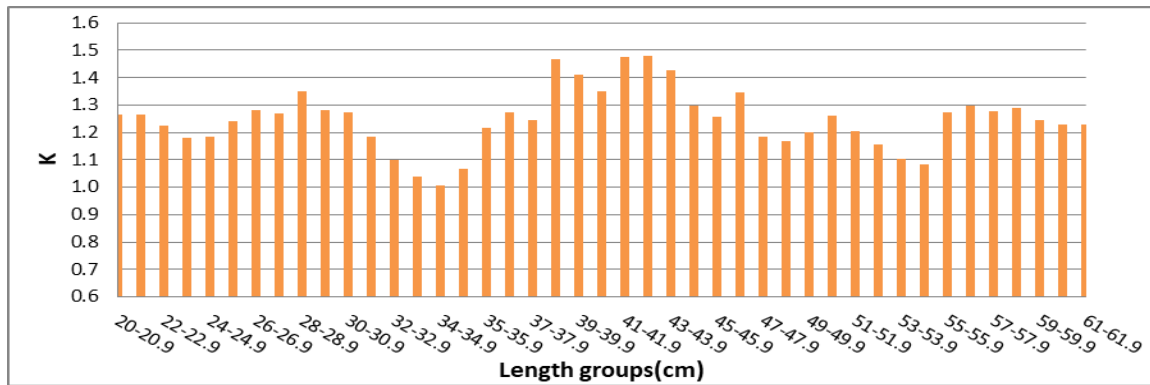

Fig. 8. Condition factor (K) of combined sexes of *E. aeneus*
at different length groups

As it is shown from Fig. 7, the highest value of condition factor (K) of females was recorded at length interval 38.0-38.9 and 42.0-42.9 cm, since K= 1.43 and 1.42 respectively. For sexes combined, K ranged from 1.01 to 1.5, in size classes 38-38.9 cm and 42- 42.9 cm respectively with a mean of 1.25. The lowest value was recorded at length interval 34- 34.9 as shown in Fig. 8.

2.2. According to different months:

Figs. 9, 10 and 11 presents condition factor of *E. aeneus* at different months for males, females and sexes combined respectively. The results show that, the lowest value of "K" for males was recorded during February and November (1.13 and 1.14 respectively) whearas the highest one during April (1.58). The lowest values of K for female was recorded during February, October and December (1.2) and the highest value of 1.43 was observed during August. Concerning sexes combined, the lowest value (1.18) and the highest value (1.47) was recorded during February and April, respectively.
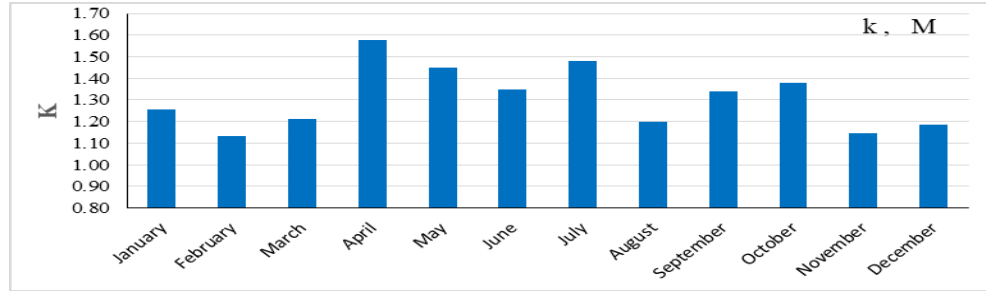
Fig. 9. Monthly variations in condition factor (K) of males of *Epinephelus aeneus*
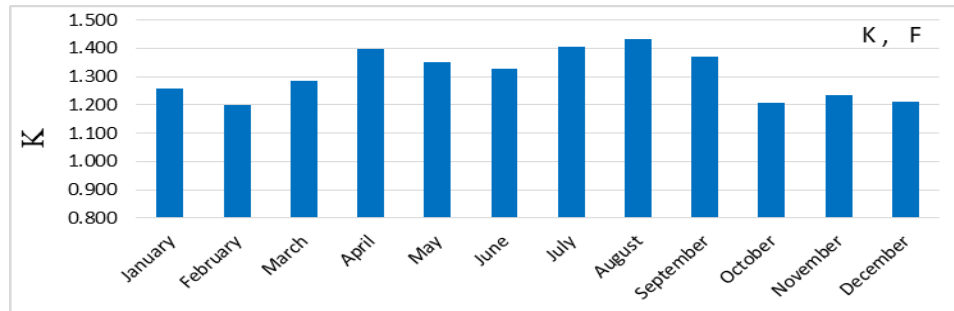

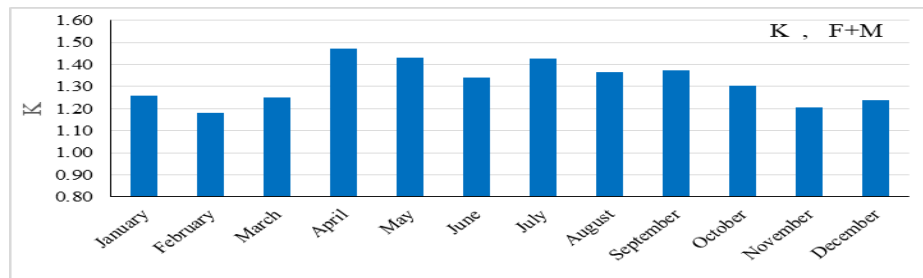Fig. 10. Monthly variations in condition factor (K) of females of *E. aeneus*

Fig. 11. Monthly variations in condition factor (K) of combined sexes of *E. aeneus*

DISCUSSION

The main concern of the paper was to study length-weight relationship and condition factor of white grouper *Epinephelus aeneus*, (Geoffrey Saint Hilaire, 1817) in the Mediterranean coast of Sinai, Egypt. The mathematical relationship of length with the weight of fish is considered as an important tool for interconversion (**Lagler, 1956)** and to deduce an inference regarding the suitability of the environment for any particular species **(Maceina and Murphy, 1988**). This relationship also provides some additional information related to spawning, growth, feeding, gonadal development and maturity time of the fish (**Dawe, 1988& Maceina and Murphy, 1988**).

In the present study, 697 specimens (including 169 females and 100 males) of *E. aeneus* were presented graphically to study length- weight relationship. As a result of low naturally occurring, the male sex ratio of the *E. aeneus* had limited ability to collect

representative sample size, whereas, that male low ratio recognized in many literatures **(Pears, 2005; Mishina *et al*., 2006 and Ogongo *et al*., 2015)**.

Lengths and weights of *E. aeneus* in the present work varying between 20.4 and 61.0 cm (mean = 34.6) and weight between 94.1 to 2788.9 g (mean= 593.0 g). **Turan *et al*., (2017)** stated that**,** lengths and weights of *E. aeneus* from Iskenderun Bay, Northeastern Mediterranean were ranged from 18.5 to 82.6 and from 50.7 to 89.2 cm & from 29.13 to 6750 and 1443.6 to 8600 g for females and males, respectively. **Özbek *et al* (2013)** reported that the Lengths of *E. aeneus* in the Gulf of Antalya, Turkey varies between 10.0 to 101.0 cm (mean 35.0 cm) and the weights varying between 37.0 to 11000 g (mean 1094.4 g). **Waly *et al.,* (2015)** reported that the total lengths and weights of the white grouper *E. aeneus* in the south-west coast of Senegal, West Africa ranged from 17.9 to 94.8 cm and between 62.8 and 10934 g, respectively. These differences may be due to the ecological condition; feeding habits; maturity stages; sampling process and methods of fishing.

The Length-weight relationship is actual index of the condition of fish and alters over the year according to factors namely food availability, feeding rate, gonad (**Waly *et al.,* 2015)** development and spawning time **(Bagenal and Tesch, 1978).**

In the present study,   length-weight relationship were w = 0.0152 L $^{2.9327}$, W=0.0178 L $^{2.8846}$ and W= 0.0083 L $^{3.1141}$ for males, females and combined sexes respectively. (b) values of males and females was less than 3, since it was 2.9327 and 2.8846 of   both sexes respectively, indicating negative allometric growth pattern .This suggests that either the weight gain was not equal to the length gain or the weight gain was slower than the length gain.

Fish is said to exhibit isometric growth when length increases in equal proportion with body weight, the regression coefficient for isometric growth is '3' and values greater than '3' indicates allometric growth **(Olurin and Aderibigbe, 2006).**

Table 1 presents comparison of length -weight relationships and regression parameters (a and b) of *E. aeneus* at different localities. Our results(value of b) are lower than that recorded by **Magnússon and Magnússon (1987)** in Cape Verde coasts & **Cury and Worms (1982)** in Senegal. In the other hand, these results were higher than that obtained by **Özbek *et al*., (2013)** in Turkey and **Fiogbe (2003)** in Benin, West Africa, Table 1. Differences in 'b' values can be attributed to the combination of several factors such as number of studied specimens, habitat, and status of stomach fullness, gonadal maturity, sex, health and overall fish condition, and differences in the observed length ranges of the specimens caught(**Abowei *et al*. , 2009).**

In the present study, condition factor (K) of males, females and combined sexes of *E. aeneus* was fluctuated related to lengths groups. When the average weight of the fish does not increase in direct proportion to the cube of its length, the condition factor is usually reduced (**Wooten, 1990**). As a result, when b = 3, K remains constant. On the other hand, if the weight increases faster than the length cube, K increases as well

(**Javaid and Akram, 1972**). With the growth of fish, K tends to decrease when the weight increases less than the cube of length (**Javaid and Akram, 1972**). The mean condition factors for all length groups in the current study were 1.2, indicating that the fish on the North Sinai coast were in good condition. This may be related to the best environmental condition in the area of study. **Anene (2005) and Sarkar *et al.*, (2013)** noted that condition factor is not constant for a species or population. From a nutritional point of view, there is the accumulation of fat and gonadal development (**Le Cren, 1951).** He also reported that, a fish's condition factor represents physical and biological parameters as well as changes caused by interactions between feeding conditions, parasite diseases, and physiological factors. This also indicates the changes in food reserves and therefore an indicator of the general fish condition. Furthermore, body condition offers an alternative to the costly in vitro proximal tissue investigations (**Sutton *et al*., 2000).**

Table 1: Comparison of L-W relationships (a and b) of *Epinephelus aeneus* from different locations.

Author	Location	a	b	r^2
Özbek *et al.*, (2013)	Turkey	0.040	2.657	0.958
Fiogbe (2003)	Benin, West Africa		2.90	
Can *et al.* (2002)	İskenderun Bay-Turkey		2.90	
Özbek *et al.*,(2013)	Gulf of Antalya, Turkey	0.040	2.657	0.958
Waly *et al* (2015)	Soumbedioune Senegal	0.013	2.96	0.98
Waly *et al* (2015)	Joal Senegal	0.006	2.99	0.97
Waly *et al* (2015)	Mbour Senegal	0.006	3.00	0.98
Ceyhan *et al.*, (2009)	southeastern Aegean Sea	0.0098	3.043	0.952
Cury and Worms (1982)	Senegal		3.230	
Magnússon and Magnússon (1987)	Cape Verde coasts		3.580	
Sangun *et al*. (2007)	Turkey	0.0128	2.987	0.99
Present study	Mediterranean coast of Sinai (males)	0.0152	2.9327	0.94
	Mediterranean coast of Sinai (females)	0.0178	2.8846	0.94
	Mediterranean coast of Sinai(combined sexes)	0.0083	3.1141	0.96

Bagenal (1978) and Wootton (1996) reported that fish with higher K values (> 1) are in a better condition than fish with lower K values (< 1). In this study, K values in the present study ranged from 1.0 to 1.5 with a mean value of 1.2. Condition factor is used for comparing the condition, fatness, or well-being of fish, based on the assumption that heavier fish of a given length are in better condition.

The values obtained from the present study showed that, *E. aeneus* was in good condition. **Le Cren (1951)** reported that environmental factors, food supply and parasitism have great influence on the health of the fish. **Abowei and Davies (2010)**

reported that, the condition factor reflects the well-being of the fish and it gives information on the physiological state of the fish in relation to its welfare.

Ighwela *et al*. (2011) reported that, when evaluating the duration of gonad maturation and following up on the degree of feeding activity of species to check if it is making appropriate use of its source, the condition factor provides information when comparing two populations living in certain feeding, density, climatic, and other conditions. It is impacted by both environmental conditions and factors such as sex, season, age, and stage of fish development. It can be used as an index to determine the state of an aquatic ecosystem (**Edah *et al.,* 2010).**

Related to differences in condition factors with different months, the lowest value of the K was recorded during February in males, females and combined sexes. The highest values of K in females were recorded in July and August (1.41 and 1.43 respectively).This may be related to the reproductive behavior of the studied species. **Desiderà *et al*., (2019)** reported that time of the *E. aeneus* spawning (24 °C at 24.7 m), in the Marine Protected Area (MPA) of Tavolara- Punta Coda Cavallo (NE Sardinia, Italy), in the Western Mediterranean Sea as well as over the 2018 summer months (July-September).

Vazzoler (1996) confirmed that lowest K values during the more developed gonadal stages might mean resource transfer to the gonads during the reproductive period**. Braga (1986),** through other authors, showed that values of the condition factor vary according to seasons and are influenced by environmental conditions. The floodplain is influenced by various biotic and abiotic elements that support the equilibrium of all species in the ecosystem; therefore similar occurrences may occur in the environment under consideration.

CONCLUSION

Based on the results, it can be concluded *E. aeneus* was in good condition in the area of study. The findings of our research will assist biologists in understanding the status of this fish and developing culture technology in natural waters, as well as fishery biologists and conservation biologists in the successful development, management, production, and ultimate conservation of Egypt's most popular food fishes.

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