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# Age, Growth, Mortality and Exploitation level of the Squirrelfish, *Neoniphon Sammara* (Forsskal, 1775) From Hurghada, Red Sea, Egypt

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**ABSTRACT**

Age, growth, and mortality of sammara squirrelfish *Neoniphon sammara* from the Red Sea were estimated for monthly samples collected during the period from January 2022 to December 2022 from the commercial catch of Hurghada, Red Sea, Egypt. The total length of sampled individuals ranged from 14 to 21.0 cm for males and 14.5 – 21.9 cm for females and there is no significant difference in the length frequency distribution between sexes. The length–weight relationship showed negative allometric growth for male, female, and combined sexes and there is no significant difference between males and females in b-values. The ages of the specimens ranged from 2 to 5 years where age group one was not represented in the samples. As there is no significant difference between sexes, von Bertalanffy growth parameters were calculated for sexes combined and found to be $L\infty$= 26.49 cm, k= 0.28/year, $t_0$ = –0.71 year for all samples. According to age–structure analysis, the total, natural, and fishing mortality rates were calculated as 1.39, 0.57, and 0.82, respectively. Accordingly, the exploitation level of this species exceeds the optimum level showing an overfishing situation of this species in the Hurghada fishing area, Egyptian Red Sea.

## INTRODUCTION

The Red Sea is deep and narrow water body, extending from Suez in the north to Bab El Mandab in the south. The Egyptian Red Sea sector stretches approximately 1080 km from Suez in the north to Mersa Halayab in the south (Mehanna, 1996; Mohammad *et al*., 2020). Like other tropical and subtropical seas, the Red Sea is characterized by rich and diverse fauna and flora (**Morcos, 1970; Shiekh-Eldin, 1988 and Ghisotti, 1995; Mehanna, 2021**).

The squirrelfishes (family: Holocentridae) exhibit a group of commercially important demersal species in Egypt. They mainly inhabit coral reefs and rocky regions (**Randall & Heemstra, 1985**) and they live at depths ranging from 0 to 46 m (Lieske & Myers, 1994). This family consists of eight genera and up to 90 species that are distributed in the tropical Atlantic, Indian, and Pacific Oceans (**Froese & Pauly, 2023**). It feeds at night on small fish, crabs, and shrimps (**Sommer *et al.*, 1996**). Squirrelfishes have great commercial importance as favorite edible fishes with reasonable prices.

Studies on the age and growth of fishes are useful in understanding longevity, population structure and dynamics of the stock (**Dominguez-Seoane *et al.*, 2006**). For most squirrelfishes' studies on biology and fisheries status are limited. This is the first work aimed to provide information on the age, growth and mortality of this species in the Egyptian Red Sea.

## MATERIALS AND METHODS

Random samples of *Neoniphon sammara* species (Fig.1) were collected monthly during the period from January 2022 to December 2022 from the commercial catch of Hurghada (N: 27° 13' 43.32"& E: 33° 50' 33.20"), Egyptian Red Sea (Fig. 2). Total length (cm) and total weight (g) were taken for each fish. The otolith was removed from each sample.

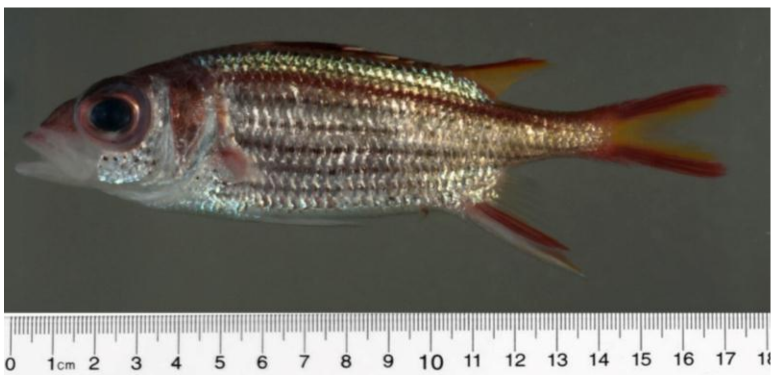

**Fig. 1.** A Photograph of *N. sammara* fish

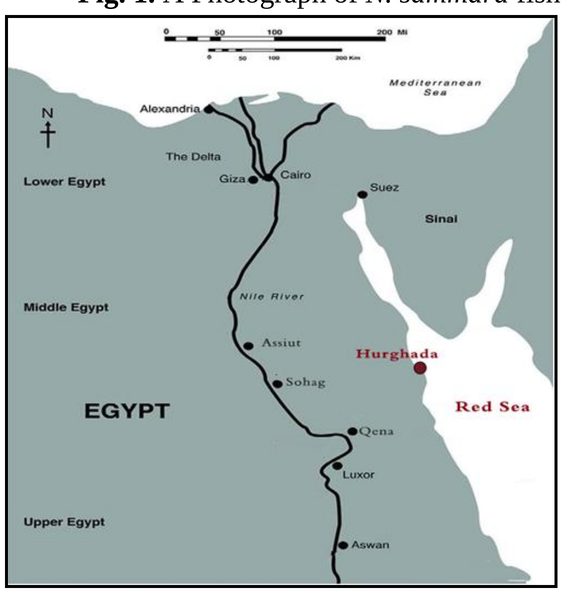


**Fig. 2.** Sampling site at Hurghada, Egyptian Red Sea.

Age determination was carried out by reading growth rings on 254 *N. sammara* otoliths. After the otolith is removed and cleaned with 10% sodium Hydroxide for 1 minute, then it is cleaned in water and stored in a dried envelope. The otolith examination is carried out by stereomicroscope (Carl Zeiss Discovery v20 connects to AxioCam ERc5s camera with software) with reflected light and a black background, at a magnification of x11. The total otolith radius (S) and the distance between the focus of the otolith and the annuli radii were measured by the ImageFocus Alpha program.

The relationship between otolith radius (S) and total fish length (TL) was determined by the least square method, where TL = a + b (S). The value (a) was used as a correction factor for back-calculated lengths and value (b) is constant.

Lee's equation (1920) was used to calculate back-calculated length at the end of each year of life from otolith measurements as follows:

$$TL_n = a + (S_n / S)\ (TL - a)$$

Where $TL_n$ is the calculated length at the end of the $n^{th}$ year, TL is the total length at capture, Sn is the otolith radius corresponding to the $n^{th}$ year, S represents the otolith radius at the time of capture, and "a" is the correction factor.

Length-weight relationship (LWR) was calculated using the power equation $W = a*TL^b$, where W is the total weight (g), TL is the total length (cm), "a" and "b" were the constant, and "b" was indicating isometric growth when equal to 3 or Positive allometric growth (b>3) or negative allometric (b<3). Student’s t-test was utilized to test whether the slope of regression was significantly different from 3, indicating the growth pattern of fish (**Ye *et al.*, 2007**).

The growth in weight was estimated by applying the length-weight equation on the back-calculated length of different age groups.

Growth of a fish can be described as an increase in either length or weight. Several mathematical equations have been created to model fish growth from which the von Bertalanffy growth model (VBGM), is the most used growth model of fishes. Von Bertalanffy growth model described as $L_t = L_\infty\ (1 - e^{-k\ (t - t0)})$ where Lt is the total length (cm) at time t (year), $L_\infty$ the asymptotic length, K the growth coefficient, and $t_0$ the theoretical age at length equal zero.

The method of **Gulland and Holt (1959)** was fitted to solve the von Bertalanffy growth function for combined sexes.

The growth performance index (φ') was estimated from the equation $\varphi' = \log (k) + 2 \log (L\infty)$ (**Pauly and Munro, 1984**).

While the constant “$t_o$” was estimated from the rearranged formula of the von Bertalanffy equation $- \ln [1 - (Lt/L\infty)] = - kt_0 + kt$, Where Lt is the length at age (t).

Total mortality (Z) was estimated by two different methods depending on length-frequency data. The first method was an analysis of length converted catch curve (**Pauly, 1983**) and the second method was the cumulative catch curve method (**Jones and Van

**Zalinge, 1981**). Total mortality estimates were carried out using FISAT II - FAO-ICLARM Stock Assessment Tool (**Gayanilo, *et al*., 2005**).

The natural mortality (M) was estimated by three methods, **Rikhter and Efanov's (1976**) empirical model as:

$$M = ((1.52/ t_{mass})^{0.72}) - 0.16)$$

Where $t_{mass}$ denotes the mean age at massive maturation. The second method was **Pauly's (1980**) empirical equation as:

$\text{Log } M = -0.0066 – 0.279 \text{ Log } L_\infty + 0.6543 \text{ Log } k + 0.4636 \text{ Log } T$ Where $L\infty$ and K are the von Bertalanffy growth parameters and T is the water temperature inhabited by the fish (25° C).

The third method was **Taylor's method (1960)** where the natural mortality coefficient was estimated according to the following equation: $M = 3/t_{max}$, where $t_{max}$ = maximum age attained. The validity of estimates of M can be judged by the M/K ratio as this ratio has been demonstrated to be within the range of 1.12–2.50 for most species around the world (**Beverton and Holt, 1957**).

The fishing mortality (F) was calculated by subtracting the natural mortality rate from the total mortality rate and the exploitation rate (E) was calculated as the proportion of fishing mortality relative to total mortality (E = F/Z).

## RESULTS

### ***1. Length-Weight relationship***

A total of 537 specimens (274 Males and 263 females) were analyzed for growth studies. Males varied between 14 -21.0 cm for total length and from 40 to 112 g for total weight while females ranged between 14.5 and 21.9cm for total length and their weights ranged between 40 and 121.6 g. The estimated length-weight equations are $W = 0.0308 L^{2.6975}$, $W = 0.0204 L^{2.843}$ and $W = 0.0262 L^{2.7555}$ for male, female and sexes combined of the investigated species respectively (Fig. 3).

Estimation of length-weight relationship showed a tendency towards allometric growth (All b-values were significantly different from 3). For males (b = 2.697, CI= 2.571 – 2.824), females (b = 2.843, CI = 2.725 – 2.961) and combined sexes (b = 2.762, CI = 2.681-2.843) indicating negative allometric growth.

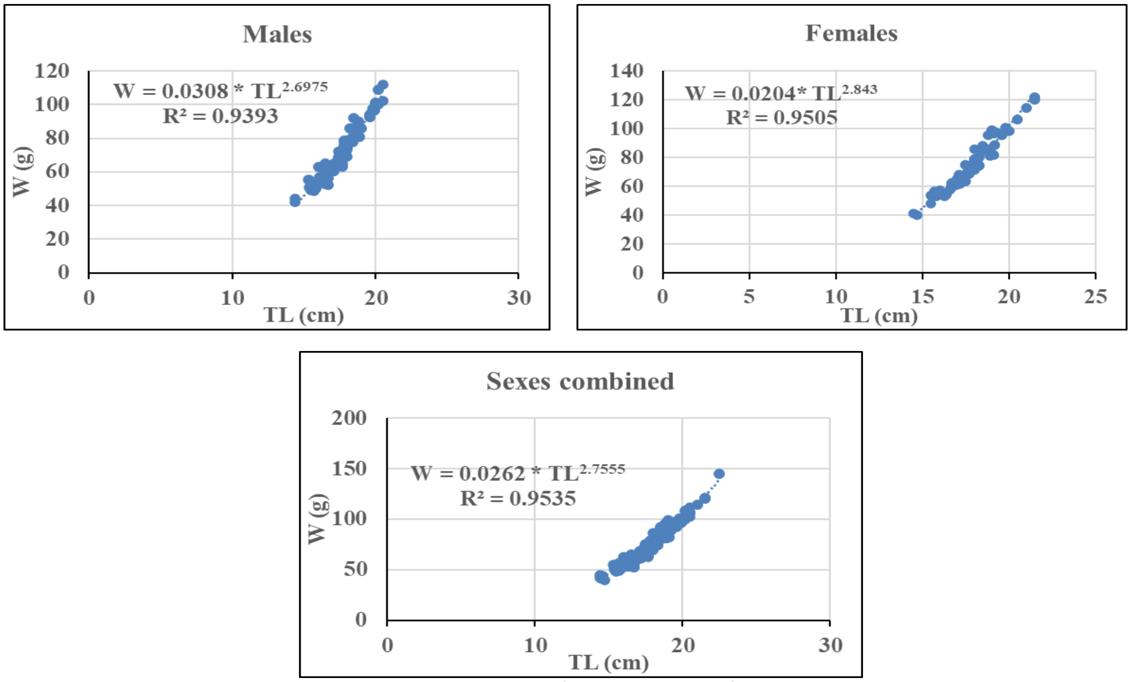


**Fig. 3.** Length-weight relationship of *N. sammara* from Egyptian Red Sea.

### *2. Age determination*

Sagittal otoliths were used for age determination (Fig 4). Counting the growth annuli on sagittal otoliths showed that the maximum life span of *N. sammara* was 5 years for males and females with the absence of age group I in this sample while age group IV was the most frequent one constituting 46.46% (Fig. 5).

There is no significant difference in age determination between the two sexes, so all further estimations were undertaken for sexes combined. Female sizes were slightly greater than that of male.

The total body length (TL) – otolith radius (S) relationship showed a strong correlation between total length and otolith radius ($R^2$ = 0.9). Figure (6) shows the relationship between total length- otolith radius which can be expressed by the following equation:

$$\mathbf{TL = 1.2015 + 29.038\ S}$$

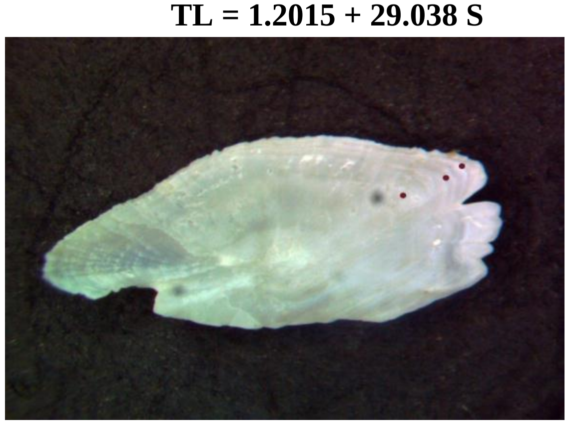

**Fig. 4.** Otolith of *N. sammara* species showing 3 years old (total length = 16.7cm).

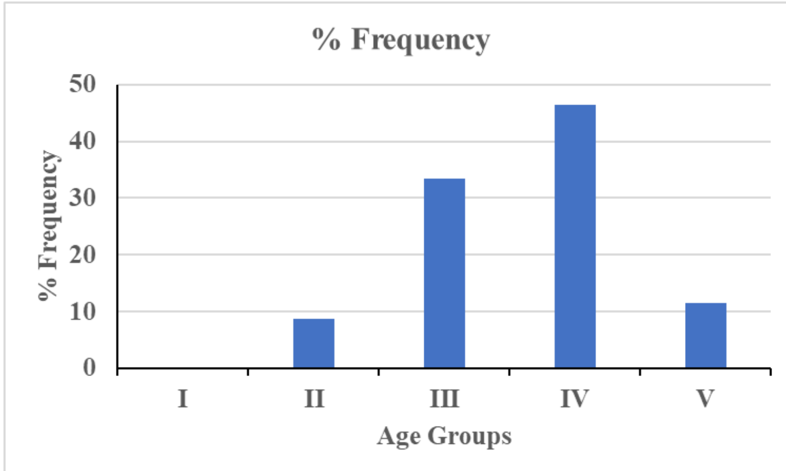


**Fig. 5.** Age composition of *N. sammara* from Egyptian Red Sea.

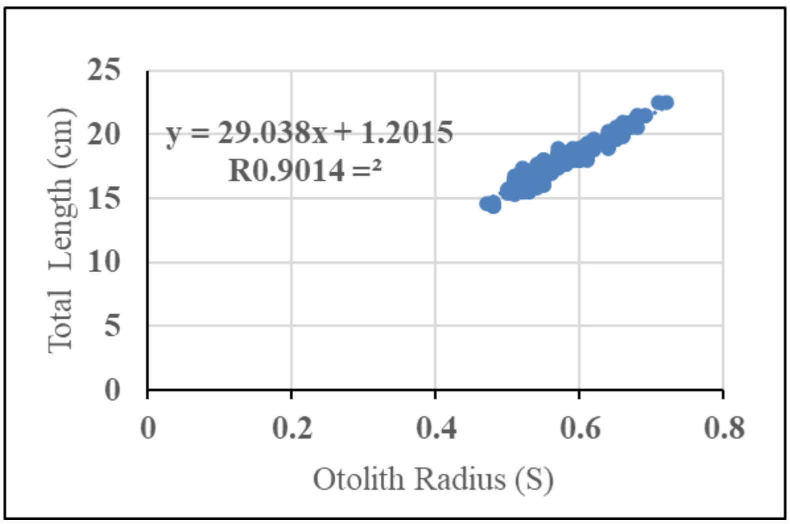


**Fig. 6.** Total length-otolith radius relationship of *N. sammara* from Egyptian Red Sea.

### *3. Back calculations*

Lengths at the end of each year of life were back-calculated according to Lee's formula (1920). Back-calculated lengths for each age group as well as the average increments are shown in Figure (7). It is clear that the fish attained lengths of 13.96, 17.05, 19.25 and 21.05 cm TL for age groups 2, 3, 4 and 5 respectively. Based on the back-calculated length corresponding to the first year of life (10.21 cm TL), the growth in length reaches its maximum value by the end of the first year of life (48.5%) after that a gradual decrease in the annual increments with further increase in age was observed.

The estimated weights by the end of each year of life for *N. sammara* was obtained by applying the length-weight equation to the back-calculated lengths (Fig. 8).

The estimated weight for each age group was estimated at 15.80, 37.41, 64.91, 90.69 and 116.02 g for the 1st, 2nd, 3rd, 4th and 5th years of life, respectively,

The growth in weight was much slower during the first year of life and increases with the increase of age reaching its highest value at the end of the third year of life 27.5 g (23.7%).

As there is no significant difference between sexes in respect to the age, growth and length distribution, all calculations were conducted for combined sexes.

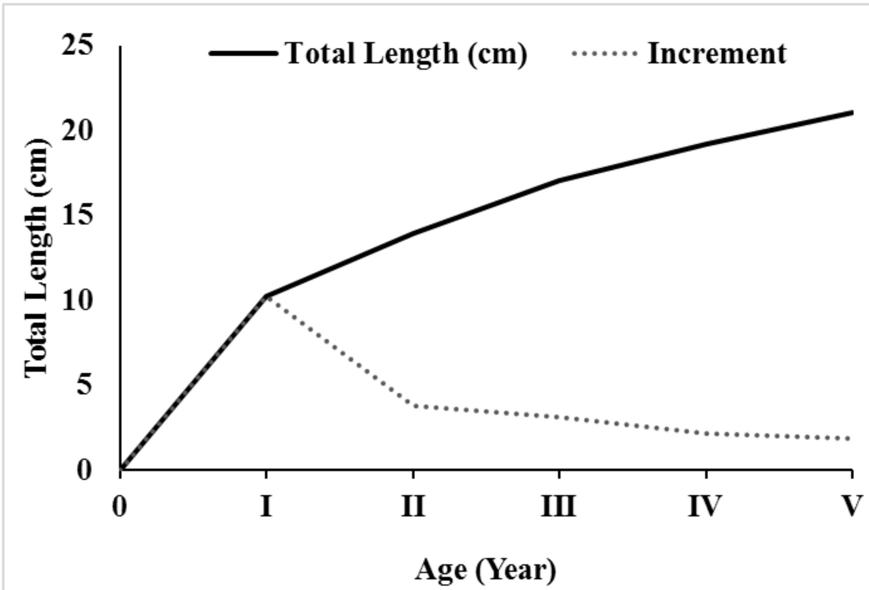


**Fig. 7.** Growth in length and its increment of *N. sammara* from the Egyptian Red Sea.

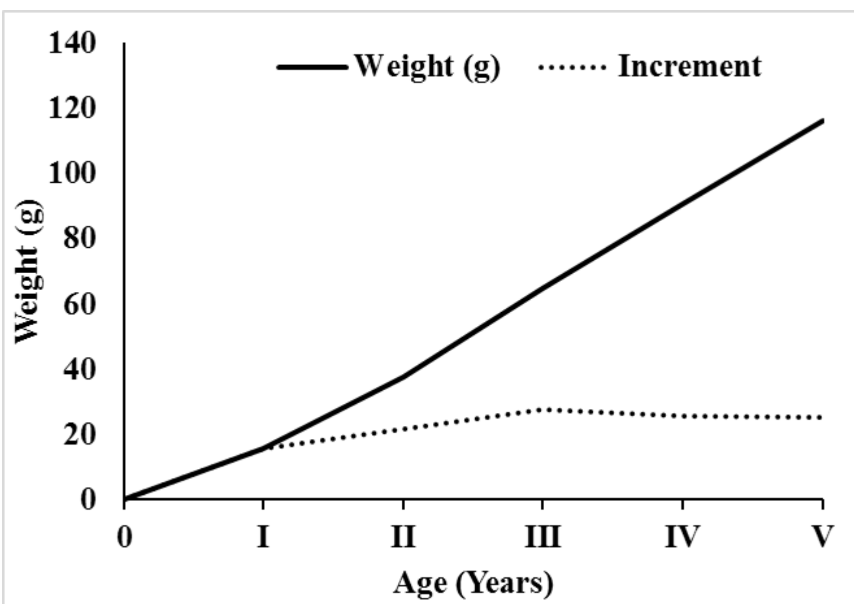


**Fig. 8.** Growth in weight and its increment of *N. sammara* from Egyptian Red Sea.

### *4. Growth parameters*

In this study, the theoretical growth of *N. sammara* was estimated by applying von Bertalanffy growth model. The growth parameters of von Bertalanffy were estimated using age-length data, they were estimated as $L_\infty$= 26.49cm, K= 0.28 year $^{-1}$ and $t_0$ = -0.71 year $^{-1}$. The von Bertalanffy growth equations for length and weight are

$Lt = 26.49 [1- e^{-0.28 (t + 0.71)}]$

$Wt = 218.58 [1- e^{-0.28 (t + 0.71)}]^{2.75}$

Where Lt and Wt are mean length and weight at age t respectively.

### *5. Growth Performance Index (Ø)*

The growth performance index **(Ø)** is an index for comparing the growth performance of organisms in terms of their growth in length and weight. The growth performance index **(Ø)** for *N. sammara* in length and weight are 2.29 and 1.42, respectively.

### *6. Mortality estimates*

Total mortality (Z) was estimated by two different methods depending on length-frequency data. The first method was the analysis of length converted catch curve (Pauly, 1983) and the second method was the cumulative catch curve method (Jones and Van Zalinge, 1981) where Z= 1.44 $y^{-1}$ and 1.34 $y^{-1}$ respectively with an average of 1.39 $y^{-1}$. while, the natural mortality (M) was estimated by three methods, Rikhter and Efanov's (1976), Pauly's (1980) and Taylor’s method (1960) where M = 0.44 $y^{-1}$, 0.67 $y^{-1}$ and 0.60 $y^{-1}$ respectively with mean value of 0.57$y^{-1}$. The fishing mortality (F) was calculated by subtracting the natural mortality rate from the total mortality rate was 0.82$y^{-1}$. The exploitation rate (E) calculated as the proportion of fishing mortality relative to total mortality (E = F/Z) is found to be E= 0.59 $y^{-1}$.

## DISCUSSION

Studies on the age and growth of squirrel fishes are very limited and hence the present study has provided some biological information with regard to the life history of *N. sammara*. In this study; the age, growth and mortality of *N. sammara* have been studied from the Hurghada fishing area, Red Sea, Egypt. Hence the results obtained from this study will be a starting point for further research about *N. sammara* in Egyptian waters.

The estimation of the length-weight relationship, condition factor and other population parameters is of great importance in the field of fish biology, stock assessment, population dynamics and fisheries management (**Mehanna *et al.*, 2008; Abdel-Hakim *et al.*, 2010; Arslan and Ismen, 2013; Ferdaushy and Alam, 2015; Mehanna and Farouk, 2021; Mehanna 2023 a&b**). In this study, the estimation of the length-weight relationship showed a tendency towards negative allometric growth (the value of “b” is less than 3) for males, females and combined sexes.

The determination of age and growth is of great importance to both fisheries biology and management. In addition, it forms the basic knowledge required for the estimation of mortality, recruitment and yield. These parameters constitute the basic information needed for the construction of a management strategy for any exploited stock (Mehanna, 1996). The present study showed that the maximum life span of *N. sammara* was 5 years with age group IV being the most frequent. The growth in length was found to be high during the first year (48.5%) while the highest growth in weight takes place at the end of the third year of life 23.17g (23.7%) after that a gradual decrease in the annual increments with further increase in age was observed. In most fishes decline in growth with an increase in age has been reported (**El-Serafy, *et al*., 2015; Hassanien, 2017; Mohammad, *et al*., 2020; Mehanna and Hassanien, 2023**). It sounds to be normal when the younger stages of fishes are known to have higher growth rates since the energy is spent for somatic growth while in matured or older fishes the energy is utilized for reproduction (**Lester *et al.*, 2004; Pecquerie, *et al.*, 2009**).

The obtained growth parameters ($L_\infty$, K and $t_0$) are the basic input data into various models used for managing and assessing the status of the exploited stocks. Besides, it facilitates the comparison between the growth of individuals belonging to different species or the same species at different times and different localities (Mehanna, 1996). Variations in growth parameters of the same fish family from different regions might be due to differences in environmental parameters or size structure at the specified localities caused by different gears used and methodologies adopted for studying the parameters (**Anbalagan, *et al.*, 2016**). In this study, the growth parameters of von Bertalanffy of *N. sammara* are $L_\infty$= 26.49 cm, K= 0.28 year $^{-1}$ and $t_0$ = -0.71 year. For *Sargocentron spiniferum*, the growth parameters $L\infty$, K, and $t_o$ were estimated as 53.25 cm, 0.23 $y^{-1}$, and -0.66 year respectively (**Mohammad, *et al.*, 2020**) of the Red Sea.

Mortality rates are a measure of describing the rate at which fish disappear from a population and are critical parameters in formulating sustainable fishing regulations (**Ogle, 2016**). The determination of mortality is essential as it is considered one of the basic input parameters for population dynamics models used in fishery analyses and management (Mehanna, 1996). If we consider population growth to be a positive aspect of the dynamics of fish populations, then mortality can be seen as a negative counterpart (**Sparre & Venema, 1998**). In the present study, the mean value of total mortality, natural mortality and fishing mortality are $1.39y^{-1}$, $0.57y^{-1}$ and $0.82y^{-1}$ respectively. The high value of fishing mortality, reflect an over-fishing condition for *N. sammara* of Hurghada, Red Sea, Egypt.

The exploitation rate is very important to evaluate the state of the stock which determines underexploited and overexploited stocks. The value of the exploitation rate for *N. sammara* is found to be E= 0.59 $y^{-1}$. This value of E is higher than the optimum level of exploitation given by **Gulland (1971)**. He mentioned that the optimum exploitation rate for any exploited fish stock is about 0.5 at F=M. So, this high value of exploitation rate indicates that the fish stock of *N. sammara* is overexploited.

## CONCLUSION

The lack of information about the biological characteristics of the family Holocentridae is indicative of the need for more data on the fishes belonging to the family Holocentridae with special attention to species that have good demand in the domestic and international fish trade market. Where the samara squirellfish *N. sammara* falls within the important commercial marine fish in Hurghada fishing area, the levels of exploitation have increased in the last few years. So, the findings of this study are significant to have scientific data on its biology and dynamics helping in managing of this species in the area.

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