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Growth, mortality and sustainable exploitation of white shrimp (*Metapenaeus stebbingi*) in Bardawil lagoon of Egypt

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ABSTRACT

Samples of the white shrimp, *Metapenaeus, stebbingi*, were collected from fish landings at Bardawil lagoon. Their length ranged from 4.6 - 10.2 cm. The estimated von Betalanffy growth parameters TL∞ and K of combined sex 10.8 cm and K = 0.7 y^{-1}, respectively. The values of the mortality rates (Z, M and F) and exploitation ratio computed using FiSAT-II software were 2.57y^{-1}, 1.05 y^{-1} , 1.52 y^{-1} and 0.59, respectively. The maximum economic yield (at E_{10}) was 0.607g, the exploitation level that maintains the biomass at 50% of fished (E_{50}) was 0.358. From the results it was concluded that proper management of the stock of *M. stebbingi* in Bardawil lagoon can be achieved by decreasing the current the exploitation rate (0.59) to 0.358 to maintain a sufficient spawning biomass through reducing the fishing effort or the number of fishing days or the number of fishing trips besides applying the closing fishing season for a suitable period.

Keywords: White Shrimp, *Metapenaeus stebbingi*, growth, mortality, exploitation rate, Bardawill lagoon.

INTRODUCTION

The Mediterranean Sea and coastal lagoons are subjected to multiple human pressures that increasingly threaten their unique biodiversity. Therefore, information is collected and the ecological status of these lakes is studied. Also studying the marine ecosystems are the key to their effective planning and management, and to help achieve environmental goals (Bevilacqua *et al*., 2020). To study the diversity of communities in different regions or habitats we rely on examining the biological features of organisms, which are often defined as any morphological, physiological, phenological or behavioral characteristic of an organism that affects its individual performance (**Cyrille** *et al.*, 2007). Invertebrates are among the organisms most studied in the analysis of biological features in the marine environment (Beauchard *et al.*, 2017).

Bardawil Lagoon is a large hyper-saline shallow and oligotrophic coastal lagoon on the Mediterranean coast of Sinai (Touliabah et al., 2002) and it represents one of the most important lagoons in Egypt as a source of good quality fish and crustaceans. Moreover, it is the least polluted wetland in Egypt and in the entire Mediterranean region and is considered the main ecological and economic natural resource of North Sinai region (Emam, 2010).

The lagoon is a highly productive coastal region of ecological and economic value because of its richness and diversity in living natural resources, comprising commercially important fish, crabs, and shrimp species. Bardawil lagoon, being an aquatic environment that is subject to several environmental and human fishing activities besides, there is a possible impact on the general environmental status of the lagoon. Penaeid shrimp are important

fishing resources in coastal regions worldwide, among the commercial species of this family, the white shrimp Metapenaeus stebbingi is the shrimp species in Bardawill lagoon. The present study was examining the growth, mortalities and sustainable exploitation of the white shrimp (*Metapenaeus stebbingi*) in Bardawil lagoon, north Sinai, Egypt.

MATERIALS AND METHODS

A total of 740 specimens of the white shrimp *Metapenaeus, stebbingi* were monthly collected from the commercial catch at Bardawil lagoon during the fishing season 2021 (Fig. 1). The total length (TL, to the nearest 0.1 mm.) was measured and the total weight (TW, to the nearest 0.1 g) as wet weight. Length weight equation $W = a L^b$ was studied, where W is the total weight in g, L is the total length in cm, a and b are constants.

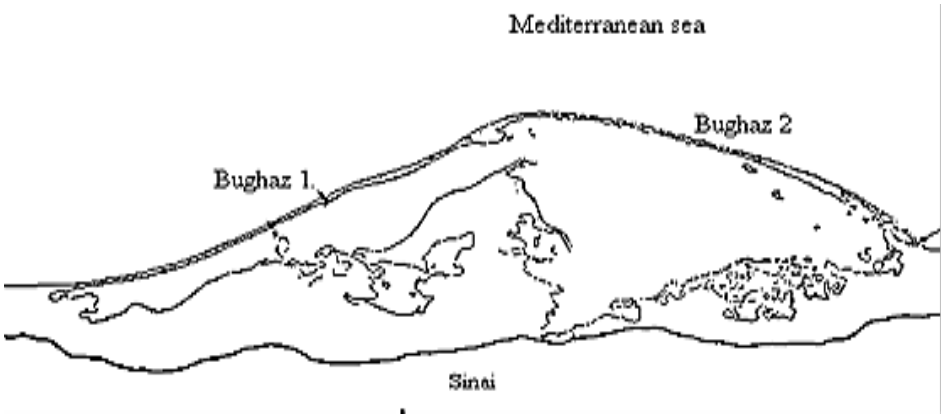

Fig. 1. Bardawil lagoon

The data were analyzed using FiSAT II (FAO ICLARM Stock Assessment Tools) as explained in details by Gayanilo *et al*. (2003). The fitting of the best growth curve was based on the ELEFAN I program (Pauly and David, 1981), which allows the fitted curve through the maximum number of peaks of the length frequency distribution. With the aid of the best growth curve, the von Bertalanffy growth maximum theoretical length ($L\infty$) and the growth coefficient (K) were estimated. The von Bertalanffy growth equation was defined as follows (Sparre and Venema, 1998):

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

Where L_t is length at time t, $L\infty$, the asymptotic length, K, the growth coefficient and t_0, is the hypothetical time at which length is equal to zero.

The total mortality (Z) was estimated using the length converted catch curve method, which has been incorporated into the FiSAT program (Gayanilo *et al*., 2003). The natural mortality rate (M) was estimated using Pauly's empirical relationship (Pauly, 1980):

$$\text{Log}_{10}M = 0.0066 - 0.279\ \text{Log}_{10}L\infty + 0.6543\ \text{Log}_{10}\ K + 0.4634\ \text{Log}_{10}T$$

Where: $L\infty$ is expressed in cm and T the mean annual environmental water temperature which equals to 23.5C for the sampling area.

Fishing mortality (F) was obtained by subtracting M from Z and exploitation rate (E) was obtained from F/Z.

The statistical analyses were performed to test and analyze differences between shrimp size classes and growth in the different habitats. One-way ANOVA was used. Data handling and refinement were carried out using Microsoft Excel 2010.

RESULTS AND DISCUSSION

The total length of the collected white shrimp *Metapenaeus, stebbingi* samples ranged from 4.6 - 10.2 cm and their weights varied from 0.26 to 6.6 g. Mehanna and Khalifa (2007) recorded the total length of the same species from the south-eastern Mediterranean Sea (Port Said region) varied between 3.1 and 11.3 cm. While, Mahmoud *et al* (2016) recorded the size of *M. stebbingi* ranged between 7 and 42 mm in the catch of Egyptian Mediterranean.

The relationship between the total length and total weight of *M. stebbingi* was shown n Fgure (2) and its equation was:

$$W = 0.0067L^{3.0147}$$

The length-weight relationship has vital importance in fisheries science. It helps in establishing the mathematical relationship between the two variables, enables conversion of one variable to describe growth in the wild (Abohweyere and Williams, 2008; Deekae and Abowee, 2010)**.** Results indicated the isometric growth which agreed with the results given by by Mehanna and EL-Gammal (2008) for the same species Lake Timsah.

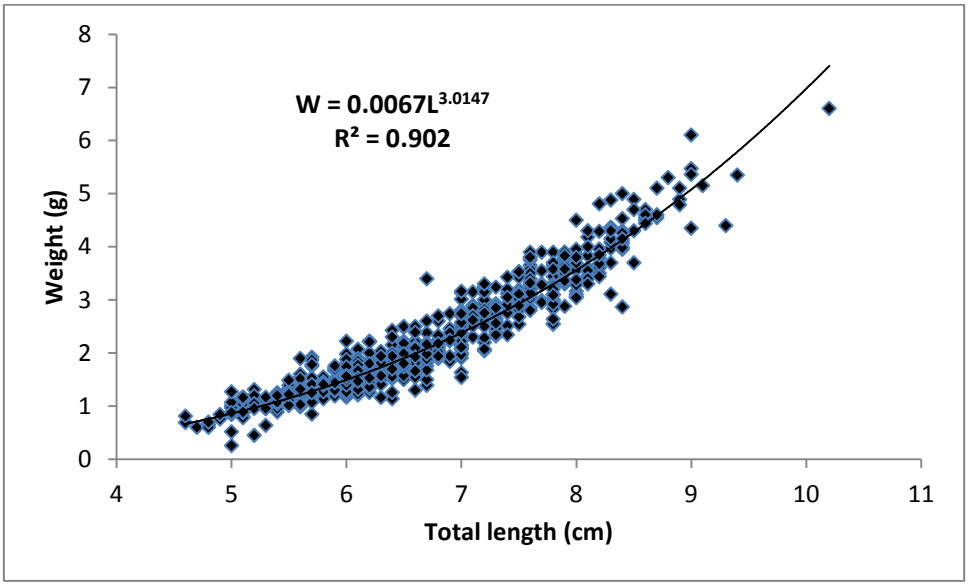

Fig. 2. Length-weight relationship of *M. stebbingi* from Bardawil lagoon during the fishing season 2021

Figure 3 shows the restructured length frequency for White shrimp, *M. stebbingi* shrimp, with superimposed growth curves. The values of the von Bertlanffy growth parameters L∞ and K were 10.8 cm and K = 0.7 year^{-1}, respectively.

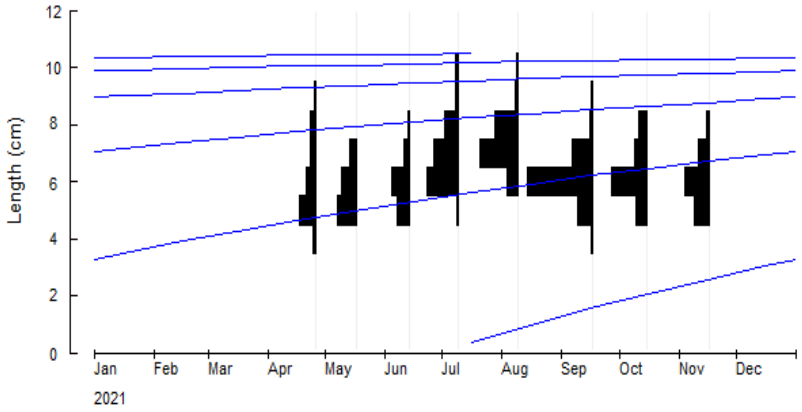

Fig. 3. Smooth growth curve of *M. Stebbingi* from Bardawil lagoon during the fishing season 2021.

Short-lived animals like shrimp reach their asymptotic length in the first or second years of their lives span and are characterized by a high K - value (Garcia and Le Reste 1981). Mehanna and Khalifa (2007) shorter life span of the same species from south-eastern Mediterranean Sea (Port Said region) with the values of K = 2.19 year^{-1} and L∞ = 12.6. Also, Mehanna and EL-Gammal (2008) for the same species recorded the values of K = 2.63 and 2.16 yr^{-1} , while L∞ = 14.84 and 16.95 cm for males and females, respectively from for the same species from Lake Timsah, Suez Canal. The growth parameters were estimated as L∞ = 94.4 mm, K = 0.81 year^{-1} and t_0 = -0.20 year for the green tiger prawns, *Penaeus semisulcatus* in Jizan area (Al Solami and Jastinah, 2018).

Using the length-converted capture curve (Fig. 4), the total mortality rates (Z) of *M. stebbingi* was estimated to be 2.57y^{-1}. The calculated values of the instantaneous rate of natural mortality (M) was 1.05 y^{-1} and the instantaneous rates of fishing mortality (F) was 1.52 y^{-1}. The natural mortality rate changes depending on the density of predators and competitors, whose presence is influenced by fishing operations, in different places (Sparre & Venema, 1998).

The exploitation ratio of *M. stebbingi* in the current study was estimated at 0.59, which is higher than the optimum one (E = 0.50) reported by Sparre andVenema (1992), meaning that there is overfishing for recruitment. Hussien, *et al.* (2016) estimated the total mortality (Z = 7.832 y-1), natural mortality (M = 2.855 y^{-1}), the fishing mortality (F = 4.977) and the exploitation rate (E = 0.635) for *M. stebbingi* in Bardawil lagoon. The lower value total (Z) mortality in the present investigation is due to stopping the artisanal fishing for shrimp by trawls in the lagoon.

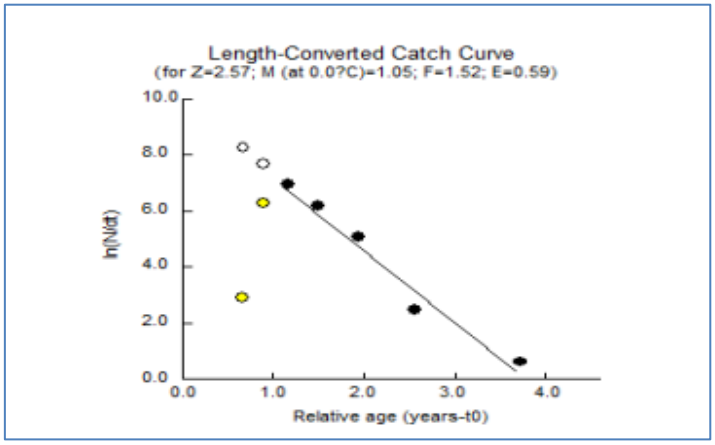

Fig. 4. Total mortality of *M. stebbingi* from Bardawil lagoon During the fishing season 2021.

The probability of capture (Fig. 5) as a length at first capture (Lc) of *M. stebbingi* in Bardawil lagoon was estimated as : Lc_{25}= 4.5 cm, Lc_{50}= 5.25 cm and Lc_{75}= 6 cm. , whereas the length at 5.25 cm is less than the length at first sexual maturity (88 mm) reported by Badawi (1975) for *M. stebbingi* in the Arabian Gulf.

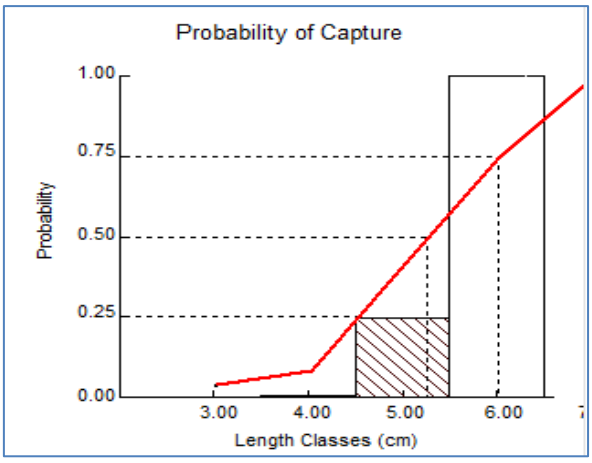

Fig. 5. Probability of capture of *M. stebbingi* from Bardawil lagoon during the fishing season 2021.

The relative yield and biomass per recruit of *M. stebbingi* were estimated as a follow: Maximum economic yield (E_{-10})= 0.607, Exploitation level which will maintain the biomass at 50% of fished (E_{-50}) = 0.358 and the maximum sustainable yield (E-max) =0.7 (Fig. 6).

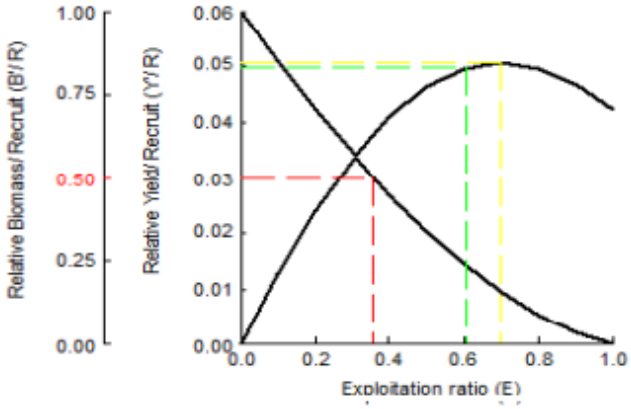

Fig. 6. Relative yield and biomass per recruit of *M. stebbingi* from Bardawil lagoon during the fishing season 2021

Conclusion:

For management of the stock of *M. stebbingi* in Bardawil lagoon, the exploitation rate must be reduced from 0.59 to 0.358 to maintain a sufficient spawning biomass. This can be achieved by reducing the effort of fishing vessels used in capture of this species or the number of fishing days or the number of fishing trips besides applying the closing fishing season for a suitable period.

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كفاءه النمو ومعدلات النفوق والاستغلال للجمبري الأبيض (*Metapenaeus stebbingi*) في منخفض البردويل بمصر

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المستخلص

فى هذه الدراسة تم تجميع عينات من الجمبري الأبيض (*Metapenaeus stebbingi*) من مناطق الانزال للصيد بمنخفض البردويل، مصر. وجد من النتائج ان اطوالها فى المصيد تتراوح بين ٤.٦-١٠.٢سم. تم تقدير معاملات فون برتلانفى النمو وتشمل الطول الكلى عند مالانهاية ($L\infty$) ومعامل النمو (K) وكانت قيمتهما ١٠.٨سم ، ٠.٧/السنة على التوالى. كما امكن من تحليل تكرارية الحجم فى اشهر الصيد ومعايير النمو المقدرة ومعدلات الوفيات ونسبة الاستغلال باستخدام برنامج .FiSAT-II . وقد وجد ان معدلات النفوق الكلى (Z) ، النفوق الطبيعي (M) والنفوق نتيجة الصيد (F) كانت ٢.٥٧/السنة ، ١.٠٥ /السنة ، ١.٥٢/السنة على التوالى. وتم حساب جهد الصيد الحالى للجمبرى الابيض (E_{cur}) ووجد يساوى (٠.٥٩) كما وجد ان الطول عند اول صيد (L_{c50}) يساوى ٥.٢٥ سم. وقد تم حساب معدل الاستغلال الاقتصادي المستمر(E_{10}) ويساوى (٠.٦٠٧) كما وجد ان معدل استغلال هذا النوع فى المصيد والذى يحقق الاستغلال الاقتصادى ويحافظ على ٥٠% من الكتلة الحيوية له يساوى ٠.٣٥٨. لذلك أوصت الدراسة بتخفيض جهد الصيد الحالى من خلال تخفيض جهد الصيد الحالى لهذا النوع بتقليل عدد المراكب او ساعات الصيد او ايام الصيد فى منخفض البردويل وتنفيذ موسم الاغلاق للمدة التى تسمح بعمليات التزاوج وانتاج الزريعة.

الكلمات المفتاحية: الجمبري الأبيض، *Metapenaeus stebbingi*، النمو، النفوق، معدل الاستغلال، منخفض البردويل