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Some biological aspects and reproductive dynamic of the black-barred halfbeak *Hemiramphus far* (family: Hemiramphidae) in Bardawil lagoon, Egypt.

Sahar F. Mehanna[1]; Mohamed Salem[2]; Hasnaa S. Mahmoud[3]

1- Fish Population Dynamics Lab, National Institute of Oceanography and Fisheries, Egypt.
2- Faculty of Aquaculture and Fisheries, El-Arish University, Egypt.
3- Fish Resources Department, Faculty of Environmental Agricultural Sciences, El-Arish University, Egypt.

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ABSTRACT

The black-barred halfbeak, *Hemiramphus far* is one of the popular fish in Bardawil lagoon which never studied before and its fishery status still unknown. The present study is undertaken to estimate some biological aspects and reproductive dynamics of the black-barred halfbeak in Bardawil lagoon. Otoliths were used for age determination and the maximum life span of this species was 4 years with the dominance of age group one in the catch. The length-weight relationship indicated a positive allometric growth for males and isometric growth for females. The overall sex ratio was 1:1.76 males to females. Monthly variations in maturity stages and gonado-somatic index revealed that this species spawn during May to July. The length at first sexual maturity (L_{m50}) was estimated at 23.1 cm. Number of ripe eggs fluctuated from 54250 eggs (21.6 cm total length) and 79250 eggs (29.2 cm total length).

INTRODUCTION

The lakes' fisheries are considered as one of the major source of fish production in Egypt. Many challenges are facing the lakes development and management which lead to serious decline in their catches and alter their catches composition (Mehanna, 2006 & 2013). Bardawil lagoon (Fig. 1) is a shallow hyper-saline lagoon with an average area of about 650 Km^2. It occupies much of the Mediterranean coast of Sinai and separated from the sea by a sandbar that varies in width between 100 m and 1 km. Bardawil lagoon is connected to the sea via two small natural inlets at its eastern extremity (Abo Salah and Boughaz Zaranik) and two man-made inlets (Boughaz I and II) (Salman, 2015). The fishing in the lagoon is seasonal starting in April and extends to the end of December. The Bardawil lagoon fisheries are operated on a small scale basis, utilizing small boats and limited technology which is comprised of trammel nets, trawl nets, shrimp and crab nets and hook and line (Khalil, 2006; Mehanna, 2006; Mehanna *et al.*, 2011; Farouk, 2014; Mehanna, 2014; Salman, 2015). It is an important source of local and economic fishes in North Sinai, and it plays an essential role in the fish production in Egypt, where it produces very economically important species of fishes such as sea bass, sea bream, sole, grey mullet, eel, meager and white grouper (GAFRD, 2017).

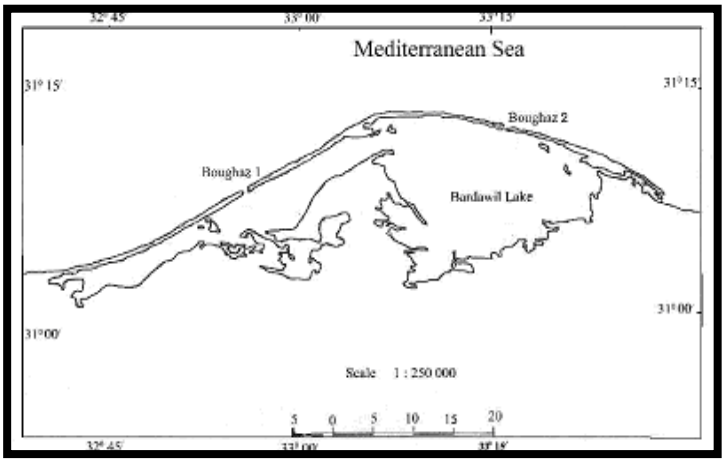

Fig. 1: Bardawil lagoon

The black-barred halfbeak (Family: Hemiramphidae) is one of the popular fish in Bardawil lagoon. It is forming a considerable amount of the fish production from the lagoon. In recent years, the demand on this species increased due to its reasonable market price that makes it appropriate for the local consumers. The needlefishes in Bardawil lagoon never studied and their fishery status still unknown. Therefore the present study will be aimed at estimation of some biological aspects and reproductive dynamic of the black-barred halfbeak, *Hemiramphus far* as an important step for assessing and managing this species in Bardawil lagoon.

MATERIALS AND METHODS

Sampling

Monthly random samples of black-barred halfbeak, *Hemiramphus far* were collected from the mixed catch of the main landing site at Bardawil lagoon. The sampling period lasted during the fishing season 2016 from April to December.

Measurements

The total length of 886 individuals of *Hemiramphus far* from the tip of the snout to the end of the caudal fin was measured to the nearest centimeter and the total weight was recorded to the nearest 0.1 gram. Sex and stage of maturity of each individual fish in the sample were recorded with naked eye. The ovaries were removed and weighed to the nearest 0.01 g then preserved in 10% formalin for further studies.

Length-weight relationship

Length –weight relationship was determined for males, females and combined sexes by using the following equation (Le Cren, 1951): $W = a L^b$ where W is the total weight in grams, L is the total length in centimeters and a & b are constants whose values were estimated by the least square method.

Coefficient of condition

The composite coefficient of condition "Kc''was calculated monthly in the period from April to December 2016 as $Kc = (W*100) / L^3$ (Hile, 1936)

While, the relative coefficient of condition "Kn" was calculated according to the following formula: $Kn = W / W^*$ (Le Cren, 1951)

Where W is the observed weight in g and W* is the calculated one.

Age determination

Otoliths of 886 individuals (420 males and 466 females) were removed, cleaned and stored dry in labeled vials. Annual rings on otoliths were counted using an optical system consisting of Nikon Zoom-Stereomicroscope focusing block, Heidenhain's electronic bi-directional read out system VRX 182, under transmitted light. The total radius of the otolith "S" and the distance between the focus of the otolith and the successive annuli were measured to the nearest 0.001 mm. The relationship between total length L and otolith radius S was calculated by least square method and represented by the equation: $L = a + b\ S$.

Where b is the slope of the regression line and the value of intercept (a) was used as a correction factor for back-calculated lengths.

The back calculated lengths at the end of each year of life from were estimated from otolith measurements by Lee's (1920) equation as $L_n = (L_t - a)\ S_n / S + a$

where: L_n is the length at the end of n years (cm), L_t is the total length at capture (cm), S_n is the otolith radius to the n^{th} annulus, S is the total otolith radius (mm) and a is the intercept with Y-axis from the relationship of length and radius.

Reproduction

Spawning season

In order to determine the spawning season, monthly variations in both of maturity stages and gonado-somatic index values were determined.

Monthly distribution of maturity stages

The gonads of 420 males and 466 females of *H. far* were used to evaluate the monthly variations in their maturity stages in Bardawil lagoon. Gonads were classified macroscopically according to a five-stage maturity index as a modification of Hjort (1910 and 1914) key.

Gonado- Somatic Index (GSI)

The gonado-somatic indices (GSI) were calculated by the equation of Bariche *et al.* (2003) as follows: GSI= Gonad Weight / Body Weight ×100

Sex ratio

Monthly sex ratio for different length groups was calculated.

Length at first maturity (L_m)

The length and age at first maturity (L_m), where 50% of fish reach their sexual maturity was estimated by fitting the maturation curve between the percentage maturities of fish corresponding to each length class interval. Then L_m was estimated as the point on the X-axis corresponding to 50% point on the Y-axis.

Fecundity

The absolute fecundity $F_{abs.}$ (the number of mature eggs in the ovaries during the spawning season) was calculated based on 38 mature ovaries of adult females with length range from 21.5 to 29.5 cm TL. The gonads were washed and dried, the subsamples were taken from the front, middle and rear sections of the ovaries. The ovarian tissue was removed and weighed to obtain the net eggs weight. The Subsamples weighed, and eggs were well mixed, and placed on Petri dish which was divided into squares. The eggs of four squares under the microscope were counted. The total number of eggs in the subsample were counted and then the total fecundity was calculated as:

F= (Gonad weight × Egg number in the subsample) / subsample weight) (Yeldan and Avsar, 2000). While, the relative fecundity (F_{rel}) was calculated as: $F_{rel} = F_{abs}$ /TL or Wt), where TL is the fish length and Wt is the body weight.

The relationship between the total length (TL) and fecundity can be described by the formula: F = a + b L, where a & b are constant whose values are determined by using the least squares method.

RESULTS AND DISCUSSION

The biological data such as age determination and length-weight relationship are considered key parameters required for population dynamics and stock assessments of fishes. Also, knowledge of reproductive biology of a fish species is essential for effective fishery management (Marshall *et al.,* 2003; Sun *et al.,* 2009). In the present study such data including age determination, LWR, condition factors, sex ratio, reproductive season, size at maturity and fecundity of *Hemiramphus far* from Bardawil lagoon are estimated.

Length-weight relationship

The parameters of the length-weight relationship (LWR) of fishes are of primary importance in fishery assessment and management (Garcia *et al.,* 2001). It provides estimates of total fish biomass even when length is only known and weight is practically not available. The LWR is also useful in assessing the relative well-being of the fish population. It is important in estimating the standing stock biomass, and comparing the ontogeny of fish population from different regions (Petrakis and Stergiou, 1995). Length-weight relationship parameters are often used as an indicator of fatness and general well-being or of gonad development of fish and are useful for between region comparisons of life histories of a specific species (Le Cren 1951; Wotton, 1990&1992). For the estimation of length-weight relationship of *Hemiramphus far* (males, females and sexes combined) collected from Bardawil lagoon, the least square method was applied. A total of 886 specimens of *H. far* (420 males and 466 females) their total length range was 16.7 - 30.0 cm for males, and was 17 - 30.5 cm for females, while their total weight ranged from 25.9 to 146 g for males and from 27 to 153 g for females. The obtained length-weight equations of *H. far* (Fig. 2) were:

$W = 0.003 * L^{3.2138}$ ($r^2 = 0.9385$) for males,

$W = 0.007 * L^{2.9432}$ ($r^2 = 0.9071$) for females

$W = 0.0046 * L^{3.0799}$ ($r^2 = 0.9251$) for sexes combined.

LeCren (1951) pointed out that the coefficient b in the LWR of fishes usually ranged from 2.5 to 3.5. In this study, the b-values of *H. far* were in this range. In the context of growth type with reference to slope, males exhibited positive allometry, while females and sexes combined displayed isometric growth. This suggests that majority of fishes in Bardawil lagoon exhibited high well-being.

In terms of the coefficient of determination (r^2), males and females of *H. far* attained values over than 0.90 indicating highly significant relationship of length to weight of this species in Bardawil lagoon.

Condition factors

In the present study, two kinds of condition factor were estimated; the composite coefficient of condition (Kc) and the relative condition (Kn). Monthly average values of Kn and Kc for the period from April to December 2016 as calculated from the observed total weight are represented in Figs. 3 and 4. It is obvious that both composite (Kc) and relative (Kn) condition factor follows the same trends of fluctuations in both males and females.

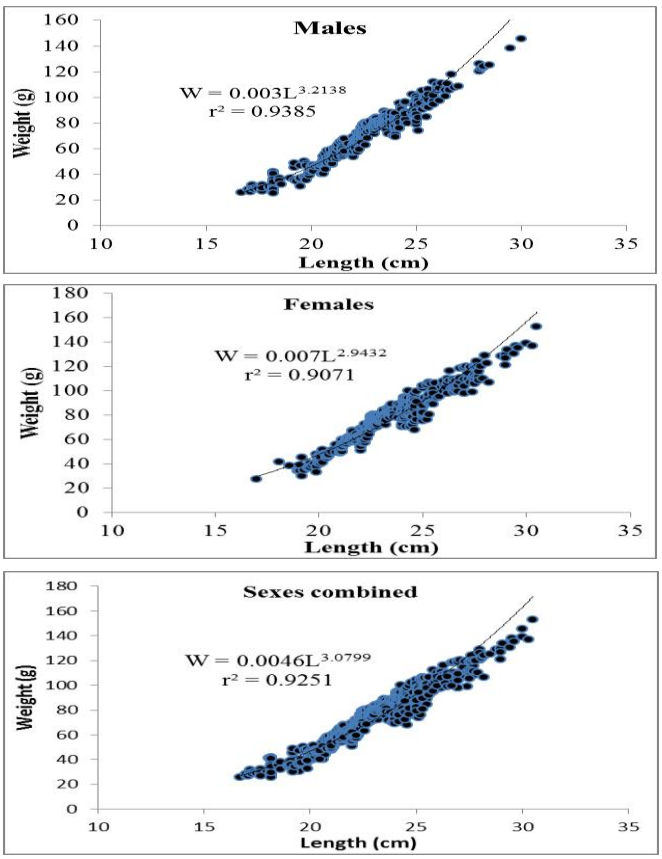

Fig. 2: Length-weight relationship of *Hemiramphus far* from Bardawil lagoon.

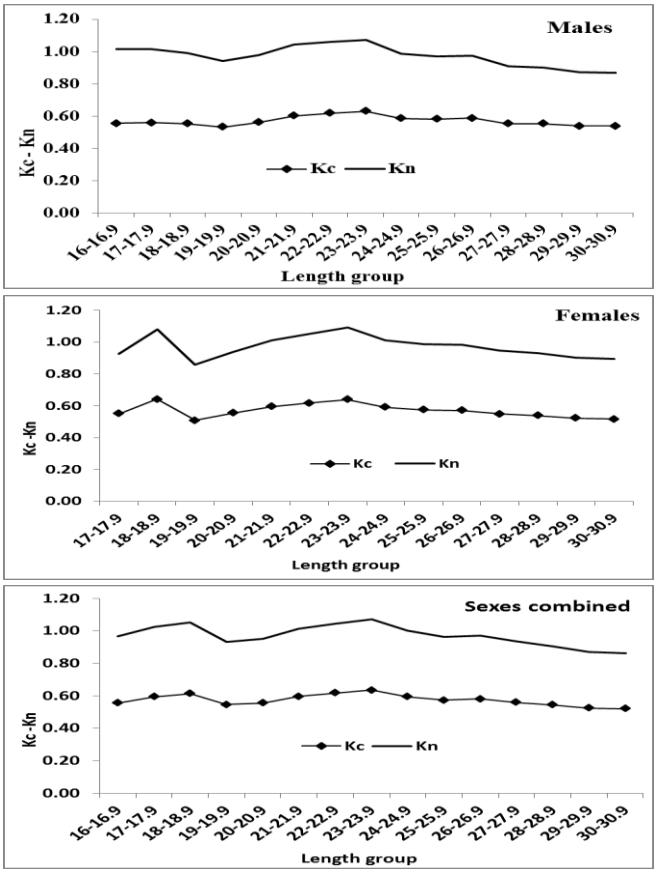

Fig. 3: Average Kc and Kn of *Hemiramphus far* according to length groups.

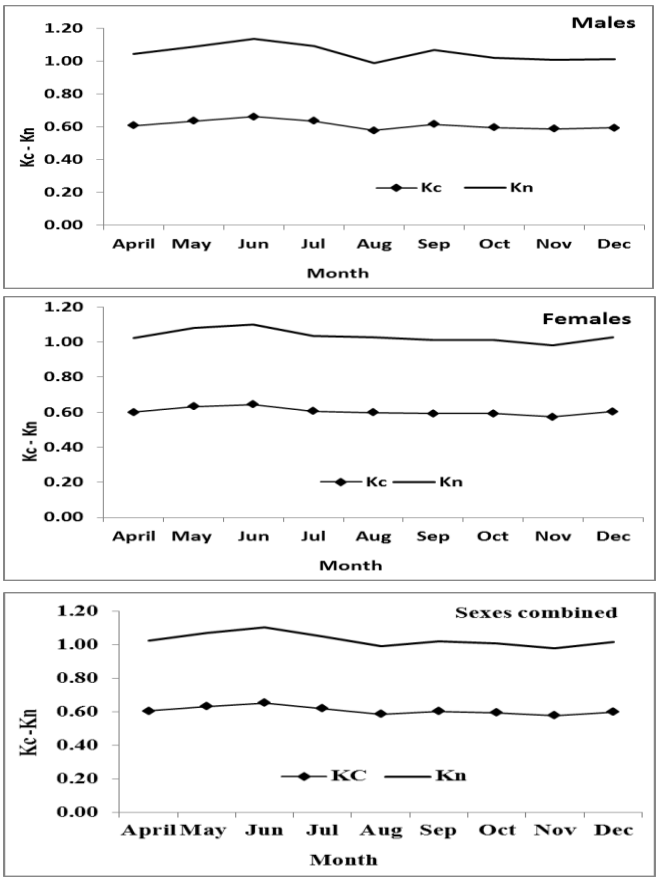

Fig. 4: Monthly variation of condition factor of *Hemiramphus far* from Bardawil lagoon.

Age determination

Age determination of fish is one of the most important prerequisite in the studies of population dynamics. It forms the basis for calculations leading to the knowledge on growth, mortality, and recruitment of fishes and also helps to assess the sustaining power of the fishery stock. Otoliths were used for age determination of *H. far* and the results showed that there is no differentiation between the two sexes. The longevity of males and females was found to be four years.

Body length – otolith radius relationship:

Otolith readings of 886 specimens of *H. far* (466 females and 420 males) caught during the fishing season 2016 from Bardawil lagoon were used for the construction of length-otolith radius relationship. The total length - otolith radius relationship was linear with high correlation (Fig. 5).

Back-calculation and Growth in length

The back calculated lengths were 19.30, 23.19, 26.43 and 28.71 cm for ages 1, 2, 3 and 4 years respectively for males and 19.86, 23.46, 26.66 and 28.89 cm for ages 1, 2, 3 and 4 respectively for females. On the other hand, the back – calculated lengths of sexes combined were 19.60, 23.33, 26.59, and 28.84 cm for ages 1, 2, 3 and 4 respectively. It was clear that the highest growth rate in length for both males and females occurred at the first year of life 19.30 and 19.86 cm for males and females respectively after which the annual increment decreases with further increase in age (Fig. 6).

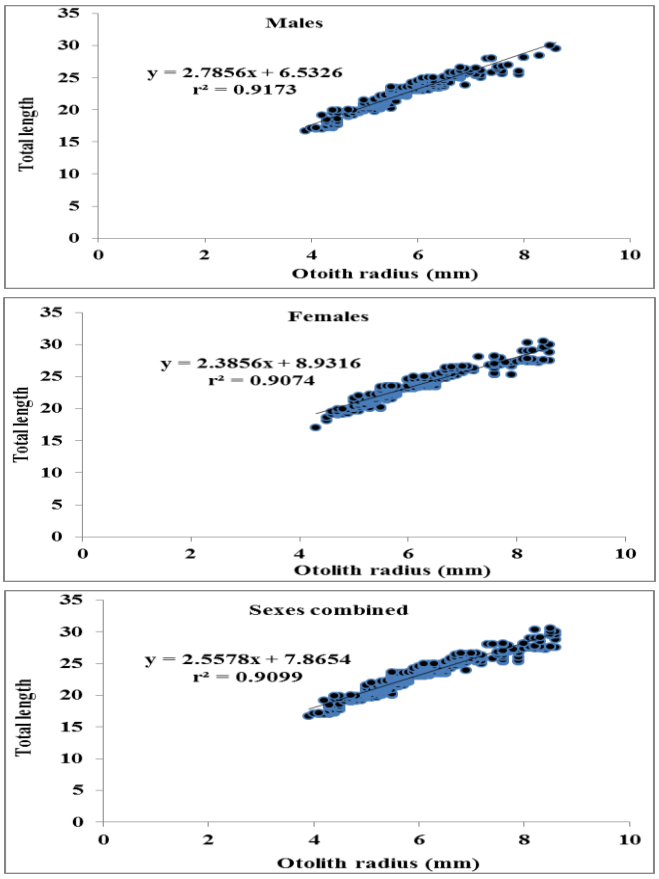

Fig. 5: Total length- otolith radius relationship of *Hemiramphus far*

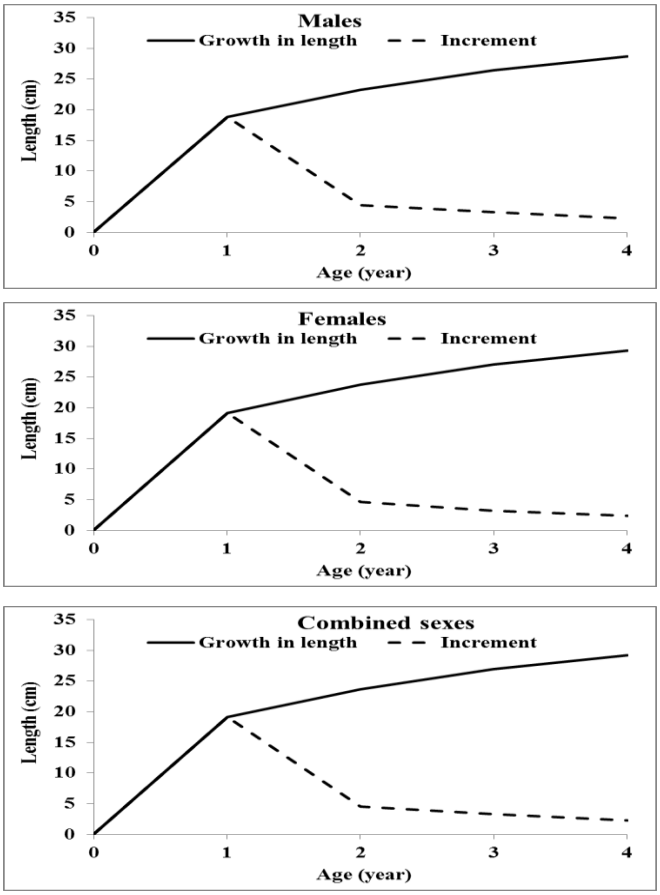

Fig. 6: Growth in length and annual increment of *Hemiramphus far* during 2016

Reproduction

Knowing the time of spawning is essential to protect both of the ripe females and the new recruits and to predict the recruitment variability. To determine the reproduction period of *H. far* from Bardawil lagoon, monthly variations in both of maturity stages and gonado-somatic index values were used.

Gonad maturation

Monthly pattern of gonadal activity showed occurrence of five maturity stages for females and males. For males and females, maturity stages I to III were dominated in all sampling months, while maturity stage IV (ripe and running stage) was appeared during late April to July. Stage V of maturation (spent stage) was recorded in July to September.

Gonado - Somatic Index (GSI):

Gonado-somatic index is one of the important parameter of fish biology, which gives the detail idea regarding fish reproduction and reproductive status of the species and help in ascertaining breeding period of fish (Gupta & Srivastava, 2001 and Shankar & Kulkarni, 2005). Monthly average gonado somatic index for both males and females of *H. far* (Fig. 7) increases progressively from April reaching its highest values during May to July with a peak in June for both sexes.

In the present study, gonads development and maturation of *H. far* occurred at highest water temperature (summer months) and this agree with the fact that gonad maturation and spawning season of fishes are correlated to environmental conditions especially water temperature (Coetzee, 1986 and Garratt, 1986).

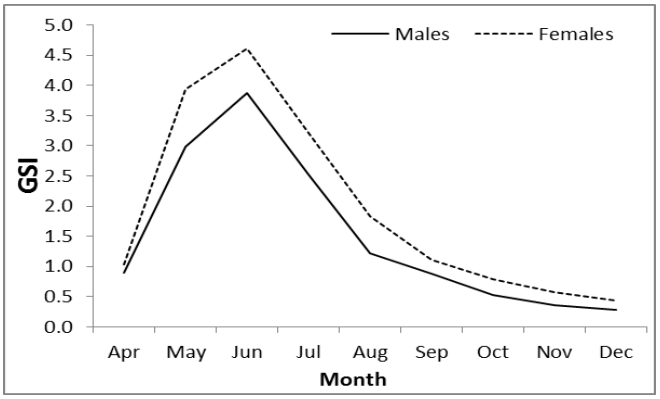

Fig. 7: GSI for *Hemiramphus far* (♀and ♂) in Bardawil lagoon during 2016.

Size at first sexual maturity

The length at first sexual maturity is important for determining the optimum length at first capture and consequently the optimum mesh size. The length at first maturity of *H .far* in Bardawil lagoon was estimated at 22.9 and 23.1 cm for males and females, respectively.

Sex ratio

The variations of sex ratio in *H. far* were studied monthly and according to the different length groups and months (Fig. 8). The sex ratio of *H. far* was fluctuated from length to length and from month to month with an overall ratio 1:1.76 males to females.

Fecundity

Fecundity estimation is useful in the estimation of population and its productivity. The knowledge of fish fecundity has much relevance in fish population studies and in successful management and exploitation of the fishery (Alam and Das, 1996). The relation between body size (total length and body weight) and fecundity

(absolute and relative) of *H. far* were calculated. The number of eggs gradually increased with the increasing of fish length or weight as fish of 21.6 cm (69.3 g) lays eggs about 54250 reaching maximum of about 79250 eggs for a fish of 29.2 cm (94.7g). The relative fecundity gradually increased from 783 to 837 eggs per g. The relation between fecundity and size was investigated and it was found that the best fitting for length-absolute fecundity and weight-absolute fecundity relationships is the straight line with the following equations: F_{abs} = 3907.2 L - 33678 and F_{abs} = 408.08 W +24213.

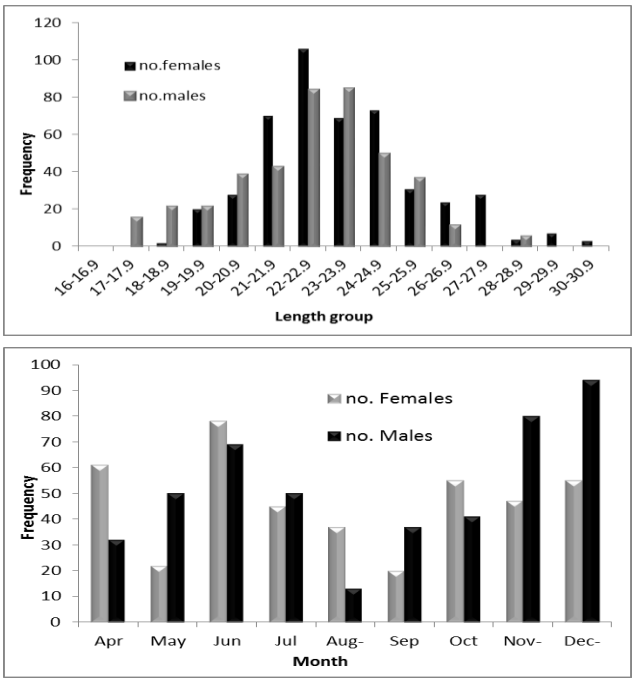

Fig. 8: Sex ratio according to length groups and month of *Hemiramphus far* in Bardawil lagoon during the fishing season of 2016.

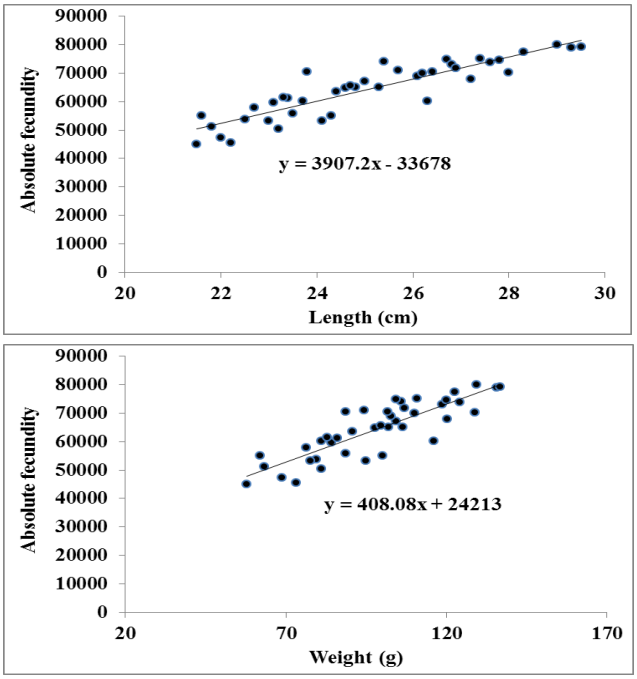

Fig. 9. Relationship between body length and weight (g) and Absolute fecundity of *Hemiramphus far* in Bardawil lagoon during the fishing season 2016

CONCLUSION

In conclusion, the study of reproductive dynamics revealed two important facts which should be considered through fisheries management of *H. far* in Bardawil lagoon, Egypt. Firstly, the spawning period for the species extends from May to July which occurs during the beginning of fishing season in the lagoon which consider the most active period of fishing. Secondly, a considerable percentage of the catch comprises fish don't reach their first sexual maturity and don't contribute in spawning. Accordingly, it is recommended to reconsider timing of fishing and closed season to protect *H. far* during its spawning season. In addition, detailed study concerned gear selectivity should be done to find the proper mesh size which guarantees the contribution of a considerable part of the stock of *H. far* during the spawning season.

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