

## Age, growth and mortality of the Bartail Flathead (*Platycephalus indicus*) in Bardawil lagoon, North Sinai, Egypt.

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### ABSTRACT

Age, growth, and mortality of bartail flathead (*Platycephalus indicus*) were studied from a small scale fishery of Bardawil lagoon, North Sinai, Egypt. A total of 947 specimens of *Platycephalus indicus* varied from 17.9 to 52.1 cm TL with weights ranging between 27.6 and 1003.7 g were collected from August to December during two fishing seasons 2019-2020. A subsample of 654 specimens was taken for age determination using otoliths readings. The relationship between length and weight was  $W = 0.002 L^{3.3402}$  ( $R^2 = 0.98$ ) indicating a positive allometric growth. Age was determined and age groups 0 to 5 years were observed. Growth in length and weight at the end of each year of life were calculated. The growth parameters of von Bertalanffy equation was calculated as  $L_{\infty} = 59.98$  cm TL,  $K = 0.34 \text{ yr}^{-1}$ ,  $t_0 = -0.44$  year and  $W_{\infty} = 1737.9$  g. Growth performance index was calculated as  $\phi = 3.09$  for length and  $\phi = 1.69$  for weight. Mortality rates were  $1.152 \text{ yr}^{-1}$ ,  $0.482 \text{ yr}^{-1}$  and  $0.67 \text{ yr}^{-1}$  for total, natural and fishing mortality, respectively. The current exploitation rate (E) was 0.583 for both sexes combined.

### INTRODUCTION

Bardawil lagoon is a large hypersaline coastal lagoon on the Mediterranean coast of Sinai, Egypt. Although it is shallow and oligotrophic (Touliabah et al., 2002), it is one of the most important lakes in Egypt as a source of good quality fish and a habitat for wildlife (Khalil and Shaltout, 2006; Mehanna, 2006a,b,c). The lagoon is considered the main ecological and economic natural resource in North Sinai region (Mehanna, 2006b; Mehanna, 2013; Mehanna et al., 2020).

The family Platycephalidae consists of approximately 80 species from 18 genera (Nelson et al., 2016). *Platycephalus indicus*, *P. scaber* and *P. macracanthus* are three famous species from the flathead family and the percentage of density of *P. indicus* is always high compared to others (Yeragi and Yeragi, 2014). This species has an important role in fisheries economy and it is a target species for capture in many places around the world (Parsamanesh et al., 2000). *P. indicus* is a benthic fish found on sandy beds in shallow areas, and opportunists carnivores (Yeragi and Yeragi, 2015).

To estimate the biomass of different fish populations, it is necessary to know the length-weight relationships (LWRs) of the studied species (Mehanna and Farouk, 2021). The length-weight relationship is very crucial in estimating the standing stock biomass and discusses the development history of fish population from various regions (Petraakis and Stergiou, 1995). It is an important fishery management tool and it is very beneficial for cultivators and fisheries managers to determine the growth of the species (Nandikeswari *et al.*, 2014b).

Age and growth is a vital component for understanding the ecology and life history of any fish species. It can be used to compare dynamics among water bodies, years, and fish sizes; describe trends over time; examine total mortality rates; and determine the general status of a population. Age is one parameter necessary to assess population dynamics and the state of exploited resources (Allain and Lorance, 2000).

Current work investigates age, growth and mortality of *Platycephalus indicus* in Bardawil lagoon. This work is the first attempt to study the age and growth as well as to estimate the mortality and exploitation rates of this species in Bardawil lagoon. This information is essential for future assessing the fishery status of this fish stock.

## MATERIALS AND METHODS

### 1. Study area

Bardawil lagoon (Fig. 1) is one of the largest salt water lagoons in the northern coast of Sinai province of Egypt. It is one of the most important fishing grounds in Egypt, since it is the largest and almost free of pollution lagoon in Egypt (El-Bokhty and El-Aiatt, 2014). Bardawil lagoon is a natural depression and covers an area of  $\approx 650 \text{ km}^2$  with a depth of 0.3 to 3 m (EEAA, 2008).



Fig. 1. A map of Bardawil lagoon.

### 2. Sampling

Monthly, random samples of bartail flathead (*Platycephalus indicus*) were collected from the mixed commercial catch of the main landing site at Bardawil lagoon. Total of 947 specimens of *P. indicus* varied from 17.9 to 52.1 cm total length with weights ranging between 27.6 and 1003.7 g were collected from August to December during two fishing seasons 2019-2020. The total length of *P. indicus* from the tip of the snout to the

end of the caudal fin was measured to the nearest centimeter, total weight to the nearest 0.1 gram was recorded for each specimen. Otoliths were removed from 654 specimens for age determination.

### **3. Methods**

#### **3.1 Age determination**

For age determination, 654 specimens as subsample were dissected and the otoliths were removed. In the present study, it was difficult to collect scales, since the scales of *P. indicus* are small and loosely embedded structures with hardly visible annual marks. Otoliths were cleaned by 8 % HCl, and then dried. For reading, the otoliths were cleared in a mixture of 50% ethyl alcohol and 50% glycerin and they were examined using microscope.

#### **3.2 Total length - otolith radius relationship**

The relationship between total length and otolith radius was calculated for all fishes as follows:  $L = a + b S$ , where  $L$  is total length of fish in cm;  $S$  is the otolith radius in mm;  $a$  and  $b$  the constant representing the intercept and the slope of the straight line respectively.

#### **3.3 Back-calculations**

Lengths by age were back-calculated using (Lee's, 1920) equation as follows:  $L_n = a + (S_n/S)*(L_c - a)$ , where  $L_n$  = length of fish at age "n",  $S_n$  = the otolith radius to "n" annulus,  $S$  = total otolith radius,  $L_c$  = fish length at capture and  $a$  is the intercept of the relation.

#### **3.4 Length-weight relationship**

The relation between the total length ( $L$ ) and total weight ( $W$ ) was computed using power equation as  $W = a L^b$  (Le Cren, 1951), where:  $a$  and  $b$  are constants whose values were estimated by the least square method

#### **3.5 Von Bertalanffy growth parameters**

Theoretical growth in length and weight was obtained by fitting the von Bertalanffy growth model, using the (Ford, 1933; Walford, 1946) method. Von Bertalanffy (1949) for theoretical growth in length can be written in the form:

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

Where:  $L_t$  = the length at age  $t$ ,  $L_\infty$  = the asymptotic length,  $K$  = growth coefficient and  $t_0$  = age at which the length is theoretically nil.

#### **3.6 Growth performance index ( $\phi$ )**

The growth performance index ( $\phi$ ) for length was estimated as:  $\phi = \log K + 2 \log L_\infty$  (Pauly and Munro, 1984), where:  $K$  and  $L_\infty$  are parameters of von Bertalanffy growth model).

#### **3.7 Mortality and exploitation rates**

The total mortality coefficient ( $Z$ ) was estimated using the linearized catch curve based on age composition data where  $Z = -b$ . The natural mortality coefficient ( $M$ ) was calculated by Hewitt and Hoenig formula (2005) as  $M = 4.22/t_{max}$  where  $t_{max} = 3/k$ , while the fishing mortality coefficient ( $F$ ) was calculated as  $F = Z - M$ . The Exploitation rate ( $E$ ) was calculated after Gulland (1971) as  $E = F/Z$ .

## RESULTS AND DISCUSSION

### 1. Length-weight relationship

The length-weight relationships can be used for forecasting both the potential yield and determining the most favorable size of capture to obtain optimum yield; these management parameters are directly related to the weight of the fish (Suresh *et al.*, 2006). Length and weigh relationship in conjunction with age data can give information on the stock composite, age at maturity, life span, mortality, growth and production. The relative robustness or degree of well-being of a fish expressed as the coefficient of condition (condition factor) is an important tool for the study of fish biology, mainly when the species lies at the base of the higher food web (Diaz *et al.*, 2000). The Length weight relationship is important for comparative growth studies (Moutopoulos and Stergiou, 2002; Mehanna and Farouk, 2021).

In the present study, the total length of the investigated species *P. indicus* was varied from 17.9 to 52.1 cm with weights ranging between 27.6 and 1003.7 g. LWR of *P. indicus* (combined sexes) is presented in Fig. (2) and the equation derived from this relationship is as follows:  $W = 0.002 L^{3.3402}$  ( $R^2 = 0.98$ ).

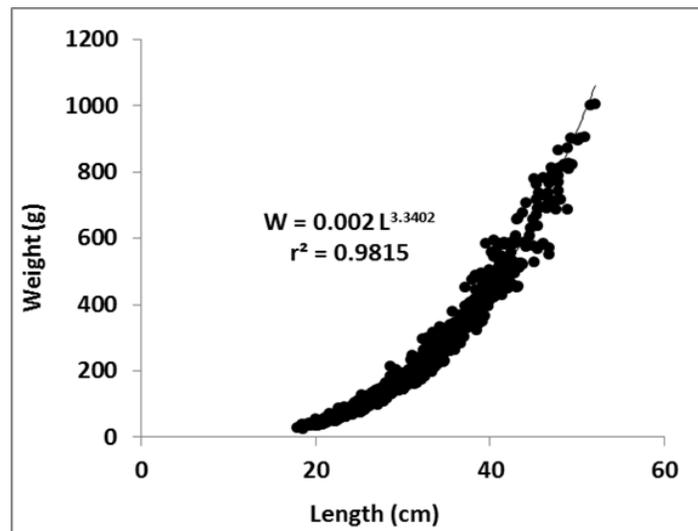


Fig. 2. Length-weight relationship of *P. indicus* (♀♂) from Bardawil lagoon

The relationship equation showed a positive allometric where  $b > 3$  ( $b = 3.3402$ ). This result agrees with (Bawazeer, 1989; Alberto *et al.*, 2003; Hashemi *et al.*, 2012; Mohammadikia *et al.*, 2012; Mohammadikia *et al.*, 2013; Sabet, 2015; Adeleh *et al.*, 2015; Samir and Akel, 2016; Akita and Tachihara, 2019; Hajjalizadeh *et al.*, 2019). All these researchers found that, the value of (b) of bartail flathead *P. indicus* was positive allometric ( $b > 3$ ) in different places. On the other hand, the b value in this study was higher than that recorded by (Naik *et al.*, 1990) where they found that, the values of (b) for the same species equals 2.99 for males and 2.91 for females in Indian waters, and also higher than that recorded by (King, 2007) in Queensland, Australia where the values of (b) was 3.

The variation of b in the different regions could be due to the seasonal fluctuations in environmental parameters, physiological conditions of the fish at the time of collection,

sex, gonad development and nutritive conditions in the environment of fish (Biswas, 1993; Mehanna and Farouk, 2021)

## 2. Total length-otolith radius relationship

The mean fish length and the average otolith radii per each length group are given in Table (1) and represented in Fig (3). The total length-otolith radius relationship is a straight line and expressed as:  $Y = -3.48 + 15.58 X$  with  $R^2 = 0.95$ .

**Table 1.** Fish frequency, mean length and mean otolith radii of *P. indicus* (sexes combined) collected from Bardawil lagoon during two fishing seasons 2019-2020

Length group (cm)	Combined sex		
	Frq.	Mean length cm	Average otolith radius
17-17.9	1	17.9	1.4
18-18.9	3	18.4	1.5
19-19.9	7	19.4	1.5
20-20.9	13	20.3	1.6
21-21.9	18	21.4	1.7
22-22.9	20	22.4	1.7
23-23.9	18	23.4	1.8
24-24.9	19	24.3	1.8
25-25.9	19	25.5	1.9
26-26.9	41	26.4	1.9
27-27.9	39	27.5	2.0
28-28.9	37	28.4	2.1
29-29.9	33	29.4	2.1
30-30.9	49	30.4	2.2
31-31.9	44	31.4	2.2
32-32.9	46	32.4	2.3
33-33.9	36	33.5	2.4
34-34.9	28	34.4	2.5
35-35.9	32	35.5	2.5
36-36.9	19	36.5	2.6
37-37.9	17	37.5	2.6
38-38.9	16	38.4	2.7
39-39.9	15	39.4	2.7
40-40.9	9	40.5	2.8
41-41.9	13	41.4	2.9
42-42.9	17	42.3	2.9
43-43.9	7	43.4	3.0
44-44.9	4	44.4	3.0
45-45.9	8	45.4	3.0
46-46.9	10	46.4	3.2
47-47.9	7	47.5	3.3
48-48.9	3	48.5	3.3
49-49.9	3	49.3	3.4
50-50.9	1	50.3	3.5
51-51.9	1	51.5	3.6
52-52.9	1	52.1	3.6
SUM	654		

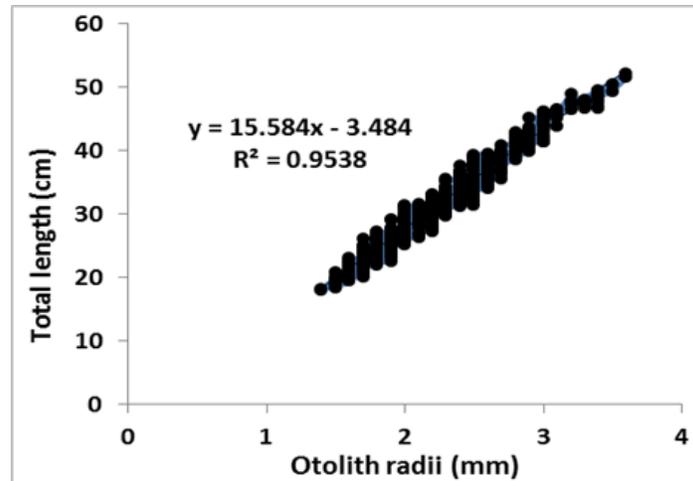


Fig. 3. The relationship between total length (TL) and otolith radius of *P. indicus* (♀♂) from Bardawil lagoon

### 3. Age composition

The age composition of *P. indicus* in Bardawil lagoon during two seasons 2019 - 2020 was determined by counting the annual rings on otoliths of 654 specimens. Five age groups were observed with percentage of fishes of each age group are shown in Fig.(4). The results showed that age group I is the dominant age group in the catch contributing 35.3%, while age group V was the lowest one in the catch of *P. indicus* in Bardawil lagoon. The present results compared with the previous ones are shown in Table (2). In this study, the results of age composition are lower than those reported by other authors, where all authors found more than five age groups for the same species in different places.

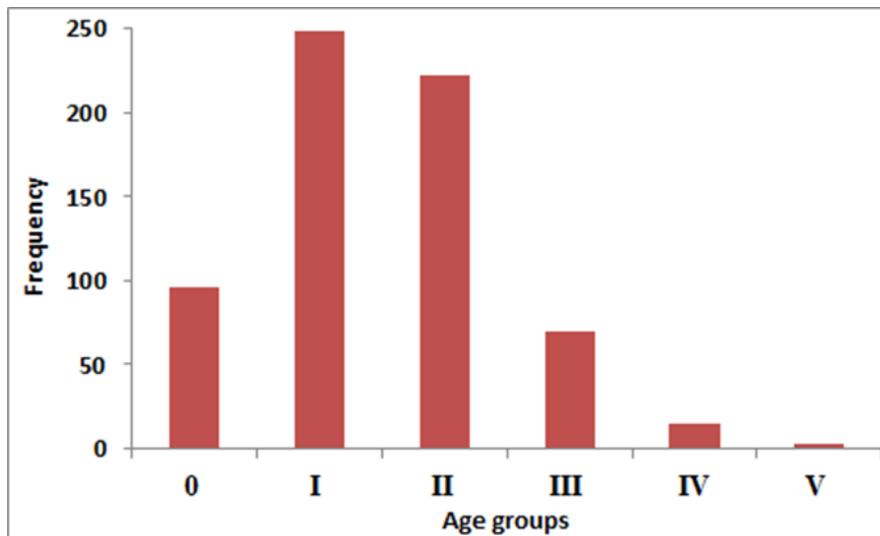


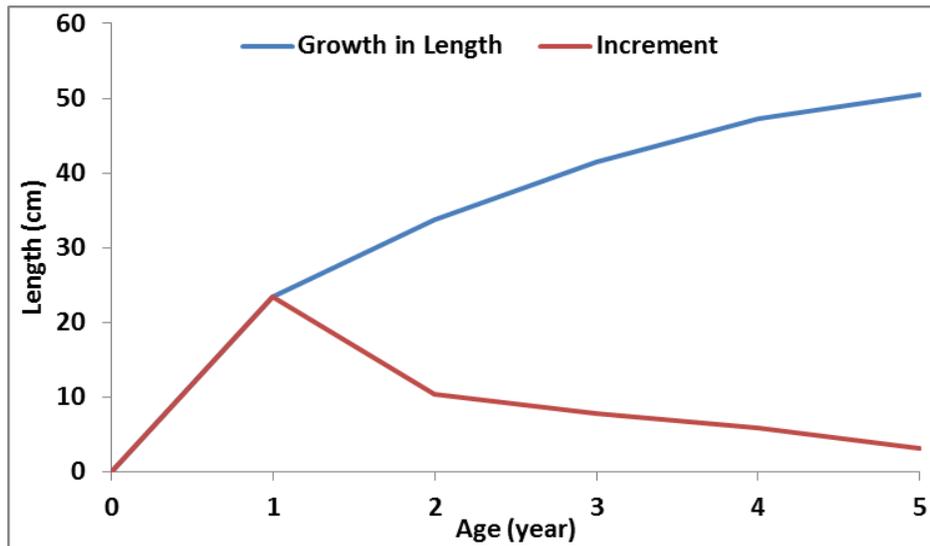
Fig. 4. Age composition of *P. indicus* (combined sexes) from Bardawil lagoon

**Table 2.** The age composition of *P. indicus* recorded in previous and present studies.

Region	sex	Age estimation method	Maximum age (Year)	Authors
Persian Gulf in Kuwait waters	♂	otoliths method	6	Bawazeer, 1989
	♀		7	
Coastal waters off west Kyushu, Japan	♂	otoliths method	11	Masuda <i>et al.</i> , 2000
	♀		16	
Coastal waters of Bandar Abbas	♂	otoliths method	4	Mohammadikia <i>et al.</i> , 2013
	♀		7	
Coastal waters of Bandar Abbas	♂	otoliths method	4	Mohammadikia <i>et al.</i> , 2014
	♀		7	
The waters around Okinawa-jima Island, Japan	♂	otoliths method	7	Akita and Tachihara, 2019
	♀		7	
Bardawil lagoon	♂♀	otoliths method	5	Present study

#### 4. Growth in length and weight

The growth in length and growth increment of the different years of life are given in Figure (5). It is clear that the highest growth in length is occurred at the first year of life. The annual increment decreases with further increase in age. The average back – calculated length of combined sexes are 23.4, 33.7, 41.5, 47.3 and 50.5 cm for ages 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> years of life, respectively. The highest increment occurred during the first year of life, while it decreases in the second year, reaching its minimal value during the fifth year of life.

**Fig. 5.** Growth in length and annual increment of *P. indicus* (♂♀) collected from Bardawil lagoon

The increasing in weight is very important than increasing in length for fishermen, where the landings are recorded as a weight. Calculated weights at the end of each year of life of *P. indicus* from Bardawil lagoon were estimated by applying the length-weight

relationship. The calculated weights of combined sexes of *P. indicus* were 74.9, 253.29, 507.73, 785.96 and 978.06 g at the end of 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> years of life, respectively.

Figure (6) shows the growth in weight and the annual increment for the sexes combined of *P. indicus* from Bardawil lagoon. The results showed that the weight increased successively and reached its maximum at age group IV.

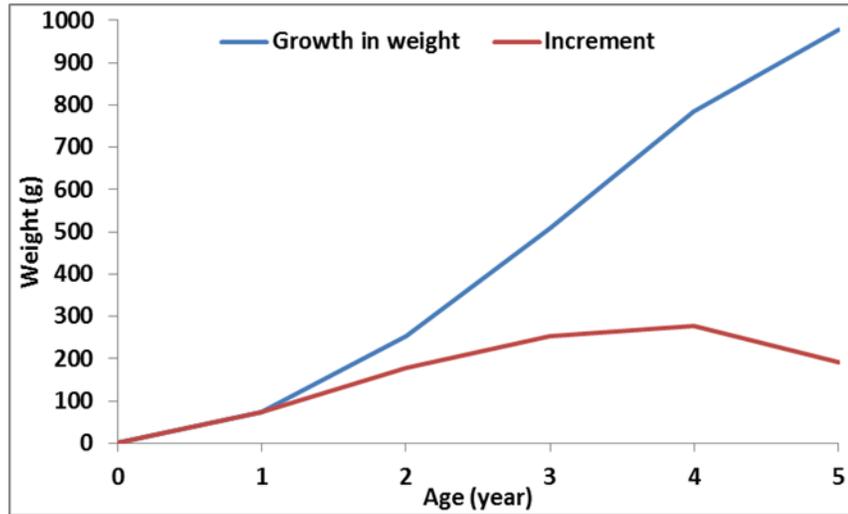


Fig. 6. Growth in weight and annual increment of *P. indicus* (♀♂) from Bardawil lagoon.

### 5. Growth parameters

The von Bertalanffy growth parameters of bartail flathead (*P. indicus*) were estimated as follow;  $L_{\infty} = 59.98$  cm,  $K = 0.34$  yr<sup>-1</sup>,  $t_0 = -0.44$  year and  $W_{\infty} = 1737.92$  g. The von Bertalanffy equations for growth in length and in weight of *P. indicus* were estimated to be as follows:

$$L_t = 59.98 \left[ (1 - e^{-0.34(t+0.44)}) \right]$$

$$W_t = 1737.92 \left[ (1 - e^{-0.34(t+0.44)}) \right]^{3.3402}$$

Tirasin (1993) and McIlwain *et al.* (2005) indicated that, growth parameters differed depending on species, population, age groups in the same population, maturity, sampling period for the same species and even sexes. So the differences observed in different locations may be accepted (Table 3).

Growth performance index ( $\phi$ ) of the same species reflects its adaptations to the environment factors. The obtained results indicated that the growth performance index of *P. indicus* was 3.09 for length. The  $\phi$  in this study was higher than that estimated by (Bawazeer, 1989) in Kuwait waters where he found that, the  $\phi$  for the same species equals 2.91, and also  $\phi$  was higher than (Hashemi *et al.*, 2014) in Iran, they found  $\phi$  equals 1.19. The  $\phi$  in this study was less than (Akita and Tachihara, 2019) in Japan where they found that, the  $\phi$  for the same species equals 3.26 (Table 3). Thus, it could be reported that the environmental condition of Bardawil lagoon is suitable for the growth of *P. indicus* under study. Such differences may be attributed partially to the different techniques used, but more likely reflect slight environmental differences such as food availability, Salinity and temperature (Pauly and Munro, 1984).

**Table 3.** Growth parameters ( $L_{\infty}$ , K and  $t_0$ ) and the growth performance index ( $\phi$ ) for *P. indicus* in different localities

Region	sex	$L_{\infty}$	K	$t_0$	$\phi$	Authors
Persian Gulf in Kuwait waters	♂	39.4	0.38	-0.858	2.77	Bawazeer, 1989
	♀	55	0.34	-0.537	3.01	
	♀♂	48.9	0.34	-0.64	2.91	
Japan	♂	43.03	0.667	-0.093	3.09	Masuda <i>et al.</i> , 2000
	♀	55.15	0.478	-0.125	3.16	
Persian Gulf, Iran	♂	43.4	0.46	-0.328	2.94	Mohammadikia <i>et al.</i> , 2014
	♀	63	0.5	-0.3	3.30	
Northwest of Persian Gulf, Iran	♂	59	0.52	-0.26	1.2	Hashemi <i>et al.</i> , 2014
	♀	64.14	0.36	-0.37	0.91	
	♀♂	62.16	0.5	-0.26	1.19	
Japan	♂	53.6	0.68	-0.379	3.29	Akita and Tachihara, 2019
	♀	72.6	0.48	-0.358	3.40	
	♀♂	67.52	0.4	-0.76	3.26	
Bardawil lagoon	♀♂	59.98	0.34	-0.44	3.09	Present study

## 6. Mortality and exploitation rates

In the present study, total mortality ( $Z$ ) of *P. indicus* from Bardawil lagoon, Egypt was  $1.15 \text{ yr}^{-1}$ , natural mortality ( $M$ ) was  $M = 0.48 \text{ yr}^{-1}$  and fishing mortality ( $F$ ) was  $0.67 \text{ yr}^{-1}$  for combined sexes. Also, the exploitation rate "E" of bartail flathead was calculated as 0.58 for both sexes.

The present  $Z$  and  $M$  values are lower than those obtained by (Hashemi *et al.*, 2014) ( $Z = 2.59$ ,  $M = 0.77$  and  $F = 1.28 \text{ yr}^{-1}$ ) for the same species in Northwest of Persian Gulf, Iran and Mohammadikia *et al.* (2014) who estimated total mortality ( $Z$ ) of *P. indicus* from the Persian Gulf, Iran as  $1.62 \text{ yr}^{-1}$  for males and  $1.43 \text{ yr}^{-1}$  for females, and estimated natural mortality ( $M$ ) as  $M = 0.736 \text{ yr}^{-1}$  for males and  $0.886 \text{ yr}^{-1}$  for females. Also, they calculated fishing mortality ( $F$ ) as 0.884 for males and 0.544 for females.

This difference can be explained by a very high fishing effort and a high natural mortality. Concerning mortality estimates, comparison is difficult because of scarcity of data and the total mortality coefficient is not a species-specific parameter, but an area specific parameter. These results could be explained by a high predation or other natural causes affecting fry and juveniles. Mortality parameters depend on both physiological factors (disease, old age, etc.), environmental factors (temperature, currents ...) (Christensen and Pauly, 1997).

The exploitation rate was estimated at 0.58 indicating that species still in healthy condition and working around the optimum exploitation.

## CONCLUSION

In conclusion, this paper highlights the basic data on the age, growth, mortality and exploitation rates of *Platycephalus indicus* in Bardawil lagoon for the first time. Results give a full information which will be considered through the management of *P. indicus* in

Bardawil lagoon. Results are still need further data analysis on reproductive biology, yield per recruit and recruitment pattern that may help in suggesting a management plan for such valuable fish. So, it is recommended to make a detailed study concerned gear selectivity, all biological and dynamical aspects as well as the catch and effort data to be make sure that the stock of *P. indicus* in Bardawil lagoon is exploited rationally.

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