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Spawning cycle, GSI index and length maturity of Deep flounder in northwest of Persian Gulf, Iran

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Abstract

During this study from December 2009 to November 2011, 363 Deep flounder fish were caught and their weights and lengths were measured. Total number of caught fishes included: 18 males, 200 females and 155 immature fishes. The mean, maximum and minimum total lengths were 264 ± 57, 415, and 115 mm, respectively. The mean, maximum and minimum total weights for this species were 238 ± 150, 827, and 14 g, respectively. The length-weight relationships were calculated as $W = 0.000007FL^{3.09}$ (n = 200, R^2 = 0.96) for females, $W = 0.00002FL^{2.90}$ (n = 18, R^2 = 0.94) for males and $W = 0.000009FL^{3.04}$ (n = 363, R^2 = 0.96) for total fishes verifying calculated b with 3, using Students t-test. There was no significant difference between calculated b and 3, and growth pattern was isometric. The mean values of condition factor (K), hepatosomatic index (HIS) and gonadosomatic index (GSI) were 1.25 ± 0.43, 1.13 ± 0.04, and 1.14 ± 0.97 for total fishes, respectively. The highest values of K, HIS, and GSI were observed in February, August and April; whereas the lowest values were observed in January, December and January. Mean GSI value indicated that spawning time were occurred during April to May. Using one-way ANOVA Test, the relationship between GSI index and temperature and salinity was significant. The mean size at first sexual maturity (Lm) was 237 mm for total fishes.

Key words: Deep flounder, Gonado somatic index, Hepatosomatic index, condition factor

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Introduction

Persian Gulf is one the most important gulf in the world from fishing industries point of view. Iran, Iraq, Saudi Arabia, Kuwait, Oman, Qatar, and Emirates are located in the coast of this gulf (Hashemi et al., 2011). The Persian Gulf is a semi enclosed sea that laying almost between the latitudes of 25^0-32^0 N and longitudes of 48^0-56^0 E. This water basin is shallow continental shelf and average of depth was 35 m, which is increasing from Arvend estuary and reach to maximum in strait of Hormuz Strata (Hashemi et al., 2011). The proper assessment and management of a fishery requires an understanding of the biology, life cycle and distribution of the species on which it is based (King, 2007).

The Deep flounder, *Pseudorhombus elevatus* (ogilby, 1912) is a member of the family Paralichthyidae and is widely distributed throughout the Indo-West Pacific, from the Red Sea and East Africa to Japan and New Caledonia. Adults are found in shallow coastal waters and the diet of this species consists of bottom-living animals. Consequently, it is exploited throughout its range with a variety of gears, including trawels (Fischer and Bianchi, 1984). This species has a gonochoristic reproductive mode and spawning occurs annually with one clear seasonal peak during April to June (Hashemi et al., 2011).

Because of its important role in economy of Khuzestan fishery and also in Persian Gulf region countries, this fish is a target species for capture. Different aspects of biological parameters of Deep flounder have been studied in Persian Gulf by Bawazeer (1989) in Kuwait waters. However, no study so far has been made on this species biology in Khuzestan Coastal Waters (northwest of Persian Gulf).

The objective of this study was to provide information pertaining to reproductive biology of this species in northwest of Persian Gulf (Khuzestan Coastal Waters, Iran) which is the first complete present of reproductive characteristics based on observation and information analysis. These data can be used to better fisheries stock management for this valuable fish.

Material and Methods

The main fishing areas of *P. elevatus* in the northwest of Persian Gulf are located in Liphe-Busafe and Bahrekan fishing area between 29° 44' to 07 'N and 48° 45' to 49° 50' (Fig. 1). A total number of 469 individuals of *P. elevatus* were captured during 2009 to 2011 using bottom trawl and gill net. Also, they were collected from recreational fishermen and then transferred in ice box to the laboratory. Monthly water samples for analysis of environmental parameters (salinity (ppt) and temperature (°C)) were collected from each station using a Nansen bottle sampler and were analyzed using standard analytical procedures (Clesceri et al., 1989). In the laboratory, Fork length (± 1.0 mm), sex, and weight (± 0.001 g wet weight) were recorded for each fish. Parameters of the length weight relationships were obtained by fitting the power function $W = a \times FL^b$ to length and weight data; where: W is the total wet weight, “a” is constant and was determined empirically, and FL is the fork length (Biswas, 1993). In order to verify if calculated b was significantly different from 3, the Students t-test was employed (Zar, 1996).

The condition factor (K) equation $K = W \times 10^2 / L^3$ was used to find fish status changes in which W = weight and L = total length, and hepatosomatic index (HIS) was calculated as follows (Biswas, 1993): $HSI = LW \times 10^2 / BW$; where LW = liver weight (g); BW = body weight (g).

The maturity stage for males and females was determined macroscopically using a 7-stage maturity key (kesteven, 1960). These stages included: virgin (I), maturing virgin (II), developing (III), late developing (IV), gravid (V), spawning (VI), and spent (VII).

Gonadosomatic index (GSI), calculated by expressing the mean gonad weight as a proportion of the total body weight (Biswas, 1993). The mean size at first sexual maturity was estimated for females by fitting the logistic function to the proportion of mature fish in 3-cm (FL) size categories $Y = 1/1 + \exp(-a\text{-}bX)$, in which Y is the proportion of the number of all mature male and females to all immature males and females in the same length class, X is total length in cm and a and b are correlation constants (King, 2007)**.** The mean size at first maturity was taken as that at which 50% of individuals were mature. Comparison of GSI values during reproductive period, HIS and K between sexes, and its temporal variation in each sex carried out by analysis of variance (ANOVA). Statistical analyses were performed with SPSS 14 software package and a significance level of 0.05 was adopted.

Results

During December 2009 to November 2011, a total number of 369 *P. elevatus* species were captured in main fishing areas of Khuzestan province and the main fishing areas of *P. elevatus* in northwest of Persian Gulf which are located in Liphe-Busafe and Bahrekan fishing area between 29° 44' to 07 'N and 48° 45' to 49° 50' (Fig. 1).

From the total number of caught fishes, 16 were males and the remaining were females, whereas 117 of total samples collected were immature. According to table 1, mean ± SD length values for this species were 264 ± 57 and maximum and minimum total length were 115 mm and 415 mm, respectively. Mean ± SD weight values were 238 ± 150 g and maximum and minimum weights were 14 and 827 g, respectively. Average length and weight in females were higher than in males (Table 1). The length-weight relationship was calculated as $W = 0.00002\ FL^{2.90}$ ($n = 18$, $R^2 = 0.94$) for males,

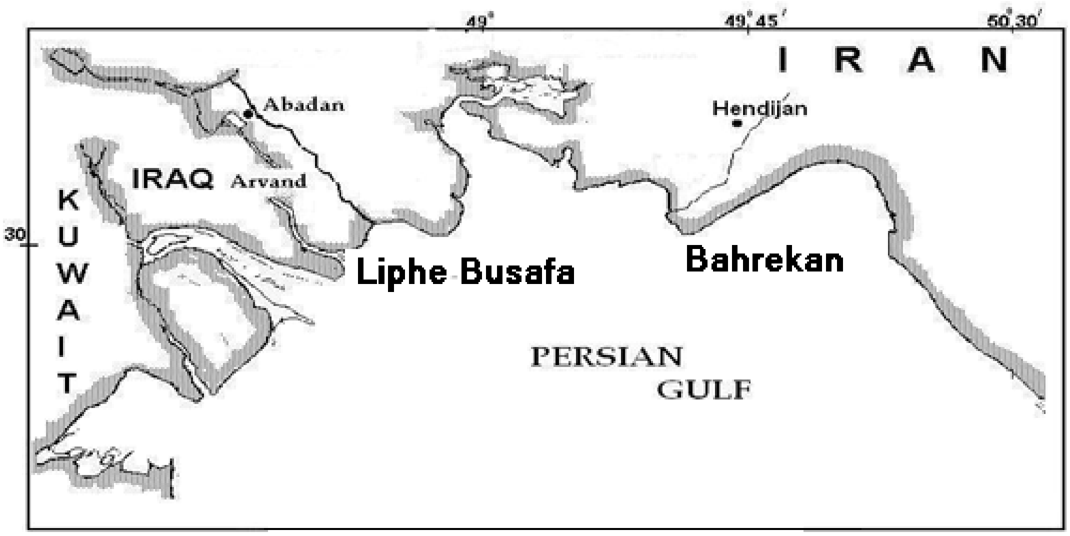

Figure 1. Location of two landing sites of Deep flounder in Khuzestan Coastal Waters (Iran)

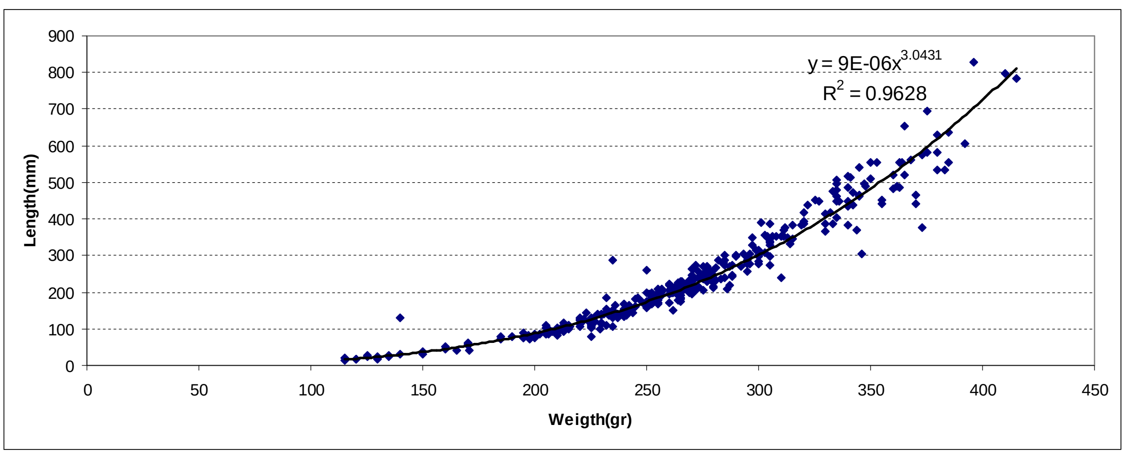

Figure 2. The length-weight relationship curve for total fish of Deep flounder in Khuzestan Coastal Waters (Iran, 2009-11).

$W = 0.0000006FL^{3.09}$ (n = 200, $R^2 = 0.82$) for females and $W = 0.000009FL^{3.04}$ (n = 363, $R^2 = 0.96$) for total fishes (Fig. 2). Verifying calculated b with 3, using Students t-test, no significant difference between calculated b and 3 was observed ($P > 0.05$).

The mean values of K and HIS were 1.10 ± 0.03 and 1.22 ± 0.38 in male specimens and 1.18 ± 0.8 and 2.60 ± 0.41 for female specimens (Fig. 3, 4). The mean values of K and HIS were 1.25 ± 0.43, and 1.13 ± 0.04 for total fishes, respectively. The highest value of K, HIS, GSI were observed in February, August and April; whereas the lowest values were observed in January, December and January (Table 2). A comparison of fish condition between sexes in each of different phase pointed, that there is significant differences between them ($P < 0.05$), and also same results were observed for HIS between sexes ($P < 0.05$).

Table 1. Average values (± SD) of size corresponding of Deep flounder in Khuzestan Coastal Waters (2009-11)

Month	N	Male	Female	Immature	Mean W ± SD (g)	Min – max	MeanTL ± SD (mm)	Min– max
January	44	-	30	13	183 ± 135	41-518	245 ± 54	165-370
February	26	5	18	3	224 ± 133	73-507	260 ± 41	198-335
March	46	7	30	9	201 ± 132	42-827	256 ± 41	171-396
April	25	3	20	2	338 ±141	112-629	306 ± 40	225-380
May	23	1	14	8	315 ±169	128-581	300 ± 54	222-375
July	63	-	50	13	287 ±135	110-693	285 ± 39	205-375
August	35	-	5	30	96 ± 60	14-785	180 ± 63	115-415
September	9	-	5	4	250 ± 88	162-378	272 ± 26	245-312
October	31	-	25	6	310 ± 151	77-532	293 ± 56	190-380
November	27	-	9	18	237 ± 86	93-345	273 ± 31	210-305
December	33	-	23	10	208 ± 128	85-479	258 ± 44	202-342
Average	-	-	-	-	150 ± 238	14-827	264 ± 57	115-415

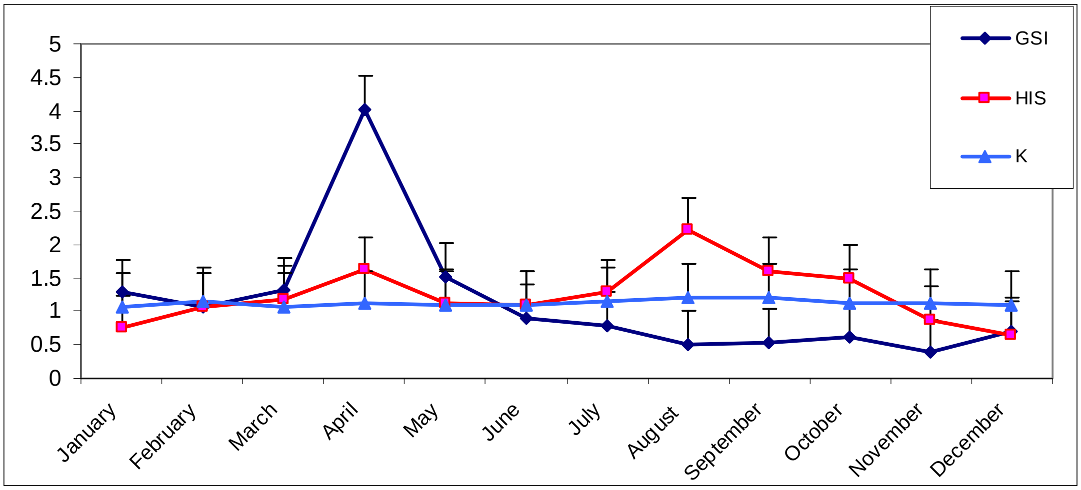

Figure 3. Mean monthly variation of GSI, HIS and K of Deep flounder in Khuzestan Coastal Waters (2009-11).

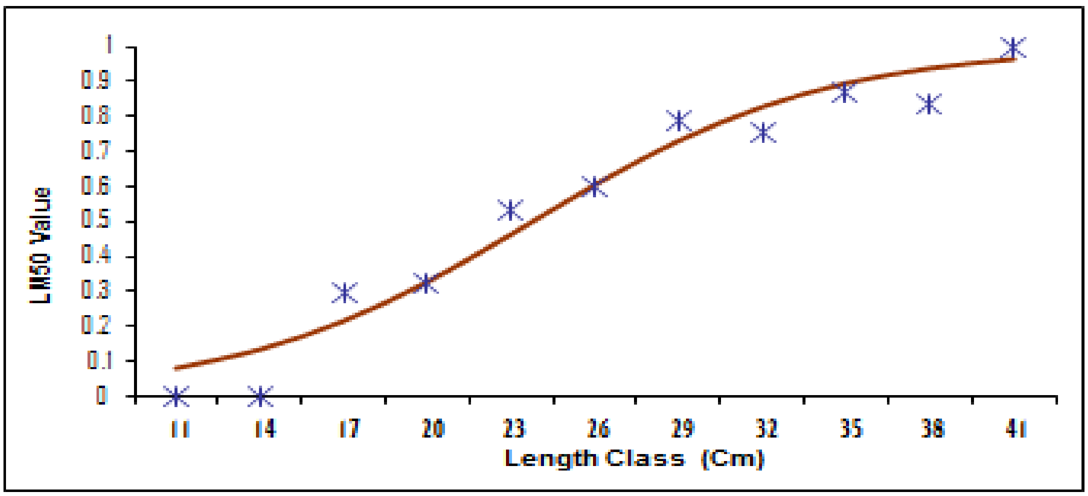

Figure 4. LM_{50} (both sex) of Deep flounder in Khuzestan Coastal Waters (2009-11).

The mean value of GSI for the male and female were 0.62 ± 0.32 and 1.22 ± 0.38, respectively. The GSI was 1.13 ± 0.09, 1.25 ± 0.28, and 1.14 ± 0.95 for total fishes. The highest values of K, HIS, and GSI were observed in April, August, and August and the lowest values were observed in November, December, and January. Mean GSI value indicated that spawning time were occurred during May. Moreover, there was a significant difference in the mean GSI indices between males and females ($P < 0.05$). Mean GSI and maturity stage indicated that spawning time was during April to May. The mean size at first sexual maturity (Lm) was 237 mm for total fishes.

During this study the water temperature and salinity ranged from 15.6°C (Jan), 37.6 PPT (Jan) to 34.5°C (Aug), 43 PPT (Jan). The average of temperate and salinity were 23.47° ± 1.59°C, 39.98 ± 5.98 PPT. Comparison between mean values of environmental parameters and GSI (Fig. 4) indicated that, there is a significant correlation between water temperature, salinity and GSI ($P < 0.05$). During spawning time in April and May the water temperature was 24°C (Fig. 5).

Table 2. Average values (± SD) of GSI, HIS and K corresponding of Deep flounder in Khuzestan Coastal Waters (2009-11)

Month	GSI (male)	GSI (female)	HIS (male)	HIS (female)	K (male)	K (female)
January	-	2.14 ± 0.10	-	0.50 ± 0.30	-	1.06 ± 0.09
February	0.30 ± 0.17	1.27 ± 0.70	1.79 ± 0.27	0.88 ± 0.70	1.10 ± 0.06	1.15 ± 0.12
March	0.99 ± 0.10	1.36 ± 0.87	0.99 ± 0.30	1.21 ± 0.39	1.13 ± 0.10	1.08 ± 0.12
April	0.79 ±0.17	4.25 ± 1.25	1.10 ± 0.20	1.66 ± 0.20	1.10 ± 0.08	1.11 ± 0.12
May	0.40 ± 0.20	1.61 ± 0.63	1.00 ± 0.80	1.30 ± 0.32	1.06 ± 0.10	1.10 ± 0.10
June	-	1.00 ± 0.22	-	1.20 ± 0.09	-	1.01 ± 0.07
July	-	0.90 ± 0.40	-	0.53 ± 0.75	-	1.15 ± 0.14
August	-	0.20 ± 0.10	-	0.70 ± 0.20	-	1.24 ± 0.11
September	-	0.52 ± 0.22	-	1.40 ± 0.30	-	1.24 ± 0.08
October	-	0.62 ± 0.12	-	1.09 ± 0.41	-	1.18 ± 0.09
November	-	0.33 ± 0.21	-	0.74 ± 0.35	-	1.35 ± 0.07
December	-	0.70 ± 0.35	-	0.40 ± 0.30	-	1.07 ± 0.11
Average	0.62	4.19	1.22	2.60	1.10	1.18
STED	0.32	1.02	0.38	0.41	0.03	0.80

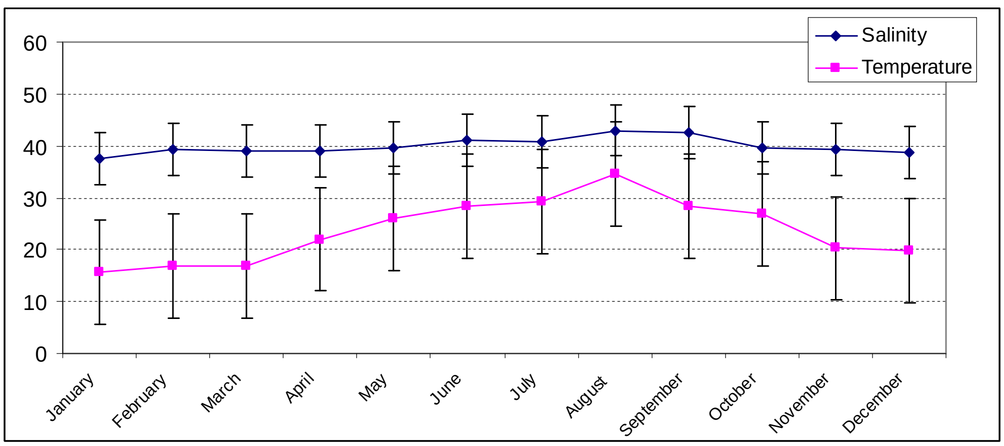

Figure 5. Monthly variation of temperature (°C) and salinity (PPT) in Khuzestan Coastal Waters (2009-11). Error bars indicate SD.

Discussion

The length-weight relationship in fish is of great importance in fishery assessments (Haimovic and Velasco, 2000). 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; Lizama et al., 2002).

The b values in the weight-length model were measured close to 3 for Deep flounder fishes indicating that weight increased isometrically with length (King, 2007). The value of b for *Cynoglossus arel* in Sistan and Blochestan waters (South of Iran) were estimated 2.99 and 2.91 for male and female, respectively (Mohamadkhani, 1997). The b value of weight-length relationship was 2.85 for total fish of *Euryglossa orientalis* species in Khuzestan province waters (Mohamadi and Khodadadi, 2007). The variation of b in the different regions could be by 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). Length–weight relationship is a practical index of the condition of fish, and may vary over the year according to several exogenous and endogenous factors such as food availability, feeding rate, health, sex, gonad development, spawning period and preservation techniques (Tesch, 1968). According to Martine (1994) the range of "b" could be from 2.5 to 4 and Tesch (1968) believed that "b = 3 in fish with isometric growth".

The highest amount of k was observed in spring after a full feeding season and decreased after spawning time in April which shows the effect of ovary weight on fatness. The K value decreased after spawning time due to use of energy in spawning time. Low value of k could be explained with ripe season (Nikpey, 1996; Eskandary, 1999; Eskandary et al., 2001). Condition factor is a well-being value and its increasing coincides with fish weight increasing (King, 2007). Seasonal growth amount can be measured by status factor and growth changes may be related to fish food or reproduction stage (King, 2007).

The HIS in *P. elevatus* were relatively low from May to June. Since most individuals began to spawn in April to May, HIS may decrease 3-4 months before spawning. From July to September, most ovaries were in the recovery phase. Changes in HSI followed a similar pattern during gametogenesis. This finding is similar to that reported for other species (Nikpey, 1996; Eskandary, 1999; Eskandary et al., 2001).

The spawning time of *P. elevatus* during April to May supports the view that seasonal reproductive cycles are common among tropical fishes (Sadovy, 1996). According to Mohamadkhani (1997) the spawning of *Cynoglossus arel* occurred during September to November in Sistan and Blochestan waters (South of Iran). This could be related to the geographical and ecological differences between the stocks of this genus. Hashemi et al. (2011) found that most of fish species in northwest of Persian Gulf (Khuzestan Coastal Waters, Iran) spawned during spring season. The single spawning period during spring in Khuzestan waters was mentioned by Hashemi et al. (2011).

The GSI patterns showed that, reproductive cycles of these species are similar to other tropical fishes (Sadovy, 1996). Regarding differences between mean value of GSI for males and females, in reviewing the reproductive biology of the most fish it is noted that values of males are commonly lower than those of females. Buxton (1990) pointed out that the cost of producing sperm is thought to be less than for producing eggs. The difference in male and female gondosomatic indices suggests that energy invested in gamete production by male is probably less than that invested by females.

During the ripping season, temperature and salinity increased. It has been observed that warm water induced later maturity stages. This pattern is similar to that reported by other authors

(Eskandary, 1999; Eskandary et al., 2001; Hashemi et al., 2011). The present of significant variability in the mean monthly and seasonal GSI values confirm the fact that Deep flounder has an all year round reproductive pulse. The fluctuations in GSI showed correlation with temperature and salinity. The highest mean GSI occurred alongside with the higher water temperature with and salinity (especially in spring season). Environmental cues, such as salinity and temperature, influence reproductive cycles of fishes by stimulating sense organs or glands to produce gonad development hormones. Gonad development hormones can then induce physiological or behavioral responses within the fish (Moyle and Cech, 1988). The hypothalamus induces gonadotropin production which is released by the anterior pituitary, resulting in stimulating hormone release by the gonads (Jameson, 1988). The combination of temperature and salinity trigger physiological processes which influence reproduction (Junk, 1999).

Mean size at first sexual maturity (Lm) for *P. elevatus* was estimated 237 mm for total fishes. Males mature earlier, therefore, their growth are slower than that of females, as a result of the high energy that they need in earlier years for their growth and reproduction. Sexual maturity is a critical life stage and length at first maturity may be different in various populations. The results of the present study showed that bartail flathead needs a protection during the spawning period from April to May, which could help in the management of their stocks.

Further research as population dynamics and stock assessment, is needed in order to obtain an adequate and comprehensive understanding of biology and ecology of this important species in future.

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