



## Reproductive Biology of white grunter (*Pomadasys hasta*) on the South-West coast of Bangladesh

Debashis Kumar Mondal, Shawon Ahmmmed, Mizanur Rahman Washim, AKM Shafiqul Alam Rubel and Md. Latiful Islam\*

Bangladesh Fisheries Research Institute, Brackishwater Station, Paikgacha, Bangladesh.

\*Corresponding Author: latiful.bfri@gmail.com

### ARTICLE INFO

#### Article History:

Received: Oct. 15, 2021

Accepted: Dec. 27, 2021

Online: Feb. 12, 2022

#### Keywords:

Gonadosomatic index,

Fecundity,

*Pomadasys hasta*,

Gonadal histology

### ABSTRACT

The present study addressed the reproductive biology of white grunter (*Pomadasys hasta*) on the South-West coast of Bangladesh. A total number of 59 fish samples were collected once monthly from august 2019 till July 2020. The highest mean value of the gonado-somatic index (GSI) was recorded in December ( $10.95 \pm 2.2$ ), whereas the lowest was in June ( $0.58 \pm 0.24\%$ ), with an average value of  $4.179 \pm 4.402$ . The fecundity range of fish individuals was 102086-3507692, and the average fecundity was at its maximum ( $1913454.4 \pm 139910$ ) in December. The minimum length of the youngest mature female was 20.38 cm. An increase was recorded in the fecundity associated with the rise of total length, body weight, and gonad weight, showing a significant linear relationship. In contrast, length-weight relationship ( $R^2=0.8653$ ) was non-linear, positively correlated, showing negative allometric growth ( $b=2.497$ ). Additionally, gonadal histology displayed seven stages of oocyte development. Early perinuclear and late yolk granule stages were detected in October and December, respectively. Based on the GSI, fecundity, and gonadal histology, the breeding season of *P. hasta* was recorded from October to January, recording a remarked peak in December. This study would assist in the development of induced breeding techniques and provide enriched data for the sustainable management of this population in an open ecosystem.

### INTRODUCTION

The white grunter or Silver Javelin Fish, *Pomadasys hasta* (Bloch, 1790) (Perciformes: Haemulidae) commonly known as 'Datina' is an important commercial species of Bangladesh coast. It is dispersed across a limited depth in the continental shelf and available in waters shallower than 50 m (Mustafa & Azadi, 1995). It also distributed in the Indo-West Pacific; throughout the Indian Ocean and the western Pacific, north to China and southern Japan, south to northern Australia (Randall, 1995). They enter freshwater at depth ranges of 15 to 115 m (Pauly & Gayanilo, 1996). They occur at temperatures ranging from 26 to 29°C (Blaber, 1980). Moreover, they feed mainly on crustacea such as *Squilla*, crab and prawns, besides teleostean fish (Deshmukh, 1973).

*Pomadasys hasta* fish significantly support the coastal fisheries, in terms of commercial and local consumptions. This species is highly demanded in the external

market for its delicious taste. In order to cover the internal protein demand, experts suggested introducing more novel species under culture system. In this context, *P. hasta* fish are the most suitable species for aquaculture. Nevertheless, its availability in nature has been recording a daily decline due to some factors, among which over exploitation, destructive fishing pressure, habitat destruction and climate changes are recognized. It is worth noting that, this species is under threat in the coastal waters of Bangladesh as well as in the mangrove habitats (Haque, 2002) and denoted in the list of least concern globally (IUCN, 2021). For the conservation of *P. hasta* through reducing fishing pressure, it is essential to develop its artificial propagation in controlled culture environment. Similarly, knowledge on breeding biology is a prerequisite to develop artificial breeding technique and the management of a fish stock.

The most indispensable parameters in studying the reproductive biology of any fish are the GSI, fecundity and gonadal histology, in addition to assessing the level of ripeness of the ovary (Nandikeswari *et al.*, 2014). GSI acts as an indicator to determine the exact time of spawning season and spawning frequency of fish species (Ghaffari *et al.* 2011, Shafi, 2012, Sadekarpawar & Parikh, 2013; Jan *et al.* 2014). Contrarily, fecundity is a pathway for the reproductive biology that demonstrates variance in the level of production resulting in an increase in the amount of fish harvested (Bagenal & Tesch, 1978). Thorough and authentic knowledge on the fecundity of the fish is inevitable for the evaluation of commercial potentialities, stock study, life history, particular culture and the management of fishery (Zin *et al.* 2011). In addition, histology serves as a useful demarcation of biological cycle *viz.*, gonad maturity stages and spawning (Hasan *et al.* 2018).

Knowledge on different indices of reproductive biology of a fish species has great importance in its domestication, brood stock development, breeding and stock improvement. Despite the enormous potentiality of *P. hasta* in brackish water aquaculture, the study of breeding biology of this valuable species has not been so far addressed on Bangladesh coast. Though limited published reports on the biology of *P. hasta* are available from the far-east and the south-eastern countries (Deshmukh, 1973 and Mustafa & Azadi, 1995), no exclusive information is available with respect to various aspects of breeding biology of this species on Bangladesh coast. Therefore, considering the importance of this species, a thorough study was conducted to investigate the reproductive biology including gonadosomatic index, fecundity, stages of gonadal development through gonadal histology for determining the peak breeding season of *P. hasta*, which would help in developing their artificial breeding techniques as well as their proper management in natural environment.

## MATERIALS AND METHODS

### Study site

Fish samples (n=59) were collected from the fishermen catch on a monthly basis, starting from August 2019 till July 2020 from the coastal river 'Shibsha', which is adjacent to the Sundarban mangrove forest (22°35.3'N 89°20.2'E). The study site is

connected to the south-west coast of Bangladesh. The fish samples were caught using seine net and cast net to ensure different size groups.

### Measurements

The Length and weight of the collected specimens were measured using scale and digital balance (Model-EK500HA, Japan), with 0.1g accuracy in the Biology Laboratory of Bangladesh Fisheries Research Institute, Brackish water station, Paikgacha. The gonads were taken out carefully in an intact form and preserved in well labeled vials with 10% formalin. Ova diameter was measured using an ocular micrometer fitted to the eye piece of the microscope (LEICA DM500).

### Gonado-somatic index (GSI)

In order to determine the sexual maturity and breeding cycle of the fish, the females were separated, and data were recorded after dissecting out the gonad of the individual. The gonado- somatic index (GSI) (Afonso-Dias *et al.* 2005) of the collected samples was calculated as follows:

$$\text{GSI} = (\text{Weight of gonad} / \text{Weight of fish}) \times 100$$

### Estimation of fecundity (F)

Gravimetric method was used to estimate the absolute fecundity of fish. The weight of ovaries was recorded with a digital electric balance (Model-HT224R, SHINKO DENSHI Co. Ltd., Japan) with 0.0001g accuracy. Then, an amount of 0.1 g of each ovary was taken separately from the anterior, middle and posterior regions of each lobe. The average number of eggs in 0.1 g was calculated and then multiplied by the total weight of the ovary, giving the total number of eggs, *i.e.* the fecundity of the respective fish (Yelden & Avsar, 2000), following the successive equation

$$\text{Fecundity (F)} = (\text{WOV}/\text{WSs}) \times \text{NOV in Ss};$$

Where, *WOV* = weight of the ovary; *WSs* = weight of the sub-samples; and *NOV* = number of mature ova in sub-samples.

### Histology of Gonad

A histological study was conducted in the Laboratory of Fisheries Biology and Genetics, Bangladesh Agricultural University, Mymensingh- 2202. The 'animal tissue technique' method (Humason, 1972) was used in this study. Tissue dehydration was performed by an automated tissue processor, Leica ASP300 S (Leica Biosystem, Germany), with a series of increasing ethanol concentrations of ranges from 70% to 100%, xylene clarification (two changes) and molten wax infiltration (two series). Paraffin-embedded blocks (2  $\mu\text{m}$  thick) were cut with a rotating microtome (Leica RM2255, Leica Biosystem, Germany), and the sections were placed in a pre-heated (40°C) water bath (Paraffin Bath-Leica Model HI1210, Leica Biosystem, Heidelberg, Germany). The sections were then placed on a glass slide to keep overnight. Afterwards, the sections were cleaned with xylene, rehydrated with alcoholic series stained with hematoxylin and eosin stains (Humason, 1972). The stained sections were mounted with Canada balsam and covered with a cover slip. A light microscope was used to examine

the slides (OLYMPUS BX 53), equipped with a camera and photographs were taken for further observation.

### Relationship between different parameters

To establish the mathematical relationship of fecundity with total length, body weight and gonad weight, the values of coefficient of determination ( $R^2$ ) were established by using the following statistical formula:

$$Y = a + bX \text{ (Achakzai et al. 2013)}$$

Where, Y = Fecundity estimate, X = total length (cm) or body weight (g) or gonad weight (g), 'a' & 'b' are regression constants.

The relationship between body weight and gonad weight was determined using the following equation:

$$Y = a + bX$$

Where, Y = Gonad weight (g), X = Body weight (g), 'a' & 'b' are regression constants.

The length-weight relationship was estimated according to power equation as follows:

$$W = a \times TL^b \text{ (Froese, 2006)}$$

Where, W is the total body weight (g), TL is the total length (cm), and a and b are constants.

### Statistical Analysis

Microsoft Excel 2010 and SPSS version 20.0 with the level of significance at  $P < 0.05$  were employed to determine linear and non-linear relationship and coefficient of determination ( $R^2$ ) of fecundity with total length, body weight and gonad weight and body weight with total length and gonad weight.

## RESULTS AND DISCUSSION

### Total length, Body weight and Gonad weight

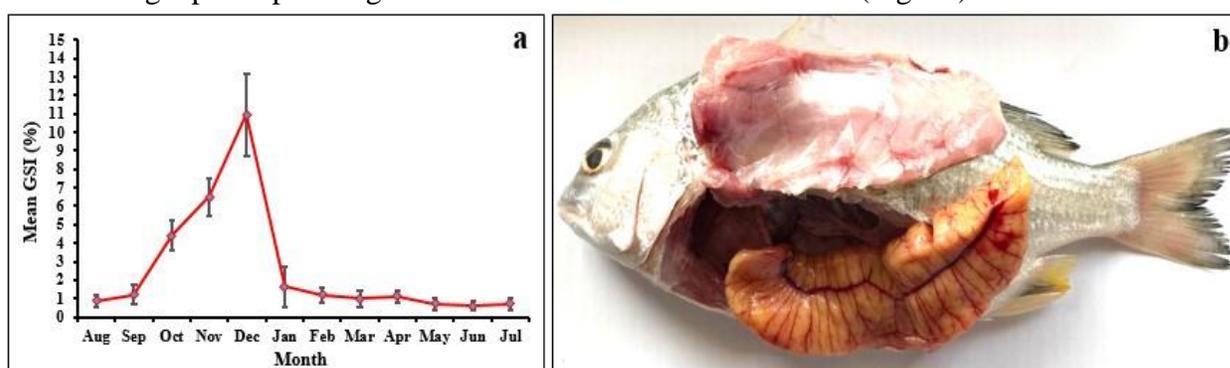
The average value of total length varied between  $24.94 \pm 4.30$  cm in January and  $31.43 \pm 6.47$  cm in November. The average body weight ranged from  $847.8 \pm 526.64$  g in December to  $268.4 \pm 158.21$  g in June. The highest average value ( $58.766 \pm 48.26$  g) of the gonad weight was detected in December, and the lowest average value was ( $1.154 \pm 1.34$  g) in June. The minimum and maximum individual value of total length was found in September and November, respectively. Considering body and gonad weights, the lowest and highest individual values were recorded in June and November, respectively (Table 1). In the present study, the length range (21.1 cm ~ 38.4 cm) is lower than that reported (TL, 29 cm ~ 64 cm) from Bombay coast, India in the study of **Deshmukh (1973)**. This difference might be due to the variation in the sampling areas associated with different feed density, as well as the differences in age, maturity and sex (**Yaglioglu et al. 2014**).

**Table 1:** Mean, maximum and minimum values of different parameters of female *P. hasta*

Parameter	Minimum	Maximum	Mean $\pm$ SD
Total length (cm)	21.1	38.4	27.489 $\pm$ 3.761
Body weight (g)	178.5	1425	463.485 $\pm$ 245.613
Gonad weight (g)	0.207	114	22.33 $\pm$ 27.732
GSI (%)	0.102	14.32	4.179 $\pm$ 4.402
Fecundity (nos.)	1,02,086	35,07,692	9,21,855.463 $\pm$ 9,54,76.3

### Gonadosomatic index and length at first maturity

The highest average GSI value of female *P. hasta* was found 10.95 $\pm$ 2.2% in December, and the lowest average value was 0.58 $\pm$ 0.24% in June. GSI values progressively increased starting from September to reach its peak in December before witnessing a sharp fall in January. Then, it showed plateau till August, which indicates that the single peak spawning season of *P. hasta* was in December (Fig. 1a).



**Fig. 1.** (a) A histogram showing monthly variation of GSI (Mean $\pm$ SD) of *P. hasta*; (b) A photo showing *P. hasta* with fully developed gonad

GSI is an indicator of the state of gonadal ripeness, which increases with fish maturation till it reaches its maximum and then declines sharply (Akter *et al.* 2012). However, Amtyaz *et al.* (2013) and Amtyaz *et al.* (2014) stated that the highest GSI value was 9.124 % and 6.679 % for female *P. stridens* and *P. maculatum*, respectively during October. They added that the spawning period occurs from September to February in the Karachi coasts of Pakistan. Vahabnezhad *et al.* (2018) revealed the apex GSI (3.62 %) of a closely related species, *P. stridens*, in December on the northern coasts of the Persian Gulf, which strongly supports the present finding. Bodji *et al.* (2013) noted that the GSI of female *P. jubelini* augmented from November to January, with a peak in January (2.56 %) in Grand-Lahou lagoon, West Africa. Remarkably, the Variation in the spawning season and periodicity depends on the diverse ecological environments (Agarwal, 2008). A scatter plot diagram of the total length with corresponding GSI are illustrated in Fig. (2a). The diagram in Fig (2a) substantiates that, the minimum length of the youngest mature female was 20.38 cm. Karimi *et al.* (2013) recorded a value of 12.6-23 cm as the minimum length at the maturity of female *P. stridens*. While, Vahabnezhad *et al.* (2018)

registered a value of 19.84 cm for the same species in the Persian Gulf, which is very close to the present finding.

### Fecundity

The lowest individual value of fecundity (1,02,086) was found at the total length of 21.5 cm, with body weight of 201g; whereas, the highest individual value (35,07,692) was recorded at 38.4 cm total length and 1425 g body weight (Tables 1, 2). This suggests that big sized fish have more energy and larger body cavity for egg production, which agrees with the finding of **Rheman *et al.* (2002)**. **Al-Nahdi *et al.* (2010)** determined the highest fecundity of 14,21,520 oocytes in *P. commersonnii*, which is lower than that of *P. hasta* of the present study. **Adebiyi (2013)** observed that the fecundity of *P. jubelini* was 10,550-65,248 eggs in fish with total length of 13.9-26.6 cm, which is much lower than the fecundity of *P. hasta* of the current study. The variation in fecundity is common in fish (**Reddy & Rao, 1991**). It depends on numerous factors, including fish stock, nutritional condition and racial characteristics (**Das, 1977**), such as size, age, sex, environmental conditions, availability of space and food (**Hunter, 1992**).

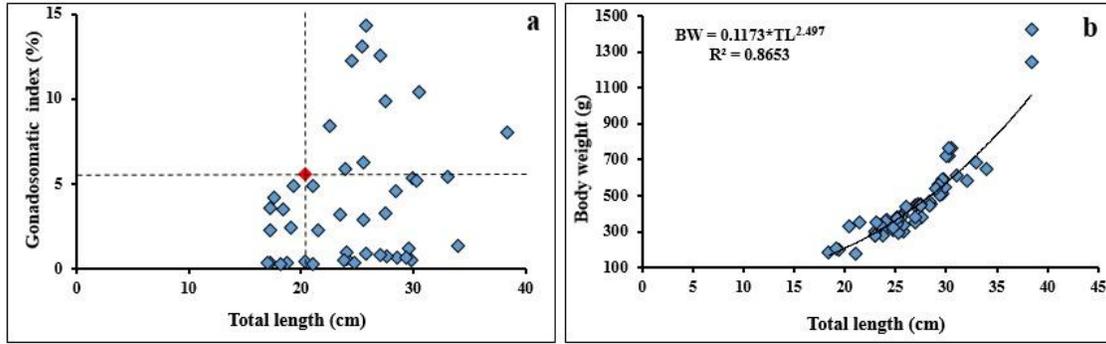
**Table 2.** Monthly recorded fecundity range of *P. hasta* during the study period

Month	No. of fish examined	Fecundity range	Mean Fecundity (nos.)
October	5	3,62,600-6,93,959	5,66,697.27±1,78,54.45
November	4	8,89,814-24,80,000	15,90,118.68±5,24,933.34
December	6	10,04,219-35,07,692	19,13,454.4±13,99,10.46
January	4	3,922.35-1,77,632	11,752.93±7,818.05

### Relationship among different parameters

#### 1. Length-weight relationship (LWR)

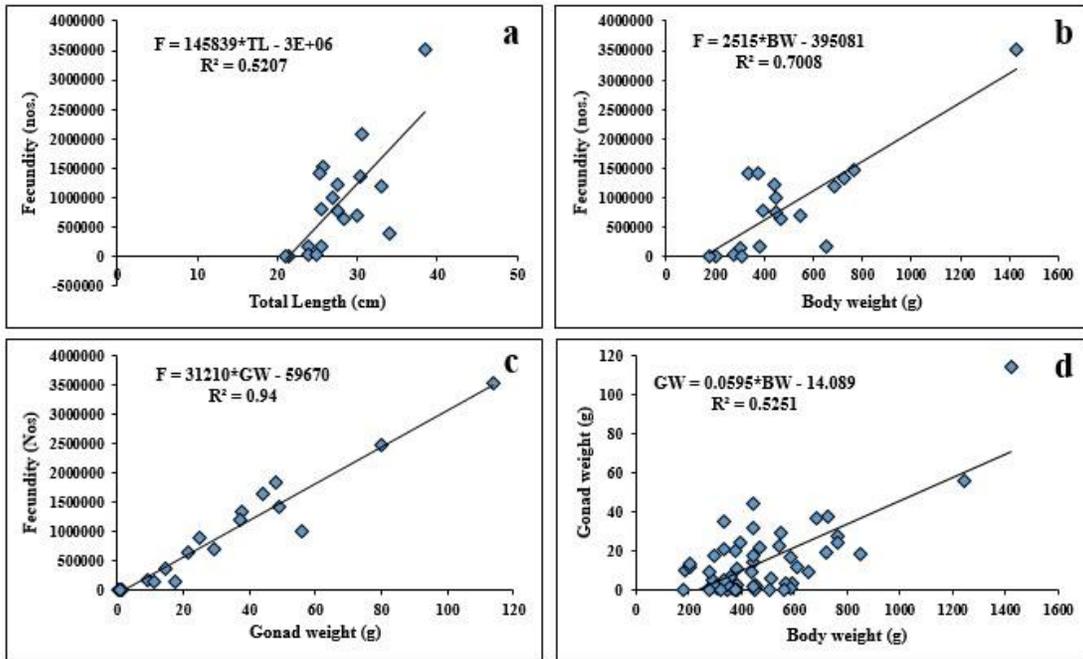
Total length and body weight showed non-linear and positive co-relationship ( $R^2=0.8653$ ), and the equation was  $BW=0.1173*TL^{2.497}$  (Fig. 2b). The exponential expression  $b$  of the length-weight relationship was 2.497 for combined sexes, which indicates a negative allometric growth ( $b<3$ ). This result coincides with those of **Agboola and Anethekhai (2008)** and **Adebiyi (2013)** for the Qua Iboe estuary ( $b = 2.81$ ) from Nigeria and *P. jubelini* from the Lagos coast ( $b = 2.91$ ). Positive allometric growth ( $b=3.27$ ) was recorded for the combined sexes of *Sardinella aurita* on the Moroccan coast (**Ayoub *et al.*, 2021**), which is disagrees with the present finding. Variation in the LWR depends on the population, season and environmental conditions (**Froese, 1998**).



**Fig. 2.** Histograms showing: (a) Relationship of total length with corresponding GSI (point with red mark indicates the youngest marure female); (b) Relationship between total length and body weight of *P. hasta*

**2. Relationship of fecundity with other parameters**

Linear and positive co-relationships were defined between gonad weight and body weight and fecundity with other parameters. The equation of these relationships, coefficient of determination ( $R^2$ ), ‘a’, ‘b’ and ‘P’ values are given in the Table (3).



**Fig. 3.** Histograms of scatter plots showing relationship between (a) Fecundity and total length; (b) Fecundity and body weight; (c) Fecundity and gonad weight & (d) Gonad weight and body weight

Robust co-relationship ( $R^2=0.94$ ) was observed between fecundity and gonad weight on the one hand, and total length with body weight ( $R^2=0.9218$ ) on the other. The relationship of body weight with fecundity ( $R^2=0.7008$ ) showed high positive co-relationships; whereas, moderate positive co-relationship was observed between body weight and gonad weight ( $R^2=0.5251$ ) and fecundity with total length ( $R^2=0.5207$ ) (Fig.

3a-d). This findings agree with the asserted deductions with respect to *Rhinomugil corsula* (Akter et al. 2012), *Sardinella aurita* (Baali et al. 2021) and *Hilsa ilisha* (Akter et al. 2007).

**Table 3.** Regression equation, coefficient of determination ( $R^2$ ), 'a', 'b' and 'P' values of different relationships

Relationship	Regression equation	$R^2$	a	B	n	P-value
Fecundity (F)-Total Length (TL)	$F=1458398*TL-3E+06$	0.5207	-3E+06	1458398	19	0.002
Fecundity (F)-Body Weight (BW)	$F=2515*BW-395081$	0.7008	-395081	2515	19	0.000
Fecundity (F)-Gonad Weight (GW)	$F=31210*GW-59670$	0.9400	-59670	31210	19	0.012
Gonad Weight (GW)-Body Weight (BW)	$GW=0.0595*BW-14.08$	0.5251	-14.089	0.0595	59	0.000
Total Length (TL)-Body Weight (BW)	$BW = 0.1173*TL^{2.497}$	0.8653	0.1173	2.497	59	0.000

### Histological observation

The development of oocyte can be divided into discrete developmental stages. The findings of our study illustrated that oocytes were developed in a asynchronized manner. Paired ovaries with matured oocytes were observed at mature stage. In the present study, month-wise gonadal developmental stages were observed histologically in female *P. hasta* (Fig. 4).

#### 1. Chromatin Nuclear Stage (CNS)

This is a preliminary stage containing chromatin threads. It is identified by the youngest and undeveloped oocytes (UO). These oocytes are rarely seen in maturity. Beside other stages, the chromatin nuclear stage was ascertained during September and January (Fig.4a).

#### 2. Early Perinucleolar Stage (EPS)

Real development of the oocyte begins with this stage. At this stage, along with oocyte growth, the nucleus starts to enlarge and numerous nucleoli are found around the circumference of the nucleus, which indicates an immature oocyte. This stage was observed in the months of September and October (Fig. 4b).

#### 3. Late Perinucleolar Stage (LPS)

This stage differs from the previous one by the expansion of the oocyte. A great number of nucleoli were apparently viewed throughout the nucleus. A follicular layer was developed around the oocyte. Chorion formation starts at this stage. This stage was mostly spotted in the month of October. (Fig. 4c).

#### 4. Yolk Vesicle Stage (YVS)

This stage was identified by the commencement of vitellogenic state, characterized by the initial evolvement of yolk vesicles (globules) in the border of the oocytes. They were first shaped as an individual row that seems colorless when the slides were stained with haematoxylin and eosin. These YV developed as tiny forms but they increased in size and

number without ceasing, which indicates a maturing oocyte. This stage was mostly found in November (Fig. 4d).

### **5. Early Yolk Granule Stage (EYGS)**

The final oocyte maturation was marked by the formation of yolk granules in oocytes, with completely developed yolk vesicles. They were stained in light pink with haematoxylin and eosin. Most of the oocytes of this stage were observed in November and the rest in December (Fig. 4e).

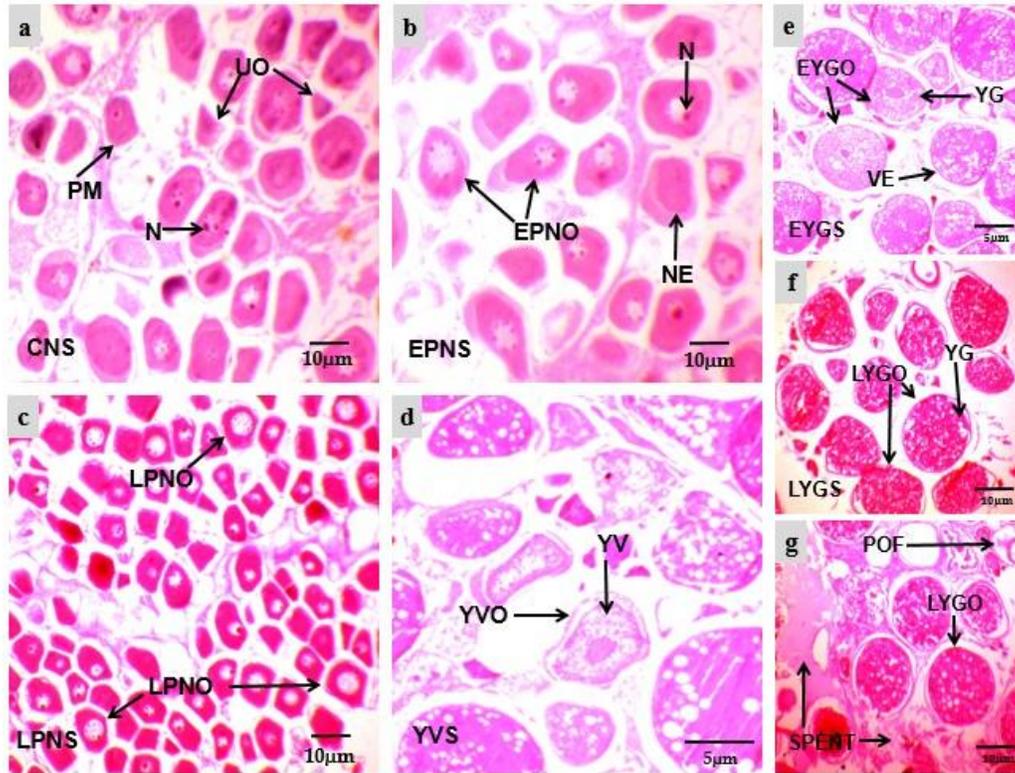
### **6. Late Yolk Granule Stage (LYGS)**

With the advancement of yolk granule stage, both the diameter of the oocytes and the number of yolk granules augmented sharply, and oil droplets appeared within the cytoplasm. The yolk granules are densely packed and occupy almost the entire oocyte. The yolk granules were deep pink in color, with haematoxylin and eosin. LYGS was detected mostly during December and partially in November (Fig. 4f) when the ovary was fully matured.

### **7. Spent Phase**

The oocyte enters the ovulatory phase at this point. Though a few matured oocytes were found in the ovary, but most of them were released to the exterior body of the fish. This implies the ovarian spent and resting phase which was found in the month of January (Fig. 4g).

The knowledge on the gonadal maturation and peak spawning period of a species can play a pivotal role for the proper management of a population. The cytological happenings associated with gonadal development observed in this study are similar to those of other findings on grunts (**Falahatimarvast et al., 2011; Vahabnezhad et al., 2018**). The previous authors reported that the vitellogenic stage of *P. stridens* is recognized by a considerable enhancement in the oocyte sizes, mainly by the addition of lipid droplets in cell cytoplasm, which is in agreement with the present study. The final oocyte development stage was identified by fully hydrated mature oocytes of *P. hasta* which is similar to that of *P. stridens* in the Persian Gulf (**Vahabnezhad et al., 2018**).



**Fig. 4.** Micrographs showing (a) CNS = Chromatin nuclear stage, (b) EPNS = Early Perinuclear stage, (c) LPNS = Late Perinuclear stage (d) YVS = Yolk vesicle stage, (e) EYGS = Early Yolk granular stage, (f) LYGS = Late Yolk Granular stage and (g) Spent.

**Note:** PM= Premature stage; N= Nucleolei; NE= Neucleolus; YG= Yolk granule; VE= Vitelline envelope; POF= Post ovulatory follicle; UO= Undeveloped oocyte; EPNO= Early perinucleolar oocyte; LPNO= Late perinucleolar oocyte; YVO= Yolk vesicle stage oocyte; EYGO= Early yolk granule stage oocyte; LYGO= Late yolk granule stage oocyte. Hematoxylin & Eosin stain. Magnification-10X.

Histological information indicates that the spawning season of *P. hasta* takes place from October to January, with a peak in December, concurring with the value of the GSI of this species. After reaching its peak, a sharp fall of the GSI value is observed, aligned with a decrease of the gonad size and the existence of the spent fish. These observations denominates the performance of one spawning season. Thus, *P. hasta* appears to be a winter breeder, with a single restricted spawning period occurring from October to January. In most of the Pomadasyidae, the spawning season is protracted (**Abu-Hakima, 1984**). **Deshmukh (1973)** recorded only one short spawning period for *P. hasta* from October to December in the Indian waters with a peak in December, which strongly confirms the present result. **Amtiyaz *et al.* (2013)** found that the peak spawning season of a closely related species, *P. stridens* takes place from September to February in the Karachi coast, Pakistan. Whereas, **Karimi *et al.* (2013)** observed that *P. stridens* fish spawn from December to March in the Persian Gulf. The spawning period of *Pomadasy incisus* occurs between August and October in the Gulf of Tunis, which is slightly earlier than the present finding. This difference could be attributed to regional variations and other environmental factors (**Karimi *et al.*, 2013**).

### Oocyte diameter and maturity stages of *P. hasta*

Oocyte diameter of *P. hasta* was measured to determine the spawning season and frequency. In the ovary of *P. hasta*, only smallest oocytes ( $0.1\pm 0.002$ mm) of stage-I were present in September; whereas, comparatively larger oocytes ( $0.155\pm 0.06$  mm) of stage-II were found in October. The further shifting of oocytes at stage-III with a diameter of  $0.305\pm 0.03$ mm was observed in November. The final augmentation of oocyte diameter at stage-IV was monitored in December ( $0.655\pm 0.07$ ). In January, the ovary was mostly spent; however, some small sized ova ( $0.21\pm 0.04$  mm) were present at stage-V, which is similarly reflected in the mean GSI and histological observation (Table 4). This approach agrees with the finding of **Vahabnezhad et al. (2018)** who addressed *P. stridens* in the Persian Gulf. In addition, the current finding mimics that of **Falahatimarvast et al. (2012)** considering *P. kaakan* in the northern Persian Gulf.

**Table 4. Mean Oocyte diameter (OD), gonadal maturity stages and characteristics of *P. hasta***

Gonad stage	Macroscopic characteristics	Microscopic characteristics	OD (mm)	Month
I Immature	Ovaries slender and white. No visible oocytes.	Chromatin threads without detectable eggs. Oocyte mostly in CN stage, but some in PN stage.	$0.1\pm 0.02$	September
II Developing	Ovaries thicker and whitish yellow color, vitellogenic oocytes were visible .	Most of the oocytes were in PNS. Follicular layer developed around the oocyte. Chorion starts to form.	$0.155\pm 0.06$	October
III Maturing	Ovaries large and pale yellow in color. Many opaque oocytes are visible.	Yolk vesicle formed in the periphery of the oocytes. Ovaries were occupied by vitellogenic oocytes.	$0.305\pm 0.03$	November
IV Spawning	Ovaries occupy whole body cavity with large and bright yellow oocytes. Egg release with gentle pressure.	Number of yolk granules was sharply increasing. Mature and hydrated oocytes were numerous.	$0.655\pm 0.07$	December
V Spent	Ovaries small, flaccid, sac-like and reddish in color. Very few big size ova scattered in a state of re-absorption.	Oocytes enters the ovulatory phase. Frequent post-ovulatory follicles with a large number of immature oocytes were observed.	$0.21\pm 0.04$	January

### CONCLUSION

This study provides some basic information on various aspects of reproductive biology viz., gonadal indices, length at sexual maturity, histological observation of the gonadal development and fecundity of *P. hasta* that would help evaluating the reproductive potential of fish species in similar studies. Moreover, this study would aid fishery biologists/managers to control the exploitation of young individuals, and hence ensure the sustainable management of this population in Bangladesh coast.

## REFERENCES

- Abu-Hakima, R.** (1984). Comparison of aspects of the reproductive biology of *Pomadasys otolithes* & *Pampus Spp.* In Kuwaiti water, Fisheries Research, 2: 177-200.
- Achakzai, W.M.; Saddozai, S.; Baloch, W.A. and Memon, N.** (2013). Length-Weight Relationships and Condition Factor of *Oreochromis mossambicus* (Peters, 1852) from Manchar Lake Distt. Jamshoro. Sindh, Pakistan. Sindh University Research Journal, 45(2): 201-206.
- Adebiyi, F.A.** (2013). Length frequency distribution, Length-weight relationship and condition factor of sompat grunt *Pomadasys jubelini* (Cuvier, 1830) off Lagos coast, Nigeria. Pertanika J. Trop. Agric. Sci., 36 (4): 337-344.
- Afonso; Dias, I.; Reis, C. and Andrade, P.** (2005). Reproductive Aspects of *Microchirus azevia* (Risso, 1810) (Pisces: Soleidae) from the south coast of Portugal. Sci. Mar. 69:275-283.
- Agarwal, N.K.** (2008). Fish Reproduction, New Delhi APH Pub, Corp 2008, 157 p.
- Agboola, J.I. and Anethekhai, M.A.** (2008) Length- weight relationship of some fresh and brackish water fishes in Badagry Creek, Nigeria. J Appl Ichthyol, 24: 623-625.
- Akter, H.; Islam, M.R. and Hossain, M.B.** (2012). Fecundity and Gonadosomatic Index (GSI) of *Corsula*, *Rhinomugil corsula* Hamilton, 1822 (Family: Mugilidae) from the Lower Meghna River Estuary, Bangladesh. Global Veterinaria, 9 (2): 129-132.
- Akter, M.A.; Hossain, M.D.; Hossain, M.K.; Afza, R. and Bhuyian, A.S.** (2007). The fecundity of Hilsa ilisha from the River Padma near Godagari of Rajshahi District. Univ. J. Zool. Rajshahi Univ., 26: 41-44.
- Al-Nahdi, A.; Al-marzouqi, A.; Jayabalan, N. and Al-habsi, S.** (2010). Maturation and spawning of the small spotted grunt *Pomadasys commersonnii* (Lacepede, 1801) in the Arabian Sea off Oman. *Thalassas*, 27: 67-79.
- Amtiyaz; Khan, M.A.; Khan, M.Z. and Hashmi, M.U.A.** (2013). Studies on Gonadosomatic Index & Stages of Gonadal Development of Striped piggy fish, *Pomadasys stridens* (Forsskal, 1775) (Family; Pomadasyidae) of Karachi Coast, Pakistan. Journal of entomology and zoology study, 1(5): 28-31.
- Amtiyaz; Khan, M. A.; Khan; M.Z. and Hashmi, M.U.A.** (2014). the sex ratio, gonadosomatic index and stages of gonadal development of saddle grunt fish, *Pomadasys maculatum* (bloch, 1793) of karachi coast. Canadian Journal of pure and applied sciences, 8(1): 2721-2726.
- Baali, A.; Belhsen, O.K.; Ouazzani, K.C.; Amenzoui, K. and Yahyaoui, A.** (2021). Age, Growth and Ovarian Histology of *Sardinella aurita* (Valenciennes, 1847) in the South of Atlantic Moroccan Coast. Tur. J. of Fish. & Aqua. Sci., 21(4):191-204.
- Bagenal, T.B. and Tesch, F.W.** (1978). Age and growth. In methods for assessment of fish production in freshwaters. 3rd ed., edited by Bagenal, T.B. Oxford: Blackwell Scientific Publications, 101-136.

- Blaber, S.J.M.** (1980). Fish of the Trinity Inlet System of North Queensland with notes on the ecology offish faunas of tropical Indo-Pacific estuaries. *Aust. J. Mar. Freshwat. Res.* 31:137-46.
- Bodji Iridjé Marcelle<sup>12</sup>, Kouadio Justin Konan<sup>1</sup>, Alla Yao Laurent<sup>1</sup>, Ouattara Nahoua Issa<sup>2</sup>, Atsé Boua Célestin. 2013. Reproductive biology of the Sompat grunt, *Pomadasys jubelini* (Cuvier, 1830) in Côte d'Ivoire lagoons complex (West Africa). *Journal of Applied Biosciences*, 72: 5855-5868.
- Das, H.P.** (1977). The fecundity of Grey Mullet, *Mugil cephalus* L. along Goa Coast. Mohasagar, *Bull. Nat. Int. Ocean.*, 11(1&2): 63-71.
- Deshmukh, V.M.** (1973). Fishery and biology of *Pomadasys hasta* (Bloch). *Indian Journal of fisheries*, 20 (2): 497- 522.
- Falahatimarvast, A.; Poorbagher, H. and Lokman, P.M.** (2011). The reproductive biology of *Pomadasys kaakan* (Osteichthyes: Haemulidae) in the northern Persian Gulf, *Cahiers de Biologie Marine*, 53:25-34.
- Fehri-Bedoui, R. and Gharbi, H.** (2008). Sex-ratio, reproduction and feeding habits of *Pomadasys incisus* (Haemulidae) in the Gulf of Tunis (Tunisia). *Acta Adriatica*, 49(1): 5-19.
- Froese, R.** (1998). Length-weight relationship for the 18 less-studied fish species. *Journal of Applied Ichthyology*, 14: 117-118.
- Froese, R.** (2006). Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. *Journal of Applied Ichthyology*, 22:241-253.
- Ghaffari, H.; Ardalan, A.A.; Sahafi, H.H. and Babaei, M.M.** (2011). Annual Changes in Gonadosomatic Index (GSI), Hepatosomatic Index (HIS) and Condition Factor (K) of Largescale Tonguesole *Cynoglossus arel* (Bloch & Schneider, 1801) In The Coastal Waters of Bandar Abbas, Persian Gulf. *J of Applied Sci. Res.*, 5:1640-1646.
- Haque, E.** (2002). The management and conservation of Fisheries in the Mangrove Forests of Bangladesh. MSc. Thesis. The University of Hull, UK. 197 pp.
- Hasan, T.; Hossain, M.F.; Mamun, M.; Alam, M.J.; Salam, M.A. and Rafiquzzaman, S.M.** (2018). Reproductive Biology of *Puntius sophore* in Bangladesh. *Fishes*, 3 (2):22.
- Humason, G.L.** (1972). *Animal tissue techniques*. 3<sup>rd</sup> Edition, W.H. Freeman and Company, San Francisco.
- Hunter, J.R.; Macewicz, N. and Kimbrell, C.A.** (1992). Fecundity, spawning and maturity of female Dover sole, *Microstomus pacificus* with an evaluation of assumptions and precision. *Fishery Bulletin*, 90: 101-128.
- IUCN** (2021). IUCN: The International Union for Conservation of Nature, Redlist of threatened species, version 2021-1, downloaded on (5 September 2021).
- Jan, M.; Jan, U. and Shah G.M.** (2014). Studies on fecundity and gonadosomatic index of *Schizothorax plagiostomus* (Cypriniformes: Cyprinidae). *J of Threat. Taxa.*, 6:5375-5379.

- Karimi, K.; Mahbobi Soofiani, N.; Paykanheirati, F. and Katiraei, E.** (2013). Reproductive Biology of Stripped Piggy (*Pomadasys stridens* Forsskal, 1775) in Northern Part of Persian Gulf (Bushehr), Journal of Applied Ichthyological Research, 2(3): 87-100 (In Persian).
- Mustafa, G.M. and Azadi, M.A.** (1995). Population dynamics of white grunter, *Pomadasys hasta* from the Bay of Bengal. Chittagong University Studies. Part II: Science, 19(1):19-22.
- Nandikeswari, R.; Sambasivam, M. and Anandan, V.** (2014). Estimation of fecundity and gonadosomatic index of Terapon jarbua from Pondicherry Coast, India. International Scholarly and Scientific Research Innovation. 8.
- Pauly, D. and Gayanilo, F.C. Jr.** (1996). Estimating the parameters of length-weight relationships from length-frequency samples and their weights. p. 136. In D. Pauly and P. Martosubroto (eds.) Baseline studies of biodiversity: the fish resource of western Indonesia. ICLARM Studies and Reviews 23.
- Reddy, Y.S. and Rao, M.B.** (1991). Gonadosomatic index and fecundity of *Heteropneustes fossilis* (Bloch) (Pisces: Heteropneustidae) from Hussain Sagar, Hyderabad. Indian. Journal of Fisheries, 38(2): 93-96.
- Rheman, S.; Islam, M.L.; Shah, M.M.R.; Mondal, S. and Alam, M.J.** (2002). Observation on the Fecundity and Gonadosomatic Index (GSI) of Grey Mullet *Liza parsia* (Ham.). Journal of Biological Sciences. 2(10): 690-693.
- Sadekarpawar, S. and Parikh, P.** (2013). Gonadosomatic and hepatosomatic indices of freshwater fish *Oreochromis mossambicus* in response to plant nutrient. World J of Zool., 1:110-118.
- Shafi, S.** (2012). Study of fecundity and gonadosomatic index of *Carassius carassius* (Linnaeus, 1758- introduced) from Dal Lake Kashmir. Journal of Biology, Agriculture and Healthcare. 2: 2224-3208.
- Vahabnezhad, A.; Mirzaei, M.R. and Karimi, S.** (2018). Reproductive Biology of *Pomadasys stridens* (Forsskal, 1775) in the Northern Coasts of the Persian Gulf, Iran. Turkish Journal of Fisheries and Aquatic Sciences, 18:1363-1370.
- Yaglioglu, D.; Deniz, T.; Erguden, D.; Gurlek, M. and Turan, C.** (2014). Age And Growth of the Nakedband Gaper, *Champsodon nudivittis* (Ogilby, 1895), from the Iskenderun Bay, Northeastern Mediterranean. Cahiers de Biologie Marine 55, 347-351.
- Yeldan, H. and Avsar, D.** (2000). A preliminary study on the reproduction of the rabbit fish *Siganus rivulatus* (Forsskal. 1775) in the North eastern Mediterranean. Tur. J of Zool., 24:173-182.
- Zin, T. and Than, A.A.** (2011). Naing TT. Fecundity (F), gonadosomatic Index (GSI), hepatosomatic index (HSI), condition factor (K) and length weight relationship (LWR) in *Channa orientalis* Bloch and Schneide, 1801. Uni. Res. J., 4:47-62.