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EFFECT OF FOOD AVAILABILITY ON REPRODUCTIVE ACTIVITY OF CATFISH

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ABSTRACT

The aim of the present study was to examine the involvement of food availability on reproductive activity in a fresh water catfish *Mystus cavasius,* locally known as gulsha. Fish undergoing active reproduction were reared with saturated feed (SF; 1.5-2.0% of body mass) and limited feed (LF; one-tenth of SF) under natural photoperiod and temperature. Reduction of food ration affected ovarian development during the reproductive season in this species. The limited feeding resulted in significant decreases in gonadosomatic index (GSI) within 15 days with disappearance of vitellogenic oocytes from the ovaries. When the LF-reared fish were re-fed with SF, their GSI was increased and vitellogenic oocytes re-appeared within 15 days. When these two feeding levels were crossed with 20, 25 and 30 ^{0}C temperature regimes, the fish maintained better ovarian conditions at 30 ^{0}C than those at 20 and 25 ^{0}C, but not under LF conditions, suggested that minimum and maximum temperatures influenced the reproductive performance of the studied fish.

Keywords: Catfish, food availability, histology, ovarian development, reproduction

Introduction

Sexual development and reproduction in vertebrates including teleost species are regulated by internal and external environmental factors such as photoperiod, temperature, tide, and rainfall (Bromage *et al.* 2001, Pankhurst and Porter 2003, Shimizu 2003). These cues do not function independently, but interfere with other environmental variables, such as salinity, water quality, and food availability which are also known to affect gonadal maturity and fecundity and the timing of seasonal breeding (Gue`ye *et al.* 2013).

Fish perceived external environmental cues through sensory organs and transduce them as internal stimuli to initiate and terminate reproductive activity in fish. However, perception and utilization of environmental cues appear to be diverse among fish species and habitats. The reproductive seasonality of fish in temperate region is typically influenced by the periodic changes of photoperiod and temperature. In contrast, fish of a tropical origin may not apply these periodic changes for seasonal repetition of their reproductive activities due to less seasonal variation of these factors in tropical waters (Hilder and Pankhurst 2003, Pankhurst and Porter 2003, Bapary *et al.* 2009). It has been reported that among external factors food availability is potential factors that are capable for the timing and frequency of reproduction in certain fish species (Bapary *et al.* 2012). In this regard, it is hypothesized that tropical fish use photoperiod and temperature as fundamental cues in aquatic environments, and that can interact with food availability as regional-limited factors to initiate and terminate reproductive activity in this species.

The gulsha, *Mystus cavasius*, is a species of freshwater catfish belonging to the family Bagridae and commonly found in rivers, lakes, and canals in and around the Indian subcontinent (Badruzzaman *et al.* 2020). Previous experimental studies showed that the *Mystus cavasius* has a restricted reproductive season from April to September and is related to periodic changes in photoperiod and temperature. The gonadal development under long photoperiod (LD14:10) and temperature at 30 ^{0}C with enough food was increased the gonadosomatic index and vitellogenic oocytes at tertiary yolk stage (TYS) in this species (Badruzzaman *et al.* 2017). However, it is not known, how the fish utilizes food resources to continue their reproductive activity under suitable photoperiod and

temperature conditions. Since food availability appears to change in relation to the tropical monsoon climate, we regard it as a regional environmental factor and assumed that this cue is also involved in determining the reproductive attainment of *Mystus cavasius*. Nonetheless, the temperature increases the metabolic rates in vertebrates including teleosts (Yoneda and Wright 2005, Donelson *et al.* 2010). Therefore, the aim of this study was to examine the involvement of food availability on reproductive activities of the gulsha fish and to evaluate its effectiveness in relation to temperature changes.

Materials and Methods

Studied fish: Gulsha (*Mystus cavasius)* with an average body weight 10-12 g were obtained from a local hatchery at the end of March 2019 and transferred to the laboratory. Fish were acclimated for several days in 500-L stock tanks with continuous aerated freshwater at ambient temperature and under natural lighting conditions until experiments were conducted in May to June 2019. Fish were fed commercial pellets (Paragon Feed Ltd. Bangladesh) twice per day at 9:00 and 17:00 hours.

Experimental design: The common procedure for all experiments were as follows: average body mass 10-12 g was recorded and all fish were euthanized with ice-cold water. The ovary was dissected out from the body cavity. After weighing, the ovary was fixed in Bouin's solution and subjected to subsequent histological observation. Gonadosomatic index (GSI) = (ovary mass/ body mass) x100 were calculated. Each experiment was performed with two replications. All experimental procedures were conducted in accordance with principles of animal care approved by Bangabandhu Sheikh Mujibur Rahman Agricultural University, Bangladesh.

Effect of food availability on ovarian development: The involvement of food availability on the ovarian development also determined under natural photoperiod and temperature conditions from June to July. Fish (n=36 per aquarium) were transferred into two glass aquaria (60-L capacity) equipped with ambient aeration and reared under saturated feed (SF, 1.5-2.0% feed of body mass) group and limited feed (LF, one tenth of SF) group, respectively. At day 15, after onset of this experiment, the females (n=6-7) were sampled from each aquarium. The ovarian conditions were compared between two groups.

Reversal of the effect of food limitation on ovarian development: To examine the effect of re-feeding on ovarian development, the fish reared under LF conditions for 15 days were divided into 2 groups: one group (n=14) was kept under the same LF conditions (LF-LF group), while the other group was re-fed with SF (LF-SF group). Female fish (n=7 per treatment) were sampled from each aquarium at 15 and 30 days after dividing the fish. The fish reared under SF conditions were also sampled at the same interval. The ovarian conditions were compared between two groups.

Interaction of food availability and water temperature: The effects of food availability and water temperature on ovarian development were determined from June to July. Fish (n=14 per aquarium) were transferred from the (60-L capacity) with ambient aeration systems. Temperatures of aquaria (two each) were set at 20, 25, or 30 ^{0}C (± 1^0 C) under natural photoperiod conditions. The aquaria at respective temperatures were further divided into the SF and LF group. Feed was initially given to SF group at 1.5-2.0% of body mass. As leftover appeared at lower temperatures, the feed in such treatments were gradually reduced and finally the fish were fed at their satiation level throughout the experiment by 0.75, 1.5 and 2.0% feed of body mass for fish reared at 20, 25 and 30 ^{0}C, respectively. One-tenth of SF was given to the LF group, respectively. The female fish (n=7 per treatment) were sampled at 15 and 30 days after onset of this experiment.

Histology: Samples were dehydrated using an ethanol series, clarified in xylene and ovaries were embedded in histoparaffin (Paraplast plus; Sigma-Aldrich). The tissue were serially sections (7 μm) using a microtome (CUT-5062, Germany) and were selected and stained with Delafield's hematoxylin-eosin for examination under a light microscope (DM 100; Leica, Wetzlar, Germany). A digital camera was used for capturing images (DFC 290; Leica).

Data analysis: All values are reported as means ± standard errors of the means (SEM). Student's t-test was used to compare the mean between groups. Two-way ANOVA was used to test the main effect or interaction. All statistical analyses were performed with SPSS software for Windows (SPSS Inc., Chicago, IL, USA) setting significance at $p < 0.05$.

Results

When the fish were reared under conditions of different food availability for 15 days, the GSI of fish fed with SF were significantly higher than those fed with LF (Figure 1). When ovarian histology was checked at the onset of this experiment, all ovaries contained vitellogenic oocytes at tertiary yolk stage (TYS) (data not shown). Similar ovarian features were observed in fish reared with SF (Figure 2a). The ovaries of fish fed with LF had only immature oocytes at peri-nucleolus stage (PNS) (Figure 2b).

When reversal of food limitation was examined in the fish group reared under LF conditions, a recovery in nutritive and reproductive parameters was observed within 30 days. The LF-SF group resulted in significant increases in GSI within 30 days (Figure 3), whereas GSI remained low in the fish group reared under LF-LF conditions until end of the experiment. When increases in GSI were further compared, no significant difference was observed between LF-SF and SF group within 30 days. It was observed that GSI was significantly related to the food availability and duration of the experiment. Histological observation revealed that immature oocytes at PNS were exclusively observed in the ovaries of fish reared under LF-LF conditions within 15 days (Figure 4a) and 30 days. In the ovaries of the LF-SF group, oocytes at TYS with PNS reappeared within 15 days (Figure 4b). Many vitellogenic oocytes at primary yolk stage (PYS) to TYS were observed in their ovaries within 30 days (Figure 4c). This ovarian feature was similar to that of the fish reared under SF conditions within this period (Figure 4d).

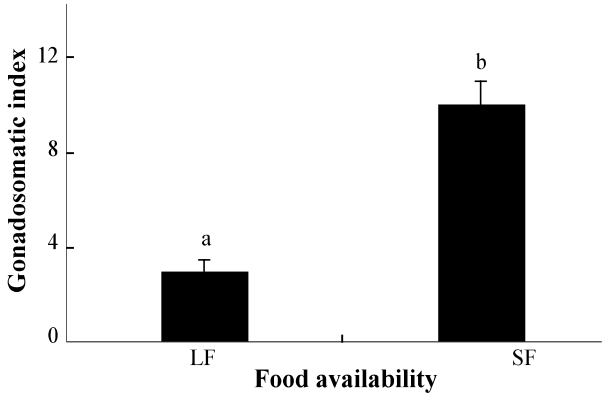


Figure 1. Changes in gonadosomatic index of the *Mystus cavasius* reared under different levels of food availability for 15 days during reproductive season. LF and SF indicate limited feed and saturated feed, respectively. Each value represents mean ± SEM. Different letters indicate significant difference at $p < 0.05$.

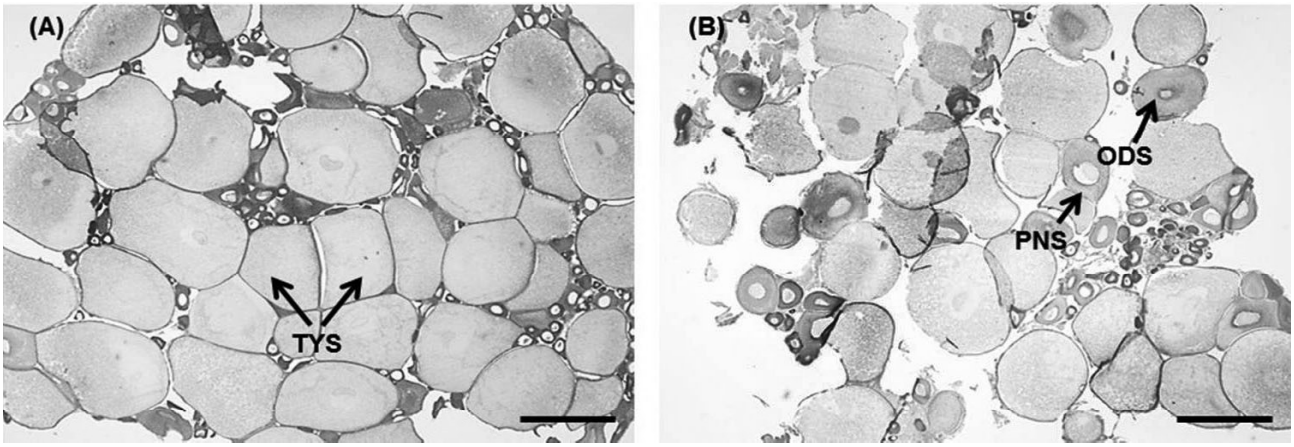


Figure 2. Changes in ovarian histology of the gulsha fish reared under different levels of food availability for 15 days during reproductive season. (a) Cross-section of an ovary (CSO) of the fish reared with SF, and (b) CSO of the fish reared with LF, respectively. PNS, peri-nucleolus stage; ODS, oil-droplet stage; TYS, tertiary yolk stage. Scale bar = 200 µm.

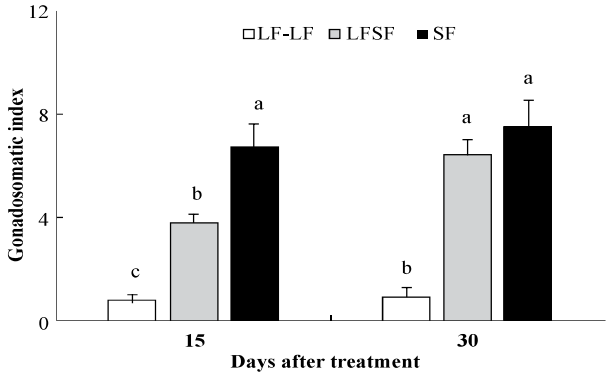


Figure 3. Effect of re-feeding on gonadosomatic index of the LF reared fish with LF (LF-LF) and SF (LF-SF), respectively. Black, gray and white column indicates fish reared under SF, LF-SF and LF-LF conditions, respectively. Data represented for 15 and 30 days after treatment. Each value represents mean ± SEM. Different letters indicate significant difference at $p < 0.05$.

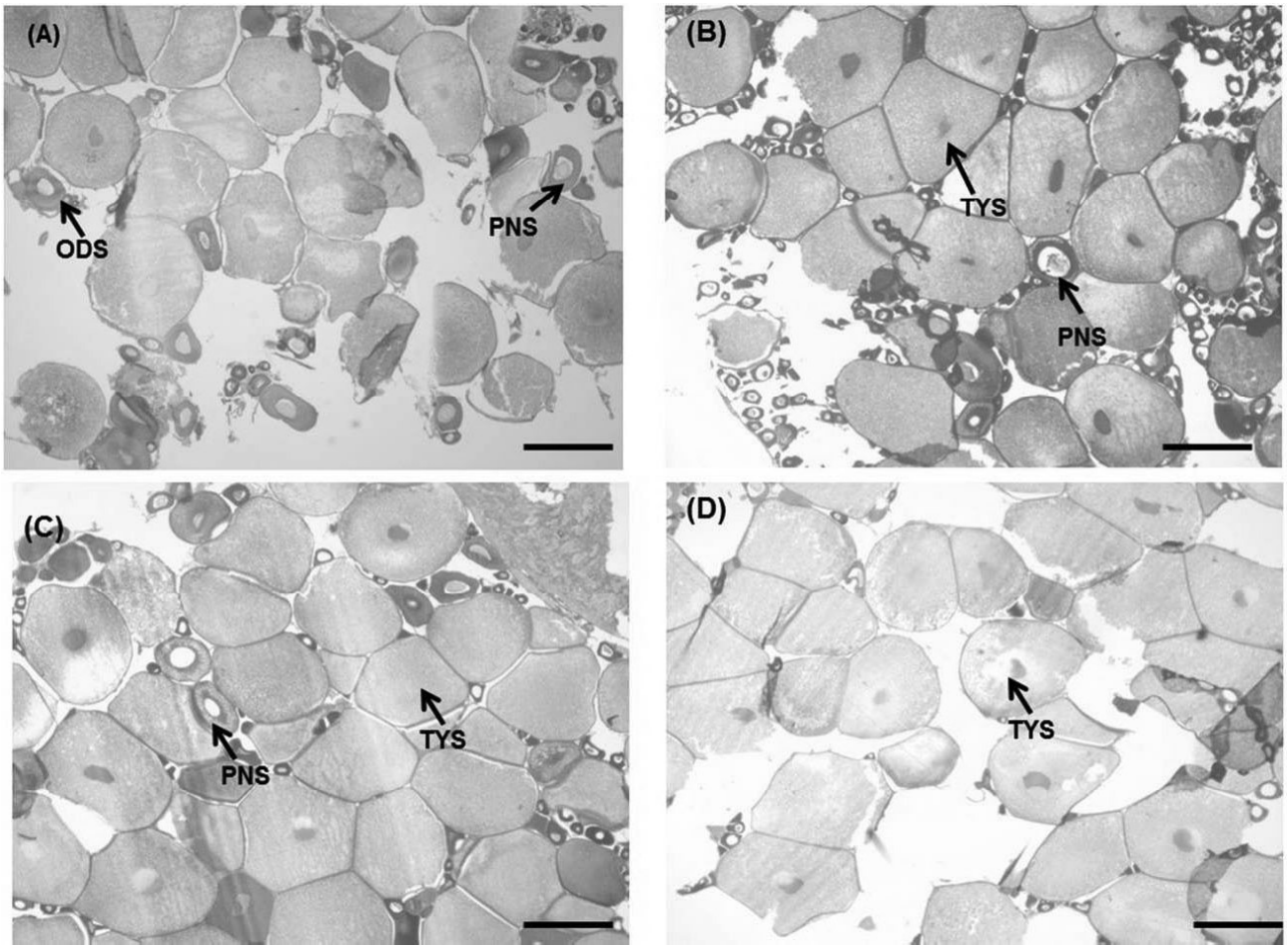


Figure 4. Effect of re-feeding on ovarian development of the gulsha fish during reproductive season. (a) Cross-section of an ovary (CSO) of the LF-reared fish re-fed with LF (LF-LF) for 15 days, (b) CSO of the LF-reared fish re-fed with SF (LF-SF) for 15 days, (c) CSO of the LF-reared fish re-fed with SF for 30 days, and (d) CSO of the fish reared under SF conditions for 30 days, respectively. ODS, oil droplet stage; PNS, peri-nucleolus stage; PYS, primary yolk stage; TYS, tertiary yolk stage. Scale bar = 200 µm.

When these two feeding levels were crossed with three different temperatures at 20, 25 and 30 ^{0}C, the nutritive and reproductive parameters differed between food rations regardless of temperature. GSI of the fish was affected by both factors of food availability and temperature. The fish reared with SF showed significantly ($p < 0.05$) higher GSI at 25 and 30^0 C than those of the fish reared with LF conditions, while no significant difference was observed at 20 ^{0}C The fish reared with SF at 25 ^{0}C and 30 ^{0}C had significantly ($p < 0.05$) higher GSI than those reared with LF at the same temperatures. No difference in GSI was observed between the experimental fish groups reared with LF and SF at 20 ^{0}C (Figure 5).

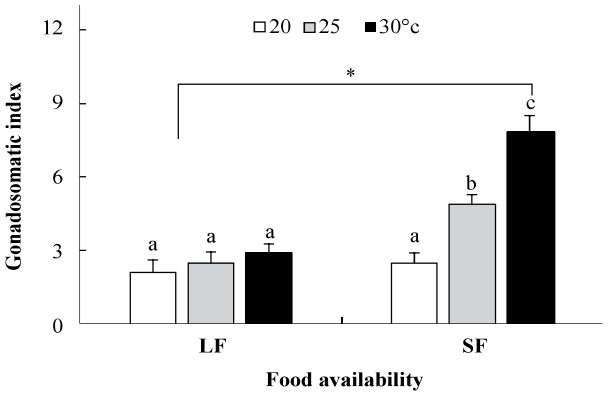


Figure 5. Changes in gonadosomatic index of the gulsha fish under different levels of food availability and temperature conditions. White, grey and black column indicate the temperatures of 20, 25 and 30 ^{0}C, respectively. Each value represents mean ± SEM. asterisks (*) indicate statistically significant difference between food availability (limited feed (LF) vs. saturated feed (SF). Different letters indicate significant difference within each group at $p < 0.05$.

Discussion

The present study demonstrated that food deprivation suppressed the gonadal development, including recrudescence of new clutches of oocytes; rapid advancement of vitellogenesis. In contrast, maintaining a sufficient nutritive situation was stimulated ovarian development and, consequently, prolongation of the reproductive period. The influence of food availability on reproductive activity had been described in several teleost species (Bapary *et al.* 2012). Donelson *et al.* (2010) also demonstrated that a high-ration diet increased the spawning frequency in Atlantic code *Gadus morhua* (Yoneda and Wright 2005). These results recommend that there is a link between food availability and reproductive activities and that food availability becomes a limiting factor for reproductive performance of fresh water fish. In this regard, it is likely that there are possible factors-temperature, plankton productivity, and winds, and rainfall in relation to food availability under influence of tropical monsoon climate (Johannes 1978, Tyler and Stanton 1995, Srinivasan and Jones 2006). It is possible to occur in the gulsha fish because we found that the gonado somatic index and vitellogenic oocytes of this species intensely changed within 15 days with variation of feeding under suitable photoperiod and temperature. Moreover, the rapid recovery of ovarian conditions in re-fed fish may support our hypothesis.

Our results showed a cross-relationship between temperature and ovarian development with feeding; when SF-fish reared at 20, 25 and 30°C were compared, ovarian performance was higher at 30°C than at 20 and 25°C. However, it was totally unable to maintain ovarian development in LF fish, even under suitable temperature. A trade-off likely occurs between food availability and reproductive obligation, and degeneration of oocytes over vitellogenic stages is possibly accelerated in the ovaries of LF-fish. It has been reported that change in temperature affects the reproductive activity of several teleosts species (Pankhurst and Porter 2003, Donelson *et al.* 2010). A different elucidation of the adverse impact of high temperatures on ovarian development is also available. Badruzzaman *et al*. (2017) showed that experimentally reared the gulsha fish under conditions of long photoperiod and temperature of 30°C beyond the reproductive season, and found that high temperature induces a rapid progress of gonadal development. In addition, low temperature retarded gonadal degeneration, suggested that degeneration speed of vitellogenic oocytes in an ovary decreased because of low metabolic rate at low temperatures.

This study also showed that there was cooperative interaction between temperature and nutritive status in the gulsha fish. Under environmental conditions with less fluctuations of water temperature and photoperiod, changes in relation to monsoon climate may be reasonably important and act as controlling factors. It is noticeable that deprived nutritive status do not initiate their reproduction even under suitable ranges of photoperiod and temperature. However, how the fish nutritive factors directly or indirectly influences reproductive endocrine axis is not yet fully understood. Further studies would be needed to clarify how these environmental cues are perceived by the fish and transduced them in the hypothalamus of the brain.

Acknowledgment

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