Environmental Effects On The Reproductive Function Of The Yellow-Finned Mahseer Of The Kumaun Himalaya

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The initiation and maturation of ovarian and testicular cycles in *Tor putitora* were manipulated by environmental factors for the values of the gonadosomatic index (G.S.I.). As compared to the wild conditions, spawning process in the female under the captive conditions was delayed by about a fortnight; in male, a clearcut effect was not clearly discernible. High temperature during winter adversely affected the ovarian development, while in the male, it led to an extention of the spermatogonial proliferation. A combination of high temperature and long day length although disfavoured the initial multiplication phase. In the male fish the combination avowedly favoured the testicular development. A scotophase and a low ambient temperature tethered the initial phases of the ovarian recrudescence and also disconcerted the spermatogenetic activity.

The reproductive function in teleosts is modified by a variety of factors \(^1\sim\,^8\), of which the daylength is of prime importance in salmonids \(^6\sim\,^{10}\) and certain perciformes \(^11\), while in other species \(^12\sim\,^{12}\) the stimulatory effect of temperature has invariably been lettered. The present study observes in *Tor putitora*, whether the production of male and female gametes is the result of exposure to certain periods of light hours or the day degrees, or to the combined effect of both the factors of the physical environment.

MATERIALS AND METHODS

Sexually mature specimens of *Tor putitora* (standard length, 18.1 cm; average weight, 46 gm) used in the present study were reared in 8 m. diameter pond under natural photoperiod (Light/Dark, LD, 10:14 hr) and temperature (8\(^\circ\)C), and were fed pelleted artificial food on alternate days.

After about a month of acclimation in the laboratory conditions, 12-16 fish were transferred, on 10 November 1985, to 3 different glass aquaria (36" × 18" × 18"), rendered
light-proof with a double black industrial grade polythene cover supported by a wooden frame. Light in each aquarium was provided by two 25 watt Philips cool-white fluorescent bulbs, located some 30 cm above the water surface. The photoperiodic regimes were controlled automatically. The temperature of the aquaria was regulated thermostatically. Temperature was recorded thrice a day. The fish were exposed to the following light-temperature regimes:

I. The temperature of the aquarium was raised to summer conditions (i.e., 28°C) without affecting the photophase, to know whether the prior exposure to the summer temperature hastens the gonadal activity.

II. The fish of this group were held in warm temperature as in group I; in addition, the photoperiod was raised to LD 18:6, to study the effect of summer temperature and photoperiod during the winter.

III. To observe the effect of photophase on the gonads, the fish were subjected to complete darkness without the temperature having been altered.

10-15 fishes were collected randomly from the natural conditions and sacrificed by decapitation during October 1985—September 1986. Again, 3-4 fish were sacrificed from each experimental group in the first week of every month between December 1985 and May 1986. The fresh unfixed samples of gonads were sponged with dry cheesecloth and weighed to nearest mg. The morphological features of the gametes and the G.S.I. were noted.

RESULTS

Gonad Development under Natural Photoperiod and Temperature Based on the GS (Fig. 1) and the photonic microscopy of the gonads the reproductive cycle in the test species under wild conditions can be divided into the following phases:

(i) During the first phase (Resting Phase extending from October to November) the oogonia and spermatogonia undergo active mitosis. The G.S.I. is low in both the sexes.

(ii) The second phase (Maturing Phase which extends from December through February) witnesses a rapid growth of the oocytes (diameter rising from 15.6 to 35 to 429 μm) up to the yolk vesicle accumulation (endogenous vitellogenesis) stage; in male spermatogonia (150 μm) differentiate into primary (9.75 ± 0.01 μm) and secondary (7.0 ± 0.1 μm) spermatocytes. The G.S.I. depicts a mild increase during this phase.

(iii) Accumulation of yolk globules (exogenous vitellogenesis) in the oocytes (570 ± 0.5 μm) marks the beginning of the third phase (Mature Phase) which lasts from
mid January to March in female and February-March in male. A number of spermatids (1·95 ± 0·01 μm) are seen in the later. The G.S.I. attains the peak during this phase (Fig. 1).

(iv) The pre-spawning phase extends from late March to April, during which the oocytes grow exponentially (825 ± 0·2 μm) as vitellogenesis advances further. In male the spermatogenetic activity augments much more avidly and quite a good number of spermatozoa could be recognized. G.S.I. is mildly reduced whereas lobule diameter shows a further increase. Degeneration of oocytes commences at the end of this phase.

(v) The spawning phase commences from late April and lasts upto July during which G.S.I. mean ova diameter and diameter of the lobule achieve reduction. The germinal vesicles of the oocytes accumulate numerous yolk globules which begin to migrate to the animal pole and to break down later on. Some of the oocytes (885 ± 0·13 to 915 ± 0·12 μm) are liberated into the body cavity after ovulation had occurred. The lobules are full of sperms (1·56 ± 0·1 μm).

(vi) The sixth phase (Post-spawning Phase) is characterized by an abundance of discharged follicles; in the testes almost all the germ cells develop into spermatozoa and become spermiated. The G.S.I. in both the sexes shows an appreciable fall (Fig. 1).

It is evident from the foregoing account that the values of G.S.I. and the ova and lobule diameters in the wild conditions reach the peak during the mature and pre-spawning
phases of the reproductive cycle and are reduced gradually to nadir values during the end of the later phase. Thenceforth, the parameters start increasing again thus, depicting a marked rhythmic reproductive pattern in the test fish. As compared to the conditions in the wild the data on the vitellogenic activity under the captive conditions portray delaying of the spawning in female but is without an effect in the reproductivity of the male Mahseer.

**Effect of High Temperature** A rise in ambient temperature from 8°C to 28°C, the highest under wild summer conditions, with the photoperiod remaining normal, delays the rate of maturation of oocytes and attenuates the yolk vesicle formation. The ova diameter (Table 1) and the G.S.I. (Fig. 2) register lower values than the controls. In male, the spermatogonia, primary and a few secondary spermatocytes are visible, although the spermiogenetic activity begins only by March. G.S.I. (Fig. 2) and lobule diameter (Fig. 3) show a gradual increase with the length of the experiment.

![Gonadosomatic Index Graph](image)

*Fig. 2—Changes in the gonadosomatic index (left panel—male; right panel—female) in Mahseer reared under different thermal and photoperiodic regimes during the initial course of the reproductive cycle.*

(——— LD, 10 : 14; Temp. 8 ± 0.5°C; ——— LD, 10 : 14; Temp. 28 ± 0.5°C; 0-0-0 LD, 18 : 6; Temp. 28 ± 0.5°C; ——— Complete darkness; Temp. 8 ± 0.5°C.
Vertical bars denote S.E.M.)
Table—1. Mean Ova Diameter (μm ± SEM) in Different Experimental Groups of *Tor putitora*

<table>
<thead>
<tr>
<th>Oocyte Stage</th>
<th>I (Control)</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>33.1 ± 0.5</td>
<td>97.1 ± 0.5</td>
<td>40.5 ± 0.7</td>
<td>33.0 ± 1.0</td>
</tr>
<tr>
<td>II</td>
<td>101.4 ± 1.2</td>
<td>72.1 ± 3.5</td>
<td>100.4 ± 2.5</td>
<td>93.6 ± 2.6</td>
</tr>
<tr>
<td>III</td>
<td>165.8 ± 12.0</td>
<td>135.6 ± 2.0</td>
<td>258.0 ± 3.7</td>
<td>243.5 ± 7.0</td>
</tr>
<tr>
<td>IV</td>
<td>331.5 ± 0.5</td>
<td>165.5 ± 2.0</td>
<td>229.0 ± 3.7</td>
<td>321.0 ± 2.0</td>
</tr>
<tr>
<td>V</td>
<td>390.0 ± 0.6</td>
<td>193.5 ± 5.0</td>
<td>570.0 ± 2.8</td>
<td>366.6 ± 5.5</td>
</tr>
<tr>
<td>VI</td>
<td>546.0 ± 1.0</td>
<td>405.0 ± 1.8</td>
<td>615.0 ± 3.0</td>
<td>404.9 ± 12.2</td>
</tr>
<tr>
<td>VII</td>
<td>645.0 ± 2.0</td>
<td>523.0 ± 2.2</td>
<td>697.5 ± 5.5</td>
<td>555.0 ± 7.5</td>
</tr>
<tr>
<td>VIII</td>
<td>780.0 ± 3.8</td>
<td>615.0 ± 2.5</td>
<td>825.0 ± 3.6</td>
<td>600.0 ± 4.4</td>
</tr>
</tbody>
</table>

**Effect of Long Photoperiod and High Temperature**

Increase in daylength along with temperature lowers multiplication and growth of oocytes early during the experiment followed by hastening of the yolk vesicle formation and exogenous vitellogenic activity. Soon after the completion of approximately two months of the experiment the ova diameter (Table 1) and G.S.I. (Fig. 2) reach their respective peaks and spawning commences nearly one month earlier than the controls. The spermatogenetic activity, too, starts early and the lobules become full of spermatids and sperms. The G.S.I. which remains high upto the first three months of the experiment, depicts a declining trend during the rest of the period; the lobule diameter (Fig. 3) remain unmodified, however.

*Fig. 3—Effect of various combinations of daylength and temperature on the lobule diameter in *T. putitora*, (Legends the same as in Fig. 2)*
Effect of Constant Darkness The yolk vesicles make their appearance early during this experiment which follows a heavy deposition of yolk in the oocytes. With a higher G.S.I. than the controls (Fig. 2) spawning in these specimens begins just before the termination of the experiment. The spermatogenesis activity starts quite early. Lower temperature and shorter daylength therefore, aggravate the testicular activity in the putitor Tor. The G.S.I. and lobule diameter which are on the higher side during the initial stages, start declining well before the end of the experiment. Spermiation in group II and III is similar except that the G.S.I. in the later decreases remarkably and regressed testis are deployable till May.

DISCUSSION

Female Reproductive Cycle The reproductive cycle in a female fish is invariably influenced by the photoperiod. For instance, in those species that spawn in spring or early summer, i.e., Mystus tengara and Girrha raha, the ovarian recrudescence is often stimulated by long photoperiods. However, subjecting the gillhead beam Sparus aurata and the landlocked salmon Oncorhynchus masou ishikawa to a longer photoperiod resulted, in contrast to those held at the natural daylength, in a clear inhibition of sexual differentiation and gonadal recrudescence. Nevertheless acceleration of spawning and maturation under a combination of long photoperiod during the early stages of the reproductive cycle and a short photoperiod during the later stages is reported in the masu salmon. Recent views establish that the length and time of illumination effect the ovarian maturation in a fish that spawns in summer. On the other hand, the species which spawn in autumn or early winter (viz., salmonids) gonadal recrudescence is favored by a short photoperiod. In rainbow trout Salmo gairdneri thus, the decreasing photoperiod is the major environmental factor involved in the sequence of endocrine events which lead to spawning, suggesting therefore, that the photophase may act by modifying an inherent reproductive rhythm. In the Himalayan loach Noemacheilus zonatus and crucian carp, secondarily adapted to the Himalayan waters Carassius carassius short continuous photoperiods favor ovarian activity.

The current weight of evidence suggests that, in Salmo, long photoperiods are important for the initiation of the gonadal recrudescence or at least for terminating a period of ovarian refractoriness, while short photoperiods are important for accelerating the gonadal development. The present work demonstrates that the timing of reproduction in mahseer can be modified by light cycles. The fish subjected to complete darkness does show an early maturation although the vitellogenic activity is retarded.

Thermal regimes are known to modify, rather than the photoperiod, the pattern of the reproductive cycle in several teleosts including, the common carp, catfish and the snakehead. In Tor putitora high temperature akinlly inhibits multiplication and growth
phases, but for the exogenous vitellogenesis, it proved to be the factor of heuristic importance. These findings in mahseer corroborate well with those reported in other teleosts. Thus, while warm temperature during winter provokes prolongation of the resting phase, a low aqua temperature favours the earlier phases of ovarian maturation. However, in a number of bony fishes, a low ambient temperature has been considered essential for ovulation.

**Male Reproductive Cycle** Many authors have delineated the extent to which the spermatogenetic activity of a fish could be modified at the phase of the environmental change. In salmonids, gastrosteids and sticklebacks, daylength exerts a primary influence over the initiation and modulation of testicular development. Quantitative indument in spermatozoa formation under constantly long or short photoperiods has recently been reported in *S. gairdneri*. In *Cirrhina reba* and *Heterophytes fossulis* long photoperiodic treatment stimulates testicular development while short photoperiod or constant darkness imparts a delaying effect. In contrast to the response in female the testes in *N. zonatus* matures early when the fish is subjected to long-day treatment. In the present species long photoperiod retards, albeit mildly, the spermatogenial proliferation, besides slowing down the conversion rate of the spermatogonia into primary spermatocytes. A short photoperiod in the fish, on the stark contrast, augments the multiplication phase.

As compared to the ovocyte maturation the role of temperature in the control of the testicular function has only meagrely been discerned. Notwithstandingly, high temperature is known to be essentially needed for not only the spermatogonial proliferation but also for spermatiation, while for the formation of the spermatocytes a low temperature is required. As in *Fundulus heteroclitus* and *N. zonatus* warm temperature during winter checks the early phases of spermatogenesis in the present species but it proves to be quite stimulatory for the later stages of the development of the testes.

The temperature dependency of photoperiodism has lately been reported, although it is just unclear as to how precisely the photoperiodic effects are intricately juxtaposed or interwoven with thermal regimes. In several of the major carps, i.e., *Labeo rohita, Catla catla, Cirrhina migala* and the Indian catfish, *H. fossilis* both photoperiod and temperature contemporaneously control reproduction and spawning to the extent that it becomes difficult enough to dissociate the effects of the either factor of the environmental milieu. In some tropical species, such as *Tinca, Epinephalus, Schomber, Chromis, Cynasian*, etc., a combination of long photoperiod and warm temperature is essential for active gametogenesis. In keeping with these studies the present data evince an inter-dependency of thermal and photoperiodic regimes and the fish exposed to a combination of warm temperature and long daylength shows advancement in the later stages of the gamete maturation whereas
a short daylength-low temperature combination provides a stimulus for gonadal development at the initial phases of the reproductive cycle, the cause of which remains to be resolved. However, the findings do indicate that, in the mahseer, the factors which stimulate gonadal maturation at different levels may be activated or retarded by the photoperiod.

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REFERENCES


