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**RESEARCH ARTICLE**

# PHOTO-THERMAL AND HORMONAL REGULATION ON MATURATION AND SPAWNING IN FISH

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**ABSTRACT**

In the Indian subcontinent, majority of the freshwater fishes breeds during the monsoon following their pre-monsoon maturity during summer. The time of breeding of each species is so precisely adjusted that spawns and fries are produced in an environment when their chance of survival is maximum. It appears that natural selection possibly favors genomes of individuals that produce their young ones at a time when their chance of survival is maximum.

Due to paucity of information, the integrated concept of environmental impact on maturation and spawning of fishes is not yet known. It is assumed that fishes sense, through extero receptor, the environmental cues with the approach of breeding season and such cues initiates endogenous rhythm to be in right phase for breeding. A variety of sensory receptors such as eyes, pineal gland (sensitive to light), olfactory organs, taste buds and thermo receptors help in detecting these cues.

Among all the environmental factors photoperiod, temperature and seasonal rainfall are the main factors in regulating reproductive cycles in teleost fishes. The approach of wet season following a long dry one brought out sudden and marked seasonal changes in water quality and food availability which help trigger maturation and spawning. The major group of teleostean fishes and their response to photo-thermal cycles towards attaining maturity and spawning as observed during experiments are as below.



## INTRODUCTION

In the Indian subcontinent, majority of the freshwater fishes breeds during the monsoon following their pre-monsoon maturity during summer. The time of breeding of each species is so precisely adjusted that spawns and fries are produced in an environment when their chance of survival is maximum. It appears that natural selection possibly favors genomes of individuals that produce their young ones at a time when their chance of survival is maximum.

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Among all the environmental factors photoperiod, temperature and seasonal rainfall are the main factors in regulating reproductive cycles in teleost fishes. The approach of wet season following a long dry one brought out sudden and marked seasonal changes in water quality and food availability which help trigger maturation and spawning. The major group of teleostean fishes and their response to photo-thermal cycles towards attaining maturity and spawning as observed during experiments are as below.

### *CAT Fish*

Extensive basic research on the role of environmental factors in the regulation of breeding cycles of the catfish has been made use of to harvest multiple crops of eggs at monthly intervals. Precociously gravid catfish obtained in early April by photo thermal treatment are induced to spawn by the administration of luteinizing hormone (LH). Spent fish when subjected to photo-thermal treatment develop second crop of yolky eggs within one month. Such gravid females again produce normal spawn on induction with LH. Thus catfishes are found to

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spawn four times between April and July in the same breeding season. This assures not only early availability of seed but in much larger numbers.

***Common Carp***

In common carp reproductive cycle is dependent more on temperature than photoperiod. In India, common carp shows two main peaks of breeding activity in a year, once during spring and again in autumn when optimal thermal condition prevail in nature. It is observed that pituitary concentration of gonadotrophin in creases in spring and early autumn i.e. at the time of gonadal recrudescence, gametogenesis and spawning (*Billard et al.,* 1978). This indicates that gonadal development in carp is associated with increasing temperature and spawning occurs when temperature is at its maximum (Billard and Bretion, 1978).

***Tilapia***

The regulatory role of photoperiod is not properly understood in tilapia but spawning is associated with the period of highest temperature and onset of rainy season. Increasing water temperature above $22^0$C induces ovarian growth. However, the species of the genus sarotherodon exhibit seasonal reproductive activity ever though photoperiod and temperature are relatively constant throughout the year (*Billard et al.,* 1978).

***Indian Major Carp (IMC)***

Indian major carps show gonadal recrudescence from March to June (according to geographical location) i.e. at a time when both photoperiod and temperature and at increment. Exposure of males and females of *cirrhina reba* to a long photoperiod (LD 14: 10 or 18: 6 i.e. 14 hr light: 10 hr. dark or 18 hr. light: 6 hr. dark) at ambient temperature ($19^0$C to $30^0$C) hastens gonadal recrudescence. Males attain maturity earlier than females. Again, when fish are subjected to gradually increasing photoperiod from LD 4: 20 to 14: 10 and finally to LD 20: 4, females mature earlier then males at ambient temperature, whereas at elevaled temperature (27.10 to 310C), males mature earlier than females (*Verghese,* 1970). Further, males kept in constant darkness mature simultaneously with those under natural photoperiod. Whereas in females constant light hastens and constant darkness retards functional maturity (*Verghese,* 1975). As males show gonadal recrudescence earlier than females under natural conditions so it is surmised that threshold temperature for testicular recrudescence is lower than that of ovarian.

Properly designed further experimental work is needed to understand the relative roles of these two factors on gonadal maturity.

***Chinese Carp***

Attains sexual maturity in 2 years in tropical climates than temperate, where it takes 10 years. It is surmised that warm temperature, long photoperiod coupled with good diet accelerate gonadal maturity.

***Spawning of IMC***

The female carps develop roe during pre-monsoon period but couldn't shed them in standing water and the reason behind still remains unsolved. It is known that rain increases the level and velocity of water, flooded the shallow areas, diluted certain ions, change the concentration of other components as also change smell and taste of water. It also brings changes in the biotic parameters such as growth of algae and other green vegetation. Specific combination of some or all of these changed factors are received by the exteroreceptor and conveyed to brain through neural connections. The sensory stimuli finally reach hypothalamus. On being stimulated it releases GnRH (Gonadotrophin releasing hormone) to activate pituitary which produce gonadotrophic hormone to induce maturation, ovulation, spermiation and spawning (Fig. I).

***Photoperiod – Thermo period Relationship***

In teleost fishes which are ecotothermal, the principal mode of thermoregulation is behavioral. This is done by exploiting the thermal heterogeneity in the environment by swimming into desired areas and remaining there. Recently, a photoperiod-thermo period relationship on the body and testicular weight gain in goldfish, subjected to increased temperatures at one of six different times in a 24 hour period, has been demonstrated (*Spieler et al.,* 1977). Depending on the time of the day when thermo cycle is commenced, body and testicular weight gain can be stimulated or inhibited. This interesting observation is similar to the presence of a daily rhythm in photoresponsiveness with sensitive phases occurring between 12 – 18 hours, after the onset of photoperiod in case of *Gasterosteus aculeatus* (Baggerman, 1957) and between 16 – 17 h and 20 – 21h after onset of photoperiod in *Heteropneustes fossilis* (vassal and sundararaj, 1975).

***Environmental Manipulation or Photo-thermo Manipulation on Maturation and Spawning of Fish***

The knowledge relating to physiological basis and ecological implications of this chronobiological approach is of considerable importance to aquaculture and may provide the key to producing precociously gravid fish. Almost all fishes use the specific phases of the annually changing cycles of day length and temperature as cues for attaining maturity and spawning. By subjecting a fish stock to a constant photoperiod regimes maturity can be maneuvered.

This can be done by maintaining the fish stock permanently under light proof covers with controlled light and temperature. Now, by placing the fish under required photoperiod and temperature, maturity can be advanced or delayed as per requirement of the farm. By maintaining 3 – 4 separate brood stock under different yearly thermo photo cycle's availability of gravid brood stock can be ensured throughout the year for conducting breeding. Thus by maneuvering control over thermo-photo period multiple breeding and spawning can be undertaken to raise more crop from the same brood stock. Once standardized this will add a new direction in the seed production industry.

### *Hormonal Control on Maturation and Spawning*

In fish hypothalamohypophyseal – gonadal axis the main rout of gonadal maturation and spawning and are activated by the seasonal changes, as mentioned, in the environment. The environmental signals are received by brain through exteroreceptor thermo receptor, photorecepter etc.), which response by releasing Gondotrophin releasing hormone (GnRH) – a decapeptide hormone. The hypothalamic hormones include both gonadotrophin releasing hormone (GnRH) and gonadotrophin inhibiting factor (GRiF) that have antagonistic actions upon the synthesis and release of gonadotrophic hormones (GTHI & GTH II) by the gonadotroph cells of the adenohypophysis of pituitary glands (Fig 2). Gonadotrophic hormones are responsible for germ cell growth and maturation initially induces the synthesis and release of estradiol – 17β from ovarian theca cell and II-ketotestosterone from testicular leydig cell. Afterwards during maturation of germ cell, GTH stimulates the release of 17α, 20β – dihydrxy – 4 – pregnene – 3 – one, also known as maturation inducing hormone (MIH), from Ovarian follicular cells as also from testicular somatic and germ cells. MIH, being a non-genomic hormone, binds with the membrane receptor and initiates the formation of a protein factor known as maturation promoting factor (MPF). During pre-mature stage MPF remain inactive, but following maturation MIH activates MPF by amino-phosphorylation. Active MPF is a complex protein and is composed of active cdc 2 kinase and cyclin B. MPF triggers all changes associated with oocyte maturation, which encompasses a series of steps like germinal vesicle breakdown (GV BD), chromosome condensation and spindle formation (Fig. 3).

In case of male GTH stimulates synthesis of 11 – ketotestosterone (11 – KT) from interstitial cell, which initiates spermatogenesis, sperm maturation, on the other hand, is activated by MIH. It is surmised that sertolie cells, under the influence of 11-KT, secrete meiosis initiating substance, which is turn, initiates spermatogenesis. MIH concentration in fish is greatly enhanced during spermiation, which indicate that final maturation is brought by MIH. Finally spawning is initiated by MPF (Fig. 3).

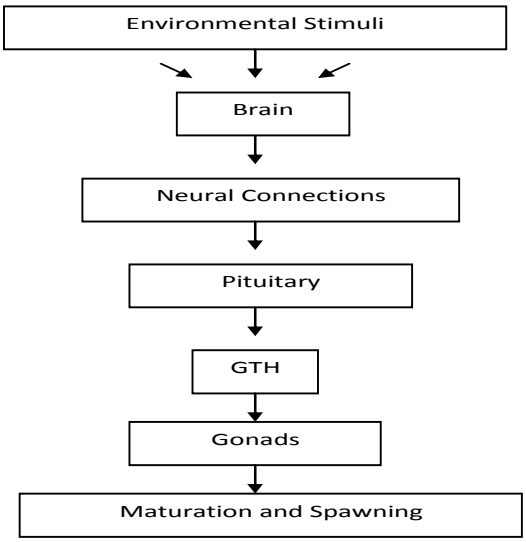


**Fig. 1** Chain of events in maturation and spawning of fish triggered primarily by environmental cues followed by Hormones

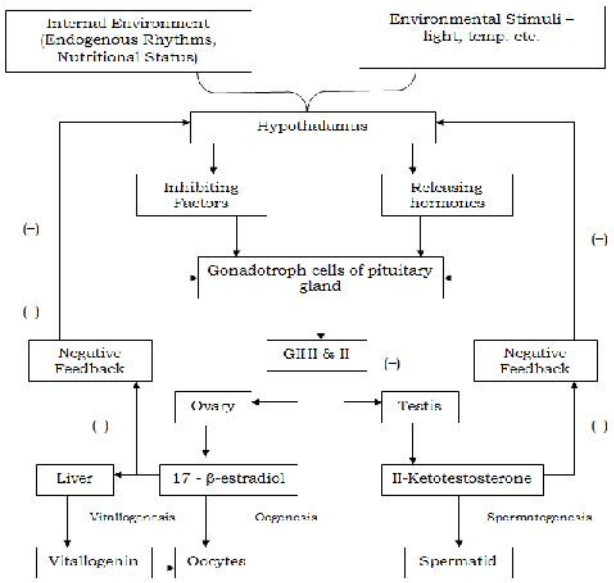


**Fig. 2** Hypothalamic – pituitary – gonadal axis indicating the major endocrine factors involved in control of reproduction of fish

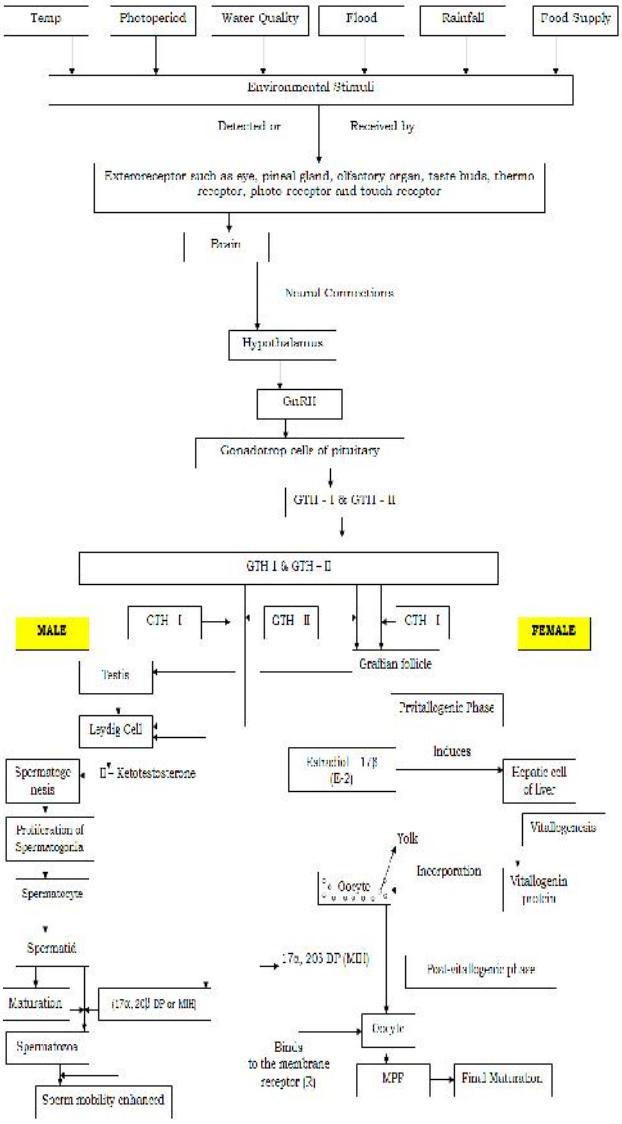


**Fig. 3** Proposed model of hormonal regulation on maturation of gametes. DP = Dihydroxy-4-pregnene-3-one

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