CHAPTER 4.

Effect of short photoperiod on the ovarian activity of *Channa punctatus* (Bloch)
Introduction

The photoperiodic phenomenon shows an interaction between the day length and the responses of animals including their reproductive behaviour. Rowan (1926) showed that the reproductive activity can be induced in a bird, *Junco hylensus* by increasing day length artificially in off season. Long photoperiod was found to cause a positive growth of the gonads in white crowned sparrow (Farner and Wieson, 1957). Wolfson (1952) had shown earlier that short photoperiod is not as effective as long photoperiod. Wolfson (1959) signified that the stimulatory photoperiod separated by long dark period induces the gonad growth, over shadowing the negative effect of darkness.

Mammals are only next to the birds which received greater attention than any other group of vertebrates. Studies of Farner (1965) clearly indicate that the reproductive cycle of *Procyon lotor* and *Lepus timidus* is governed by long photoperiod whereas in sheep and goat the cycle is under the control of short photoperiod.

The fishes are not far behind than birds and mammals as far as the study of photoperiod is concerned. Hoover and Hubbord (1937) observed that the rate of spawning was accelerated in brook trout, *Salvelinus fontinalis* by increasing its day length with a secondary short photoperiod treatment. It was later confirmed that longer day length followed by a short day length causes the advancement of maturity by four months (Hazard and Eddy, 1951).
In *Phoxinus laevis*, Bullough (1940) proved experimentally that a short day length caused delay in the process of oogenesis and spermatogenesis.

Baggeman (1957) studied extensively the role of photoperiod during reproductive cycle in three spined stickleback, *Gasterosteus aculeatus* where there is alternation of reproductive and non-reproductive periods. She could produce a 200 days smooth cycle by treating fish by long day length (16:16) coupled with high temperature (26°C) and concluded that the photoperiod plays an important role in the regulation of reproduction. However, she was not sure about the photo-receptor (Baggeman, 1969, 1972). Henderson (1963) concluded that the effect of photoperiod depends upon the stage of gametogenesis in progress. Pyle (1969), Poston and Livingstone (1971) and Biemierz and Biemierz et. al., (1976) observed that the advancement in the maturity of gonads in brook trout is caused by constant light and dark.

Kaya and Hasler (1972) observed that the gonadal recrudescence can be stimulated in both the sexes of *Leopomis cyanellus* during winter when exposed to long photoperiod (15:15) and elevated water temperature (15°C). Takano et. al., (1973) were able to produce most advanced oocytes in the ovary of medaka, *Oryzias latipes* by treating the fish with 12L:12D photoperiod. Sunderaraj and his associates (1970 a,b,c, 1973 and 1976) observed the role of photoperiod and temperature in the reproduction of female cat fish, *Heteropneustes fossilis* and concluded that these factors work together in the ovarian recrudescence expecting a

Recently, Takashima and Yamada (1984) and Elliot et al. (1984) noticed trigger action in stages of early gonadal development by long or increased day length in rainbow trout while short photoperiod accelerated the growth of gonads in the later stages, confirming observations of Henderson (1963) and Bromage et al. (1982 b). Burns (1985), in Poeciliopsis gracilis and P. sphenops, observed more yolky eggs under longer photoperiod in comparison to short one. Similarly, Skarphedinson et al. (1985) in Salmo gairdneri noticed maturation in male gonads during longer photoperiod. Davies and Hanyu (1986) and Davies et al. (1986) observed maturation and spawning period manipulation under high and low temperature during different regimes of photoperiod in common carp.
In this chapter an attempt has been made to determine a photosensitive phase for ovarian activity in *Channa punctatus* (Bloch).

**Observations**

To study the effect of photoperiod in the female *Channa punctatus* (Bloch), the fishes were exposed to light for six hours during different periods of the day. The fishes were collected and acclimatized to the laboratory conditions for a week. The fishes were divided into five experimental groups. Group First was illuminated from 00.00 hrs to 06.00 hrs, Group Second from 06.00 hrs to 12.00 hrs, Group Third from 12.00 hrs to 18.00 hrs and Group Fourth from 18.00 hrs to 24.00 hrs under 6L:18D photoperiod while Group Fifth served as experimental control exposed to regular day length under laboratory conditions. The samples were collected on 0 day, 15th day and 40th day and evaluated histologically as well as statistically.

**Determination of photosensitive phase of the ovary in female fish, Channa punctatus during different regimes of photoperiod (6L: 18D).**

**Histological Changes:**

Following changes were observed in the state of ovary on 0 day (initial control), 15th day and 40th day (control and experimental).

1. **Initial Control:**

   The fishes of initial group show most of the oocytes in advanced stages of maturity reaching up to the early and late yolk
stages and the mature stage with a number of atretic follicles. Yolk vesicle stages are the next largest population of oocytes. Perinucleolus stages are very few. Some of the oocytes also show the process of resorption in the stroma of the ovary (Fig. 38).

2. Changes on 15th day:

Following changes were observed in the samples of different group of fishes exposed to a photoperiod 6L : 16D for 15 days.

(A) Control: The oocytes of fishes under normal laboratory conditions showed significant changes. The oocyte population consists of maximum number of early yolk stage. The yolk globules have occupied only a small area in the oocyte that too at peripheral region. Along with these stages peri-nucleolus stages and yolk vesicle stages of oocyte are also observed (Fig. 39).

(B) Group First: 6L : 16D; 00.00 hrs to 06.00 hrs photoperiod

The oocytes in this group of fishes are in the form of chromatin nucleolus, peri-nucleolus, yolk vesicle and early yolk stages. The gonads in general are predominated by late peri-nucleolus stage (Fig. 40).

(C) Group Second: 6L : 16D; 06.00 hrs to 12.00 hrs photoperiod

This group of fishes indicates less advancement in comparison to the control as well as to the fishes of Group First. The oocytes are dominated by peri-nucleolus stages. A few oocytes of early yolk stage are also visible. The connective tissue is also sparsely distributed throughout (Fig. 41).
Photomicrographs of transverse sections of the ovary of *Channa punctatus* during different regimes of 6L:18D photoperiod in:

Fig. 38 - Initial control group

Fig. 39 - 15th day control group

Fig. 40 - 15th day experimental, Group First
(00.00 hrs to 06.00 hrs photoperiod)

Fig. 41 - 15th day experimental, Group Second
(06.00 hrs to 12.00 hrs photoperiod)

**Abbreviations:**

C.A. - Corpus atreticum
E.Y. - Early yolk stage
E.Y.V. - Early yolk vesicle stage
L.P.N. - Late peri-nucleolus stage
L.Y. - Late yolk stage
M. - Mature stage
Photomicrographs of transverse sections of the ovary of *Channa punctatus* during different regimes of 6L:18D photoperiod in:

**Fig. 42** - 15th day experimental, Group Third (12.00 hrs to 18.00 hrs photoperiod)

**Fig. 43** - 15th day experimental, Group Fourth (18.00 hrs to 24.00 hrs photoperiod)

**Fig. 44** - 40th day control group

**Abbreviations:**

- **C.A.** - Corpus atreticum
- **E.P.N.** - Early peri-nucleolus stage
- **E.Y.V.** - Early yolk vesicle stage
- **L.Y.** - Late yolk stage
- **L.Y.V.** - Late yolk vesicle stage
- **M.** - Mature stage
(D) **Group Third**: 6L: 18D; 12.00 hrs to 18.00 hrs photoperiod

This group is dominated by the oocytes of peri-nucleolus stage. Chromatin nucleolus, yolk vesicle and early yolk stages also make their appearance. Few early yolk stages are present with a little quantity of yolk. The connective tissue in the stroma of ovary is less and the disposition of ovigerous lamellae is also not clearly marked (Fig. 42).

(E) **Group Fourth**: 6L: 18D; 18.00 hrs to 24.00 hrs photoperiod

The ovary is well marked with the oocytes of late yolk and mature stages full of yolk globules along with a very few early stages of oocytes. The ovigerous lamellae are obliterated with a little or no connective tissue in between the oocytes. A few atretic follicles are also seen in different stages of resorption (Fig. 43).

**Concluding Remarks**:

From the study of initial control, 15th day experimental control and experimental group (first, second, third and fourth) it may be concluded that the initial control group fishes were matured with the dominance of oocytes of mature stages and atretic follicles. During the 6L: 18D photoperiod the fishes responded in a very quick succession. A new crop of oocytes had already appeared and the gonads started growing with a faster speed than in the natural state. Noteworthy is the Group Fourth (18.00 hrs to 24.00 hrs photoperiod) where the growth of oocytes was most extensive and the ovaries are filled up with the later stages of oogenesis. The ovaries of Group First (00.00 hrs to
06.00 hrs photoperiod) also quite responded to the short photoperiod and stand second to Group Fourth where the growth of oocytes was remarkable. Such a quick photoperiodic response i.e., resorption of atretic follicles and proliferation of new crop of oocytes and their development upto mature stage needs further confirmation after exposure of different group of fishes to the short photoperiod (6L : 18D) regimes for some more days.

3. Changes on 40th day:

Following are the changes after 40th day of experiment with the same parameters of photoperiodic phase (6L : 18D), as described earlier:

(A) Control:

The oocytes of this group of fishes do not exhibit any significant growth except that the oocytes increase in size and the number of early stages is reduced (Fig. 44).

(B) Group First: 6L : 18D; 00.00 hrs to 06.00 hrs photoperiod.

Oocytes of early yolk stages still make their appearance as usual with more yolk in the ooplasm. The oocytes of early stages like peri-nucleolus and yolk vesicle stages increase in size. The connective tissue in stroma is sparse (Fig. 45).

(C) Group Second: 6L : 18D; 06.00 hrs to 12.00 hrs photoperiod.

The oocytes show little advancement in their growth. These are mostly in the late yolk stage with more yolk globules in the ooplasm. The oocytes of yolk vesicle stage, early yolk stage and peri-nucleolar stage increase in their size (Fig. 46).
Photomicrographs of transverse sections of the ovary of *Chaenopephalus punctatus* during different regimes of 6L:18D photoperiod in:

Fig. 45 - 40th day experimental, Group First (00.00 hrs to 06.00 hrs photoperiod)

Fig. 46 - 40th day experimental, Group Second (06.00 hrs to 12.00 hrs photoperiod)

Fig. 47 - 40th day experimental, Group Third (12.00 hrs to 18.00 hrs photoperiod)

Fig. 48 - 40th day experimental, Group Fourth (18.00 hrs to 24.00 hrs photoperiod)

**Abbreviations:**

C.A. - Corpus artericum  
E.Y. - Early yolk stage  
E.Y.V. - Early yolk vesicle stage  
L.P.N. - Late peri-nucleolus stage  
L.Y. - Late yolk stage  
M. - Mature stage
(E) **Group Third**: 6L : 18D; 12.00 hrs to 18.00 hrs photoperiod.

This group of fishes does not show appreciable changes in the ovarian activity in comparison to what was observed on 15th day except that the stages grow more in size. The number of oocytes of late yolk stage is comparatively more. The state of ovarian stroma and ovigerous lamellae also remains same (Fig. 47).

(E) **Group Fourth**: 6L : 18D; 18.00 hrs to 24.00 hrs photoperiod

The oocytes show pronounced changes in their growth. The number of mature oocytes has also increased in comparison to all other groups. The number of atretic follicles is also enhanced. Oocytes of early stages are very few. Condition of ovigerous lamellae is the same as observed earlier (Fig. 48).

**Concluding Remarks:**

Study of ovarian tissue on 40th day of experimentation signifies the trend of oocyte growth. In Group First (00.00 hrs - 06.00 hrs), Second (06.00 hrs - 12.00 hrs) and Third (12.00 hrs - 18.00 hrs) the changes in the ratio of different oocyte stages are not that significant as in the Group Fourth (18.00 hrs - 24.00 hrs) where abundance of oocytes of mature stage and the presence of atretic follicles indicates the influence of photoperiod on the ovarian activity distinctly.

**Results:**

Above experiment on female *Channa punctatus* signifies the presence of a photosensitive phase for ovarian development and maturation. It is beyond doubt that the light, if enters in between 18.00 hrs to 24.00 hrs (i.e. for six hours) after a
complete darkness of 18 hrs, is sufficient to bring about a change in the process of oogenesis and such period may be called as "photosensitive phase" for the fish. However, this six hours phase may be still wide as even a very short photoperiod could be sufficient to bring about such changes.

Keeping in view the above observations, another experiment was conducted to determine the "specific photosensitive phase".

**Determination of "Specific Photo-sensitive phase" by short photoperiod 1L : 23D during photo-sensitive phase.**

To determine the specific photosensitive phase, the female fishes were divided into seven different groups (one control and six experimental). Each experimental group was illuminated for one hour in a day in between 18.00 hrs to 24.00 hrs.

**Group First (1L : 23D) of fishes received illumination from 18.00 hrs to 19.00 hrs, Group Second (1L : 23D) from 19.00 hrs to 20.00 hrs, Group Third (1L : 23D) from 20.00 hrs to 21.00 hrs, Group Fourth (1L : 23D) from 21.00 hrs to 22.00 hrs, Group Fifth (1L : 23D) from 22.00 hrs to 23.00 hrs and Group Sixth (1L : 23D) from 23.00 hrs to 24.00 hrs.** The changes were observed histologically and statistically.

1. **Initial Control**

The oocytes are in the early stages of oogenesis. Oocytes of peri-nucleolus stage are in abundance with few oocytes of yolk-vesicle stage. The ovigerous lamellae are well formed and the connective tissue in the ovarian stroma is thick (Fig. 49).
2. Changes on 20th Day

Following changes were observed in the samples of 20th day in different group of fishes exposed to light for 1L:23D.

(A) **Control**

The oocytes have reached to the early yolk stage. The oocytes of peri-nucleolar stage and yolk vesicle stage are in good number. The stroma in the ovary is marked by a thin sheet of tissue in between the oocytes. The ovigerous lamellae are well formed (Fig. 50).

(B) **Group First**: 1L:23D; 16.00 hrs to 19.00 hrs photoperiod.

The oocytes are in chromatin nucleolus, peri-nucleolus and early yolk vesicle stages. A few oocytes of late yolk vesicle and early and late yolk stages have also been observed. The ovigerous lamellae are well marked containing these stages of oocytes (Fig. 51).

(C) **Group Second**: 1L:23D; 19.00 hrs to 20.00 hrs photoperiod.

The ovaries are very well stuffed with the peri-nucleolus stage as well as yolk vesicle stage. Few oocytes of late yolk stage are also present whereas the oocytes of early yolk stage are found to be very less in number (Fig. 52).

(D) **Group Third**: 1L:23D; 20.00 hrs to 21.00 hrs photoperiod.

The oocytes of early stages (i.e. early and late peri-nucleolus stage) are abundant. The yolk vesicle stages are also present but their number is less in comparison to peri-nucleolus stages. Along with early stages, few oocytes of yolk stage are
Photomicrographs of transverse sections of the ovary of *Channa punctatus* exposed to short photoperiod 1L:23D during photosensitive phase (18.00 hrs to 24.00 hrs) in:

Fig. 49 - Initial control group
Fig. 50 - 20th day control group
Fig. 51 - 20th day experimental, Group First (18.00 hrs to 19.00 hrs photoperiod)
Fig. 52 - 20th day experimental, Group Second (19.00 hrs to 20.00 hrs photoperiod)

**Abbreviations:**

E.P.N. - Early peri-nucleolus stage
E.Y. - Early yolk stage
E.Y.V. - Early yolk vesicle stage
L.P.N. - Late peri-nucleolus stage
Photomicrographs of transverse sections of the ovary of *Channa punctatus* exposed to short photoperiod 1L:23D during photosensitive phase (18.00 hrs to 24.00 hrs) in:

**Fig. 53** - 20th day experimental, Group Third (20.00 hrs to 21.00 hrs photoperiod)

**Fig. 54** - 20th day experimental, Group Fourth (21.00 hrs to 22.00 hrs photoperiod)

**Fig. 55** - 20th day experimental, Group Fifth (22.00 hrs to 23.00 hrs photoperiod)

**Fig. 56** - 20th day experimental, Group Sixth (23.00 hrs to 24.00 hrs photoperiod)

**Abbreviations:**

- **E.Y.V.** - Early yolk vesicle stage
- **L.P.N.** - Late peri-nucleolus stage
- **L.Y.** - Late yolk stage
- **L.Y.V.** - Late yolk vesicle stage
also present. The ovigerous lamellae are intact with some connective tissue in its stroma (Fig. 53).

(E) **Group Fourth**: 11:23D; 21.00 hrs to 22.00 hrs photoperiod.

Peri-nucleolus stage and early yolk vesicle stages are dominant oocytes in the ovary. Oocytes of later stages (i.e. late yolk vesicle and early and late yolk stages) are very few. The ovigerous lamellae are well formed with little connective tissue in the ovarian stroma (Fig. 54).

(F) **Group Fifth**: 11:23D; 22.00 hrs to 23.00 hrs photoperiod.

Most of the oocytes are in peri-nucleolus stage. Yolk vesicle and early yolk stages are very few in number. Oocytes of late yolk stage are not observed. The ovigerous lamellae and connective tissue are well disposed (Fig. 55).

(G) **Group Sixth**: 11:23D; 23.00 hrs to 24.00 hrs photoperiod.

The oocytes of peri-nucleolus stage are dominant over other stages occupying most of the ovarian space. The oocytes of yolk vesicle stages (early and late) are also in appreciable number. A good number of yolk-stages are also present. The ovigerous lamellae and connective tissue in the stroma are moderately developed (Fig. 56).

**Concluding Remarks**

From the above study of oocytes in the different experimental groups, it is inferred that no particular group indicates extraordinary changes, however, in Group Second (19.00 hrs - 20.00 hrs) later stages of oocytes (i.e. yolk vesicle and yolk stages) are comparatively high signifying higher activity
level in the ovaries. It seems that illumination for about 20 days was not sufficient to derive any conclusion hence the experiment was continued further upto 45 days to get better understanding and interpretation of results.

3. **Changes on 45 Day**

Following changes were observed in the control and experimental groups on 45 days of experimentation under the same condition of light and darkness (i.e. 1L : 23D).

**(A) Control**

No remarkable change was observed in the ovaries of 45 days control when compared with those of 20 days control (Fig. 57).

**(B) Group First : 1L:23D; 18.00 hrs to 19.00 hrs photoperiod.**

The oocytes developed upto late yolk and pre-maturation stage, however, the oocytes of prematuration stage are very few. The peri-nucleolus stage and yolk stages are uniformly distribute in the ovarian stroma. The number of early stages is comparativel less. The ovigerous lamallae are well formed. (Fig. 58).

**(C) Group Second : 1L:23D; 19.00 hrs to 20.00 hrs photoperiod.**

The ovaries of this group contain a large number of oocytes of later stages. The oocytes of late yolk stage and pre-maturation stage are abundant. The oocytes of earlier stages are few in comparison to those found in the 20th day in the same group. This indicates that a remarkably faster rate of oogenesis was exhibited in the fishes of this group (Fig. 59).
(L) **Group Third**: 11:23D; 20.00 hrs to 21.00 hrs photoperiod.

The oocytes show an advancement in the growth as compared to the group of fishes sampled on 20 days of experiment which is evident by the presence of a larger number of oocytes of early and yolk stages. Though the oocytes of pre-maturation stages are also found their occurrence is quite insignificant (Fig. 60).

(E) **Group Fourth**: 11:23D; 21.00 hrs to 22.00 hrs photoperiod.

The number and size of yolk vesicle stages increases. Few oocytes grow further up to early yolk stage and a still few reach up to pre-maturation stage (Fig. 61). This group is important in this respect that the growth of later stages of oocytes is quite fast and early oocytes are less in number.

(F) **Group Fifth**: 11:23D; 22.00 hrs to 23.00 hrs photoperiod.

The oocytes are in the early stages of oogenesis with a slight increase in the size as compared to oocytes in the sample of 20 days. No significant growth of oocytes is marked in this group. The process of oogenesis seems to be slow in comparison to the other experimental groups (Fig. 62).

(G) **Group Sixth**: 11:23D; 23.00 hrs to 24.00 hrs photoperiod.

The early and late peri-nucleolus stages are prevalent over the yolk vesicle and early yolk stages of the oocytes. The process of oocyte growth in this group is not as sharp notable changes as observed in first four groups of fishes. (Fig. 63).
Photomicrographs of transverse sections of the ovary of *Channa punctatus* exposed to short photoperiod 1L:23D during photosensitive phase (18.00 hrs to 24.00 hrs) in:

- **Fig. 57** - 45th day control group
- **Fig. 58** - 45th day experimental, Group First (18.00 hrs to 19.00 hrs photoperiod)
- **Fig. 59** - 45th day experimental, Group Second (19.00 hrs to 20.00 hrs photoperiod)
- **Fig. 60** - 45th day experimental, Group Third (20.00 hrs to 21.00 hrs photoperiod)

**Abbreviations**:

- E.Y. - Early yolk stage
- L.Y. - Late yolk stage
- L.Y.V. - Late yolk vesicle stage
- P.M. - Pre maturation stage
Photomicrographs of transverse sections of the ovary of *Channa punctatus* exposed to short photoperiod 1L:23D during photosensitive phase (18.00 hrs to 24.00 hrs) in:

**Fig. 61** - 45th day experimental, Group Fourth (21.00 hrs to 22.00 hrs photoperiod)

**Fig. 62** - 45th day experimental, Group Fifth (22.00 hrs to 23.00 hrs photoperiod)

**Fig. 63** - 45th day experimental, Group Sixth (23.00 hrs to 24.00 hrs photoperiod)

**Abbreviations**:

E.Y. - Early yolk stage  
E.Y.V. - Early yolk vesicle stage  
L.P.N. - Late peri-nucleolus stage  
L.Y.V. - Late yolk vesicle stage
Concluding remarks:

From the above observations on their development, relative number and growth of the oocytes during different regimes of short photoperiod (14:23L) it can be concluded that in all the six groups, the ovarian development on 20 days is not very sharp however, on 45th day there is a sharp increase in the oogenesis in group second (19.00 hrs - 20.00 hrs photoperiod). Group first (18.00 hrs - 19.00 hrs) and group third (20.00 hrs - 21.00 hrs) exhibit little to moderate acceleration in the growth of oocytes while group fifth (22.00 hrs - 23.00 hrs) and group sixth (23.00 hrs - 24.00 hrs) fail to characterize significant development over the observations made on 20th day of experiment.

Result:

On the basis of above experiment it can be concluded that the most sensitive photo-phase for the female Channe punctatus exists in between 19.00 hrs to 20.00 hrs. As the process of oogenesis is also prominent in group first (18.00 hrs - 19.00 hrs) and group third (20.00 hrs - 21.00 hrs), it is possible that the sensitive phase may be in overlapping state within these three groups. It may also be concluded that group first (18.00 hrs - 19.00 hrs) is the preparatory phase and marks the onset of photo response. Group second (19.00 hrs - 20.00 hrs) is the most sensitive photo-phase while group third (20.00 hrs - 21.00 hrs) and group fourth (21.00 hrs - 22.00 hrs) may be considered as post photo-sensitive periods.
Quantitative assessment of gonosomatic index and oogenetic stages under the influence of photoperiod.

The ovarian changes observed histologically during the experiments were further assessed quantitatively by calculating their gonosomatic index and the relative number of oocytes in different stages of their development and maturation.

The gonosomatic index was calculated separately for each fish with the help of the following formula and then average values were obtained for each experimental group:

$$\text{Gonosomatic Index} = \frac{\text{Weight of the ovary}}{\text{Weight of the fish}} \times 100$$

The average Gonosomatic Index values of control and experimental groups of fishes have been given in Tables 6, p. 127 and 10, p.138 and are plotted in Figs. 64 and 66. The maximum diameter of oocytes was measured with the help of ocular micrometer disc calibrated with a stage micrometer. On the basis of their size, the oocytes were categorised into five stages which are as follows:

- C.010 mm to C.120 mm - Stage I
- C.130 mm to C.300 mm - Stage II
- C.312 mm to C.425 mm - Stage III
- C.437 mm to C.600 mm - Stage IV
- C.612 mm onwards - Stage V

The relative percentage of these stages of oocytes in each group has been given in Tables 7, p. 130 and 11, p. 141 and shown in
Figs. 65 and 67. The standard deviation, standard error and values of 't' were calculated by the following formulae:

\[ S.D. = \delta = \sqrt{\frac{(\bar{X}^2) - (\frac{\bar{X}}{N})^2}{N}} \]

\[ \bar{X} = \text{average number of oocytes} \]

\[ N = \text{number of fishes} \]

\[ S.D. = \text{Standard Deviation} \]

\[ S.E. = \frac{\delta}{\sqrt{N}} \]

\[ S.E. = \text{Standard Error} \]

\[ \delta = \text{Standard Deviation} \]

\[ N = \text{Number of Fishes} \]

The values of standard deviation and standard error for each control and experimental groups have been given in Tables 8, p. 133 and 12, p. 144 along with average of percentages of different oocytes classes. The changes in the number and diameter of the oocytes were also assessed by calculating 't' values using following of Brownlee (1949):

\[ t = \frac{\bar{X}_1 - \bar{X}_2 \sqrt{\frac{N_1 N_2}{N_1 + N_2}}}{\sqrt{\frac{(\bar{X}_1^2) - (\frac{\bar{X}_1}{N_1})^2}{N_1} + \frac{(\bar{X}_2^2) - (\frac{\bar{X}_2}{N_2})^2}{N_2}} \sqrt{N_1 + N_2^2}} \]
$$X_1 = \text{Average value of number of oocytes (control)}$$

$$X_2 = \text{Average value of number of oocytes (Experimental)}$$

$$N_1 = \text{Number of fishes (Control)}$$

$$N_2 = \text{Number of fishes (Experimental)}$$

The calculated values of 't' and values of probability (Fisher's table) have been given in Tables 9, p. 134 and 13, p. 145 to show the level of significance from one group to another in respect of different oocyte classes.

**Assessment of Gonosomatic Index and relative number of oocytes in Channa punctatus during different regimes of photoperiod 6L:16L.**

1. **Initial Control**

The gonads are fully mature and voluminous. The Gonosomatic Index value in this group is 3.780. Oocytes of Stage I, II and IV are uniformly present while Stage III oocytes are very few in number (Table 7, p. 136).

2. **On 15th Day**

(A) **Control**: The Gonosomatic Index is relatively low as compared to the initial control group of fishes. There is a sharp and significant ($P > 0.005$) increase in the number of oocytes of Stage I and Stage III (Table 7, p. 136).

(B) **Experimental**: In group First (6L:16L; CC:CC hrs - 06:CC hrs photoperiod) the Gonosomatic Index is relatively low. When compared with the
15th day control, the number of oocytes of Stage I is relatively greater (49.35%) than other stages. The number of oocytes of Stage III is relatively less and is significant at $P > 0.05$ level in comparison to control group (Fig. 65).

In Group Second (6L:16D; 06.00 hrs - 12.00 hrs photoperiod) the gonosomatic index is low. The oocytes of Stage III are relatively still less and the pattern of growth is statistically significant ($P > 0.05$).

In Group Third (6L:18L; 12.00 hrs - 18.00 hrs photoperiod) like Group First and Second the gonosomatic Index is reduced (Table 6, p. 127). The oocytes of Stages I and II only represent this group.

In Group Fourth (6L:16L; 18.00 hrs - 24.00 hrs photoperiod) the gonosomatic Index is relatively high (2.615) in comparison to Group First, Second and Third. The oocytes of all the five stages (I to V) are distributed with the dominance of Stage II (39.5%). Stages I, IV and V are significantly different at $P > 0.001$, $P > 0.001$ and $P > 0.100$ level respectively in comparison to control group (Table 9, p. 134).

3. On 40th Day

(A) Control:

When compared to 15th day control gonosomatic Index remains low. The oocytes of Stages I (46.39%) and II (45.04%) dominate over the Stages III (6.16%) and IV (6.2%). Oocytes of Stage II are relatively more ($P > 0.010$) while oocytes of Stage IV are relatively less ($P > 0.01$) in comparison to 15 day control group.
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<th>WEIGHT OF THE FISH IN gms (MEAN)</th>
<th>WEIGHT OF THE GONADS IN gms (MEAN)</th>
<th>GONOSOMATIC INDEX</th>
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<td>12.00-18.00</td>
<td>07.02</td>
<td>06.24</td>
<td>0.115</td>
<td>1.642</td>
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<td>18.00-24.00</td>
<td>08.20</td>
<td>07.54</td>
<td>0.118</td>
<td>2.615</td>
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<tr>
<td>3.</td>
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<td>CONTROL</td>
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<td>08.02</td>
<td>0.143</td>
<td>1.650</td>
</tr>
<tr>
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<td></td>
<td>C0.00-06.00</td>
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<td>06.06</td>
<td>0.104</td>
<td>1.223</td>
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<td>C6.00-12.00</td>
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<td>1.125</td>
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<td>1.531</td>
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<td>08.10</td>
<td>07.68</td>
<td>0.138</td>
<td>1.659</td>
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TABLE 6: Showing Gonosomatic Index in female Channa punctatus (Bloch) during different regimes of photoperiod (6L:18D).
Fig. 64 - Showing the Gonosomatic Index
of the female Channa punctatus on
different days during different regimes
of 6L:18L photoperiod in a day:

Abbreviations:

C - Control group
I - Experimental, Group First
   (06.00 hrs to 06.00 hrs photoperiod)
II - Experimental, Group Second
     (06.00 hrs to 12.00 hrs photoperiod)
III - Experimental, Group Third
      (12.00 hrs to 18.00 hrs photoperiod)
IV - Experimental, Group Fourth
     (18.00 hrs to 24.00 hrs photoperiod)
<table>
<thead>
<tr>
<th>S.No.</th>
<th>DAYS PHOTOPERIOD IN HOURS</th>
<th>PERCENTAGE (± S.E.) OF OOCYTES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>STAGE I</td>
</tr>
<tr>
<td>1.</td>
<td>INITIAL CONTROL</td>
<td>26.67 ± 0.834</td>
</tr>
<tr>
<td></td>
<td>CONTROL</td>
<td>55.39 ± 0.378</td>
</tr>
<tr>
<td></td>
<td>06.00-06.00</td>
<td>49.35 ± 0.579</td>
</tr>
<tr>
<td>2.</td>
<td>15th</td>
<td>62.64 ± 0.551</td>
</tr>
<tr>
<td></td>
<td>06.00-12.00</td>
<td>59.83 ± 0.668</td>
</tr>
<tr>
<td></td>
<td>12.00-18.00</td>
<td>24.12 ± 0.398</td>
</tr>
<tr>
<td></td>
<td>18.00-24.00</td>
<td>46.39 ± 0.378</td>
</tr>
<tr>
<td></td>
<td>CONTROL</td>
<td>54.31 ± 0.643</td>
</tr>
<tr>
<td></td>
<td>06.00-06.00</td>
<td>47.23 ± 0.351</td>
</tr>
<tr>
<td>3.</td>
<td>40th</td>
<td>42.31 ± 0.391</td>
</tr>
<tr>
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<td>06.00-12.00</td>
<td>22.14 ± 0.501</td>
</tr>
</tbody>
</table>

**TABLE 7**: Showing percentage of oocytes and standard error (S.E.) of mean (-) among different groups of oocytes exposed to photoperiod 6L18D in female *Channa punctatus* (Bloch.).
Fig. 65 - Histograms showing relative number of oocytes in the ovary of *Channa punctatus* on different days during different regimes of 6L:18D photoperiod in a day:

**Abbreviations:**

- **C** - Control group
- **Ex.I** - Experimental, Group First
  (00.00 hrs to 06.00 hrs photoperiod)
- **Ex.II** - Experimental, Group Second
  (06.00 hrs to 12.00 hrs photoperiod)
- **Ex.III** - Experimental, Group Third
  (12.00 hrs to 18.00 hrs photoperiod)
- **Ex.IV** - Experimental, Group Fourth
  (18.00 hrs to 24.00 hrs photoperiod)

- [ ] Stage I of oocytes
- [ ] Stage II of oocytes
- [ ] Stage III of oocytes
- [ ] Stage IV of oocytes
- [ ] Stage V of oocytes.
<table>
<thead>
<tr>
<th>S.No.</th>
<th>DAYS</th>
<th>PHOTOPERIOD IN HOURS</th>
<th>STANDARD DEVIATION (+ S.E.) OF OOCYTES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td>STAGE I</td>
</tr>
<tr>
<td>1.</td>
<td>0</td>
<td>INITIAL CONTROL</td>
<td>16.44 ± 0.634</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CONTROL</td>
<td>16.72 ± 0.772</td>
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<td></td>
<td></td>
<td>CC,CC=06.00</td>
<td>19.40 ± 0.579</td>
</tr>
<tr>
<td>2.</td>
<td>15th</td>
<td>CC,CC=12.00</td>
<td>22.96 ± 0.551</td>
</tr>
<tr>
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<td>12.00-18.00</td>
<td>22.93 ± 0.668</td>
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<tr>
<td></td>
<td></td>
<td>16.00-24.00</td>
<td>05.71 ± 0.398</td>
</tr>
<tr>
<td>3.</td>
<td>40th</td>
<td>CC,CC=12.00</td>
<td>13.76 ± 0.821</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CC,CC=06.00</td>
<td>20.55 ± 0.643</td>
</tr>
<tr>
<td></td>
<td></td>
<td>09.74 ± 0.351</td>
<td>21.04 ± 0.617</td>
</tr>
<tr>
<td></td>
<td></td>
<td>09.67 ± 0.397</td>
<td>25.77 ± 0.939</td>
</tr>
<tr>
<td></td>
<td></td>
<td>06.94 ± 0.501</td>
<td>08.34 ± 0.514</td>
</tr>
</tbody>
</table>

**TABLE 6**: Showing Standard Deviation (S.D.) and Standard Error (S.E.) of mean among different groups of oocytes of female *Channa punctatus* (Bloch.), during different regimes of photoperiod, 6L18L.
<table>
<thead>
<tr>
<th>S.No.</th>
<th>DAYS</th>
<th>PHOTOPERIOD IN HOURS</th>
<th>VALUES OF 't' IN DIFFERENT STAGES OF OCYTES</th>
<th>STATE IST</th>
<th>STAGE IINE</th>
<th>STAGE IIIA/B</th>
<th>STAGE IVTH</th>
<th>STATE VTH</th>
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</thead>
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<td>INITIAL CONTROL</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CONTROL</td>
<td>04.90 P&gt; 0.005</td>
<td>18.08</td>
<td>04.72 P&gt; 0.005</td>
<td>03.39 P&gt; 0.025</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CC.CC-06.00</td>
<td>12.82</td>
<td>16.76</td>
<td>02.72 P&gt; 0.050</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>2. 15th</td>
<td>06.00-12.00</td>
<td>13.83</td>
<td>12.39</td>
<td>02.08 P&gt; 0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>12.00-18.00</td>
<td>17.90</td>
<td>13.39</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>18.00-24.00</td>
<td>06.06 P&gt; 0.001</td>
<td>09.99</td>
<td>12.36</td>
<td></td>
<td>05.46 P&gt; 0.001</td>
<td>01.746 P&gt; 0.10</td>
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</tr>
<tr>
<td></td>
<td>CONTROL</td>
<td>11.02</td>
<td>04.51 P&gt; 0.010</td>
<td>11.07</td>
<td></td>
<td>03.98 P&gt; 0.01</td>
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<tr>
<td></td>
<td>CC.CC-06.00</td>
<td>13.09</td>
<td>01.98 P&gt; 0.10</td>
<td>19.52</td>
<td></td>
<td>13.72</td>
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<td></td>
</tr>
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<td>3. 40th</td>
<td>06.00-12.00</td>
<td>12.63</td>
<td>09.67</td>
<td>17.89</td>
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<td>12.86</td>
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<td></td>
<td>12.00-18.00</td>
<td>10.99</td>
<td>12.67</td>
<td>02.09 P&gt; 0.10</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>18.00-24.00</td>
<td>05.09 P&gt; 0.005</td>
<td>03.42 P&gt; 0.025</td>
<td>04.32 P&gt; 0.005</td>
<td>02.556 P&gt; 0.050</td>
<td>7.654 P&gt; 0.001</td>
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<td></td>
</tr>
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</table>

**TABLE 9**: Showing the values of 't' and the probability of significance in the female *Channa punctatus* (Bloch.), during different regimes of photoperiod, 6Li18D.
(B) **Experimental**

In Group First (6L:16L; 06.00 hrs - 06.00 hrs photoperiod) the Gonosomal Index is relatively high. Oocytes of Stage I are relatively more (54.3%) while those of Stage IV which are too less (0.59%). The oocytes of Stage II get reduced in number in comparison to the control and Group First of 15th day (Table 7, p. 130). Such change in the pattern is significant (P > 0.10).

In Group Second (6L:18L; 06.00 hrs to 12.00 hrs photoperiod) the Gonosomal Index is lower than the control and the sample of 15th day (Fig. 64). Oocytes of Stages I, II, III and IV are present but their number is showing a descending trend (Table 7, p. 130) indicating no significant development (Table 9, p.134).

In Group Third (6L:16L; 12.00 hrs - 16.00 hrs photoperiod) the Gonosomal Index decreases. The number of oocytes of Stage II is increased relatively (56.68%) while oocytes of Stage III are decreased (0.99%).

In Group Fourth (6L:16L; 18.00 hrs - 24.00 hrs photoperiod) the Gonosomal Index is at its maximum (Fig. 64). All the five stages (I to V) of oocytes are present in this group. On comparison, this group showed overall development as is evident by significant increase in Gonosomal Index (1.559) and in the number of oocytes of Stages IV and V (Table 7, p. 130).

**Concluding Remarks**

From the observations of gonosomal index and the relative number of oocytes in different stages of various groups under 6L:16L photoperiod, it may be concluded that the Gonosomal
Index is high in the initial control group of fishes and it falls sharply on 15th day in all the groups (control and experimental). The Gonosomatic Index continues to increase and remains maximum in group fourth exposed to light in between 16.00 hrs to 24.00 hrs on 40th day of experiment.

The relative number of oocytes in different photoperiodic group of fishes do not show appreciable changes on 15th day except Group Fourth where all the stages of oocytes (I to V) are significantly increased on 40th day.

The quantitative assessment of these groups is in confirmation to the histological changes observed and prove that the photo-sensitive phase for the gonadal growth of *Channa punctatus* exists in between 16.00 hrs to 24.00 hrs.

**Assessment of Gonosomatic Index and relative number of oocytes in Channa punctatus during LL:23L photoperiodic from 16.00 hrs to 24.00 hrs.**

1. **Initial Control:**

   The Gonosomatic Index at the start of experiment was 0.565. The oocytes were in the Stages I and II. The percentage of Stage I was high (72.12%) in comparison to that of Stage II (26.41%).

2. **On 20th Day:**

   (A) **Control:**

   The Gonosomatic Index increases to 0.761 (Fig. 66). The oocytes are in Stages I to IV. Oocytes of Stage I and II are abundant and almost equal in number while those of Stage III and
IV are few. Oocytes of Stage II and III are significantly higher numerically \((P > 0.001\) and \(P > 0.025\) respectively) in comparison to those found in initial control group (Table 13, p. 145).

(B) Experimental

In Group First (11:23L; 18.00 hrs - 19.00 hrs photoperiod), the Gonosomatic Index declines (Fig. 66). The oocytes of Stage I are in abundance while those of Stage III are too less in number (Table 11, p. 141).

In Group Second (11:23L; 19.00 hrs to 20.00 hrs photoperiod), the Gonosomatic Index increases (Table 10, p. 138). The oocytes of Stage I to Stage IV are mostly present, though the percentage of oocytes of Stage III and Stage IV is very less (Table 11, p. 141). The number of oocytes of Stage IV is significantly different \((P > 0.05)\) in comparison to control group.

In Group Third (11:23L; 20.00 hrs to 21.00 hrs photoperiod) the Gonosomatic Index is slightly increased than the control fishes (Fig. 66). The number and percentage of oocytes of different stages is very similar to Group First exposed to light from 18.00 hrs to 19.00 hrs.

In Group Fourth (11:23L; 21.00 hrs to 22.00 hrs photoperiod) the Gonosomatic Index and the relative number of oocytes is almost similar to Group First and Group Third exhibiting no significant changes statistically.

In Group Fifth (11:23L; 22.00 hrs to 23.00 hrs photoperiod) and Group Sixth (11:23L; 23.00 hrs to 24.00 hrs photoperiod) the Gonosomatic Index and the relative number of oocytes exhibit no
<table>
<thead>
<tr>
<th>S.No.</th>
<th>DAYS IN HOURS</th>
<th>PHOTOPERIOD</th>
<th>LENGTH OF THE FISH IN cm (MEAN)</th>
<th>WEIGHT OF THE FISH IN gms (MEAN)</th>
<th>WEIGHT OF THE GONADS IN gms (MEAN)</th>
<th>GONOSOMATIC INDEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>INITIAL CONTROL</td>
<td>12.90</td>
<td>18.58</td>
<td>1.104</td>
<td>0.565</td>
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<td>CONTROL</td>
<td>13.13</td>
<td>21.01</td>
<td>0.162</td>
<td>0.781</td>
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<td>21.63</td>
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<td>26.73</td>
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<td>23.00-24.00</td>
<td>10.98</td>
<td>13.37</td>
<td>0.072</td>
<td>0.536</td>
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</tbody>
</table>

**TABLE 1C:** Showing Gonosomatic Index of the female *Channa punctatus* (Bloch.) during photo-sensitive phase (18.00 hrs to 24.00 hrs) under short photoperiod 1L:23D.
Fig. 66 - Showing the Gonosomatic Index of the female *Channa punctatus* on different days during different regimes of short photoperiod 11:23D during photo-sensitive phase (16.00 hrs to 24.00 hrs).

**Abbreviations:**

C - Control group  
I - Experimental, Group First  
   (18.00 hrs to 19.00 hrs photoperiod)  
II - Experimental, Group Second  
    (19.00 hrs to 20.00 hrs photoperiod)  
III - Experimental, Group Third  
    (20.00 hrs to 21.00 hrs photoperiod)  
IV - Experimental, Group Fourth  
    (21.00 hrs to 22.00 hrs photoperiod)  
V  - Experimental, Group Fifth  
    (22.00 hrs to 23.00 hrs photoperiod)  
VI - Experimental, Group Sixth  
    (23.00 hrs to 24.00 hrs photoperiod)
FIG. 66

MEAN GONOSOMATIC INDEX

NUMBER OF DAYS

0
0.5
0.6
0.7
0.8
0.9
1.0

I
II
III
IV
V
VI
<table>
<thead>
<tr>
<th>S.No.</th>
<th>DAYS</th>
<th>PHOTOPERIOD IN HOURS</th>
<th>PERCENTAGE (± S.E.) OF OOCYTES</th>
<th>STAGE 1ST</th>
<th>STAGE 2ND</th>
<th>STAGE 3RD</th>
<th>STAGE 4TH</th>
<th>STAGE 5TH</th>
<th>STAGE 6TH</th>
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<td>1.</td>
<td>0</td>
<td>INITIAL CONTROL</td>
<td>72.12 ± 1.496</td>
<td>26.41 ± 0.612</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td></td>
<td>CONTROL</td>
<td>45.88 ± 0.728</td>
<td>49.15 ± 0.529</td>
<td>04.11 ± 0.372</td>
<td>00.64 ± 0.278</td>
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<td>18.00-19.00</td>
<td>68.75 ± 0.249</td>
<td>26.64 ± 0.556</td>
<td>02.604 ± 0.421</td>
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<td></td>
<td>19.00-20.00</td>
<td>56.74 ± 0.617</td>
<td>31.26 ± 0.263</td>
<td>06.99 ± 0.190</td>
<td>02.48 ± 0.346</td>
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<tr>
<td>2.</td>
<td>20th</td>
<td>20.00-21.00</td>
<td>50.33 ± 0.553</td>
<td>45.33 ± 0.751</td>
<td>04.33 ± 0.317</td>
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<td>21.00-22.00</td>
<td>59.85 ± 0.377</td>
<td>38.38 ± 0.433</td>
<td>01.76 ± 0.425</td>
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<td>22.00-23.00</td>
<td>41.41 ± 0.439</td>
<td>32.02 ± 0.278</td>
<td>06.56 ± 0.721</td>
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<td>23.00-24.00</td>
<td>43.61 ± 0.503</td>
<td>51.06 ± 0.339</td>
<td>05.31 ± 0.311</td>
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<td>CONTROL</td>
<td>39.54 ± 0.722</td>
<td>48.98 ± 0.523</td>
<td>06.58 ± 0.432</td>
<td>05.01 ± 0.232</td>
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<td>18.00-19.00</td>
<td>40.08 ± 0.901</td>
<td>50.54 ± 0.419</td>
<td>04.76 ± 0.654</td>
<td>04.60 ± 0.742</td>
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<td>19.00-20.00</td>
<td>44.98 ± 0.280</td>
<td>26.35 ± 0.572</td>
<td>13.87 ± 0.789</td>
<td>14.37 ± 0.605</td>
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<tr>
<td>3.</td>
<td>45th</td>
<td>20.00-21.00</td>
<td>43.88 ± 0.343</td>
<td>26.70 ± 0.796</td>
<td>25.37 ± 0.503</td>
<td>03.96 ± 0.489</td>
<td>02.16 ± 0.291</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>21.00-22.00</td>
<td>49.07 ± 0.521</td>
<td>32.14 ± 0.596</td>
<td>16.67 ± 0.663</td>
<td>02.16 ± 0.291</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>22.00-23.00</td>
<td>60.21 ± 0.649</td>
<td>36.32 ± 0.468</td>
<td>03.56 ± 1.437</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>23.00-24.00</td>
<td>57.02 ± 0.592</td>
<td>38.55 ± 0.598</td>
<td>04.40 ± 0.595</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**TABLE 11**: Showing percentage of oocytes and standard error (S.E.) of mean among different groups of oocytes exposed to short photoperiod, 11:23L from 18.00 hrs to 24.00 hrs in female *Channa punctatus* (Bloch).
Fig. 67 - Histograms showing relative number of oocytes in the ovary of *Channa punctatus* on different days exposed to short photoperiod 14:23L during photo-sensitive phase (18.00 hrs to 24.00 hrs).

**Abbreviations:**

- C - Control group
- Ex.I - Experimental, Group First
  (18.00 hrs to 19.00 hrs photoperiod)
- Ex.II - Experimental, Group Second
  (19.00 hrs to 20.00 hrs photoperiod)
- Ex.III - Experimental, Group Third
  (20.00 hrs to 21.00 hrs photoperiod)
- Ex.IV - Experimental, Group Fourth
  (21.00 hrs to 22.00 hrs photoperiod)
- Ex.V - Experimental, Group Fifth
  (22.00 hrs to 23.00 hrs photoperiod)
- Ex.VI - Experimental, Group Sixth
  (23.00 hrs to 24.00 hrs photoperiod)

- - Stage I of oocytes
- - Stage II of oocytes
- - Stage III of oocytes
- - Stage IV of oocytes
- - Stage V of oocytes
<table>
<thead>
<tr>
<th>S.No.</th>
<th>DAYS PHOTOPERIOD IN HOURS</th>
<th>STAGE I</th>
<th>STAGE II(??)</th>
<th>STAGE III(?)</th>
<th>STAGE IV(?)</th>
<th>STAGE V(?)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>0 INITIAL CONTROL</td>
<td>37.40C ± 1.49</td>
<td>12.94C ± 0.612</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td></td>
<td>CONTROL</td>
<td>09.879 ± 0.382</td>
<td>10.43C ± 0.512</td>
<td>07.86C ± 0.321</td>
<td>01.97C ± 0.621</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>18.00-19.00</td>
<td>09.369 ± 0.249</td>
<td>07.357 ± 0.556</td>
<td>01.632 ± 0.421</td>
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<td>-</td>
</tr>
<tr>
<td></td>
<td>19.00-20.00</td>
<td>17.96C ± 0.617</td>
<td>05.715 ± 0.263</td>
<td>01.914 ± 0.190</td>
<td>02.36C ± 0.546</td>
<td>-</td>
</tr>
<tr>
<td>2.</td>
<td>20th</td>
<td>11.775 ± 0.553</td>
<td>09.484 ± 0.751</td>
<td>02.06C ± 0.317</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>21.00-22.00</td>
<td>08.56C ± 0.377</td>
<td>06.08C ± 0.453</td>
<td>01.70C ± 0.425</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>22.00-23.00</td>
<td>06.855 ± 0.439</td>
<td>04.69C ± 0.276</td>
<td>03.68C ± 0.721</td>
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<td>-</td>
</tr>
<tr>
<td></td>
<td>23.00-24.00</td>
<td>07.65C ± 0.503</td>
<td>05.74C ± 0.339</td>
<td>01.74C ± 0.311</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3.</td>
<td>45th</td>
<td>12.30C ± 0.834</td>
<td>11.60C ± 0.43C</td>
<td>04.21C ± 0.228</td>
<td>03.09C ± 0.372</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>18.00-19.00</td>
<td>17.45C ± 0.961</td>
<td>08.69C ± 0.419</td>
<td>04.24C ± 0.654</td>
<td>06.39C ± 0.597</td>
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<tr>
<td></td>
<td>19.00-20.00</td>
<td>04.920 ± 0.280</td>
<td>06.19C ± 0.572</td>
<td>06.59C ± 0.805</td>
<td>09.092 ± 0.958</td>
<td>-</td>
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<tr>
<td></td>
<td>20.00-21.00</td>
<td>04.062 ± 0.343</td>
<td>07.76C ± 0.796</td>
<td>06.549 ± 0.563</td>
<td>02.494 ± 0.489</td>
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<td></td>
<td>21.00-22.00</td>
<td>11.14C ± 0.521</td>
<td>09.79C ± 0.956</td>
<td>07.645 ± 0.663</td>
<td>01.730 ± 0.291</td>
<td>-</td>
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<td></td>
<td>22.00-23.00</td>
<td>16.28C ± 0.849</td>
<td>08.17C ± 0.468</td>
<td>07.874 ± 1.437</td>
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<tr>
<td></td>
<td>23.00-24.00</td>
<td>12.28C ± 0.592</td>
<td>09.977 ± 0.596</td>
<td>03.366 ± 0.595</td>
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<td>-</td>
</tr>
</tbody>
</table>

**TABLE 2**: Showing Standard Deviation (S.D.) and Standard Error (S.E.) of mean among different groups of oocytes of female *Channa punctatus* (Bloch.) during different regimes of short photoperiod, 1L:23L in between 18.00 hrs to 24.00 hrs.
<table>
<thead>
<tr>
<th>S.No. D.AYS</th>
<th>PHOTOPERIOD IN HOURS</th>
<th>VALUES OF 't' IN DIFFERENT STAGE OF OCYTES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>STAGE IST</td>
<td>STAGE IIIND</td>
</tr>
<tr>
<td>1. 0</td>
<td>INITIAL CONTROL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CONTROL</td>
<td>12.72</td>
</tr>
<tr>
<td></td>
<td>18.00-19.00</td>
<td>16.32</td>
</tr>
<tr>
<td></td>
<td>19.00-20.00</td>
<td>08.97</td>
</tr>
<tr>
<td>2. 20th</td>
<td>20.00-21.00</td>
<td>17.92</td>
</tr>
<tr>
<td></td>
<td>21.00-22.00</td>
<td>32.32</td>
</tr>
<tr>
<td></td>
<td>22.00-23.00</td>
<td>30.02</td>
</tr>
<tr>
<td></td>
<td>23.00-24.00</td>
<td>09.31</td>
</tr>
<tr>
<td></td>
<td>CONTROL</td>
<td>10.02</td>
</tr>
<tr>
<td></td>
<td>18.00-19.00</td>
<td>08.92</td>
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<tr>
<td></td>
<td>19.00-20.00</td>
<td>09.81</td>
</tr>
<tr>
<td>3. 45th</td>
<td>20.00-21.00</td>
<td>11.01</td>
</tr>
<tr>
<td></td>
<td>21.00-22.00</td>
<td>10.72</td>
</tr>
<tr>
<td></td>
<td>22.00-23.00</td>
<td>11.64</td>
</tr>
<tr>
<td></td>
<td>23.00-24.00</td>
<td>12.83</td>
</tr>
</tbody>
</table>

**Table 13:** Showing the value of 't' and the probability of significance in the female *Channa punctatus* (Bloch) during different regimes of short photoperiod, 1L:23D in between 18.00 hrs to 24.00 hrs.
statistical significance. In both the groups the oocytes of Stages I, II and III are uniformly tabled without any significant difference from that of Groups I, III and IV.

3. **On 45th Day**

(A) **Control**:

The Gonosomatic Index further increases to 0.623 (Table 10, p. 136). The oocytes of Stage II are dominant over those of Stages I, III and IV. Percentage of oocytes of Stage IV is quite significant ($P > 0.05$) than any other stage of oocytes when compared with 20 days control (Table 13, p. 145).

(B) **Experimental**

In Group First (11:23L; 16.00 hrs to 19.00 hrs photoperiod) there is sharp increase in the Gonosomatic Index (Fig. 66). The number of oocytes of Stage II is approximately half of the total number of oocytes (Table 11, p. 141). Oocytes of stages III and IV though relatively small in number, stand significantly different ($P > 0.05$).

In Group Second (11:23L; 19.00 hrs to 20.00 hrs photoperiod) the Gonosomatic Index increases to the maximum among all the groups (Fig. 67). Relatively, the number of oocytes of Stage IV is also high and significant ($P > 0.05$). Oocytes of Stage II are too less ($P > 0.025$) while those of Stage III are relatively more in number than control ($P > 0.025$) (Table 13, p. 145).

In Group Third (11:23L; 20.00 hrs to 21.00 hrs photoperiod) the Gonosomatic Index increases, the number of oocytes of Stages
II and IV declines ($P > 0.025$ and $P > 0.005$) in comparison to control.

In Group Fourth (11:123L; 21.00 hrs to 22.00 hrs photoperiod) the oocytes of Stage I to Stage IV are present. The number of oocytes of stages I and II is far more than those of Stages III and IV. The number of oocytes of Stage IV is too less in comparison to those of control and other experimental groups exposed to light during 18.00 hrs - 19.00 hrs; 19.00 hrs - 20.00 hrs and 20.00 hrs - 21.00 hrs (Fig. 67).

Both the Groups Fifth (11:123D; 22.00 hrs to 23.00 hrs photoperiod) and Sixth (11:123D; 23.00 hrs to 24.00 hrs photoperiod) show similar trend of Gonosomatic Index oocytes number (Tables 10, p. 136 and 11, p. 141).

**Concluding Remarks**

From the statistical assessment of Gonosomatic Index and the relative number of oocytes of different groups of short photoperiod, it can be concluded that the response of light is most effective in the Group Second which was exposed to light in between 19.00 hrs to 20.00 hrs. The Gonosomatic Index as well as the number of different stages of oocytes is relatively higher in comparison to any other group of fishes exposed to the short photoperiod.

Therefore, the most specific photo-phase for the growth of ovarian tissue in *Channa punctatus* exists in between 19.00 hrs to 20.00 hrs. The statistical assessment corroborates the histological appearance of gonads. It can also be interpreted that though, the
"specific photo-sensitive phase", exists in between 19.00 hrs - 20.00 hrs, it may slightly be overlapped by the durations 18.00 hrs to 19.00 hrs and 20.00 hrs to 21.00 hrs.

**DISCUSSION**

A number of workers have shown that light stimulates various phases of gonadal development (Hoover and Hubbard, 1937; Hazard and Lacy, 1951; Corson, 1955; Kingsbury, 1957; Comb et al., 1959; Hencerson, 1963; Kaya and Hasler, 1972; Sundararaj and Vasal, 1973 and 1976). Kingsbury (1957) in *Salmo trutta*, Comb et al., (1959) in blue back salmon and Hencerson (1962, 1963) in *Salvelinus fontinalis* observed that functional maturity can be induced several months before the normal time by subjecting the fish to a light scheme of increasing and decreasing photoperiod irrespective of the normal solar change. According to Comb et al., (1959) the functional maturity of *Onchorhyncus nerka* can be hastened by 3 to 4 weeks merely by reducing the natural day length in late summer. Hencerson (1963) noticed delay in the maturity of *Salvelinus fontinalis* when the fishes were exposed to continuous long photoperiod of 20 hours a day.

Bullough (1939) in *Phoxinus laevis* observed that high temperature alone can accelerate the initial stages of secondary growth of ova, but the long photoperiod is necessary for further growth. Kaya and Hasler (1972) in green fish, *Leoplosis cyanellus* showed that a long artificial photoperiod and elevated temperature is essential for maturation of gonads. Sundararaj and Senegal (1970 a,b,c), Sundararaj and Vasal (1973, 1976) and Vasal and
Sundararaj (1975) have shown that combination of temperature and photoperiod can manipulate gonadal maturation in cat fish *Heteropeustes fossilis*, however, Atz (1957) has stressed on the particular set of environmental conditions which may vary with the reproductive cycle of a fish.

Circadian responses of oocytes in *Pugil cephalus* (Kuo and Watanabe, 1978) and advancement of reproductive cycle by enhanced photoperiod has been demonstrated in *Uncorhynchus kisutch* and *Uncorhynchus corbuscha* (Macquarrie et al., 1978 and Clarke et al., 1981), *Dicentrarchus labrax*, *Scophthalmus maximus* and *Sparus auratus* (Girin and De Vanchelle, 1978) and *Salmo gairdneri* (Whitehead et al., 1977, 1978; Bourlier and Billard, 1984, Bromage et al., 1984 and Skarphedinsson et al., 1985). Organisms maintained under environmental light-dark cycle, exhibit rhythmicity which has a definite relation to the cycle. These processes may be at their maximum during any time of the day and the biological clock of the animal goes round accordingly. The photoperiodic responses to the ovaries of *Channe punctatus* have revealed that the ovary responds to the light and then enters in a rhythmic manner.

of gonads. Above observations are not true in the case of *Channa punctatus* under present study. The short photoperiod 11:23L caused early maturation of ovaries, however, a specific photophase under short photoperiod is sufficient to bring about oocyte development and maturation.

Besides photoperiod, some other exogenous factors have also been observed responsible for regression of gonads in fish. Clement and Reed (1967) considered the diet factor is held responsible for regression. Gillet *et al.*, (1976) in *Carassius auratus* found temperature to be responsible for regression of gonads. Similarly Henderson (1963) in *Salvelinus fontinalis*; Bromage (1962, b), Boulier and Billard (1964) and Elliot *et al.*, (1964) in rainbow trout noticed the regression of gonadal growth due to the effect of temperature. In the present study on *Channa punctatus* the fishes were exposed to different photoperiod regimes without altering the diet and environmental temperature. It revealed that a most "specific photo-phase" lying in between 19.00 hrs to 20.00 hrs is sufficient to accelerate the ovarian growth.

A number of experiments were performed to locate the gonad stimulating photo-inducible phase but the mechanism involved was not clearly understood. Farmer (1965), Wolfson (1966) and Farmer and Follett (1966) put forth a hypothesis that the effect of photoperiod influenced by a light dependent reaction which produces chemical compound. The release, accumulation and duration of physiological activity of this compound has been considered as an indicator of photoperiodic responses. Bunning (1960, 1969) propounded another theory, according to which the efficiency of any light and dark cycle depends upon a portion of underlying circadian sensitivity to the illumination during that particular
light and dark cycle. This view seemed to be more relevant since the circadian rhythm of cellular function consists of a light and dark cycle. The one half of cycle requiring light is known as photophil phase and other half of the cycle requiring dark is denoted as scotophil phase. Roughly, each phase of this cycle consists of 12 hours duration. The photoperiodic induction to long day length needed during different processes is caused by extending the photoperiod into the scotophil phase of cycle.

Laggerman (1969 and 1972) proved that photoperiodic responses are based on a daily rhythm (probably circadian rhythm) of sensitivity to light in *Anabas testesus aculeatus*. Her findings confirmed that it is not the quantity and duration of light which is important but the phase which is light sensitive and a possible change is produced which proves endogenous rhythm. Sundararaj and Vasal (1976) in *Heteropneustes fossilis* found that the magnitude of ovarian recrudescence was less in fishes exposed to a photoperiod 9L:15D or 14L:16D than in fishes given 1 hour additional light from 06.00 hrs - 07.00 hrs during scotophil phase. It was observed that the fishes exposed to light for 1 hour showed significant ovarian recrudescence in comparison to the fishes given light for 7 hours or kept in a continuous dark. They also observed that the sensitive phase falls in between 20.00 hrs - 05.00 hrs and more specifically its duration is from 04.00 hrs - 05.00 hrs. Kuo and Watanabe (1978) in *Lagil cephalus* found that circadian responses of oocytes appeared to be 'timed' under the control of light phase. Asahina and Hanyu (1963) in *Phoxinus ocellatus ocellatus* considered the light as terminating factor (decreasing day length) and critical
period falls between 13.00 hrs - 14.00 hrs. They also emphasised that such critical period could also be changed. The present fish Channa punctatus, when exposed to a photoperiod 6L:18D in a day, showed that sensitive phase lies in between 18.00 hrs to 24.00 hrs while specific photo-sensitive phase lies in between 19.00 hrs to 20.00 hrs indicating an endogenous rhythm.

The phenomenon of photosensitive phase appears to be present in other animals including birds and insects.

Hammer (1964) in house finch, Carpodacus mexicanus; Kenarkar (1965) in house sparrow, Passer domesticus; Farmer (1965) in a migratory white crowned sparrow, Zonotrichia leucophrys; Wolfson (1966) in Junco sp. and Lilichonyx oryzivorus suggested that there is difference in sensitivity and light signals at different parts of circadian cycle in birds. In insects also such peak of intense activities have been recorded to establish the light sensitive period (Roberts, 1965).

Sengal and Sundararaj (1970) and Sundararaj and Sengal (1970) showed that the gravel fish, Heteropneustes fossilis can be made available in the first week of April after subjecting it to a long photoperiod of 14 hour / day at 25°C for six weeks and explored the possibility of harvesting four crops of eggs in a year. Pyle (1969), Poston and Livingstones (1971) and Bieniarz (1973) in brook trout suggested that by manipulating the photoperiod, the maturity in female can be advanced by about 12 weeks. Macquarie et. al., (1976) in coho salmon, Oncorhynchus kisutch and pink salmon, Oncorhynchus gorbuscha observed an advancement of reproductive cycle by 78-90 days by photoperiodic treatments of various combinations. Girin and Levanchella (1976) in
Scolopthalmus maximus and gilthead sea bream, Sparus aurata also observed the reduction in average spawning period by five months. Whitehead et al. (1977, 1978) in salmon, Salmo salar demonstrated that the fishes kept under normal 12 months photoperiod not only indicate a change in calcium serum and oestradiol 17β but also show an advancement of spawning by 6 weeks in 9 months and by 12 weeks under the 6 months regime of photoperiod. In rainbow trout, a number of workers have observed the effect of photoperiod (Whitehead et al., 1980; Bromage, 1982; Bromage et al., 1982 and Scott et al., 1984) and suggested a modification of spawning time by stimulatory influence of long photoperiod. Bromage et al., (1982) noticed the advancement of cycle by 12 and 6 weeks. Bromage et al., (1984) also observed that such altered seasonal cycles for the modification of spawning time do not produce adverse effect on fecundity. The eggs obtained were of acceptable size which can be retained for the production of fry.

The acceleration of spawning by photoperiodic manipulation in the cycle confirms the importance of day length (long or short) as the trigger for the advancement of gonadal development. The present work in Channa punctatus indicates possibility of harvesting more crops by advancement of spawning by way of photoperiodic manipulation as reported in other fishes. From the commercial point of view, the use of light cycles of constant length would be far earlier to use in inducing maturity and finally the breeding of fish in fish farms.