INTRODUCTION

Life on earth is and always has been exposed to strong and rhythmic geophysical environmental changes brought about earth’s rotation on its own axis and revolution around the sun. Movements of these planets in relation to each other give rise daily cycle of changes in illumination at the earth’s surface. The length of light phase (day length) changes with the season, at least away from the equator, and the intensity of light at any one time of day changes with the weather even at the equator. Other environmental factors, such as the temperature and humidity, change more or less reliably in parallel with the changes in the daily illumination, but these are subjected to considerable variation as result of the local weather conditions. None of the non-light agents are as reliable as the light illumination intensity. Most organisms therefore appear using daily cycle of light and dark from the environment as an entraining agent (zeitgeber – zeit = time; geber = giver) to synchronize their periodic activity with the most appropriate time of the year. Day length appears adaptive to a wide variety of animals and plants. Seasonality, represented by the initiation-termination-reinitiation of physiological processes, is a compulsory adaptation for survival in many species. Many species use annual change in day length (photoperiod) as “calendar” to time their seasonal physiological and behavioral functions. Birds are
seasonal; adult individuals exhibit seasonal cycle in several functions but almost all appear centered on successful reproduction at the most suited time of the year.

The mechanism that provides the “time sense” to species using daily light-dark cycle is described under the heading – Photoperiodism. Hillman (1979) defined photoperiodism as the control of some aspects of life cycle in a species by the timing of light and darkness. This definition encompasses two main elements: (1) photoperiodism regulates long lasting events, not the transient events of minutes and hours, and (2) photoperiodic influence is through the timing of light (hence darkness), and not the total amount of light that an organism receives from the environment. Therefore to affect photoperiodic control, light must be perceived, the duration of light: dark cycle to be measured, the photoperiodic message be transduced, and the transduced message be translated into changes in certain neuroendocrine secretions.

It was Baker (1938) who clearly recognized for the first time that seasonal breeding in higher vertebrates is controlled by two sets of environmental factors: the proximate and the ultimate factors. Whereas proximate factors ‘gate’ a temporal window during the year for seasonal events to happen, the ultimate factors ensure that actual seasonal event occurs during the ‘gated window’. For example, in timing the seasonal reproduction, day length acts as the proximate factor, while food and other factors act possibly as an ultimate factor. It may be noted that the proximate and ultimate factors act in coordination, and not in isolation.

Periodic breeding and associated physiological processes are evolved through the development of the timing mechanisms that are governed by the oscillatory systems, which are endogenous and genetic in origin (Aschoff, 1981; Kumar, 2001,
2002; Kumar et al., 2004a). In the natural environment, these oscillatory systems are expressed as daily overt rhythms since they occur synchronized with day and night. The existence of such an oscillatory mechanism in regulation of a seasonal event can be tested and probed using appropriate lighting protocols.

Two mechanisms appear involved in regulation of seasonality. One is the photoperiodism, in which environmental photoperiod times the component events of seasonality. The other is the circannual rhythm generation, in which a self-sustained endogenous rhythmicity of approximately 1-year times these component events. Both these mechanisms may not be mutually exclusive and, in fact, might interact closely, albeit as per adaptive needs of the species. However, many would argue an opposite proposition; photoperiodism and circannual rhythm generation are evolved as separate mechanisms. A commonly held view is that a photoperiodic species lacks a strong circannual component, and a circannual species lacks a strong photoperiodic component. Part of this widely held assumption stems from studies that (1) show maintenance of the post-reproductive photorefractoriness until a long day photoperiodic bird species is kept under stimulatory long day lengths (Sansum and King, 1976), and (2) show circannual rhythm generation in low-latitude and equatorial species that are not considered typically photoperiodic species (Gwinner, 1986). Misra et al., (2004), however, provide data indicating probability that an endogenous seasonal rhythm underlies photoperiodism in the blackheaded bunting (Emberiza melanocephala). This suggests the possibility that photoperiodism and circannual rhythm generation mechanisms coexist in the same photoperiodic species.
Structure of the present thesis

The present thesis includes investigations on photoperiodism of house sparrow (Passer domesticus) using the population living at Meerut (29°N, 77°45'E). Covering the objectives, series of experiments have been performed. Including the results from different studies, the present thesis starts with a general introduction and ends with general discussion, summary and references. The main body of the experiments and results is presented in the following four studies.

Study 1. Role of photoperiod in control of seasonal responses

This study is summarized in following four series of experiments.

Series I. Seasonal responses under natural day length in the wild at 29°N; 77°45'E

This series of experiments deal with changes in body mass and gonadal size (testicular volume of male and follicular diameter of female) in birds collected every month from the wild to investigate the seasonality in changes in body mass and gonadal growth and development in both male and female house sparrows.

Series II. Response under artificial photoperiods

In this series we have analyzed responsiveness of the photoperiodic response system of house sparrows to different lighting conditions and also examined if photoresponsiveness is altered in the year even though birds are maintained on non-stimulatory short day lengths.
Series III. Photoperiodic Time Measurement

We have reconfirmed the mechanism(s) involved in photoperiodic time measurement of house sparrows using two widely used experimental protocols.

1. T-photocycle experiments
2. Night-interruption experiments

Series IV: Importance of light wavelength in photoperiodic induction

Here, we investigated whether stimulation of a photoperiodic response under long day lengths was light wavelength-dependent. Two experiments were performed.

Experiment 1: Effects of light wavelengths on long day photostimulation

Experiment 2: Effects of light wavelengths on long and short photoperiods

Study 2: Role of social interaction in photoperiodism

Two experiments were performed. In the first experiment, the effects of pairing of male and female (social interaction) birds were exposed to social stimuli such that they can/cannot interact with another individual. This will address whether or not the visual contact is sufficient to induce social effects. In the other experiment, we have examined the effects of disturbances in the environment on the seasonal responses. Birds exposed to stimulatory LD cycles were disturbed by noise to assess the physiological responses.

Study 3: Role of food in modulation of photoperiodic effects

In this study, we analyzed the acute and temporal effects of food availability on photoperiod-induced seasonality. Birds were exposed to stimulatory LD cycles and
then were given measured quantity of food for short duration at the same and different times. The effects will be measured in body mass and gonadal development.

*Experiment 1: Effects of duration of food availability*

*Experiment 2: Effects of the timing of food availability*

**Study 4. Role of gonadal steroids**

This study addressed on the role of gonadal steroids. Birds were exposed to stimulatory or non-stimulatory LD cycles and then primed by exogenous testosterone. We have analyzed the effects on body mass and testicular development in sparrows using two widely used experimental protocols.

**Study 5. Histology of the Testis**

Here, we have presented the details of histology of testis from birds under selected photoperiodic experiments.