Photoperiodically Induced Ovarian Growth in the Subtropical House Sparrow (*Passer domesticus*)

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The annual cycle of reproduction in many birds is regulated by seasonal changes in day length. While a great deal is known about the temperate forms, photoperiodic control of reproduction in tropical and subtropical birds are scanty. Due to the lack of experimental data concerning photoperiodic regulation of reproduction in subtropical and tropical birds, particularly females, we performed the above experiment using subtropical female house sparrow, a resident passerine bird. House sparrow is unique among photoperiodic species in that daily photoperiods of both greater and lesser duration than minimum induces gonadal growth. In the view of contradictory opinion expressed from a number of authors regarding photoperiodic responses of house sparrow, we conducted experiments with photosensitive subtropical female house sparrow in which the birds were exposed to continuous light (LL), continuous dark (DD), short days (8L: 16D), long days (15L: 9D) and natural day length (NDL). Data from the birds exposed to continuous light and long days shows that ovarian growth was followed by regression and onset of refractoriness; short days and continuous dark failed to make any ovarian response and natural day length capture bird, show gonadal growths only when they received increasing day length of summer. The sparrows exposed under different treatment did not show any significant variation in their body weight responses.

Our results conclude that:

(a) The subtropical house sparrow is photosensitive and light stimulation is a prerequisite to its reproductive activities.

(b) The photoperiodic responses of this bird seems to support the Bunning Hypothesis (external coincidence model).

**INTRODUCTION**

Day length has been shown to control the annual cycle of reproduction in many species of birds (Lofts & Murton, 1968; Farner & Lewis, 1971). However, most of the abundant literature concerning avian photoperiodism pertains to temperature zone birds. Less is known about the importance of day length in controlling reproduction of tropical and subtropical birds. In the tropics and subtropics, because of small annual variations, photoperiod may be of little use in regulating metabolic and reproductive functions of birds (Immleman, 1971). Recent works from our laboratory (Tewary & Kumar, 1982; Tewary & Kumar, 1983) has shown that the day length has more pronounced role in control of reproduction and associated events than has hitherto been assumed. In general, these studies contain relatively little information on females due to the complexities of gonadal system. Moreover, house sparrow appears to be unique among photoperiodic species in that daily photoperiods of both greater and lesser duration than minimum induces gonadal growth (Threadgold, 1960;
Due to the lack of critical approach on the photoperiodic control of reproduction in subtropical and tropical birds, especially in females, we conducted the present experiments using subtropical, resident female house Sparrow (Passer domesticus), to determine if this bird uses day length to control its seasonal reproductive activities and exhibits photorefractoriness. The experimental birds were exposed to various artificial photoregimes, continuous light, continuous dark and natural day length.

MATERIALS AND METHODS

Animals—capture, maintenance and pretreatment

Adult female house sparrows were caught locally at Varanasi during September 1987 and were kept in an out door aviary. They were housed in small groups in wirenet cages (50 x 35 x 30). Then they were brought indoors and allowed to acclimatize to laboratory condition for 15 days. Acclimatized sparrows were then put on a short daily photocycle consisting of 8 h light and 16 h dark (8L: 16D; lights on beginning at 06:00 h) for eight weeks to ensure their sensitivity to light. Laparotomy at the end of this period showed that the birds had maintained a minimal ovarian condition (ovarian weight, OW = 5-6 mg). These photosensitive birds were used during different photoperiodic investigations.

EXPERIMENTAL DESIGN

Photosensitive birds were held on various programmed schedules (as indicated in Table 1):

| Table 1 |
|----|----|----|----|----|----|----|----|----|
| Treatment | I | II | III | IV | V | VI | VII | VIII | IX |
| DD | 0 | 40 | 80 | 120 | 160 | 200 | | |
| (20) | (10) | (8) | (6) | (4) | (3) | | |
| LL | 0 | 30 | 60 | 90 | 120 | 150 | 180 | 210 | 240 |
| (20) | (20) | (7) | (6) | (6) | (5) | (5) | (5) | (3) | |
| 8L/16D | 0 | 40 | 80 | 120 | 160 | 200 | 240 | 280 | |
| (10) | (8) | (7) | (5) | (4) | (4) | (4) | (3) | |
| 15L/9D | 0 | 40 | 80 | 120 | 160 | 200 | 240 | 280 | |
| (15) | (12) | (10) | (10) | (8) | (6) | (6) | (5) | |
| NDL | 0 | 30 | 60 | 90 | 120 | 150 | | |
| (5) | (5) | (5) | (5) | (5) | |

DD—continuous dark; LL—continuous light, NDL—natural day length. Figures in Parenthesis indicate the number of birds laparotomized or killed.

General methods of investigation

The cages were illuminated by 10W fluorescent tubes and the light intensity was about 400 lux at perch level. The first experimental photophase was always in phase with the pretreatment schedule. Food and water were freely available and were replenished when the lights were ‘on.’ In continuous dark (DD) experiment food and
water were changed on alternate days. For this purpose a dim blue light supplied by a torch wrapped with several folds of blue paper was used during a brief exposure. The temperature of photoperiodic chambers was not regulated closely, but it did not vary more than 2°C from the temperature of the bird room. Ovarian growth was assessed by as ovarian weight and by comparing the size of the ovary *in situ* with standard series of known weights. The error in this method is less than 15%. The experimental birds were laparotomized and weighed every 40 days under short photoperiod (8L: 16D) and long photoperiod (15L: 9D) while every 30 days in natural day length (NDL) and continuous light (LL). In the continuous dark (DD) experiment, three birds were weighed and killed on every 40 day and their ovarian weights were taken. Significance between experimental groups were calculated by Student's $t$-test.

**RESULTS**

Under continuous illumination (LL), in sparrows held for 240 days, ovarian growth was followed by regression and refractoriness. The stimulated ovaries attained their peak growth ($p < 0.001$) on day 30 and maintained high values up to day 60 and then gradually decreasing on days 90, 120, ..., 210 and attained minimal size on day 240 (Fig. 1). Continuous dark (DD) could not stimulate ovaries, indicating that light is a prerequisite for house sparrows in attaining reproductive maturity (Fig. 2).

Ovarian growth followed by regression was evident in the birds exposed to long photoperiod 15L: 9D (Fig. 2). Significant ovarian growth was ($p < 0.001$) observed on day 40 and the peak ovarian growth persisting to day 80 and regressed ($p < 0.001$) gradually on day 160, 240, being of minimal size again on day 280. Birds under...
8L: 16D treatment failed to exhibit ovarian recrudence throughout the experiment (Fig. 2). Birds subjected to natural day lengths (NDL) did not show ovarian growth until they were exposed to the increasing day lengths of summer (day length 12.14 hr in March). No significant changes in body weights occurred in any of the groups during the experiment. The range of mean body weights of the group were 20.62 to 19.46 g under LL; 20.7 to 21.00 g under 8L: 16D; 18.5 to 19.6 g under 15L: 9D and 21 to 20 g under natural day length.

DISCUSSION

Our data clearly indicates that the subtropical female house sparrow is photosensitive and light stimulation is a prerequisite to its reproductive activities. The photoperiodic response of this bird resembles those of many north temperate birds in which long photoperiods cause full gonadal development followed by regression and onset of photorefractoriness; short days and continuous dark are ineffective, and natural day length birds show gonadal growth only when they receive increasing day lengths of summer. Our results are not consistent with temperate zone house sparrow in which continuous darkness (DD) induced testicular development (Vaugien & Vaugien, 1961; Farner, 1977), but it should be pointed out here that at the time of transfer to DD sparrows were showing initiated testes growth under the influence of natural photoperiod of late spring and early summer. It is suggested that after transfer to DD gonadotrophic release persists for longer. Farner and his co-workers (1977), suggested that in temperate zone house sparrow DD has neutral effect and the effect of DD on the testis depends on the number of days of pretreatment by long photoperiod (16L: 8D). They further suggests that the continuation of testes growth under DD is due to carry-over phenomenon (Follet et al., 1967). Wolfson (1966) has also described similar results with Juncos, Juncohyemelis. In our case no ovarian growth was observed under DD, where birds were held for 200 days pretreated with short photoperiod (8L: 16D) and only a brief exposure to dim blue light was provided for cage cleaning and during replenishment of food and water. The maintenance of small regressed testes under continuous darkness in this species support the Bunning hypothesis (external coincidence model) based on the importance of direct coincidence of light with the circadian photosensitive phase inducing gonadal development (Farner, 1975; Turek, 1978). So our results are not in accordance with observation of Vaugien & Vaugien, 1961; Farner et al., 1977 and Binkely (1978) on the temperate zone house sparrows, but seems to be partially consistent with Farner et al. (1977) of experiment 1 of series 11 and Turek (1973) in two races of white crowned sparrows.

Results obtained with continuous light (LL) show ovarian growth followed by regression and development of photorefractoriness and its suggests that this response of female house sparrows is like those of males (Prasad & Tewary, 1981) and is comparable to those of north temperate birds (Hammer, 1968; Schwab, 1971). Continuous light, in contrast, suppresses gonadal development in the subtropical spotted munia, Lonchura punctulata (Chandola et al., 1975). The response of subtropical house sparrows to LL is different than its temperate zone population in some respects because LL make birds arrhythmia as reported by McMillan et al. (1975) and Binkely (1977).

The data on the response of house sparrows kept under 15L: 9D shown ovarian
growth, followed by regression and refractoriness and suggest that long days are essential for the initiation of gonadotrophic function in this bird. The results are in apparent agreement with males and females of other species, Follet & Farner, 1966; Morrison & Wilson, 1972; Dolink, 1976; Tewary & Tripathi, 1983; Tewary & Dixit, 1986). Indian Baya weaver, *Ploceus philippinus* and Rufous collard sparrow *Zonotrichia capensis* are good examples, which show longer photoperiod in their reproductive cycles, but lack post reproductive refractory period (Thapliyal & Tewary, 1964; Lewis et al., 1974). Other sedentary subtropical birds like black headed munia, *Lonchura malacca* has shown testicular growth when exposed to long days (Thapliyal & Saxena, 1964) and in spotted munia respond to short photoperiod but long days fail to stimulate gonadal growth (Chandola et al., 1975).

Short days fail to initiate ovarian growth in female common canaries, *Serinus canaria* (Follet et al., 1973), red headed bunting, *Emberiza bruniceps* (Tewary & Tripathi, 1983) and rose finches *Carpodacus erythrinus* (Tewary & Dixit, 1983). The same appears true in the subtropical house sparrow. Menaker (1968) reported that testes of temperate zone house sparrows in the laboratory show rapid growth where the birds are exposed to more than 12 hr of light per day, but grow much slowly, if at all, in shorter photoperiods. It may be noted that the rate of growth and period of gonadal activity in females is less than males. It is general that only partial development of the ovary occurs under artificial photoperiodic treatments. This substantial reduction in ovarian response in photoperiodic birds is due to the failure of long photoperiods to induce vitellogenesis and the culminating stages of follicular development (Farner & Follet, 1966; Payne, 1969; Kern, 1970).

Our data indicates that subtropical house sparrow uses the length of the daily photoperiod as a source of information for regulating their seasonal cycle even though annual variation in the day length at Varanasi are only about 3 hr 8 min. The difference in the response by the same species of different populations under similar experimental conditions studied at dissimilar zones could be explainable on the assumption that there may be difference in ecophysiological needs of the same species at different ecological conditions.

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(和文抄録)

亜熱帯域に生息するイエズスメの卵巣の光周期による発達の差異

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亜熱帯域に生息するイエズスメは、恒温および恒明環境に200日から240日、または亜熱帯域の自然日長、8L:16D の短日、または15L:9D の長日環境に280日間おかれ、それらのグループの生殖腺（卵巣）の発達の日長依存性が調べられた。その結果、恒明と長日環境には反応して卵巣の発達がみられたが、恒暗、短日環境には反応せず、卵巣の発達はみられなかった。また、自然日長のもとでは、卵巣の発達は認められなかったが、夏の日長にもどしたら卵巣の反応がみられるようになった。

これらの結果から、日長差の少ない亜熱帯域に生息するイエズスメも、生殖腺の発達が日長依存性を維持していることが判明した。

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