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PHOTOPERIODIC REGULATION OF REPRODUCTION IN SUBTROPICAL FEMALE YELLOW-THROATED SPARROWS (*GYMNORHIS XANTHOCOLLIS*)[1]

P. D. TEWARY AND ANAND S. DIXIT
Department of Zoology, Banaras Hindu University, Varanasi 221 005, India

Abstract. Ovarian development followed by regression occurred in Yellow-throated Sparrows (*Gymnorhis xanthocollis*) that were kept on short daily photoperiods of 8 hr (8L:16D) for eight weeks and were then exposed to long days (15L:9D). No ovarian growth occurred if they were kept on 8L:16D. This species did not exhibit ovarian growth on normal day lengths at Varanasi, India, until they experienced the increasing day lengths of summer. When Yellow-throated Sparrows were exposed to photoperiods between 6–20 hr/day for 35 days, ovarian growth did not occur unless day length was 12 or more hr/day.

Our results indicate that female Yellow-throated Sparrows are photoperiodic and that annual changes in day length are responsible for ovariogenesis. Photoperiod is not apparently responsible for seasonal changes in body weight in this species.

Key words: Photoperiod; ovariogenesis; Yellow-throated Sparrows; Gymnorhis xanthocollis; *India.*

INTRODUCTION

To effect seasonal reproduction and related events, many birds use predictable and stable environmental cues, of which day length is best known. Day length has been shown to control the annual cycle of reproduction in many species of birds (Lofts and Murton 1968, Farner and Lewis 1971).

The role played by light in controlling reproductive functions of temperate zone birds is relatively well established (Farner and Follett 1966, Lofts and Murton 1968). 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 (Immelmann 1971). We recently examined this possibility and found that in spite of small photofluctuations, light plays a much more significant role than has hitherto been assumed (Tewary and Kumar 1982).

Due to the paucity of experimental data concerning the photoperiodic control of reproduction in tropical and subtropical birds, particularly females, we performed the present study using subtropical, resident, female Yellow-throated Sparrows (*Gymnorhis xanthocollis*), a sexually dimorphic sedentary species, to determine if this bird uses day length to control seasonal activities, if it exhibits photorefractoriness, and also if it has a minimum photoperiodic requirement for ovarian growth.

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MATERIALS AND METHODS

Adult female Yellow-throated Sparrows were trapped in August 1982 near Varanasi, India (25°18′N, 83°01′E), while the gonads were completely regressed (ovarian weight, OW = ca. 4 mg) and the body had no conspicuous subcutaneous fat. These birds were then acclimatized to laboratory conditions for two weeks. There they were subjected to natural variations of photoperiod and temperature. Acclimatized birds were then exposed to a short daily photoperiod (consisting of 8 hr light and 16 hr dark, 8L:16D) for eight weeks (pretreatment period). This was done to ensure the photosensitivity of the birds if indeed they proved to be photosensitive. Laparotomies at four-week intervals during the pretreatment period revealed that the birds had regressed ovaries. Their body weights were unaffected by the pretreatment. These birds were then used in the following experiments.

SERIES I

One group of photosensitive birds (n = 15) was placed on long daily photoperiods (15L:9D, lights on from 0600–2100) for 210 days. A second group (n = 15) continued on short days (8L:16D). A third group of birds (n = 30) having ovary of minimum size (ovarian weight, OW = ca. 4 mg) was also brought indoors directly from nature in August 1982 and kept for this 210-day period under photoperiodic conditions that are normal at Varanasi (NDL). The difference between shortest and longest day lengths at Varanasi is 3 hr and 8 min. Unrestricted natural light was available to birds in this third group through windows of the laboratory.

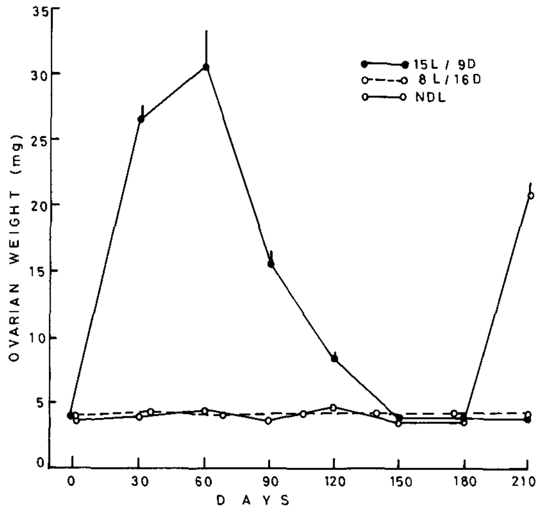

FIGURE 1. Ovarian responses of Yellow-throated Sparrows exposed to long (15L:9D) and short (8L:16D) days, and to normal day lengths (NDL) at Varanasi, India. Each point represents the mean for a group. Vertical lines represent standard errors that extended beyond the limits of symbols.

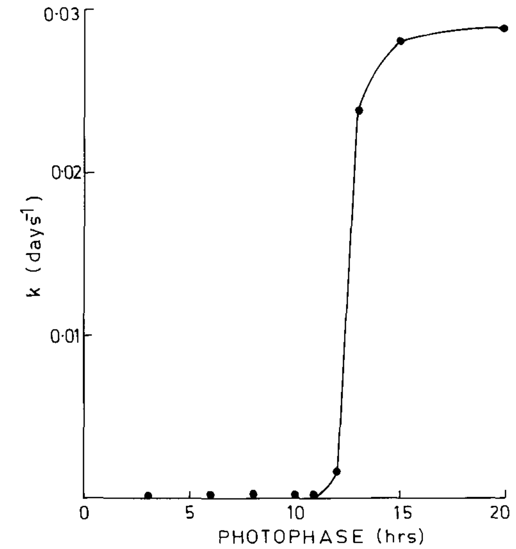

FIGURE 2. The rate of ovarian development (k) of Yellow-throated Sparrows as a function of the duration of the daily photoperiod (p).

SERIES II

Groups of birds (n = 4 to 6) were subjected to nine different photoperiodic regimes simultaneously, i.e., 3L:21D, 6L:18D, 8L:16D, 10L:14D, 11L:13D, 12L:12D, 13L:11D, 15L:9D, and 20L:4D for 35 days and were weighed and examined by laparotomy at the beginning and the end of the experiment.

The initial photophase to which each group was exposed commenced at 0600. Food and water were freely available to the birds and were replenished when the lights were on. Light was provided by fluorescent tubes and had an intensity of about 400 lux at perch level. In Series I, birds were laparotomized and weighed every 30 days under 15L:9D and NDL while every 35 days in 8L:16D treatment, to assess ovarian condition and body weight, respectively.

Ovarian growth, expressed as ovarian weight, was determined by comparing the size of the ovary in situ with a standard series of ovaries of known weights. The error inherent in this method is approximately 20%. Standard error was represented as standard error of mean (SEM). Significance of the differences between control and various experimental groups were calculated by Student's t-test or Student-Newman-Keul's multiple range t-test at 95% confidence limit following analysis of variance (Bruning and Kintz 1977) unless otherwise stated. Correlation between ovarian weights and changing photoperiod was also studied. Regression analysis of ovarian weight on photoperiod was performed using regression equation $Y = a + bx$ where ovarian weight was taken on X axis and varying photoperiod on Y axis. Birds that died during investigation were not included in statistical analysis.

RESULTS

SERIES I

Ovarian growth followed by regression was evident in the birds exposed to 15L:9D (Fig. 1). Under this treatment, significant ovarian growth ($P < 0.001$) was observed on day 30. Ovaries apparently exhibited peak development on day 60, and regressed ($P < 0.001$) thereafter on day 90 and 120, being of minimal size again on day 150. In contrast, ovarian growth did not occur in the birds kept on short days (8L:16D). Birds exposed to natural day lengths did not show ovarian responses until they were exposed to the increasing day lengths of summer (day length 12.1 hr in March). No significant changes in body weight occurred in any of the groups during this experiment. The range of mean body weights of the groups were 17.0 to 19.0 g under 15L:9D, 17.4 to 18.6 g under 8L:16D and 18.0 to 19.0 g under NDL.

SERIES II

Daily photoperiods of 12 hr and less (3L:21D, 6L:18D, 8L:16D, 10L:14D, 11L:13D, and 12L:12D) failed to induce ovarian growth in Yellow-throated Sparrows. However, birds experiencing photoperiods longer than 12 hr (13L:11D, 15L:9D, and 20L:4D) showed significant ovarian growth ($F = 277.34$, $P < 0.001$), the rate of growth being a direct function of the length of the photoperiod (Fig. 2).

Photoperiods longer than 12 hr have provided significant correlation with the variation in ovarian weight ($r = +0.979$, $P < 0.001$). When regression of ovarian weight was studied on photoperiods (12 hr as zero point), the regression equation found was $Y = 10.16 + 0.233X$. Slope ($b = 0.233$, $P < 0.01$) was also significant. No significant differences were observed between initial and final body weights of the birds in these groups.

DISCUSSION

Results obtained from the present investigation and the subsequent statistical evaluation of data indicate that Yellow-throated Sparrows are photosensitive. The photoperiodic response of this bird resembles those of many north temperate birds in which long daily photoperiods cause full gonadal development followed by regression and onset of photorefractoriness, whereas short photoperiods, by failing to stimulate the hypothalamo-hypophyseal complex, do not (Farner and Follett 1966, Lofts and Murton 1968, Follett and Davis 1975). Photoperiod probably does not affect body weight in this bird, as no significant photoperiodically induced changes in body weights were found. It is important to note here that Yellow-throated Sparrows do not undergo an annual cycle of fat storage (Tewary and Dixit, unpubl. data).

The variation of daily photoperiods at low latitudes may be too small to provide birds with reliable environmental information for timing seasonal events (Farner and Lewis 1971). Nonetheless, in such regions the effects of photoperiod as evidenced by the few experimental investigations that have been performed on low latitude species, may be more pronounced than has been assumed hitherto (Tewary and Kumar 1982, 1983).

Some sedentary low latitude forms, e.g., Baya Weavers (*Ploceus philippinus*) and Rufous-collared Sparrows (*Zonotrichia capensis*) show testicular growth when exposed to long day lengths, but they do not have a photorefractory period in their gonadal cycles (Thapliyal and Tewary 1964, Lewis et al. 1974). Other sedentary subtropical forms behave quite differently. In Black-headed Munias (*Lonchura malacca*), for example, long and short day lengths are gonado-stimulatory (Thapliyal and Saxena 1964). Spotted Munias (*L. punctulata*) respond to short photoperiods, but long ones fail to stimulate gonadal growth (Chandola et al. 1975).

Photoperiodically induced gonadal growth in females of photoperiodic species is less dramatic than in males. Among the photoperiodic species, it is rather general that only a partial development of the ovary occurs under artificial photoperiodic treatments, especially in passerine birds. The substantial reduction in ovarian response of photoperiodic birds is due to failure of long daily photoperiods to induce vitellogenesis and the culminative stages of follicular development (Farner et al. 1966, Payne 1969, Kern 1970). These functions are reported to be largely influenced by essential supplementary factors (Farner 1964) at least some of which are species specific and may involve environmental information, for example, presence of an active mate, of nesting material, or of a nest site (Hinde 1967). Ovarian growth and maturation in photoperiodic species is biphasic (Payne 1969, Kern 1970). There is an initial period of slow growth of ovarian follicles, followed by a phase of rapid growth during which most of the deposition of yolk occurs and during which the largest follicles mature.

Short days (8L:16D and 10L:14D) fail to produce ovarian growth in female Common Canaries, *Serinus canaria* (Follett et al. 1973) and in many other song birds, including Red-headed Buntings, *Emberiza bruniceps* (Tewary and Tripathi 1983) and Rosefinches, *Carpodacus erythrinus* (Tewary and Dixit 1983). The same appears to be true for Yellow-throated Sparrows (Fig. 2), since they have a definite photoperiodic threshold of gonadal sensitivity (between 12L:12D and 13L:11D). Threshold photoperiods for gonadal growth for tropical and subtropical birds are reported to lie between 11 to 12 hr per day in Weaver Birds (Singh and Chandola 1981); Black-headed Buntings, *E. melanocephala* (Kumar and Tewary 1983); Red-billed Dioch, *Quelea quelea* (Morel and Bourliere 1956) and between 12 to 13 hr per day in female Red-headed Buntings (Tewary and Tripathi 1983) and Rosefinches (Tewary and Dixit 1983).

In males of photoperiodic species, the logarithmic growth rate constant of the testes is usually a positive function of the duration of the daily photoperiod (Farner and Wilson 1957). In female Yellow-throated Sparrows, the growth rate of the ovary also increases with increasing photoperiods. Ovarian growth similarly follows a log-linear relationship in Japanese Quail, *Coturnix japonica* (Follett and Farner 1966), White-crowned Sparrows, *Zonotrichia leucophrys gambelii* (Farner et al. 1966, Morton et al. 1985) and Tree Sparrows, *Spizella arborea* (Morrison and Wilson 1972). The photoresponse curve in Figure 2 is similar to male Japanese Quail (Follett and Maung 1978), Black-headed Buntings (Kumar and Tewary 1983), female Red-headed Buntings

(Tewary and Tripathi 1983), and Rosefinches (Tewary and Dixit 1983).

The time of annual breeding of Yellow-throated Sparrows is March to June (day length 12 to 13 hr) which corresponds with the time predicted from the photoresponse curve in Figure 2. Our results provide evidence that this species can detect changes in the length of daily photoperiods as small as those normally experienced by the birds at Varanasi, India (3 hr and 8 min), because they respond only when the daily photoperiod exceeds 12 hr. The results of this study thus provide evidence that female Yellow-throated Sparrows can utilize the annual solar cycle to time their reproductive activities.

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