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Photoperiod Experiments on the American Robin (*Turdus migratorius* L.)

Abstract

The American Robin of southwestern British Columbia was tested in captivity under four light regimes: LD 8:16, 12:12, 16:8, all under artificial light, and natural daylight increment from LD 12:12 to 16:8. Robins under the latter two regimes gained in gonadal weight and in follicular and seminiferous growth, and the males developed spermatocytes and, under natural light, spermatids. Perch activity was monitored in the groups on LD 8:16 and on natural photoperiod. The group on short controlled daylength was inactive on the perch at night, whereas that on natural photoperiod was very active in the first half of the dark period, activity that is possibly related to nocturnal movement in the wild.

Introduction

Northward migration and the caroling dawn chorus of the American Robin (*Turdus migratorius* L.) herald the arrival of spring in most portions of North America. Timing of this predictable annual event and the phenology of reproductive stages have long been associated in this species with geographical and climatological features. Recent studies that examine this relationship are those of James and Shugart (1974) and of Knupp, Owen, and Dimond (1977).

The abundance of the American Robin and its widespread distribution and habitat selection make this species an ideal candidate for tests involving manipulation of environmental parameters which may affect the timing of its migration and reproduction. For about 60 species of north Temperate birds, increasing daylength has proven to be a powerful influence on gonadal recrudescence and migratory behavior (Immelmann, 1971). Photostimulation has induced males into spermatogenesis and females into early stages of ovarian development (Immelmann, 1971). Our study tested both for gonadal response and for evidence of possible migratory restlessness. To our knowledge, this is the first study of this species that examines and experimentally alters a feature of the environment—in this case, photoperiod—under test situations.

Methods and Materials

The tests were performed on the campus of The University of British Columbia, Vancouver, in conjunction with a field study of the breeding biology of robins in the same area (Kemper and Taylor, 1981). Two sets of controlled photoperiod experi-

ments were designed to demonstrate the effect of altered photoperiod on gonadal development. One also tested for migratory restlessness. Caged birds were housed under natural daylight for one week prior to testing.

In the first experiment, 21 robins were maintained on three different light regimes. One group (4 males, 2 females) was given a light:dark (LD) cycle of 8:16 hours, respectively. Another group (7 males, 1 female) was maintained on LD 12:12, and the third group (6 males, 1 female) received LD 16:8. Experimental conditions began 1 February and the birds were sacrificed on 19 April.

Groups of three to five birds were housed in wire cages 120 x 60 x 60 cm. Each cage was provided with one perch, one food dish, and one water dish. Commercial chick starter, ground beef, and water were freely available. The cages were enclosed by a 6 mil black vinyl plastic which effectively blocked all natural light. Illumination was provided by a single 20-watt cool white fluorescent light for each cage. This light emits an average of 1150 lumens. The cages were outside and exposed to ambient outdoor temperatures.

In the second experiment, conducted outdoors from 6 March to 5 May, two photoperiods were maintained: one was LD 8:16 (2 males, 1 female), and the other was the natural daylight photoperiod of the area for the duration of the experiment (3 males). The six robins were housed individually in cages 35 x 40 x 40 cm containing a food dish, a water dish, and a single perch. The perch was connected to a microswitch that tripped when the bird hopped on or off. The switch connected to an Esterline-Angus 20-channel event recorder. The three robins on LD 8:16 were illuminated and protected against interfering light by the same means as those of the previous experiment. These three were tested against the three on natural photoperiod, in which daylight (including civil twilight) increased from 12 to 16 hours.

The birds were sacrificed and the gonads weighed and fixed in Bouin's solution for histological preparation at the end of the experiments. One testis from each male was embedded in paraffin, sectioned at 7 μ , and stained with Delafield's hematoxylin and eosin. The slides were examined for tubule diameter and stage of sperm development. The number and size of developing follicles were recorded for each ovary.

Results

First Experiment

Changes in testicular development of males on different photoperiods are summarized (Table 1). Neither the LD 8:16 nor the LD 12:12 groups showed any histological

TABLE 1. Testis weight and seminiferous tubule diameter at the conclusions of the photoperiod experiments.

	N	Testis weight (mg) of a pair (mean, standard error, and range)	Seminiferous tubule diameter (μ) mean, standard error, and range)	Sperm
First experiment				
LD 8:16	4	20.0 \pm 8.4 (8.2-39.2)	39.4 \pm 0.9 (37.8-41.2)	—
LD 12:12	7	26.6 \pm 8.4 (12.3-59.4)	45.0 \pm 9.1 (30.9-72.8)	—
LD 16:8	6	390.7 \pm 77.9 (174.7-617.5)	110.3 \pm 9.0 (82.9-143.1)	—
Second experiment				
LD 8:16	2	34.0, 61.9	7.6, 21.9	—
LD Natural Daylength (12:12 - 16:8)	3	623.2 \pm 106.6 (441.1-810.2)	124.7 \pm 1.73 (121.1-126.7)	—

evidence of testicular recrudescence, whereas the group on the LD 16:8 developed spermatocytes but no sperm. The natural daylength at the termination of the experiment was $15\frac{3}{4}$ hours, by which time wild male robins are spermatogenic (Kemper and Taylor, 1981).

The two females on LD 8:16 had ovarian weights of 26.8 mg and 40.9 mg and showed no follicular development (follicular diameter averaged 0.5 mm). The ovary of the single female on LD 12:12 weighed 56.8 mg and similarly showed no follicular development, but that on LD 16:8 weighed 183.1 mg and had nine follicles, two of which were 2 to 3 mm in diameter. In early February, wild robins show no sign of follicular activity, but 19 April, the day the tests were terminated, is at the onset of the height of breeding activity in the wild (Kemper and Taylor, 1981).

Second Experiment

Males on LD 8:16 showed no development of secondary spermatocytes or presence of spermatids at the end of this experiment in early May. Testis weight and seminiferous tubule diameters are given in Table 1. The ovary of the female under this treatment weighed 28.3 mg, and follicles averaged 0.5 mm in diameter. Males on naturally increasing daylength had the largest testes of any captive group. Developing spermatocytes and spermatids were plentiful, but mature sperm were absent. Testes weights of these captives are comparable to those of wild robins sampled on 5 May, the same day; however, wild birds with seminiferous tubule diameters that exceed 120μ show full spermatogenic activity (Kemper and Taylor, 1981).

Perch activity of both photoperiod groups is presented in Figure 1. In most instances, the activity index of the group on natural photoperiod was considerably greater in the first half of darkness than in the remaining dark period, and in daylight hours was generally well below that of the group on shortened photoperiod.

Discussion

Annual periodicity in daylight has been demonstrated to be a control system in the reproductive cycle of about 60 north Temperate species of birds. Included are *Junco oreganus shufeldti* (Wolfson, 1942) and *Zonotrichia leucophrys pugetensis* (Farner, 1975), species that are sympatric breeders with the American Robin in southwestern British Columbia. Our two sets of experiments, designed to test stimulatory influences of increasing daylength on gonadal development in the American Robin, showed a positive correlation. Although males showed more gonadal response than females, in neither sex did the test birds attain a reproductive state comparable to that of wild breeding robins.

A factor in our experimental design that may have retarded or inhibited full gonadal recrudescence is quality of light. The light source used emits light mainly in the yellow portion of the visible spectrum, between 545 and 575 Å, with another less powerful emission at the blue portion that peaks at 440 Å. Male Starlings (*Sturnus vulgaris*) respond gonadally to full spermatogenic activity only between 580 and 680 Å. In the same spectral region that was used in our experiments, Starlings either progressed no farther than the spermatocyte stage or sperm production was very reduced (Burger, 1943).

It is unlikely that intensity of light was a deterrent to sexual recrudescence in our

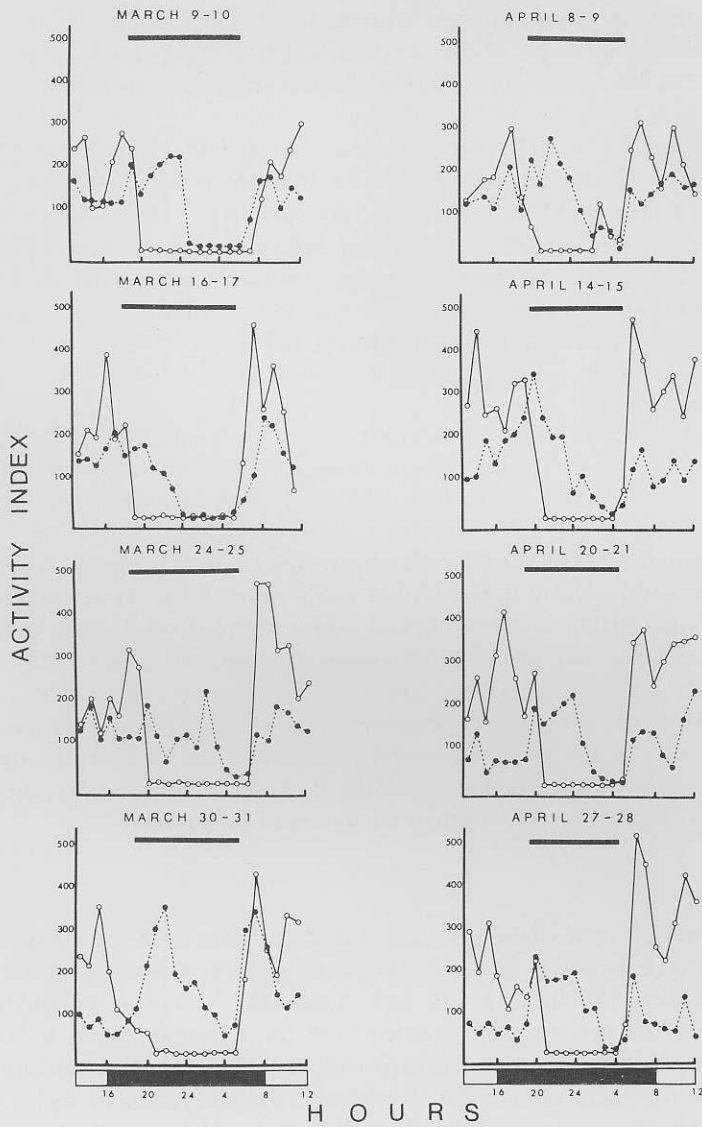


Figure 1. The perch activity for the LD 8:16 group and the group on natural daylength increment is represented by open circles and solid lines and by solid circles and dotted lines, respectively. The plots are averaged by group. Each graph represents one 24-hour period each week for 8 weeks, from 9 March to 28 April. The period from 16:00 hours to 8:00 hours the next morning is the dark phase of the birds on LD 8:16; it is indicated as the dark area of the hours bar at the bottom of the figure. The dark portion of the changing natural daylength, to which only the second group was exposed, is indicated by a fine bar at the top of each graph.

experiments. In both sets of experiments that used fluorescent lighting, the robins received 60-120 foot-candles of light at the bottom of the cage farthest from the light source and greater amounts elsewhere. This range of intensity is much higher than the minimum required in early spring to elicit gonadal response in, for example, the English Sparrow, *Passer domesticus* (Menaker, 1971).

The second experiment also examined whether artificially shortened photoperiod would inhibit nocturnal restlessness during a migratory period, as has been shown for many other North American species (Rowan, 1926; Wolfson, 1942, 1959; Farner, 1955; Farner *et al.*, 1960). Virtually no night activity was expressed by robins on LD 8:16 photoperiods, whereas those on longer days underwent such activity at levels comparable to their diurnal activity, from the first test (9-10 March) five days after the start of experimental conditions to the conclusion of the test period, a span of almost two months (Fig. 1).

Few attempts have been made to discover whether the American Robin is a nocturnal or diurnal migrant, or both (Graber, Graber, and Kirk, 1971). Our results suggest that the strong nocturnal component of the cage activity under conditions of increasing daylength may be expressed as nocturnal movement of this species in the wild. This interpretation is tentative, however, because some question exists as to whether nocturnal restlessness in birds can really be equated with a physiological state of migratory behavior (see Berthold, 1975, for discussion).

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