TESTICULAR GROWTH IN HARRIS' SPARROW (*ZONOTRICHIA QUERULA*)[1]

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PHOTOPERIODIC control of testicular growth is apparently quite general among Temperate Zone species of birds (Farner, 1959, 1964*a*; Wolfson, 1959; Hamner, 1966). Yet detailed information on the course of testicular growth induced by stimulatory daily photoperiods of constant duration is limited to only a few. Although testicular growth is known to be photoperiodically controlled in *Zonotrichia querula* (Rowan, 1938; King and Farner, 1963), the relationship between testicular weight and time in photosensitive, photostimulated birds has neither been expressed nor quantified. The present study was undertaken to determine the temporal course and rate of testicular growth in *Z. querula* exposed to long (20-hour) daily photoperiods.

MATERIALS AND METHODS

Immature and adult Harris' Sparrows (for plumage characteristics, see Swenk and Stevens, 1929) were captured with mist nets from wintering populations (Swenk and Stevens, 1929; Swenk, 1930) near Manhattan, Kansas, during the period 30 December 1965–5 February 1966. Captive birds of both sexes were retained, one or two per cage, in small cages (22 × 25 × 41 cm) housed in adjacent rooms from which daylight, as well as extraneous light, was excluded. Prior to the experiment all birds were subjected to 8-hour daily photoperiods (0830–1630 CST); illumination was provided by fluorescent lamps at an intensity of at least 300 lux. Food (a vitamin- and mineral-enriched chick-starter crumble supplemented with commercially prepared parakeet foods) and water were freely available. Temperatures to which the birds were exposed varied within a few degrees of 21°C.

Ninety birds of undetermined sex were divided into groups designated PSS ($N = 45$) and PSL ($N = 45$). On 5 March 1966 the photoperiod of PSL birds was extended to 20L 4D (0830–0430 CST); PSS birds were retained on 8L 16D (0830-1630 CST). On the same day five PSS males were sacrificed to obtain an estimate of the weight of the left testis. At 5-day intervals thereafter, testes were taken from males of both groups. Left testes were fixed for 5 days in an aqueous mixture of acetic acid, ethanol, and formalin (Farner *et al.*, 1966); then they were transferred to 70 per cent ethanol. Ten days after sacrifice they were weighed to the nearest 0.1 mg on a torsion balance.

RESULTS AND DISCUSSION

The relationship between testicular weight and time in Harris' Sparrows subjected to constant daily photoperiods of long and short durations is revealed in Figure 1. Testicular weights of PSL birds suggest that, until the weight of the left testis reaches about 60 mg, there is an approximately

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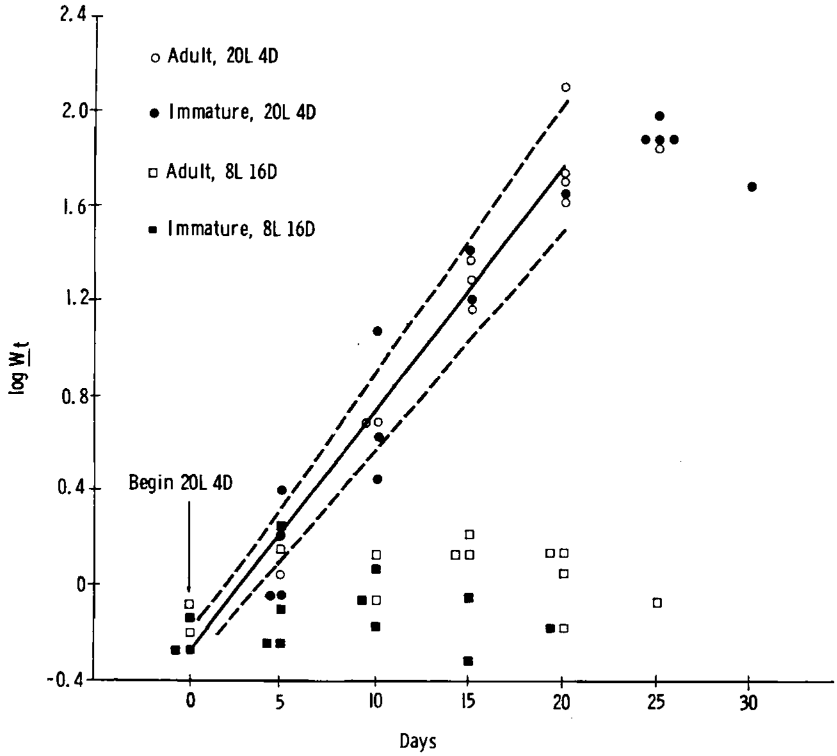

Figure 1. Weight of the left testis (W_t) as a function of time. The photoperiod of PSL birds was changed from 8 to 20 hours on day 0; PSS birds were retained on 8-hour daily photoperiods. The regression line for PSL birds was obtained by the method of least squares; broken lines represent upper and lower 95 per cent confidence limits. The coefficient of regression for PSS birds does not differ significantly from zero (Table 1).

linear relationship between the logarithm of testicular weight and time that may be expressed as

$$\log W_t = \log W_0 + kt, \quad (1)$$

where W_t is the weight of the left testis at t days, t is the period in days of exposure to long daily photoperiods, k is the logarithmic testicular growth-rate constant (= coefficient of regression; see Figure 1) in days^{-1}, and log W_0 is the ordinate-intercept of the line relating log W_t to t, or the logarithm of the estimated weight of the left testis at the beginning of the period of exposure to long daily photoperiods (W_0). As k for immature birds of Group PSL is not significantly different from that for adults (Table 1), data for the two age classes were combined for purposes of constructing the regression line (for procedure, see Simpson *et al.*, 1960).

TABLE 1
THE RELATIONSHIP BETWEEN TESTICULAR WEIGHT AND TIME IN HARRIS' SPARROWS EXPOSED TO 8- AND 20-HOUR DAILY PHOTOPERIODS

Group	*Duration of daily photoperiod, hours*	*Age class*	*log* W_o[1]	k, *days*$^{-1}$[2]
PSL	20	Adult	-0.264±0.100 (12)	0.103±0.014 (12)
PSL	20	Immature	-0.309±0.126[3] (13)	0.103±0.021[3] (13)
PSL	20	Ad + Im	-0.298±0.067 (25)	0.104±0.010[4] (25)
PSS	8	Adult	-0.028±0.086 (13)	0.005±0.011 (13)
PSS	8	Immature	-0.158±0.102[3] (13)	0.004±0.017[3] (13)
PSS	8	Ad + Im	-0.132±0.065 (26)	0.009±0.009 (26)

[1] Ordinate-intercept (equation 1; see also Figure 1) ± 95 per cent confidence interval. The number of birds in each sample is indicated in parentheses.

[2] Logarithmic testicular growth-rate constant ± 95 per cent confidence interval. For birds of Group PSL, k is estimated for the interval day 0–20; for birds of Group PSS, for the interval day 0–25. The number of birds in each sample is indicated in parentheses.

[3] Not significantly different from adults of the same group.

[4] Significance of difference from Group PSS (Ad + Im): $P < 0.001$.

On this basis the estimates and 95 per cent confidence intervals for k and log W_0 are 0.104 ± 0.010 days^{-1} and −0.298 ± 0.067, respectively. Testicular weights of PSS birds suggest the absence of a true rectilinear relationship between the logarithm of testicular weight and time (Figure 1) as the 95 per cent confidence interval for k includes zero (Table 1). The difference in k between Groups PSL and PSS is highly significant ($P<0.001$).

These observations confirm earlier, although quantitatively deficient, reports of photoperiodically induced testicular growth in Harris' Sparrows (Rowan, 1938; King and Farner, 1963) and are consistent with the thesis that long daily photoperiods have an important and often indispensable role in the vernal development of gonads in many seasonally breeding birds of the North Temperate Zone (for reviews see Farner, 1959, 1961, 1964*a*; Wolfson, 1959). In addition both the temporal course and rate of photoperiodically induced testicular growth are comparable to those in White-crowned Sparrows (*Zonotrichia leucophrys gambelii*) subjected to essentially similar photoperiodic conditions at approximately the same time of year (Farner and Wilson, 1957; Laws, 1961; Middleton, 1965). Corresponding relationships between testicular weight and time apparently also exist for the Brambling (*Fringilla montifringilla*), the Chaffinch (*Fringilla coelebs*), and the Greenfinch (*Chloris chloris*) (Dolnik, 1963), for the House sparrow (*Passer domesticus*) (see Farner, 1959, 1964*b*; Middleton, 1965), and for Japanese Quail (*Coturnix coturnix japonica*) (Mather and Wilson, 1964; Follett and Farner, 1966). The data of Wolfson (1966) on *Junco hyemalis* and *Zonotrichia albicollis*, as well as those of Hamner (1966) on *Carpodacus mexicanus*, likewise suggest conformance with equation (1).

TABLE 2

AN APPROXIMATE TIME COURSE OF PHOTOPERIODICALLY INDUCED TESTICULAR GROWTH IN HARRIS' SPARROWS AFTER CHANGING THE DAILY PHOTOPERIOD FROM 8 TO 20 HOURS

Age class	*Initial weight of left testis, mg*[1]	*log* W_t[2]
Adult	1.16±0.21 (13)	(−0.472±0.106) + (0.115±0.021)t
Immature	0.80±0.22 (13)	(−0.390±0.172) + (0.109±0.034)t
Ad + Im	0.98±0.16 (26)	(−0.423±0.086) + (0.112±0.015)t

[1] Mean ± 95 per cent confidence interval. These estimates are based on the weights of testes taken from birds of Group PSS at 5-day intervals during the 25-day experimental period. The number of birds in each sample is indicated in parentheses.

[2] $\log W_t = \log W_0 + kt$. The estimates of $\log W_0$ and k (± 95 per cent confidence interval) are based on the weights of testes taken from 10 immature and 10 adult birds of Group PSL at 5-day intervals between day 5 and 20 of the experimental period. These estimates of k are not significantly different from the less precise estimates (*cf.* Group PSL) noted in Table 1.

Although k is somewhat greater for first-year White-crowned Sparrows than for adults (Farner and Wilson, 1957; Farner, 1959), there is no apparent difference in k between immature and adult Harris' Sparrows (Table 1). As this and the more restricted range of weights over which equation (1) is valid (~ 1–60 mg for Harris' Sparrows versus ~ 1–100 mg for White-crowned Sparrows) may be reflections of limited sample size rather than specific differences in performance characteristics of the response mechanisms, the photoperiodic testicular response of Harris' Sparrows should not be regarded at this time as differing importantly from that of White-crowned Sparrows (Farner and Wilson, 1957; Farner, 1959).

As birds of Group PSS show no significant regression of the logarithm of testicular weight on time (Table 1), the testicular weights of 26 birds continued on 8-hour daily photoperiods and sacrificed at intervals during the experimental period probably reflect the range in W_0 more accurately than those of five birds sacrificed on day 0. If this is true, then an initial nonlinear relationship appears to exist between $\log W_t$ and t for the group exposed to 20-hour daily photoperiods (Table 2). Since W_0 for adult birds is slightly greater than that for immature birds, the nonlinear relationship between $\log W_t$ and t is somewhat more pronounced in the case of adults. Because of possible nonlinear relationships, the rate of change in $\log W_t$ between days 5 and 20 (0.112 ± 0.015 days^{-1}) is probably a more precise estimate of the logarithmic testicular growth-rate constant than the rate of change in $\log W_t$ between days 0 and 20 (0.104 ± 0.010 days^{-1}). However, for this series of data, the estimates of k are not significantly different. Farner and Wilson (1957) have demonstrated for first-year White-crowned Sparrows a reasonably good conformance with equation (1) until the combined weight of the testes reaches about 200 mg. Although the same is generally true for adults, the possibility of an initial nonlinear relationship between $\log W_t$ and t has been noted.

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Summary

When Harris' Sparrows (*Zonotrichia querula*) that have been retained on 8-hour daily photoperiods for one to two months following capture during midwinter are subjected to 20-hour daily photoperiods, testicular growth is rapidly induced. Harris' Sparrows continued simultaneously on 8-hour daily photoperiods fail to show testicular growth.

Testicular growth induced by 20-hour daily photoperiods approximates a logarithmic function of time until the weight of the left testis reaches about 60 mg.

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