Technical Papers

The Roles of Darkness and Light in the Activation of Avian Gonads[1]

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Recently Kirkpatrick and Leopold (*1*) have shown with quail (*Colinus virginianus*) that interruption of the dark period results in photoperiodic gonadal response not obtainable with a continuous dark period and the same amount of photoperiod. They conclude that the dark period is an inhibiting factor in this species, and suggest that the duration of the dark period is a major controlling factor in photoperiodic responses. Jenner and Engels (*2*) have obtained similar results with male finches and conclude that there is a critically important *dark-dependent phase* in avian photoperiodism, although rapid testicular development has been obtained (*3, 4*) by treatment with continuous light.

We have recently completed a pertinent series of experiments on the photoperiodic responses of white-crowned sparrows (*Zonotrichia leucophrys gambelii*), the details of which are summarized in Tables 1 and 2. The light treatments (30–40 ft-c) were applied for 29–30 days, beginning on February 14. Differences between all possible pairs of arithmetic means are significant ($P = 0.01$) except those of B-D, C-E, C-F, and E-F; however, C-E and E-F are significant at the 5% level. Analyses of logarithms of testicular weights indicate that the differences between all possible pairs of geometric means except C-F are significant ($P = 0.01$).

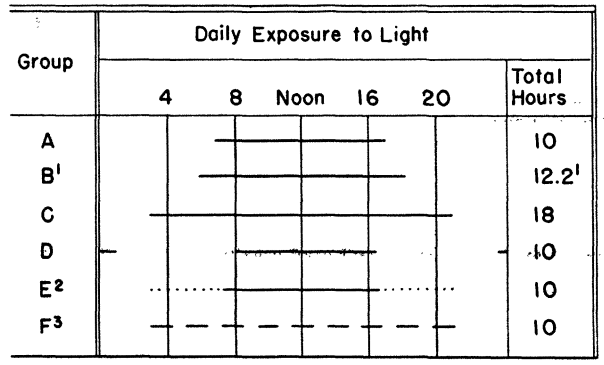
These results suggest the possibility that the light-stimulated gonadotropic mechanism, which doubtless involves the anterior pituitary and hypothalamus (*5*), is of such nature that it becomes active almost immediately after the beginning of the photoperiod and has a persistent carry-over period of activity after the end of the photoperiod. We envision the effective duration of the carry-over period to be of the order of a fraction of an hour to several hours and probably a function of the duration and nature of the preceding photoperiod, its characteristics varying also according to species. The rate of testicular response would then be a direct function of the summated daily gonadotropic effects of the photoperiods and carry-over periods. Several possible physiologic bases for such a carry-over period will be discussed in a subsequent and more detailed paper.

This hypothesis accounts for the difference between groups A and D as the effect of the additional carry-over period in D. The treatment and responses in group D were similar to those described by Jenner and Engels (*2*). The differences between D and E could be attributed to the greater number of carry-over periods in E. The differences between E and F could be the result of greater activity in carry-over periods which follow 1-hr photoperiods than in those which follow 1-min photoperiods. The inverse relation between the length of the longest dark period and the response in quail (*1*) might be explained as the attainment of maximum effects of two carry-over periods by optimum spacing. This hypothesis also apparently rationalizes similar results obtained in treatment of ducks (*6*) and starlings (*7*) with interrupted light. It may be applicable to the light-stimulated increase in egg production of the domestic fowl, since it has been shown (*8–10*) that fractionation of the photoperiod increases the response. However, the available information (*11–13*) suggests that this hypothesis should not be extended to photoperiodism in mammals.

In most, if not all, avian species which show marked gonadal photoperiodism, there develops, following a

TABLE 1

LIGHT TREATMENTS



[1] Wild controls; mean Feb. 14–Mar. 16, including civil twilight.
[2] Continuous light 0710–1650 plus 1 min each half-hour from 0300 to 0700 and from 1700 to 2100.
[3] Nine 1.11-hr light periods separated by eight 1-hr periods of darkness (0300–2100).

TABLE 2

TESTICULAR WEIGHTS

Group	Number	Arithmetic mean, mg	Geometric* mean, mg	Range, mg
A	8	1.2	1.2	0.6–1.6
B	12	3.9	3.8	3.0–6.0
C	7	190	170	79–250
D	10	8.2	6.8	3.0–25
E	15	87	65	17–210
F	13	170	140	35–310

* Obtained by logarithmic transformation of testicular weights.

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cycle of gonadal activity, a refractory period during which an increase in daily photoperiod does not evoke gonadal development. Apparently short daily photoperiods, or long dark periods, are necessary to terminate this refractory period (*14, 15*). However, once the refractory period has ended, our hypothesis suggests, apparently contrary to those cited above (*1, 2*), that the daily dark period per se has no positive function, although the effect of a carry-over period may be exerted during the dark period. Possibly the differences are semantic; we feel, however, that our hypothesis is basically different and represents a more logical rationalization of the available data. Like Hammond (*13*), we feel that the assignment of an active role to the dark period is an unnecessary assumption; however, our alternative hypothesis is somewhat different.

Although analogies (*1, 2*) with photoperiodisms of plants, in which there are essential dark-dependent reactions (*16*), are attractive, extreme caution must be exercised since it is quite possible that the effect of darkness in the avian photoperiodic mechanism may be only that of cessation of a process, or processes, requiring light. Our hypothesis is proposed as one possible rationalization of the available information on the mechanism of avian photoperiodism. We feel that its tentative acceptance is favored by the Law of Parsimony as the simplest apparent rationalization.

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A Simplified Method for Measuring Emotional Defecation in the Rat

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Hall's (*1*) unwieldy open field test has been established as the yardstick for measuring the intensity of emotionality in the rat (*2, 3*). Some important observations on the defecation of rats in simpler situations seem to have been overlooked. For example, it had been established that the defecation of rats placed in a strange enclosure decreased from trial to trial, until practically all defecation ceased (*4, 5*). This factor, in conjunction with other investigations, led Hall to the realization that defecation was an index of emotionality in all unfamiliar situations.

It seemed to the present writer that if strangeness were the decisive factor in producing emotional defecation, then, Hall's open field test was not necessary to determine emotionality. Any simple unfamiliar situation should do as well. A review of the literature and correspondence with C. S. Hall indicated that no investigator seems to have related a simple, strange situation with the open field.

The present report discloses a procedure whereby savings in laboratory space, money, and time may be made by substituting a simple, strange situation for the 8 ft of apparatus needed for the open field test.

Ten adult male rats were used as subjects. Each was randomly introduced into one of three situations. Following this, a regular sequence was observed. If a rat was placed in the open field first, for example, he would next be placed in a familiar situation. The familiar situation consisted of a standard $7 \times 7 \times 10$ cage placed on top of the rat's community cage. Following exposure here the rat would then be placed in the simple, unfamiliar situation. This situation was another standard cage placed in an unfamiliar room—a laboratory storage room in which no rats had been kept.

Each rat had one 5-min trial a day for 10 days in each of the 3 situations. The field and cages were cleaned immediately after any trial in which urination or defecation occurred.

The statistical sign test (*6*) was employed to compare emotional defecation in the 3 situations. In comparing emotional defecation in the open field test and in the familiar situation, the sign test was significant at the 1% level of confidence. In comparing emotional defecation in the strange situation and in the familiar situation, the sign test was significant at the 5% level of confidence. Such levels of confidence indicated that emotional defecation in both the open field test and the strange situation was significantly different from emotional defecation in the familiar situation. No differences in emotional defecation were found in a sign test comparison of defecation in the open field and in the strange situation.

These findings suggest that a clean, relatively odorfree, standard rat cage, placed in a strange situation, will elicit emotional defecation in a manner similar to that of Hall's open field test. If such is the case the open field test does not need to be used to measure emotionality in rats. The rather large amount of space the open field requires, the expense involved in purchasing material with which to build it, and the time taken to construct it, can all be put to other uses in the laboratory. A clean standard cage placed in an unfamiliar room should do as well.