INFLUENCE OF DECREASED LENGTH OF DIFFERENT SPECTRAL PHOTOPERIODS ON TESTIS DEVELOPMENT OF DOMESTIC FOWL

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Summary. White Leghorn cockerels between 14 and 18 weeks of age were subjected to a decrease in hours of clear, red, blue and green photoperiods. The decrease in photoperiod length of clear and red light inhibited testis development and spermatogenesis. The decrease in photoperiod length in blue and green light failed to show the inhibitory effect. Pituitary gonadotrophin activity indicated that both production and release of gonadotrophins were inhibited by decreased hours of clear and red light.

INTRODUCTION

Influence of spectrum on gonad development and the reproductive activity of birds has been the subject of many studies. Light from the red end of the spectrum is gonad-activating, while blue and green spectra have little or no effect on gonad activity (Benoit, 1964; Bissonette, 1932; Dakan, 1934; Ringoen, 1942; Scott & Payne, 1937).

Length of photoperiod has also been shown to influence sexual development and reproductive activity in birds. Increasing the length of photoperiod results in early sexual maturity and egg production (King, 1961; Morris & Fox, 1958; Lert, Wilson & Hart, 1960), whereas decreasing the length of photoperiod inhibits reproductive activity (King, 1961; Lowe & Heywang, 1964; Shutze, Matson & McGinnis, 1961, 1963).

In recent experiments, Harrison, McGinnis, Schumaier & Lauber (1969) observed that White Leghorn pullets exposed to green and blue light attained sexual maturity earlier than pullets exposed to red and clear light. These results were contrary to those reported in the literature (Benoit, 1964). However, in the experiment by Harrison et al., length of the photoperiod was decreased during the rearing period. A reduction in length of photoperiod of a gonad-activating spectrum inhibits gonad development, but a decrease in hours of a non-gonad-active spectrum should not affect testicular development. The experiment herein reported was designed to test this hypothesis.
MATERIALS AND METHODS

One-day-old, Single Comb, White Leghorn cockerels were randomly placed into twelve separate light-control chambers. Treatments consisted of three units of four different spectra of filtered light. The colours used were clear, red, blue and green. The distribution of the spectrum and intensity from the various filtered lights are reported by Klein (1964) and Harrison & McGinnis (1967). Maximum intensity in the blue, green, red and clear light treatments was 0·08, 0·11, 0·14 and 3·2 μw cm⁻² m⁻¹, respectively.

One unit of the four colour treatments received 14 hr of light and 10 hr dark (14L/10D) throughout the experiment. The two remaining units of the four colour treatments received 14L/10D to 14 weeks of age and the photoperiod then was reduced to 6L/18D between 14 and 18 weeks of age.

Body weights were recorded for all the birds at 10, 14 and 18 weeks of age. Testis weights were noted on half the cockerels from each light chamber at 14 weeks of age (just before the change in length of photoperiod). Testis weights were taken on the remaining half at 18 weeks of age. Testes were stored in formalin and histologically examined for spermatogenic stages of development. Ten seminiferous tubules from ten individuals in each photoperiod (colour and length) treatment were examined for stages of sperm development. The presence of primary and secondary spermatocytes and also of spermatids was recorded for each of the randomly selected tubules. The percentage development was then based on the spermatogenic stages recorded for the 100 tubules per treatment.

Pituitary gonadotrophin activity was determined for the 18-week-old birds from all the different photoperiod length and coloured light treatments. Chick testis weight response, as described by Byerly & Burrows (1938), Herrick, McGibbon & McShan (1962) and Shellabarger (1953), was used to assay the gonadotrophin activity of the pituitaries. Following chloroform asphyxiation of the cockerels, pituitaries were rapidly removed and placed in acetone. Anterior pituitaries were separated after acetone storage and pooled according to light treatment. Before injection, the anterior pituitary tissue was weighed, homogenized with a tissue grinder and taken up in distilled water.

RESULTS

Testis growth was greater at 14 weeks of age in clear light than in any of the restricted spectrum treatments (Table 1). Testis size at 14 weeks was intermediate in the red light when compared to clear light and to the blue and green end of the spectrum. This response is typical of that reported in the literature (Benoit, 1964). However, after 18 weeks on 14L/10D in the various spectra, the 14-week relationship of testis size was not the same. Those in clear light again showed the greatest amount of testis development while the birds in the red light had the smallest testis. The magnitude of the difference between the different coloured light treatments on 14L/10D was much less at 18 weeks than at 14 weeks.

When the hours of light were reduced to 6L/18D at 14 weeks, testis size was
reversed when compared with the measurements at 14 weeks and 18 weeks of age on 14L/10D (Table 1). These data indicate that the decrease in length of the photoperiod of clear and red light effectively inhibited gonad development, whereas the decrease in hours of blue and green light failed to inhibit gonad development. In the blue and green spectra, the cockerels subjected to decreased length in photoperiod (6L/18D) continued to develop at the same rate as those on 14L/10D. Reduction in length of the red spectrum photoperiod prevented any further development between 14 and 18 weeks of age, and the reduction in clear light even appeared to reverse some of the development that had already occurred by 14 weeks.

**Table 1**

<table>
<thead>
<tr>
<th>Photoperiod change at 14 weeks (hr of light/day)</th>
<th>Age (weeks)</th>
<th>Blue</th>
<th>Colour of photoperiod</th>
<th>Red</th>
<th>Clear</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>14</td>
<td>(50)* 1.38 ± 0.327†</td>
<td>(55) 1.45 ± 0.298</td>
<td>(79) 3.12 ± 0.274</td>
<td>(79) 6.28 ± 0.376</td>
</tr>
<tr>
<td>14 to 14</td>
<td>18</td>
<td>(22) 10.92 ± 1.423</td>
<td>(20) 11.39 ± 1.503</td>
<td>(20) 8.45 ± 1.788</td>
<td>(19) 15.69 ± 1.406</td>
</tr>
<tr>
<td>14 to 6</td>
<td>18</td>
<td>(40) 10.97 ± 1.066</td>
<td>(39) 8.60 ± 0.910</td>
<td>(41) 3.61 ± 0.680</td>
<td>(40) 1.54 ± 0.268</td>
</tr>
</tbody>
</table>

* Number of birds in treatment.
† Mean ± S.E.

**Table 2**

<table>
<thead>
<tr>
<th>Photoperiod change at 14 weeks (hr of light/day)</th>
<th>Age (weeks)</th>
<th>Blue</th>
<th>Colour of photoperiod</th>
<th>Red</th>
<th>Clear</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10</td>
<td>(135)* 1.176†</td>
<td>(142) 1.144</td>
<td>(138) 1.026</td>
<td>(145) 0.999</td>
</tr>
<tr>
<td>0</td>
<td>14</td>
<td>(133) 1.476</td>
<td>(141) 1.485</td>
<td>(138) 1.462</td>
<td>(143) 1.389</td>
</tr>
<tr>
<td>14 to 14</td>
<td>18</td>
<td>(22) 1.839</td>
<td>(20) 1.830</td>
<td>(20) 1.920</td>
<td>(19) 1.839</td>
</tr>
<tr>
<td>14 to 6</td>
<td>18</td>
<td>(40) 1.832</td>
<td>(39) 1.762</td>
<td>(41) 1.802</td>
<td>(40) 1.721</td>
</tr>
</tbody>
</table>

* Number of birds in treatment.
† Mean.

The change in testis development reflected a direct effect of light on the gonads rather than an overall somatic development. This is demonstrated by the rate of increase in body weight with age in the various light treatments (Table 2). There was no apparent difference or consistent trend between body weights at different ages in the various spectra of light. Those subjected to the decreased length of photoperiod gave some indication of a slower growth rate between 14 and 18 weeks of age. However, regardless of the length of the light period, somatic development continued between 14 and 18 weeks of age.

Pituitary gonadotrophin activity at 18 weeks of age showed no consistent
relationship to testis size. Pituitaries from the birds in 14L/10D of red and clear light did stimulate significantly greater testis development in the assay chicks than those from the blue and green treatments (Table 3). The 14L/10D-treated birds in clear light had the largest testis and greatest pituitary gonadotrophin activity. However, in red light, testis size was the least and the levels of pituitary gonadotrophins were the second highest and significantly greater than those in the blue and green treatments.

Except in the blue spectrum, pituitary gonadotrophin response was less in the assay chicks within each coloured light treatment when the hours of light were decreased between 14 and 18 weeks of age. Lack of consistency prevents any conclusions concerning light effects on pituitary gonadotrophins but it appeared from the data that light treatment affected both release and production of gonadotrophins. The birds in clear light (14L/10D) had the largest testis size and greatest pituitary gonadotrophin potency, which indicates that maximum production and release of gonadotrophins occurred in this light regimen. When the daily hours of clear and red light were decreased, the data indicated that both production and release of gonadotrophins were inhibited, since there was no accumulation of pituitary gonadotrophins which would increase their gonadotrophin content.

At 14 weeks of age, spermatogenesis was greater in the clear and red lights than in the blue and green treatment (Table 4). This response corresponds with testis weight difference in these same treatments. Sperm maturation was not different at 18 weeks when the birds remained on 14 hr of light. Within all coloured light treatments remaining on 14L/10D to 18 weeks of age, the percentage of maturing sperm cells increased with age.

When the length of photoperiod was changed from 14L/10D to 6L/18D, spermatogenesis between 14 and 18 weeks of age was different in the various coloured light treatments. Clear light decreased to 6 hr daily resulted in a lesser percentage of tubules showing spermatids than the clear light at 14 weeks. In

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**Table 3**

<table>
<thead>
<tr>
<th>Photoperiod change at 14 weeks (hr of light/day)</th>
<th>Blue</th>
<th>Colour of photoperiod</th>
<th>Testis wt (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Green</td>
<td>Red</td>
</tr>
<tr>
<td>14 to 14</td>
<td>(4)* 30-2</td>
<td>(4) 47-4</td>
<td>(4) 53-4</td>
</tr>
<tr>
<td></td>
<td>±1-8†cd</td>
<td>±1-8 abc</td>
<td>±1-5 ab</td>
</tr>
<tr>
<td>14 to 6</td>
<td>(6) 46-6</td>
<td>(6) 29-4 abc</td>
<td>(6) 43-0</td>
</tr>
<tr>
<td></td>
<td>±1-6 abc</td>
<td>±1-4 cd</td>
<td>±2-4 abc</td>
</tr>
</tbody>
</table>

* Number of assay chicks.
† Mean ± S.E. Means not having same letters (a, b, c, d, e) are significantly different at the 5% level of probability using the Duncan Multiple Range Test. Average testis weight of chicks receiving distilled water injection was 10-2±0-8 e.

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**TABLE 4**

**SPERMATOGENESIS IN WHITE LEghORN COCKERELS SUBJECTED TO DIFFERENT PHOTOPERIODS**

<table>
<thead>
<tr>
<th>Photoperiod change at 14 weeks (hr of light/day)</th>
<th>Age (weeks)</th>
<th>Blue</th>
<th>Green</th>
<th>Colour of photoperiod</th>
<th>Red</th>
<th>Clear</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Secondary spermatocytes (% cells)</td>
<td>Secondary spermatocytes (% cells)</td>
<td>Secondary spermatocytes (% cells)</td>
<td>Secondary spermatocytes (% cells)</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>14</td>
<td>62±8·8</td>
<td>±8·9</td>
<td>47±11·1</td>
<td>±8·0</td>
<td>(20)*</td>
</tr>
<tr>
<td>14 to 14</td>
<td>18</td>
<td>99±1·0</td>
<td>±8·5</td>
<td>96±2·2</td>
<td>±15·4</td>
<td>100±4·0</td>
</tr>
<tr>
<td>14 to 6</td>
<td>18</td>
<td>97±2·1</td>
<td>±2·1</td>
<td>97±3·0</td>
<td>±14·2</td>
<td>(20)*</td>
</tr>
</tbody>
</table>

* There were ten birds in all except two samples, each of which had twenty birds.
† Mean ± S.E.
the treatment on 6 hr daily of red light, spermatogenesis at 18 weeks of age was at the same stage as it was at 14 weeks. In both blue and green light, the 8-hr decrease in photoperiod did not affect rate of sperm development. These data further demonstrate that a decrease in the length of photoperiod of blue and green light fails to inhibit gonadotrophin production and release, whereas a decrease in the hours of red and clear light inhibits gonadotrophic activity.

DISCUSSION

Decreased testis size, spermatogenesis and pituitary gonadotrophin activity in the cockerels subjected to decreased length of clear and red photoperiods indicate that both production and release of gonadotrophins were inhibited. The continued increase in testis size and spermatogenesis in decreased hours of blue and green light indicate that change in the hours of these spectra fail to inhibit gonadotrophin function.

The results from the birds on 6L/18D blue and green light confirm the hypothesis that a decrease in the hours of a non-gonad-active spectrum has no effect on testis development. The reason for the testis development in the blue and green light being comparable to the 14L/10D red and clear light will require further investigation. The development seen in the blue and green light, regardless of the length of the light period, may reflect normal gonad growth rate under constant hours of light or even constant darkness.

ACKNOWLEDGMENT

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REFERENCES


Testis growth in various spectra and photoperiods


