

SEXUAL PHOTOPERIODICITY IN THE BLUE JAY
(*CYANOCITTA CRISTATA*)¹

BY THOMAS HUME BISSONNETTE

STUDIES too numerous to cite here in full have shown that many, but not all birds, are sexually photoperiodic, and that some respond to factors other than light or in addition to it. Some may be controlled by an inherent rhythm accelerated or retarded by changes in environmental factors or independent of them. Not all sexually photoperiodic birds respond in the same way to changing length of day (Benoit, 1935-7; Bissonnette, 1936, 1938, 1939; Marshall, 1936, 1937; Ringo and Kirschbaum, 1939; Rowan, 1938a, b; Witschi, 1935). It is, therefore, necessary to know how each species reacts in this regard, both in general and in detail, to gain a full and accurate picture of the phenomena of sexual photoperiodicity. In this study the Blue Jay (*Cyanocitta cristata*) has been tested for response by sexual activation to increasing periods of exposure to light in winter.

MATERIAL AND METHOD

Blue Jays of both sexes were subjected to night-lighting from a 60-watt bulb for 6 hours each night, after normal daylight, in an unheated basement room, from December 3 to 31. They were fed mixed grains and ground-up table scraps, the food used to trap them, with some "fox food" added. They were sacrificed for study on the latter date.

Control females were shot from the wild on January 7; males on March 16, two within ten minutes of each other, to check on uniformity of testicular stages under normal "wild" conditions and for comparison with the experimental birds. Judged by intestinal contents, these controls ate food like that given the lighted birds. Their total daylight time and intensity were somewhat greater than those of experimentals in the basement. This has been correlated, in Starlings (*Sturnus vulgaris*), with a slightly more advanced degree of sexual activity than that of "inside controls." The stages of these birds may be expected to differ slightly less from the experimentals than would controls on normal daylight in the basement.

Testes, epididymides, ovaries and oviducts were sectioned from paraffin at 10 μ after Bouin's fixation and stained in iron-hematoxylin with and without eosin. Representative sections of all were photomicrographed at comparable magnifications for exact comparison to supplement microscopical study, as shown in legends to the figures.

OBSERVATIONS

Males

Testes. Testes of controls (Figs. 1, 2), killed on March 16, exhibited two different states in the two birds killed within ten minutes of

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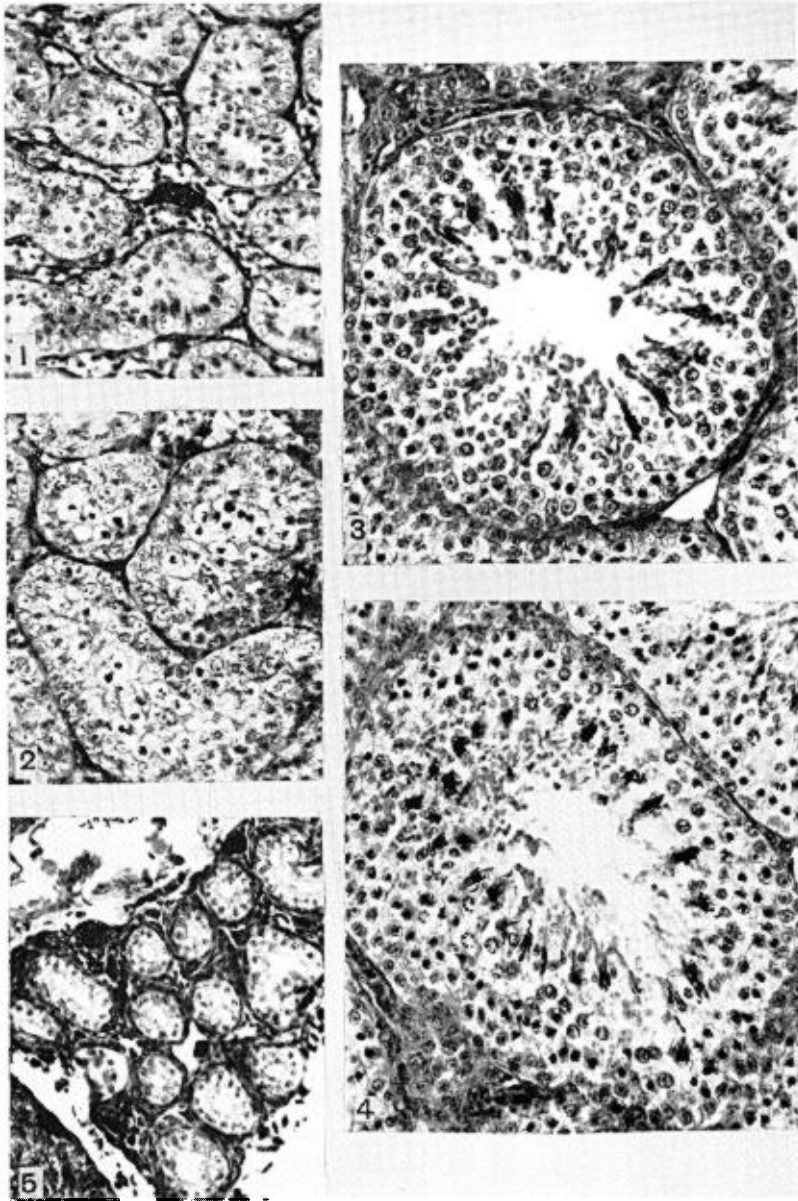
each other and others in different birds. In one (fig. 1), marked increase in size, elongation, and activity of Sertoli cells and mitoses of spermatogonia were beginning to occur; but no synizesis was reached in any regions of the gonads. Interstitials were behaving as they do in Starlings at comparable dates, *i.e.*, becoming flattened and reduced in apparent size. In the other (fig. 2), similar elongation of Sertoli cells and multiplication of spermatogonia were accompanied by synizesis stages and marked segregation of cytoplasm to individual nuclei in many, but not all, tubules of the testes. It is probable that the first bird was a juvenile and the second a mature bird in the previous year, although no external differences could be distinguished to indicate this. Their stages of activation represent ones about one to two weeks apart on the spermatogenic cycle.

Testes of lighted birds killed on December 31 (figs. 3, 4) at 28 days of lighting had reached almost, if not quite, complete spermatogenesis with all stages of germ cells including sperms with tails and spirally twisted heads. Though it cannot be stated with certainty whether these have reached their climax of activity or not, it seems improbable. Interstitial cells were flattened and their cytoplasm did not appear to be active. They resembled those of Starlings at similar stages (Bissonnette, 1930-32).

In both controls and experimentals a few scattered aggregates of pigment were to be seen in widely separated interstitial regions, so small in amount as to leave the gonad white in appearance. It is noteworthy that the testes of Blue Jays, although smaller in size both relatively and actually than those of Starlings at comparable stages on the cycle, have larger cells and nuclei. They would, therefore, produce much fewer germ cells of all stages in their testes than do Starlings at given states of activation. Testicular tubules of these lighted birds were smaller in diameter than those of Starlings at or nearing complete spermatogenesis.

Epididymides. "Control" epididymides of March 16 (figs. 5, 6) differed but little from each other in stage of activation. Cubical or low columnar epithelium without ciliary processes lined both. Neither cellular debris nor germ cells were found in their lumina. Their staining reactions suggest the mere beginnings of activation.

"Experimental" epididymides of December 31 (figs. 7, 8), on the contrary, had greatly enlarged tubules gorged with cellular debris and germ cells from primary spermatocytes to almost, if not completely, metamorphosed sperms. Columnar epithelial lining, little if any taller than in controls, appears to have ciliary processes considerably shorter than in mammals at similar stage of activity. Pressure of contents apparently flattens the columnar lining as it does in mammals when tension is high.



Figs. 1 and 2. Testis tubules from "outside" or "wild" controls, killed March 16 at 9:05 and 9:13 A.M. Note difference in stages of spermatogenesis. (x 276, approximately).

Figs. 3 and 4. Testis tubules from males lighted experimentally six hours each night, Dec. 3 to 31. Note the fairly close correspondence of stages, almost complete activation, and fairly large germ cells and nuclei. (x 276, approximately).

Fig. 5. Epididymides from "control" bird supplying fig. 1. (x 276, approximately).

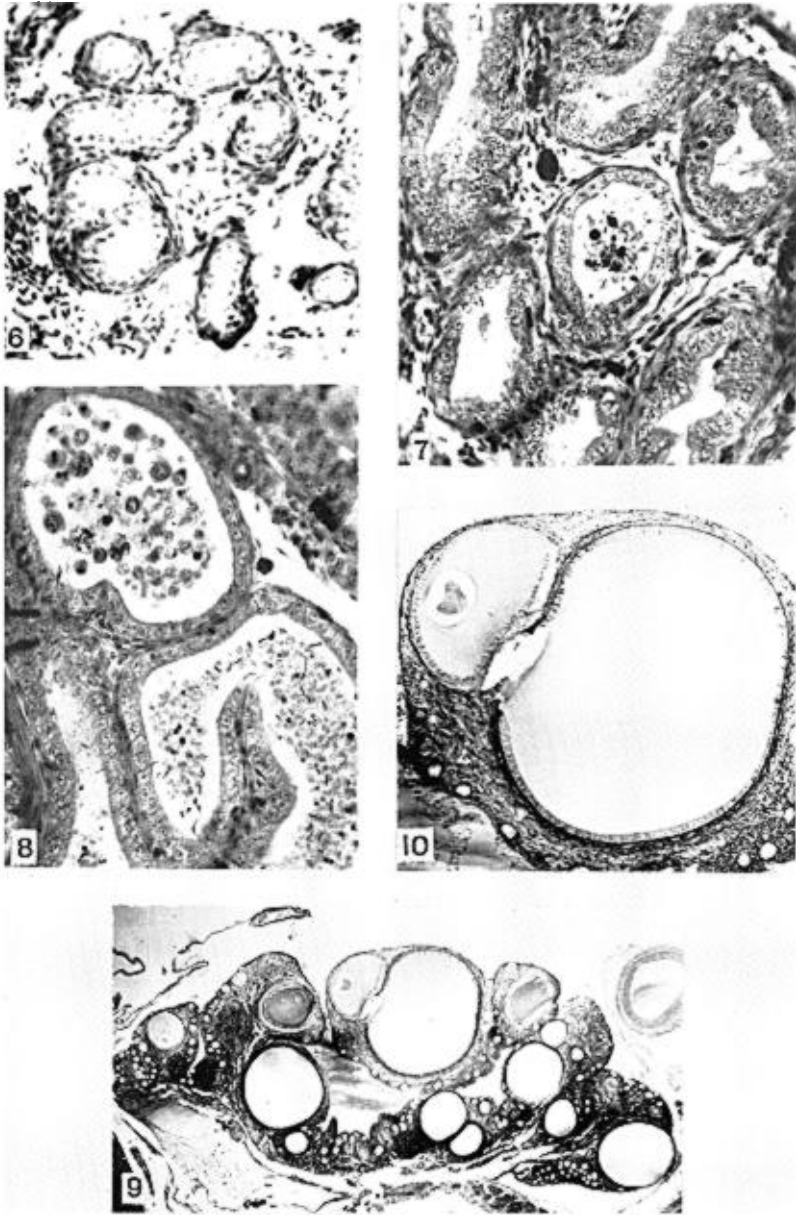
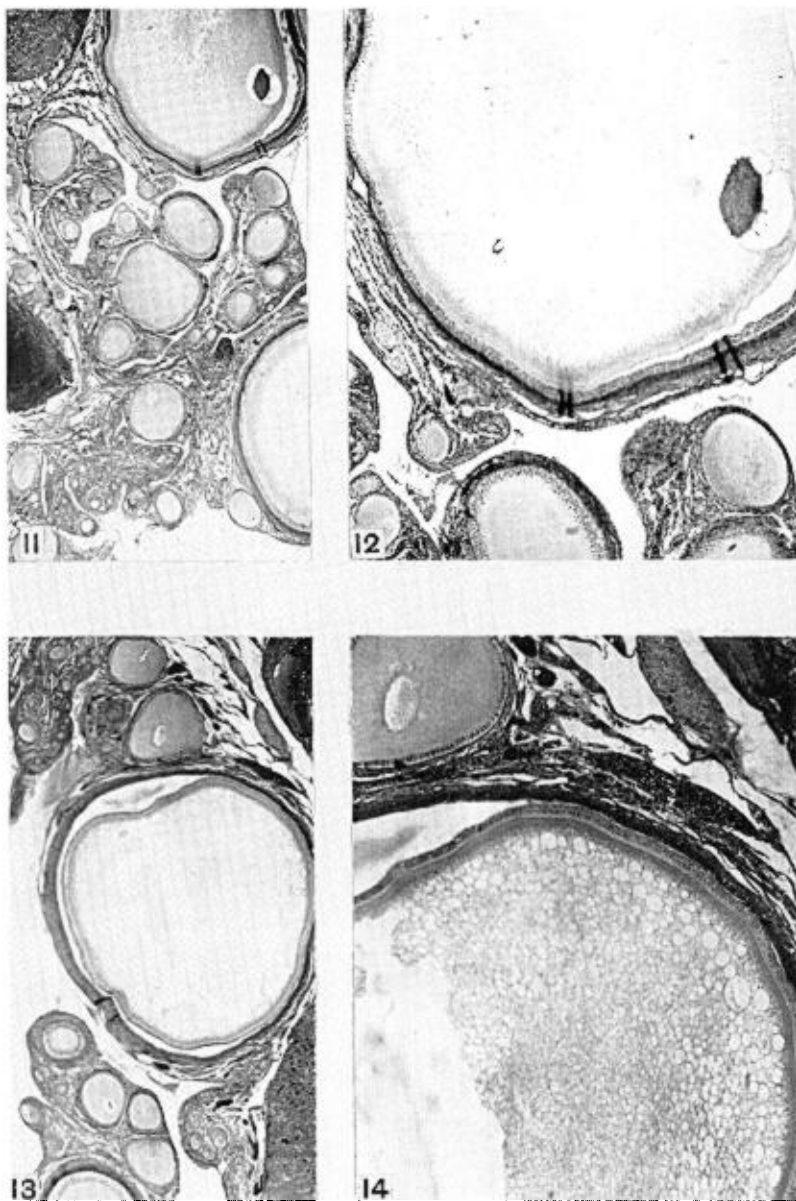


Fig. 6. Epididymides from "control" bird supplying fig. 2. (x 276, approximately).

Figs. 7 and 8. Epididymides from "experimental" birds supplying figs. 3 and 4. (x 276, approximately).

Figs. 9 and 10. Sections from ovary of "control" bird, Jan. 7. (x 28 and 69 approximately, respectively).



Figs. 11 and 12. Sections from ovary of "experimental" female, Dec. 31, after 28 days lighting. (x 28 and 69 approximately, respectively).

Figs. 13 and 14. Sections from ovary of another "experimental" female, Dec. 31, after 28 days lighting. (x 23 and 69 approximately, respectively).

Females

Ovaries. Ovaries of "wild controls" on January 7 (figs. 9, 10) exhibited many medium sized follicles, but none as yet in the later stages of growth and yolk deposition described for the cycle in Starlings (Bissonnette and Zujko, 1936). Those of lighted birds on December 31 (figs. 11, 12, 13, 14) had two or three of their largest follicles entering the later stages of growth and deposition of yolk, with diameters at least 1.33 to 2.27 times those of the largest follicles in the "control" ovaries of January 7.

Oviducts. Experimental birds exhibit moderate to very pronounced increase in diameter, convolutions and total length of oviducts over those of controls killed eight days later in the season and therefore likely to be more advanced on the cycle. They resemble those of English Sparrows described by Ringoen and Kirschbaum (1939) after night-lighting in winter. The amount of their fluid contents was also increased over that in controls and apparently distended them, suggesting increase in secretory activity of the epithelium. They are not figured here since Ringoen and Kirschbaum's figures for the sparrow are so similar.

DISCUSSION

Activation of testes and epididymides, leading to almost complete spermatogenesis in 28 days in December as contrasted with the conditions of these same organs in controls as late as March 16 leave no doubt about sexual photoperiodicity in Blue Jays. Response is at least as quick and rapid as in Starlings. Larger size of germ cells in the smaller testes of the Blue Jay make technical treatment and microscopical study easier than with Starlings. The birds are easy to feed in captivity and their temperaments good for experimental work. Public opinion is more or less against them as it is with Starlings because Blue Jays are inclined to bully smaller song birds in towns and villages, so they make good experimental material if they can be trapped in sufficient numbers.

The presence of pigment in a few interstitial regions indicates that they differ from the Starling only quantitatively in this respect. As in the Starling, sexual activation by increased lighting or its reverse, either by reduced light or by forced exercise, is not apparently a cause of variations in the actual amount of pigment, as Rowan (1938) suggested to be a cause for its concentration with reduction of testis size in Starlings subjected to periods of forced exercise in contrast to periods of additional lighting. As Bissonnette pointed out, it is apparently only the amount of pigment relative to other testicular elements that increases, as forced exercise or reduced lighting induces reduction of these other elements. Concentration is reversed by added experimental lighting

with both Starlings and Blue Jays, so it can hardly be evidence of activation by forced exercise as Rowan seems to wish. Parallelism with the Starling in these details is apparent.

Changes in ovaries and oviducts of lighted birds as contrasted with unlighted ones parallel those described for the English Sparrow by Ringoen and Kirschbaum (1939), and by Riley and Witschi (1939) and confirmed in this laboratory by Dr. J. W. Burger (unpublished data). Starlings react in the same way (Bissonnette, Burger, unpublished data). In all these cases the ovary is less completely and uniformly activated by lighting than the testis. It is probable that courtship posturing and other reciprocal behavior are required to bring the female bird into complete synchrony of sexual activation with the male. In pigeons, at least, the sight of another bird or the image of a bird (even of itself) is needed to induce laying and, presumably, the other later stages of egg-production (Marshall, 1936; Matthews, 1939). In some birds that nest in flocks, it has been learned that the sight of a certain number, at least, of other pairs courting and nesting is required to stimulate the females to lay (Darling, 1938). It is indicated that both the lighting and these other visual stimuli modify the activities of the anterior pituitary which in turn activates the sex glands (Bissonnette, 1932b; Marshall, 1936; Matthews, 1939). It has been demonstrated that removal of the pituitary in ferrets prevents this chain of reactions to increased lighting (Hill and Parkes, 1933; Bissonnette, 1938a).

Rowan (1938a, b) has criticized our experimental results with Starlings on the basis of lack of exact uniformity of stages in the testes, even though controls also showed similar variations whether they were "inside controls" or animals killed from the wild. His own early papers, written with his materials fresh before him, frequently lamented lack of uniformity in the sex organs of his experimental birds. The two male Blue Jays, killed within ten minutes of each other on March 16, again demonstrate what we found to be true for Starlings and other birds under "normal" conditions, namely, a quite close correspondence within certain limits, but no exact uniformity, even in birds of similar ages nor in all parts of the same gonad, especially in early stages of activation. We, therefore, have not expected exact uniformity in such stages when experimentally induced. Rates of response differ with different birds of the same species and age and under the same conditions. We feel that Professor Rowan has demanded more uniformity from our materials and results than from his own or than occurs in nature, as shown again by these two male Blue Jays. He has also shifted his point of view from maintaining that increased physical exercise is the real causative factor for sexual activation by increased lighting to stating that it is merely increase of periods of wakefulness and "physiological activity," whatever the latter expression may mean in living

animals which we are accustomed to believe are undergoing physiological activity, sleeping or waking. As Riley (1937) has shown, the mitotic germ-cell activity in the testes of sparrows and perhaps other birds is greatest at night between two and four in the morning when the temperature and metabolic rates of the birds are lowest, and this can be transferred to the daylight hours by reversing the light cycle of the birds experimentally.

SUMMARY AND CONCLUSIONS

(1) The male Blue Jay is sexually photoperiodic and responds to increased illumination in December by almost, if not quite, complete spermatogenesis and activation of the epididymis to breeding condition in twenty-eight days.

(2) Females also respond, but more slowly and less completely. Oviducts increase markedly in size and activity in a majority if not all experimentally lighted females.

(3) Exact uniformity of stages of activity of germ cells was not found in males taken from the wild within ten minutes of each other in March nor in experimentally activated birds at time of killing. This is also true of females.

(4) Larger germ cells and nuclei and smaller size of testes in Blue Jays than in Starlings make them easier to treat technically and study microscopically.

(5) Blue Jays are hardy, easily kept and fed in captivity, and temperamentally good for experimental work.

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TRINITY COLLEGE, HARTFORD, CONNECTICUT.