LIGHT VERSUS ACTIVITY AS A REGULATOR OF THE SEXUAL CYCLE IN THE HOUSE SPARROW [1]

BY GARDNER M. RILEY

IT has been well established for the male House Sparrow, *Passer domesticus,* (Riley, 1936, 1937; Kirschbaum and Ringoen, 1936; Ringoen and Kirschbaum, 1939), as well as for a large number of other birds (literature reviewed by Rowan, 1938), that artificial lengthening of the daily period of wakefulness during the inactive phase of the sexual cycle results in a recrudescence of the gonads. It is generally assumed that the external factor exerts its primary effect on the anterior lobe of the pituitary, causing this gland to release the gonad stimulating hormones. This view is supported by the work of Benoit (1936) who found that hypophysectomized ducks did not respond to light treatment. It has also been reported (Benoit, 1935) that pituitaries from light-treated immature ducks stimulate ovarian development in the immature female mouse, whereas pituitaries from untreated ducks fail to bring about this response.

Two methods have been used to prolong experimentally the daily period of wakefulness. By the first method, and the one most commonly used, the birds are subjected to gradually lengthened daily light periods. In the second method, instead of increasing the daily illumination, a gradually increased period of enforced activity in darkness is added to a basic light day.

In the Junco (*Junco hyemalis*) Rowan (1929) observed gonadal recrudescence regardless of which method was employed. Appearing to corroborate this finding was the observation (Rowan, 1937) that Starlings (*Sturnus vulgaris*) collected within the city of London, where they are subject to frequent disturbances, approached the breeding condition almost two months in advance of country birds. More recently, in a brief note this author (Rowan, 1938*b*), announced that both House Sparrows and Juncos showed advanced gonadal development after subjection to increased periods of enforced wakefulness in total darkness, "following a preliminary training period of two weeks in a faint and continuously diminishing glow." On the basis of these observations Rowan advances the hypothesis, well stated in a recent review article (Rowan, 1938*b*), that "light is concerned only insofar as it provides a means of keeping the animals awake and physiologically active, but is in itself of no further significance, and that increasing diurnal activity induced by increasing increments of illumination, is the stimulating factor that activates the pituitary."

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Bissonnette (1931), using the Starling, but otherwise following an experimental procedure very similar to that employed by Rowan, observed that increased periods of activity resulted in no increase in spermatogenic activity. As Rowan (1938) has already pointed out, however, this author's data do not indicate entirely negative results since the testes of two Starlings were described as being "enlarged considerably." In general, however, the gonads of Starlings subjected to increased exercise failed to show the recrudescence which uniformly followed increased illumination, leading Bissonnette to consider light, per se, as the essential external factor in the modification of the sex cycle.

In spite of widespread interest in problems relating to the factors controlling rhythms of sexual activity, it still remains an open question as to whether light or physiological activity is responsible for the seasonal activation of the bird pituitary. It was in an effort to provide further experimental data in support of one view or the other that an improved type of apparatus for enforcing activity was devised and the following experiments undertaken.

Material and Methods

An apparatus for insuring a constant state of wakefulness in complete darkness was constructed from a metal drum similar to the common oil drum 34.5 inches in length and 23 inches in diameter (Fig. 1).

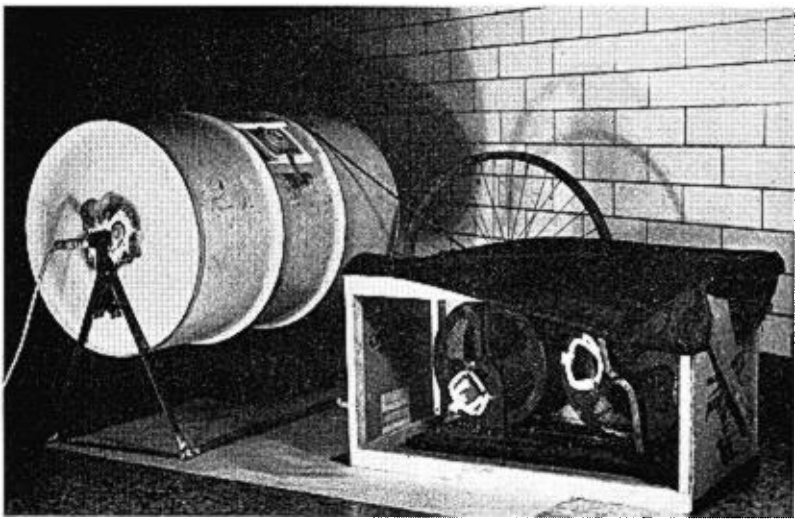

Fig. 1. Photograph of the apparatus used to enforce wakefulness in complete darkness.

The activation chamber was equipped with axles and mounted on a metal frame. Access to the interior was made possible by a flanged door fitted to the wall of the drum. For ventilation a hole one-half inch in diameter was drilled at the base of each axle and an air line conducted through one of them. The apparatus was driven by an electric motor, the speed of rotation being regulated by a system of intermediate pulleys. In Experiment 3 two small wire-mesh exercise cages (6 inches wide by 12 inches in diameter) were added to the above described apparatus. These small cages were enclosed in a dark compartment, tightly sealed on five sides and covered with a double thickness of black sateen in front. In Experiment 3 light was added to the large activity drum. The cord for this light (60 watt bulb) was passed through the second vent at the base of the axle.

The House Sparrows were caught in barns located in the vicinity of Iowa City and kept in large stock cages in the laboratory until a few days before the start of each experiment. At this time the birds were laparotomized and the size of the left testis was determined by caliper measurement or the ovary inspected and compared with the stages described for the House Sparrow by Riley and Witschi (1938). With the exception of the periods when the activity-treated birds were in the revolving drum the birds were divided into groups of four or five and kept in wire cages, 10 inches wide, 13 inches high, and 20 inches long. Except where it is stated otherwise, the Sparrows were maintained on a diet of cracked corn. The food was removed from all birds at the end of the basic light day.

Bouin's fluid was used as a fixative in all instances and Heidenhain's iron haematoxylin as a stain for the testicular tissue.

Conditions and Results of Experiment 1

Thirty male sparrows were started in the first experiment on November 16, 1938. The birds were kept in a windowless room with a 100 watt bulb providing the source of light for a basic 9 hours. At the end of this time (5:00 P.M.) 15 birds were transferred to the drum and kept awake for an additional 7½ minutes. The drum rotated at the rate of one revolution every one and one-half minutes. The remaining 15 birds were left exposed to the light. Both motor and light were connected with the same automatic switch. At 8:00 A.M. the following morning, the light was again turned on and the birds in the drum were returned to the light-exposed cages. Each day until the termination of the experiment (December 31, 1938) this procedure was followed, the period of wakefulness always being increased an additional 7½ minutes.

At the termination of the experiment (46 days from the start) only 6 birds remained in the light-treated group while 13 remained in the activity group. Another bird in the latter group was healthy up to the

forty-third day of the experiment but was found dead, apparently as the result of an injury. The fifteenth bird in this group had been sacrificed earlier since there were indications of injury. The high mortality in the light treated group was due primarily to an eye infection which is known to affect House Sparrows in nature as well as in the laboratory.

From the third week on there was definite evidence of progressive testicular changes in the light-treated birds as evidenced by a progressive darkening of the bills. This change of bill pigmentation was in marked contrast to the bills of the activity-treated Sparrows which continued to retain the yellow color characteristic of the sexually quiescent male Sparrow (Keck, 1934). The findings at autopsy, summarized in Table 1, showed testicular enlargement in all light-treated birds, whereas the testes of activity-treated birds had remained the same size as they were at the beginning or had even regressed.

It is to be noted that the testis size attained by light-treated birds falls considerably short of that attained by the testis during the normal breeding season. It is also less than the average testis size (7.9 mm.) in four Sparrows that had been subjected to light treatment for 25 days just previous to the start of this experiment. There was one essential difference in the method of treatment of these birds as compared with that used in earlier experiments. Previously the birds were not on a basic light day but were exposed to daylight and the gradually increasing light intensities of morning. Whether these conditions offer more favorable conditions for such experiments has not yet been determined. It was with the intention of bettering the general environmental conditions, however, that certain changes were made in the second experiment.

Conditions and Results of Experiment 2

In the second experiment (starting January 8, 1939) the equipment was moved to a better ventilated room, well lighted by windows on one side. For the basic 9-hour day, the birds were in cages a few feet from, and facing these windows. At the end of the 9-hour day the birds to be kept awake by activity were transferred to the drum as in the previous experiment while the birds to be light-treated were moved to cages within a large metal tank, covered by black sateen. Thus both groups of birds were subjected to the same amount of handling and very similar environmental conditions at all times. Again, the source of the additional light was a 100 watt bulb, and the daily increment was 7½ minutes. The rotation of the drum, however, was only half as fast as in Experiment 1, making one revolution in three minutes.

In this experiment, the activity group of Sparrows consisted of 10 males and 10 females. Half of the birds, with the sexes equally divided,

TABLE 1

EFFECT OF INCREASED LIGHT AND ACTIVITY PERIODS ON MALE SPARROWS

Bird No.	Treatment	Period of experiment	Dimensions of left testis (mm.)		Volume[1] of left testis (mm.)		Final bill color
			Beginning	End	Beginning	End	
29	Light	Nov. 16–Dec. 31	2.0 x 1.5	3.3 x 2.0	2.4	7.1	Brown
36	Light	Nov. 16–Dec. 31	2.5 x 2.0	4.6 x 3.3	5.5	24.0	Blue
50	Light	Nov. 16–Dec. 31	1.5 x 1.0	4.0 x 2.8	0.8	16.5	Brown
810	Light	Nov. 16–Dec. 31	1.5 x 1.0	3.0 x 2.5	0.8	10.6	Brown
811	Light	Nov. 16–Dec. 31	2.0 x 1.5	4.2 x 3.2	2.4	22.6	D. Blue
844	Light	Nov. 16–Dec. 31	1.3 x 1.0	6.5 x 5.0	0.7	86.6	D. Blue
808	Activity	Nov. 16–Dec. 31	2.0 x 1.5	1.6 x 1.0	2.4	0.8	Yellow
812	Activity	Nov. 16–Dec. 31	1.5 x 1.0	1.2 x 1.0	0.8	0.6	Yellow
813	Activity	Nov. 16–Dec. 31	2.5 x 2.0	1.8 x 1.0	5.5	0.9	Yellow
814	Activity	Nov. 16–Dec. 31	1.5 x 1.0	1.5 x 1.0	0.8	0.8	Yellow
815	Activity	Nov. 16–Dec. 31	2.0 x 1.5	1.5 x 1.0	2.4	0.8	Yellow
816	Activity	Nov. 16–Dec. 31	1.5 x 1.0	1.6 x 1.0	0.8	0.8	Yellow
818	Activity	Nov. 16–Dec. 31	2.0 x 1.5	1.5 x 1.0	2.4	0.8	Yellow
820	Activity	Nov. 16–Dec. 31	1.2 x 1.0	1.4 x 1.0	0.6	0.7	Yellow
821	Activity	Nov. 16–Dec. 31	1.2 x 1.0	1.5 x 1.0	0.6	0.8	Yellow
822	Activity	Nov. 16–Dec. 28	1.2 x 1.0	1.2 x 1.0	0.6	0.6	Yellow
823	Activity	Nov. 16–Dec. 31	1.2 x 1.0	1.4 x 0.9	0.6	0.7	Yellow
824	Activity	Nov. 16–Dec. 31	1.5 x 1.2	1.3 x 1.0	1.1	0.7	Yellow
832	Activity	Nov. 16–Dec. 31	1.5 x 1.0	1.5 x 1.0	0.8	0.8	Yellow
842	Activity	Nov. 16–Dec. 31	1.8 x 1.0	2.0 x 1.0	0.9	1.0	Yellow
846	Indoor Control	Dec. 31	—	1.7 x 1.0	—	0.9	Yellow
847	Indoor Control	Dec. 31	—	1.4 x 0.9	—	0.7	Yellow
848	Indoor Control	Dec. 31	—	1.8 x 1.0	—	0.9	Yellow

[1] The formula $(4/3\ \pi\ Rr^2)$ for computing the volume of an ellipse was used with R representing the radius of the greatest diameter and r the least diameter.

were placed on the regular corn diet, while the other half were placed on a diet of egg, bread and milk. The light-treated group consisted of 10 males and 6 females. As with the previous group, half the males and females were fed corn and the other half the mixed diet.

Very soon after the start of the experiment it was noted that coccidiosis was prevalent in the stock of Sparrows and within 20 days, twelve of the activity-treated and five of the light-treated birds had died or were sacrificed because of such infection.

At the termination of the experiment on the thirty-fifth day, there were only 5 birds left in the activity-group and 8 in the light-group. At autopsy, the findings were in complete agreement with those of the previous series (Table 2). The bills of light-treated males had darkened in every case, whereas the bills of the two surviving males subjected to prolonged activity remained light. The testes of birds of the light group had increased in size and histologically exhibited a picture of progressive spermatogenesis. The gonads of birds in the activity-group remained unchanged.

With the females, neither increased light nor activity resulted in stimulation of the ovary. We have pointed out earlier (Riley and Witschi, 1938) that the female House Sparrow responds much less readily to light stimulation than does the male, so the present negative results are not surprising. Although the testis differences in the birds on corn and mixed diets are not great, more birds on the latter diet survived, indicating that its use was somewhat advantageous.

Conditions and Results of Experiment 3

In the third experiment, started March 4, 1939, the experimental birds were divided into three groups. One group of 8, 4 males and 4 females, was subjected to the conditions of the revolving drum plus light from a 60 watt bulb; a second group, 2 males and 2 females, was subjected to activity in darkness in the small activity cages, while a third group, 2 males and 2 females, received additional illumination (60 watt bulb) in the aforementioned tank.

Since the male Sparrows under natural conditions are approaching the breeding condition at the time when this experiment was begun, a careful selection was necessary. Only those males were used which had a light bill or a wide yellow base (indicating gonadal regression) and whose testes were small.

The results (Table 3) corroborate those of the previous experiments. The testes of all birds treated with light, regardless of whether they were subjected to the conditions of the drum or not, were all markedly enlarged (Fig. 2). Histologically, advanced stages of spermatogenesis were found in the testes of birds of both groups. The testes of two males (Fig. 2) which had been subjected to increased increments

TABLE 2

EFFECT OF INCREASED LIGHT AND ACTIVITY PERIODS ON SPARROWS ON DIFFERENT DIETS

Bird No.	Sex	Conditions of Experiment		Period of experiment	Dimensions of left testis (mm.) or ovarian stage		Vol. of left testis (mm.)		Final bill color[2]
		Treatment	Diet		Begin.	End	Begin.	End	
896	F	Act.	Corn	Jan. 8–Feb. 12	0[1]	0			Y
882	M	Act.	Mixed	Jan. 8–Feb. 12	1.6 x 1.0	1.8 x 1.2	0.8	1.4	Y
892	M	Act.	Mixed	Jan. 8–Feb. 12	1.5 x 1.0	1.5 x 1.0	0.8	0.8	Y
831	F	Act.	Mixed	Jan. 8–Feb. 12	0	0			Y
898	F	Act.	Mixed	Jan. 8–Feb. 12	0	0			Y
835	M	Light	Corn	Jan. 8–Feb. 12	1.5 x 1.0	2.8 x 1.5	0.8	3.3	Br.
853	M	Light	Corn	Jan. 8–Feb. 12	1.5 x 1.0	2.7 x 1.8	0.8	4.8	Br.
834	M	Light	Mixed	Jan. 8–Feb. 12	1.7 x 1.2	3.0 x 1.5	1.3	3.5	Bl.
874	M	Light	Mixed	Jan. 8–Feb. 12	1.7 x 1.0	3.0 x 1.5	0.9	3.5	Bl.
875	M	Light	Mixed	Jan. 8–Feb. 12	1.8 x 1.3	5.0 x 3.8	1.6	9.0	D. Bl.
880	M	Light	Mixed	Jan. 8–Feb. 12	1.3 x 0.9	3.0 x 2.0	0.5	6.3	Bl.
856	F	Light	Mixed	Jan. 8–Feb. 12	0	0			Y
894	F	Light	Mixed	Jan. 8–Feb. 12	0	0			Y
847	M	Control	Mixed	Jan. 8–Feb. 12	1.5 x 1.0	1.5 x 1.0	0.8	0.8	Y
854	M	Control	Mixed	Jan. 8–Feb. 12	1.8 x 1.0	1.8 x 1.2	0.9	1.4	Y
825	F	Control	Mixed	Jan. 8–Feb. 12	0	0			Y
827	F	Control	Mixed	Jan. 8–Feb. 12	0	0			Y

[1] Ovarian Stage 0 refers to the typical quiescent condition described by Riley and Witschi, 1938.
[2] In describing the bill color; Y = yellow, Br. = dark brown, Bl. = blue, D. Bl. = dark blue.

of activity in darkness remained small and showed no progressive spermatogenic changes. In no group did the females show an appreciable positive response, the ovaries and oviducts remaining at a stage comparable to that observed at laparotomy.

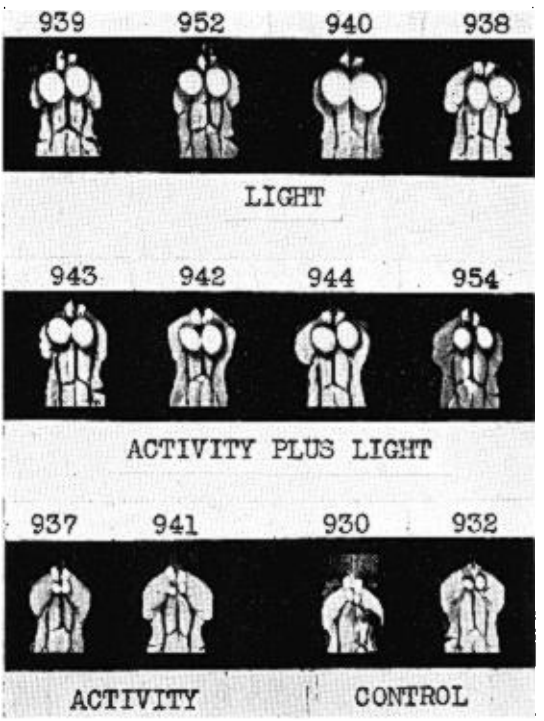

Fig. 2. The testes of experimental and control birds of Experiment 3 are shown. The gonads of all birds receiving light, whether alone or in combination with activity, show enlargement; those of activity-treated birds show the lack of any stimulation. Actual size.

Discussion

When the factors, light and activity, are completely separated there seems little doubt as to the importance of the former in stimulating testicular development in the House Sparrow. It is probable that the failure to separate these two factors may explain, at least in part, the results of previous workers. The six Juncos used in Rowan's original exercise experiment showed definite gonadal recrudescence, the testis of the last bird killed (after 42 days of treatment) measuring 3.4 mm. in length. In this experiment, light, though reduced to a minimum

TABLE 3

COMPARISON OF THE EFFECTS OF LIGHT, LIGHT PLUS ACTIVITY AND ACTIVITY ALONE ON SPARROWS

Bird No.	Sex	Treatment	Period of experiment	Dimensions of left testis (mm.) or ovarian stage		Vol. of left testis (mm.)		Final bill color
				Begin.	End	Begin.	End	
938	M	Light	Mar. 4–Apr. 8	3.0 x 2.0	4.2 x 3.3	6.3	23.8	Bl.
939	M	Light	Mar. 4–Apr. 8	2.2 x 1.8	4.5 x 3.3	3.7	25.5	Bl.
940	M	Light	Mar. 4–Apr. 8	1.7 x 1.2	5.5 x 4.5	1.3	58.5	D. Bl.
952	M	Light	Mar. 11–Apr. 8	2.2 x 1.3	4.2 x 3.2	1.9	22.6	D. Bl.
948	F	Light	Mar. 4–Apr. 8	I[1]	I			Y
949	F	Light	Mar. 4–Apr. 8	I	I			Y
927	F	Light	Mar. 11–Apr. 8	I	I			Y
934	F	Light	Mar. 11–Apr. 8	I	I			Y
942	M	Act. Light	Mar. 4–Apr. 8	2.2 x 1.4	4.0 x 3.0	2.3	18.9	D. Bl.
943	M	Act. Light	Mar. 4–Apr. 8	2.0 x 1.3	4.5 x 3.5	1.8	28.9	D. Bl.
944	M	Act. Light	Mar. 4–Apr. 8	2.7 x 2.0	4.0 x 3.0	5.7	18.9	Y. B.[2]
954	M	Act. Light	Mar. 11–Apr. 8	2.6 x 1.8	4.0 x 2.8	4.4	16.5	D. Bl.
946	F	Act. Light	Mar. 4–Apr. 8	I	I			Y
947	F	Act. Light	Mar. 4–Apr. 8	I	I			Y
950	F	Act. Light	Mar. 4–Apr. 8	0	0-I			Y
937	M	Activity	Mar. 4–Apr. 8	1.6 x 1.2	1.8 x 1.0	1.2	0.8	Y
941	M	Activity	Mar. 4–Apr. 3	1.6 x 1.0	1.5 x 1.0	0.8	0.8	Y
931	F	Activity	Mar. 4–Apr. 8	I	I			Y
953	F	Activity	Mar. 11–Apr. 8	0	0			Y
930	M	Indoor control	Mar. 4–Apr. 8	2.0 x 1.5	1.7 x 1.0	2.4	0.9	Y
932	M	Indoor control	Mar. 4–Apr. 8	2.8 x 1.8	1.8 x 1.3	4.7	1.6	Y
974	F	Indoor control	Preserved Apr. 8	—	0			Y
975	F	Indoor control	Preserved Apr. 8	—	0			Y

[1] Ovarian Stage I is characterized by an ovary somewhat enlarged over the quiescent condition with small follicles conspicuous on its surface.
[2] Y.B.=yellow base.

and described by the author as a "feeble glow," was necessary to prevent the birds from being killed by a moving bar and accompanying gearing. The control birds exposed to the same intensity of light but not subjected to enforced exercise showed no testicular development. The important difference between these two groups of birds appears to be the fact that the birds in the activity cage remained awake while the controls were "permitted to sleep." In other words, it is possible that the birds that were forced to remain awake were also able to perceive the feeble light present, while the sleeping birds, with closed eyelids and heads tucked under their back feathers, were subject to none of this additional light.

Again in Bissonnette's experiments we find that the "work cages remained in deep shade." Of a total of 12 male Starlings subjected to "increased muscular work," Bissonnette records that the gonads of two (treated from January 15 to April 15) were medium in size and further describes them as being "enlarged considerably." It appears surprising that after 90 days of "work" treatment the testes of these birds should be larger than those of a control bird. However, one would hesitate to give the same interpretation to these cases as was given to Rowan's results. Here a complicating factor is introduced since for the first 63 days of the experimental period the birds were subject to increasing day lengths (normal astronomical increase in day length), while for the last 27 days the birds were on a reduced and constant light schedule of 10 hours daily. Bissonnette suggests that the increase in testis size might have all taken place before the change in the light schedule was made. The absence of any appreciable stimulation in 9 other Starlings subjected to prolonged activity treatment, in spite of the fact that the experiment was not conducted in complete darkness, indicates that the Starling may require higher intensities of light than the Junco or, as already suggested by Rowan (1938a), negative reactions may be the result of unfavorable excitation of the birds.

It is not the purpose of this discussion to consider at length the subject of light intensity in relation to the sex cycle but certain observations are pertinent to the above considerations. Rowan (1929) suspected that his failure to get uniform results in his earliest experiments with Juncos was due to too low intensity of light. This was corrected in later experiments with more uniformity in results and led this author to express the view that an optimum light intensity was essential to keep the birds physiologically active and uniformly responsive (Rowan, 1938). On the other hand, Miyazaki (1934) described the Japanese practice of "yogai" whereby bird fanciers place a burning candle before their bird cages at the end of the day so that they might have singing birds during the winter holiday season. Certainly this is a response to a light of very low intensity. However, it does not mean that Rowan's conclusion was unfounded since the birds

in the "yogai" were household pets, and thus subject to more disturbance than isolated laboratory birds. It appears that if there is some outside disturbance or a mechanical means of keeping the birds awake, light of a relatively low intensity is sufficient to stimulate the pituitary; otherwise, the light must be sufficiently strong to act as a disturbing factor itself.

It is difficult to state what factor is responsible for the sexual precocity of the London Starlings as compared with country birds, since here again light and disturbance are not entirely separated. An interesting alternative to Rowan's explanation has recently been advanced by Bullough and Carrick (1939). On the basis of their observation these authors conclude that the majority of the country Starlings are of the migratory, continental type, whereas the London starlings are of non-migratory, British type. It is shown "that a difference exists between the time of onset of sexual activity in these two types of birds," the migratory group leaving England before the testes begin to enlarge but at a time when the permanent resident group has already become activated.

The significance of the results of the present study lies in the complete separation of the two factors, light and physiological activity. In our experience there is no exception to the rule that lengthened periods of wakefulness in darkness do not provide a stimulus for testicular development. On the other hand, when light is supplied to these "activity" birds, a similar testicular recrudescence takes place as in birds receiving the light treatment alone.

The question arises as to whether the strange conditions of the mechanical activator might not result in such a state of excitation that the bird would be in a physiological condition unfavorable to spermatogenic activity. In Experiment 3 with the Sparrows in the revolving activator lighted, it could be observed that some of the birds were more excited than is customary in the light experiments. This excitability and enforced activity, however, did not result in extraordinarily high body temperatures. The temperature of Sparrows in the three groups (light, light with activity, activity in darkness) ranged from 106° F. to 108° F. after three hours of treatment. During the day it is not unusual to record a temperature as high as 111° F. In birds asleep during the middle of the night it is about 104° F. (Riley, 1937). It is not probable that the activity birds were subject to fatigue since in spite of enforced periods of wakefulness considerable fat deposits were observed at autopsy.

The experiments of Benoit (1937) in which the duck pituitary was directly illuminated emphasize the importance of light as a gonad-stimulating factor. When light was projected through a glass rod to that part of the orbit that is closest to the pituitary, a strong gonad stimulation resulted after 20 days of treatment. On the other hand,

the response was negligible in ducks with an opaque rubber shield lining the orbit and subjected to a stream of light directed toward the region of the sectioned optic nerve and pituitary. All these birds were subjected to similar disturbing conditions, such as removal of the eyeball, manipulation of foreign objects within the orbit, and enforced immobilization, yet, only when light was permitted to penetrate to the region of the pituitary was gonadal stimulation observed.

Rowan (1938a and 1938b) suggested that the negative results which Bissonnette obtained with the Starling as compared with his own successful stimulation of Juncos may have been due to a difference in temperament between these two species. If the negative results observed in our present experiments are due to unfavorable excitation, then we must conclude that, in spite of such a condition, light is capable of stimulating the hormonal mechanism responsible for the progressive development of the testis resulting in spermatogenic activity and the release of the male sex hormone.

Conclusions

Rowan (1925, 1926) first brought out the fact that "light stimulation" brings about a precocious development of seasonal sex activity in some (possibly all) birds of the northern Temperate Zone. In an effort to elucidate further the mechanism of this effect the same author considered the possibility of such intermediate factors as increase in vitamin D supply (Rowan, 1931) or, later, of prolonged physiological activity. The first suggestion has been revived in somewhat modified form by Perry (1938). While Rowan had assumed that increased irradiation produced the vitamin in the oil of the plumage, Perry contended that it was in the food, also exposed to extra lighting, that this increase was effective. The latter alternative seems obviated through our experiments. All birds, whether finally showing enlargement of the testes or not, were fed only during the normal day, which was spent in stock cages under identical conditions. No lighting was given to the food of the "light" birds. Rowan's activity theory was opposed by Benoit (loc. cit.) and Bissonnette (loc. cit.). The present study also leads to the conclusion that the light stimulation of the hypophysis is independent of general physiological activity of the bird. The temperature readings suggests that it is even independent of the metabolic rate though it is not certain yet that light may successfully stimulate the hypophysis while the bird is sound asleep and its temperature at the usual accompanying low of 104° F.

Summary

1. A study was undertaken to determine the efficacy of two factors, increasing light and increasing activity periods, in producing an activation of the House Sparrow's pituitary.

2. The method of lengthening the daily light period was similar to that followed by most authors engaged in this work, i.e., the gradual lengthening of a basic light day with increments of electric light. For gradually increasing the daily period of activity, a revolving drum was used which forced the birds to remain awake in complete darkness.

3. The experiments were conducted during a period extending from November 16, 1938 to April 8, 1939. The duration of treatment ranged from 35 to 45 days.

4. Without exception the testes of Sparrows subjected to light treatment showed significant enlargement and progressive spermatogenic changes. A darkening of bill pigmentation accompanied the gonadal development. On the other hand, the bills of activity-treated males retained the light color characteristic of the sexually inactive male, and the testes remained in a quiescent state. The absence of any progressive spermatogenic changes was confirmed histologically.

5. A combination of forced activity and extra lighting stimulates the testes to a condition approximating that of the light treated birds.

6. In females neither increased light nor activity rations were effective in stimulating ovarian development.

7. The incomplete separation of the two factors, light and activity, is suggested as the possible explanation for the positive results of the enforced activity experiments of previous authors.

8. When the two disputed factors, light and activity, are completely separated there seems little doubt as to the importance of the former in regulating sexual activity in the Sparrow.

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