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fishing centers there is no doubt that the situation is of some direct commercial importance. The data that we have obtained also indicates that the percentage of infection increases throughout the summer and reaches its height in the early fall. An attempt has been made to show that the yellow perch is the principle reservoir of the infection. Perhaps the infection could be most easily checked by reducing the numbers of the great blue heron, but the consequences of such an undertaking can only be conjectured. Before any definite moves be made in attempting to reduce the high percentage of infection of fish with *Clinostomum marginatum* in northern Minnesota, much intensive work along the lines of this survey is needed.

FOOD AND DEVELOPMENT OF THE WORKER AND THE QUEEN HONEYBEE

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THE LIGHT RESPONSE OF THE MARINE TUBIFICID WORM, *CLITELLIO ARENARIUS*

(O. F. Müller) Published in Jour. Exp. Zool. 82:397–417. 1939.

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LIGHT AND PITUITARY ACTIVITY IN THE BIRD

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The seasonal character of reproductive activity in many of our wild birds is substantial evidence for the belief that some environmental factor is concerned in effecting the sexual cycle. Ever since the initial observations of Rowan [1, 2] on the junco and of Bisson-

[1] Rowan, W. Relation of light to bird migration and developmental changes. Nature. 115:494–495. 1925.

[2] ———. The riddle of migration. The Williams and Wilkins Co., Baltimore. 1931.

nette[3, 4] on the starling, it has been repeatedly demonstrated by a number of investigators that it is possible to alter the periodicity of the cycle by means of increased increments of illumination.

On the basis of the well known functional correlation between the gonads and the pituitary, the claim appears to be fully justified that whatever the effects of light on reproductive phenomena may be the outstanding fact remains that the pituitary gland is the intermediary. The most widely favored concept today is that the light stimulus falling on the eyes (or some other receptors) acts upon the pituitary through the intermediation of the nervous system.[5] The pituitary through mediation of its gonadotropic hormonal substance activates the development of the gonads.

The purpose of the present paper is to give an account of the effects of light stimulation on testicular development and the importance of the eyes as receptors for the stimulus afforded by light in the acceleration of gonadal development. The results are based on a study of juvenile male English sparrows. Beginning on November 5th, fifteen males were given 7 hours of additional light daily (4:00 P. M. to 11:00 P. M.); nine specimens were capped during the daily periods of light exposure; nine males were exposed to ordinary daylight. The first and third groups of birds plus two specimens from the wild served as controls. The capped birds were the test animals.

Testicular length, diameter and volume for the three groups are given in Table I. The volumes for the capped bird gonads, excluding 1, 2, and 8, extended from 0.8 cu. mm. to 2.2 cu. mm.; testes of the "light birds," excluding 5, 9, and 12, ranged in volume from 24.8 cu. mm. to 272.1 cu. mm., and the gonads of the non-stimulated control group had volumes of 0.7 cu. mm. to 3.0 cu. mm. Reference is made in the table to the color of the beak. According to Keck,[6] darkening of the beak is indicative of male hormone production.

Histologically the gonads of the six capped birds which failed to manifest testicular hypertrophy were identical with the quiescent testis found normally at the same time of the year. The important features were: small seminiferous tubules filled with a matrix, mitotically inactive spermatogonia arranged peripherally within the tubules in a single layer and abundant intertubular tissue. Certain identification of glandular interstitial cells (Leydig cells) was quite impossible. Of the capped group maximum spermatogenic develop-

[3] Bissonnette, T. H. Studies on the sexual cycle in birds. I. Sexual maturity, its modification and possible control in the European starling (Sturnus vulgaris). Am. J. Anat. 45:289–305. 1930.

[4] ———. Ibid. IV. Experimental modification of the sexual cycle in males of the European starling (Sturnus vulgaris) by changes in the daily period of illumination and of muscular work. J. Exp. Zool. 58:281–319. 1931.

[5] For an extended account of pituitary activity as influenced by light, reference is made to Bissonnette's chapter on "Light and pituitary activity" in a recent publication on "The pituitary gland." Williams and Wilkins Co., Baltimore. 1938.

[6] Keck, W. M. The control of the secondary sex characters in the English sparrow, Passer domesticus (Linnaeus). J. Exp. Zool. 67:315–347. 1934.

TABLE I

Testis length, diameter, volume and degree of spermatogenic activity of four groups of juvenile sparrows. 'O' is indicative of spermatogonia; '+' spermatocytes; '++' spermatids and occasionally sperms; '+++' complete spermatogenic activity

BIRD NO.	KILLED, DEC.	DAYS OF ADDED LIGHT	BILL COLOR	BODY WEIGHT	LEFT TESTIS			GERM CELLS
					Length	Diameter	Volume	
				Cap Birds				
				gm.	*mm.*	*mm.*	*mm.*^{3}	
1	16	41	Black	28	5.0	4.0	42.0	+
2	16	41	Yellow	25	3.3	3.0	15.6	+
3	16	41	Yellow	24	1.4	1.2	1.1	0
4	17	42	Yellow	28	2.0	1.4	2.1	0
5	19	44	Yellow	26	2.1	1.4	2.2	0
6	19	44	Yellow	29.5	1.3	1.1	0.8	0
7	19	44	Yellow	27.5	1.4	1.1	0.9	0
8	19	44	Yellow	29	2.8	2.1	6.5	+
9	19	44	Yellow	29	1.9	1.0	1.0	0
Average		42.8		27.5	2.4	1.8	8.0	
Temperature		57°–74° F.						
				Light Birds				
1	13	38	Black	26	7.0	7.0	180.1	+++
2	16	41	Black	31	6.1	4.0	51.2	++
3	16	41	Black	30.5	5.2	4.0	43.6	+++
4	17	42	Black	30.5	10.0	7.2	272.1	+++
5	17	42	Yellow	30.5	2.0	1.5	2.4	0
6	19	44	Black	29	7.4	5.2	131.2	+++
7	19	44	Black	31	7.0	4.5	74.0	+++
8	19	44	Black	28	7.3	6.2	146.8	+++
9	19	44	Yellow	24.5	1.3	1.0	0.7	0
10	19	44	Black	27	7.6	6.8	184.0	+++
11	19	44	Black	28	8.0	6.2	160.8	+++
12	21	46	Yellow	23	3.2	2.4	9.6	+
13	21	46	Gray	28	5.0	3.8	37.6	++
14	21	46	Yellow	22	4.6	3.2	24.8	+
15	22	47	Black	29	8.3	6.0	156.4	+++
Average		43.5		28.0	6.0	4.6	98.4	
Temperature		57°–74° F.						
				Caged Controls				
1	16	0	Yellow	34	1.5	1.2	1.1	0
2	16	0	Yellow	25.5	1.2	1.1	0.8	0
3	16	0	Yellow	29	1.5	1.2	1.1	0
4	17	0	Yellow	27	1.3	1.0	0.7	0
5	21	0	Yellow	25.5	1.4	1.0	0.7	0
6	21	0	Yellow	29.5	1.5	1.2	1.1	0
7	21	0	Yellow	30	1.7	1.1	1.1	0
8	22	0	Yellow	30	2.0	1.7	3.0	0
9	22	0	Yellow	27.5	1.7	1.3	1.5	0
Average		0		28.5	1.5	1.2	1.2	
Temperature		56°–70° F.						
				Outside Controls				
1	21	0	Yellow	25	2.0	1.3	1.8	0
2	22	0	Yellow	28	1.5	1.2	1.1	0
Average		0		26.5	1.8	1.3	1.5	

ment was observed in bird number 1. The seminiferous tubules were enlarged, the tubules contained lumina and spermatocyte division was evident.

The most differentiated spermatogenic elements encountered in test and control material are given in the table. There were only spermatogonia in six capped birds, spermatocytes in three (1, 2, 8); spermatogonia in two light-treated birds (5 and 9); spermatids and spermatozoa (immature) in 2 and 13; complete spermatogenic activity in nine light-treated specimens; controls showed only spermatogonia.

Summary of Results

In six of the nine capped birds it was observed that covering the eyes during the period of exposure to added daily light inhibited gonadal development. The limited response in the other three test birds is attributed to incomplete exclusion of light as an ocular stimulant. Although these results indicate that ocular stimulation by light is necessary if the stimulus is to be effective, it must be admitted that the factor of activity is not adequately controlled in such experiments.

Ivanova [7] found that plucking the feathers of light-treated sparrows accelerated gonadal response. She believes that light may be effective through the skin as well as the eyes. According to Benoit's [8, 9] experiments, light exerts its effect by direct activation of the hypophysis. Pituitary bodies of light-stimulated ducts, upon implantation into mice, were more effective than hypophyseal implants of non-irradiated birds in producing ovarian and uterine growth. Localized illumination of the pituitary area through a thin glass tube placed in the orbit stimulated hypophyseal activity which resulted in testicular growth. When the eyes were enucleated the cut ends of the optic nerves were apparently capable of receiving the light stimulus since gonadal hypertrophy was evident in light-exposed ducks whose eyes had been removed. Whetham [10] claims that there are two possible avenues of reception for light stimuli, the skin and the eyes. According to her, the neural mechanism associated with color vision is probably concerned since different wave lengths of light have been shown to possess different degrees of stimulating action.

Judging from previous experimental results it is indicated that the female pituitary is either less responsive to light treatment than

[7] Ivanova, S. Über den Mechanismus der Wirkung von Licht auf die Hoden der Vögel (Passer domesticus). Arch. Exp. Pathol. Pharmakol. 179:349–359. 1935.

[8] Benoit, J. Facteurs externes et internes de l'activité sexuelle. I. Stimulation par la lummière de l'activité sexuelle chez la Canard et la Cane domestiques. Bull. Biol. France et Belgique. 70:487–533. 1936.

[9] ———. Stimulation of the hypophysis and genital glands in the duck by electric light. Effect of thyroidectomy on the testis and liver. Anat. Rec. 67:81–82. 1936.

[10] Whetham, E. O. Factors modifying egg production with special reference to seasonal changes. J. Agric. Sci. 23:383–411. 1933.

that of the male or the ovary is less sensitive than the testis to pituitary stimulation. The problem as to whether the differential response in the sexes is resident in the gonads or the pituitary gland has been very recently investigated by Kirschbaum, Pfeiffer, Van Heuverswyn and Gardner.[11] According to their findings, " . . . the testis can be stimulated when grafted into females exposed to added daily light. The testis is then under the influence of the secretions of the female hypophysis, and is activated when the animals' own ovaries show no stimulation." Quoting further, "If the ovary inhibits the hypophysis such inhibition is not effective in preventing testicular development. It would seem, then, that the difference in response of testis and ovary is primary in the gonads themselves."

Witschi,[12] Riley and Witschi[13] claim that activity of the sparrow pituitary is rhythmical — wholly independent of progressive or regressive changes in the gonads. Seasonal activity of the avian pituitary has been demonstrated by Benoit.[14] It was found that the pituitaries of ducks whose gonads were developing in the normal manner during the spring time or in response to light stimulation during the season of sexual quiescence when grafted into immature mice showed a marked gonadotropic effect. Kirschbaum and Ringoen[15] found that photostimulation of the gonads in the female sparrow was more easily effected the closer to the breeding season that it was attempted. It might be that a pituitary cycle independent of seasonal light change exists, although it is definitely indicated that incidence of daily light can markedly modify pituitary activity.

It has recently been claimed by Rowan,[16, 17] however, 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."

Summary

Reference is made to the more important literature on light and pituitary activity and the results and conclusions of the author's

[11] Kirschbaum, A., C. A. Pfeiffer, J. D. Van Heuverswyn and W. U. Gardner. Studies on gonad-hypophyseal relationship and cyclic osseous changes in the English sparrow, Passer domesticus L. Anat. Rec., 75:249–263. 1939.

[12] Witschi, E. Seasonal sex-characters in birds and their hormonal control. Wilson Bull. 47:177–188. 1935.

[13] Riley, G. M. and E. Witschi. Comparative effects of light stimulation and administration of gonadotropic hormone on female sparrows. Anat. Rec., 70:50. 1937.

[14] Benoit, J. Maturité sexuelle et ponte obtenues chez la Cane domestique par l'éclairement artificiel (avec démonstration). C. R. Soc. Biol. 70:905–907. 1935.

[15] Kirschbaum, A. and A. R. Ringoen. Seasonal sexual activity and its experimental modification in the male sparrow, Passer domesticus Linnaeus. Anat. Rec., 64:453–473. 1936.

[16] Rowan, W. London starlings and seasonal reproduction in birds. Proc. Zool. Soc. London, 108:51–77. 1938.

[17] ———————. Light and seasonal reproduction in animals. Biol. Reviews, 13:374–402. 1938.

own researches. It is concluded that the ocular region is probably the light receptor which acts on the pituitary in the induction of precocious development of the gonads. Provided that light was excluded from the ocular region during the period of increased daily light exposure, testicular development was inhibited (six of the nine capped birds). Partial response in three of the capped specimens might be explained on the basis of an incomplete blocking out of light from the orbital area.

A CYTOLOGICAL STUDY OF THE CILIATED EPITHELIUM OF THE FRESH-WATER MUSSEL

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REACTIONS OF THE GUINEA PIG TESTES TO EXPERIMENTAL TUBERCULOSIS

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THE EFFECT OF THE ADRENAL CORTEX ON MEMBRANE PHENOMENA

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