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Effect of season and photoperiod on the follicle-stimulating hormone receptors in a subtropical bird

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Abstract. Annual changes in and photoperiodic influence oh the weight of gonads, a parameter of gonadal activity, are much smaller in female birds than in males. Effect of season and photoperiod on the follicle-stimulating hormone receptors in the testis or ovary was studied using a subtropical weaver finch. The number of follicle-stimulating hormone binding sites per unit testicular weight showed a peak in the non-breeding phase; while the total number of binding sites per two testes was maximal in the breeding phase and minimal in the regressive phase. In contrast, seasonal changes in follicle-stimulating hormone binding sites in the ovary were less marked. Exposure to short-day during the breeding phase induced marked decreases in the numbers of binding sites per unit testicular weight and per two testes. These numbers markedly increased after transfer to long-day during the non-breeding phase. However, there was no significant effect of short-day or long-day exposure on follicle-stimulating hormone binding sites in the ovary. These results suggest that photoperiod is an effective environmental factor in the regulation of follicle-stimulating hormone receptors in the testis and the effect is manifested by pronounced changes in the testicular weight during annual breeding cycle.

Keywords. Follicle-stimulating hormone receptor; annual change; subtropical bird.

1. Introduction

Birds are successful animals surviving and reproducing under various environmental conditions on the earth. The gonadal activity of wild birds shows a seasonal variation, and is regulated by the interaction between external environmental and internal hormonal factors. In most species of temperate birds photoperiod is the prime environmental factor. It is known that annual changes in and photoperiodic influence on the weight of gonads, a parameter of gonadal activity, are much smaller in female birds than in males (Farner and Moore 1985). Gonadotropins are essential for gonadal function, and the initial event of gonadotropin action is the binding of the hormone to the specific membrane receptors in target cells (Ishii and Farner 1976; Ishii and Adachi 1977; Tsutsui and Ishii 1978). Therefore, the sex difference in gonadal weight may be due to the difference of changes in plasma gonadotropin concentrations or gonadotropin receptor numbers. The question we ask in the present study is how do testicular and ovarian gonadotropin receptors change in birds subjected to natural and different artificial environmental conditions.

We used the male and female Indian baya weaver, *Ploceus philippinus* inhabiting in the subtropical zone. This species has been shown to use highly photosensitive

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and photoperiodic information for timing its annual reproductive cycle. The annual breeding cycle of Indian weaver birds is divided into breeding (June-July), regressive (August-October), non-breeding (November-February) and progressive (March-May) phases (Malhotra *et al* 1979). This paper summarizes our studies on follicle-stimulating hormone (FSH) receptors in subtropical birds under natural and artificial environmental conditions. Several investigators have detected FSH receptors in the testis (Ishii and Farner 1976; Tsutsui and Ishii 1978; Bona Gallo and Licht 1979; Tsutsui and Ishii 1980) and the ovary (Etches and Cheng 1981; Ritzhaupt and Bahr 1987) in temperate birds. However, the characterization of FSH receptors in subtropical birds has not yet been reported. This will be dealt with in the first part of this paper.

2. Basic properties of FSH binding

The binding experiment was conducted by the method of Tsutsui *et al* (1985, 1988). When radioiodinated rat FSH was incubated with homogenates of various organs of adult Indian weaver birds, only gonads showed a high level of specific FSH binding. Hormone specificity of the receptor can be examined by competitive inhibition of the binding of radioiodinated hormone by various unlabelled hormone preparations. We showed with this technique that specific FSH binding was specifically inhibited by mammalian FSHs but not by mammalian luteinizing hormones or prolactin. Specific binding of radioiodinated rat FSH of adult birds increased rapidly during the first 30 min of incubation at 37°C, reaching a plateau after 100 min. The dissociation constant (K_d) and the number of binding sites (capacity) for rat FSH were determined with Scatchard plot analyses. Scatchard plots showed straight lines in the gonad of adult birds, indicating the presence of one kind of FSH-binding sites. Scatchard plot analyses of the binding also suggested that different natural and artificial environmental conditions have no significant influence on K_ds.

3. Annual changes in FSH-binding sites

In order to determine annual changes in the number of FSH-binding sites, the binding experiment was performed using adult birds in the breeding, regressive, non-breeding and progressive phases. The testicular weight and the number of FSH-binding sites markedly changed during annual breeding cycle. The weight of testes was maximal in the breeding phase and minimal in the non-breeding phase (data not shown). The number of FSH-binding sites per unit testicular weight reached a peak in the non-breeding phase (table 1). The total number of FSH-binding sites per two testes was maximal in the breeding phase and minimal in the regressive phase (table 1). In contrast to the testis, annual changes in the ovarian weight and the number of FSH-binding sites were less marked. Although the weight of ovary was minimal in the non-breeding phase, the changes throughout the year in the ovarian weight were less pronounced than those of the testis (data not shown). The number of FSH-binding sites per unit ovarian weight tended to show a peak in the non-breeding phase, but the peak level was not significantly different from the levels in other phases (table 2). Annual changes in the total number of FSH-binding sites per ovary were also less pronounced than those of the testis (table 2).

Table 1. Annual changes in the number of FSH-binding sites in the testis.

Phase	No. of binding sites (fmol)	
	per mg tissue	per testes
Breeding	2·61 (2·40–2·97)[a]	331
Regressive	0·64 (0·51–2·45)	5·76
Non-breeding	4·03 (3·30–25·5)	7·25
Progressive	0·82 (0·66–1·86)	12·2

[a]95% confidence interval.

Table 2. Annual changes in the number of ESH-binding sites in the ovary.

Phase	No. of binding sites (fmol)	
	per mg tissue	per ovary
Breeding	3·85 (2·74–7·91)[a]	127
Regressive	2·88 (1·83–7·08)	38·3
Non-breeding	8·70 (6·58–19·9)	57·4

[a]95% confidence interval.

4. Photoperiodic influence on FSH-binding sites

In order to examine the effects of artificial photoperiods on the number of FSH-binding sites, adult birds were transferred to short-day (SD) photoperiods (8 h light, 16 h dark) during the breeding phase or to long-day (LD) photoperiods (16 h light, 8 h dark) during the non-breeding phase. Exposure to SD for 6 weeks induced a marked decrease in the testicular weight (data not shown). Similarly, both numbers of FSH-binding sites per unit testicular weight and per two testes markedly decreased 6 weeks after transfer to SD (table 3). On the other hand, SD influence on the ovarian weight was much smaller than that on the testicular weight (data not shown). In contrast to testicular FSH-binding sites, there was no significant effect of SD exposure on the number of FSH-binding sites per unit ovarian weight (table 4). Similarly, the decrease in total number of FSH-binding sites per ovary was less pronounced than that of the testis (table 3 and 4). The sex difference in changes in FSH-binding sites were more evident in birds subjected to LD environment. Both numbers of FSH-binding sites per unit testicular weight and per two testes markedly increased 10 weeks after transfer to LD (table 3). In contrast, there were no significant changes in FSH-binding sites both per unit ovarian weight and per ovary (table 4).

5. Discussion

It is well known that in birds annual changes in gonadal weight, a parameter of gonadal activity, are more pronounced in the male than in the female. The present study indicated that in this subtropical bird the number of FSH receptors in the testis markedly changed during annual breeding cycle, but that the number of

Table 3. Photoperiodic influence on FSH-binding sites in the testis.

Phase/treatment	No. of binding sites (fmol)	
	per mg tissue	per testes
Breeding		
Initial control	2·61 (2·40–2·97)[a]	331
6 weeks SD	1·65 (1·32–2·09)	28·1
Non-breeding		
Initial control	4·03 (3·30–25·5)	7·25
10 weeks LD	14·1 (10·8–29·2)	1215

[a]95% confidence interval.

Table 4. Photoperiodic influence on FSH-binding sites in the ovary.

Phase/treatment	No. of binding sites (fmol)	
	per mg tissue	per ovary
Breeding		
Initial control	3·85 (2·74–7·91)[a]	127
6 weeks SD	2·60 (2·02–6·52)	49·1
Non-breeding		
Initial control	8·70 (6·58–19·9)	57·4
10 weeks LD	3·48 (2·65–7·30)	51.2

[a]95% confidence interval.

ovarian FSH receptors was rather stable. Therefore, the sex difference of annual changes in gonadal weight may be due, at least partly, to such a difference in the responsiveness of FSH receptors to natural environmental factors between the sexes. Photoperiod as an effective environmental factor induced marked changes in the number of FSH receptors only in the testis. Similar effects of artificial photoperiod on testicular FSH receptors have been reported in white-crowned sparrows (Ishii and Farner 1976) and Japanese quails (Tsutsui and Ishii 1978, 1980) inhabiting in the temperate zone. In conclusion, the present study suggests that photoperiod is an effective environmental factor in the regulation of FSH receptors in the testis and the effect is manifested by pronounced changes in the testicular weight during annual breeding cycle.

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References

Bona Gallo A and Licht P 1979 Differences in the properties of FSH and LH binding sites in the avian gonads revealed by homologous radioligands; *Gen. Comp. Endocrinol.* **37** 521-532

Etches R J and Cheng K W 1981 Changes in the plasma concentrations of luteinizing hormone, progesterone, oestradiol, and testosterone and in the binding of follicles during the ovulation cycle of the hen (*Gallus domesticus*); *J. Endocrinol.* **91** 11-22

Farner D S and Moore M C 1985 An assessment of the role of daylength in the control of the annual cycle of reproduction and molt in birds; in *Current trends in comparative endocrinology* (eds) B Lofts and W N Holmes (Hong Kong: Hong Kong University Press) pp 705-706

Ishii S and Adachi T 1977 Binding of avian testicular homogenate with rat follicle stimulating hormone and inhibition of the binding by hypophyseal extracts of lower vertebrates; *Gen. Comp. Endocrinol.* **31** 287-294

Ishii S and Farner D S 1976 Binding of follicle-stimulating hormone by homogenate of testes of photostimulated white-crowned sparrows, *Zonotrichia leucophrys gambelii; Gen. Comp. Endocrinol.* **30** 443-450

Malhotra L, Ravi Kant, Baweja P K and Saxena R N 1979 Light induced changes in the hypothalamo-hypophyseal-gonadal axis of the male Indian weaver bird *Ploceus philippinus; Indian J. Exp. Biol.* **17** 729-731

Ritzhaupt L K and Bahr J M 1987 A decrease in FSH receptors of granulosa cells during follicular maturation in the domestic hen; *J. Endocrinol.* **115** 303-310

Tsutsui K and Ishii S 1978 Effects of follicle-stimulating hormone and testosterone on receptors of follicle-stimulating hormone in the testis of the immature Japanese quail; *Gen. Comp. Endocrinol.* **36** 297-305

Tsutsui K and Ishii S 1980 Hormonal regulation of follicle-stimulating hormone receptors in the testes of Japanese quail; *J. Endocrinol.* **85** 511-518

Tsutsui K, Kawashima S, Masuda A and Oishi T 1988 Effects of photoperiod and temperature on the binding of follicle-stimulating hormone (FSH) to testicular preparations and plasma FSH concentration in the Djungarian hamster, *Phodopus sungorus;* Endocrinology **122** 1094-1102

Tsutsui K, Shimizu A, Kawamoto K and Kawashima S 1985 Developmental changes in the binding of follicle-stimulating hormone (FSH) to testicular preparations of mice and the effects of hypophysectomy and administration of FSH on the binding; *Endocrinology* **117** 2534-2543