卵巣除去,テストステロン及び17β-エストラジオール投与が雌七面鳥の成長速度とと体成分組成に及ぼす影響

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Effects of Ovariectomy, Testosterone and 17 β-Estadiol on Growth Rate and Body Composition of Female Turkeys

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To determine the effects of testosterone and 17 β-estradiol on female turkey growth, 36 female turkeys were ovariectomized and 36 female turkeys were sham-operated at 11 weeks of age in Experiment 1 and at 15 weeks of age in Experiment 2. One week after surgery, turkeys were implanted with pellets containing either placebo, testosterone or 17 β-estradiol at the dose of 8.2 mg/kg body weight at 12 weeks (Experiment 1) or 10.8 mg/kg body weight at 16 weeks (Experiment 2). Turkeys were weighed weekly and body composition was determined at 21 weeks of age. Ovariectomy increased ($P \leq 0.05$) the growth rate when performed at 15 weeks, but not when performed at 11 weeks. 17β-Estradiol had no effects on the growth rate, whereas testosterone decreased the growth rate when implanted in turkeys at 16 weeks of age. Steroid implants interacted with ovariectomy to affect body composition in Experiment 1, in which 17β-estradiol reduced ($P \leq 0.05$) the moisture content and increased ($P \leq 0.05$) the fat content in intact female turkeys, but not in ovariectomized turkeys. Results in this study related 17β-estradiol only to body fat accumulation and ovarian development to the growth pattern characteristic to female turkeys.

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Key words : turkey, growth, testosterone, 17β-estradiol, ovariectomy, body composition, shank length

Introduction

Testosterone has been successfully used to improve growth rates (FENNELL and SCANES, 1992 b ; MARUYAMA *et al.*, 1996a) and to increase the lean yield of male turkeys (MARUYAMA *et al.*, 1996b). The growth-promoting action of testosterone is independent of age and gonadal status of turkeys and growth depression due to castration does not become evident until 16 weeks of age (MARUYAMA *et al.*, 1996a), when male turkeys begin to produce endogenous testosterone (CECIL and BAKST, 1991). Little information is available on physiological actions of testosterone and estrogen on female turkey growth. Synthetic analogs of both testosterone and estrogen produce increased growth rates and carcass leanness in ruminants (HANCOCK *et al.*, 1991). In poultry, hexoestrol increased the deposition of fat in female chickens (RYLEY *et al.*, 1970) and diethylstilbestrol increased growth rates, but not body fat, in female turkeys (MORENG

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et al., 1963). The present study examined the hypothesis that testosterone stimulates body growth and reduces body fat, and estrogen depresses body growth and increases body fat, by implanting testosterone and estrogen pellets in intact and ovariectomized female turkeys.

Materials and Methods

Details of turkeys and management have been described in a companion article (MARUYAMA *et al.*, 1996a). Briefly, 240 female day-old poults of Large White hybrid turkeys were purchased from a commercial hatchery (British United Turkeys of America, Lewisburg, WV 24901) and brooded in floor pens. Turkeys weighing within the range of one standard deviation from the mean weight at 6 weeks of age were used in two experiments to determine effects of gonadal status, steroid implants and ages when the implants were given. In Experiment 1, 36 turkeys were ovariectomized and 36 turkeys were sham-operated at 11 weeks of age. At 12 weeks of age, 12 ovariectomized turkeys and 12 sham-operated turkeys were implanted with the steroid implants. In Experiment 2, 36 turkeys were ovariectomized and 36 turkeys were sham-operated at 15 weeks of age. At 16 weeks of age, 12 ovariectomized turkeys and 12 sham-operated turkeys were implanted with the steroid implants. In both experiments, gonadal status and steroid implants were two variables in a 2×3 factorial arrangement. The gonadal status was either intact or ovariectomized, and the steroid implants were either placebos (control), 17β-estradiol pellets, or testosterone pellets. The steroids were administered as cholesterol-based pellets at the dose of 8.2 mg/kg body weight in Experiment 1 and at the dose of 10.8 mg/kg in Experiment 2. Twelve turkeys were randomly assigned to each treatment and distributed in 12 pens. One turkey from every treatment, in the total of 6 turkeys, was housed in each pen. Turkeys were reared in floor pens with wood shavings. Lighting was provided for 14 hours a day with a 15-watts light bulb per pen.

Ovariectomy was performed as follows. Turkeys were anesthetized by injecting sodium pentobarbital into the left brachial vein through a 21-gauge butterfly infusion needle at the dose of 12 mg/kg body weight. All feathers were stripped from the abdominal and upper thigh area on the right side. The area was thoroughly scrubbed with 70% ethanol. An incision was made at the caudal edge of the pectoral girdle and extended toward the thigh. The opening was spread with retractors. After the intestine was pushed aside, the membrane over the ovary was carefully teased out, and a wire loop was placed under the ovary. The loop was locked in the claw of a needle holder. While the ovary was held with a pair of forceps, the wire loop was dragged along the vena cava to excise the ovary. The ovary and loose tissue fragments were carefully picked off and bleeding sites were sealed with an electric cauterizer.

Turkeys were weighed and shank length was determined at 12, 13, 14, 15, 16, and 20 weeks of age in Experiment 1, and at 16, 17, 18, 19, and 20 weeks of age in Experiment 2. Body weights were determined using electronic balances and recorded with three significant numbers. Shank length was measured from the knee to the hock along *Tibiotarsus* and *Fibula* bones using micrometers and recorded to the nearest millimeter.

At 21 weeks of age, turkeys were killed and body composition was determined. The moisture content was determined by drying samples in an oven at 105℃ for 24 hours. The crude protein content was calculated from the total nitrogen content (N×6.25) that was determined by measuring thermal conductivity after combustion of nitrogenous materials in a nitrogen analyzer (Leco Corp. St. Joseph, MI 49085-2396, USA). The fat content was determined by extracting fat in diethyl ether according to AOAC-Soxhlet method, in duplicate.

Statistical analysis was performed using the General Linear Models procedure (SAS Institute, 1989). The experimental design was a randomized complete block design with 12 pens as blocks of each expriment. The criterion for statistical significance was set at 0.05 level of probability ; however, *P* values are also provided in ANOVA summaries of tables as reference.

Results

Body Weights, Shank Length, and Body Composition of Intact and Ovariectomized Turkeys Implanted with 17β-Estradiol and Testosterone at 12 Weeks of Age (Experiment 1)

Body weights and shank length of 12-week-old turkeys were not affected by ovariectomy performed at 11 weeks of age (Table 1). When female turkeys were

Table 1. Effects of ovariectomy, 17β-estradiol, and testosterone on body growth and shank growth of female turkeys (Experiment 1)[1]

Main effect		N	Body weight at 12 wk	A verage daily gain[2]			Shank length at 12 wk	Shank growth rate[2]		
				12-16 wk	16-20 wk	Overall		12-16 wk	16-20 wk	Overall
			(kg)	(g/day)			(mm)	(mm/day)		
Gonadal status	*Implant*									
Intact	Placebo	12	—	97.3	90.5	93.9	—	0.10	0.06	0.08
	17β-Estradiol	12	—	98.0	85.4	91.7	—	0.10	0.04	0.07
	Testosterone	12	—	97.7	85.9	91.8	—	0.11	0.05	0.08
Intact mean		36	6.13	97.7	87.3	92.5	148.8	0.10	0.05	0.08
Ovariectomized	Placebo	12	—	110	84.8	97.4	—	0.09	0.03	0.07
	17β-Estradiol	12	—	104	85.6	94.8	—	0.16	0.03	0.10*
	Testosterone	12	—	104	79.8	91.7	—	0.09	0.02	0.06
Ovariectomized mean		36	5.98	106	83.4	94.6	149.3	0.12	0.03	0.07
Implant main effect	Placebo	24	—	104	87.6	95.7		0.10	0.05	0.07
	17β-Estradiol	24	—	101	85.5	93.3	—	0.13	0.03	0.08
	Testosterone	24	—	101	82.8	91.7	—	0.10	0.04	0.07
Pooled SEM										
for main effect			—	3.7	3.1	2.3	—	0.02	0.01	0.008
for individual means			0.09	5.3	4.3	3.3	0.62	0.03	0.02	0.01
	P values for Gonadal status×Implant interaction									
Interaction (*df*=2)			—	0.76	0.32	0.84	—	0.23	0.63	0.02

[1] : Female turkeys were ovariectomized at 11 weeks of age and given cholesterol pellets containing either placebo (cholesterol) or testosterone at the dose of 50 mg in total or 8.2 mg/kg body weight at 12 weeks of age.

[2] : Values with asterisks are significantly different from the respective control at $P \leq 0.05$ (*).

implanted with 17β-estradiol or testosterone at 12 weeks of age, the rate of weight gain was not affected by either ovariectomy or steroid implants. The average daily gain (ADG) for the period of 12 to 16 weeks was 97.7 g/day for intact turkeys and 105.9 g/day for ovariectomized turkeys, however, the difference was not statistically significant ($P=0.06$). Shank growth was not affected by either ovariectomy or steroid implants. But, there was an interaction ($P\leq0.05$) of gonadal status and implants on the overall shank growth rate. In ovariectomized turkeys, the shank growth rate was increased by 17β-estradiol (0.07 mm/day for placebos and 0.10 mm/day for 17β-estradiol).

Effects of ovariectomy performed at 11 weeks of age and steroid implants given at 12 weeks of age on body composition of 21-week-old turkeys are summarized in Table 2. The moisture content was not affected by either ovariectomy or steroid implants. However, there was a significant ($P\leq0.05$) interaction of two main effects. In pairwise comparison, the moisture content of intact female turkeys receiving 17β-estradiol (60.2%) was less ($P\leq0.05$) than those of intact turkeys receiving placebos (63.0%) or testosterone (62.0%). There was no difference in the moisture content of intact turkeys receiving placebos (63.0%) and ovariectomized turkeys receiving 17β-estradiol (62.1%). The moisture content was higher in ovariectomized turkeys (62.1%) than in intact turkeys (60.2%) when implanted with 17β-estradiol. The fat content was not affected

Table 2. Effects of ovariectomy, 17β-estradiol, and testosterone on body composition of female turkeys (Experiment 1)[1]

Main effect		N	Body composition[2]		
			Moisture	Fat	Protein
				(%)	
Gonadal status	*Implant*				
Intact	Placebo	6	63.0	13.1	18.8
	17β-Estradiol	6	60.2**	16.0*	18.8
	Testosterone	6	62.0	14.3	19.0
Intact mean		18	61.7	14.5	18.9
Ovariectomized	Placebo	6	61.1	15.0	18.5
	17β-Estradiol	6	62.1	14.3	18.9
	Testosterone	6	60.3	15.9	18.4
Ovariectomized mean		18	61.2	15.1	18.6
Implant main effect	Placebo	12	62.1	14.1	18.6
	17β-Estradiol	12	61.1	15.2	18.9
	Testosterone	12	61.2	15.1	18.7
Pooled SEM					
for main effect			0.44	0.47	0.16
for individual means			0.62	0.66	0.23
	——— *P* values for Gonadal status×Implant interaction ———				
Interaction ($df=2$)			0.006	0.02	0.33

[1] : Female turkeys were ovariectomized at 11 weeks of age and given cholesterol pellets containing either placebo (cholesterol) or testosterone at the dose of 50 mg in total or 8.2 mg/kg body weight at 12 weeks of age.

[2] : Moisture, protein, and fat contents were determined on the wet weight basis. Values with asterisks are significantly different from the respective control at $P\leq0.05$ (*), $P\leq0.01$ (**).

by either ovariectomy or steroid implants. But, there was a significant ($P \leq 0.05$) interaction of two main effects. In pairwise comparison, the fat content of intact female turkeys receiving 17β-estradiol (16.0%) was higher ($P \leq 0.05$) than that of intact turkeys receiving placebos (13.1%). There was no difference in the fat content of intact turkeys receiving placebos (13.1%) and ovariectomized turkeys receiving 17β-estradiol (14.3%). When implanted with 17β-estradiol, the fat content was not different in ovariectomized turkeys (14.3%) and intact turkeys (16.0%). No significant interaction of testosterone implants and gonadal status was observed on body moisture and fat contents. The protein content was not affected by either ovariectomy or steroid implants, or by their interaction.

Body Weights, Shank Length, and Body Composition of Intact and Ovariectomized Turkeys Implanted with 17β-Estradiol and Testosterone at 16 Weeks of Age (Experiment 2)

Body weights and shank length of 16-week-old turkeys were not affected by ovariectomy performed at 15 weeks of age (Table 3). When female turkeys were implanted with 17β-estradiol or testosterone at 16 weeks of age, the rate of weight gain was affected ($P \leq 0.05$) by both ovariectoy and steroid implants. The interaction of gonadal status by steroid implants was not significant ($P=0.06$). The ADG for the period of 16 to 20 weeks was increased ($P \leq 0.05$) by 17.5% by ovariectomy. The ADG

Table 3. Effects of ovariectomy, 17β-estradiol, and testosterone on body growth and shank growth of female turkeys (Experiment 2)[1]

Main effect		N	Body weight at 16 wk	Average daily gain[2] 16–20 wk	Shank length at 16 wk	Shank growth rate[2] 16–20 wk
			(kg)	(g/day)	(mm)	(mm/day)
Gonadal status	*Implant*					
Intact	Placebo	12	—	105	—	0.06
	17β-Estradiol	12	—	107	—	0.03
	Testosterone	12	—	97.3	—	0.09
Intact mean			9.17	103	153	0.06
Ovariectomized	Placebo	12	—	129	—	0.09
	17β-Estradiol	12	—	130	—	0.07
	Testosterone	12	—	103	—	0.08
Ovariectomized mean			9.13	121***	153	0.08
Implant main effect	Placebo	24	—	117	—	0.07
	17β-Estradiol	24	—	118	—	0.05
	Testosterone	24	—	100***	—	0.08
Pooled SEM						
for main effect			—	3.0	—	0.02
	P values for Gonadal status × Implant interation					
Interaction ($df=2$)			—	0.06	—	0.49

[1]: Female turkeys were ovariectomized at 15 weeks of age and given cholesterol pellets containing either placebo (cholesterol) or testosterone at the dose of 100 mg in total or 10.8 mg/kg body weight at 16 weeks of age.

[2]: Values with asterisks are significantly diferent from the respective control at $P \leq 0.001$ (***).

was reduced ($P \leq 0.05$) by 14.5% by testosterone implants, but was not affected by 17β-estradiol. Shank growth was not affected by either ovariecomy or steroid implants.

Body composition of 21-week-old turkeys was not affected by either ovariectomy performed at 15 weeks of age or steroid implants given at 16 weeks of age (Table 4).

Discussion

In the present study, growth rates of female turkeys were increased by ovariectomy, decreased by testosterone implants, and not affected by 17β-estradiol implants when ovariectomy was performed at 15 weeks of age and steroid implants were given at 16 weeks of age (Experiment 2). However, when ovariectomy was performed at 11 weeks of age and steroid implants were given at 12 weeks of age, growth rates were not affected by ovariectomy or steroid implant (Experiment 1). Testosterone-induced growth depression was observed in intact female turkeys as well as in ovariectomized turkeys. It was observed only when testosterone was given at 16 weeks of age, and not at 12 weeks. In male turkeys, growth rates were increased by testosterone when testosterone implants were given 9, 11 or 13 weeks of age and at about 16 weeks of age, growth depression due to a loss of gonads became evident in male turkeys (MARUYAMA *et al.*, 1996a).

Testosterone was reported to increase the growth rate of 6-week-old intact female

Table 4. Effects of ovariectomy, 17β-estradiol, and testosterone on body composition of female turkeys (Experiment 2)[1]

Main effect		N	Body composition[2]		
			Moisture	Fat	Protein
				(%)	
Gonadal status	*Implant*				
Intact	Placebo	6	62.0	14.5	18.5
	17β-Estradiol	6	60.9	14.8	19.3
	Testosterone	6	60.9	14.7	18.7
Intact mean		18	61.3	14.7	18.8
Ovariectomized	Placebo	6	61.8	13.9	18.9
	17β-Estradiol	6	62.7	12.9	19.3
	Testosterone	6	61.1	15.2	18.3
Ovariectomized mean		18	61.9	14.0	18.8
Implant main effect	Placebo	12	61.9	14.2	18.7
	17β-Estradiol	12	61.8	13.8	19.3
	Testosterone	12	61.0	15.0	18.5
Pooled SEM					
for main effect			0.55	0.66	0.24
	——— *P* values for Gonadal status × Implant interaction ———				
Interaction ($df=2$)		2	0.42	0.43	0.51

[1] : Female turkeys were ovariectomized at 15 weeks of age and given cholesterol pellets containing either placebo (cholesterol) or testosterone at the dose of 100 mg in total or 10.8 mg/kg body weight at 16 weeks of age.

[2] : Moisture, protein, and fat contents were determined on the wet weight basis.

turkeys (FENNELL and SCANES, 1992 b) and to decrease the growth rate of 2-, 6- and 10-week-old intact female chickens (FENNELL and SCANES, 1992 a). In the present study, the growth rate was increased after ovariectomy in Experiment 1 ($P=0.06$) and in Experiment 2 ($P=0.0001$), suggesting that a loss of gonads in female turkeys removed unknown negative factors for body growth. It is reasonable to preclude the possibility that 17β-estradiol plays a critical role in determining growth characteristics of female turkeys because 17β-estradiol implants failed to reverse the growth-stimulating effect of ovariectomy when given to 16-week-old turkeys. When tamoxifen, an antiestrogen, was given to chicken embryos to induce hormonal imprinting, the weight of adipose tissue was reduced, but body weights at 8 weeks were not increased in female chickens (ROZENBOIM *et al.*, 1989). In turkeys, 17β-estradiol was effective only in increasing body fat and decreasing body moisture, but had no effect on the growth rate. Hence, the estrogen action is probably secondary to unknown physiological events which take place at around 16 weeks of age to determine the patterns of body growth for male and female turkeys. The hypothesis tested in the present study, that testosterone stimulates body growth and reduces body fat, and estrogen depresses body growth and increases body fat in female turkeys, was not supported. An alternative hypothesis is that sexual dimorphism of turkey growth is marked by physiological events, other than testosterone and 17 β-estradiol production, in gonadal organs of male and female turkeys at around 16 weeks of age.

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卵巣除去，テストステロン及び17β-エストラジオール投与が雌七面鳥の成長速度とと体成分組成に及ぼす影響

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外因性テストステロンと17β-エストラジオール投与が七面鳥の成長に及ぼす影響を検討するために，11（実験1）あるいは15（実験2）週齢時に卵巣除去と偽手術をそれぞれ72羽の雌七面鳥について行った。これらの七面鳥を手術後1週目に，テストステロンあるいは17β-エストラジオールを含むペレット，及びホルモンを含まないペレットを埋没投与する3試験区に分けた。投与量は12週齢の七面鳥（実験1）には体重1kg当たりそれぞれ8.2mgとなるように，また16週齢の七面鳥（実験2）には同じく10.8mgとなるように設定した。体重測定は毎週1回行い，と体の成分組成の測定は21週齢時に行った。卵巣除去は，除去手術を15週齢時に行ったときには成長速度を増加させた（$P<0.05$）が，11週齢時に行ったときには影響を及ぼさなかった。17β-エストラジオールは成長速度には影響を及ぼさなかったが，テストステロンは16週齢時に投与した場合成長速度を減少させた。実験1において，ステロイド投与と卵巣除去は相互に作用し合い，と体の成分組成に影響を及ぼした。つまり，17β-エストラジオールは正常雌のと体の水分量を減少させ，脂肪量の増加をもたらした（$P<0.05$）が，卵巣除去雌ではそのような効果は見られなかった。以上の結果から，17β-エストラジオールは体脂肪蓄積にのみ関与し，卵巣の発達が雌七面鳥特有の成長様式に影響するものと推察された。

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キーワード：七面鳥，成長，テストステロン，17β-エストラジオール，卵巣除去