Research Articles

Effect of Sex on Growth Curve, Production Performance and Carcass Quality of Cherry Valley Ducks

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Abstract

The objective of this study was to determine the effect of sex dimorphism on growth curve, production performance and carcass quality of Cherry valley ducks. Fifteen male and fifteen female ducks were randomly kept in an individual metabolic cage under evaporative cooling system. Ducks were fed with a starter-1 diet (22.00% crude protein [CP], and 2,850 metabolizable energy [ME] kcal/kg) from 1 to 9 days, a start-2 diet (20.00% CP and 2,900 ME kcal/kg) from 10 to 16 days, a grower diet (18.50% CP and 2,900 ME kcal/kg) from 17 to 42 days, and a finisher diet (16.99% CP and 2,950 ME kcal/kg) from 43 to 49 days. Water and feed were offered *ad libitum* throughout experimental period. The Gompertz model was used to develop the growth curve for male and female ducks. A two-sample *t*-test was used to compare the effect of sex dimorphism on production performance and carcass quality. The results showed that there were significant differences (P<0.05) in body weight (BW), average daily gain and feed intake between male and female ducks from 42 days. The accuracy of R2with Gompertz equations was 0.9907 and 0.9857 for male and female ducks, respectively. For carcass quality and internal organs at 49 days of age, male ducks had greater skeleton, breast meat, feet and gizzard (P<0.05), whereas female tended to have greater (P=0.10) skin with subcutaneous fat. In conclusion, since the sex dimorphism of ducks showed significant effect on growth rate from 42 days of age, the separate sex growing should be considered to obtain the uniformity of BW and carcass quality of Cherry Valley ducks.

Keywords: Carcass quality, Cherry Valley duck, Growth curve, Performance, Sex

Introduction

In commercial duck production, males and females are worldwide reared together due to the cost of sexing at hatching, while sexual dimorphism has an enormous impact on growth performance and carcass quality of ducks on slaughter age (Farhat and Chavez, 2000; Steczny et al., 2007). Several factors including feed utilization and nutrient requirements tend to favor separate rearing of male and female ducklings (Downing, 2010). As shown in previous research, male ducks have a faster growth rate (Scott and Dean, 1991; Normand et al., 1996; Downing, 2010), better feed efficiency (Downing, 2010), and lower carcass fat (Normand et al., 1997) when compared to female ducks. These phenomena may be due to the differences in hormones and metabolic functions (Smith and Pesti, 1998). In addition, female hormones may stimulate fat deposition, resulting in fatter carcass in female birds rather than in male birds (Rondelli et al., 2003). Alternatively, separate sex growing of ducks may add an advantage of management to obtain the uniformity of body weight (BW) and carcass quality at the market age. Therefore, the growth model is needed to attribute the beneficial method to estimate BW of males and females for obtaining uniformity of carcass at different age.

Gompertz model is a nonlinear regression analysis, which can be used to develop the growth curve in livestock animals such as cattle and diary (Bullock et al., 1993; Koene et al., 1996), guinea fowl (Nahashon et al., 2006), chicken (Rogers et al., 1987), and duck (Kaewtapee et al., 2011). A sigmoid or S-shaped curve is normally used to study growth curve, which divided into 3 phases as self-accelerating, linear, and self-decelerating (Lawrence et al., 2002). The models included exponential function, logistic function, cubic curvilinear function, and Gompertz model (Yee et al., 1993; Nahashon et al., 2006; Roush et al. 2006). Kaewtapee et al. (2011) reported that Gompertz model showed a high accuracy to predict the BW of Cherry Valley ducks. Therefore, the objective of this study was to determine the effect of sexual dimorphism on production performance and carcass quality of Cherry Valley ducks. Gompertz model was used to develop the prediction equations of growth curve for male and female Cherry valley ducks.

Materials and Methods

Experimental Animals and Diets

Fifteen male and fifteen female Cherry Valley ducks were kept in an individual metabolic cage (0.6x0.5 m; 0.3 m^2 floor space per duck), which located in an evaporative cooling system. The lighting period was 23 h/d for the first 3 days and was reduced by 1.0 h every day until reached 18 h/d. The temperature was set at 35 ^oC during the first 3 d and then was reduced 1 ^oC degree every day until reached 27 ^oC. The ducks were fed a starter-1 diet from 0 to 9 days, a starter-2 diet from 10 to 16 days, a grower diet from 17 to 42 days, and a finisher diet from 43 to 49 days (Table 1). Water and feed were offered ad libitum throughout the experimental period. Body weight was daily recorded at 17:00 h throughout the experiment period. Feed intake was recorded weekly, while the average daily gain (ADG) and feed conversion ratio (FCR) were calculated for each duck.

Chemical analyses

Official standard methods (AOAC, 2000) were used to determine the contents of crude protein, crude ash, crude fat, crude fiber, calcium and total phosphorus. The crude protein was calculated as N x 6.25. Concentrations of lysine, methionine, cystine and threonine in the basal diet were determined using ion-exchange chromatography with post-column derivatization with ninhydrin (Llames and Fontaine, 1994). Tryptophan was determined using HPLC with fluorescence detection (extinction 280 nm, emission 356 nm), after alkaline hydrolysis with barium hydroxide octahydrate for 20 h at 110 °C according to the procedure as outlined by Commission Directive (2000). The calculated metabolizable energy and analyzed chemical composition are shown in Table 1.

Carcass Quality

At the end of experiment (49 days of age), after overnight feed deprivation, ducks were weighed and sacrificed using CO_2 by asphyxiation in an atmosphere of less than 2% oxygen (air displaced by CO_2) for 1.5-2.0 min. Thereafter, ducks were subjected to defeathering and evisceration. Skin with subcutaneous fat was removed from the carcass (without the forearms and wing tips) according to the outline described by Bochno et al. (2007). The carcasses were dissected into breast, wing (including forearm and wing tip), drummatte, drumstick, thigh, abdominal fat, skeleton and feet. Liver, gizzard, heart, pancreas and spleen were manually removed and weighted.

Model Development

The Gompertz model was developed for male and female Cherry Valley ducks (Rogers et al., 1987) using the NLIN procedure of the SAS statistical program (SAS, 1988). The model was presented as follow:

$$W = A \exp[-\log(A/B)\exp(-Kt)]$$

where W is the weight to age (t), A is asymptotic mature BW, B is the rate of mature BW, K is a rate of exponential decay of growth rate. The cubic curvilinear function was developed for FCR of male and female Cherry Valley ducks (Croquet et al., 2007). The model was presented as follow:

$$FCR = \beta_0 + \beta_1 t + \beta_2 t^2 + \beta_3 t_3$$

where t is day of age, and ? is a rate constant. The accuracy of each predictive model was determined by the regression coefficient squared (R^2), computed as:

$$R^2 = 1 - (SSE/SST)$$

where SSE is the sum of squared errors, and SST is the sum of squares for treatments (Mendenhall et al., 2003).

Statistical Analysis

A two-sample t-test was used to compare the effect of sex on each parameter by SAS (1988). Statistical differences were established at $P<0.05$, whereas 0.05P0.10 were considered a trend. All statistical analyses were computed in accordance with the Steel and Torrie (1980).

Results and Discussions

Growth curve

The effect of sex dimorphism on growth curve of Cherry Valley ducks is shown in Figure 1. The scatter plot of BW showed that male ducks had greater ($P<0.05$) BW than female ducks from 42 days. The Gompertz equations for male and female ducks were presented as follows:

Male: $W = 4556.10 \exp[-\log(4556.10/49.69)\exp(-0.06t)]$; $R^2=0.9907$

Female: $W = 3987.80 \exp[-\log(3987.80/30.09)\exp(-0.07t)]$; $R^2=0.9857$

With regard to the Gompertz equations, male ducks showed greater mature BW (4556.10 g) and growth rate (49.69 g) than female ducks (3987.80 and 30.09 g, respectively) at 42 days of age. In addition, male ducks showed lower rate of exponential decay of growth (-0.06 g) than female ducks (-0.07 g). Roush et al. (2006) reported that Gompertz model showed a high accuracy to predict BW of broiler chicken. Similar to the present study, the growth curve equations were well fitted with Gompertz model, and the accuracy of R2 was 0.9907 and 0.9857 for male and female ducks, respectively. With regard to the prediction equations, if the market weight of most Cherry Valley ducks in Thailand is 3.3 kg, the slaughter age should be 44 and 47 days for male and female ducks, respectively. Therefore, it is confirmed that Gompertz model is more accurate function to predict the BW of male and female Cherry Valley ducks in commercial production.

Production performance

Production performances are shown in Table 2. There were significant differences ($P<0.05$) in ADG and feed intake between male and female ducks from days 42 to 49. However, no difference ($P>0.05$) in FCR was observed between male and female ducks throughout the experimental period, but the response curve of FCR showed lower ($P<0.05$) in male than in female ducks from 21 to 49 days (Figure 2). The cubic regression for male and female ducks were presented as follows:

Male: $FCR = 0.0002t^3 - 0.0114t2 + 0.2719t - 0.3733$; $R^2=0.9015$

Female: $FCR = 0.0002t3 - 0.0125t2 + 0.3082t - 0.6540$; $R^2=0.9013$

The sexual dimorphism has been reported to show the difference in growth performance of Pekin duck at 35 days (Normand, 1977; Farhat and Chavez, 2000), or at 42 days (Normand et al, 1996; Steczny et al., 2007). Previous researches reported that male ducks had faster growth rate than female ducks at day 42, ranging from 100 to 300 g (Scott and Dean, 1991; Farhat and Chavez, 2000). Farhat and Chavez (2000) reported that male ducks had greater feed intake than female up to 42 days and had a significant lower FCR at 49 days. In agreement with the present study, male ducks had greater BW and ADG than female ducks from 42 to 49 days, and the BW of male ducks was 90 g and 180 g heavier than female at 42 and 49 days, respectively. However, there were no difference in FCR between male ducks and female ducks as the greater growth rate in male ducks was associated with the higher feed intake, resulting in the same proportion of feed efficiency when compared to female ducks. Notably, the response curve of FCR in male ducks showed a better feed efficiency when compared to female ducks. Therefore, these results suggested that male ducks could be slaughtered earlier than female ducks, when raised separately.

Carcass quality

The male ducks showed a greater ($P<0.05$) percentage of skeleton, breast, and feet, whereas female ducks tended to have greater ($P=0.10$) percentage of skin with subcutaneous fat (Table 3). With regard to internal organs, male ducks had greater ($P<0.05$) percentage of gizzard, and tended to have greater ($P=0.10$) percentage of pancreas than female (Table 3).

The faster growth rate of male ducks resulted in greater carcass and breast yields compared with female ducks (Downing, 2010; Farhat and Chavez, 2000). In a recent study (Steczny et al., 2017), male ducks showed greater breast and leg muscles compared with female ducks. The authors also reported that a percentage of gizzard was significantly greater in male ducks. Similar to the present study, male had high percentage of gizzard, resulting in greater breast meat. The explanation is that a greater proportion of gizzard may be indicative of better muscle growth in gizzard, which can increase nutrient digestion and absorption (Kokoszynski et al., 2017). In addition, a greater size of pancreas may increase pancreatic enzymes (Kadhim et al., 2014), which resulted in a better nutrient digestibility in male ducks compared with female ducks.

The sex differences also influence carcass fat (Normand, 1997), and the greater fat accumulation in female ducks is probably a direct result of the secretion of estrogen hormone from ovary, which is responsible for an increase in the hepatic synthesis of the yolk lipo-protein (Scanes et al., 2004). As a result, fat deposition increases if the lipids in blood stream is not used in the manufacture of egg yolks (Lorenz et al., 1983). Steczny et al. (2017) reported that female ducks showed greater skin with subcutaneous fat and abdominal fat than male ducks (Steczny et al., 2017). Similar findings were reported in studies with broiler chicken in which female had greater abdominal fat than male (Rondelli et al., 2003; Santos et al., 2004; Bogosavljevic-Boskovic et al., 2006). In the present study, there was no difference in abdominal fat between two sexes, but a greater skin with subcutaneous fat can be observed in female ducks. Notably, ducks have a thicker layer of subcutaneous fat to provide insulation and to tolerate low temperatures (Cherry and Morris, 2008). Therefore, the subcutaneous fat of ducks has to be taken into account when fat accumulation is concerned (Bochno et al., 2007).

Conclusions

The equations of growth curve obtained from the Gompertz model can be used to predict the BW for male and female of Cherry Valley ducks. The differences in growth rate of male and female ducks started from 42 days of age, and the separate sex growing may add an advantage that male can be slaughtered earlier than female ducks. As male ducks have higher feed intake and greater growth than female ducks, further studies are needed to show the different nutrient requirement for male and female ducks to obtain the uniformity of carcass at the same slaughter age.

Table 1 Composition of experimental diets

	Starter 1 (0 to 9 days)	Starter 2 (10 to 16 days)	Grower (17 to 42 days)	Finisher (43 to 49 days)
Ingredient (%, as fed-basis)				
Corn	29.97	29.98	30.01	29.99
Broken rice	3.55	12.97	10.67	14.40
Rice bran	12.92	2.71	9.02	10.00
Defatted rice bran	-	-	0.98	-
Wheat bran	14.56	20.00	20.00	20.00
Oil	4.00	4.00	4.00	3.94
Soybean meal	30.44	25.67	21.33	17.65
Calcium carbonate	1.67	1.63	1.98	2.04
Monodicalcium phosphate (21%)	1.58	1.73	0.92	0.81
Salt	0.42	0.42	0.42	0.42
Choline chloride (75%)	0.08	0.08	0.08	0.08
Anti-mold	0.05	0.05	0.05	0.05
DL-methionine	0.26	0.26	0.17	0.21
Lysine	0.26	0.23	0.14	0.12
Threonine	0.08	0.12	0.08	0.14
Anti-oxidant	0.01	0.01	0.01	0.01
Vitamin and mineral premix	0.15	0.15	0.15	0.15
Calculated metabolizable energy (ME kcal/kg, as dry matter basis)	2,850	2,900	2,900	2,950
Analyzed chemical composition (%, as dry matter basis)				
Crude protein	22.00	20.00	18.50	16.99
Ash	7.37	6.68	6.70	6.46
Ether extract	7.71	6.38	7.27	7.35
Fiber	4.07	3.71	4.07	3.95
Calcium	1.0	1.0	1.0	1.0
Available phosphorus[2]	0.50	0.50	0.35	0.32
Lysine	1.35	1.17	1.00	0.88
Methionine	0.55	0.52	0.45	0.47
Methionine + Cystine	0.90	0.84	0.75	0.75
Threonine	0.90	0.85	0.75	0.75
Tryptophan	0.26	0.24	0.22	0.20

[1]Vitamin and mineral premix content (per kg of diet): retinyl acetate 4.13 mg, cholecalciferol 75 μg, α-tocopherol acetate 13.5 mg, vitamin K_3 1.5 mg, vitamin B_1 1.5 mg, vitamin B_2 5 mg, vitamin B_6 2 mg, vitamin B_{12} 0.05 mg, niacin 25 mg, Ca-D-panthothenate 8 mg, folic acid 3 mg, biotin 0.12 mg, choline chloride 0.16 mg, antioxidant 30 mg, manganese 80 mg, zinc 60 mg, iron 40 mg, copper 8 mg, iodine 0.05 mg, cobalt 0.10 mg, selenium 0.10 mg.

[2]Calculated value

Table 2 Effect of sex dimorphism onproduction performances of Cherry Valley ducks (Means ± SD)

Item	Day	Male	Female	P-value
ADG, g/d	7	27.45 ± 3.97	27.91 ± 3.29	0.74
	14	71.80 ± 11.70	69.28 ± 9.93	0.53
	21	90.09 ± 8.83	91.92 ± 15.51	0.69
	28	107.15 ± 25.22	102.94 ± 21.09	0.67
	35	126.33 ± 33.57	118.85 ± 31.46	0.53
	42	138.44 ± 49.83	105.10 ± 22.00	0.03
	49	78.31 ± 29.82	53.71 ± 11.77	0.02
Feed Intake, g/d	7	29.98 ± 6.50	29.73 ± 3.60	0.90
	14	88.66 ± 9.17	89.39 ± 6.31	0.80
	21	153.22 ± 17.28	152.68 ± 11.47	0.92
	28	185.92 ± 19.07	190.75 ± 17.20	0.47
	35	200.81 ± 23.44	199.89 ± 28.97	0.92
	42	234.25 ± 29.65	203.79 ± 33.96	0.02
	49	245.58 ± 56.56	189.43 ± 22.08	0.02
FCR	7	1.09 ± 0.20	1.07 ± 0.07	0.66
	14	1.26 ± 0.18	1.31 ± 0.16	0.40
	21	1.71 ± 0.17	1.69 ± 0.19	0.78
	28	1.81 ± 0.36	1.92 ± 0.31	0.42
	35	1.68 ± 0.41	1.77 ± 0.46	0.57
	42	1.89 ± 0.55	2.02 ± 0.47	0.53
	49	3.41 ± 1.23	3.62 ± 0.87	0.75

Table 3 Effect of sex dimorphism oncarcass quality and internal organs (% of carcass) of Cherry Valley ducks on day 49 (Means ± SD)

Item	Male	Female	P-value
Carcass quality			
Skeleton	37.02 ± 1.70	34.26 ± 3.50	<0.01
Breast	24.70 ± 1.22	24.46 ± 4.29	<0.01
Skin with subcutaneous fat	15.71 ± 1.08	16.48 ± 1.34	0.10
Thigh	9.78 ± 0.53	10.06 ± 0.48	0.71
Drumstick	7.86 ± 0.65	8.13 ± 0.63	0.93
Drummette	6.67 ± 0.49	6.74 ± 0.43	0.63
Wing	6.22 ± 0.30	6.46 ± 0.26	0.55
Feet	4.21 ± 0.49	3.94 ± 0.27	<0.05
Abdominal fat	0.86 ± 0.22	0.85 ± 0.19	0.59
Internal organ			
Liver	2.07 ± 0.21	1.98 ± 0.25	0.29
Gizzard	1.98 ± 0.30	1.79 ± 0.21	<0.05
Heart	0.55 ± 0.08	0.52 ± 0.05	0.19
Pancreas	0.18 ± 0.03	0.16 ± 0.03	0.10
Spleen	0.08 ± 0.03	0.08 ± 0.02	0.83

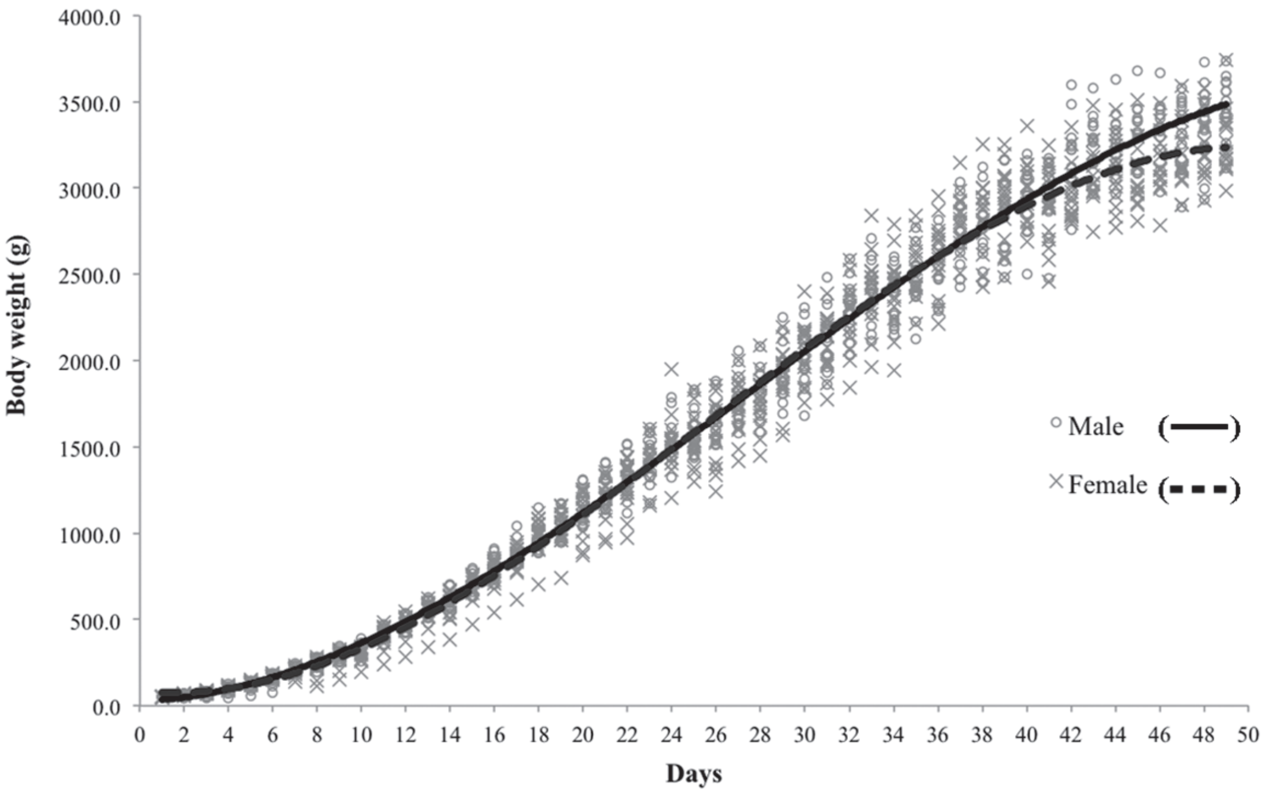

Figure 1 The growth curves of Cherry Valley ducks from 1 to 49 days

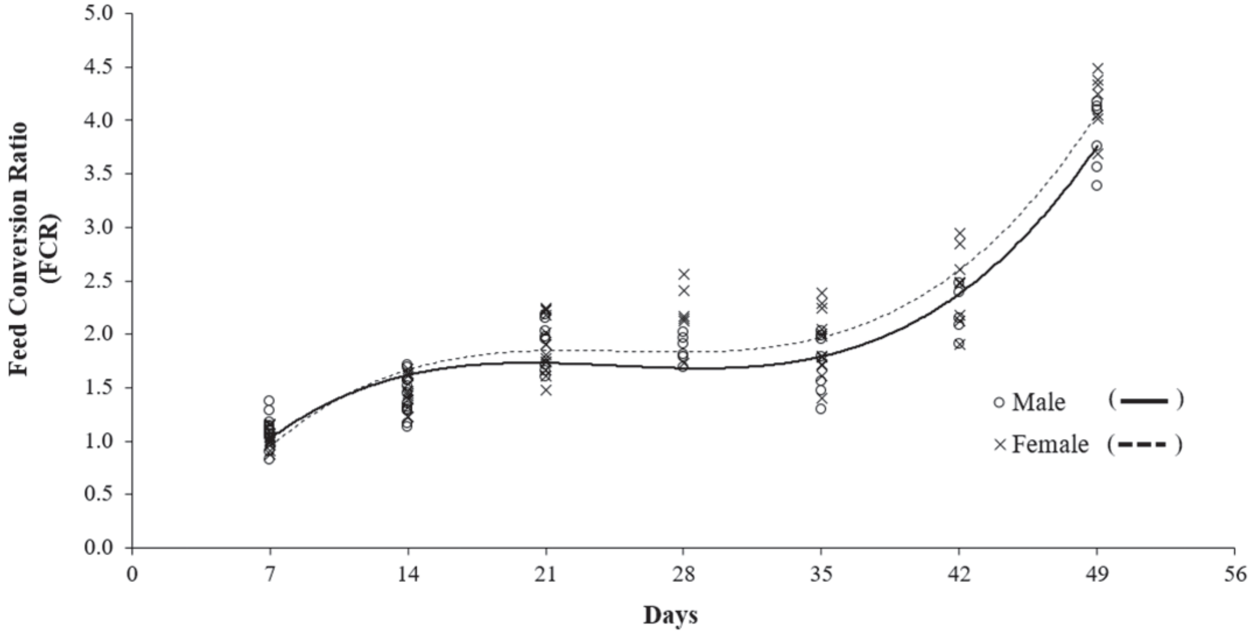

Figure 2 The response curve of feed conversion ratio (FCR) for male and female ducks from 7 to 49 days

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