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Growth and Body Nutrient Deposition of Two Broiler Commercial Genetic Lines

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ABSTRACT

The objective of this work was to study growth and body nutrient deposition profiles of male and female Cobb and Ross broilers using Gompertz equations. A total number of 1,920 one- to 56-day-old broilers were used. A randomized experimental design in a factorial arrangement (2 strains x 2 sex), with 4 replicates of 120 birds each, was applied. Diets were formulated to supply the nutrient requirements recommended by the genetic companies. A sample of birds was weekly weighed and sacrificed after 24 hours fasting. Carcasses were de-feathered and weighed again. The parameters of the Gompertz equation for body weight and its components (water, ashes, protein, and fat) were estimated. An interaction ($p<0.05$) between sex and breed was observed for mature weight (Wm) (kg), growth rate (b) (daily) and time at maximum growth rate (t*) (day) of body weight, and body water and ash. Cobb was presented earlier growth and body protein and ash deposition. Ross strain was superior in body water deposition.

INTRODUCTION

In the last few years, the poultry industry presented a significant increase in the animal production sector. Genetic improvement was the main factor that contributed for this important development of broiler production.

Genetic companies currently apply careful processes to improve broiler performance. The selection for body weight changed the growth curve, increased feed efficiency, causing birds to reach market age earlier. However, different genotypes have different growth curves and different body compositions, which makes them have different nutritional requirements. According to Gous *et al.* (1999), fitting bird growth curve is the first step to predict the nutritional requirements of the different genotypes, thereby supporting the selection process, and contributing for the assessment of bird genetic potential.

Many non-linear mathematic models have been used to describe animal growth and body nutrient deposition, but some authors (Fialho, 1999; Gous *et al.*, 1999; Macleod, 2000; Sakomura *et al.*, 2005; Santos *et al.*, 2005; Neme *et al.*, 2006) indicate that the Gompertz function is the one that best describes them.

The determination of the parameters of Gompertz equations is extremely important for poultry production. In addition to predicting weight and nutrient deposition of birds at any age, these equations help to define the best market weight, and to establish specific feeding programs according to genetic line and sex, thus contributing to improve performance and to reduce production costs.

Growth curves, as determined by prediction equations, are important for the development of simulation models, which are usually used as software in poultry companies. Some of these software applications are available in the market for broilers, such as IGM®, Fortell Model™, Omnipro II® and Chickopt™ (Rostagno *et al.,* 2006).

When determining which parameters need to be included, some considerations must be made. For instance, as feather growth prediction is extremely complex due to difficult estimation of feather loss and skin sloughing, Emmans (1995) proposes that body weight is expressed as de-feathered body, and to establish its relation with the other body components.

Gous *et al.* (1999) described carcass, breast and feather development, as well as protein, fat, water, and ash carcass content during a period of 1 to 16 weeks of age of birds from two different lines using the Gompertz curve. According to the live weight results, mature males were heavier (Wm) and lower maximum growth rates (b) as compared to females. As to chemical composition of de-feathered birds, males presented higher Wm parameters for protein and water as compared to females, revealing that males took longer to reach maximum protein and water deposition rates. Nevertheless, the opposite was found for fat deposition: females took longer than males to reach maximum body fat deposition rates.

Similar results were found by Sakomura *et al.* (2005), who evaluated growth potential of male and female Ross broilers in terms of body weight and chemical composition. The authors observed that males presented higher growth potential, and consequently higher nutrient deposition capacity as compared to females, except for fat deposition.

The present study aimed at estimating body weight, de-feathered carcass weight, and body nutrient deposition growth parameters of two commercial broiler breeds.

MATERIAL AND METHODS

The experiment was carried out in the experimental poultry house of the Poultry Sector of the Department of Animal Science of the School of Agrarian and Veterinary Science of UNESP, Jaboticabal, SP, Brazil. A total number of 1,920 male and female Ross 308 and Cobb 500 one-day-old chicks was used. Birds were housed in pens with a capacity of 10 birds/m^2, equipped with tube feeders and bell drinkers. Total experimental period was 56 days.

Chicks were individually weighed, and were designated to the treatments in groups of similar average weight. A completely randomized experimental design in a 2 x 2 (2 breeds x 2 sexes) arrangement, with 4 replicates of 120 birds each (16 experimental units), was applied.

During the experimental period, birds were vaccinated for IBD at 7, 21 and 35 days of age, and for Infectious Bronchitis and Newcastle Disease at 14 days of age.

Water and feed were offered *ad libitum*. Feeds were based on corn and soybean meal, and formulated to supply the birds' nutritional requirements according to the recommendations of the genetic companies for each rearing phase. Feeds contained 3010 kcal ME/kg and 22% de CP (1-7 days); 3150 kcal ME/kg and 21,50% CP (8-28 days); 3200 kcal ME/kg and 20% CP (29-49 days) and 3245 kcal ME/kg and 18% CP (50-56 days).

All birds were weekly weighed to calculate average body weight, based on which birds representing experimental unit (EU) average weight were selected. In the first week, 10 birds per EU (total = 160 birds) were selected and sacrificed. In weeks 2 and 3, 5 birds per EU (total = 80 birds), and 4 birds per EU (total = 64 birds) were selected and sacrificed. Before sacrifice, birds were submitted to 24-h fasting to allow complete emptying of the gastrointestinal tract. Birds had access to water during fasting. After fasting, birds were individually weighed to obtain fasted weight, and sacrificed by CO_2 asphyxia in compliance with international ethics criteria.

De-feathered carcasses (whole bird with no feathers) were individually weighed, placed in duly identified plastic bags, and frozen for later processing and sample collection. Carcasses were cut with a saw and ground in an industrial meat grinder in order to produce homogenous samples. Out of the total sample, a 60 to 80g subsample was taken, placed in a disposable plastic Petri dish, and freeze-dried at -50°C in a Thermo VLP200 apparatus to obtained pre-dried matter. Samples were then ground in a IKA micro-grinder, and submitted to the laboratory for nitrogen, ether extract, dry matter, and ashes determination. The applied methodologies are described in Silva & Queiroz (2002).

Growth curve parameters for fasted body weight, de-feathered bird weight, and body nutrient deposition, obtained weekly, were estimated using the following Gompertz equation (1825): $W_t = W_m . \exp .(- \exp . (- b .(t - t^*)))$, where: W_t = weight (g) of the bird at time t, expressed as a function of W_m; W_m = mature weight (g); b = growth rate (daily); t^* = time (days) when growth rate is maximal. Based on the estimated equations, growth rates (g/day) were calculated as a function of time (t), using the Gompertz equations derivate.

In addition to growth parameters, the logarithm allometric relations were calculated. The dependent variable is the body component quantity (protein, fat, water, ashes, and energy), and the independent variable is body protein weight. The following equation was applied: Log_{10} (component weight) = a + b Log_{10} (CP), where component weight is the total body quantity, and CP is body protein weight. The parameters were analyzed using the option Separate lines, estimate differences from level of the procedure Simple Linear Regression with Groups of the software GenStat, 10th Edition (2007),

The parameters indicated in the Gompertz equation were submitted to analysis of variance using the procedure ANOVA of SAS (2001). Means were compared by the F test (5%). The regression equations and the Gompertz functions used to describe growth were separately fit to each sex and breed data using SAS (2001).

RESULTS AND DISCUSSION

Interactions between breed and sex were significant (p<0,05) for all parameters of the Gompertz equation for fasted live weight, de-feathered carcass weight, and water and ashes deposition. The details of the breed vs. sex interaction are shown in Table 1. Cobb females and Ross males were different from Ross females and Cobb males for fasted live weight and de-feathered carcass weight.

Cobb males were different (p<0,05) from Ross males and Cobb females for all Gompertz equation parameters in terms of carcass water content. However, as for ashes, Ross males were different than Cobb males and Ross females for Wm, b and t*.

Mature weight (Wm), according to Duarte (1975), represents genetic growth potential and the effect of genes that determines growth, making this asymptotic measure a parameter resulting from previous growth stages. Ross females and Cobb males presented higher Wm values, but had lower and similar maturity rate (b) values, respectively, for fasted live weight and de-feathered carcass weight, which is possible due to the selection for maximum growth rate. This means that growth rates are different between breeds and sexes, reflecting the differences in nutritional requirements and rearing management of the studied birds.

According to Silva (1998), for the same mature weight, low maturity rate (b) values indicates that the birds reaches maturity later. In the present experiment, Cobb males presented the lowest b values for water deposition, and Ross males, for ashes deposition, and both reached maximum growth age (t*) later.

rowth rate increases with bird age up to a limit, when rate is maximum, and then gradually decreases. This is called the inflection point, where the concave curve becomes convex, and corresponds of age at maximum growth (t*) (Kessler, 2000). According to Duarte (1975), the inflection point of the Gompertz model is fixed, corresponding to 37% of the Wm value. The same occurred in the present study: the inflection point varied between 36 and 37,7% of the Wm value for fasted live weight and de-feathered carcass weight.

As shown in Figure 1 and Table 2, growth rates for fasted live weight and de-feathered carcass weight were different between breeds. Cobb birds presented higher growth rates up to 35 days, and thereafter,

Table 1- Gompertz equation parameter estimates for fasted live weight, de-feathered carcass weight*, and water and ashes deposition in male and females Coob and Ross broilers.

Breeds	Males	Females	Males	Females	Males	Females
	Wm¹ (g)		b² (daily)		t*³ (days)	
			Fated live weight			
Ross	6627,84 A	4657,74 B	0,042 B	0,0468 Ab	39,19 A	34,41 Ba
Cobb	6812,30 A	4282,88 B	0,0416 B	0,051 Aa	39,41 A	32,07 Bb
			DE-Feathered carcass weight			
Ross	6351,55 A	4319,04 B	0,042 B	0,042 B	39,24 A	33,95 B
Cobb	6715,50 A	3999,10 B	0,041 B	0,041 B	40,34 A	31,80 B
			Water			
Ross	3215,70 Ab	2269,96 B	0,052 Ba	0,057 A	32,73 Ab	28,96 B
Cobb	4027,97 Aa	2342,57 B	0,045 Bb	0,054 A	37,28 Aa	29,21 B
			Ashes			
Ross	360,34 Aa	115,06 B	0,038 Bb	0,061 Ab	52,63 Aa	29,15 B
Cobb	173,83 Ab	87,35 B	0,051 Ba	0,082 Aa	34,12 Ab	23,85 B

1- Wm (kg) = mature weight. 2- b (daily) = growth rate. 3- t* (day) = time when growth is maximal* Weight of the de-feathered carcass of bird fasted for 24 h..ab Means in the same column followed by different small letters are different (p<0,05) by the F test.AB - Means in the same row followed by different capital letters are different (p<0,05) by the F test.

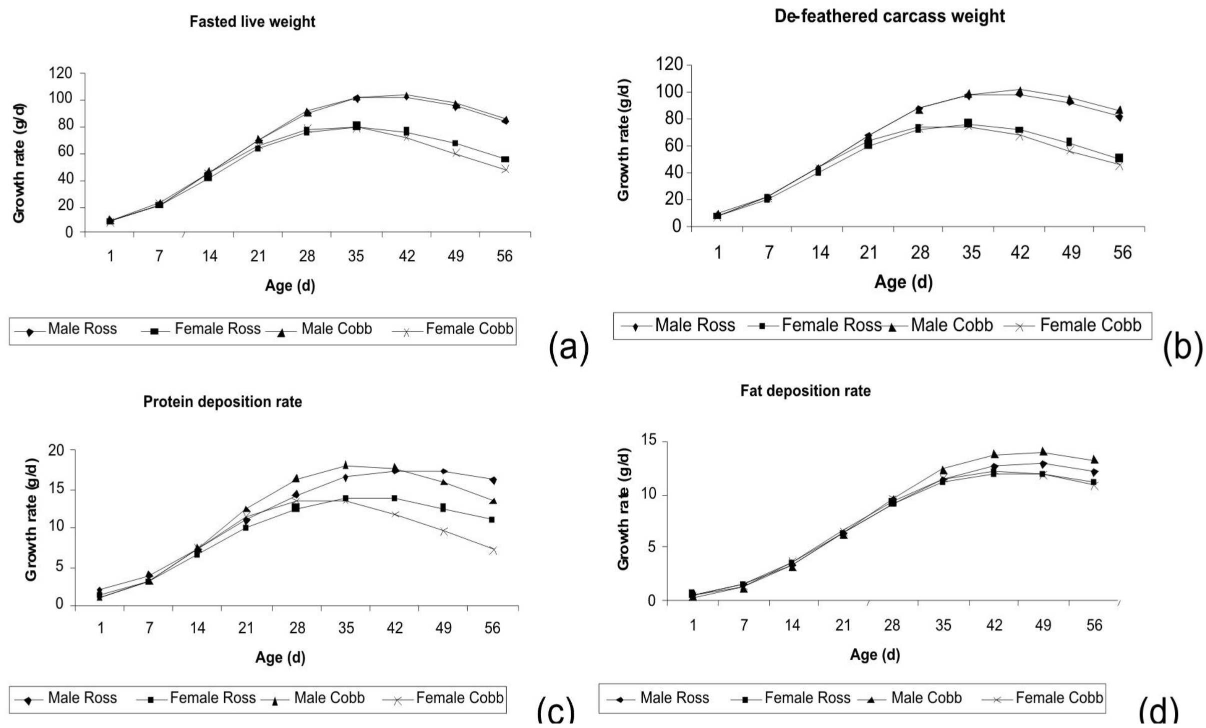

Figure 1 - Growth rates of fasted live weight (a), de-feathered carcass weight (b), and protein (c) and fat (d) deposition in male and females Cobb and Ross broilers.

Table 2 - Growth rates of fasted live weight, de-feathered carcass weight*, and protein, fat, water, and ashes deposition in male and females Cobb and Ross broilers.

Age (days)	Live weight (g/d)		De-feathered weight (g/d)		Deposition (g/d)							
					Protein		Fat		Water		Ashes	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
						ROSS						
1	11,60	10,73	8,76	7,96	1,88	1,26	0,55	0,54	4,99	4,81	0,08	0,15
7	24,90	23,73	21,04	19,93	3,88	3,09	1,50	1,52	14,40	13,91	0,28	0,57
14	47,00	44,12	42,63	39,99	7,18	6,28	3,50	3,58	31,48	29,09	0,79	1,42
21	71,69	64,14	66,81	59,86	10,91	9,77	6,25	6,36	48,67	41,98	1,65	2,23
28	92,91	77,82	86,50	72,64	14,25	12,49	9,12	9,12	59,10	**47,19**	2,73	**2,58**
35	106,33	**82,66**	97,16	**75,85**	16,54	**13,80**	11,39	11,15	**60,64**	44,86	3,78	2,44
42	**110,64**	79,64	**98,19**	71,14	**17,52**	13,71	12,65	**12,08**	55,34	38,08	4,57	2,03
49	107,04	71,41	91,73	61,78	17,30	12,58	**12,84**	11,95	46,53	29,96	4,96	1,55
56	97,97	60,75	80,83	50,78	16,17	10,89	12,16	11,05	36,96	22,40	**4,97**	1,12
						COBB						
1	10,33	10,22	9,39	7,99	1,06	0,92	0,37	0,48	5,70	5,91	0,21	0,07
7	23,96	24,53	21,67	20,91	3,15	3,07	1,21	1,47	14,43	15,21	0,64	0,54
14	47,67	47,20	42,89	42,39	7,37	7,23	3,23	3,64	29,99	29,61	1,51	1,71
21	74,52	68,22	66,74	62,43	12,34	11,35	6,30	6,60	47,04	41,50	2,46	**2,55**
28	97,16	80,42	86,67	73,54	16,27	**13,55**	9,65	9,50	60,08	**46,43**	3,11	2,50
35	110,54	**82,00**	98,25	**74,09**	**18,07**	13,44	12,37	11,51	**66,03**	44,53	**3,28**	1,92
42	**113,49**	75,41	**100,57**	66,91	17,74	11,77	13,85	**12,28**	65,01	38,41	3,05	1,29
49	107,86	64,42	95,34	55,97	15,94	9,47	**14,03**	11,93	59,08	30,82	2,61	0,80
56	96,74	52,22	85,31	44,37	13,44	7,20	13,18	10,80	50,63	23,53	2,10	0,48

1- M= males , F= females. The highest growth rates are shown in bold letters.

lower rated as compared to Ross birds. These results indicate Cobb broilers should be slaughtered between 35 and 42 days of age, but Ross broilers, at an older age.

Table 3 shows that there was no interaction between breed ad sex ($p>0,05$), for Gompertz equation parameter estimated values for protein and fat deposition. Cobb broilers presented earlier protein deposition as compared to Ross broilers, as the former presented higher ($p<0,05$) b value, and consequently, lower ($p<0,05$) t* value. These results show that these two breeds present different protein deposition rates, which is consistent with Kesller (2000), who reported the protein, i.e., lean tissue, deposition is highly controlled by genetics.

In terms of fat deposition, there was no difference (P>0,05) between breeds for Wm and t*, but maturity rate (b) was different (p<0,05). The opposite happened for sex: there was no difference (p>0,05) b, but all other parameters were different (p<0,05) between sexes. Despite no significant differences between breeds were detected for fat deposition, Ross birds reached maximum growth 4 days later as compared to Cobb birds, which can be explained by the fact that Cobb presented higher fat deposition rate at maturity as compared to Ross. According to Michelan Filho (1986), bird carcass fat content is heritable. However, other factors contribute to fat deposition in animals, such diet and environmental conditions.

According to Gous *et al.* (1999) and Sakomura *et al.* (2005), fat deposition rates at maturity are higher in males as compared to females. However, the opposite was observed in the present study, where females presented higher b values than males. Males presented higher fat deposition rates than females due to their higher gain potential. The differences between the results of our study and those found in literature may have been influenced by age at slaughter. In the present work, birds were slaughtered at 56 days of age, whereas in the studies of Gous *et al.* (1999) and Longo (2000), birds were slaughtered with approximately 120 days, with females presenting higher fat deposition rates as compared to males. Gous *et al.* (1999) indicated that in females, fat deposition rate significantly increased after 56 days of age, and suggest that this additional fat deposition after this period allows birds to prepare for future egg laying.

In our study, fat deposition occurred later than protein deposition, for both breeds and sexes. According to Kessler (2000), birds deposit more body fat as they age. This fact is related to the achievement of maturity and occurs in most animals. Protein (lean tissue) deposition is mostly controlled by genetics, and therefore there is a limit for its daily deposition, independently from intake. On the other hand, fat deposited in any development phase is directly related to the amount of energy available.

As shown in Figure 1 and Table 2, Ross birds reached maximum protein deposition rate a week later as compared to Cobb. The highest protein deposition rates were found 35- and 42-day-old males and 28- and 35-day-old females of the breeds Cobb and Ross, respectively, indicating higher lean tissue accretion potential of males and Cobb birds. According to Albino *et al.*(2000), females present lower lean tissue accretion and higher body fat content, and these differences tend to intensify as broilers age.

Cobb broilers deposited protein earlier, but after the inflection point, their protein deposition rate becomes slower, whereas Cobb was faster. According to Kessler *et al.* (2000), the higher and the longer is the protein deposition plateau, the more efficient is the bird to produce meat, and the better will be its carcass composition.

Griffiths *et al.* (1977) commented that there are differences in abdominal fat deposition among breeds, and the highest fat deposition usually occurs in breeds with the highest weight gain potential. As shown in Figure 1 and Table 2, fat deposition was higher in Cobb as compared to Ross birds.

A relationship was found between water and fat deposition: when water deposition starts to decline, fat deposition increased.

Cobb birds presented earlier fasted live weight, de-feathered carcass weight, protein and ash deposition growth rates, whereas Ross had earlier water deposition rates, but both had similar fat deposition rates. These results show that there are difference in growth between breeds, despite both being selected for high growth rate. Cobb presented high growth rate in the beginning, whereas Ross was slower in the beginning, but faster at the end. The selection process for body weight may have contributed for these differences. Despite the differences in growth rate and nutrient deposition, weight gain at 42, 49, and 56 days of age were not significantly different between breeds (Marcato *et al.*, 2005).

The importance of the use of mathematic models to obtain growth and body composition estimates of birds of different breeds and sexes, in addition to help to estimate nutritional requirements, also contributes to establish the optimal market age, supplying the demands of the poultry companies and reducing production costs.

Growth and body nutrient deposition can also be estimated by allometric equations. These equations determine body nutrients as a function protein weight. The use of protein weight in allometric ratios provides higher precision to the equations, as differences between sexes and breeds are often small.

The allometric equations for fat, ashes, and water weight as a function of protein weight are presented

Table 3 – Gompertz equation parameter estimations for protein and fat deposition in male and female Cobb and Ross carcasses.

	Wm[1] (g)			b[2] (daily)			t*[3] (days)		
	Males	Females	Mean	Males	Females	Mean	Males	Females	Mean
Breeds					**Proteína**				
Ross	1308,61	865,69	1087,2a	0,037	0,044	0,040 b	44,02	37,88	40,95 a
Cobb	1041,95	666,68	854,3 b	0,047	0,056	0,051 a	37,19	31,02	34,10 b
Mean	1175,28 A	766,18 B		0,037	0,044	0,040 b	44,02	37,88	40,95 a
					Gordura				
Ross	907,16	810,91	859,0	0,039	0,041	0,039 b	46,78	44,51	45,64
Cobb	930,73	780,78	855,7	0,041	0,043	0,042 a	46,47	42,99	44,73
Mean	918,95 A	795,85 B		0,040	0,041	46,62 A	43,75 B		

1- Wm (kg) = mature weight. 2- b (daily) = growth rate. 3- t* (day) = time when growth is maximal* Weight of the de-feathered carcass of bird fasted for 24 h..[ab] Means in the same column followed by different small letters are different (p<0,05) by the F test.[AB] Means in the same row followed by different capital letters are different (p<0,05) by the F test.

Table 4 – Estimated parameters for logarithmic linear regressions[1] of body component weights as a function of protein weight of male and female Ross and Cobb broilers.

Component(g)	Parameter [2]	Males		Females	
		Cobb	Ross	Cobb	Ross
		Carcass (g)			
Water	a	1,788 [a]	1,795 [a]	1,728 [a]	1,848 [a]
	b	0,925 [a]	0,921 [a]	0,929 [a]	0,910 [a]
Ether extract	a	-1,483 [a]	-1,770 [b]	-1,767 [b]	-1,837 [b]
	b	1,164 [b]	1,210 [ab]	1,243 [a]	1,263 [a]
Ashes	a	-1,167 [a]	-1,182 [a]	-0,981 [a]	-1,209 [a]
	b	0,916 [a]	0,923 [a]	0,865 [a]	0,923 [a]

1- [a-b] Within each component, values followed by different letters in the same row are different (P>0,05). [1] Natural logarithm (Neperian).[2] a = regression constant; b = coefficient of the regression slope.

in Table 4. According to these equations, there were no breed or sex differences for water and ash body weight. Body fat weight was different for Cobb males as compared to Ross males and females and to Cobb females.

The results obtained in the present study demonstrate that growth curves and nutrient deposition was different between Ross and Cobb and males and females. This suggests that Cobb and Ross must apply different feeding programs to allow maximum growth. The obtained data are consistent with Neme (2006), who asserts that the knowledge of the body weight is not sufficient to determine bird requirements, and that body composition must be evaluated to improve feeding programs.

CONCLUSIONS

Growth rates and body nutrient deposition were different for the studied breeds and sexes. Cobb birds presented earlier growth and protein and ash deposition, whereas Ross birds had earlier water deposition.

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