Modeling Growth Characteristics of Meat-Type Guinea Fowl

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ABSTRACT This study was conducted to describe the growth pattern of the French guinea fowl, a meat-type variety. Using BW data from hatch to 9 wk, 2 nonlinear mathematical functions (Gompertz and logistic) were used to estimate growth patterns of the French guinea fowl. The French guinea fowl did not exhibit sexual dimorphism for growth characteristics. From the Gompertz model, the asymptotic BW, growth rate, and age at maximum growth were 2.05 kg, 0.25 kg/wk, and 5.74 wk in males, respectively, and 2.03 kg, 0.25 kg/wk, and 5.72 wk in females, respectively. The ages at maximum growth were 5.75 and 5.74 wk for males and females, respectively, using the logistic model. Differences in asymptotic BW between males and females were not significant in both Gompertz and logistic models. However, the average asymptotic BW of about 1.50 kg for both sexes predicted by the logistic model was below the average predicted BW from the Gompertz model (2.04 kg) at 9 wk. Also, the logistic model overestimated hatching weight (0.06 kg) more than the Gompertz model (0.03 kg), suggesting that the growth pattern of the French guinea fowl is Gompertz. The inverse relationship between the asymptotic weight and age at maximum growth of the French guinea fowl is similar to that of the pearl gray guinea fowl, chickens, quail, and ducks. Understanding the growth characteristics of French guinea fowl will contribute to the efforts of improving production efficiency of this least studied avian species.

Key words: guinea fowl, growth pattern, Gompertz and logistic models

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INTRODUCTION

Guinea fowl production as a meat bird has proven to be a viable and profitable enterprise, thus providing opportunity for commercialization in many parts of the globe. A recent survey (Nahashon et al., 2004) indicated that interest in guinea fowl as an alternative poultry and specialty meat bird in the United States appears to be increasing. Earlier, Phillips and Ayensu (1991) also reported that the United States was studying ways to establish industrial production of guinea fowl. The French variety of guinea fowl is raised primarily for meat. Although their growth rate is slower than that of broiler chickens, the carcass yield of male and female guinea broilers at 12 wk of age is about 76.8 and 76.9%, respectively (Hughes and Jones, 1980). In recent studies evaluating the optimum CP and ME for the French guinea fowl broiler, Nahashon et al. (2005) reported carcass yields of about 70% at 8 wk of age.

Turning guinea fowl production into a profitable enterprise will, in part, require understanding of their growth characteristics and patterns. The growth patterns will allow the design of optimum management practices and profitability of the guinea fowl production enterprise. The general importance of mathematical models of growth and their use in poultry was emphasized in earlier reports (Anthony et al., 1991; Knížetová et al., 1991; Aggrey, 2002). These models are useful because they summarize time series data into a few parameters to enable an objective comparison of the growth efficiencies. When these functions are expressed graphically, irregular fluctuations in weight caused by random environmental effects are usually eliminated. The application of mathematical growth models in combination with feed consumption data is important in bioeconomical studies because, according to Pasternak and Shalev (1983), the cumulative feed consumption up to slaughter weight is dependent on both growth rate and the shape of the growth curve. Brody (1945) suggested that the asymptotic or mature weight, rate of attainment of mature weight, and the standardized age at which an animal attained the inflection point of the curve were quantities that could be manipulated by geneticists. Sigmoid, logistic, and polynomial models have been fitted to growth curves of chickens (Grossman and Bohren, 1982). The Gompertz model (1925) as modified by Laird et al. (1965) has been cited as the model of choice for chicken data because of its overall fit and the biological meaning of the model parameters (Ricklefs, 1985; Mignon-Grasteau et al., 1999). Aggrey (2002) recently compared 3 nonlinear (Richards, logistic, and

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Gompertz) and spline linear regression models for describing chicken growth curves. Although recent reports have highlighted the growth pattern of the pearl gray guinea fowl (Nahashon et al., 2004), information on the growth characteristics of the French guinea fowl broiler is scanty. It would be useful to study the growth pattern of French guinea fowl broiler to provide the basis for improvement. The objective of this study was to describe the growth pattern of the French guinea fowl broiler using the 2 nonlinear mathematical models: Gompertz and logistic. The information realized from this study will be used to design optimum management schemes, including feeding regimens for the French guinea fowl broiler.

MATERIALS AND METHODS

Animals and Management

A total of 216 day-old randombred guinea keets of the French variety were obtained from a commercial source (Ideal Poultry Breeding Farms, Cameron, TX). Birds were weighed individually and randomly assigned to electrically heated, thermostatically controlled Petersime (Petersime Incubator Company, Gettsburg, OH) battery brooders equipped with raised wire floors from hatch to 4 wk of age (**WOA**). The battery cages measured 99 × 66 × 25 cm, and each housed about 11 birds. At 1 d of age, the brooder temperature was maintained at 32.2°C for the first week and was reduced gradually by 2.8°C every week until 23.9°C, and from this point on no artificial heating was provided to the birds. At 5 WOA the keets were transferred into growing batteries that were not supplied with supplemental heating, but room temperature was maintained at 21.1°C. The growing batteries measured 162 × 68 × 33 cm and housed 11 birds from 5 to 9 WOA. Ventilation within the growing cages was maintained by exhaust fans controlled by a thermostat. The birds received 23 h constant lighting from hatch to 9 WOA. All birds were fed corn-soy-based diets containing 23% CP and 3,100 kcal of ME/kg of diet at hatch to 4 WOA and 21% CP and 3,150 kcal of ME/kg of diet from 5 to 9 WOA (Table 1). These diets were reported to provide optimum performance of the French variety of guinea fowl (Nahashon et al., 2005). The diets were fed in mash form and were provided for ad libitum consumption. Body weights were measured weekly from hatch to 9 wk, and mortality was recorded as it occurred.

Growth Models

Most poultry growth data is fit with the Gompertz model (Anthony et al., 1991; Barbato, 1992; Aggrey, 2002). The Gompertz model was therefore used as the standard to which the logistic model was compared.

Gompertz-Laird Model. The Laird form of the Gompertz equation (Laird et al., 1965) was fit to the data. The following equation describes the Gompertz-Laird growth curve:

Table 1. Composition of experimental diets

Ingredient	Week of age ME, kcal/kg CP, %	0 to 4 3,100 23	5 to 9 3,150 21
		%	
Corn, yellow #2 (8% CP)		52.32	57.00
Soybean meal (48% CP)		35.70	30.90
Alfalfa meal (17% CP)		1.00	1.00
Meat and bone meal (50% CP)		3.00	3.00
Poultry blended fat		4.90	5.05
Dicalcium phosphate (18% P, 22% Ca)		1.86	1.86
Limestone flour (38.8% Ca)		0.52	0.52
Salt		0.30	0.30
Vitamin-mineral premix[1]		0.25	0.25
DL-Methionine[2] (98%)		0.15	0.12
Calculated level			
Metabolizable energy, kcal/kg of diet		3,100	3,150
Crude protein, %		23	21
Calcium, %		1.00	1.00
P, total		0.71	0.71
Available P, %		0.47	0.47
Methionine, %		0.51	0.45
Methionine + cystine, %		0.88	0.80
Lysine, %		1.27	1.14

[1]Provided per kilogram of diet: retinyl acetate, 3,500 IU; cholecalciferol, 1,000 ICU; DL-α-tocopheryl acetate, 4.5 IU; menadione sodium bisulfite complex, 2.8 mg; vitamin B_{12}, 5.0 mg; riboflavin, 2.5 mg; pantothenic acid, 4.0 mg; niacin, 15.0 mg; choline, 172 mg; folic acid, 230 mg; ethoxyquin, 56.7 mg; manganese, 65 mg; iodine, 1 mg; iron, 54.8 mg; copper, 6 mg; zinc, 55 mg; selenium, 0.3 mg.

[2]Degussa Corporation, Kennesaw, GA.

$$W_t = W_0 \exp[(L/K)(1 - \exp\text{-}Kt)],$$

in which W_t is the weight of bird at time t, W_0 is the initial body (hatch) weight, L is the instantaneous growth rate (per week), K is the rate of exponential decay of the initial specific growth rate, L, which measures the rate of decline in the growth rate. The parameters derived for the inflection point, ti, the body weight at the inflection point, and the asymptotic body weight, W_A, are

$$ti = (1/K)\log(L/K),$$
$$Wi = W_0 \exp((L/K)^{-1}), \text{ and}$$
$$W_A = W_0 \exp(L/K).$$

Logistic Model. The following equation describes the logistic (Robertson, 1923) growth model:

$$W_t = W_A/[1 + \exp\text{-}K(t - ti)],$$

in which W_t is the body weight at time t, W_A is the asymptotic body weight, K is the exponential growth rate, and ti is the age at the inflection point. Differences between sex and growth curve parameters among prediction models were evaluated by the *t*-test (SAS, 1999).

RESULTS AND DISCUSSION

The Gompertz and logistic models were used to assess growth patterns of the French guinea fowl, a meat-type variety. Means and SD of BW of both male and female

Table 2. Means and standard deviation for body weight at different ages in a randombred population of the French guinea fowl broiler

	BW (g)	
Age (wk)	Male (n = 125)	Female (n = 91)
0	28.9 ± 4.4	27.8 ± 4.7
1	74.8 ± 8.6	73.6 ± 8.7
2	160.1 ± 24.4	157.8 ± 24.3
3	296.2 ± 40.3	293.3 ± 40.9
4	465.7 ± 58.4	462.2 ± 57.1
5	561.4 ± 67.3	555.9 ± 67.9
6	810.9 ± 95.4	808.6 ± 85.5
7	1,017.3 ± 105.2	1,013.2 ± 108.2
8	1,145.6 ± 114.7	1,138.9 ± 118.9
9	1,312.5 ± 132.6	1,304.9 ± 123.8

French guinea fowl broilers are presented in Table 2. Generally, males appeared to be slightly heavier than females; however, these differences between the sexes were not significant. These observations were consistent with previous reports (Nahashon et al., 2004) in which males of the Pearl Grey variety of the guinea fowl also exhibited higher BW than their female counterparts. The SD of the predicted BW increased with age, a common phenomenon of time series data (Table 2). The fitted parameters for 2 nonlinear models for growth are presented in Table 3.

From Table 3 the logistic model overpredicted hatching weights and also underpredicted the asymptotic BW of the French variety of the guinea fowl when compared with the Gompertz model. The average asymptotic BW of 1.50 kg predicted by the logistic model was lower than the asympototic BW of 2.04 kg predicted by the Gompertz models. This implies that the growth pattern of the French variety of the guinea fowl broiler was closer to the Gompertz than the logistic model. The age at maximum growth predicted by the Gompertz model for both males and females was comparable with the predictions from the logistic model. The average ages at maximum growth were 5.74 and 5.75 wk in males, and 5.72 and 5.74 wk in females for the Gompertz and logistic models, respectively. The exponential growth rate was also higher (0.55) in males and females for the logistic model than the Gompertz model (0.25), which may further explain the underprediction of the asymptotic BW by the logistic model. This augments the fact that the logistic model least fit the data on the French guinea fowl broiler compared with the Gompertz model. An inverse relationship between the asymptotic weight and both hatch weight and age at maximum growth was observed in the French guinea fowl broiler. The higher the asymptotic BW, the lower the hatch weight and age at maximum growth. Similar observations were reported previously for the pearl gray guinea fowl (Nahashon et al., 2004), geese, chickens, and quail (Knížetová et al., 1991; Mignon-Grasteau et al., 1999; Aggrey, 2002; Aggrey et al., 2003).

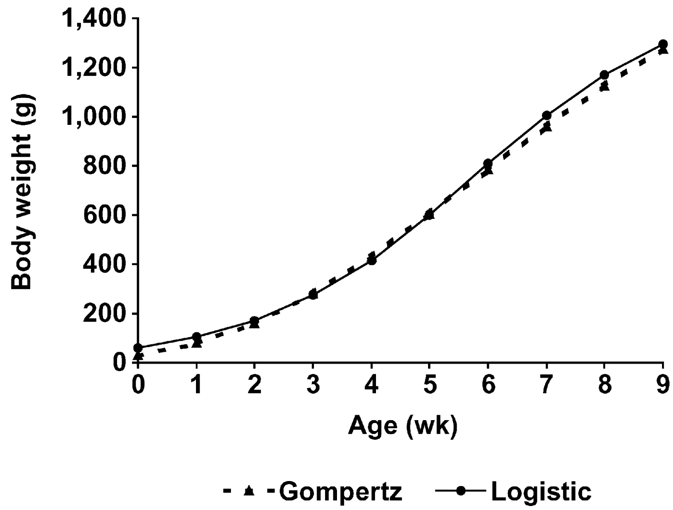

Figure 1. Growth curve of French guinea fowl broiler as predicted by Gompertz and logistic models.

Unlike the Pearl Grey guinea fowl (Nahashon et al., 2004), chicken (Mignon-Grasteau et al., 1999; Aggrey, 2002), and geese (Knížetová et al., 1994), the French guinea fowl broiler did not exhibit sexual dimorphism. However, males of the French guinea fowl broiler exhibited a high asymptotic BW compared with the females. Males of chickens and geese have also exhibited higher asymptotic BW compared with the females (Knížetová et al., 1991; Mignon-Grasteau et al., 1999). A similar pattern was observed in quail (Aggrey and Cheng, 1994; Du Preez and

Table 3. Estimated coefficients (±SE) and confidence limits (CL) for Gompertz and logistic model growth parameters in a randombred population of the French guinea fowl broiler

Model	Male (n = 125) Parameter	95% CL	Female (n = 91) Parameter	95% CL
Gompertz				
Hatching weight (W_0)	31.93 ± 2.48	27.07 – 36.80	30.80 ± 2.81	25.28 – 36.32
Initial growth rate (L)	1.03 ± 0.04	0.95 – 1.12	1.04 ± 0.04	0.95 – 1.14
Rate of decay (K)	0.25 ± 0.01	0.23 – 0.26	0.25 ± 0.01	0.23 – 0.27
Age of maximum growth[1] (t*)	5.74 ± 0.04	5.24 – 5.92	5.72 ± 0.06	5.32 – 5.97
Asymptotic weight[1] (W_A)	2,050.75 ± 12.60	1,978.36 – 2,173.84	2,027.14 ± 11.96	1,915.40 – 2,089.31
Logistic				
Asymptotic weight (W_A)	1,511.70 ± 18.75	1,474.91 – 1,548.52	1,499.00 ± 21.28	1,457.22 – 1,540.77
Exponential growth rate (K)	0.55 ± 0.01	0.53 – 0.57	0.55 ± 0.01	0.53 – 0.58
Age of maximum growth (ti)	5.75 ± 0.06	5.63 – 5.87	5.74 ± 0.07	5.60 – 5.87
Hatching weight[1] (W_0)	61.16 ± 3.55	59.42 – 63.78	59.84 ± 3.17	58.25 – 60.46

[1]Derived parameters.

Sales, 1997; Aggrey et al., 2003). The growth curves of the French guinea fowl broiler as predicted by the Gompertz and the logistic models are presented in Figure 1. Mean BW estimates from hatch to 2 WOA, and 6 to 9 WOA using the Gompertz model seem to lag compared with that of the logistic model. However, the 2 models do not seem to differ in their estimates of BW for the French guinea fowl broiler from 2 to 6 WOA.

Growth curves of animals have undoubtedly displayed significant evolutionary and fitness implications in contemporary breeding programs (Famula et al., 1988). Therefore, success in studying the growth characteristics of the French guinea fowl broiler will contribute to the efforts of genetically improving this least studied avian species. In addition, understanding growth characteristics of the French guinea fowl will aid in designing feeding schemes to maximize production efficiency while minimizing production cost. Feeding accounts for about 60 to 80% of the total cost of poultry production (Pym, 1990); thus, designing birds that are highly efficient in utilizing feed for growth in concurrence with appropriate feeding schemes will profit the guinea fowl industry (Fedkiw et al., 1992).

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