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Growth Functions of Live Body Weight and Edible Parts of Japanese Quail and Dandarawi Chickens

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ABSTRACT

A total number of 700 Dandarawi chickens (150 males and 450 females) and a total number of 480 Japanese quail (120 males and 360 females) used to estimate growth curve in Gompertz and Logistic models. Data of body weight, empty carcass weight, giblets (liver, gizzard, and heart), neck, breast and femur muscle weights were fitted with age to compared values obtained by applying the Gompertz and logistics. Logistic was the best model in this study to describe growth of quail and Dandarawi chickens.The results indicated that an inverse relationship was found between asymptotic body weight and empty carcass weight with corresponding K value when comparing the species. The same relation was noticed between sexes but with less extend. The exponential growth rate of empty carcass weight was higher than that of body weight.There was also positive relationship in sexes within species between asymptotic weight and age at inflection point. That is mean the heavy body weight of specific sex and empty carcass weight spent more time in the phase of fast growth compared with the sex of lower asymptotic weight. It was found that the larger liver weight, the lower exponential growth rate. Giblets and neck of Japanese quail had higher exponential growth rate compared to Dandarawi chickens. Exponential growth rate of female quail was lower compared to other giblets; this may due to the different type of growth of liver. Minor pectoralis muscle takes more time in fast growth phase than that of major pectoralis and femur muscles in both quail and Dandarawi chicken. All studies of chicken muscles spent more time in fast growth phase compared to those of quail. All muscles studied of Japanese quail had higher exponential growth rate than the Dandarawi chickens.

Key words: Growth, Live body weight, Edible parts, Japanese quail, Dandarawi chickens.

Introduction

Growth functions are the most adequate means for describing the growth pattern of live body weight (BW) or body parts, because they summarize the information into a few parameters that may be interpreted biologically. The general importance of mathematical models of growth and their use in poultry was emphasized in earlier reports (Anthony *et al.,* 1991; Knizetova *et al.,* 1991 a and b; Aggrey, 2002). These models are useful because they summarize time series data into 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 bio-economical 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. Understanding the biology of model parameters and their relationships provides a sound basis for developing a breeding strategy to modify or change the trajectory of growth.

A number of nonlinear models (NLM) have been used to describe growth curves in chickens. Sang (1962), Grossman and Bohren (1982), and Grossman *et al.,* (1985) applied the logistic function to chickens data, although its symmetrical form does not correspond to the growth pattern of chickens (Knizetova *et al.,* 1991a). The Laird form (Laird *et al.,* 1965) of the Gompertz model (Gompertz, 1825) has been the model of choice for chickens data (Tzeng and Becker, 1981; Anthony *et al.,* 1991; Barbato, 1991 and Mignon-Grasteau *et al.,* 1999) because of its overall fit and the biological meaning of the model parameters (Ricklefs, 1985).

Variation in growth curves of different species of birds has been discussed extensively by Ricklefs (1968, 1973, and 1979). Many of the differences among species are related to the pattern of development, a particular species must complete prior to maturity. Within precocial species there is a broad spectrum of growth curves (Ricklefs and Marks, 1985). Despite evolutionary consistencies between Japanese quail and chickens and general similarities in heritabilities for BW of quail (Nestor *et al.,* 1982) and chickens (Kinney, 1969 and Scanes, 1987), there are physiological differences in growth. The BW of the Japanese quail at sexual maturity is similar to the BW of chickens at 3 wk of age. These vast differences in BW, however, are not within the same time frame, because the approximate age of sexual maturity for quail and chickens is 6 and 22 weeks,

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respectively (Ensminger, 1980). Sexual dimorphism typically found in the chickens is not seen in quail; females are heavier than males through much of the growth period.

In general, growth curves of precocial poultry species follow the sigmoid curve as described by Brody (1945). Growth curve analysis revealed that selection may alter the pattern of growth through adjustments in maximum BW (asymptote) and form of the growth curve as described by point of inflection (POI) (Anthony *et al.,* 1986). The BW selection that occurred during the varying durations of domestication [quail, 11th century AD and chickens, 4,000 BC (Ensminger, 1980)] may have influenced growth curves.

Aspects of interest may then be compared among species, sexes, or lines. Of interest are asymptote, point of inflection, and hatching weight. Ricklefs (1967) stated that growth curves of the same or different species are not necessarily best described by the same equation. These may be classified into three groups. The first implies that variation in growth rates may be related directly to the environment. The second suggests variations represent the effect of parental reproductive effort - the parents ability to feed and satisfy all the young produced. The third suggests that variations in growth rate are results of constraints imposed on the anatomy and physiology of the bird (Ricklefs, 1985). Each is a three parameters model that describes growth in terms of an asymptote or mass at maturity, a rate at which the asymptote is attained and mass of the organism at zero age (Ricklefs, 1973).

The experiment aimed to determine the best equation for BW and edible part weights of males and females in the Japanese quail and Dandarawi chickens. Determination of growth curve parameters such as asymptotic weight and POI are also one of the objectives. The information realized from this study will be used to design feeding and/or selection programs for the Japanese quail and Dandarawi chickens raised for meat consumption.

Materials and Methods

Experimental birds and design:

The study was conducted at the Poultry Experimental Station, Faculty of Agriculture, Al-Azhar University, Nasr City, Cairo, Egypt, to investigate growth curves in two types of birds (Dandarawi chickens and Japanese quail). The study was executed in two experiments to accomplish its objectives. First experiment was conducted on Dandarawi chickens obtained from Al Azab farm, Fayoum. A total number of 700 Dandarawi chickens (150 males and 450 females) were used in first experiment. The experiment lasted from day old up to 30 weeks of age. In second experiment a total number of 480 (120 males and 360 females) Japanese quail obtained from Faculty of Agriculture, Benha University- Moshtohor. The experiment lasted from day old up to 12 weeks of age.

Experimental diets and management:

All chicks were reared on floor pens. All birds were healthy and clinically monitored. The brids were vaccinated on a standard vaccination schedule. The composition and calculated chemical analysis of the experimental diets are summarized in Table (1 and 2).

Birds were subjected to standard light regimes during growth and laying period. Birds had free access to feed and water.

Experimental data:

Body weight (BWT):

Live body weight of Japanese quail and Dandarawi chickens was individually recorded to the nearest (0.1g) weekly from the 1st to the end of experiment.

Sacrifice trail:

Ten birds (5 males and 5 females) were randomly taken weekly during experimental period and slaughtered for carcass evaluation. After slaughtering, empty carcass, neck and the giblet (gizzard, liver and heart) weights were recorded to the nearest 0.001 g. In addition, minor and major left pectoral muscles and biceps femoris of left femur were excised and weight to the nearest 0.001g.

Statistical analysis:

Data were fitted to Gompertz equation according to laird (1965) and logistic equation according to Robertson (1923). Hatch weight, asymptotic weight, age and weight of infliction point and rate of exponential decay of the initial specific growth rate (k) and initial growth rate (L) were determined. The statistical analysis of data was carried out by applying the software package of SAS (1988) using NLIN procedure with Marquardt minimizing method. Standard deviation of residuals (SD) and R^2 were used to compare the validity of fitting data to the functions.

Table 1: Composition of experimental diets of Japanese quail (Coturnix coturnix japonica).

Ingredients	**Grower diet**	**Layer diet**
Ground yellow corn 8.8%	53.56	60.50
Soybean meal 44%	34.75	21.14
Corn gluten meal 60%	8.70	10.60
Dicalcium phosphate	0.81	1.23
Limestone	1.35	5.68
[1]Vitamin and mineral premix	0.30	0.30
Sodium Chloride (NaCl)	0.30	0.30
DL-methionine	0.09	0.08
L-lysine-HCl	0.14	0.17
Total (Kg)	**100**	**100**
Calculated analysis[2]		
Crude protein%	24.05	20.01
ME. cal/Kg feed	2900.37	2900.84
C/P ratio	120.60	144.97
Calcium%	0.80	2.50
Available Ph.%	0.30	0.35
Lysine%	1.30	1.00
Methionine%	0.50	0.45
Methionine + Cystin%	0.92	0.82

*[1]**Composition of vitamin and mineral premix.** Each 3Kg of vitamin and minerals mixture contain: Vit. A 10,000,000 IU, Vit. D3 2,000,000 IU, Vit. E 10,000 mg, Vit. K3 1,000 mg Vit. B1 1,000 mg, Vit. B2 5,000 mg, Vit. B6 1,500 mg, Vit B12 10 mg, Niacin 20,000 mg, Pantothenic acid 10,000 mg, Folic acid 1,000 mg, Biotin 50 mg, Choline chloride 500,000 mg, Copper 4,000 mg, Iodine 300 mg, Iron 30,000 mg, Manganese 60,000 mg, Zinc 50,000 mg, Cobalt 100 mg and Selenium 100 mg.*
[2] According to NRC,(1994).

Table 2: Composition of experimental diets of Dandarawi chickens.

Ingredients	**1 – 3 weeks**	**4 – 8 weeks**	**9 – 16 weeks**	**17 weeks – first egg**
Ground yellow corn 8.8%	56.5	59.5	68	60.39
Soybean meal 44%	14.5	21.1	17.53	14.29
Corn gluten meal 60%	14.5	5.39	-	8.7
Wheat bran 15.7%	10	10	11	10
Dicalcium phosphate	1.91	1.72	1.35	1.77
Limestone	1.47	1.41	1.4	4.07
[1]Vitamin and mineral premix	0.3	0.3	0.3	0.3
Sodium Chloride (NaCl)	0.3	0.3	0.3	0.3
DL-methionine	0.06	0.09	0.12	0.02
L-lysine-HCl	0.46	0.19	-	0.16
Total (Kg)	**100**	**100**	**100**	**100**
Calculated analysis[2]				
Crude protein%	21.03	18.54	14.6	17.57
ME. Cal/Kg feed	2903	2804	2815	2802
C/P ratio	138.04	151.24	192.81	159.48
Calcium%	1.05	1	0.91	2
Available Ph.%	0.48	0.45	0.37	0.45
Lysine%	1.2	1.03	0.71	0.85
Methionine%	0.47	0.4	0.34	0.36
Methionine + Cystin%	0.85	0.74	0.61	0.69

*[1]**Composition of vitamin and mineral premix.** Each 3Kg of vitamin and minerals mixture contain: Vit. A 10,000,000 IU, Vit. D3 2,000,000 IU, Vit. E 10,000 mg, Vit. K3 1,000 mg Vit. B1 1,000 mg, Vit. B2 5,000 mg, Vit. B6 1,500 mg, Vit B12 10 mg, Niacin 20,000 mg, Pantothenic acid 10,000 mg, Folic acid 1,000 mg, Biotin 50 mg, Choline chloride 500,000 mg, Copper 4,000 mg, Iodine 300 mg, Iron 30,000 mg, Manganese 60,000 mg, Zinc 50,000 mg, Cobalt 100 mg and Selenium 100 mg.*
[2] According to NRC,(1994).

Results and Discussion

Growth functions comparison:

Fitting data of body weight, empty carcass, giblets (Liver, gizzard and heart), neck, breast and femur muscle weights with time using logistic and Gompertz equations for males and females Dandarawi chickens and Japanese quail produced parameters showed in tables (3, 5, and 7, respectively) for logistic and tables (4, 6, and 8, respectively) for Gompertz. All models were significant ($P \leq 0.0001$) and R^2 of all equations ranged between 0.99 and 0.98 for the specified weights. The standard deviation of residuals of logistic equations was mostly lower than that of Gompertz.

In tables (3, 4, 5, 6, 7 and 8) fitting data using logistic equation showed better fitting for asymptotic weight in most of the specified weights. The same trend was found by Gompertz but for quail only. In addition, table (4) revealed that Gompertz equation is overestimating the asymptotic weight of body weight, and empty carcass weight. On the other hand, tables (7, and 8) showed that the asymptotic weights of femur muscle were underestimated by either logistic or Gompertz equations.

Concerning day old chick, logistic equation fitted data of body weight, empty carcass, and quail liver, gizzard and neck weights with good approach (Tables 3, 5, 7). However, hatch weight of other organ weights fitted by logistic were overestimated or underestimated. Concerning fitting with Gompertz, body weight of Dandarawi was good (Table, 4). All other organ weights of quail showed underestimated weights by Gompertz equation (Tables 4, 6 and 8). Dandarawi data failed to converge when fitted with Gompertz equation except for body weight data (Tables, 4, 6 and 8).

This reveals that logistic equation is the equation of choice to describe the growth of body weight, empty carcass, giblets, neck, and muscle weights in both sexes and species. The use of logistic equation for fitting the data of males and females chicken body weight was found to be valid (Nahashon *et al.,* 2006; Grossman and Bohren, 1985) for males and females Japanese quail growth data.

Live body weight and empty carcass weight:

Parameters of logistic growth function:

Table (3) shows that age at inflection point of males and females Japanese quail for body weight were 4.04 and 4.42 weeks of age, respectively. These represented 33.7 and 36.8 % of the age to asymptotic weight, respectively. Meanwhile, the corresponding ages for Dandarawi chickens were 14.85 and 14.02 weeks of age, respectively. These represented 49.5 and 46.7% of the age to asymptotic weight, respectively. Eleroglu, *et al.,* (2014) they found that age at inflection point 11.04 and 10.37 weeks for males and females in Hubbard Grey Barred chickens.

Age at inflection point of males and females Japanese quail for empty carcass weight were 4.48 and 4.56 weeks of age, respectively. These represented 37.33 and 38.00 % of the age to asymptotic weight, respectively. Meanwhile, the corresponding ages for Dandarawi chickens were 16.12 and 15.16 weeks of age, respectively. These represented 53.73 and 50.53% of the age to asymptotic weight, respectively.

Table (3) shows that the exponential growth rate (K) of males and females Japanese quail for body weight were 0.71 and 0.68, respectively. Meanwhile the corresponding exponential growth rate of Dandarawi chickens were 0.21 and 0.22, respectively. The exponential growth rate of males and females Japanese quail for empty carcass weight were 0.74 and 0.77, respectively. Meanwhile, the corresponding ages for Dandarawi chickens are 0.21 and 0.22, respectively.

Generally an inverse relationship was noticed between asymptotic body weight and empty carcass weight with corresponding K value when comparing the species. The same relation was noticed between sexes but with less extend. The high exponential growth rate of quail than Dandarawi chickens may interpret the high protein requirement of quail compared to Dandarawi chickens. The exponential growth rate of empty carcass weight was higher than that of body weight.

There was also positive relationship in sexes within species between asymptotic weight and age at inflection point. That means the heavy body weight of specific sex and empty carcass weight spent more time in the phase of fast growth compared with the sex of lower asymptotic weight.

Empty carcass spent more time in the fast growth phase than the live body weight as indicated by the percent of age at inflection point to age of asymptotic weight.

Giblets and neck weights:

Parameters of logistic growth function:

Table (5) shows that age at inflection point of males and females Japanese quail for liver were 2.43 and 4.09 weeks of age, respectively. These represented 20.25 and 34.1 % of the age to asymptotic weight, respectively. Meanwhile the corresponding ages for Dandarawi chickens were 8.44 and 9.87 weeks of age, respectively. These represented 28.13 and 32.90% of the age to asymptotic weight, respectively.

Age at inflection point of males and females Japanese quail for gizzard were 2.02 and 2.28 weeks of age, respectively. These represented 16.83 and 19.00 % of the age to asymptotic weight, respectively. Meanwhile the corresponding ages for Dandarawi chickens were 9.55 and 10.28 weeks age, respectively. These represented 31.83 and 34.26% of the age to asymptotic weight, respectively.

Age at inflection point of males and females Japanese quail for heart were 3.71 and 3.88 weeks of age, respectively. These represented 30.91 and 32.33 % of the age to asymptotic weight, respectively. Meanwhile the corresponding ages for Dandarawi chickens were 12.49 and 12.02 weeks, respectively. These represented 41.63 and 40.06% of the age to asymptotic weight, respectively.

Age at inflection point of males and females Japanese quail for neck were 3.59 and 3.77 weeks, respectively. These represented 29.91 and 31.41 % of the age to asymptotic weight, respectively. Meanwhile the corresponding ages for Dandarawi chickens were 14.34 and 13.45 weeks of age, respectively. These represented 47.80 and 44.83% of the age to asymptotic weight, respectively.

The exponential growth rate of males and females Japanese quail for liver were 0.91 and 0.63, respectively. Meanwhile the corresponding ages for Dandarawi chickens were 0.29 and 0.25, respectively. Exponential growth rate of males and females Japanese quail for gizzard were 0.86 and 0.83, respectively. Meanwhile the corresponding ages for Dandarawi chickens were 0.12 and 0.19, respectively. The exponential growth rate of males and females Japanese quail for heart were 0.72 and 0.74, respectively. Meanwhile the corresponding ages for Dandarawi chickens were 0.21 and 0.20, respectively. The rate of exponential growth rate of male and female Japanese quail for neck were 0.67 and 0.63, respectively. Meanwhile the corresponding ages for Dandarawi chickens were 0.25 and 0.22, respectively.

It could be noticed that the larger liver weight, the lower exponential growth rate. Giblets and neck of Japanese quail had higher exponential growth rate compared to Dandarawi chickens. Exponential growth rate of females quail liver was lower compared to other giblets this may due to the different types of growth of liver. The major increase in live weight is due to accumulation of fats before sexual maturity. However, the increase in weight in other giblets is due to increase in cell number and/or sizes.

Breast and thigh muscles:

Parameters of logistic growth function:

Table (7) shows that age at inflection point of males and females Japanese quail for minor pectoralis were 4.97 and 5.29 weeks of age, respectively. These represented 41.41 and 44.08 % of the age to asymptotic weight, respectively. Meanwhile the corresponding ages for Dandarawi chickens were 22.66 and 19.58 weeks, respectively. These represented 75.53 and 65.26% of the age to asymptotic weight, respectively.

Age at inflection point of males and females Japanese quail for major pectoralis were 4.71 and 4.49 weeks of age, respectively. These represented 39.25 and 37.41 % of the age to asymptotic weight, respectively. Meanwhile the corresponding ages for Dandarawi chickens were 16.11 and 16.45 weeks of age, respectively. These represented 53.70 and 54.83% of the age to asymptotic weight, respectively.

Age at inflection point of males and females Japanese quail for femur muscles were 4.33 and 4.50 weeks of age, respectively. These represented 36.08 and 37.50 % of the age to asymptotic weight, respectively. Meanwhile the corresponding ages for Dandarawi chickens were 16.66 and 16.60 weeks of age, respectively. These represented 55.53 and 55.33% of the age to asymptotic weight, respectively.

Table (7) shows that the exponential growth rate of males and females Japanese quail for minor pectoralis were 0.87 and 0.86, respectively. Meanwhile the corresponding ages for Dandarawi chickens were 0.16 and 0.18, respectively. The exponential growth rate of males and females Japanese quail for major pectoralis were 0.87 and 1.00, respectively. Meanwhile the corresponding ages for Dandarawi chickens were 0.22 and 0.21, respectively. The exponential growth rate of males and females Japanese quail for femur muscles were 0.85 and 0.84g, respectively. Meanwhile the corresponding ages for Dandarawi chickens were 0.21 and 0.23g, respectively.

It could be noticed that the minor pectoralis muscles spent more time in fast growth phase than that of major pectoralis and femur muscles in both quail and Dandarawi chicken. All studies of Dandarawi chickens muscles spent more time in fast growth phase compared to those of quail. All muscles studied of Japanese quail had higher exponential growth rate than the Dandarawi chickens.

Table 3: Parameter values of logistic growth model fitted to the live body weights and empty carcass weight data of males and females Japanese quail and Dandarawi chickens.

Variables	Breed	Sex	W0 (g)	AW0 (g)	Inflection point		WA (g)	AWA (g)	K	R2	SD
					Wi (g)	Ti (wk)					
Body weight	Q	M	10.57	9.59 ±0.3	98.35	4.04 ±0.11	196.7 ±3.17	197.18 ±5.01	0.71 ±0.05	0.98	12.81
	Q	F	10.54	9.54 ±0.3	111.70	4.42 ±0.18	223.4 ±5.97	231.94 ±5.01	0.68 ±0.07	0.98	22.23
	D	M	76.40	27.58 ±1.05	901.95	14.85 ±0.09	1803.9 ±10.04	1722.6 ±18.05	0.21 ±0.003	0.99	31.79
	D	F	60.68	27.47 ±1.05	693.40	14.02 ±0.12	1386.8 ±10.61	1313.2 ±18.05	0.22 ±0.004	0.99	38.42
Empty carcass	Q	M	4.29	4.09 ±0.12	61.15	4.48 ±0.11	122.3 ±2.10	125.15 ±3.82	0.74 ±0.05	0.98	8.25
	Q	F	3.60	4.02 ±0.12	62.15	4.56 ±0.15	124.3 ±2.84	129.44 ±3.82	0.77 ±0.07	0.98	11.31
	D	M	37.20	11.2 ±0.43	567.80	16.12 ±0.09	1135.6 ±7.22	1074 ±11.28	0.21 ±0.003	0.99	19.94
	D	F	28.69	11.04 ±0.43	417.25	15.16 ±0.12	834.5 ±6.46	806 ±11.28	0.22 ±0.004	0.99	21.16

W_0 = the initial (hatch) weight, AW_0 = Actual weight at hatch, Ti = Age at the inflection point, Wi = Weight at the inflection point, W_A = Asymptotic weight, AW_A = Actual asymptotic weight, K = Rate of exponential decay of the initial specific growth rate, R^2 = Coefficient of determination, SD = Standard Deviation of residuals, Q = Japanese quail, D = Dandarawi chicken, M= Male F = Female.

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Table 4: Parameter values of Gompertz-Laird growth model fitted to the live body weights and empty carcass weight data of males and females Japanese quail and Dandarawi chickens.

Variables	Breed	Sex	W0 (g)	AW0 (g)	Inflection point		WA (g)	AWA (g)	L	K (g)	R2	SD
					Wi (g)	Ti (wk)						
Body weight	Q	M	2.79 ±1.49	9.59 ±0.3	74.99	3.18	203.82	197.18 ±5.01	1.88 ±0.34	0.45 ±0.03	0.98	13.49
	Q	F	3.15 ±2.11	9.54 ±0.3	86.24	3.55	234.41	231.94 ±5.01	1.85 ±0.51	0.42 ±0.05	0.98	22.51
	D	M	26.63 ±2.33	27.58 ±1.05	753.58	12.87	2048.38	1722.6 ±18.05	0.50 ±0.01	0.11 ±0.002	0.99	34.77
	D	F	21.78 ±3.20	27.47 ±1.05	565.63	11.85	1537.49	1313.2 ±18.05	0.52 ±0.03	0.12 ±0.004	0.99	46.61
Empty carcass	Q	M	0.51 ±0.03	4.09 ±0.12	46.77	3.67	127.12	125.15 ±3.82	2.56 ±0.55	0.47 ±0.04	0.99	8.67
	Q	F	0.26 ±0.03	4.02 ±0.12	47.50	3.78	129.13	129.44 ±3.82	2.99 ±0.90	0.48 ±0.05	0.99	11.63
	D	M	CPM									
	D	F	CPM									

W_0 = the initial (hatch) weight,AW_0 = Actual weight at hatch, Ti = Age at the inflection point, Wi = Weight at the inflection point,W_A = Asymptotic weight,AW_A = Actual asymptotic weight, K = Rate of exponential decay of the initial specific growth rate, R^2 = Coefficient of determination, SD = Standard Deviation of residuales,Q = Japanese quail, D = Dandarawi chicken, M= Male F = Female,CPM= Converge not met

Table 5: Parameter values of logistic growth model fitted to the giblets and neck data of males and females Japanese quail and Dandarawi chickens.

Variables	Breed	Sex	W0 (g)	AW0 (g)	Inflection point		WA (g)	AWA (g)	K (g)	R2	SD
					Wi (g)	Ti (wk)					
Liver	Q	M	0.36	0.43 ±0.02	1.83	2.43 ±0.16	3.66 ±0.08	3.69 ±0.18	0.91 ±0.12	0.98	0.45
	Q	F	0.50	0.46 ±0.02	3.53	4.09 ±0.21	7.05 ±0.22	7.18 ±0.18	0.63 ±0.07	0.98	0.79
	D	M	2.10	1.12 ±0.04	13.17	8.44 ±0.18	26.34 ±0.28	26.82 ±1.52	0.29 ±0.01	0.99	1.88
	D	F	2.36	1.22 ±0.04	15.07	9.87 ±0.21	30.14 ±0.37	28.61 ±1.52	0.25 ±0.01	0.99	2.11
Gizzard	Q	M	0.35	0.42 ±0.01	1.17	2.02 ±0.14	2.34 ±0.04	2.16 ±0.04	0.86 ±0.09	0.98	0.24
	Q	F	0.35	0.42 ±0.01	1.34	2.28 ±0.18	2.67 ±0.07	2.54 ±0.04	0.83 ±0.12	0.98	0.34
	D	M	3.73	1.43 ±0.06	13.31	9.55 ±0.21	26.62 ±0.31	26.28 ±0.56	0.19 ±0.01	0.99	1.31
	D	F	2.58	1.42 ±0.06	15.01	10.28 ±0.15	30.01 ±0.27	29.22 ±0.56	0.23 ±0.01	0.99	1.35
Heart	Q	M	0.09	0.08 ±0.004	0.73	3.71 ±0.16	1.46 ±0.03	1.44 ±0.05	0.72 ±0.07	0.98	0.14
	Q	F	0.08	0.08 ±0.004	0.72	3.88 ±0.22	1.44 ±0.05	1.43 ±0.05	0.74 ±0.10	0.98	0.19
	D	M	0.57	0.25 ±0.01	4.21	12.49 ±0.14	8.41 ±0.07	7.81 ±0.08	0.21 ±0.01	0.99	0.29
	D	F	0.48	0.25 ±0.01	2.88	12.02 ±0.20	5.76 ±0.07	5.18 ±0.08	0.20 ±0.01	0.99	0.26
Neck	Q	M	0.38	0.34 ±0.011	2.30	3.59 ±0.11	4.60 ±0.07	4.54 ±0.10	0.67 ±0.04	0.98	0.30
	Q	F	0.42	0.33 ±0.011	2.45	3.77 ±0.16	4.90 ±0.11	4.95 ±0.10	0.63 ±0.06	0.98	0.43
	D	M	1.62	1.10 ±0.05	29.95	14.34 ±0.24	59.89 ±0.61	57.06 ±2.08	0.25 ±0.01	0.99	3.21
	D	F	1.96	1.02 ±0.05	19.91	13.45 ±0.20	39.81 ±0.79	37.57 ±1.81	0.22 ±0.01	0.99	2.34

W0 = the initial (hatch) weight,AW0 = Actual weight at hatch, Ti = Age at the inflection point, Wi = Weight at the inflection point,WA = Asymptotic weight,AWA = Actual asymptotic weight, K = Rate of exponential decay of the initial specific growth rate, R2 = Coefficient of determination, SD = Standard Deviation of residuales,Q = Japanese quail, D = Dandarawi chicken, M= Male, F = Female.

Table 6: Parameter values of Gompertz-Laird growth model fitted to the giblets and neck data of males and females Japanese quail and Dandarawi chickens.

Variables	Breed	Sex	W0 (g)	AW0 (g)	Inflection point		WA (g)	AWA (g)	L	K (g)	R2	SD
					Wi (g)	Ti (wk)						
Liver	Q	M	0.21 ±0.01	0.43 ±0.02	1.37	1.72	3.71	3.69 ±0.18	1.78 ±0.54	0.61 ±0.08	0.98	0.45
	Q	F	0.23 ±0.01	0.46 ±0.02	2.72	3.16	7.39	7.18 ±0.18	1.36 ±0.38	0.39 ±0.05	0.98	0.81
	D	M	CPM									
	D	F	CPM									
Gizzard	Q	M	0.26 ±0.01	0.42 ±0.01	0.87	1.27	2.35	2.16 ±0.04	1.34 ±0.32	0.62 ±0.07	0.98	0.25
	Q	F	0.26 ±0.01	0.42 ±0.01	0.99	1.50	2.70	2.54 ±0.04	1.34 ±0.39	0.57 ±0.08	0.98	0.35
	D	M	CPM									
	D	F	CPM									
Heart	Q	M	0.03 ±0.002	0.08 ±0.004	0.55	2.86	1.51	1.44 ±0.05	1.75 ±0.45	0.46 ±0.05	0.98	0.15
	Q	F	0.02 ±0.002	0.08 ±0.004	0.54	3.04	1.48	1.43 ±0.05	1.97 ±0.74	0.47 ±0.07	0.98	0.20
	D	M	CPM									
	D	F	CPM									
Neck	Q	M	0.20 ±0.05	0.34 ±0.011	1.75	2.68	4.76	4.54 ±0.10	1.37 ±0.22	0.43 ±0.03	0.98	0.32
	Q	F	0.21 ±0.08	0.33 ±0.011	1.87	2.84	5.10	4.95 ±0.10	1.28 ±0.26	0.41 ±0.04	0.98	0.43
	D	M	CPM									
	D	F	CPM									

W0 = the initial (hatch) weight,AW0 = Actual weight at hatch, Ti = Age at the inflection point, Wi = Weight at the inflection point,WA = Asymptotic weight,AWA = Actual asymptotic weight, K = Rate of exponential decay of the initial specific growth rate, R2 = Coefficient of determination, SD = Standard Deviation of residuales,Q = Japanese quail, D = Dandarawi chicken, M= Male F = Female.
CPM = Converge not met

Table 7: Parameter values for logistic growth model fitted to the edible muscles of males and females in Japanese quail and Dandarawi chicken.

Variables	Breed	Sex	W0 (g)	AW0 (g)	Inflection point		WA (g)	AWA (g)	K (g)	R2	SD
					Wi (g)	Ti (wk)					
Left minor pectoralis muscle (m. pectoralis profoundus)	Q	M	0.05	0.011 ±0.001	2.02	4.97 ±0.14	4.04 ±0.10	4.24 ±0.16	0.87 ±0.09	0.98	0.39
	Q	F	0.05	0.010 ±0.001	2.45	5.29 ±0.15	4.90 ±0.12	5.19 ±0.16	0.86 ±0.09	0.98	0.48
	D	M	1.08	0.03 ±0.002	20.81	22.66 ±0.55	41.62 ±1.57	33.01 ±0.41	0.16 ±0.01	0.99	1.19
	D	F	0.79	0.03 ±0.002	13.84	19.59 ±0.36	27.67 ±0.68	25.60 ±0.41	0.18 ±0.01	0.99	0.96
Left major pectoralis muscle (m. pectoralis supficialis)	Q	M	0.23	0.08 ±0.002	6.98	4.71 ±0.15	13.95 ±0.35	14.11 ±0.70	0.87 ±0.12	0.98	1.35
	Q	F	0.16	0.08 ±0.002	7.15	4.49 ±0.14	14.29 ±0.32	14.68 ±0.70	1.00 ±0.09	0.98	1.61
	D	M	1.99	0.08 ±0.003	35.50	16.11 ±0.10	71.00 ±0.49	68.4 ±0.69	0.22 ±0.003	0.99	1.39
	D	F	1.92	0.09 ±0.003	31.27	16.45 ±0.12	62.54 ±0.53	59.14 ±0.69	0.21 ±0.004	0.99	1.44
Left femur muscle (m. biceps fermoris)	Q	M	0.11	0.17 ±0.02	2.25	4.33 ±0.10	4.49 ±0.07	8.83 ±0.21	0.85 ±0.06	0.98	0.30
	Q	F	0.10	0.158 ±0.02	2.31	4.50 ±0.19	4.61 ±0.14	7.25 ±0.21	0.84 ±0.11	0.98	0.57
	D	M	2.31	0.31 ±0.01	39.38	16.66 ±0.15	78.75 ±0.80	106.5 ±1.67	0.21 ±0.004	0.99	2.02
	D	F	1.33	0.27 ±0.01	24.72	15.60 ±0.15	49.43 ±0.52	67.13 ±1.67	0.23 ±0.01	0.99	1.67

W_0 = the initial (hatch) weight,AW_0 = Actual weight at hatch, Ti = Age at the inflection point, Wi = Weight at the inflection point,W_A = Asymptotic weight,AW_A = Actual asymptotic weight, K = Rate of exponential decay of the initial specific growth rate, R^2 = Coefficient of determination, SD = Standard Deviation of residuales,Q = Japanese quail, D = Dandarawi chicken, M= Male F = Female.

Table 8: Parameter values for Gompertz-Laird growth model fitted to the edible muscles of males and females in Japanese quail and Dandarawi chickens.

Variables	Breed	Sex	W0 (g)	AW0 (g)	Inflection point		WA (g)	AWA (g)	L	K (g)	R2	SD
					Wi (g)	Ti (wk)						
Left minor pectoralis muscle (m. pectoralis profoundus)	Q	M	0.0002 ±0.00005	0.011 ±0.001	1.36	4.25	3.70	4.24 ±0.16	5.28 ±2.00	0.53 ±0.06	0.98	0.39
	Q	F	0.0001 ±0.00002	0.010 ±0.001	1.73	4.61	4.69	5.19 ±0.16	5.80 ±2.26	0.52 ±0.06	0.98	0.47
	D1	M	CPM									
	D1	F	CPM									
Left major pectoralis muscle (m. pectoralis supficialis)	Q	M	0.002 ±0.0004	0.08 ±0.002	5.29	3.98	14.38	14.11 ±0.70	4.86 ±1.78	3.98 ±0.06	0.98	1.38
	Q	F	0.0001 ±0.0001	0.08 ±0.002	5.37	3.87	14.62	14.68 ±0.70	8.33 ±3.97	3.87 ±0.08	0.98	1.61
	D	M	CPM									
	D	F	CPM									
Left femur muscle (m. biceps fermoris)	Q	M	0.004 ±0.0004	0.17 ±0.02	1.70	3.60	4.63	8.83 ±0.21	3.87 ±0.95	0.55 ±0.05	0.98	0.32
	Q	F	0.003 ±0.0005	0.16 ±0.02	1.95	3.84	5.30	7.25 ±0.21	4.06 ±1.80	0.53 ±0.08	0.98	0.58
	D	M	CPM									
	D	F	CPM									

W_0 = the initial (hatch) weight,AW_0 = Actual weight at hatch, Ti = Age at the inflection point, Wi = Weight at the inflection point,W_A = Asymptotic weight,AW_A = Actual asymptotic weight, K = Rate of exponential decay of the initial specific growth rate, R^2 = Coefficient of determination, SD = Standard Deviation of residuales, Q = Japanese quail,D = Dandarawi chicken, M= Male F = Female. CPM= Converge not met.

It could be concluded that the logistic function was valid to represent mathematically the data of live body weight, empty carcass weight, giblets weight and breast and thigh muscles weight in Japanese quail and Dandarawi chicken over time. In this type of equation, exponential growth rates were generally higher in quail than those of chicken. The difference in growth rate represented the differences of nutrient requirements between the two species. Japanese quail spent more time before inflection point than that of the chicken in most variables which supported the former conclusion.

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