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Comparison of non-linear mixed effect models of the growth curve of commercial turkeys

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Abstract

The description of the growth curve in domestic animals is of importance in management and economic decision-making. The aim here was to determine the best non-linear mixed model to adjust the growth curve in commercial turkeys. The data come from an intensive turkey farm under a subhumid tropical climate. The live weight records of 266 female and 275 male turkeys, weighed weekly, from birth to 23 weeks, were used. The models of Gompertz, $y_t = A \times \exp(-b \times \exp(-k \times t))$, and von Bertalanffy, $y_t = A \times (1-b \times \exp(-k \times t))^3$ were used to estimate parameters and predict the growth curve; where: yt = live weight at the t-th week of age; A = the expected mature weight; b = the integration constant; k = the maturation rate. Six non-linear models using the Gompertz, and von Bertalanffy functions: one with only fixed effects, four mixed models considering the fixed, 1 to 3 random effects, and a last model including the random effect of turkey were used. The analyses were performed using the NLMIXED procedure of SAS, and the selection of the best-fit model was chosen based on the Akaike (AIC) and Bayesian (BIC) information criteria. AIC and BIC values improved with the inclusion of 1 to 3 random effects, in both models for females and males. Based on AIC and BIC criteria, the best mixed NLM was the model that included random effects for A, b, and k. However, the predicted weight values of the mixed models were similar.

Keywords: Gompertz model; von Bertalanffy model; Age at maturity; Growth rate; Tropics.

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Additional information and declarations can be found on page 12

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Study contribution

Fitting growth curves for turkeys and other species is important for planning better feeding systems, improving management, and making economic decisions to increase production per bird and by batch. This study contributes to better modeling the growth curve of commercial turkeys and calculate more precise parameter estimates. It is also the first study that includes three random parameters to model the growth curve of domestic animals under tropical conditions. The results showed that mixed models with all random coefficients describe the growth curve of turkeys more precisely. Therefore, it represents an alternative to the traditional use of the non-linear fixed effects models to describe the growth curves of turkeys and probably other species.

Introduction

Knowledge of the growth curve of domestic animals in general and particularly in poultry provides an idea of the pattern of weight gain, which could be used to increase production per bird and batch; therefore, it is of importance for management and economic decision-making. The growth curve represents the live weight of the animals as a function of its age and it depends on the statistical model, genetics, feeding, and handling of the animals.

Different non-linear models like Gompertz, von Bertalanffy, Logistic, Brody, have been used to describe the growth curve in living animals, but have established the parameters of the equation as fixed effects.(1) Two of the most frequently used in domestic birds to describe growth curves are Gompertz and von Bertalanffy.(1-3) On the other hand, recently has been a great interest in mixed-effect models, which refers to the presence in the equation of the parameters of the curves, as fixed and random like with repeated measurement dataset. Fixed effect models assume that the explanatory variables have a fixed or constant relationship with the response variable across all observations.

Random models consider that some factors affecting the outcome may vary randomly across individuals or groups, which normally occurs when working with animals. Mixed models (fixed and random effects in the model) are commonly used in experiments with repeated measurements in animals when data are generated by observing an individual repeatedly over time. However, in studies with repeated measures, the measures taken in each individual are not independent, which violates some assumptions for fixed models. In addition, mixed-effects models are popular, because it is possible to manipulate the (co)variance structure matrix for non-constant correlation between observations and unbalanced data.(4) Currently, statistical programs are available for data analysis using non-linear mixed models, such as NLMIXED.(5)

Mixed models to describe growth in chickens have been described by some authors.(6,7) In turkeys, studies have been conducted using fixed-effect models to determine which one fits body weight and age data and describes the best growth curve.(1,3,8) However, to the knowledge of the authors, no information has been published on the description of the growth curve in turkeys using mixed models and under tropical conditions. The present study aimed to determine the best

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mixed model to adjust the growth curve in commercial turkeys under subhumid tropical conditions.

Materials and methods

Ethical statement

The experimental protocol was approved by the Bioethical Committee of the Faculty of Veterinary and Animal Science of the Universidad Autónoma de Yucatán, México (registration number: CB-CCBA-I-2024-002).

Study location

The study was conducted on two open houses with a capacity for 1000 turkeys each. The commercial farm was in Uman, Yucatan, Mexico, with a warm subhumid climate, rains in summer, average annual temperature of 26.2 °C, and average annual rainfall of 1 024 mm, with average relative humidity of 80 %.(9) The farm aimed to produce animals for sale. Contemporary commercial female and male turkeys (n = 266 and 275, respectively) of the hybrid converter line were wing-banded and used in this study. Management and feeding of turkeys at the farm have been described previously.(3)

Briefly, birds were kept in the open house, they had free access to water and were fed a commercial feed based on maize and soybean with the following characteristics: Diet 1 contained 28 % crude protein (CP), and 3 020 kcal metabolizable energy (ME)/kg feed from week 1 to 4; Diet 2, with 26 % CP and 3 100 kcal ME/kg feed from week 5 to 8; Diet 3, with 24 % CP and 3 150 kcal ME/kg feed in week 9 and 10; Diet 4 with 22 % CP and 3 250 kcal ME/kg in weeks 11 and 12; Diet 5 with 20 % CP and 3 350 kcal ME/kg in weeks 13 and 14; Diet 6 with 18 % CP and 3 350 kcal ME/kg in weeks 15 to 18; and Diet 7 with 16 % CP and 2 800 ME kcal/kg in weeks 19 to 23. The turkeys were vaccinated against the infectious diseases prevalent in the region. The wing-banded birds were weighed weekly from birth to 23 weeks of age.

Data collection

Data collected during the study included 4 876 and 5 098 body weights of 266 female and 275 male turkeys respectively. Each bird was measured from 9 to 23 times, because some of them died.

Growth curve model

The Gompertz and von Bertalanffy functions were used to determine the best-fit model for weight and age data, including curve coefficients as fixed and random effects. The models used here are shown in Table 1.

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Table 1. Gompertz and von Bertalanffy models to describe the growth curve of commercial turkeys using a fixed-effect model as reference and different mixed models with fixed and 1, 2 or 3 random effects

	Gompertz	von Bertalanffy
NLM0	$y_t = A \times \exp(-b \times \exp(-k \times t))$	$y_t = A \times (1\text{-}b \times \exp(-k \times t))^3$
NLM1	$y_t = (A+u_0) \times \exp(-b \times \exp(-k \times t))$	$y_t = (A+u_0) \times (1\text{-}b \times \exp(-k \times t))^3$
NLM2	$y_t = (A+u_0) \times \exp(-(b+u_1) \times \exp(-k \times t))$	$y_t = (A+u_0) \times (1\text{-}(b+u_1) \times \exp(-k \times t))^3$
NLM3	$y_t = (A+u_0) \times \exp(-b \times \exp(-(k+u_2) \times t))$	$y_t = (A+u_0) \times (1\text{-}b) \times \exp(-(k+u_2) \times t))^3$
NLM4	$y_t = (A+u_0) \times \exp(-(b+u_1) \times \exp(-(k+u_2) \times t))$	$y_t = (A+u_0) \times (1\text{-}(b+u_1) \times \exp(-(k+u_2) \times t))^3$
NLM5	$y_t = A \times \exp(-b \times \exp(-k \times t)) + u_{id}$	$y_t = A \times (1\text{-}b \times \exp(-k \times t))^3 + u_{id}$

Where: y_t = live weight at t-th week of age; A = mature weight; b = integration constant; k = maturation rate, t = weighing age in weeks. A, b, and k = fixed effects, and u_0, u_1 and u_2 = random effects of the model. The random effects u_0, u_1, and u_2 had means equal to zero, variances s^2u_0, s^2u_1, s^2u_2, and covariances s_{01}, s_{02}, s_{12}.

The fixed and random parameters of the growth curve of the different models were estimated using the NLMIXED procedure, using the iterative process: Adaptive Gaussian Quadrature for NLM0, NLM1, NLM2, NLM4 and first order (FIRO) for NLM4.[(5)] The fixed-effect model was included as a benchmark for comparing the values obtained with the mixed model coefficients. The goodness of fit of the best model was determined using the Akaike information criterium (AIC) and Bayesian information criterium (BIC), where smaller values indicate a better fit for the curve. The probability of choosing the best of two models was calculated as P = exp(-| AIC difference|/2)/(1 + exp(-| AIC difference|/2); where $P < 0.05$ indicates the significant difference between pairs of models compared.[(10)] Additionally, the correlation coefficients of the predicted weight values across between the six models were calculated.

Results

The values of AIC and BIC, as well as the values of the parameter estimates of the growth curves for Gompertz and von Bertalanffy models and by sex are shown in Tables 2 to 5. AIC and BIC values and residual errors decreased in both sexes as the number of random parameters increased, either in the Gompertz or von Bertalanffy models. The fixed model (NLM0) was included as a reference, as it is the most widely used. Based on the AIC and BIC criteria, the models with the weakest data fit were the fixed-effect model and the model that included the turkey as a random effect. The best-mixed model, for both females and males, was NLM4. Differences between models (Gompertz or Bertalanffy) or sex were significant ($P < 0.05$).

Figures 1 to 4 show the growth curves for the NLM0 and NLM4 models, as well as the growth curve of the original data, using the arithmetic means of turkeys' body weights per week of age. The expected mature weight (A) was higher and the maturation rate (k) was lower in males compared to females, in both, Gompertz and von Bertalanffy models. The correlation coefficients between the six models used are shown in Tables 6 and 7. The correlation coefficients (r) of the predicted weight values between models were high ($r > 0.95$). However, the predicted weight values of the five mixed models were also high and more similar among them ($r > 0.99$). This is supported by the Figures 1 to 4.

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Table 2. Estimates of Gompertz growth curve and selection criteria in female commercial turkeys in the tropics of Mexico parameters' (n = 266)

	Models					
Item[1]	NLM0	NLM1	NLM2	NLM3	NLM4	NML5
A	13.225±0.0636	13.349±0.077	13.171±0.0815	12.853±0.1035	12.763±0.0988	13.579±0.0655
b	4.716±0.03720	4.707±0.0196	4.762±0.0264	4.825±0.0188	4.824±0.0294	4.460±0.0408
k	0.159±0.0013	0.157±0.0007	0.1602±0.0007	0.1658±0.0011	0.165±0.0014	0.153±0.0011
AIC	7788	2482.8	1736.8	1414.0	1284.3	5432.9
BIC	7814	25007	1761.9	1439.1	1320.1	5450.8
s^2_{u0}		1.0400±0.1002	1.1969±0.1211	2.0978±0.2190	2.5127±0.2432	
s^2_{u1}			0.0913±0.01012		0.1386±0.01912	
s^2_{u2}				0.00017±0.00002	0.00039±0.00002	
S_{u01}			0.1270±0.02625		-0.2051±0.03920	
S_{u02}				-0.0139±0.00187	-0.0232±0.00186	
S_{u12}					0.00532±0.00058	
s^2id						0.1333±0.0130
s^2e	0.2887±0.00585	0.0802±0.00167	0.0622±0.00133	0.05717±0.00122	0.0526±0.00116	0.1534±0.00320

[1] Non-linear model (NLM) with or without coefficients of the curve model as random effects, and NLM5 with turkey as random effect; A = expected mature weight; b = integration constant; k = maturation rate; AIC = Akaike Information Criterion; BIC = Bayesian information criterion; s^2_{u0} = variance due to random effect of A; s^2_{u1} = variance due to random effect of b; s_{u01} = covariance between random effects of A and b; s^2_{u2} = variance due to random effect of k; s_{u02} = covariance between random effects of A and k; s_{u12} = covariance between random effects of b and k; s^2_e = variance of error; s^2_{id} = variance due to the animal.

Table 3. Estimates of von Bertalanffy growth curve and selection criteria in female commercial turkeys in the tropics of Mexico parameters' (n = 266)

	Fitted models					
Item[1]	NLM0	NLM1	NLM2	NLM3	NLM4	NML5
A	14.649±0.0948	14.925±0.0933	14.782±0.0972	14.647±0.1245	14.521±0.1264	14.624±0.0814
b	0.9317±0.0058	0.9268±0.0029	0.9325±0.0037	0.9337±0.0027	0.9380±0.0038	0.9431±0.0061
k	0.1146±0.0012	0.1125±0.0006	0.1140±0.0006	0.1148±0.0009	0.1160±0.0010	0.1193±0.0009
AIC	7639	1875.6	1068.7	889.0	755.6	5191.7
BIC	7665	1893.5	1093.8	914.1	791.4	5209.6
s^2_{u0}		1.3052±0.1250	1.5099±0.1506	2.8780±0.2711	3.1453±0.2817	
s_{u10}			0.0187±0.00387		-0.0272±0.00429	
s^2_{u1}			0.00163±0.00018		0.00223+0.00002	
s_{u20}				-0.01188±0.00096	-0.0175±0.00127	
s^2_{u2}				0.00009±0.00000	0.00018±0.00001	
s^2_{id}						0.1193±0.01109
s^2e	0.2800±0.00567	0.0703±0.00146	0.0537±0.00115	0.05155±0.00110	0.0477±0.00104	0.1465±0.00305

[1] Non-linear model (NLM) with or without coefficients of the curve model as random effects, and NLM5 with turkey as random effect; A = expected mature weight; b = integration constant; k = maturation rate; AIC = Akaike Information Criterion; BIC = Bayesian information criterion; s^2_{u0} = variance due to random effect of A; s^2_{u1} = variance due to random effect of b; s_{u01} = covariance between random effects of A and b; s^2_{u2} = variance due to random effect of k; s_{u02} = covariance between random effects of A and k; s_{u12} = covariance between random effects of b and k; s^2_e =variance of error; s^2_{id} = variance due to the animal.

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Table 4. Estimates of Gompertz growth curve and selection criteria in male commercial turkeys in the tropics of Mexico parameters' (n = 275)

Fitted model						
Item[1]	NLM0	NLM1	NLM2	NLM3	NLM4	NML5
A	21.506±0.1716	21.523±0.1629	21.101±0.1841	20.6331±0.2442	20.450±0.3152	22.519±0.1814
b	4.757±0.0377	4.754±0.01847	4.794±0.0275	4.8235±0.01681	4.824±0.0253	4.398±0.0433
k	0.1310±0.0013	0.1306±0.0008	0.1333±0.0007	0.1355±0.0011	0.1364±0.0017	0.1233±0.0012
AIC	13126	6860.8	6015	5408.16	5299.0	10801
BIC	13152	6878.8	6040.7	5433.4	5335.1	10819
s^2_{u0}		4.9297±0.2995	5.9539±0.5785	15.0460±1.5577	25.2641±3.7976	
s_{u10}			0.4982±0.07158		-0.5148±0.2007	
s^2_{u1}			0.1174±0.01279		0.0807±0.02948	
s_{u20}				-0.0656±0.00763	-0.1098±0.01009	
s_{u21}					0.00476±0.00155	
s^2_{u2}				0.00036±0.00005	0.00062±0.00001	
s^2_{id}						0.3742±0.03743
s^2e	0.7675±0.01520	0.1840±0.00374	0.1407±0.00294	0.1167±0.00244	0.1130±0.00244	0.4188±0.00857

[1] Non-linear model (NLM) with or without coefficients of the curve model as random effects, and NLM5 with turkey as random effect; A = expected weight at maturity; b = integration constant; k = maturation rate; AIC = Akaike Information Criterion; BIC = Bayesian information criterion; s^2_{u0} = variance due to random effect of A; s^2_{u1} = variance due to random effect of b; s_{u01} = covariance between random effects of A and b; s^2_{u2} = variance due to random effect of k; s_{u02} = covariance between random effects of A and k; s_{u12} = covariance between random effects of b and k; s^2_e =variance of error; s^2_{id} = variance due to the animal.

Table 5. Estimates of von Bertalanffy growth curve and selection criteria in male commercial turkeys in the tropics of Mexico parameters' (n = 275)

Fitted model						
Item[1]	NLM0	NLM1	NLM2	NLM3	NLM4	NML5
A	25.655±0.3019	25.869±0.2229	25.412±0.2397	25.399±0.3699	24.977±0.3655	25.907±0.2636
b	0.9097±0.0054	0.9077±0.0024	0.9119±0.0034	0.9135±0.0022	0.9157±0.0028	0.9047±0.0058
k	0.0869±0.0012	0.0860±0.0006	0.0877±0.0006	0.0877±0.0009	0.0889±0.0010	0.0860±0.0010
AIC	12918	5911.4	4963.3	4280.7	4165.7	10518.0
BIC	12944	5929.5	4988.6	4306.0	4201.8	10536.0
s^2_{u0}		6.2300±0.5799	8.5013±0.8148	31.859±2.4017	39.427±2.6196	
s_{u10}			0.0695±0.00982		-0.1036±0.00852	
s^2_{u1}			0.00164±0.00018		0.0011±0.0007	
s_{u20}				-0.06174±0.00281	-0.09623±0.00037	
s_{u21}					0.00044+0.00000	
s_{2u2}				0.00015±0.000003	0.00030±0.00003	
s^2id						0.2998±0.02728
s^2e	0.7367+0.01459	0.1512±0.00307	0.1127±0.00235	0.09578±0.00020	0.0908±0.00195	0.3996±0.00812

[1] Non-linear model (NLM) with or without coefficients of the curve model as random effects, and NLM5 with turkey as random effect; A = expected mature weight; b = integration constant; k = maturation rate; AIC = Akaike Information Criterion; BIC = Bayesian information criterion; s^2_{u0} = variance due to random effect of A; s^2_{u1} = variance due to random effect of b; s_{u01} = covariance between random effects of A and b; s^2_{u2} = variance due to random effect of k; s_{u02} = covariance between random effects of A and k; s_{u12} = covariance between random effects of b and k; s^2_e =variance of error; s^2_{id} = variance due to the animal.

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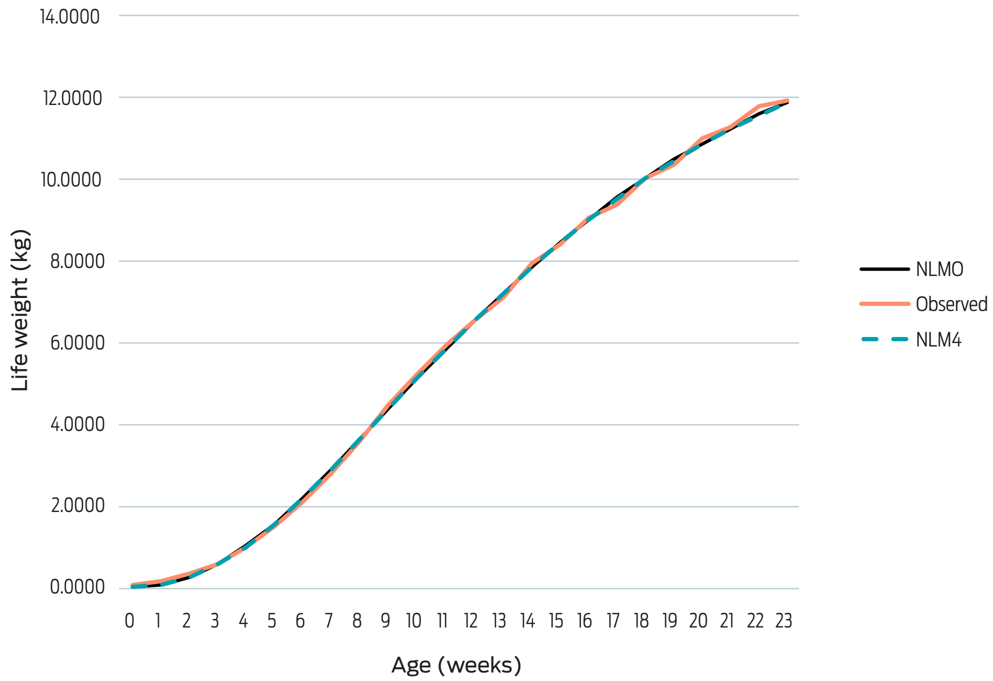

Figure 1. Growth curves for observed data NLM0 and NLM4 of von Bertalanffy models in female turkeys.

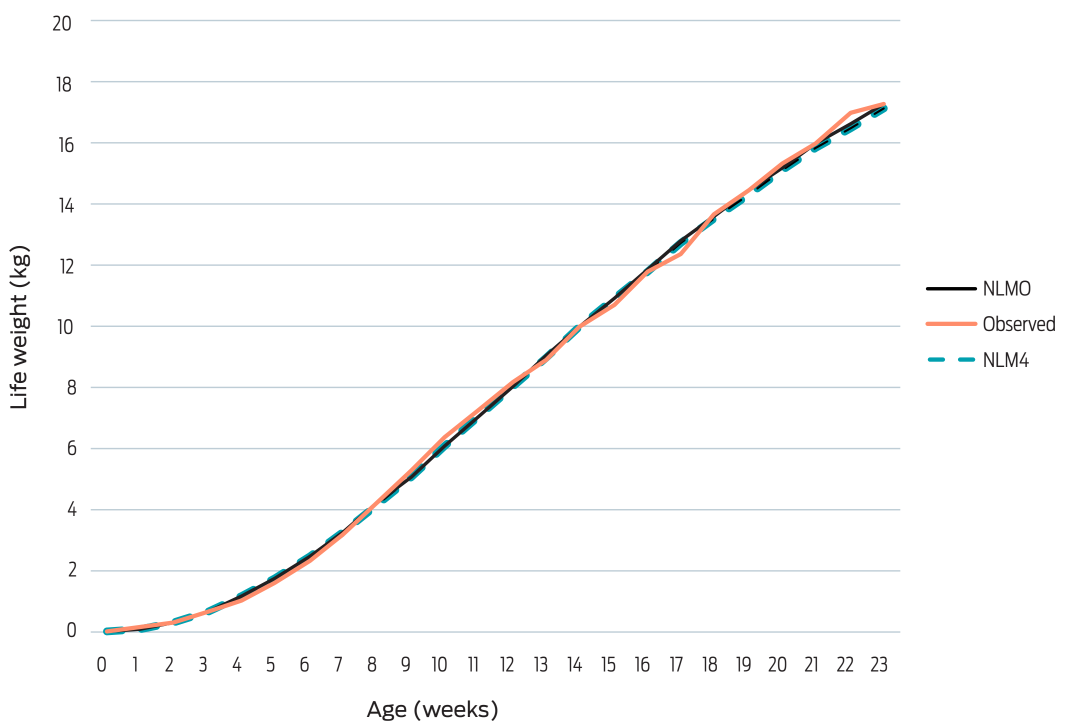

Figure 2. Growth curves for observed data NLM0 and NLM4 of von Bertalanffy models in male turkeys.

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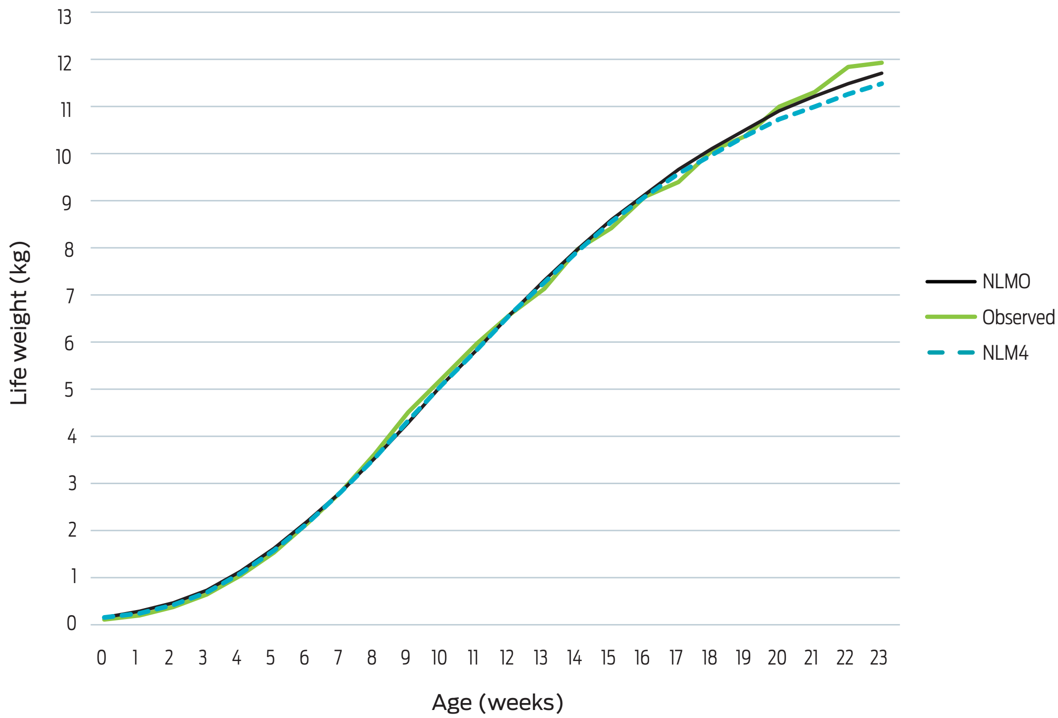

Figure 3. Growth curves for observed data NLM0 and NLM4 of Gompertz models in female turkeys.

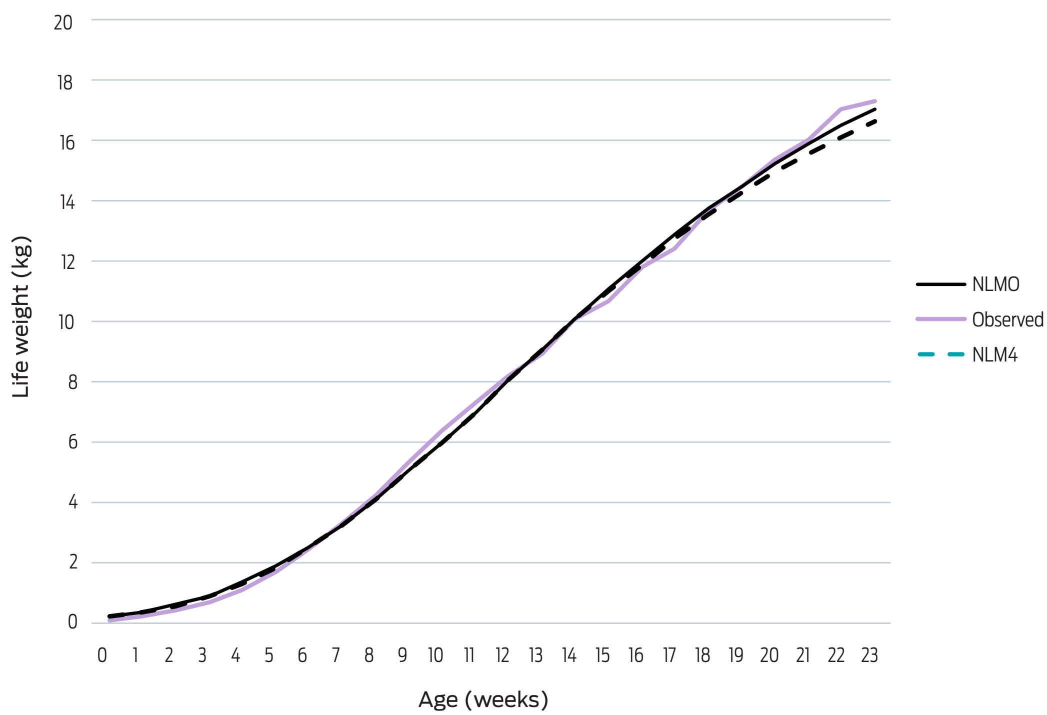

Figure 4. Growth curves for observed data NLM0 and NLM4 of Gompertz models in male turkeys.

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Table 6. For the Gompertz function: above diagonal, correlations of predicted values of females for different non-linear models. Below diagonal, correlations of predicted values of males for different non-linear models

	NLM0	NLM1	NLM2	NLM3	NLM4	NLM5
NLM0	1	0.95350	0.95365	0.95335	0.95405	0.94696
NLM1	0.99537	1	0.99999	0.99991	0.99990	0.99968
NLM2	0.99537	1	1	0.99995	0.99993	0.99966
NLM3	0.99538	0.99998	0.99998	1	0.99999	0.99967
NLM4	0.99538	0.99993	0.99993	0.99999	1	0.99966
NLM5	0.99540	0.99990	0.99990	0.99997	1	1

NLM0 = Fixed model; NLM1 = Fixed and A coefficient random; NLM2 = fixed and A and b coefficients random; NLM3 = fixed and A and k coefficients random; NLM4 = fixed and A, b and k coefficients random; NLM5 = fixed and bird as random.

Table 7. Bertalanffy function: values of female and male non-linear models.

	NLM0	NLM1	NLM2	NLM3	NLM4	NLM5
NLM0	1	0.95242	0.95268	0.95307	0.95169	0.94300
NLM1	0.95585	1	1	0.99998	0.99994	0.99937
NLM2	0.95576	1	1	0.99999	0.99994	0.99936
NLM3	0.95574	0.99999	0.99999	1	0.99998	0.99938
NLM4	0.95458	0.99994	0.99995	0.99999	1	0.99957
NLM5	0.94189	0.99978	0.99881	0.99887	0.099909	1

NLM0 = Fixed model; NLM1 = Fixed and A coefficient random; NLM2 = fixed and A and b coefficients random; NLM3 = fixed and A and k coefficients random; NLM24= fixed and A, b and k coefficients random; NLM5 = fixed and bird as random.
Von Bertalanffy function: above the diagonal, are values of predicted female correlations for different non-linear models. Below the diagonal, are values of predicted male correlations for different non-linear models

Discussion

In the characterization of the growth curve of domestic animals, non-linear models with fixed effects have commonly been used;(1) however, there is scarce information on the use of mixed models, particularly in turkeys. Here, growth curve description models improved when 1 to 3 of the random coefficients were included, in both, female and male turkeys, based on AIC and BIC. The best-fit model was the one that included the random effects of parameters A, b, and k of the growth curve. This agrees well with that observed by Ibiapina-Neto et al.,(6) who compared seven mixed models including at the same time 1, 2 or all 3 parameters of the growth curve in the Gompertz, Logistic and von Bertalanffy models, in naturalized chickens. However, under the conditions of the study and structure of the data used, the high correlation coefficients ($r > 0.99$) between the mixed models indicate that the use of more complex random models to describe growth curves is not worthed (parsimonious principle).

Thus, when sufficient repetitions per animal are available, as in this study, the model that best described the growth curve of females and males was that of von Bertalanffy with random effects associated with the three parameters. In this regard, Ibiapina-Neto et al.(6) mention that the mixed models of Gompertz and Logistic were the ones that best described the growth curve of the males and the Logistic model with random effects associated with the three parameters the one that best

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described the growth of the males, based on the BIC evaluation criterion. P values of model comparisons are not reported here, because according to Motulsky and Christopoulos[10] formula, differences between AIC values > 5.89 will be significant ($P < 0.05$), which is easy to detect from the tables.

Additionally, Figures 1-4 illustrate very similar curves for the fixed-effects model and the best-fit model (NLM4), indicating no improvement when using either one. However, the accuracy of the parameter estimates (standard error) for the curves improves significantly, as can be seen in Tables 2-5, where the residual variance decreased with the addition of 1, 2 or all three random effects to the model, in both assessed sexes. Similar results showing a reduction in residual variance after adding random effects to the model have been reported by other authors.[6, 11, 12]

Therefore, it could be argued that the inclusion of random effects in the growth curve model generates more accurate parameter estimates compared to nonlinear fixed-effect models. In addition, when introducing the random effects of the parameters of the curves, indications of differences between individuals could be observed, given that different individuals grow differently and may have different numbers of weightings during the study period. It is worth mentioning that the growth curves in turkeys and other species can be modified with genetic improvement, feeding, management, season or time of year, model used, etcetera.

In Tables 2 to 5, important differences in mature weight (A) between the sex of turkeys and the Gompertz and von Bertalanffy models were found. This indicates that the growth of males and females should be evaluated separately because sexual dimorphism is a notable characteristic of the species. Similarly in intensive production systems turkeys and chickens are typically raised separately and under different feeding regimes. Growth differences between males and females have also been reported in chickens by other authors.[6, 13, 14]

In Large White turkeys in Turkey up to 18 weeks of age, Sogut et al.[2] using fixed models, reported similar A values to those here found in males (25.66 and 21.51 kg) and females (14.65 and 13.21 kg) for von Bertalanffy and Gompertz models, respectively. Higher values for males than females were also found by Juárez-Juárez-Caratachea et al.[15] and Arando et al.[16] using fixed-effect models for local turkeys from Mexico and Spain respectively.

This indicates that the self-inhibiting phase of growth, when the growth rate begins to decrease, is faster in females than in males, and consequently, they reach a lower asymptotic weight and final weight at the same age. However, Sengul and Kiraz[8] in Large White turkeys, using the Gompertz model, disagree with those results, where the weight at maturity was higher in females than in males (15.16 and 14.62 kg respectively). The difference between the results of Şengül and Kiraz[8] and those found here, could be associated with the fact that they used a positive sign for kt in the Gompertz formula, instead of a negative sign for kt, which is the correct way.[1–3, 17]

k values found for males in the Gompertz and von Bertalanffy models (0.0869 and 0.131 kg/week respectively) were lower than those for females (0.1146 and 0.1588 kg/week respectively). Similar results were found in a commercial line of turkeys,[3] and in local turkeys[15, 16] using Gompertz or von Bertalanffy models. Therefore, the data presented here are consistent with those reported for other lines and under different operating conditions and climates. In addition, it is worth

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mentioning that, in this study, Gompertz's model overestimated and von Bertalanffy model underestimated the hatch weight of turkeys.

Conclusions

Under the conditions of the present study, the best-fitting model for the growth curve description of turkey was von Bertalanffy, when it included the random effects of the three parameters of the growth curve. Female turkeys had lower maturity weights and faster growth compared to males. Including random effects in the von Bertalanffy and Gompertz models resulted in lower variance residuals in estimating the parameters of the growth curves. Based on AIC and BIC, the best mixed model was the one that included the three random effects for the parameters A, b and k. However, the correlation coefficients between mixed models suggest no differences of the predicted weight values.

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Data availability

The original datasets used in this research and supporting information files, are deposited and available for download at the SciELO Dataverse repository doi: 10.48331/scielodata.OT1BOI.

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Conflicts of interest

The authors declare that they have no conflict of interest.

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