Growth Curve Analysis of Body Weight of Mixed-Sex Egyptian Native Geese (*Anser Anser Domesticus*) Using Three Nonlinear Mathematical Functions

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Abstract. *Three non-linear growth models (logistic, Gompertz and von Bertalanffy) were used to describe and estimate growth parameters of 10-week age-body weight relationship of mixed-sex Egyptian indigenous geese. The estimated asymptotic weight (A), scaling parameter (B), maturity index (K), inflection weight (Wi) and time (Ti) were respectively 3254.00 g, 13.15, 0.48 g/day, 1627 g and 5.37 weeks; 3895.00 g, 3.33, 0.25, 1431.99 g and 4.81 weeks; and 4559.00 g, 0.72, 0.17, 1350.81 g and 4.53 weeks for the logistic, Gompertz and von Bertalanffy growth function. The application of four goodness-of-fit criteria [coefficient of determination (R^2), root mean square error (RMSE), Akaike's information criterion (AIC) and Bayesian information criterion (BIC)] revealed that von Bertalanffy was the best fitting model describing age-body weight relationship of Egyptian native geese. This was premised on the fact that the von Bertanlanffy model had the highest R^2 (0.896) and lowest RMSE (327.05), AIC (8806.50) and BIC (5747.86) compared with the Gompertz (R^2: 0.897; RMSE: 328.70; AIC: 8813.05; BIC: 5754.40) and logistic (R^2: 0.891; RMSE: 338.90; AIC: 8841.71; BIC: 5783.07) models. The information provided in this study could be exploited for planning appropriate management practices and further genetic studies on improvement of Egyptian native goose for increased body weight.*

Introduction

The process of growth measured as body mass or body weight on a longitudinal time frame has often been summarized using mathematical equations fitted to growth curves or models (Onder et al., 2017). These models consist of functions which accept, on the basis of the reality of the biological growth of an animal, that the dependent variable has an estimated asymptotic value when the independent variable is at infinity (Narinc et al., 2017). Growth curve models provide a set of parameters that describe the growth pattern over time and estimate the expected weight of animals at certain ages (Lupi et al., 2015). The growth curve is represented mathematically as a function of age and live weight, covering all or part of the animal's lifespan (Echeverri et al., 2013) and these functions could display the summarized growth information in some indices, which may also have a biological interpretation (Ahmadi and Mottaghitalab, 2007).

The growth models have multifaceted applications in enhancing better understanding of the nexus between age and body weight of living organisms. These mathematical models have biological interpretations due to their ability to summarize a large quantity of data collected from body weight over time (Masoudi and Azarfar, 2017; Safari Alighiralou et al., 2017). Besides, growth curves are used to express the time-dependent nonlinear variation of live weight through mathematical functions and the generated equations can be used to predict the expected weight of a group of animals at a certain age (Kim et al., 2016). It is imperative to note that understanding growth patterns and associated growth curve parameters is important and they could serve as principal genetic tools for animal breeders in arriving at a logical conclusion on growth description and making informed decisions in developing appropriate animal improvement strategies.

There are many mathematical functions that have been applied to model the growth of poultry species and livestock in general. However, each model is unique with its own peculiar characteristics while some are modified forms of others. Among the growth curve fitting functions, the most widely used ones in modelling the age-body weight relationship of poultry are the three-parameter Gompertz, logistic, and von Bertalanffy models and the four-parameter Richards function. It is noteworthy that the most commonly used three-parameter models – logistic, Gompertz

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and von Bertalanffy – have fixed growth forms with the point of inflection at about 50%, 37% and 30% of the asymptote, respectively (Eleroglu et al., 2014). However, synthesis of empirical studies has revealed that the Gompertz function is the most widely used nonlinear regression equation in describing growth of poultry (Narinc et al., 2017).

Among African countries, the highest number of geese is found in Egypt, thus reflecting its acceptance and significant contribution to the menu and socio-economic activities of the populace. It is noteworthy that in spite of the highest population of geese in Egypt among African countries, there are currently no intensive or commercial geese farms in Egypt but production depends mainly on unimproved native geese which descended from Greylag goose (Makram, 2018) and small-size flocks reared by smallholder farmers around the upper, middle and delta regions of the Nile valley (Makram 2018; Makram et al., 2018).

Body weight is an important economic trait in farm animals. High premium is attached to it by livestock farmers (Oguntunji, 2017). This metric trait contributes significantly to the profit margin of livestock farmers, especially to livestock enterprises where the main target is market weight or dressed meat (Oguntunji, 2017). In view of the economic importance attached to this quantitative trait, different statistical methods have been applied by researchers to analyse and describe growth parameters such as feed intake, body weight gain, body weight, and feed conversion ratio among others.

In spite of abundant literature on growth modelling of poultry species, related empirical reports on the growth curve fitting of African indigenous waterfowls (ducks and geese) are not available. Therefore, the present study was conducted to describe the growth curve of Egyptian native geese using von Bertalanffy, Gompertz and logistic models.

Materials and Methods

Location of the experiment and management of experimental birds

The experiment was conducted in Fayoum governorate, Egypt on coordinate 29°18'35.82" N 30°50'30.48" E. Forty-five (45) day-old Egyptian indigenous gooslings were sourced from small holder farmers and were brooded on gravels under natural lighting.

From day-old to the fourth (0–4) week, the goslings were placed on 23% crude protein and 2900 Kcal/ME/kg feed supplemented with alfafa grass. The experimental birds were also fed 18% crude protein and 2900 KCal/ME/kg with alfafa grass between weeks 4 and 8. At the final phase of the experiment (weeks 8–10), the birds were fed feed containing 21% of crude protein and 3000 Kcal/ME/kg without grass supplement.

Data collection

The birds were wing-tagged at day-old for easy identification, and weekly body weight (BW) records of each bird were taken for 10 weeks using a sensitive digital scale calibrated to 2 decimal places. The BW measurement was taken at 7:00 hours before feeding. Besides, general handling of the birds during the experimental period and data collection followed the international best practices to reduce handling stress to the barest minimum.

Statistical procedures and data analysis

Three nonlinear growth functions: logistic, Gompertz and von Bertalanffy were fitted on the weekly body weight of experimental birds using the SPSS version 23 in order to identify the best growth function to describe the growth curve of native Egyptian geese.

The functional forms of the non-linear regression models are presented in Table 1.

Accuracy of the growth curves

The accuracy of predictive growth models was determined using 4 goodness-of-fit statistics: coefficient of determination (R^2), root mean square error (RMSE), Akaike's information criterion (AIC) and Bayesian information criterion (BIC) according to Sanusi and Oseni (2020). Growth curve function with the lowest AIC, BIC and RMSE (Sanusi and Oseni 2020) and the highest R^2 (Lupi et al., 2015) was selected as the best growth function.

Results

Maturity weight (A)

The descriptive statistics of the body weight of the mixed-sex Egyptian geese are presented in Table 2. There was an increase in body weight from day old to the terminal age of the experiment. The estimated asymptotic weight was highest in the von Bertalanffy (4559.00 g) followed by the Gompertz (3895.00 g) but least in the logistic (3254.00 g) model (Table 3).

Table 1. The growth curve functions of logistic, Gompertz and Von Bertalanffy models

Model	Y_t	W_i	t_i
Logistic	$A(1+Be^{-kt})^{-1}$	A/2	(Ln.B)/k
Gompertz	$A\exp(-Be^{-kt})$	A/e	(Ln.B)/k
Von Bertalanffy	$A(1-Be^{-kt})^3$	A(8/27)	(Ln.3B)/k

Y_t: body weight (g) of geese at t (week/day of age); A: the asymptotic weight (g) when time goes to infinity; B: scaling parameters (constant of integration); k: maturing rate (g/day); e: constanta (2.72); t: time (day); W_i: weight at inflection (g); t_i: time of inflection (week).

Table 2. Descriptive statistics of body weight (g) of mixed-sex geese (N = 45) at 0 to 10 weeks of age

Age (week)	Mean	SD (±)	CV (%)	Minimum	Maximum
0	97.78	12.73	13.02	75.00	120.00
1	239.67	69.53	29.01	150.00	400.00
2	512.00	129.39	25.27	235.00	675.00
3	731.78	199.08	27.20	435.00	1100.00
4	1321.33	423.20	32.03	630.00	1900.00
5	1560.00	413.15	26.48	800.00	2400.00
6	1840.00	397.23	21.59	1000.00	2600.00
7	2123.11	374.29	17.63	1350.00	2800.00
8	2392.33	406.48	16.99	1500.00	3100.00
9	2706.67	362.06	13.38	1800.00	3500.00
10	3077.00	366.23	11.90	2700	3950.00

SD: standard deviation; CV: coefficient of variation.

Table 3. The growth curve parameters for body weight of mixed-sex Egyptian native geese

Model	A (g)	B	K (g/day)	W_i (g)	t_i (week)	Iteration
Logistic	3254.00 ± 91.99	13.15 ± 1.02	0.48 ± 0.02	1627.00	5.37 (37.59 days)	7
Gompertz	3895.00 ± 190.20	3.33 ± 0.12	0.25 ± 0.02	1431.99	4.81 (33.67 days)	6
Von Bertalanffy	4559.00 ± 320.34	0.72 ± 0.02	0.17 ± 0.02	1350.81	4.53 (31.71 days)	5

A: the asymptotic weight (g) when times goes to infinity; B: scaling parameters (constant of integration); k: maturing rate (g/day); t: time (week/day); W_i: weight at inflection (g); t_i: time of inflection (week).

Scaling parameter (B)

The result of the scaling parameter (Table 3) was 13.15 in the logistic model, distantly followed by 3.33 in the Gompertz model and 0.72 in the von Bertalanffy model.

Maturing rate (K)

The result of the slope of the non-linear regression models (Table 3) indicated that the lowest K value was recorded for von Bertalanffy (0.17 g/d), followed by Gompertz (0.25 g/d) but highest in the logistic model (0.48 g/d).

Inflection weight (Wi)

Table 3 shows that the estimated body weight at inflection was 1350.81 g, 1431.99 g and 1627.00 g for the von Bertalanffy, Gompertz and logistic models, respectively.

Inflection time (Ti)

The time of inflection of the body weight followed the same trend as observed in weight at inflection; the shortest Ti (4.53 weeks, 31.71 days) was reported in the von Bertalanffy, intermediate in Gompertz (4.81 weeks; 33.67 days) but highest in the logistic (5.37 weeks, 37.59 days) model (Table 3).

Determination of the best-fitting model

The values of goodness-of-fit tests are presented in Table 4. Across the models, the R^2 value was 0.898 for von Bertalanffy, 0.897 and 0.891 for Gompertz and logistic models, respectively. Contrastingly, for other three goodness-of-fit criteria (RMSE, AIC, and BIC) used in this study, the lowest values were obtained for von Bertalanffy (B), followed by Gompertz (G) and logistic (L) models (RMSE: B-327.05, G-328.70, L-338.90; AIC: B-8806.50, G-8813.05, L-8841.71 and BIC: B-5747.86, G-5754.40, L-5783.07).

Growth curve description

All the nonlinear regression models fitted well the growth curve of Egyptian indigenous geese as reflected in the sigmoidal shape of the models (Fig. 1).

Table 4. The goodness-of-fit criteria for the growth curve models in mixed-sex Egyptian native geese

Model	R^2	RMSE	AIC	BIC
Logistic	0.891	338.90	8841.71	5783.07
Gompertz	0.897	328.70	8813.05	5754.40
von Bertalanffy	0.898	327.05	8806.50	5747.86

R^2: coefficient of determination; RMSE: root mean square error; AIC: Akaike's information criterion; BIC: Bayesian information criterion.

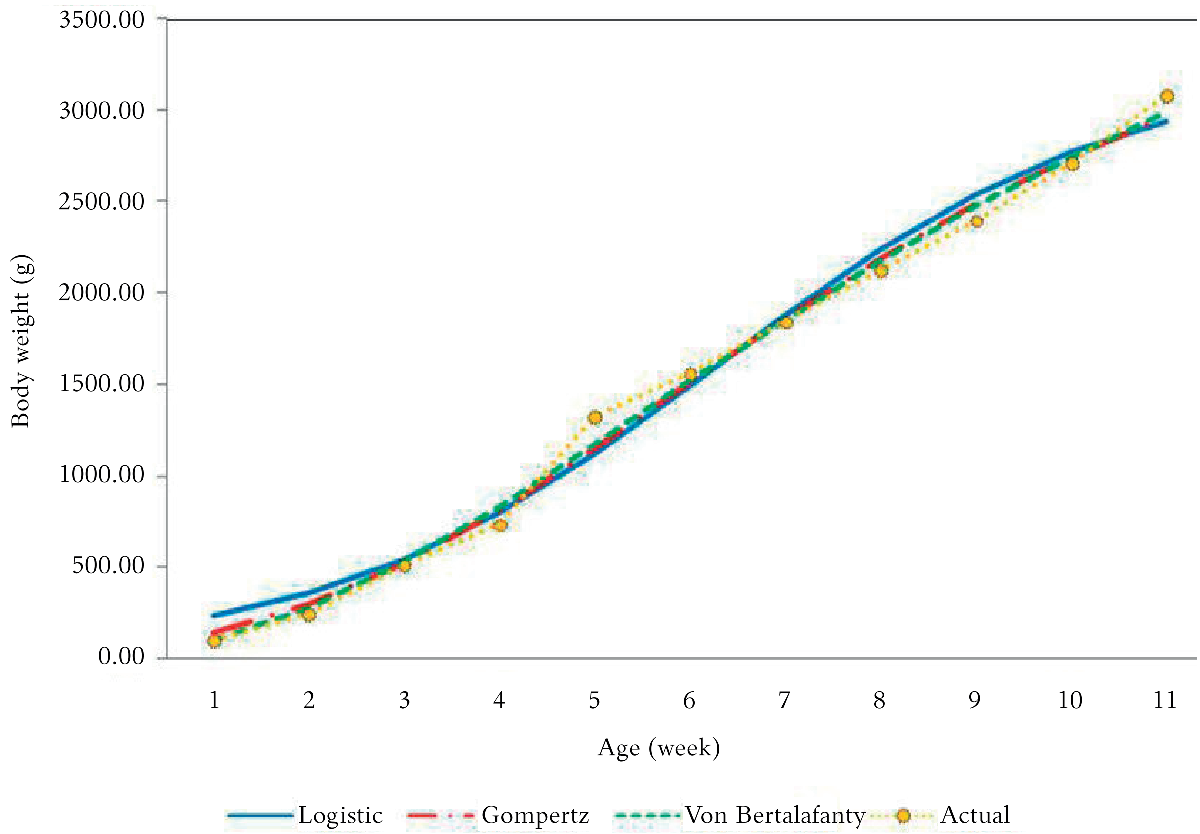

Fig. 1. The growth curve of body weight in mixed-sex goose based on the logistic, Gompertz and von Bertalanffy models

Discussion

Maturity weight (A)

The trend of asymptote in the present study whereby the asymptotic weight was highest in the von Bertalanffy model intermediate in Gompertz but lowest in the logistic model is consistent with the trend reported for the three growth functions in related studies involving mixed-sex and non-mixed sex geese breeds (Ibtisham et al., 2017; Onder et al., 2017; Karadavut et al., 2022; Liu et al., 2022).

Furthermore, the range of the asymptotic value reported for the three growth curve models in this study (3254.00–4559.00 g) was much higher than the values reported for Turkish native geese (logistic: 92.02 g, Gompertz: 169.37 g, and von Bertanlanffy: 207.84 g) reared in different environmental enrichments (Karadavut et al., 2022). However, it compares favourably with 3,425 g, 3,840 g and 4,181 g reported for the logistic, Gompertz and von Bertalanffy model, respectively in indigenous Chinese geese (Liu et al., 2022). Conversely, the range of estimated A obtained for these growth models was lower compared with the values reported by Cyril et al. (2021) for mixed-sex Slovakian breeds of geese (Landes: 5332.51 g; Pomeranian: 6186.14 g and Steinbacher: 5048.27 g) using the Gompertz model.

The range of the values of asymptotic weight clearly indicated the possible highest average body weight of Egyptian local geese reared for 10 weeks. The A parameter indicates mature weight or asymptotic weight or the potential final weight of the animal over time (Cak et al., 2017). It is worth emphasising that A does not imply the heaviest body weight attained by the individual, but it indicates the average weight of matured animal independent of short term fluctuation in weight due to temporary environmental effect (Gbangboche et al., 2008).

Furthermore, in studies involving growth curve modelling of poultry, synthesis of empirical reports unequivocally demonstrated that the asymptotic weight was influenced by myriads of genetic and non-genetic factors such as line (Karabag et al., 2017), genotype (Ibtisham et al., 2017; Cyril et al., 2021), management system (Karadavut et al., 2022), sex (Onder et al., 2017), and model type (Onder et al., 2017) among others. The observed influence of interplay of genotype and environment on maturity weight is not unexpected because body weight is a polygenic quantitative trait and is responsive to both genetic and diverse environmental stimuli. For instance, Karabag et al. (2017) reported an increase of 60.9% and 33.2% in mature weight parameter (A) of high body weight and low body weight line of Japanese quails, respectively, compared with the control line using Richards function after 11 generations of divergent selection for 5-week body weight.

Scaling parameter (B)

The range of the integration constant reported for the three non-linear growth models (0.72 to 3.33) was within the range reported for geese in various studies

(Ibtisham et al., 2017; Cyril et al., 2021; Liu et al., 2022).

Similar to the result herein reported, it is noteworthy that in most geese growth curve studies involving Gompertz, logistic and von Bertalanffy models, the logistic function consistently had the highest B value followed by Gompertz but lowest in the von Bertalanffy model (Ibtisham et al., 2017; Onder et al., 2017; Liu et al., 2022) except in a recent report (Karadavut et al., 2022) on local Turkish geese where the scaling parameter was lowest in the logistic model, intermediate in von Bertalanffy but highest in the Gompertz model.

The scaling parameter is established by the initial body weight at birth/hatch and relates weight at hatching (hatching, t = 0) to asymptotic weight (Sanusi, 2018). This parameter is model-dependent and can influence the asymptotic time when the asymptotic age is reached (Sanusi, 2018). Similarly, Gbangboche et al. (2008) corroborated this submission that parameter B indicates the proportion of the asymptotic mature weight to be gained after birth and is established by the initial values of weight. Nevertheless, it is worthy of note that this growth parameter does not have biological meaning but is related to the time interval between birth to maturity (Cak et al., 2017).

The lack of biological meaning of the scaling parameter is consistent with the fact that the estimated B values (0.72 to 13.35 g) for the three growth functions are inconsistent with the ideal day-old body weight of goslings irrespective of the parental genotype (i.e. local, exotic or hybrid). For instance, goosling body weight at day old has been reported to be in the range of 90 to 94 g (Onder et al., 2017) and 79.58 to 114.98 g (Ibtisham et al., 2017) in recent studies, and 75–120 g in the present study (Table 2).

Maturing rate (K)

Similar to the trend of results of K values reported herein, reports of related studies on indigenous Turkish (Onder et al., 2017; Karadavut et al., 2022) and Chinese (Liu et al., 2022) geese breeds using the von Bertalanffy, Gompertz and logistic models also indicated that the parameter K values followed same trend.

It is noteworthy that irrespective of the breed, sex, management and growth functions used in previous studies, the range of estimated maturity rate reported for the growth functions in this study (0.17–0.48 g/d) was higher than the range of 0.031 to 0.071 and 0.00252 to 0.000655 reported for indigenous Chinese (Liu et al., 2022) and Turkish (Karadavut et al., 2022) goose breed, respectively. In similar vein, the maturity rate of 0.25 g/day reported for Gompertz model in this study is five-fold higher than 0.05 g/day documented for three Slovakian native geese breeds (Cyril et al. 2021) using the Gompertz model.

It is worth emphasizing that for the three non-linear regression models, values of parameter K were higher than 0, thus implying a relative growth rate from hatch to maximum growth (Sanusi and Oseni, 2020). The maturity index of growth rate estimates the relative rate at which the asymptotic value is reached (Sanusi, 2018), represents the rate of maturity of animal and indicates the growth velocity in reaching the asymptotic weight from the initial weight (Lupi et al., 2015). The highest value of K implies earlier maturity; thus, the higher the K value, the faster the animal reaches or attains the mature weight and low values indicate animals with a delayed maturity or those that tend to mature more slowly (Lupi et al., 2015).

The highest K value estimated for the logistic growth function implies that growth of geese described by this growth model would have the fastest growth rate and would reach maturity age earlier than those described with the Gompertz and von Bertalanffy models. Therefore, it is noteworthy that this growth curve parameter is an important economic trait because of its direct effect on mature body weight and inflection weight of animals. In view of this, geese that attain the estimated maximum growth rate (K) at earlier ages can be selected for breeding, since this growth parameter is moderately heritable (Kaplan et al., 2016). This submission is consistent with an earlier submission of Kopuzlu et al. (2014) that parameter K describes the earliness of maturing and offers a unique trait to evaluate animals, and the relationships between size and productivities.

Inflection weight (Wi)

The comparison of the trend of Wi reported for Egyptian local geese in this study with similar studies indicated that Wi values followed the same trend in indigenous Chinese (Ibtisham et al., 2017; Liu et al., 2022) and Turkish (Ibtisham et al., 2017; Onder et al., 2017) breeds of geese.

It is noteworthy that the inflection weight of 1431.99 g reported for the Gompertz model was much lower than the range (1855.98 g to 2274.38 g) reported for three mixed-sex Slovakian geese breeds (Cyril et al., 2021), using the Gompertz model. However, it was higher than 1413 g reported for Magang goose (Liu et al. 2022) and 1263.66 g reported for Sichuan White goose (Liu et al., 2017) using the Gompertz model.

Furthermore, the highest Wi (1627.00 g) reported for the logistic model was lower in contrast to 1712 g and range 2033 g to 2452 g reported for Magang female geese (Liu et al., 2022) and native Turkish breed of geese (Onder et al., 2017), respectively, but higher than 1321.7 g reported for Sichuan White goose (Liu et al., 2017). The weight at inflection for the von Bertalanffy model (1350.81 g) in this study is comparable to 1343.81 g reported for mixed-sex Chinese Sichuan White goose (Liu et al., 2017).

Inflection time (Ti)

The comparison of the estimated Ti values with similar studies indicated that the estimated Ti for the von Bertalanffy model (4.53 weeks; 31.71 days) in the present study was much lower compared with

5.05 weeks reported for Sichuan white goose (Liu et al., 2017), but higher than 25.86 days and 21.60 to 22.50 days documented for Magang geese (Liu et al., 2022) and Turkish native geese (Onder et al., 2017), respectively. In similar vein, the estimated inflection time for the logistic model (5.37 week) compared favourably with 5.0–5.34 weeks reported for native Chinese geese breeds (Qu et al., 2017) but higher than the range (4.10–4.30 weeks) estimated for Wanxi white (Wang et al., 2014) and Sichuan white (Liu et al., 2017) geese.

A critical look at the estimated Wi and Ti for Egyptian native geese in the present study reveals that it takes a shorter period (31.71 days) for geese to reach the highest Wi (1350.81) using the von Bertalanffy model but takes extra two and six days for Gompertz (Ti 33.67 days; Wi 1431.99 g) and logistic (Ti 37.59 days; Wi 1627g) growth functions, respectively, to reach inflection weights.

The inflection point indicates the period with the fastest growth rate, after which the growth rate will gradually slow down (Ibtisham et al., 2017). The inflection age, i.e. the age at maximum instantaneous relative growth rate can be used to predict the market age (Guo et al., 2016). Early maturity age is an economic trait in livestock enterprise. Early-maturing animals have propensity to reach adult and market weights earlier than the late maturing ones. In addition, the early maturing animals tend to reach puberty earlier and commence reproductive activities earlier than late maturing ones, thus, producing more progenies in their lifetime with attendant higher economic returns compared with late maturing ones.

It is noteworthy that empirical studies on estimated genetic parameters for growth models in poultry are sparse; nevertheless, reports of diverse growth curve studies of poultry species such as turkey (Aslam et al., 2011) and quails (Kaplan et al., 2016; Karabag et al., 2017) have unequivocally demonstrated that the reported growth curve parameters (A, B and K) and inflection points (I_A and I_W) are heritable and could be altered via selection. In view of this, sound understanding and exploitation of growth curve parameters and inflection points would be of invaluable assistance in selection and improvement of the understudied Egyptian native geese.

Determination of the best-fitting model

Based on the values of the coefficient of determination, it could be deduced that Bertalanffy was the best (having highest R^2) followed by Gompertz and logistic models.

It is noteworthy that the values (0.891–0.898) of R^2 for the three mathematical growth functions in this study were lower compared with 0.987 to 0.995 (Onder et al., 2017), 0.9504 to 0.9686 (Karadavut et al., 2022), 0.992 to 0.999 (Ibtisham et al., 2017), and 0.997 to 0.998 (Cyril et al., 2021) reported for different breeds of geese. The remote and immediate reasons for the trend are not clearly understood. Nevertheless, the high R^2 reported for all the models indicated that all the models applied suitably fitted the growth data and that 89.10 to 89.80% variability in the body weight of Egyptian local geese was well explained by the three growth functions.

In growth curve studies, the goodness-of-fit helps to determine adequacy of a model in describing analyzed data and, because of its importance in choosing the best models, researchers often apply more than one model to arrive at the best goodness-of-fit tests in growth models, thus helping to choose the most appropriate model for the data analyzed (Sanusi, 2018) due to limitations of different goodness of-fit criteria.

For instance, R^2 and adjusted R^2 have been reported not representing a good metric for assessing the performance of nonlinear models since they do not account for the number of parameters amongst others; hence, it was proposed that they should not be used in isolation, but in combination with other goodness-of-fit algorithms (Archontoulius and Miguez, 2015). In view of this, the decision to choose the best fit model could not be based on the R^2 alone due to the aforementioned limitations and its limitation in not penalizing over-parameterization (Sanusi and Oseni, 2020) but would be based on agreement with other goodness-of-fit criteria.

Nevertheless, it is noteworthy that the application of other goodness-of-fit criteria corroborated R^2, identifying the von Bertalanffy model as the best growth-fitting model followed by Gompertz while the logistic model was the poorest. This conclusion was hinged on the fact that the goodness-of-fit test values reported for the von Bertalanffy model were highest for R^2 but lowest for RMSE, AIC and BIC. Therefore, based on the highest R^2 and lowest RMSE, AIC and BIC values reported for the von Bertalanffy model compared with Gompertz and logistic models, it can be concluded that von Bertalanffy was the best growth model describing the growth curve of Egyptian local geese. In similar vein, the von Bertalanffy function was identified as the best fitting model in related studies using similar growth models in Turkish native (Onder et al., 2017) and Chinese Magang (Liu et al., 2022) breeds of geese.

The von Bertalanffy model being the best fitting growth function in this study is not unexpected. Growth fitting curves with flexible inflection points such as Richards, Morgan and von Bertalanffy have been identified to describe nonlinear growth curves better than Gompertz and logistic models with fixed inflection points (Porter et al., 2010). Similarly, Zuidhof (2005) reported that the sigmoidal models with a flexible point of inflection predicted carcass part weights better than Gompertz with a fixed point of inflection. However, synthesis of empirical studies on growth curve of geese revealed that studies adjudging von Bertalanffy as the best model were few but Gompertz and logistic (Liu et al., 2022) and

Richards (Ibtisham et al., 2017) were mostly adjudged best predictive models.

Growth curve description

It is noteworthy that the growth functions overestimated the growth of geese from hatch (0 day) to 4 weeks of age but slightly underestimated the growth between 4 and 6 weeks of age. Furthermore, they perfectly fitted the curve between weeks 6 and 7 but slightly overestimated the growth again after week 7. Nevertheless, the differences between the observed and estimated values were negligible but higher in the logistic model than in others.

A recent report by Safari et al. (2021) has adduced poor fitting of growth curves with a fixed or little flexible inflection point to the dependency of their inflection points on the weight at sexual maturity. A possible principal factor contributing to superior fitting of data of growth of Egyptian local geese by the von Bertanlanfy function could be attributed to its lower inflection point (31.73 days) compared with curves with fixed inflection points (Gompertz – 33.67 days; logistic – 37.59 days). This submission was accentuated by earlier reports of Schulim-Zeuthen et al. (2008) that the Schumacher equation with a flexible inflection point described the growth curve better, and its superior fitting of the growth model was linked to its inflection point at an earlier age compared with the Gompertz and logistic models.

Conclusion

The study demonstrated that the three mathematical growth functions explained well the variability in the age-body weight relationship of Egyptian local geese. However, putting into consideration the values of goodness-of-fit tests, the von Bertalanffy was the best growth-fitting curve model based on its highest R^2 and lowest RMSE, AIC and BIC compared with Gompertz and logistic models. The estimated growth parameters and growth descriptors could be exploited by geese farmers in making informed decision on feeding strategies and exploration of the growth parameters and descriptors by animal breeders in genetic improvement of Egyptian indigenous geese.

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Competing interests

The authors declare that they have no potential conflict of interest.

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