RESEARCH ARTICLE

Bertalanffy Model Reflects Growth Trajectory in Aseel Chicken

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Abstract

Aseel, a popular breed of native chicken, characterized by its pugnacity, fighting strength and royal gait, is being used to create crosses for domestic chicken production. However, information on its growth models is scanty. An experiment was conducted to evaluate different non-linear models and to find out best fitting model in Aseel, being maintained at Central Avian Research Institute, Izatnagar, Bareilly. Data on body weights from 12-weeks of age to 20-weeks of age at biweekly intervals were recorded on a random bred single-hatched flock. Owing to the non-linear characteristic of growth, three non-linear models namely, Gompertz, Bertalanffy and Logistic models were evaluated. Goodness of fit for all the models were checked using coefficient of determination (R^2), adjusted coefficient of determination (Adj-R^2), mean square error (MSE), mean absolute error (MAE) and Akaike information criterion (AIC). The Bertalanffy model most accurately characterized the growth trend in males, females and pooled sex data. The study revealed that this model may be used to ascertain the average body weights in Aseel chicken under random mating. The investigation has generated baseline data on growth modelling of random bred groups and may be used in similar investigations on other native chicken breeds.

Keywords: Aseel, Bertalanffy model, Gompertz model, Growth models, Logistic model.

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Introduction

Poultry sector has witnessed a remarkable change in terms of structure and operation. India is the third-leading producer of eggs and the fourth-largest supplier of broilers. Enhancement of the productivity of backyard and extensive systems of agriculture requires improving native germplasm through selective breeding. It is necessary to have knowledge of pattern of growth in poultry in order to optimise production. Prediction of growth is important factor that contributes to the profitability of an operation in poultry production. Studies have been made toward the growth pattern of various species of livestock along with poultry and several attempts have been made to deduce the law of growth from these data. The growth, is an increase in body size per time unit and is a fundamental property of biological system (Lawrence and Fowler, 2002) and the growth of the fowl is similar to the growth of other birds and consist of 3 or 4 cycles after hatching (Grossman and Koops, 1988). Growth functions have been shown to be valuable tools for analysing growth responses to genetic selection, environmental change and estimation of daily nutrient requirements for growth. An appropriate growth function provides a good way of summarizing the information embraced in such data into a few parameters that can be interpreted biologically and physically. Modelling growth curve is also necessary for enhancing the profitability of the poultry production. Mathematical models of growth curves are valuable because they allow for the visualisation of patterns of growth through time and may be used to estimate the projected weight of birds at a certain age (Tzeng and Becker, 1981). Non-linear models have several advantages, including parsimony, interpretability, and prediction. Growth model parameters such as asymptotic weight and rate of maturity are extremely important since they are often used in poultry growth research to anticipate growth at any age. Furthermore, these factors may aid in defining dietary requirements throughout various stages of development (Yakubu and Madaki, 2017). Various authors, (Prasad and Singh, 2006; Ganeshan, 2015; Rathi 2021; Vinay Mohan, 2022 and Kumar *et al.*, 2022) have attempted the growth modelling in various native chicken breeds in India.

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Aseel is the popular breed of Indian native chicken. It is well known for pugnacity, fighting strength, apart from excellent meat qualities. However, information of modelling growth trends in random bred population is scanty. So, the present experiment was conducted to generate important baseline information on growth modelling of random bred Aseel chicken population.

Materials and Methods

Experimental Birds

The birds belonging to random bred population Aseel Peela (Golden Red Variety) being maintained at Desi Fowl Unit at ICAR- Central Avian Research Institute, Izatnagar, India were used in the experiment.

Management and Parameters Recorded

Standard feeding and management practices and vaccination schedule were followed. The individual body weights from 12 weeks of age to 20 weeks of age at biweekly intervals were recorded on 247 random bred birds of Aseel native chicken, obtained in a single hatch, using digital weighing balance.

Statistical Analyses

Owing to non-linear nature of growth in biological systems, growth patterns of body weights of Aseel were analysed using following nonlinear models:

Gompertz model: It is a sigmoid curve named after Benjamin Gompertz. It is most prominent model for growth, and has following form:

$$Y_t = a \exp(-b \exp(-c\ t)) + e$$

Logistic model: This model is symmetrical about point of inflection (Pearl and Reed, 1923) and the model is as below:

$$Y_t = a/(1+b \exp(-c\ t)) + e$$

Bertalanffy model: This model is given by Von Bertalanffy (1960). It is a three-parameter model. Its mathematical form is as follows:

$$Y_t = a\ [1-b \exp(-c\ t)]3 + e$$

Where,

Y_t = observed body weight of the chick at t^{th} week,

a = asymptotic weight,

b = scaling parameter,

c = rate of maturity,

t = age of the chick in weeks,

e = error term.

Goodness of fit: Various parameters, *viz.,* coefficient of determination (R^2), adjusted coefficient of determination (Adj-R^2), mean square error (MSE), mean absolute error (MAE) and Akaike information criterion (AIC) were used to check the goodness of fit of the models.

Results and Discussion

The body weights (g) at 12, 14, 16, 18 and 20 weeks of age averaged 687.20, 930.84, 1072.94, 1232.36 and 1353.34, respectively, in males of Aseel native chicken. The corresponding body weights (g) in females were 618.25, 793.85, 898.18, 992.74 and 1082.94, respectively (Table 1).

Table 1: Average body weight (g) of different gender of Aseel chicken in random bred flock at different weeks of age

Age (week)	Male (n=117)	Female (n=130)	Combined-sex (n=247)
12	687.2±11.47	618.25±8.44	650.91±7.34
14	930.84±15.49	793.85±10.58	857.84±10.15
16	1072.94±16.57	898.18±10.29	978.28±10.96
18	1232.36±17.95	992.74±10.24	1102.95±12.60
20	1353.34±20.78	1082.94±12.15	1207.28±14.65

n = Number of observations

Three non-linear growth models namely Gompertz, Logistic and Bertalanffy were used to model the growth and fitted to average body weight in males (n=117), females (n=130) and pooled sex data (n=247) of random bred flock. The parameter estimates, *viz.,* asymptotic weight, scaling parameter and rate of maturity of nonlinear models are given in Table 2. The asymptotic weight appeared to be higher in males as compared to females while rate of maturity was found to be higher in females than that of males in all the three models. The parameters of goodness of fit in males, females and pooled sex data of random bred flock of Aseel chicken are presented in Table 3, wherein**,** out of the three models, the Bertalanffy model best described the growth trend in males, females and pooled sex data. For best fit model, the parameters of goodness of fit were estimated as R^2= 0.997, Adj-R^2= 0.988 and AIC= 19.129, in males, R^2= 0.997, Adj-R^2= 0.988 and AIC= 17.645 in females and R^2= 0.997, Adj-R^2= 0.988 and AIC= 18.368 in pooled sex (Table 3).

Similar to this study, Mata-Estrada *et al.* (2020) reported Bertalanffy model to be the best model to describe growth in Mexican Creole chicken strains. Contrastingly, Kumar *et al.* (2022) reported that Gompertz model is the best model for describing growth in males, and Logistic model and Gompertz model for females in selected Aseel chicken. Kausar *et al.* (2016) reported Logistic model to be the best fit model in males and Gompertz model in females of random bred flock of Rhode Island Red and Rhode Island White chicken. They further reported that Bertalanffy model was the best model followed by Logistic model in Rhode Island Red and Rhode Island White random bred groups, which is quite similar to the present findings. Contrarily, Gompertz model was found to be the best model for describing growth in selected strain of Aseel chicken in combined sex data by Kumar *et al.* (2022).

Table 2: Parameter estimates and their standard errors of non-linear models in random bred flock of Aseel chicken

Models	Group	Asymptotic weight	Scaling Parameter	Rate of maturity
Gompertz	Male	1634.730±136.997	7.941±3.043	0.186±0.038
	Female	1251.991±85.959	6.817±2.689	**0.190±0.39**
	Combined sex	1429.925±110.259	7.249±2.793	0.186±0.37
Logistic	Male	1535.633±105.387	29.661±14.440	0.258±0.047
	Female	1199.482±71.148	20.233±9.887	**0.268±0.47**
	Combined sex	1356.301±88.011	24.035±11.630	0.261±0.47
Bertalanffy	Male	1686.504±156.212	1.717±0.608	0.159±0.035
	Female	1277.176±93.942	1.588±0.582	**0.168±0.37**
	Combined sex	1466.831±123.001	1.629±0.581	0.162±0.36

Table 3: Goodness of fit of various non-linear models in random bred flock of Aseel chicken

Models	Group	R^2	Adj-R^2	MAE	MSE	AIC
Gompertz	Male	0.997	0.988	57.74	469.92	19.36
	Female	0.996	0.984	45.6	237.19	17.875
	Combined sex	0.996	0.984	52.13	331.565	18.603
Logistic	Male	0.995	0.98	69.12	628.59	19.992
	Female	0.995	0.98	52.41	315.451	18.495
	Combined sex	0.995	0.98	60.86	443.789	19.236
Bertalanffy	Male	0.997	0.988	53.76	422.5	19.129
	Female	0.997	0.988	43.26	213.311	17.645
	Combined sex	0.997	0.988	49.11	297.624	18.368

R^2: Coefficient of determination; R^2 (Adj): Adjusted Coefficient of Determination; MAE: Mean Absolute Error; MSE: Mean Square Error; AIC: Akaike Information Criterion

The differences in various reports with regards to growth trends and models might be attributed to the differences in the genetic background of the stocks studied, interval between successive data recordings, as well as environmental variables such as feed, pathological conditions and other factors that existed throughout the investigation.

Conclusions

In this study, Bertalanffy model was found to be the best model in males, females and pooled data of random bred flock of Aseel native chicken. Female birds attained the inflection point earlier than male birds as they have higher rate of maturity. The study revealed that these models can be used to determine the average body weights at any given point of time in Aseel chicken under random mating. The investigation has generated baseline data on growth modelling of random bred groups and can also be used in similar investigations on other native chicken breeds.

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