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Research Article

Growth Modelling in Aseel Native Chicken

Amit Kumar[1], Sanjeev Kumar[2]*, Manjari Pandey[3], Chirag Chaudhari[3], TS Aruna[3], Ruhi Meena[3], Hanumant L Kanadkhedkar[4], Chandrahas[5] and Med Ram Verma[6]

[1]M.V.Sc. Scholar, Division of Animal Genetics, ICAR-Indian Veterinary Research Institute, Izatnagar, Bareilly, Uttar Pradesh, India

[2]Principal Scientist and Head, Division of Avian Genetics and Breeding, ICAR-Central Avian Research Institute, Izatnagar, Bareilly, Uttar Pradesh, India

[3]Ph.D. Scholar, Division of Animal Genetics, ICAR-Indian Veterinary Research Institute, Izatnagar, Bareilly, Uttar Pradesh, India

[4]Subject Matter Specialist, BGDSRDTC, Borgaon, Manju, Akola, Maharashtra, India

[5]Principal Scientist, Division of Avian Genetics and Breeding, ICAR-Central Avian Research Institute, Izatnagar, Bareilly, Uttar Pradesh, India

[6]Principal Scientist, Division of Livestock Economics, Statistics and Information Technology, ICAR-Indian Veterinary Research Institute, Izatnagar, Bareilly, Uttar Pradesh, India

***Corresponding Author:** Sanjeev Kumar, Principal Scientist and Head, Division of Avian Genetics and Breeding, ICAR-Central Avian Research Institute, Izatnagar, Bareilly, Uttar Pradesh, India.

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Abstract

Aseel, an important Indian native chicken breed, characterized by its aggressive behaviour, fighting ability and majestic gait is being utilized in India for developing crosses for backyard poultry farming. Therefore, information regarding its growth models is a pre-requisite which is yet not available. So, present investigation is first of its kind in India which was carried out to evaluate various non-linear models and to find out the best fitting growth model in Aseel. Data on body weights from second week of age to 20 weeks of age at biweekly intervals were recorded on 1054 progenies from 30 sires and 139 dams hatched in three hatches and maintained at Desi Fowl Unit of Central Avian Research Institute, Izatnagar, Bareilly. Owing to the non-linear characteristic of growth, three non-linear models namely, Gompertz model, Bertalanffy model and Logistic model 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 body weights at 0, 2, 4, 6, 8, 10, 12, 14, 16, 18 and 20 weeks of age averaged 28.18g, 65.94g, 138.99g, 237.06g, 359.95g, 533.74g, 718.28g, 922.33g, 1149.7g, 1321.65g and 1477.14g, respectively in males of Aseel native chicken. The corresponding body weights in females were 27.94g, 64.04g, 128.28g, 214.50g, 317.00g, 462.54g, 615.53g, 782.14g, 956.48g, 1077.65g and 1183.50g, respectively. Out of the three models, the Gompertz model, with R^2 = 1.000, Adj-R^2 = 1.000 and AIC = 29.839, best described the growth trend in males. In females, the Logistic model, with R^2 = 0.999, Adj-R^2 = 0.999 and AIC = 29.734 was found to be the best. In pooled or combined sex data, Gompertz model, having R^2 = 0.999, Adj-R^2 = 0.999 and AIC = 30.004, was determined as the best. The study revealed that these models can be used to determine the average body weights at any given point of time in Aseel native chicken under normal conditions. The investigation has generated baseline data on growth modelling and can also be used in other native chicken breeds.

Keywords: Aseel; Growth Models; Gompertz Model; Logistic Model; Bertalanffy Model

Introduction

Poultry sector, being the sunrise sector of Indian economy has been showing remarkable growth ever-since its inception. Today, India is the 3rd largest egg producer in the world after China, United States of America, and the 4th largest broiler producer after China, Brazil and the United States of America [1]. It produces 122.04 billion eggs and 4.40 million metric tons of poultry meat each year [2], the majority of which comes from commercial poultry operations, however rural poultry also adds substantially around 11.5 percent.

In poultry, body weight is one of the most significant traits which is associated with the growth rate. Growth patterns can be analysed in different time periods depending on the objective, the most important would be the growth patterns up to the marketing age of the birds for which body weights at different time points may be recorded and analysed. Such analysis of growth is highly desirable in developing countries like India for chalking out strategies for maximizing genetic gain in the improvement program and ultimately overall economic gain to the poultry farmer.

Growth is an irreversible, correlated, and coordinated increase in body mass during a specific time period. The process of growth as measured by body mass or body weight over time has frequently been described using mathematical equations fitted to a growth curve. One of the goals of these growth curves is to characterize the rise in body weight over time or age using mathematical parameters that are biologically interpretable [3]. Many authors have predicted the developmental trajectory of poultry [4-6]. A functional growth function should accurately reflect the data and include physiologically and physically relevant characteristics [7]. Bertalanffy [8], Gompertz [9], Richards [10], Logistic [11,12] and Stevens [13] models are used in poultry to characterize asymptotic growth patterns. There are different models used for assessment of the best fit model for growth. The linear model assumes that the relative growth rate is constant, while the log-linear model assumes that the absolute growth rate is constant. However, these growth rates vary depending on the individual and the environment. An unbiased model, the nonlinear model provides a better fit because it produces smaller residuals.

Aseel, the most popular native chicken breed, well known for its aggressive behaviour, fighting ability and majestic gait is being utilized for developing crosses for backyard poultry farming, however, information on its growth pattern and trends is scanty. Information on the best fitting growth models is also not available. So, this investigation was carried out to reveal best fitting growth model and to generate baseline data on growth modelling in native chicken breeds.

Materials and Methods

Experimental birds

Aseel Peela has been undergoing selective breeding programme for higher body weight at 20 weeks of age. Four generations of selection were already over and the experimental birds belong to the 5th generation of selection.

Data and traits recorded

The required data were recorded on the pedigreed birds of Aseel native chicken, maintained at Desi Farm Unit, ICAR- Central Avian Research Institute, Izatnagar. The individual chick weight and body weights from second week of age to 20 weeks of age at biweekly intervals were recorded on 1054 progenies, from 30 sires and 139 dams hatched in three hatches, using digital weighing balance. Standard feeding and management practices and vaccination schedule were followed.

Statistical analyses

Growth patterns of body weights of Aseel were analysed using following nonlinear models

Gompertz model

It is a sigmoid curve named after Benjamin Gompertz. Wright appears to have first suggested the use of this model for biological growth and following him [14], Davidson used this curve to represent body weights in cattle [15,16]. 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 [17] and model is as below:

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

Bertalanffy model

This model is given by Bertalanffy. 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

The goodness of fit of the models was checked by 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).

Results

The body weights at 0, 2, 4, 6, 8, 10, 12, 14, 16, 18 and 20 weeks of age averaged 28.18g, 65.94g, 138.99g, 237.06g, 359.95g, 533.74g, 718.28g, 922.33g,1149.7g, 1321.65g and 1477.14g, respectively in males of selected flock of Aseel native chicken. The corresponding body weights in females of selected flock were 27.94g, 64.04g, 128.28g, 214.50g, 317.00g, 462.54g, 615.53g, 782.14g, 956.48g, 1077.65g and 1183.50g, respectively (Table 1).

Three non-linear growth models namely Gompertz, Logistic and Bertalanffy were used to model the growth and fitted to average body weight in males of selected flock (n = 506). The parameter estimates of nonlinear models and goodness of fit in males of selected flock of Aseel native chicken are presented in table 2.

Gompertz model was found to be the best model to describe growth in males of selected flock with R^2, Adj-R^2 and AIC as 1.000, 1.000 and 29.839, respectively. The corresponding assessment in females of selected flock (n = 548) revealed that Logistic model was found to be the best model to describe growth in females of selected flock with R^2, Adj-R^2 and AIC as 0.999, 0.999 and 29.734, respectively. The parameter estimates of nonlinear models and goodness of fit in females of selected flock of Aseel native chicken are presented in table 3. In pooled-sex data also, analysis revealed that Gompertz model is found to be the best model to describe growth with R^2, Adj-R^2 and AIC as 0.999, 0.999 and 30.004, respectively. The parameter estimates of nonlinear models and goodness of fit in selected flock of Aseel native chicken (Combined sex) are presented in table 4.

Week	Male (n = 506)	Female (n = 548)	Combined sex (n = 1054)
0	28.18 ± 0.14	27.94 ± 0.13	28.05 ± 0.084
2	65.94 ± 0.68	64.04 ± 0.64	64.92 ± 0.44
4	138.99 ± 1.62	128.28 ± 1.49	133.36 ± 1.05
6	237.06 ± 2.28	214.50 ± 2.09	225.23 ± 1.57
8	359.95 ± 3.11	317.00 ± 2.76	337.46 ± 2.21
10	533.74 ± 4.23	462.54 ± 3.47	496.57 ± 3.02
12	718.28 ± 5.58	615.53 ± 4.46	664.68 ± 3.97
14	922.33 ± 6.50	782.14 ± 5.09	849.21 ± 4.75
16	1149.70 ± 7.72	956.48 ± 5.63	1048.85 ± 5.71
18	1321.65 ± 9.15	1077.65 ± 6.20	1194.35 ± 6.61
20	1477.14 ± 10.20	1183.50 ± 7.06	1323.96 ± 7.58

Table 1: Average body weight (in gram) of different gender of Aseel chicken at different weeks.

n: Number of observations.

Discussion

The body weight in Aseel females, at 20-week of age is found to be higher than the one reported earlier i.e., 1036.02 ± 13.64g [18]. The difference might be due to the fact that the data belong to two different generations of Aseel native chicken. Similar to the present findings, it was reported that Gompertz model is the best fit model for growth in males of selected flock of Rhode Island Red (RIR) and Rhode Island White [19].

Results of this study are in fully agreement with those reported previously where Logistic model was found to be the best fit growth model in females of Nicobari and Ghagus indigenous breeds of chicken [20]. Contrarily in females of selected flock, Gompertz

Model	Parameter	Estimate	Std. Error	R^2	R^2 (Adj.)	MAE	MSE	AIC
Gompertz	a	2469.713	106.236	1.000	1.000	95.380	146.945	29.839
	b	4.591	0.099					
	c	0.110	0.005					
Logistic	a	1736.484	44.320	0.999	0.999	126.450	276.672	32.862
	b	30.580	2.107					
	c	0.256	0.009					
Bertalanffy	a	3640.648	485.148	0.999	0.999	162.760	411.360	34.756
	b	0.859	0.018					
	c	0.061	0.007					

Table 2: Parameter estimates of nonlinear models and goodness of fit in males of selected flock of Aseel native chicken.

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

Model	Parameter	Estimate	Std. Error	R^2	R^2 (Adj)	MAE	MSE	AIC
Gompertz	a	1821.706	85.335	0.999	0.999	100.610	163.725	30.355
	b	4.369	0.126					
	c	0.117	0.006					
Logistic	a	1353.412	27.062	0.999	0.999	93.310	143.470	29.734
	b	26.677	1.615					
	c	0.259	0.008					
Bertalanffy	a	2475.582	313.849	0.998	0.997	163.300	398.715	34.607
	b	0.839	0.0					
	c	0.069	0.008					

Table 3: Parameter estimates of nonlinear models and goodness of fit in females of selected flock of Aseel native chicken.

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

Model	Parameter	Estimate	Std. Error	R^2	R^2 (Adj)	MAE	MSE	AIC
Gompertz	a	2125.799	94.906	0.999	0.999	96.950	152.118	30.004
	b	4.482	0.111					
	c	0.113	0.005					
Logistic	a	1535.429	34.869	0.999	0.999	108.820	200.481	31.323
	b	28.619	1.851					
	c	0.257	0.008					
Bertalanffy	a	3008.524	391.085	0.999	0.999	162.680	401.072	34.635
	b	0.849	0.020					
	c	0.064	0.008					

Table 4: Parameter estimates of nonlinear models and goodness of fit in selected flock of Aseel native chicken (Combined sex).

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

model and Bertalanffy model were reported to be the best models in RIR and Ankaleshwar breeds, respectively [19,21].

Similar results as of present study were reported in pooled sex data of chicken germplasm at different places viz. in medium growing broilers at Turkey [22] and in Fulani chicken (*Gallus domesticus*) at Nigeria [23]. Earlier investigations have also reported that Gompertz model is best fit growth model in Aseel [24,25] and Ankaleshwar native chicken [21] while Logistic model is the best fit model for pooled sex data of poultry in Nicobari, Ghagus and CARI-Red chicken [20].

The differences in the results regarding growth trends and models reported in different reports might be attributed to the differences in the genetic background of the stocks studied, interval between successive data recordings, as well as macro- and micro-environmental variables such as feed, pathological conditions, and other factors that existed throughout the investigation.

Conclusion

In this study, Gompertz model was found to be the best growth model in males and pooled data while Logistic model was found to be the best model to describe growth in females of selected flock. 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 native chicken under normal conditions. The investigation has generated baseline data on growth modelling and can also be simulated in other native chicken breeds.

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