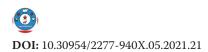# Comparison of Four Growth Curve Models for Fortnightly Body Weights in Japanese Quail

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ABSTRACT

The growth curve parameters of Japanese quail (*Coturnix coturnix japonica*) help in developing breeding strategies by modifying the management practices and can be useful in pre-selection of the birds as it provides prediction of future growth at any age. The study was conducted on fortnightly body weights of 681 black and 565 white plumage Japanese Quails. Four growth curve models viz. Gompertz, Von Bertalanffy, Richard's and Logistic functions were fitted to the body weights for estimation of the curve parameters and identification of the best function based on root mean squares error (RMSE) values. The parameter estimates viz. asymptotic (mature) weight, scaling parameter, maturing rate and shape parameter were ranging from 189.34-217.20, 0.92-15.86, 0.35-0.68 and 0.55-0.73, respectively. The RMSE values were 3.12, 4.50, 1.77 and 2.21 g for overall data; 3.48, 4.62, 2.14 and 2.28 g for male quails; 3.58, 5.00, 2.48 and 2.97 g for female ones; 3.83, 4.88, 3.03 and 3.27 g for black quails; and 3.08, 4.63, 2.65 and 1.87 g for white quails; respectively using these functions. Richards function was the best fit for overall, male, female and black categories of observations whereas Logistic function had the better fit for white quails than Richards function.

HIGHLIGHTS

⊙ Four growth curve functions were fitted to the fortnightly body weights in black and white strains of Japanese quails.
⊙ Richards function had the best fit for different classifications followed by Logistic function based on RMSE values.

Keywords: Asymptotic weight, growth curve, Japanese quail, RMSE

Japanese quails are considered as a model in poultry related research for genetic study because of their short generation interval, high adaptability, rapid growth rate, less capital requirement, better feed efficiency, high disease resistance, fast reproduction, high rate of lay and so on. The growth of birds is a function of both genetics and environment where the change leading to substantial increase in size, shape, weight, etc is accompanied by the utilization of resources. The growth curves are mathematical equations which summarizes the transformation brought about by weight gain in regular intervals. There are two important stages of the growth curve which is sigmoid in shape. The inflection/maximum rate of growth is the first one and asymptote/highest value with further zero/no growth is the second phase.

The parameters of the growth curve are valuable *tools* for making selection and culling decisions. The critical variations unfolded by random events and environmental means can be studied by the growth parameters (Aggrey, 2003) by modifying the genetic makeup or management practices. Various selection experiments (Narianc *et al*., 2014; Kaplan *et al*., 2016) have been conducted on the utility of growth functions and their importance. Accordingly, the study was undertaken to compare the growth curve models and estimate the curve parameters in Japanese quails.

MATERIALS AND METHODS

The present investigation were carried out on two strains (black and white) of Japanese quails maintained at poultry breeding farm under Directorate of Livestock Farms of Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana. The study was conducted on 565 white (141 male and 424 female) and 681 black (173 male and 508 female) plumage Japanese quails during 2019-20.

Four growth curve models viz. Gompertz, Von Bertalanffy, Richard's and Logistic functions were fitted to the least squares mean (SPSS software 24.0) fortnightly bodyweights (hatch, 2nd, 4th, ……20th week) of Japanese Quails.

1. Gompertz function

$$Y_t = A * e\{-B * e(-K * t)\}$$

2. Von Bertalanffy function

$$Y_t = A * \{1 - B * e(-K * t)\}^3$$

3. Richard's function

$$Y_t = (B * A) / \left\{ \left[B^D + (A^D - B^D) * e(-K * t) \right]^{(1/D)} \right\}$$

4. Logistic function

$$Y_t = A / \{1 + B * e(-K * t)\}$$

Where,

Y_t = body weight (g) of birds at t weeks of age

A = asymptotic (mature) weight when time goes to infinity

B = scaling parameters (constant of integration) related with initial values of weight

K = maturing rate (instantaneous growth rate)

D = shape parameter

The most suitable model was identified on the basis of the lowest root mean square error (RMSE) value using Microsoft excel solver.

RESULTS AND DISCUSSION

The least squares mean fortnightly body weights of different categories of observations (overall, male, female, black and white) of Japanese quails are presented in Table 1. For both male and female quails, black plumage quails had lower body weights than the white plumage through different ages which are in agreement with the findings of Bagh *et al.* (2016). Body weights at fortnight intervals were used for fitting the growth curve functions. The RMSE values and parameter estimates of different growth curve functions of different classification of observations are presented in Table 2. The fitting of the curves using the four functions (Gompertz, von Bertalanffy, Richards and Logistic) viz. overall, male, female, black and white quails are presented graphically in Figs. 1 to 4.

For Gompertz function the asymptotic (mature) weight (A) ranged from 191.43 to 215.94; scaling parameter (B) from 3.92 to 4.12; and maturing rate (K) from 0.40 to 0.46. However, Raji *et al.* (2014) reported the values of model parameters of A, B and K as 132.71±1.41, 0.9338±0.03 and 0.3765±0.01 in male and 168.83±1.7121, 0.9507±0.02 and 0.3262±0.01 in female quails, respectively. Adedeji *et al.* (2017) reported these estimates as 155.40 ± 2.333, 2.705 ± 0.281 and 0.045 ± 0.003 in Japanese quails of Nigeria. Our results are supported by findings of Kaplan and Gurcan (2018) for A, B and K that are 222.8, 3.494, 0.059 and 287.7, 3.588, 0.051; respectively in male and female quails. Haqani *et al.* (2021) also reported these estimates as 185.46, 6.3288, 0.5434 and 226.53, 6.0278, 0.4917 in large sized male and female quails, respectively.

Using von Bertalanffy function, parameter estimates of A, B and K ranged from 192.10 to 217.20; 0.92 to 0.97 and 0.35 to 0.41; respectively. Adedeji *et al.* (2017) reported these parameters as 156.60 ± 2.447, 0.656 ± 0.053 and 0.039 ± 0.003 in 235 numbers of Japanese quails. Kaplan and Gurcan (2018) reported these estimates using this function as 265.6, 0.740, 0.039 in male and 374.8, 0.751, 0.031 in female ones.

The estimates for shape parameter (D) and A, B, K using Richards function ranged from 0.55 to 0.73; 189.78 to 213.99; 9.36 to 9.88 and 0.51 to 0.62; respectively. Sezer and Tarhan (2005) also reported that these estimates of A, B, K and D ranged from 182.102 to 261.727, 7.437 to 8.630, 0.067 to 0.113 and 0.170 to 0.618 while comparing among three varieties (white, black and wild) within male

Table 1: Least squares mean of fortnightly body weights (BW) in Japanese quails

BW	Overall		Male		Female		Black		White	
	N	μ ± SE	N	μ ± SE	N	μ ± SE	N	μ ± SE	N	μ ± SE
0D (Hatch)	1246	7.01±0.04	314	7.01±0.07	932	7.02±0.04	681	6.64±0.05	565	7.39±0.06
2W	1232	40.36±0.30	311	39.80±0.51	921	40.92±0.30	676	40.09±0.38	556	40.64±0.42
4W	1221	91.91±0.74	310	92.37±1.24	911	91.45±0.75	670	89.25±0.92	551	94.56±1.01
6W	1217	150.77±0.90	310	149.52±1.52	907	152.01±0.92	668	145.73±1.14	549	155.80±1.24
8W	1204	183.14±0.86	307	176.92±1.45	897	189.36±0.87	664	177.15±1.07	540	189.14±1.18
10W	812	194.34±0.99	210	185.21±1.64	602	203.46±1.01	423	185.52±1.26	389	203.15±1.31
12W	809	198.95±0.96	209	188.88±1.60	600	209.02±0.98	422	188.68±1.23	387	209.22±1.28
14W	807	198.40±0.91	208	186.42±1.51	599	210.38±0.93	420	186.77±1.16	387	210.04±1.21
16W	807	201.72±0.98	208	186.89±1.62	599	216.54±0.99	420	192.67±1.24	387	210.76±1.29
18W	801	204.22±1.04	204	191.12±1.74	597	217.31±1.05	417	198.76±1.32	384	209.67±1.39
20W	780	201.79±1.05	187	193.38±1.82	593	210.21±1.00	401	193.66±1.36	379	209.92±1.33

Table 2: Estimates of growth curve parameters for the studied growth functions in Japanese quails

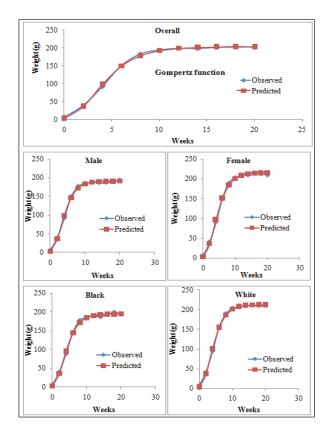| Functions	A	B	K	D	RMSE (g)
Gompertz					
Overall	203.60	4.01	0.43		3.12
Male	191.43	4.12	0.46		3.48
Female	215.94	3.96	0.40		3.58
Black	194.67	3.92	0.43		3.83
White	212.52	4.10	0.43		3.08
Von Bertalanffy					
Overall	204.55	0.94	0.37		4.50
Male	192.10	0.97	0.41		4.62
Female	217.20	0.92	0.35		5.00
Black	195.64	0.92	0.37		4.88
White	213.47	0.96	0.37		4.63
Richard's					
Overall	201.84	9.58	0.55	0.60	1.77
Male	189.78	9.54	0.62	0.73	2.14
Female	213.99	9.88	0.51	0.55	2.48
Black	192.96	9.36	0.55	0.60	3.03
White	210.71	9.82	0.55	0.62	2.65
Logistic					
Overall	201.02	15.30	0.64		2.21
Male	189.34	15.86	0.68		2.28
Female	212.88	15.09	0.60		2.97
Black	192.15	15.01	0.64		3.27
White	209.89	15.59	0.63		1.87

Fig. 1: Observed and predicted fortnightly body weights by Gompertz Function

Fig. 2: Observed and predicted fortnightly body weights by Von Bertalanffy Function

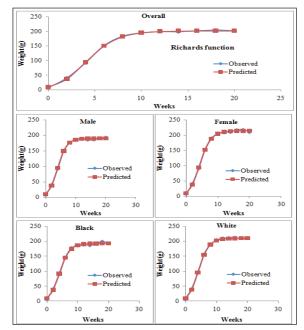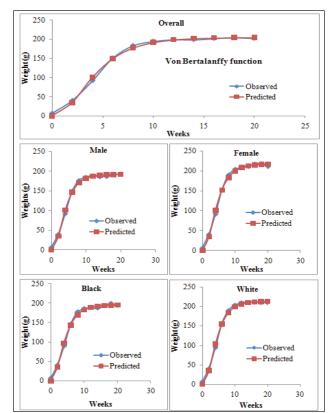**Fig. 3:** Observed and predicted fortnightly body weights by Richard's Function
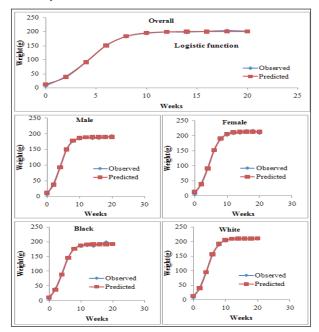

Fig. 4: Observed and predicted fortnightly body weights by Logistic Function

and female Japanese quails. Our findings are in agreement with the observation of Haqani *et al*. (2021) who reported these estimates as 0.4327, 221.20, 3.3941, 0.6037 and 0.3592, 183.98, 2.1132, 0.6437 in large sized female and male quails, respectively.

The range of A, B and K parameters using Logistic function were 189.34 to 212.88; 15.01 to 15.86 and 0.60 to 0.68, respectively. The values are 153.40 ± 2.368, 7.543 ± 1.506 and 0.065 ± 0.006 as per reports of Adedeji *et al*. (2017) in Japanese quails of Nigeria. Our findings are in agreement with that of Kaplan and Gurcan (2018) who reported these estimates as 183.3, 15.492, 0.118 and 219.4, 16.679, 0.109 in male and female Japanese quails, respectively.

The root mean squares (RMSE) values for Gompertz, von Bertalanffy, Richards and Logistic functions ranged from 3.08 to 3.83 g, 4.62 to 5.00 g, 1.77 to 3.03 g and 1.87 to 3.27 g, respectively. Adedeji *et al*. (2017) reported Mean Square Error (MSE) values as 65.744, 51.363 and 49.731 using Logistic, Gompertz and von Bertalanffy functions, respectively. Our results are supported by Kaplan and Gurcan (2018) who reported the MSE values using Gompertz, von Bertalanffy, Richards and Logistic functions as 4.00, 4.90, 3.62, 17.68 and 6.10, 8.86, 6.01, 13.17 in female and male Japanese quails, respectively. Reports of Beiki *et al*. (2013) also confirms better fit of Richard's function by MSE criteria and the values were 18.987, 11.502, 9.514 and 21.894; respectively for unselected random bred Japanese quails. Experiments of Haqani *et al*. (2021) also in agreement with our findings who reported the RMSE values for Gompertz, Richards and Logistic models as 2.140, 1.996, 3.433 and 2.995, 2.699, 4.056 for large sized male and females, respectively whereas the corresponding values were 1.983, 1.965, 3.065 and 1.386, 1.361, 2.746 for normal sized male and females, respectively.

CONCLUSION

The lowest RMSE value was observed in Richard's model for overall, male, female and black categories of quails, whereas logistic function had lowest RMSE for the white Japanese Quails. Richard's function was found out to be the best fit followed by logistic function for the body weight gain through different fortnightly weeks in Japanese quails. It is recommended to take into account the parameter estimates of these functions in selection and breeding programmes.

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