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Modeling growth curves for Indian Native vs Exotic chicken breeds to assist in selection strategies

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ABSTRACT

The knowledge of growth curves in poultry is worth for determining economic efficiencies. With the availability of advance and potent computing algorithm, we can develop suitable statistical procedures for model evaluation which suites for the estimation of parameters influencing body weight in native and exotic chicken breeds. In this study, three breeds of chicken . Brown Nicobari (119), Ghagus (118) and Dahlem Red (125) were taken which were hatched at the same time using 20 sires and eighty dams from each breed and maintained at ICAR-Directorate of Poultry Research, Hyderabad under same milieu. Genetic parameters, for body weight up to 14 weeks of age, of all the three breeds have been evaluated. Data on parameters like egg weight (at the time of incubation), birth weight and weight at weekly intervals up to 14 weeks of age were recorded. The animal growth data are generally non-linear in nature so an attempt has been made to fit non-linear growth models, viz. exponential, logistic, Gompertz and monomolecular on data pertaining to body weight of native and exotic poultry breeds. The study concludes that the two criteria Mean Absolute Error and Root Mean Square Error support the logistic model which was found to be most suitable growth model for poultry birds.

Key words: Body weight, Chicken, Exotic, Growth curves, Native

Though native chickens are slow grower and poor layers with small sized eggs, they however, have good mothering ability and broodiness character and possess natural immunity against common diseases (Tadelle 2003, Dessie *et al.* 2011). TheGhagus breed is of medium size having fairly good mothering ability and broodiness character and it is native of Kolar district of Karnataka (Haunshi *et al.* 2015, Vij *et al.* 2006). Nicobari fowl, the highest egg producer among all the native breeds of India is an indigenous and endemic breed of Andaman and Nicobar Islands (Kundu *et al.* 2012). Dahlem Red bird, an exotic breed,is originated from Germany. Many workers tried to fit non-linear growth model on pigs (Sarkar *et al.* 2009) and cattle and buffalo milk production trends (Yadav *et al.* 2013), and for meat export (Paul *et al.* 2013). The information related to the best statistical model suited in relation to body weight parameters of native vis-à-vis exotic breed under similar milieu is lacking. Therefore, this study was conducted to develop a suitable statistical procedure for model evaluation which suites for estimation of parameters influencing body weight in native and exotic chicken breeds.The animal growth data are generally non-linear in nature thus, an attempt has been made to fit non-linear growth models, viz. exponential, logistic, Gompertz and monomolecular with the data pertaining to body weight of poultry birds.

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MATERIALS AND METHODS

Random bred pedigreed populations of Brown Nicobari, Ghagus and Dahlem Red maintained at ICAR-Directorate of Poultry Research, Hyderabad, India was used in this study. The birds were hatched through random breeding using 20 sires and 80 dams from each breed. All eggs were weighed individually and marked with pencil before putting them into the incubator (37.5°C, RH 55%, with rotation). At 17th day of incubation, eggs were moved to hatcher in pedigree pan for individual hatching. Hatched chicks were weighed, wings tagged and placed in a pan with free access to food and water. A total of 367 birds from three breeds, Brown Nicobari (119), Ghagus (118) and Dahlem Red (125) were taken for the study. All the birds were immunized against Newcastle disease with lentogenic LaSota vaccine through eye drops at 7thday and ND with live mesogenic R2B vaccine at 9 weeks of age.The experiment was carried out with prior approval of Institute's Animal Ethics committee. The chicks were weighed immediately after hatch and at weekly intervals. Chicks of all the three breeds were simultaneously hatched, housed and reared under similar management and healthcare conditions with *ad lib.* access to food and water. The ambient temperature of the shed was 30^{o}C.The body weight gain of chicks at weekly

Table 1. Parameter estimate of Exponential, Logistic, Gompertz and Monomolecular growth models (using 0–14 week weight)

Breed	Sex	Model	α	β	γ	MAE	RMSE	Statistical important level
Ghagus	Female	Exponential	80.3803	–0.1745	–	34.84	39.37	<.0001
		Gompertz	28.2535	0.3053	1190.5	7.26	9.21	<.0001
		Logistic	2463.3	4.4669	0.1037	5.84	7.46	<.0001
		Monomolecular	9.1195	–0.1068	–243.9	14.79	17.61	<.0001
	Male	Exponential	84.9565	–0.1784	–	38.38	43.14	<.0001
		Gompertz	30.5742	0.3091	1339.5	7.13	8.78	<.0001
		Logistic	2827.3	4.5950	0.1039	5.70	7.74	<.0001
		Monomolecular	6.5058	–0.1116	–254.3	15.96	18.75	<.0001
Brown Nicobari	Female	Exponential	66.2275	–0.1820	–	24.88	28.97	<.0001
		Gompertz	32.4629	0.2855	1270.8	9.11	10.84	<.0001
		Logistic	4057.6	4.9138	0.0794	5.97	7.96	<.0001
		Monomolecular	18.0766	–0.1301	–136.5	13.67	15.89	<.0001
	Male	Exponential	76.5196	–0.1794	–	30.22	34.14	<.0001
		Gompertz	30.4074	0.2907	1337.3	5.53	6.89	<.0001
		Logistic	3414.4	4.6936	0.0893	5.19	6.88	<.0001
		Monomolecular	13.7316	–0.1195	–192.7	11.74	13.86	<.0001
Dahlem Red	Female	Exponential	77.9081	–0.1737	–	33.02	37.35	<.0001
		Gompertz	27.6527	0.3026	1146.4	6.88	8.81	<.0001
		Logistic	2393.6	4.4406	0.1024	5.78	7.17	<.0001
		Monomolecular	10.1804	–0.1064	–233.9	13.86	16.61	<.0001
	Male	Exponential	82.4138	–0.1780	–	35.82	40.16	<.0001
		Gompertz	29.9522	0.3029	1320.6	6.22	7.84	<.0001
		Logistic	2892.3	4.5859	0.1000	5.92	7.76	<.0001
		Monomolecular	8.6097	–0.1124	–238.7	14.15	16.68	<.0001

MAE, mean absolute error; RMSE, root mean square error.

interval was recorded and relative growth rate of chicks were assessed.

Statistical analysis: The analysis for this paper was generated using SAS/STAT software, Version 9.4 of the SAS System for Windows. Final weight (14thweek) of male and female birds has been compared and it was found that weight of male birds were significantly different from female birds and mean weight of male and female birds were 1012.05 g and 850.50 g, respectively.

The body weight of male and female birds were compared using Proc GLM in SAS, all breeds were compared with respect to the body weight and their interaction was also estimated. Growth curve for livestock is generally of sigmoid shape and it follows non-linear trend hence, Exponential (Draper and Smith 1998, Prajneshu and Chandran 2005), Logistic, Gompertz (Chandran and Prajneshu 2004) and Monomolecular growth models were tried to model the growth pattern of body weight gain in poultry.

Criteria for model selection: There are situations in which the use of model is not particularly well founded and several competing models may appear to fit the data equally well in practice. Hence, there is a need to know the criteria that will help to test goodness of fit vis-à-vis comparison among different competing models. The two most prominent criteria of fitting the models are Mean Absolute Error (MAE) and Root Mean Square Error (RMSE).

RESULTS AND DISCUSSION

Since body weight of males and females follow different patterns, ($P<0.0001$) we shall fit growth curve separately for male and females. It is worth to note that all the three breeds ($P=0.038$) are also performing significantly different but there is no significant interaction of breeds with sex ($P=0.9514$). in table this value will be added.

Model for the body weight of male and female birds for all the three breeds namely Brown Nicobari, Ghagus and Dahlem Red) have been fitted separately as ANOVA revealed that different breeds are significantly different ($P<0.05$) with respect to body weight gain pattern and sex.

The parameter estimate ofExponential, Logistic, Gompertz and Monomolecular growth models are given in Table 1.

The results of the fitted model for Brown Nicobari female birds (Table1) indicate that values of MAE and RMSE are minimum for Logistic model i.e. 5.97 and 7.96, thus Logistic model is found to fit growth curve for Brown Nicobari female birds. The results of the fitted model for Brown Nicobari male birds (Table 1) indicate that values of MAE and RMSE are minimum for Logistic model i.e. 5.19 and 6.88, respectively thus Logistic model is found to fit growth curve for Brown Nicobari male birds.

The results of the fitted model for Dahlem Red female birds (Table1) indicate that values of MAE and RMSE are minimum for Logistic model i.e. 5.78 and 7.17, thus Logistic

Table 2. Comparison of different growth models with actual data

Breed	Weekly bird weight and estimated weights using non-linear growth models					
	Week	Weight	Exponential	Gompertz	Logistic	Monomolecular
Brown Nicobari (Female)	0	29.481	66.227	29.8	37.976	18.077
	1	46.522	79.45	43.36	50.029	39.557
	2	70.287	95.312	61.31	65.704	64.022
	3	94.237	114.341	84.429	85.944	91.885
	4	120.533	137.169	113.461	111.841	123.62
	5	145.32	164.555	149.075	144.589	159.763
	6	182.481	197.408	191.829	185.392	200.927
	7	235.13	236.821	242.14	235.303	247.81
	8	295.685	284.102	300.261	294.999	301.206
	9	347.648	340.823	366.269	364.509	362.02
	10	446.963	408.869	440.063	442.963	431.283
	11	530.685	490.499	521.369	528.456	510.168
	12	616.963	588.428	609.757	618.128	600.012
	13	724.722	705.907	704.656	708.494	702.337
	14	784.907	846.841	805.384	795.959	818.878
Brown Nicobari (Male)	Week	Weight	Exponential	Gompertz	Logistic	Monomolecular
	0	30.456	76.52	31.254	42.581	13.732
	1	46.042	91.555	46.673	56.341	39.929
	2	72.612	109.545	67.352	74.293	69.452
	3	101.932	131.07	94.193	97.53	102.72
	4	131.442	156.825	128.01	127.302	140.21
	5	163.858	187.64	169.467	164.954	182.458
	6	213.238	224.511	219.037	211.792	230.066
	7	278.599	268.626	276.968	268.879	283.716
	8	344.833	321.409	343.268	336.751	344.174
	9	399.945	384.565	417.71	415.098	412.303
	10	504.794	460.13	499.842	502.52	489.078
	11	595.852	550.543	589.02	596.445	575.596
	12	689.827	658.721	684.441	693.346	673.092
	13	791.676	788.157	785.183	789.22	782.959
	14	881.148	943.025	890.246	880.231	906.769
Dahlem Red (Female)	Week	Weight	Exponential	Gompertz	Logistic	Monomolecular
	0	30.881	77.908	28.219	40.011	10.18
	1	44.028	92.685	43.471	53.488	37.567
	2	70.377	110.264	64.208	71.214	68.027
	3	98.961	131.177	91.307	94.307	101.904
	4	129.482	156.057	125.469	124.024	139.583
	5	160.258	185.656	167.162	161.667	181.491
	6	210.576	220.869	216.578	208.406	228.101
	7	273.403	262.761	273.619	265.021	279.941
	8	337.453	312.598	337.908	331.579	337.599
	9	390.113	371.887	408.821	407.131	401.727
	10	488.741	442.422	485.531	489.556	473.051
	11	578.774	526.335	567.066	575.673	552.378
	12	658.009	626.163	652.364	661.68	640.608
	13	753.712	744.925	740.329	743.79	738.738
	14	814.008	886.213	829.879	818.876	847.879
Dahlem Red (Male)	Week	Weight	Exponential	Gompertz	Logistic	Monomolecular
	0	30.921	82.414	29.486	42.665	8.61
	1	45.551	98.47	45.628	57.104	38.027
	2	73.019	117.655	67.733	76.14	70.943
	3	104.312	140.577	96.834	101.014	107.775
	4	136.808	167.964	133.807	133.145	148.988
	5	172.386	200.688	179.291	174.038	195.104
	6	227.789	239.787	233.635	225.109	246.706
	7	299.51	286.504	296.874	287.409	304.446

(*Contd...*)

(*Table 2. Contd*)

Breed	Weekly bird weight and estimated weights using non-linear growth models					
	Week	Weight	Exponential	Gompertz	Logistic	Monomolecular
	8	371.001	342.322	368.723	361.266	369.055
	9	429.387	409.015	448.608	445.91	441.349
	10	539.16	488.701	535.705	539.238	522.243
	11	638.071	583.912	628.995	637.855	612.761
	12	731.598	697.673	727.33	737.484	714.045
	13	839.855	833.597	829.486	833.671	827.379
	14	922.257	996.002	934.227	922.555	954.194
Ghagus (Female)	Week	Weight	Exponential	Gompertz	Logistic	Monomolecular
	0	30.768	80.38	28.285	40.695	9.12
	1	45.389	95.708	43.927	54.561	37.652
	2	72.329	113.96	65.323	72.85	69.401
	3	101.517	135.691	93.416	96.749	104.73
	4	131.373	161.567	128.962	127.592	144.043
	5	165.18	192.377	172.466	166.769	187.787
	6	218.46	229.062	224.133	215.536	236.464
	7	285.211	272.743	283.852	274.736	290.629
	8	350.154	324.754	351.212	344.451	350.901
	9	405.026	386.683	425.533	423.673	417.969
	10	508.899	460.421	505.92	510.129	492.598
	11	603.793	548.222	591.324	600.413	575.642
	12	688.213	652.765	680.602	690.46	668.048
	13	784.905	777.244	772.579	776.245	770.874
	14	849.933	925.461	866.1	854.476	885.292
Ghagus (Male)	Week	Weight	Exponential	Gompertz	Logistic	Monomolecular
	0	31.058	84.96	28.563	42.423	6.506
	1	46.438	101.55	44.951	57.133	37.281
	2	74.541	121.39	67.647	76.641	71.688
	3	105.836	145.1	97.776	102.28	110.156
	4	139.343	173.44	136.28	135.574	153.164
	5	175.653	207.33	183.823	178.147	201.247
	6	234.07	247.82	240.737	231.516	255.005
	7	308.521	296.23	306.989	296.788	315.107
	8	384.105	354.1	382.194	374.247	382.303
	9	444.336	423.27	465.643	462.945	457.428
	10	560.747	505.95	556.363	560.46	541.42
	11	663.495	604.78	653.182	662.979	635.325
	12	763.068	722.92	754.803	765.815	740.311
	13	868.79	864.14	859.875	864.226	857.688
	14	953.547	1032.94	967.054	954.246	988.917

model is found to fit growth curve for Dahlem Red female birds. The results of the fitted model for Brown Nicobari male birds (Table1) indicate that values of MAE and RMSE are minimum for Logistic model i.e. 5.92 and 7.76, thus Logistic model is found to fit growth curve for Dahlem Red male birds.

The results of the fitted model for Brown Nicobari female birds (Table1) indicate that values of MAE and RMSE are minimum for Logistic model i.e. 5.84 and 7.46, thus Logistic model is found to fit growth curve for Ghagus female birds. The results of the fitted model for Ghagus male birds (Table1) indicate that values of MAE and RMSE are minimum for Logistic model i.e. 5.70 and 7.74, thus Logistic model is found to fit growth curve for Ghagus male birds.

The growth of three breeds of poultry birds Brown Nicobari and Ghagus (native) and Dahlem Red (exotic) maintained at ICAR-DPR, Hyderabad was studied for fitting of suitable statistical non-linear models, viz. Exponential, Logistic, Gompertz and Monomolecular growth models. These models have been examined to obtain the best fitted model using the criteria based on Mean Absolute Error (MAE)and Root Mean Square Error (RMSE). It was found that the selected criteria Mean Absolute Error (MAE) and Root Mean Square Error (RMSE) supported the logistic model which was found to be most suitable growth model for poultry birds. It can therefore, be concluded that best strategy can be formulated for efficient poultry production by using the logistic model which will assist in predicting the meat production at maturity age and thereby facilitating in optimum use of resources in the farm.

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