Indian Journal of Animal Sciences **86** (5): 612–615, May 2016/Short communication
https://doi.org/10.56093/ijans.v86i5.58536

Modelling of Rhode Island Red chicken strains

HINA KAUSAR[1], MED RAM VERMA[2], SANJEEV KUMAR[3], VIJAY BAHADUR SHARMA[4], ANANTA KUMAR DAS[5] and LEENA DILLIWAR[6]

ICAR - Indian Veterinary Research Institute, Izatnagar, Bareilly, Uttar Pradesh 243 122 India

Received: 29 May 2015; Accepted: 28 September 2015

Key words: Adjusted R^2, Durbin Watson (DW) test, MAE, MSE, Non linear models, R^2

(Graphical abstract available only online)

Poultry farming has assumed much importance due to the growing demand of poultry products especially in urban areas because of their high food value. The poultry has the highest rate of growth in agricultural sector in India with a growth rate of 8 to10% in eggs and 15 to 20% in broilers over the last two decades. From the year 1999–2000 onwards the production of egg improved substantially and it reached 69,731 million numbers in the year 2012–13 (BAHS 2014). The growth is an irreversible, correlated and coordinated increase in the mass of body in a definite interval of time (Brody 1945). It is necessary to have knowledge of pattern of growth in poultry because body growth is an important factor that contributes to the profitability in poultry production. Fitting growth curves to longitudinal measurements is a standard method to analyze growth pattern in poultry (Berkey 1986). Growth models relate the average weight of different poultry birds as a function of their age. From these models one can determine the expected average weight of a group of birds of the same breed at any given age under normal conditions (Prasad and Singh 2006). Several nonlinear models are being used in poultry which define the relationship between age and live weight (Prasad *et al.* 2008, Prasad and Singh 2006, Paul *et al.* 2011). The objective of these growth curves is to describe the behaviour of the body weight with increase in time or age with mathematical parameters that are biological interpretable.

Data on body weights of 3 pure strains of Rhode Island Red were compiled from the study conducted by Das (2013) during 2011 at Central Avian Research Institute, Izatnagar, Bareilly, Uttar Pradesh. For analysing the growth pattern of body weight of Rhode Island Red strains chicken following nonlinear models were used (Prasad *et al.* 2008, Singh *et al.* 2014).

Gompertz model: $y_t = a \exp(-b \exp(-ct)) + e$

Logistic model: $y_t = \dfrac{a}{1 + b\exp(-ct)} + e$

Bertalanffy model: $y_t = a\,[1-b \exp(-ct)]^3 + e$

where y_t, observed body weight of the chick at t^{th} week; t, age of the chick in weeks; e, the error term; a, asymptotic weight; b, scaling parameter; c, rate of maturity.

The goodness of fit of the models was checked by coefficient of determination (R^2), adjusted coefficient of determination ($\bar{R}^2$), Mean square error (MSE), mean absolute error (MAE) and Akaike Information Criterion (AIC). To test the assumptions about the independence of errors Durbin Watson (DW) test was used and Shapiro Wilk's test was used to test the normality of errors. For studying the growth pattern in poultry, data on average body weights of 3 strains of Rhode Island Red namely Rhode Island Red (1,308 birds), Rhode Island Control (643 birds) and Rhode Island White (232 birds) were used. The data on average body weights of chicken during 0, 1, 2, 3, 4, 6, 8 and 12 weeks of 3 Rhode Island Land strains are given in Table 1.

The average body weight of the male chicken varied between 37.64 g in 0 week to 1,050.42 g in 12^{th} week. However the body weight of the female chicken varied between 37.32 g in 0 week to 914.61 g in 12^{th} week (Table 1). The estimates of the growth parameters of Rhode Island Red chicken strains are given in Table 2. The R^2 values were high for all growth models indicating a significant relationship between age and weight in both sexes for Rhode Island Red chicken. Based on the different goodness of fit criteria the Bertalanffy was the best fitted model with the highest values of R^2, adjusted R^2 ($\bar{R}^2$) and lowest values of MAE and AIC for Rhode Island Red chicken. For the male birds of RIR, Bertalanffy gave the best fit and for the female chicken gompertz was the best fitted model on the basis of different goodness of fit criteria.

Present address: [1,6]M.V.Sc. Scholar (sanavet13@gmail.com, dilliwar123@gmail.com), [2]Senior Scientist (medramverma @rediffmail.com), [4]Ph.D. Scholar (drvijaybhardwaj @gmail.com), Division of Livestock Economics, Statistics and Information Technology. [3]Principal Scientist (skgicar @gmail.com), ICAR- Central Avian Research Institute, Izatnagar. [5]Subject Matter Specialist (dasugenvet@gmail.com), Howrah KVK, West Bengal.

Table 1. Average body weight of different Rhode Island Red strains chicken during different weeks

Strain	Sex	Number of birds	Average body weight during different weeks							
			0	1	2	3	4	6	8	12
RIR	Male	701	37.64	57.03	92.63	158.64	206.93	365.43	600.14	1050.42
	Female	607	37.32	56.85	90.39	151.03	193.78	331.84	561.69	914.61
	Combined	1308	37.90	56.95	91.56	155.08	200.71	350.56	585.41	985.55
RIC	Male	355	34.54	52.49	82.37	144.56	174.37	279.77	422.13	765.43
	Female	288	34.35	51.21	82.88	134.82	167.78	261.11	397.92	705.46
	Combined	643	34.46	51.84	82.60	139.65	171.41	270.60	410.59	738.18
RIW	Male	141	35.03	50.84	79.49	137.40	188.02	329.48	498.67	945.28
	Female	91	35.35	50.59	76.82	134.63	181.01	311.04	488.18	811.01
	Combined	232	31.16	50.75	78.55	136.46	185.32	322.10	479.37	892.30

Table 2. Parameter estimates of models and goodness of fit statistics of Rhode Island Red chicken

Sex	Model	Parameter	Estimate	SE	R^2	$\bar{R}^2$	MSE	MAE	AIC	DW
Male	Bertalanffy	a	6563.642	1086.229	0.999	0.998	200.4	9.56	53.7	2.13
		b	0.832	0.006						
		c	0.05	0.006						
	Gompertz	a	1754.504	663.234	0.882	0.811	376.63	12.29	59.38	2.51
		b	19.903	33.947						
		c	–0.302	0.214						
	Logistic	a	2079.418	169.504	0.996	0.993	1574.465	27.098	72.255	2.62
		b	28.194	3.62						
		c	0.287	0.023						
Female	Bertalanffy	a	2443.846	264.176	0.999	0.998	660.026	11.577	64.43	2.82
		b	0.794	0.015						
		c	0.087	0.009						
	Gompertz	a	1829.161	95.666	0.999	0.998	229.7264	9.488	54.932	2.19
		b	3.997	0.11						
		c	0.148	0.009						
Combined	Bertalanffy	a	3849.163	463.684	0.999	0.998	214.084	9.58	54.297	2.74
		b	0.81	0.008						
		c	0.067	0.006						
	Gompertz	a	2478.382	173.105	0.999	0.998	40541.23	105.49	101.49	1.613
		b	4.143	0.092						
		c	0.127	0.008						
	Logistic	a	1720.349	110.931	0.996	0.994	1250.596	23.61	70.182	2.042
		b	25.024	3.296						
		c	0.302	0.024						

Durbin Watson (DW) test indicated that there was no autocorrelation and Shapiro-Wilk's test indicated that errors were normally distributed. However, Prasad *et al.* (2008) also observed that gompertz model best described the growth pattern in Indian native chicken. Kuhi *et al.* (2003) also observed the better performance of Bertalanffy model than logistic and gompertz models for describing the growth performance of chicken.

Rhode Island control male and female chicken varied from 34.35 g during 0^{th} week to 765.43 g in 12^{th} week. The R^2 values were high for all growth models indicating a significant relationship (Table 3) between age and weight in both sexes for Rhode Island Control chicken. Based on the various goodness of fit measures Bertalanffy was the best fitted model for Rhode Island Control chicken strain. For the body weights of the male RIC logistic model best described the data with highest R^2 and adjusted R^2 and minimum MSE, MAE and AIC. For the female birds of RIC strain Gompertz model gave the best fit with highest R^2 and adjusted R^2 and minimum value of MSE, MAE, and. Durbin Watson (DW) test indicated that there was no autocorrelation and Shapiro-Wilk's test indicated that errors were normally distributed. The gompertz function has been preferred over the logistic function for fitting monophasic growth curves of chickens (Laird 1966). However Prasad *et al.* (2008) also observed that gompertz model best described the growth pattern in Indian native chicken. Kuhi *et al.* (2003) also observed the better performance of Bertalanffy model than logistic and gompertz models for describing the growth performance of chicken.

The estimates of the growth parameters of Rhode Island White strain are given in Table 4. The R^2 values were high

Table 3. Parameter estimates of models and goodness of fit statistics Rhode Island Control

Sex	Model	Parameter	Estimate	SE	R^2	$\bar{R}^2$	MSE	MAE	AIC	DW
Male	Bertalanffy	a	605.013	131.884	0.826	0.721	13270.28	65.18	91.44	2.15
		b	0.931	0.542						
		c	0.278	0.171						
	Gompertz	a	598.823	113.29	0.836	0.737	12522.16	61.27	90.91	2.34
		b	4.307	2.95						
		c	0.333	0.181						
	Logistic	a	591.693	86.832	0.854	0.766	11099.84	52.804	89.83	2.02
		b	19.969	22.328						
		c	0.52	0.229						
Female	Bertalanffy	a	568.367	121.035	0.837	0.739	10589.73	57.88819	89.408	2.06
		b	0.89	0.47						
		c	0.269	0.159						
	Gompertz	a	561.344	102.636	0.847	0.769	9943.89	54.52708	88.84242	2.19
		b	4.113	2.577						
		c	0.325	0.168						
Combined	Bertalanffy	a	3559.83	473.48	1	1	83.67	6.025	45.84	2.25
		b	0.793	0.006						
		c	0.055	0.005						
	Gompertz	a	2050.16	126.87	1	1	40351.58	105.57	101.44	3.2
		b	3.94	0.052						
		c	0.112	0.006						
	Logistic	a	1318.23	68.58	0.998	0.996	348.84	14.25	58.69	0.25
		b	22.088	1.852						
		c	0.282	0.016						

Table 4. Parameter estimates of models and goodness of fit statistics of Rhode Island White

Sex	Model	Parameter	Estimate	SE	R^2	$\bar{R}^2$	MSE	MAE	AIC	DW
Male	Bertalanffy	a	878.483	158.527	0.917	0.867	11447.37	65.64	90.11	2.68
		b	1.032	0.441						
		c	0.244	0.11						
	Gompertz	a	856.487	123.208	0.926	0.809	12302.38	59.456	90.757	2.17
		b	5.126	2.598						
		c	0.306	0.115						
	Logistic	a	591.693	86.832	0.854	0.766	7906.561	48.148	86.779	3.12
		b	19.969	22.328						
		c	0.52	0.229						
Female	Bertalanffy	a	754.235	127.402	0.922	0.875	7790.591	53.541	86.64605	2.53
		b	0.945	0.348						
		c	0.241	0.102						
	Gompertz	a	736.171	100.047	0.93	0.906	6976.908	48.389133	85.65325	2.72
		b	4.524	1.966						
		c	0.3	0.106						
Combined	Bertalanffy	a	828.165	146.05	0.918	0.869	9968.862	61.0941	88.865	2.57
		b	0.999	0.406						
		c	0.244	0.107						
	Gompertz	a	808.141	114.266	0.927	0.883	8933.686	55.2718	87.87	2.68
		b	4.884	2.344						
		c	0.304	0.112						
	Logistic	a	781.965	74.097	0.943	0.908	6946.761	44.62781	85.614	2.86
		b	27.667	21.504						
		c	0.508	0.142						

for all growth models indicating a significant relationship between age and weight in both sexes for Rhode Island White chicken. Based on the goodness of fit criteria logistic model presented best adjustment to the body growth data with maximum R^2 and adjusted R^2 and minimum values of MSE, MAE and AIC. In case of male birds of the Rhode Island White Bertalanffy gave the best fit as evident from the highest value of R^2, adjusted R^2 and minimum values of MSE, MAE and AIC. For the female birds gompertz model gave the best fit with highest R^2 and adjusted R^2 and lowest MSE and MAE. Durbin Watson (DW) test indicated that there was no autocorrelation and Shapiro-Wilk's test indicated that errors were normally distributed. However, Prasad and Singh (2006) observed that modified logistic model best described the growth pattern in male and female chicken. However, Prasad *et al.* (2008) observed that gompertz model best described the growth pattern in Indian native chicken. Kuhi *et al.* (2003) also observed the better performance of Bertalanffy model than logistic and gompertz models for describing the growth performance of chicken.

SUMMARY

To study the growth pattern in body weight of 3 strains of Rhode Island Red chicken Bertalanffy, gompertz and logistic nonlinear models were fitted. From the data on body weights of three strains of Rhode Island Red, we observed that average body weights of male chicken were higher than the female chicken. Based on the various measures of goodness fit criteria we have observed that in modelling of body weight of the Rhode Island Red chicken Bertalanffy was the best fitted model. In case of Rhode Island Control, Bertalanffy was the best fitted model and for Rhode Island Control male chicken logistic was the best fitted model. In case of Rhode Island White chicken logistic was the best fitted model and in case of Rhode Island White male chicken Bertalanffy was the best fitted model. In case of female chicken of Rhode Island Red, Rhode Island Control and Rhode Island White strains gompertz model was the best fitted model. From these fitted models one can determine the expected average body weight of a group of birds of three strains of RIR chicken at any given age under normal conditions.

ACKNOWLEDGEMENT

The authors are highly thankful to the learned referees and the Assistant Editor for their valuable comments on the original version of the paper.

REFERENCES

BAHS (Basic Animal Husbandry Statistics). 2014. Department of Animal Husbandry, Dairying and Fisheries, Govt. of India.

Berkey C S. 1986. Nonlinear growth curve analysis: Estimating the population parameters. *Annals of Human Biology* **13**: 111–28.

Brody S. 1945. *Bioenergetics and Growth; With Special Reference to the Efficiency Complex in Domestic Animals*. pp: 491–661. Hafner Press, Reinhold, New York, USA.

Das A K. 2013. 'Microsatellite polymorphism, immunocompetence profile and performance evaluation in Rhode Island Red chicken and its crosses.' Ph.D. thesis, Indian Veterinary Research Institute, Izatnagar.

Kuhi H D, Kebreab E, Lopez S and France J. 2003. An evaluation of different growth function for describing the profile of live weight with time (age) in meat and egg strains of chicken. *Poultry Science* **82**: 1536–43.

Laird A K. 1966. Postnatal growth of birds and mammals. *Growth* **30**: 349–63.

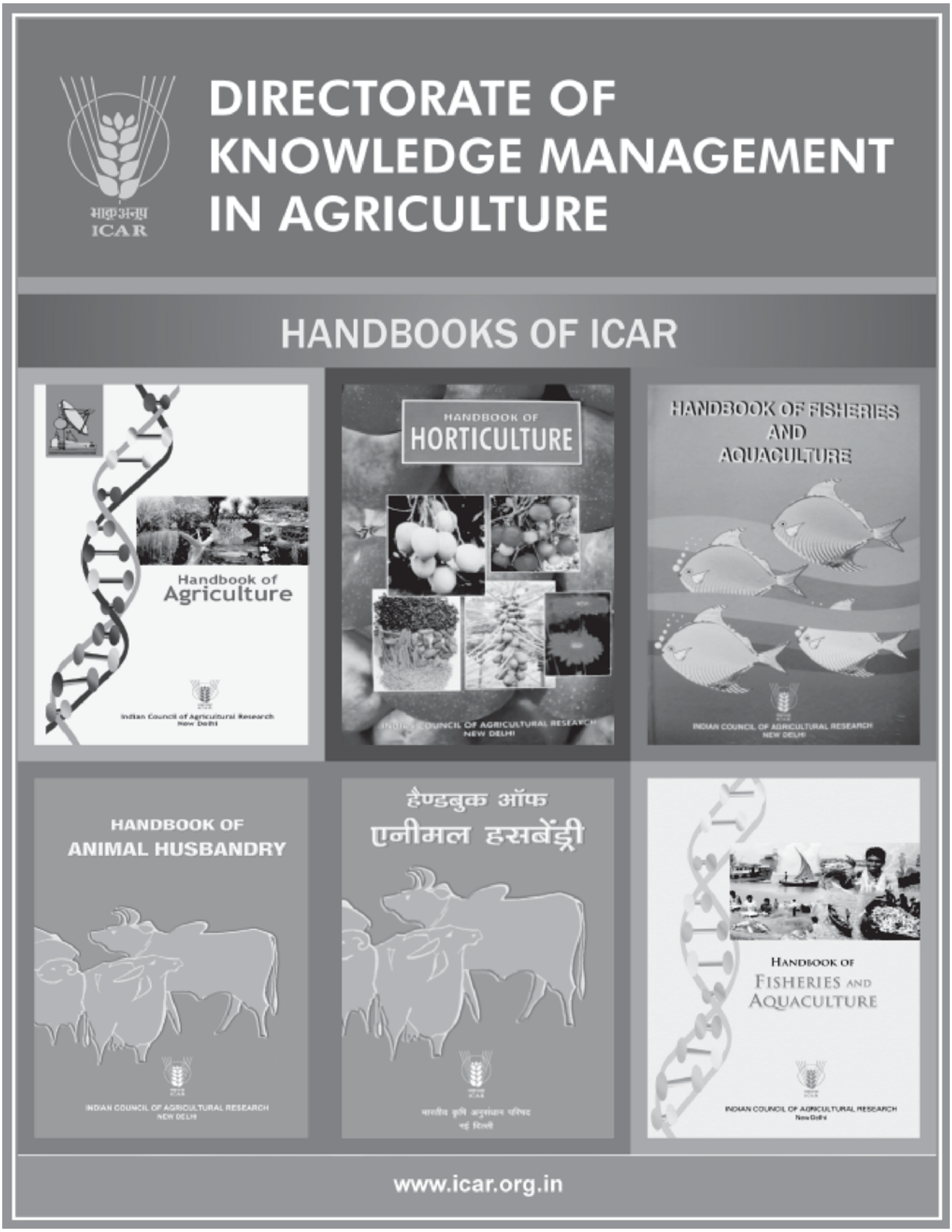
Paul A K, Singh S, Kumar A, Singh O, Raman R K, Haunshi S and Verma M R . 2011. Nonlinear growth models for body growth of Vanraja poultry birds. *IUP Journal of Genetics and Evolution* **4** (4): 65–69.

Prasad Shiv and Singh D P. 2006.An adjustment model of Logistic form to describe the growth pattern of chickens. *Indian Journal of Poultry Science* **41** (3): 280–82.

Prasad Shiv, Singh D P and Singh Rajendra. 2008. Nonlinear describe growth pattern of Indian native chickens. *Indian Journal of Animal Sciences* **78** (6): 645–48.

Sengul T and Kiraz S. 2005. Nonlinear model for growth curve in large white turkeys. *Turkish Journal of Veterinary and Animal Science* **29**: 331–37.

Singh Umesh, Singh R B and Gautam S S. 2014. Nonlinear stochastic model for describing growth of soybean production in Madhya Pradesh and India. *International Journal of Agricultural and Statistical Sciences* **10** (2): 375–79.


ICAR
DIRECTORATE OF KNOWLEDGE MANAGEMENT IN AGRICULTURE
HANDBOOKS OF ICAR
Handbook of Agriculture
Indian Council of Agricultural Research New Delhi
HANDBOOK OF HORTICULTURE
INDIAN COUNCIL OF AGRICULTURAL RESEARCH NEW DELHI
HANDBOOK OF FISHERIES AND AQUACULTURE
INDIAN COUNCIL OF AGRICULTURAL RESEARCH NEW DELHI
HANDBOOK OF ANIMAL HUSBANDRY
INDIAN COUNCIL OF AGRICULTURAL RESEARCH NEW DELHI
हैण्डबुक ऑफ
एनीमल हसबेंड्री
HANDBOOK OF FISHERIES AND AQUACULTURE
INDIAN COUNCIL OF AGRICULTURAL RESEARCH New Delhi
www.icar.org.in