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Modeling for body growth of crossbred piglets

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Piggery is an important sector of income generation in rural areas and it has been adopted by many rural people as a principal remuneration enterprise. Considering the importance of this sector, the study of growth of body weight in relation to age of pigs is important. Many researchers studied production of cattle products by applying non-linear growth models (Ramesh *et al.* 2003). Lal *et al.* (2003) applied non-linear models to the study of poultry meat production. Singh *et al.* (2010) studied growth pattern of cattle, and Krishanlal *et al.* (2003) studied non-linear models in growth of pigs. Yadav *et al.* (2010) fitted non-linear models for describing growth of Muzaffarnagri lambs.

An appropriate model can forecast future pork production and may also determine appropriate time of maturity of pigs. This information may also be useful for planning of future meat production at micro-as well as at macro-level. The aim of this study is to apply different non-linear growth models to establish the best growth model for important crossbreed (Landrace × Desi) piglets and to examine the difference in growth pattern of male and female piglets.

The data collected between 1994 and 2001 at piggery farm, IVRI, Izatnagar, Uttar Pradesh on body weight at different age of piglets was used for the present study. The body weight (kg) of the piglets was collected at unequal intervals of months and they were available at 13 different points of time i.e. 0, 1, 2, 3, 4, 5, 6, 7, 8, 12, 16, 20 and 24 months. A sample of 270 males and 270 females was taken for the study.The data on body weights of the piglets were plotted against the age for both male and female separately and the shape of the curve was examined. On the basis of the shape of the curves, the following models were fitted to the data set for obtaining the appropriate model.

Logistic model:

$$Y_t = \frac{\beta_1}{1+\beta_2 \exp(-\beta_3 t)}$$

Gompertz model:

$$Y_t = \beta_1 \exp\left[-\beta_2 \exp(-\beta_3 t)\right]$$

Von-Bertalanffy model:

$$Y_t = \frac{\beta_1}{\left[1-\beta_2 \exp(-\beta_3 t)\right]^3}$$

Brody model:

$$Y_t = \frac{\beta_1}{\left[1-\beta_2 \exp(-\beta_3 t)\right]}$$

Where β_1, β_2 and β_3 are the parameters to be estimated and Yt is the body weight of the piglet at time t. The parameter β_1 represents the limiting growth value or asymptotic size, the scaling parameter β_2 and β_3 the rate of maturity. The above growth models are nonlinear in nature as at least one derivative with respect to at least one parameter of different models being a function of the parameter(s). Details of non-linear models have been given by Ratkowsky (1990). There are four main methods available in literature (Seber and Wild, 1989) to obtain estimate of the unknown parameters of a non-linear regression model, namely (a) Gauss-Newton Method, (b) Steepest-Descent Method, (c) Levenberg-Merquadt Technique and (d) Do Not Use Derivative (DUD) Method. Levenberg-Merquadt method is the most widely used and reliable procedure for computing nonlinear least square estimates and it has been applied under the present study.

The above non-linear growth models were fitted to available dataset to examine model performance of each model. For non-linear models, root mean square error (RMSE), mean absolute error (MAE) and mean absolute predicted error (MAPE) are often used for determine the best fitted model.

$$RMSE = \left[\frac{1}{n}\sum_{t=1}^{n}(Y_t - \hat{Y}_t)^2\right]^{1/2}$$

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Table 1. Estimates and measures of fitted models for male and female piglets

Sex	Model	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	MAE	RMSE	MAPE
Male	Logistic	45.035 (6.105)	14.519 (1.729)	0.154 (0.016)	0.917	1.194	31.634
	Gompertz	70.261 (16.036)	3.408 (0.156)	0.062 (0.010)	0.729	0.909	22.824
	Von Bertalanffy	56.029 (10.061)	1.796 (0.118)	0.093 (0.012)	0.801	1.022	26.362
	Brody	45.035 (6.105)	–14.519 (1.729)	0.154. (0.016)	0.801	1.022	31.634
Female	Logistic	46.886 (7.001)	19.007 (2.238)	0.148 (0.013)	0.624	0.873	24.609
	Gompertz	97.805 (30.492)	3.921 (0.238)	0.050 (0.008)	0.523	0.678	18.137
	Von Bertalanffy	65.919 (14.382)	2.151 (0.162)	0.063 (0.060)	0.570	0.755	20.830
	Brody	46.886 (7.001)	–19.007 (2.238)	0.148 (0.013)	0.624	0.873	24.609

$$MAE=\frac{1}{n}\sum_{t=1}^{n}\left|\left(Y_t-\hat{Y}_t\right)\right|,$$

and

$$MAPE=\frac{1}{n}\sum_{t=1}^{n}\left|\frac{Y_t-\hat{Y}_t}{Y_t}\right|\times 100$$

where, $\hat{Y}_t$ Predicted weight of pig at age t; n Number of observations, t=1,2,..., n; on the criteria that the best model will have the lowest numerical values for these statistics.

In addition, the randomness assumption of the residuals needs to be tested before taking final decision about the adequacy of the model. To achieve the above task, the run test procedure is available (Ratkowsky 1990), but the normality assumption is not stringent for selection of nonlinear models because their residuals may not follow normal distribution.

The models were fitted using the NLIN option available in SAS 9.2 (SAS, 2009). Different sets of initial parameter values were tried to meet the global convergence criterion for best fitting of the nonlinear models.

The 4 different growth models are fitted to the above weight-at-age data of crossbreed variety of pig. The estimates of parameters, RMSE, MAE, MAPE values are presented in Table 1. The analysis showed that the Gompertz model performs better than other models on the basis of RMSE, MAE and MAPE criteria to identify the best model. The data revealed that in male pigs, the values of MAE (0.729), RMSE (0.909) and MAPE (22.824) were least in Gompertz model followed by Von Bertalanffy model, whereas in female pigs the MAE (0.523), RMSE (0.678) and MAPE (18.137) were also least for Gompertz model. Therefore Gompertz model may be considered as the best fit to the growth of male and female piglets.

SUMMARY

This paper attempts to describe growth pattern in terms of body weight of crossbred variety (Landrace× *desi*) of pig for both male and female separately maintained at piggery farm, Indian Veterinary Research Institute (IVRI), Izatnagar. The suitability of the model was established on the criteria of mean absolute error (MAE), root mean squared error (RMSE) and mean absolute predicted error (MAPE). On these criteria, Gompertz model was found to be the best fitted model as the shape of the curve for body weight and predicted weights were also quite closed.

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