Original Article

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GROWTH CURVES OF SWAMP BUFFALOES (*Bubalus b. carabanensis*) UNDER REARING IN COW HOUSE

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ABSTRACT

The objective of this study was to evaluate the growth curve of 525 monthly body weight data of 19 males (n=313) and 8 females (n=212) swamp buffaloes (*Bubalus b. carabanensis*), from birth to slaughter age (25 months). The nonlinear models used were: logistic, Gompertz, Von Bertalanffy and Brody. The parameters were estimated by NLIN procedure, and the criteria used to evaluate the adjustment given by the models were Akaike's information criterion (AIC), Bayesian information criterion (BIC) and coefficient of determination (R^2). The results indicated that the better fit of Brody model than the Logistic, Gompertz, and Von Bertalanffy models to our data. The parameters estimate for Brody model [$WT = \alpha * (1-\beta e^{-k*AGE})$] were α = 902.00±45.9912, β = 0,9727±0.0089, k = 0.0483±0.0044, R^2 = 0.9748. The estimation of birth and slaughter weights were 24.6596±8.8367 and 639.6467 6.4019 kg, respectively as well as the maturation rate (k) to achieve the mature weigh (α) of 902.00±45.9912 kg was 0.0483±0.0044. Growth curve of weight vs. age of swamp buffalo rearing under intensive system from birth to 25 months old adjusted to the Brody nonlinear model showed growth in a sigmoid-curve model and more accurate in expecting the birth weight of these animals.

Keywords: *Bubalus bubalis*, buffaloes, growth curves, cow house, rearing, swamp buffaloes

INTRODUCTION

Growth characteristics clearly have an important effect on the commercial value of livestock. For example, the value of buffaloes when they are sent to the slaughter depends to a large degree on the amount of muscle on the carcasses; body weight is strongly associated with other economically important characteristics, including production and reproduction traits. Research to improve genetic improvement programs is important to maintain the productivity of buffalo. Body weight gain after weaning in buffalo represents the growth potency of the animal, which is a important feature in the selection of animals (Moran, 1992). Therefore, body weight is the

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most commonly used criterion for considering the growth of animals.

The growth curve in eight species of domestic animals, but not buffalo, were evaluated. Using seven nonlinear models, where the logistical model was identified as the most appropriate to measure the data of animal growth (Freitas, 2005). In another study, the Logistic model was the best to describe the growth curve of buffaloes grazing on a tropical pasture in Cuba (Torres *et al*., 2009). The Logistic and Gompertz models were recommended for growth curve in Murrah buffaloes (Araújo *et al*., 2012). The Logistic nonlinear model was also recommended for growth curve in Mediterranean buffaloes (Alves and Franzolin, 2015). Recently, the Von Bertalanffy model had the best fit for growth curves of Jaffarabadi, Mediterranean and Murrah buffaloes (Malhado *et al*., 2017). No information on the growth curve of swamp buffaloes was found in the literature.

Nonlinear mathematical functions, empirically developed by plotting body weight against age, have been shown suitable to describe the growth curve of many different species (Wurzinger *et al*., 2005; Malhado *et al*., 2009; Osei-Amponsah *et al*., 2011; Lopes *et al*., 2012; Fradinho *et al*., 2016). Such models are a good way of condensing the information contained in a temporal data series into two parameters with biological meaning that can be used for inter-species or inter-breed comparisons. There have been several studies assessing growth curves in Buffaloes (Malhado *et al.,* 2008; Ramos *et al.,* 2007; Agudelo-Gómez *et al.,* 2009; Araújo *et al.,* 2012; Alves and Frazolin, 2015).

The aim of this study was to determine the growth curve according to birth weight to the final slaughter body weights in swamp buffaloes under rearing in cow house.

MATERIALS AND MATHODS

Animals

Swamp buffalo herd of Department of Animal Science, Faculty of Agriculture at Kampaeng Saen, Kasetsart University, Nakhon Pathom were used in this study. Monthly records of weight were measured from birth to slaughter age (25 months) of 19 males (n=313) and 8 females (n=212) born between 2017 and 2020.

After weaning, the buffalo calves (4 months age), male animals were castrated by special tools. The animals were kept in cow house with concrete floor. Animals were fed 1% concentrate in 3 periods, with 18.5% protein 70% TDN in growth period (4 to 8 month), with 15% 71% TDN in fattening I period (9 to 14 month) and 12% protein 72.5% TDN in fattening II period (15 to 26 month). Animals were fed roughage with rice straw or grass and water *ad libitum*.

Method of data analysis

The PROC NLIN of SAS (SAS Institute, Inc., Cary, NC, USA), using the Gauss-Newton method was used for body weight (kg) and age (month) data analysis of nonlinear models: Logistic, Gompertz, Von Bertalanffy and Brody curves. The models used to describe growth of animals were the Logistic [WT= α *(((1+exp(-k*AGE)))**-m)], Gompertz [WT= α *exp(-β*exp(-k*age)], Von Bertalanffy [WT= α $(1-\beta e^{-kt})^3$ and Brody [WT= α * $(1-\beta e^{-k*AGE})$]. in which WT = weight of the animal at an age (t); α = asymptotic value (average maturity weight); β = constant of integration; k = rate of change of the exponential function (maturation rate) referring to the relative growth rate until reaching the mature weight); m = the parameter that shapes the curve and e = the natural logarithm base.

Criteria for Goodness of fit

In this study, models were compared using the Akaike's information criterion (AIC) and the Bayesian information criterion (BIC) for goodness of fit our data.

RESULTS AND DISCUSSION

Goodness of fit

In Table 1, Brody model has lower values of AIC, BIC and R^2 than Von Bertalanffy, Gompertz, and Logistic models. Thus, the Brody model has the best fit to the data in terms of model selection criteria, AIC and BIC, followed by Von Bertalanffy, Gompertz, and Logistic models using classical approach. However, Firat *et al*. (2016) had also used AIC and BIC for goodness of fit to the growth of Japanese quail. On the other hand, Araújo *et al*. (2012) had used other criteria: asymptotic standard deviation (ASD); coefficient of determination (R^2) and the average absolute deviation (AAD) to select the best growth curve model.

Parameters estimation

In Table 2, the α parameter (representing average mature weight) of 902.00 kg by the Brody model was higher than that estimated by Von Bertalanffy, Gompertz, and Logistic models, respectively. Genetic and environmental factors influence the body weight-age curve. Value of the α parameter depends on species, breed, management system and environmental conditions (Malhado *et al*., 2009). For example, the estimates of parameter α among the males of three buffalo breeds were compared, the means α parameter of Jaffarabadi (716.26±48.54 kg), followed by Mediterranean (696.64±8.50 kg) and Murrah (694.69±17.97 kg) in males. The means α parameter of Mediterranean, Jaffarabadi and Murrah were 678.53±9.44, 629.28±32.11 and 556.53±15.49 kg in females, respectively, (Malhado *et al*., 2017).

The k parameter (representing maturation rate) indicates the growth speed to achieve the weight at maturity. The k estimates (0.0483 kg/day) by the Brody model were lower than that estimated by Von Bertalanffy, Gompertz, and Logistic models, respectively. (Table 2). K value (0.0483 kg/day) by the Brody model of swamp buffaloes in this study was closed to K value (0.058 kg/day) of Angus breed cattle and 0.066 kg/day of the Shorthorn breed cattle (Stewart and Martin, 1981). Animals with high k values indicate a precocious maturity in relation to those with lower k values with similar initial weight (Malhado *et al*., 2009).

Estimated body weight

In Table 3, Logistic, Gompertz and Von Bertalanffy models overestimated the weight at birth (WB) for swamp buffaloes in 82.53, 73.60, 61.26 kg, respectively, whereas Brody model estimated the weight at birth in 24.65 kg and 639.64 kg of slaughter weight at 25 months of age. The findings of this study come to agreement to Agudelo-Gomez *et al*. (2009) to recommend the Brody model to describe the growth curve of multibreed animals. The Brody nonlinear model showed growth in a sigmoid-curve model (Figure 1). Further study should be carried out to 36 months of age to observe a real maturity weight.

CONCLUSION

Considering the models used in this study, the Brody model was better adjusted the growth curve of swamp buffaloes. Swamp buffaloes under rearing in cow house have high weight at maturity.

Table 1. The goodness of fit of growth curve models for body weight (BW) in swamp buffalo.

Model	AIC	BIC	R^2
Logistic	5858.8	5875.8	0.9776
Gompertz	5844.9	5862.0	0.9778
von Bertalanffy	5831.2	5848.3	0.9772
Brody	5812.0	5829.1	0.9748

Note: AIC = Akaike's information criterion; BIC = Bayesian information criterion.

Table 2. Estimated parameters and their 95% confidence interval for four growth curve models in swamp buffalo.

Model	Parameter	Estimate	SE	95%CI
Logistic	α	675.10	14.4869	646.64-703.56
	k	0.1440	0.0065	0.1313-0.1567
	m	3.0320	0.0794	2.8760-3.1879
Gompertz	α	698.18	17.2964	664.20-732.16
	β	2.2498	0.0619	2.212812.3715
	k	0.1208	0.0063	0.1084-0.1332
von Bertalanffy	α	731.54	21.4271	689.44-773.63
	β	0.5625	0.0121	0.5387-0.5862
	k	0.0977	0.0058	0.0863-0.1091
Brody	α	902.00	45.9912	811.66-992.35
	β	0.9727	0.0089	0.9551-0.9902
	k	0.0483	0.0044	0.0396-0.0569

Table 3. Estimated growth curve in swamp buffalo.

Age (Month)	Logistic		Gompertz		von Bertalanffy		Brody	
	BW (kg)	SE	BW (kg)	SE	BW (kg)	SE	BW (kg)	SE
0	82.5391	5.4584	73.6028	5.5988	61.2644	6.1511	24.6596	8.8367
1	101.8704	5.4326	95.0722	5.5729	85.9958	6.0295	66.0179	7.1378
2	123.7807	5.2398	119.2798	5.3360	113.5049	5.6219	105.4266	5.7675
3	148.1077	4.9073	145.8385	4.9452	143.0392	5.0600	142.9775	4.7267
4	174.5787	4.4895	174.2791	4.4821	173.9002	4.4738	178.7583	4.0117
5	202.8244	4.0655	204.0872	4.0428	205.4679	3.9790	212.8523	3.5958
6	232.4027	3.7277	234.7390	3.7187	237.2103	3.6575	245.3392	3.4153
7	262.8269	3.5513	265.7302	3.5644	268.6849	3.5307	276.2946	3.3822
8	293.5976	3.5532	296.5990	3.5708	299.5338	3.5536	305.7908	3.4148
9	324.2310	3.6802	326.9403	3.6750	329.4765	3.6486	333.8965	3.4556
10	354.2840	3.8467	356.4142	3.8003	358.3009	3.7451	360.6773	3.4725
11	383.3718	3.9778	384.7484	3.8875	385.8541	3.7975	386.1956	3.4514
12	411.1793	4.0274	411.7361	3.9039	412.0328	3.7848	410.5110	3.3912
13	437.4656	3.9792	437.2317	3.8406	436.7756	3.7057	433.6802	3.2994
14	462.0621	3.8422	461.1432	3.7088	460.0546	3.5742	455.7571	3.1912
15	484.8675	3.6474	483.4251	3.5366	481.8692	3.4172	476.7934	3.0883
16	505.8393	3.4458	504.0702	3.3680	502.2402	3.2742	496.8380	3.0183
17	524.9842	3.3041	523.1024	3.2587	521.2043	3.1931	515.9377	3.0120
18	542.3477	3.2915	540.5691	3.2661	538.8108	3.2222	534.1370	3.0974
19	558.0049	3.4537	556.5354	3.4297	555.1174	3.3942	551.4784	3.2923
20	572.0518	3.7927	571.0791	3.7551	570.1877	3.7148	568.0023	3.6002
21	584.5972	4.2743	584.2855	4.2179	584.0890	4.1657	583.7473	4.0124
22	595.7576	4.8520	596.2445	4.7817	596.8901	4.7176	598.7500	4.5138
23	605.6514	5.4841	607.0474	5.4111	608.6602	5.3413	613.0456	5.0884
24	614.3956	6.1392	616.7847	6.0778	619.4676	6.0124	626.6672	5.7218
25	622.1034	6.7947	625.5447	6.7604	629.3790	6.7116	639.6467	6.4019

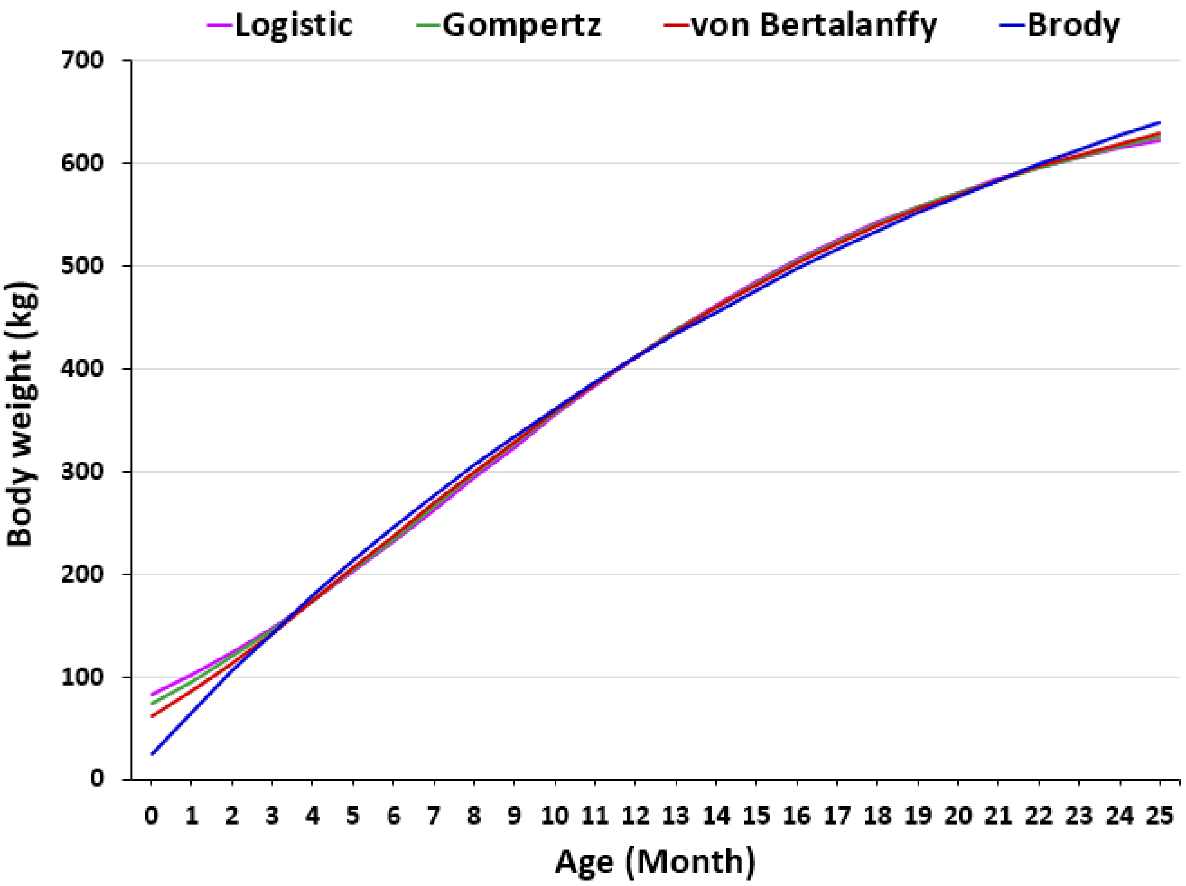

Figure 1. Growth curve of weight vs. age of swamp buffalo rearing under intensive system from birth to 25 months old adjusted to 4 nonlinear models.

The growth speed was closed to Angus and Shorthorn breed cattle.

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