COMPARISON OF GROWTH CURVES OF PUREBRED AND CROSSBRED RABBITS.

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SUMMARY

Three nonlinear models, von Bertalanffy, Gompertz and logistic, were fitted to weight-age data for two breeds of rabbits (New Zealand Whites (NZW) and Tan Rabbits (TR)) and their reciprocal crosses (NZW x TR and TR x NZW). Comparisons were made among these models for their suitability to describe the shape of the growth curve in rabbits. The most accurate model was the von Bertalanffy function, followed by the Gompertz and logistic functions. All models consistently underestimated weights at 28, 35, 42, 56 and 140 days. Mature weight, and age and weight at puberty, were fitted the best by the von Bertalanffy curve for all compared genotypes of rabbits, giving estimates of 3523g, 84days, 1044g for NZW; 2785g, 66days, 825g for TR; 3224g, 77days, 957g for NZW x TR; and 3257g, 75days, 965g for TR x NZW.

INTRODUCTION

An effective method of condensing the information contained in several weight-age data points into a few parameters with a biological interpretation is the use of growth curve models. There are a number of such models available (von Bertalanffy, 1957, Nelder, 1961, Richards, 1959), but the choice of the most appropriate function for a particular species of animals requires experimental comparisons of the models (Fitzhugh, 1976, Ptak, 1987).

This work was undertaken to compare the von Bertalanffy, Gompertz and logistic models for goodness of fit and biological interpretability of parameters for fitting weight-age data as well as describing the growth patterns of two rabbit breeds and two crosses.

MATERIALS AND METHODS

The material consisted of body growth data of 340 rabbits of two breeds (New Zealand Whites (NZW) and Tan Rabbits (TR)) and their reciprocal crosses ((♀ NZW x ♂ TR) and (♀ TR x ♂ NZW)) and of both sexes. The animals were born in spring in first litters of dams and were weaned at 42 days of age. The rabbits were fed traditionally and kept outside in three level wooden cages. The animals were weighed from birth to 140 days of age, at 7-day intervals up to 70 days and at 14-day intervals afterwards.

The following functions were fitted to the weight-age data from birth to 140 days of age for individual rabbits by the nonlinear least squares procedure:

von Bertalanffy $y(t) = A(1-Be^{-Kt})^3$

logistic $y(t) = A\left(1+e^{-Kt}\right)^{-M}$

Gompertz $y(t) = Ae^{-Be^{-Kt}}$

where y(t) is weight (in grams) at age t (in days), and A, B, K, M are fitted parameters. Parameter A is interpreted as average weight at maturity and parameter K, as the rate of maturing (the larger the value of K, the earlier the animals mature). The point of inflection (t_i, y_i) at which the growth rate is maximum gives an estimate of age and weight at puberty.

Pooled residual mean squares (RMS) were used as the measure of goodness of fit.

RESULTS

Goodness of fit was evaluated by comparing the pooled residual mean squares presented in Table 1. The von Bertalanffy function gave the best fit for rabbit data in comparison with the Gompertz and logistic functions.

Table 1. Residual mean squares (RMS) for the three growth models.

Genotype	No of records	Model: von Bertalanffy	Logistic	Gompertz
NZW	116	1963	2828	2427
TR	101	2533	3828	3225
NZW x TR	74	1025	1417	1193
TR x NZW	49	844	1378	1091
Total	340	2130	2746	2424

Table 2. Means of estimated parameters for the three growth models.

		Model								
		von Bertalanffy			logistic			Gompertz		
Genotype	Sex	A	B	K	A	K	M	A	B	K
NZW	♂	3668	.709	.0098	2470	.0190	4.39	2734	3.24	.0153
	♀	3392	.702	.0104	2376	.0196	4.33	2610	3.20	.0159
NZW		3523	.705	.0101	2420	.0193	4.36	2669	3.22	.0156
TR	♂	2616	.665	.0137	2027	.0231	3.98	2176	2.93	.0190
	♀	2897	.678	.0123	2126	.0214	4.09	2305	3.02	.0175
TR		2785	.673	.0128	2086	.0221	4.04	2254	2.98	.0181
NZW x TR	♂	3120	.731	.0108	2253	.0208	4.67	2454	3.44	.0169
	♀	3292	.723	.0110	2307	.0207	4.58	2526	3.37	.0168
NZW x TR		3224	.726	.0109	2287	.0208	4.61	2500	3.40	.0168
TR x NZW	♂	3092	.724	.0116	2266	.0216	4.58	2458	3.38	.0176
	♀	3442	.740	.0114	2387	.0215	4.75	2609	3.51	.0176
TR x NZW		3257	.732	.0115	2323	.0216	4.66	2529	3.44	.0176
Total		3203	.704	.0113	2278	.0208	4.36	2489	3.22	.0169

The means of the estimated growth constants for several genotype groups are shown in Table 2. They were used for comparing models as well as for examining differences in growth patterns of different genotypes in rabbits. The values of parameter A, estimating the asymptotic mature weight, were the closest to the observed values in the von Bertalanffy model (3523g for NZW and 2785g for TR), although all functions underestimated these weights. Standard deviations of A and K parameters made up approximately 30% of their values, whereas for B and M they were from 5% to 10% of their values.

In Table 3 the means of estimated coordinates for age and weight at puberty from three models were presented. All models provided similar estimates of them.

Table 3. Means of coordinates of point of inflection (t_I,y_I) for the three growth models.

			Model					
			von Bertalanffy		logistic		Gompertz	
Genotype	Sex	No of records	t_I^a	y_I	t_I^b	y_I	t_I^c	y_I
NZW	♂	55	87	1087	81	1004	81	1006
	♀	61	80	1005	78	967	77	960
NZW		116	84	1044	79	984	79	982
TR	♂	40	59	775	63	831	61	801
	♀	61	70	858	70	869	69	848
TR		101	66	825	68	854	66	829
NZW x TR	♂	27	76	924	75	911	74	903
	♂	47	78	975	75	934	75	929
NZW x TR		74	77	957	75	925	75	920
TR x NZW	♂	26	72	916	72	917	71	904
	♀	23	78	1020	74	963	74	960
TR x NZW		49	75	965	73	939	72	930
Total		340	76	949	74	926	73	916

[a] $(t_I, y_I) = \left(\frac{\ln 3B}{K}, \frac{8}{27}A\right)$

[b] $(t_I, y_I) = \left(\frac{\ln M}{K}, A\left(\frac{M}{M+1}\right)^M\right)$

[c] $(t_I, y_I) = \left(\frac{\ln B}{K}, Ae^{-1}\right)$

DISCUSSION

The accuracy with which the observed data are described by different growth curve models is very important. Because of correlated errors among repeated measurements of weight over time, the usual tests of goodness of fit are not appropriate. Eisen (1969) and Brown et al. (1976) pooled residual mean squares to compare various growth functions. Using the same criterion, residual mean squares for each model were computed and compared. The von Bertalanffy model was slightly more accurate than the two other functions, i.e. Gompertz and logistic, which was in agreement with the findings of Ptak et al. (1993). In all models the largest differences between predicted and observed weights occurred at the beginning and the end of the studied growth period. The best fit of all the curves was found at 14 and 70 days. Fluctuations among predicted and observed weights were the smallest in the case of the von Bertalanffy model. These were the reasons the comparisons of growth of various genotypes in rabbits were drawn using the parameters estimated from the von Bertalanffy function.

The observed differences in the estimates of parameter A (asymptotic mature weight) for different genotype groups and both sexes were in agreement with the growth characteristics of the examined breeds (NZW and TR) and their reciprocal crosses (NZW x TR and TR x NZW). New Zealand Whites grow to heavier mature weights than Tan Rabbits. As a consequence, NZW are later-maturing animals than TR; that was confirmed by the estimates of rate of maturing (0.0101 for NZW and 0.0128 for TR). The range of K estimates indicated about a 25% difference in the rate of maturing between the two breeds, whereas that difference was only 5% when comparing K for the two crosses. The intermediate rate of maturing of the reciprocal crosses in relation to the pure breeds could indicate a lack of epistatic and overdominance effects. The mean ages at puberty (t_I) for NZW and TR were 84 and 66 days, respectively. In the case of reciprocal crosses these values were close to the mean of the original breeds (77 days for NZW x TR and 75 days for TR x NZW). All these values were underestimated. The estimated weight at puberty (y_I) was almost the same as the weight achieved by rabbits at that age. Heavier rabbits at the point of inflection tended to grow to heavier mature weights.

All parameters examined above and estimated from the Gompertz and logistic models gave a much worse fit to observed growth data, significantly underestimating weight at maturity (A) and overestimating rate of maturing (K), but estimates of age and weight at puberty were comparable to those fitted in the von Bertalanffy model.

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