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THE USE OF A STOCHASTIC MODEL OF RABBIT GROWTH FOR CULLING

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Abstract: A stochastic modeling approach was used to detect at an early stage in their growth the individuals with the best growth performance. The procedure can be helpful for culling purposes or to check if an animal is growing according to a regular pattern. The stochastic model can be based on any known rabbit growth curve but its parameters should be historically chosen in relation to the breed being raised. In this study five New Zealand White females randomly chosen from different litters were weighed weekly from birth to reproduction age (154 days). A Gompertz growth curve showed best fit to the data. Historical information on New Zealand White and average birth weight from current data were used to define the model $W_t^* = 51 \exp \{ 0.113 [1-\exp(-0.026 t)] / 0.026\}$, where W_t^* is the estimated animal weight in g on day t. The stochastic approach is very effective, as it requires the true weight obtained in the last measurement (W_{t-1}) and provides the expected weight value for age t, $E(W_t)= W_t^*[(W_{t-1})/ (W^*_{t-1})]^{0.8}$. When a rabbit at age t shows real weight $W_t > E(W_t)$, it means it is an above average animal and can be used for culling purposes. In following the growth of a given animal, when the above inequality shows consistence in sequential ages and then abruptly changes, it is supposed that some source (probably external) affected its growth and is a signal that some action needs to be taken.

Key words: growth hazards, stochastic growth model, weight selection.

INTRODUCTION

Under adequate feeding conditions, different rabbit breeds follow specific patterns in time. When modeling rabbit growth, Gompertz equations produce a reasonable fit. Adding a stochastic element to a deterministic growth model was suggested by Sandland and Mcgilchrist (1979) but did not attract enough attention to encourage further development. Henstridge and Tweedie (1984) presented a

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stochastic growth model which required the previous animal's weight before predicting the next outcome in the growth process, measured at fixed time intervals. Due to its dependence on conditions, such a recursive model is not always practical when the objective is to predict weight in the long term. However, as the stochastic approach considers both the average response of a breed and the last yield of the animal, the next yield estimate will be close to its true value. Then, following a known growth pattern, if at a certain age a target animal presents a higher weight than its stochastic expectancy, it will probably turn out to be an outstanding animal within its group, and can be used for culling purposes. In following the growth of a given animal, when its actual weight abruptly changes in relation to its stochastic weight estimate, it is supposed that some source (probably external) affected its growth and is a signal that some action is necessary.

MATERIAL AND METHODS

Animals: Five New Zealand White females were randomly chosen from different litters (average size 6), tattooed and kept with litters until weaning (on day 30), when they went to individual cages. Weight was recorded weekly from birth to day 154, when the animals were selected for reproduction.

Locale and feeding regime: The experiment took place at the Experimental Unit in Igarape, southwestern Brazil, under temperatures ranging from 21 to 28°C. After weaning, *ad libitum* feeding was provided by automatic feeder and drinking nipple. Animals were fed a complete, pelletized diet with 16% crude protein, 19% acid detergent fiber, 1.1% calcium, 0.8% phosphorus and 2500 kcal of digestible energy/kg throughout the experiment.

Stochastic model: GOODALL and SPREVAK (1984) suggested the model with multiplicative error $W_t = W^*_t\,\varepsilon_t$, where W_t is the true weight at time t, and W^*_t is the deterministic component of the model corresponding to a Gompertz equation

$$W^*_t = A \exp \{ B [1-\exp(-C\ t] / C\}$$

and ε_t is the error element. Hence, $\log W_t = \log W^*_t + \log \varepsilon_t$. The term $\log \varepsilon_t$ can be considered as a function of time forming a time series with a high degree of correlation. If an auto correlation is then defined, the value of $\log \varepsilon_t$ can be modeled as

$$\log \varepsilon_t = \alpha \log \varepsilon_{t-1} + e_t$$

This is a first order autoregressive model, where e_t is independent and normally distributed with mean zero and $|\alpha|<1$, estimated from any real rabbit data by the least squares procedure. Then $E(W_t) = W^*_t [W_{t-1} / W^*_{t-1}]^{\alpha}$ where $E(W_t)$ is the estimated weight for a given rabbit at age t corrected for stochastic variation.

Setting the standard growth curve: The deterministic component must be numerically defined in order to feed the stochastic process. Under the assumption that growth pattern follows a Gompertz equation, the parameters A, B and C should be provided in advance. Sampaio and Ferreira (1998) estimated values of C=0.023 to 0.029, so it is advisable to set C=0.026. In other experiments, New Zealand White females weighed around 51 g at birth and 3600 g at maturity (Rao *et al*, 1977; Nunes *et al*, 1984 a, b). Then, if A is taken as 51 (taking into consideration that the Gompertz equation overestimates birth weight), B can be calculated in the equation by setting a known weight for a time t (for example, 3600 g at age 154 days). Due to the prospective nature of the study, the equation so obtained does not attempt to obtain the best fit for a set of data which still does not exist. However the stochastic approach is very effective in correcting distortions caused by the proposed standard equation (Sampaio, 1988).

Culling rabbits by growth rate: Many causes may disrupt an expected growth pattern. External causes are signalled by an abrupt change when growth is observed sequentially. When this happens, the stochastic process tries to redirect the animal's growth towards the natural trend. It may then recover and reach the expected potential weight. Genetic causes cannot be corrected because they are inherent to the animal.

The stochastic process adjusts animal weight for eventual fluctuations, but actual weight is generally higher than its stochastic estimate when the animal is an above average individual. Thus, when at age t the animal shows weight $W_t > E(W_t)$, it is condidered a high performance rabbit in terms of growth. Litter size effect can disturb the process during lactation time; therefore, this type of growth capacity test should be performed only after weaning stress has been overcome.

RESULTS AND DISCUSSION

Birth weights varied from 50 to 53 g and averaged 51 g, so the value of A was taken as 51. If C is historically 0.026, and adult weight for a New Zealand White female ready for reproduction is around 3600 g (at age 154 days), then B can be calculated from the Gompertz equation, and was 0.113. Therefore, the standard equation used as the deterministic component was

$$W^*_t=51 \exp \{0.113 [1-\exp(-0.026 t)] / 0.026\}$$

To apply the stochastic model $E(W_t)= W^*_t [W_{t-1}/ W^*_{t-1}]^{\alpha}$,the value of α was calculated from historical data and was set at 0.8 (ranging from 0.7 to 0.9 and in actual data set α=0.77). Figure 1 shows the standard Gompertz equation, the observed weights for two females (namely the heaviest and lightest females at 154 days), and their stochastic growth curves.

The standard Gompertz equation does not represent the average growth response of all five studied animals, but defines the growth pattern according to the stochastic algorithm. So this equation should not be taken as a critical line separating rabbits with high and low performance. What really counts is the relative position of the real weight with respect to the stochastic response curve for a given rabbit at age t. If a Gompertz equation was estimated from actual data the best fit would correspond to the model W^*_t= 61.6 exp{ 0.110 [1-exp(-0.0266 t)] / 0.0266}, but this would only be known at the end of the trial. In fact the main objective is to anticipate technical information at age t before the animal reaches maturity.

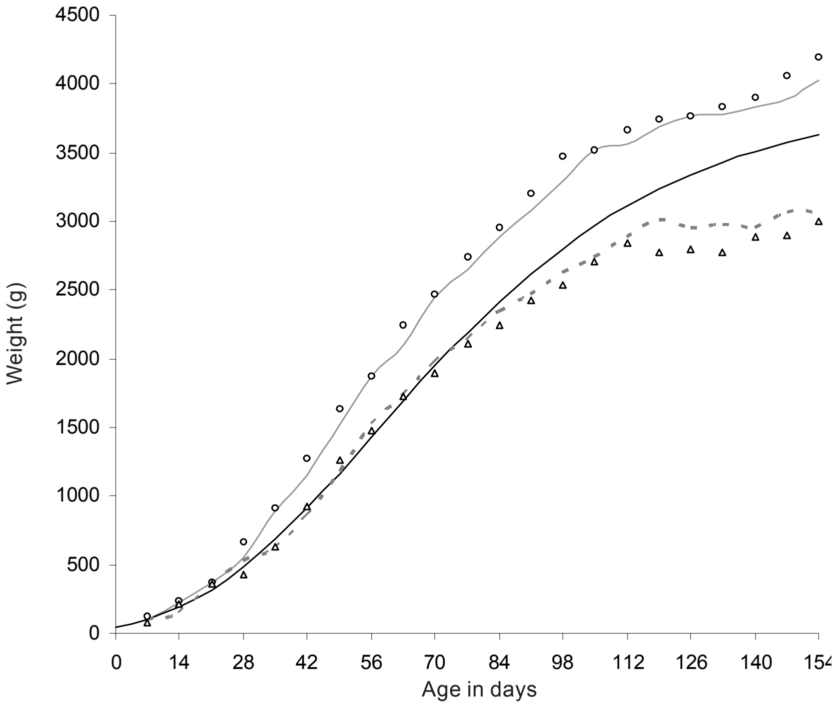

Figure 1: New Zealand White female weights as a function of age in days: standard Gompertz equation (——), stochastic model for heaviest (—) and lightest (---) females and observed weights of female heaviest (O) and lightest (Δ).

Lightest female can be taken as a low performance individual when its growth is checked up to maturity (Figure 1). However, after weaning (30 days) and free of competition, it showed compensatory growth that affected its classification. From day 35 to 49, its real weight was higher than its stochastic estimate, $W_t > E(W_t)$. At 56 days however it reverted to its real classification. Animals meant for reproduction need constant attention during growth; not only by checking their classification but also by early detection of any disruption in their growth trend. Growth of lightest female from 77 to 112 days shows a nearly linear pattern (Figure 1). Between 112 and 119 days something must have happened because at day 119 it weighed 2770 g, much less than expected from the stochastic algorithm. As W_{112}=2840 g, W^*_{112}=2892.4 g and W^*_{119}=3232.5 g, its stochastic estimate of next weight $E(W_{119})$ is then 3232.5 $[2840/2892.4]^{0.8}$ = 3007.6 g. It can also be observed that female lightest never recovered its former growth trend. Intervention should have been initiated at day 119 if the stochastic approach had been available.

CONCLUSIONS

When dealing with high quality animals destined for reproduction, stochastic modeling can be a tool for culling and checking growth patterns of rabbits. Disturbances in the growth pattern can be detected in time and any necessary remedial action can be taken.

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