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A SIMPLE APPROACH TO CALCULATE THE SAMPLE SIZE TO BUILD GROWTH CURVES IN ANIMALS

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ABSTRACT

The objectives of this study were to propose a simple approach to calculate the sample size to build growth curves and to show the effect of sample size on curve fit and parameter estimates. Sample size was calculated based on the body weight, of turkeys, with the largest coefficient of variation, from hatch to 23 weeks of age. Also, a simulation study was carried out to determine the effect of sample size on growth curve fit and parameters precision. Curves were built by age for data of 15, 30, 50, 100, 200 and 5000 male turkeys, randomly generated using the means and standard deviations of the observed data, and by means of the von Bertalanffy model. A table to estimate sample size for a continuous variable is provided. As expected, sample size was a function of the CV. Sample size affected the fit of the curve and precision of parameter estimates. In conclusion, the approach here used can be applied to build growth curves using the formula to estimate the sample size for body weight. Large samples provide better fit of the curve and are more precise.

Keywords: Sample Size, Simulation, Body Weight, Turkey

INTRODUCTION

In any production system, included livestock production, it is a common practice to take a sample of animals to estimate a given parameter of interest. The measurement of a sample of animals is always cheaper and less time consuming than to measure the whole population. Sample size is commonly determined in studies willing to estimate a mean or a proportion (prevalence). Formula and software exist to calculate the appropriated sample size, with a given precision and level of confidence to estimate a given trait, such as body weight at a given age or any other important economic trait in livestock. This also apply to the calculation of any type of coefficients (regression, correlation); however, to the authors knowledge, there is not a formula to calculate sample size to build grow curves. Growth curves are commonly build fitting body weight data to non-linear models such as Gompertz, von Bertalanffy, Logistic etc. Of nine articles reviewed on growth model description in chicken, and in turkeys, none of them explains how the sample size was calculated. In turkey studies, the sample size ranged from 40 to 288 animals (Takma et al 2004; Sengul and Kiraz 2005; Ersoy et al 2006; Perez-Lara et al 2013), in broilers samples varied from 60 to 94 (Duan-yai et al 1999; Matis and Mohamed 2012; Sekeroglu et al 2013) and in one study on laying poults used 33 animals (Galeano and Ceron 2013). In those studies, sample size seems to be determined arbitrarily or on availability of animals. The objective of this study was to propose a simple approach to calculate the sample size to build growth curves and to determine the effect of sample size on curve fit and precision of parameter estimates.

MATERIAL AND METHODS

The data were obtained from a total of 245 Hybrid Converter® male turkeys, raised on deep litter system from June to November of 2013, under commercial conditions typical of the region. All the birds were identified individually, and weekly body weights of each bird were recorded from day 1 to week 23 of age. The means and standard deviations for body weight ranged from 56.6±4.1 g at day 1 to 17.3±1.64 kg at 23 weeks of age; corresponding the highest coefficient of variation to the 23 weeks of age birds (9.5%). In order to calculate the sample size of the growth curve, the body weight with the largest coefficient of variation was used, because the largest variation will give the largest sample to build the best curve in terms of precision and it will fit better the curve. This approach could be also applied to calculate sample size in other species.

Sample size, to estimate a mean (v. gr. Body weight) for a large population was calculated using the formula:

$n = (Z^2 * CV^2)/p^2)$, which is a modification of the known formula $n = (Z^2 * \text{variance})/e^2$ used in classic books (Cochran 1977). Where Z is the table value for a variable normally distributed with mean zero and standard deviation 1; variance is the variance of the trait of interest (2.69 kg^2 at 23 weeks of age); e is the precision or error desired in absolute value for example (0.0865 kg, equivalent to 5% of the mean), CV is the coefficient of variation (standard deviation/mean), and p is the desired precision as a proportion (normally p=0.05). Then variance/e^2 was substitute by CV^2/p^2. To adjust for population size (N), the sample size needs to be adjusted by the factor: $n/(1+N/n)$, according to Segura and Honhold (2000).

Further, a simulation study was carried out to build growth curves using the von Bertalanffy model ($y = A*(1-b*\exp(-k*t)^3)$; where: y = turkey weight at time (t), A= mature weight, b= integration constant, k= relative growth coefficient, and t= age of the animal. Random samples of 15, 30, 50, 100, 200 and 5000 turkeys were generated using the SURVEY procedure of SAS (SAS 2012). Means and standard deviations used to generate random values corresponded to the mean and standard deviations obtained in a previous study on male turkeys (Segura et al 2016).

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Growth curves were built using the NLIN procedure of SAS (2012), using the overall mean weights by age and using also the individual weights of each turkey.

RESULTS AND DISCUSSION

Table 1 provides the sample sizes needed for a given trait and for different coefficients of variation and relative precisions, and for a 95% confidence level. As expected, sample size increased with large CV and when more precision is needed. It will be, therefore, advisable that studies on growth curves do provide the means and standard deviations of the age when animals got the largest body weight CV. Actually, none of the studies reviewed by the authors of this study (Duan-yai et al 1999; Takma et al 2004, Sengul and Kiraz 2005, Ersoy et al 2006, Matis and Mohamed 2012, Galeano and Ceron 2013, Perez-Lara et al 2013, Sekeroglu et al 2013) provided the CV of body weight by age or the information needed to calculate it. In this study, the largest CV (9.5%) was obtained at 23 weeks of age; therefore, for a very large population, at least a sample size of 14 animals is necessary to estimate body weight growth curve of male turkeys with a confidence level of 95% and precisions of 5%. For a 2.5% precision a sample of 56 will be needed.

Table 1. Coefficients of variation and precisions to estimate the sample size for a continuous trait*

	Precision (% of the mean)		
CV	**10**	**5**	**2.5**
0.10	4	15	61
0.15	9	35	138
0.20	15	61	246
0.25	24	96	384
0.30	35	138	553
0.35	47	188	753
0.40	61	246	983
0.45	78	311	1244
0.50	96	384	1536
0.55	116	465	1859
0.60	138	553	2212
0.65	162	649	2596
0.70	188	753	3011
0.75	216	864	3456
0.80	246	983	3932
0.85	277	1110	4439

0.90	311	1244	4977
0.95	347	1386	5545
1.00	384	1536	6144

*confidence level of 95%

For the simulation study, but considering a 20% CV, it can be seen (Figure 1) that the growth curves using 50, 100, 200 and 5000 were quite close, whereas the use of a sample of the body weights of 30 or 15 turkeys deviate from the expected curve (n=5000). In consequence, sample size affects the fit of the curve, the precision of the mean body weight at each measured age and in consequence the precision of the parameter estimates of the von Bertalanffy growth curve (A, b and k). Precision is expected to be affected, because is a function of the standard error, and it is known that standard error increases as the sample size decreases.

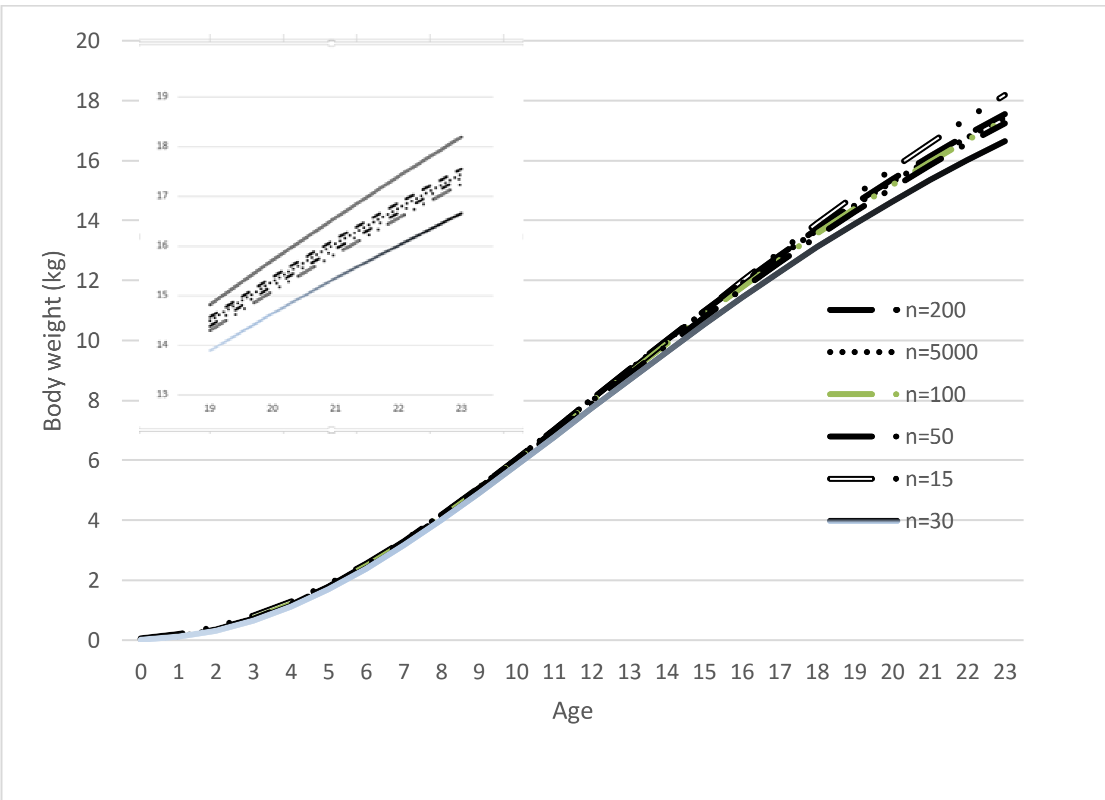

Figure 1. Von Bertalanffy growth curves for different sample sizes and 20% coefficient of variation

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At a given sample size, the growth curves of turkey using only the overall means by age or the individual body weights of turkeys are the same (Figure not provided), which demonstrate that when the interest is to just build growth curves of animals, they do no need to be individually identify; except, when the interest is to build the curve for each animal, calculate the precision or for other reasons.

In conclusion, this approach provides an objective way to select the minimum sample size needed to build growth curves with a desired precision and make the selection of the sample size, in this type of studies, less arbitrary.

A more sophisticated and complex formulas could be developed to calculate the minimum sample size to estimate body weight growth curves; however, the approach presented in this paper is easy, and parsimonious.

Sample size affect the fit of the growth curve and the precision of parameter estimates.

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