A Comparison of Methods for Describing Irregular Animal Growth and Testing for Treatment Effects

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In many designed experiments with animals liveweight is recorded several times during the trial. Such data are commonly referred to as repeated measures data. An aim of such experiments is generally to compare the growth patterns for the applied treatments. This paper discusses some of the methods of analysing repeated measures data and illustrates the use of cubic smoothing splines to describe irregular cattle growth data.

One of the simplest and easiest methods to understand is separate ANOVAs at each time point. However, such analyses are not independent and provide little information about the overall time trends. ANOVA of selected measures such as liveweight at the end of the trial or overall ADG can be useful. If the growth pattern is linear, the regression coefficients derived from fitting a linear regression to data from each experimental unit can be subjected to ANOVA. This method uses the whole growth profile, but is of little use for irregular growth data.

Another common and readily understood method is a split-plot ANOVA in time. This analysis assumes a uniform structure for the covariance matrix of the repeated measures, an assumption which often does not hold leading to greater likelihood of invalidly concluding there are significant effects (Everitt, 1995). To adjust for the departure from the assumptions, the split-plot ANOVA in time can be modified by estimating and applying a correction factor (Greenhouse and Geisser, 1959). An alternative method is multivariate ANOVA. This method makes no assumptions about the covariance structure, but takes no account of the ordering and is inefficient with small samples.

Verbyla *et al*. (1999) show how the method of maximum likelihood can be applied to develop a suitable mixed model. Advantages of this method include the ability to model time trends within treatments and between treatments, the ability to specify the covariance structure of the data and the ability to handle missing and irregular data.

The data used here to illustrate the method were from an trial designed to consider the effect of two treatments, feedlot naïve (N) and feedlot pre-exposed (P), on the liveweight performance of Brahman steers fed for 100 days in an experimental feedlot (Holroyd *et al*., 1996). The steers, aged 2 to 3 years, were randomly allocated on liveweight to the two treatments. The P group was exposed to simulated feedlot conditions for 9 days prior to transportation to the feedlot. There were 10 feedlot pens each of 10 animals. Steers were weighed twice prior to feedlot entry (at day 0) and 12 times during feedlotting.

Steers lost weight in the period prior to feedlot entry resulting in growth not following a traditional, linear pattern. A linear mixed model using cubic smoothing splines (Verbyla *et al*., 1999) to describe the growth response was fitted to the liveweight data using Genstat, with the pen as the experimental unit. A separate spline was fitted for each pen, partitioned into an overall spline, a treatment spline and a unit spline.

Figure 1 illustrates the data and the fitted cubic splines for each treatment. The fitted curves differ significantly ($p<0.05$), a result not found by some of the other methods.

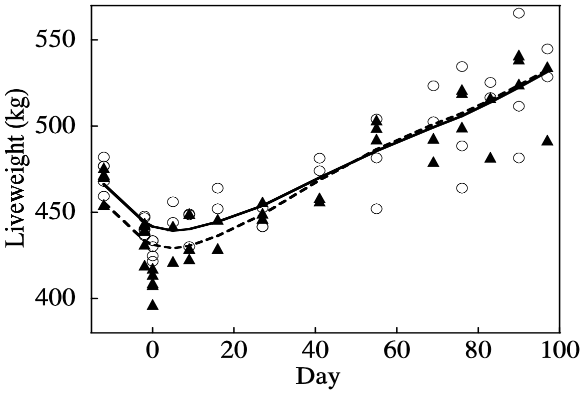

Figure 1. Liveweight gain for feedlot naïve (o) and feedlot pre-exposed (▲) steers.

Although the model development process can be complex and computationally intensive, this method of modelling non-linear growth responses is flexible and takes account of the covariance structure of the data.

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Verbyla *et al*. 1999. J. R. Statist. Soc. C. 48:269-312.

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