THE ESTIMATION OF GENETIC PARAMETERS

FOR CATEGORICAL TRAITS

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ABSTRACT

The estimation of heritabilities, genetic and environmental variances and covariances, and the prediction of breeding values, is a major concern among animal breeders. This study adapts existing statistical methods to provide a new method of estimating these parameters for categorical traits.

The problems associated with the analysis of categorical data arise because of the relationship between the mean and variance of the sampling distribution. The parameters of the sampling distribution are assumed to be a non-linear function of values on an underlying scale. It is further assumed that fixed and random effects are additive on the underlying scale. This scale cannot be observed and information about it must be deduced from the observed categorical trait.

A common practice has been to estimate parameters (fixed effects and variances) on the categorical variable itself and then to transform these estimates to values applicable to the underlying scale. This procedure is theoretically invalid except for a fully random model in which the only fixed effect is the mean. The method developed in this thesis attempts to estimate parameters directly in the underlying scale by transforming the data before calculating estimates of the parameters. It is a synthesis of mixed model procedures (Henderson et al., 1959) and generalized linear models (Nelder and Wedderburn, 1972) and is called the generalized linear mixed model. The general method is for analysing data presumed to arise from a two-stage sampling procedure when the second sampling has an error distribution belonging to the single parameter exponential family.

The detailed algebra for applying the new method to binomial and multinomial traits for the estimation of fixed effects is presented. The logit transformation is used in this application and the resulting system of equations is called the logistic linear mixed model. A procedure for estimating

variances, covariances and the intraclass correlation on the underlying scale is also developed.

The logistic linear mixed model is evaluated by comparing parameter estimates from the method with true values used to generate the data being analysed. Biases appear to be small except for some extreme combinations of parameters when assumptions made while developing the algebra break down.

The logistic linear mixed model is applied to two real problems for which fixed and random effects and variance components are estimated and comparisons made with parameters estimated by other methods. The first problem is the analysis of data on the feet characteristics of 2513 lambs, the second is the analysis of 1396 lambing performance records.

The concluding discussion considers the general use of the logistic linear mixed model and its relationship with other models.

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Table of Contents

List of Tables

Table page

List of Figures

Figure page