Statistical Analyses of Experimental Data

General.

Analysis of well designed breed evaluation experiments is relatively simple compared with genetic analyses of field data, where more complex adjustments for environmental variables are required. Good design minimizes possible sources of error affecting the critical contrasts of genetic groups, such as age of animal, year, season or other environmental effects. Error for breed comparisons includes genetic variation among sires and dams sampled from each breed. Because results are intended to guide future choices among breeds, it is essential that the sires and dams sampled from each breed be representative and large enough in number to minimize error in detecting breed and heterosis effects. If the sires sampled from each breed for a crossbreeding experiment have also been used extensively in an industry progeny testing system, it may be possible to use their expected progeny differences to adjust the experimental ranking of breeds to the mean for each breed and for any genetic trends to a common time period (Notter and Cundiff, 1991).

Certain genetic (e.g., heterosis) comparisons even can be made between matings by the same sires and from dams by the same sires (e.g., A(BC)–AB + A(CB)–AC, Table 2, when the same sires are also used to produce the BC and B or CB and C ♀, Table 1). In this extreme case, error degrees of freedom would be those for interaction between sires of progeny and sires of dams, plus residual.

A range in fractions of individual and maternal breed and heterozygosity effects are represented among the means for the pure breeds and crosses in a well designed breed evaluation experiment. The volume of data also may vary among the breeding class means. Thus use of a linear regression model to estimate effects of each genetic parameter may be more efficient than fitting constants for each breed group (Batra and Touchberry, 1974; Robison et al, 1981).

Adjustment for Non-genetic Variation.

Variation in non-genetic influences increases the sampling error of genetic comparisons. Variation among years or seasons can be avoided by basing genetic comparisons on variation within years or seasons. Variation within years or seasons from such influences as age at measurement or parity may be reduced by linear or quadratic covariate adjustment appropriate to each genetic class, if interaction with genetic class is important. In some cases adjustment may be made most accurately by using the information for each individual, as for weight at a standard weaning age. Because early growth is nearly linear with age, weaning weight of lambs or pigs is accurately predicted from weight at birth and a variable age at weaning as, e.g., birth weight + 56x (daily gain to weaning). Covariate adjustment assumes that the environmental factor has the same influence on each individual within a genetic interaction subclass. Thus, the covariate adjustment, for example, may satisfactorily remove age bias in comparison of genetic groups, but may under-adjust the larger or faster growing individuals and over-adjust the smaller or slower growing animals.

Care should be taken to avoid adjusting for variable influences which are really part of the genetic performance being measured. For example, adjustment of mortality in piglets, lambs or even cattle for litter size or individual weight at birth helps to partition breed differences in survivability, but would be obviously misleading if applied to breed differences in numbers or weight per litter weaned. Similarly, adjusting postweaning gain or feed/gain for midweight removes not only the effect of initial weight (W_i), but also the effect of differences in daily gain, because midweight $\approx W_i$ + l/2(daily gain x length of a nearly constant growth period). Other examples are adjustment of milk records to a common length of dry or lactating period, and adjustment of carcass composition to a common carcass weight. One alternative is to adjust individuals of each genetic group to their own mean for the covariate whenever the covariate is really a part of the performance comparison desired. Another alternative is to not adjust for variables which are part of the genetic trait evaluated (e.g., in lactation length from calf loss or illness under adverse environment, Madalena et al., 1989).

Editing of Data.

Experimental data should be carefully edited to detect erroneous observations before the data are analyzed, because such errors can very seriously bias the results and their interpretation. One approach in editing data is to identify observations that are more than about three standard deviations above or below the general mean for each trait measured. Suspect observations can then be rechecked for reasonableness. Observations for some traits can be checked systematically for consistency by examining their relationship to other traits of the same animal. For example, observations on weights at birth, weaning and marketing can be compared with rates of daily gain pre- and post-weaning and lengths of the pre-and post-weaning periods. Dates of death can be compared with dates of recorded weights or other observations.

Detection of errors in pedigree is especially important in genetic analyses, e.g., by checking pen assignments of sires and dams at breeding, dates of mortality and parturition of breeding females, etc. However, there is no complete substitute for care at the time data are first recorded. Unreasonable observations are best detected at the source, and rechecked at that time.

Evaluation of Net Production Efficiency.

The most useful economic criterion for choices among breeds or breeding systems is net production efficiency. As discussed earlier, effects on total cost per unit of output value are the ultimate basis for comparing systems of breeding or breeds for a given breed role in a specified breeding system and production environment.

If prior production system analysis has already provided a satisfactory basis for weighting component traits to predict effects of the chosen breed role on net efficiency of the production systems, choices among breeds and breeding systems are simplified. For example, see Tess et al. (1983b) and Bennett et al. (1983) for swine, Wang and Dickerson (1991) for sheep, and Núñez-Dominguez et al. (1992) for beef cattle. However, if such analyses of production systems have not been made, they become an essential part of the final interpretation of breed evaluation information.

Essential components of input costs to be predicted are the feed intakes required for breeding female maintenance, reproduction and product synthesis, and for maintenance and growth of progeny to market weight. If direct measures of feed intake are not possible, intake can be estimated from female measures of body weight, reproduction and product output (e.g., milk, wool, eggs) and progeny rate and composition of growth, as discussed ' earlier. Non-feed input costs for land, housing, labour, health maintenance and capital investment require management studies of the production system.

Output volume and value are generally measured more easily in terms of weights and composition of the animal products and of their values per unit based on studies of the range of market prices in the expected production-marketing systems, see Green et al. (1991) and Núñez-Dominguez et al. (1992) for examples in beef cattle.

Comparisons of breeds for a given breed role and the costs and prices of the input/output production system should be based on the optimum equilibrium age composition for each, including any significant differences in the timing of discounted expenses *vs* revenues within a year. If sufficient information is available on the changes in output to be expected with altered input or environments, rankings can be generalized, including effects for ranges of prices for both inputs and outputs (Melton et al., 1979;. Melton and Colette, 1992). When comparisons of breeding systems are based on annual input costs and output values for populations at optimum age equilibrium, differences in timing of expense and income seem unlikely to have important effects on efficiency rankings.