Performance Measures Required

General.

The cost of animal products depends primarily upon the efficiency of three basic biological functions: 1) reproduction and viability, 2) female product output and 3) rate and composition of growth (Dickerson, 1970, 1976, 1990; Harris, 1970). Total costs can be separated into two major categories: 1) for the producing and reproducing female population and 2) for growing weaned or hatched progeny to market age or weight. Product output similarly comes either 1) directly from the females - as milk, wool or eggs, or 2) from market value of progeny - as meat. Overall efficiency is measured by the ratio of total costs to product output, in economic equivalents, over a given period of time for the production-marketing system (E).

Average costs per female-year include those for replacements, R = (cost of a replacement female less average return per culled or dead female)/(mean number of years of herd or flock life), plus those of a breeding female (d) for fixed labour, housing and other (I_d), variable maintenance feed (F_{md}) and variable feed above maintenance for production (F_{pd}). Costs per female year for each of N progeny (o) from weaning to market include average daily costs for fixed items (I_o), variable maintenance feed (F_{mo}) and variable above-maintenance feed for growth (F_{po}), all multiplied by days of postweaning growth (D), plus fixed costs for marketing, slaughter, vaccines, etc. (S_o). Yearly output per breeding female includes units of direct output (e.g., milk, wool or eggs) multiplied by value/unit ($P_d \cdot V_d$) plus the product from N market progeny of P_o weight and V_o value/unit weight. Thus overall efficiency in terms of cost/unit of output value can be visualized as:

$$E = \frac{\text{Cost / yr}}{\text{Output / yr}} = \frac{(R + I_d + F_{md} + F_{pd}) + N \bullet D(I_o + F_{mo} + F_{po}) + N \bullet S_o}{P_d \bullet V_d \qquad + \qquad N \bullet P_o \bullet V_o} \quad (1)$$

It is sometimes convenient to express output values in terms of equivalent value units (e.g., as feeder calf weight from both calves and cull cows marketed, or as market lamb weight from lambs, cull ewes and wool sold). Input costs are best expressed in monetary units based on quantities and cost per unit (e.g., F_{md} = units of feed for maintenance × cost/unit, plus F_{pd} units of feed for milk or egg production × cost/unit, and similarly for maintenance = F_{mo} and gain = F_{po} of market progeny). If replacement females are produced within the herd, R = (postweaning to breeding cost-income from a culled female divided by mean cow herd life).

Input/output efficiency (E, Formula 1) can be calculated for herds or flocks at equilibrium age composition over a typical period of time (e.g., year). Thus differences in timing of costs and income are minimal, and consideration of differences in discounted costs *vs* income are not important for comparisons among breeds for a given role in a production system. However, there can be real differences among breeding systems in the timing of input costs *vs* output income (e.g., straightbred *vs* terminal sire × maternal F_1 crossbred female) that may justify including the discounting of expense and income to the same point in time for the systems compared.

The performance information required for evaluating breed and cross differences in efficiency include both outputs and inputs. Outputs are much more easily and frequently measured. However, differences in output alone greatly exaggerate the real differences in efficiency, because increased output also increases inputs, especially of feed intake.

Measures of Output.

Among traits affecting output, the very important ones for meat animals are those controlling N, the number of progeny marketed per female maintained. Increasing N directly reduces costs per unit of meat output for replacements (R) and for breeding female maintenance (F_{md}), costs that are proportionately so much greater for species with low (e.g., cattle) than with high (e.g., poultry) reproductive rate. Traits controlling N include fertility, parturition interval, number of young per parturition and viability of young. Viability may also be affected by the female's maternal ability in terms of ease of parturition, temperament and especially milk production. Other measures related to reproduction that can be important in difficult environments include those for tolerance of heat or cold, resistance to ticks and diseases, and ability to maintain body condition under sparse or variable nutrient environments. The other meat output components, of course, are the weight (P_o) and the value per unit of weight (V_o) for each market animal, the latter indicated by measures of conformation and especially composition and eating qualities.

Output from culled adult females also reduces the net cost for young female replacements (R), which is determined by adult mortality and culling for infertility or other failures, and the relative unit value of young *vs* adult cull female weight. These factors also determine the optimum terminal age and severity of culling for infertility of breeding females (e.g., Núñez-Dominguez et al., 1992), which differs greatly among species.

Measures of output from the female herself also include both quantity (P_d) and unit value (V_d) of such products as milk, fiber and eggs. A wide variety of measurements is usually required to estimate value per unit of adult product output (V_d) (e.g., composition of milk, wool character, egg size and quality).Generally, in species maintained for such specialized direct female output (e.g., dairy cattle, water buffalo, sheep, goats, egg chickens), the total value of such direct output may make income from progeny quite secondary. However, the relative importance of direct and progeny output varies greatly with the production-marketing system, from specialized meat or milk to dual purpose.

Measures of Input

Feed intake is the major measure of input cost required in comparing breeds and their crosses, but is much more difficult to obtain than measures of output, especially for breeding females of ruminant species. Feed intake for female maintenance ($F_{md)}$ varies most with her body size and that for market progeny output ($N \bullet P_o$) varies with progeny number (N), body size maintained (F_{mo}) and rate of growth (F_{po}) over days in the feeding period (D).

To the extent possible, direct measurement of feed intake is preferable to indirect estimates of feed intake, because it involves fewer assumptions. However, especially for grazing females of ruminant species, it is often necessary to estimate feed intake from experiments with subsamples of each breed or cross, or indirectly from measures of body size and composition plus product volume and composition, using prediction formulas based upon extensive published results of prior research on energy metabolism (e.g., Graham, 1967; Koong et al., 1985).

Direct measurement of feed intake for progeny from weaning (or hatching) to market, is generally preferable and often feasible, except when growing performance is measured on pasture. When feed intake cannot be measured directly on growing market animals, it can be estimated from body weights over the feeding period.

Accuracy of feed intake estimates can be improved by obtaining body composition and/or calorimetry measures of fasting heat production for subsamples from each breeding group evaluated (e.g., Baker et al., 1991). Such basic experiments with subsamples, including indirect or direct calorimetry, permit detection of possible differences in maintenance requirements and its association with body size and composition (Olthoff and Dickerson, 1989). Non-feed costs for such items as labour, housing, health care, interest on capital tend to be only partially proportional to feed inputs. Estimates of changes in these costs with increases in components of performance should be included in evaluations to avoid upwardly biased evaluation of genetic effects on production efficiency. Improvements in such traits as fertility and mortality reduce feed and other costs more than gains in female egg or milk production or growth rate of market meat animals.