USE OF LIFETIME NET INCOME IN DAIRY GENETICS RESEARCH

B.G. Cassell and D.J. Weigel
Department of Dairy Science, Virginia Tech, Blacksburg

SUMMARY

The utility of a dairy cow to her owner depends on profitable performance across a relatively long productive life. Long term breeding objectives need to reflect the influence of those several traits which influence lifetime performance. The challenge to producers is to select for the combination of traits most conducive to profitable lifetime performance and to provide those management conditions which facilitate optimum expression of the traits selected. Thus, breeding programs designed to produce optimum economic response in lifetime performance will depend on a balancing of several selection objectives in a multivariable system. Defining those objective criteria requires a working definition of the objective to be obtained, one which can be measured efficiently on many dairy cows. This article reviews development of one such objective, lifetime relative net income and examines some of the research findings of work applying the function to field data.

MEASURING LIFETIME ECONOMIC RETURN FROM FIELD DATA

Detailed economic data across entire lifetimes are prohibitively expensive for designed experiments including many individuals. Research efforts in lifetime performance of dairy cattle will be limited by the ability of researchers to generate meaningful measures of economic performance from production records kept for purposes other than detailed economic analysis. In the United States, the most widely collected performance information is production data routinely collected by Dairy Herd Improvement organizations. These data include relatively complete records of birth and calving dates and production information, usually restricted to the first 305 days of production, for milk, fat, and in recent years, protein. A growing body of somatic cell score information is also being collected. No reliable information is widely available on sex, weight, and disposition of offspring, weight of cow, final disposition of a cow, health expenses, and so forth.

Researchers have used DHI production information to estimate lifetime profit or net income for many years. In 1976, Gill and Allaire (6) published the first of three articles based on a profit function applied to 933 cows in the Ohio NC-2 research project. Income sources were milk adjusted for fat percent, number of calvings, and a salvage value. Expenses included feed for maintenance, growth, pregnancy and lactation, breeding expenses, rearing costs, and a fixed cost applied to all days in the herd. Lifetime profit for these cows averaged $689 across an average herdlife of 1066 days. The authors used their function to evaluate impact of management practices on lifetime profit. Genetic relationships between traits measured early in life and lifetime profit were reported in other work using this function. The authors concluded "The results encourage further investigations toward estimating economic returns from more than milk yield but something less than complete detailed information."

The first use of the profit function, lifetime relative net income (RNI), was by Norman, et al (7) in a study of production and type characteristics in Jerseys in 1981. The first version of RNI included income from milk and fat adjusted for feed costs for production, a value for each freshening reflecting value of an average calf adjusted for breeding costs, and a salvage value. Additional costs were considered for growth after freshening, feed costs and fixed and operating costs during

productive life, and rearing cost which depended on age at freshening. The study included RNI and RNI per day of productive life. Lifetime relative net income from this function averaged $699 but was more variable than that of Gill and Allaire (6). The data used were 10,139 classified Jerseys in 1014 herd-years of first freshening. More diverse environmental conditions may have produced the increased variance, as major income and expense sources were similar in the two studies. The purpose of the study was to evaluate the utility of type scores in identifying profitable Jerseys. Conclusions were that production dominated type in identifying cows with high RNI, but that higher scores for final score, suspensory ligament and mammary system did produce higher RNI.

DHI DATA, PRICES USED, AND OPPORTUNITY LENGTH

The profit function in (7) was applied to a large population using lifetime production files. Cows were allowed opportunity to produce through 72 months of age. Opportunity to produce is essential to avoid biasing lifetime performance of cows born recently or younger cows in herds going off test. A question remaining after the study of Norman, et al (7) was the accuracy of RNI compared to a thorough economic analysis. This question was examined by Tigges, et al (9) using more complete records on cows in the Beltsville Agricultural Research Center (BARC) herd. As an example, BARC cows had detailed data on birth and freshening weights, weight gains, culling weight, number of cases of mastitis and number of breedings. Results were that a function much like RNI of (7) accounted for 95% of variation in profit estimated from detailed information. Authors concluded that RNI and RNI per day of productive life were accurate estimates of relative cow profitability.

Economic assumptions are necessary to calculate RNI. Constant prices across several years of a large study is a questionable assumption. Research was needed to establish the impact of prices on RNI. This work was published by Beaudry, et al (2) in 1988. The study was based on 176,902 Holstein cows with opportunity for production through 72 months of age. Three product prices from $23.15/100kg to $35.27/100 kg were examined along with three feed prices, from $.12 to $.24/Mcal. Finally, low and high rearing and fixed and operating costs were examined. Correlations between different estimates of RNI exceeded .95 in most cases. However, extreme combinations like high feed and low product values produced economically unsustainable results, with average RNI values that were quite negative. Relationships of management/genetic factors like days of productive life, first lactation production, and lifetime production with RNI were affected by prices assumed. Authors concluded, however that reasonably accurate prices would not likely invalidate major conclusions from studies using RNI. They questioned whether additional modifications like discounting to remove effects of time on income and expense streams would be beneficial.

Effect of discounting RNI was examined by Cassell, et al (3,4). The procedure discounted lactation product value back from 120 days into lactation, calf value from dam's age at freshening, salvage value from age at disposal, rearing cost from half of age at first freshening, and lactation costs for maintenance, fixed and operating expense from age of cow 180 days into each lactation. Cows examined were those in (2). Correlations between RNI with and without discounting were 1.00 when the same herdlife opportunity lengths were examined. Correlations between age at first freshening, days of productive life, and first lactation milk were changed very little by discounting, leading authors to conclude that discounting did not alter results in any meaningful way. In (3) discounted RNI appeared to be a slightly different trait when expressed in grade or registered cows. However, that study did not compare results from RNI with and without discounting.

Length of opportunity to express lifetime traits is a critical question to studies of lifetime performance. Short herdlife opportunity increases the number of cows contributing data to studies and allows more recent data to contribute. This can be critical for questions affected by traits

undergoing strong genetic trend like production in dairy cattle. On the other hand, longer herdlife opportunities allow different traits to affect results, if those traits only express themselves in older animals. There are, for instance, indications in the literature that type characteristics like udder depth, fore udder attachment, and teat placement exert more influence on lifetime performance with longer herdlife opportunities where most culling for production has already occurred. In (4), RNI was calculated using only records initiated prior to 48, 60, and 72 mo of age. Phenotypic correlations were .88 between 48 and 60 month RNI, .80 between 48 and 72 month RNI, and .94 between 60 and 72 month RNI. Influence of age at first freshening declined as herdlife opportunity was extended, with correlations or -.23, -.16, and -.12 for 48, 60, and 72 month opportunity. Correlations of days of productive life increased from .72 to .80 to .84 for 48, 60, and 72 month opportunity. Influence of first lactation milk yield on each profit function declined with longer herdlife opportunity, with correlations of .63, .57 and.52 for 48, 60 and 72 month opportunity. Length of herdlife opportunity chosen for a study will affect relationships of production, health, type or other traits and lifetime net income. Thus, this decision needs to be carefully considered by researchers from the outset.

OPPORTUNITY COST

Van Arendonk (10) proposed that profit functions be adjusted for the opportunity cost (OC) of a postponed replacement. Interpretation of OC has varied among researchers and the concept is not uniformly accepted. However, failure to account for the income that a replacement heifer could generate with the same space and management resources as an existing cow distorts the returns generated by that cow. The resulting profit function could overstate the importance of days of herdlife. An application of OC to RNI was made by de Haan, et al (5) and further studied by Cassell, et al (4) using large data sets. The approach was to estimate average RNI for each herd-year of first freshening and to use that RNI (expressed per day of productive life) as an estimate of OC for cows first calving in that herd and year. This approach ignores genetic trend in RNI which would cause higher OC for later freshenings on cows with multiple records. Work on that question is presently in print. In (4), phenotypic correlations between RNI and RNI adjusted for OC (RNIOC) was .97 for 48 month herdlife opportunity, .96 for 60 month herdlife opportunity, and .95 for 72 month herdlife opportunity. In (5), a study comparing influence of production and type on net income in registered and grade cows, authors reported that production dominated predictions of RNI regardless of adjustment for OC. However, some type traits did influence RNI, but had less impact following adjustment for OC. Results are consistent with the prediction of Van Arendonk (10) that adjustment for OC reduces impact of length of productive life.

RESEARCH APPLICATIONS

Lifetime profit functions have appeal in guiding development of selection objectives. In one of the major studies using this approach, Strandberg (8) used a profit function to examine breeding strategies to improve lifetime performance. A major conclusion was that lifetime profit was an effective aggregate genotype for genetic improvement, preferable to alternatives such as production through a fixed age. Selection to improve production through 42 months of age could lead to prolonged first calving intervals, for instance. The RNI function described in this article has been helpful in evaluating utility of traits measured earlier in the life of a cow. The function has been used to evaluate genetic influences on lifetime performance (1,3,5,7). Studies with RNI have improved understanding of the influence of management on lifetime performance. Higher RNI has been reported for registered cows in herds with a mix of grades and registered animals (4). Relationships between sire evaluations for RNI and other traits (3) have shown that different linear type traits influence RNI in grade and registered Holsteins. However, when individual cow records are studied using grades in classified herds, grades appeared to be managed in much the same manner as registered cows (5). This result was verified in (11), a study including more recent data than (5) and

using multivariant REML techniques. The importance of production and linear type traits in prediction RNI has been a dominant theme in these studies (3,5,7,11).

Properly designed breeding programs will increase the frequencies of genes associated with increased lifetime profit of dairy cows. This objective will best be achieved by a diversity of research approaches. One approach is to examine herdlife itself, its relationships with other characteristics of the cow, its economic worth, and combine evaluations for it with other available genetic evaluations. This method does require that the economic value of herdlife be estimated. Lifetime profit functions aid in establishing the value of all traits which can be measured on dairy cows. Direct measures of herdlife, health traits, immune response measures, or mating systems may be evaluated with profit functions. Profit functions have an important role to play as efforts continue to define the role of ever diverse performance characteristics of dairy cows.

REFERENCES

1. BEAUDRY, T.F., B.G. CASSELL, and H.D. NORMAN. 1988. Relationships of lifetime profit to sire evaluations from first, all, and later records. J. Dairy Sci. 71:204.
2. BEAUDRY, T.F., B.G. CASSELL, H.D. NORMAN, and R.E. PEARSON. 1988. Impact of prices on profit functions in dairy cattle. J. Dairy Sci. 71:485.
3. CASSELL, B.G., R.E. PEARSON, J. STOEL, and S. HIEMSTRA. 1990. Relationships between sire evaluations for linear type traits and lifetime relative net income from grade or registered daughters. J. Dairy Sci. 73:198.
4. CASSELL, B.G., B.B. SMITH, and R.E. PEARSON. 1993. Influence of herd-life opportunity and characteristics of cows and herds on different net income functions. J. Dairy Sci. 76:1182.
5. de HAAN, M.H.A., B.G. CASSELL, R.E. PEARSON, and B.B. SMITH. 1992. Relationship between net income, days of productive life, production and linear type traits in grade and registered Holsteins. J. Dairy Sci. 75:3553.
6. GILL, G.S., and F.R. ALLAIRE. 1976. Relationship of age at first calving, days open, days dry, and herdlife to a profit function for dairy cattle. J. Dairy Sci. 59:1131.
7. NORMAN, H.D., B.G. CASSELL, R.E. PEARSON, and G.R. WIGGANS. 1981. Relation of first lactation production and conformation to lifetime performance and profitability in Jerseys. J. Dairy Sci. 64:104.
8. STRANDBERG, E. 1991. Breeding for lifetime performance in dairy cattle. Ph.D. Diss., Swedish Univ. of Ag. Sci., Uppsala.
9. TIGGES, R.J., R.E. PEARSON, and W.E. VINSON. 1984. Use of dairy herd improvement variables to predict lifetime profitability. J. Dairy Sci. 67:180.
10. VAN ARENDONK, J.A.M. 1991. Use of profit equations to determine relative economic value of dairy cattle herd life and production from field data. J. Dairy Sci. 74:1101.
11. WEIGEL, D.J. 1993. Relationships among estimated net income, herdlife, and linear type traits in dairy cattle. Ph.D. Diss., Virginia Polytechnic Institute and State University, Blacksburg.