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TECHNICAL NOTES: Economic Weights for Direct and Fetal Genetic Effects in Choosing Sires

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Economic Weights for Direct and Fetal Genetic Effects in Choosing Sires

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ABSTRACT

A procedure is developed to determine the relative economic values of effects of sire of cow and sire of fetus. The economic weights for selection will depend on the time and discount rate. For example, for 10 yr and a 10% discount rate, the relative economic weights are 1.240 and 1.284 for the sire's direct genetic and fetal genetic effects when the fetal effect of the sire affects only the subsequent lactation of the mate of the sire. If the fetal effect is carried over to each future lactation of the mate, the relative economic weights are 1.240 for the direct and 3.184 for the fetal sire effects.

INTRODUCTION

If genetically determined fetal effects on subsequent production are important, the dairyman is faced with a dilemma when choosing a bull (1, 3). Does he pick the bull whose fetal effect will increase subsequent production of the cow or does he pick the bull whose direct genetic effect will increase the production of a replacement heifer born from that mating? The classical selection index approach to selection for more than one trait is to assign appropriate net economic values to each trait and to select for an aggregate economic genetic value. The assignment of economic values in most cases, however, is arbitrary. Assignment of economic values to direct and fetal genetic effects is less arbitrary since there is only one measured and marketable trait – the result of both direct and fetal effects.

METHODS

Only two sources of variation in income were considered: the effect of the service sire derived from fetal effects on his mate's record and effect of the sire on a replacement heifer that results from that mating. Since in this discussion the fetal effect is assumed to begin at its initiation of the subsequent lactation, all calculations are made after a live birth of the fetus in the herd.

Value of Offspring's Production

The discounted return from a heifer that freshens in the herd can be calculated as described by Everett (2) and Van Vleck and Everett (5). Tables of the fraction of age adjusted and discounted value for each added unit of production transmitted by the sire can be calculated and are shown in Table 1, which is an expansion of Table 2 of (5). The key parameters are the probabilities of surviving from one lactation to another (1.00, .82, .68, .52, .34, .25, .16, and .11 for lactations 1 to 8), the inverse of the mature equivalent age factors (.73, .85, .95, .98, .99, 1.00, 1.00, and 1.00), the years in the investment period, and the discount rate. The procedure also accounts for production of descendants of the heifer. The expected fraction of sire superiority is discounted back to the time of breeding.

Let T_g be the expected discounted fraction of sire superiority from each heifer that freshens, which can be obtained from Table 1 for various times and discount rates. This value must be adjusted for the probability a calf will freshen, given that a calf is born. If one-half of calves are heifers and 83% (2) survive to freshen, the probability of freshening is (.5)(.83) = .415. Thus, the expected return from milk from each birth is $G_i = .415(T_g)(\hat{s}_i)(v)$, where $\hat{s}_i$ is a sample of the transmitting ability of bull i and v is the net value above feed costs per unit of milk.

One complication is that $\hat{s}_i$ is actually a sample of $g_i/2 + f_i/4$, where g_i is the additive direct genetic value and f_i is the additive fetal genetic value of bull i (4).

If the fetal effect on the first lactation persists through all subsequent lactations, then $\hat{s}_i$

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is appropriate as the coefficient of $.415T_g v$ since the $f_i/4$ is expressed at the same time as $g_i/2$. If the fetal effect is not constant, then the procedure for calculating economic value must be modified.

Value of Mate's Production

The production of the mate attributed to the sire of the calf also must be discounted back to time of conception. Two possibilities will be considered: 1) the effect of sire of first fetus persists through each subsequent lactation, and 2) the effect of sire of fetus affects only the first lactation.

If the effect of sire of fetus remains constant through all lactations, the value of that effect on production of mates of bull i is

$$H_i = [v(\hat{f}_i/2)] \left\{ \sum_{j=1}^{8} [p_j/a_j] \; [1/(1+d)^j] \right\}$$
$$= [v(\hat{f}_i/2)] T_f$$

where a_j is the mature equivalent age factor for lactation j; p_j is the probability of having that lactation ($p_1 = 1.00, \ldots, p_8 = .11$); and d is the fractional discount rate. Table 2 gives values of T_f for up to eight lactations and eight discount rates. The probability of survival to a ninth lactation was assumed to be zero.

Then the expected value of a bull for a first breeding is

$$V_i = G_i + H_i$$
$$= .415vT_g\hat{s}_i + vT_f(\hat{f}_i/2)$$

where $\hat{s}_i$ is the sample of a sire's transmitting ability and $\hat{f}_i/2$ is the sample half of the genetic effect of sire of fetus. The net value per unit of product, v, is part of both coefficients so that relative economic weights do not depend on the actual value of the product.

If $g_i/2$ is separated from $f_i/4$, the expression can be rewritten as

$$V_i = .415vT_g(\hat{g}_i/2 + \hat{f}_i/4) + vT_f(\hat{f}_i/2)$$
$$= .415vT_g(\hat{g}_i/2) + v(.2075T_g + T_f)(\hat{f}_i/2)$$

The relative economic weights for the direct and fetal effects become

$$.415T_g \text{ and } .2075T_g + T_f.$$

TABLE 1. Fraction of sire superiority in transmitting ability for direct and fetal effects per milking heifer, age adjusted and discounted back to time of conception, for four investment periods and eight discount rates.

Years in investment period	Discount rate							
	.00	.02	.04	.06	.08	.10	.12	.14
5	2.20	2.04	1.88	1.34	1.62	1.50	1.40	1.30
10	5.32	4.70	4.18	3.72	3.33	2.99	2.69	2.44
15	7.16	6.13	5.29	4.60	4.02	3.53	3.13	2.79
20	8.31	6.94	5.87	5.01	4.31	3.74	3.28	2.90

TABLE 2. Fraction of effect of sire of fetus on mate's production adjusted for age, probability of mate surviving for other lactations, and discounted back to time of conception.[a]

Lac-	Discount rate							
tation	.00	.02	.04	.06	.08	.10	.12	.14
1	.73	.716	.702	.689	.676	.664	.652	.640
2	1.43	1.389	1.349	1.312	1.276	1.242	1.210	1.179
3	2.08	2.001	1.927	1.857	1.792	1.7305	1.673	1.618
4	2.59	2.472	2.363	2.229	2.167	2.079	1.997	1.920
5	2.93	2.780	2.642	2.483	2.398	2.290	2.190	2.096
6	3.18	3.002	2.840	2.660	2.556	2.431	2.316	2.210
7	3.34	3.141	2.962	2.766	2.649	2.513	2.389	2.274
8	3.45	3.235	3.042	2.835	2.709	2.564	2.433	2.313

[a]Assumes the effect carries over to all subsequent lactations. If the effect is specific to only the subsequent lactation then the first line should be used.

As an example, suppose 10 yr and 10% discount rate so that $T_g = 2.99$ and $T_f = 2.564$ (no value is added after the 8th yr). The expected economic value is

$$V_i = v[.415(2.99)\hat{s}_i + 2.564(\hat{f}_i/2)] \text{ or}$$
$$V_i = v[1.240(\hat{g}_i/2) + 3.184(\hat{f}_i/2)] .$$

The relative economic weights are approximately 2.5:1 for fetal as compared to direct genetic effects.

If the fetal effect of the sire is specific only to the subsequent lactation then

$$H_i = [v(\hat{f}_i/2)]\ [p_1/a_1]\ [1/(1 + d)] \ .$$

The coefficient of $v(\hat{f}_i/2)$ is given in the first row of Table 2.

In the preceding example, T_f would be .664 and

$$V_i = v[1.240\hat{s}_i + .664(\hat{f}_i/2)] \text{ or}$$
$$V_i = [1.240(\hat{g}_i/2) + 1.284(\hat{f}_i/2)] .$$

The relative economic weights would be approximately equal.

The economic weights which can be determined are in terms of the relative values per unit of increase due to the direct and fetal effects. The importance of the effects in sire selection, however, is determined also by differences among sires for direct and fetal effects. The variance components for effects of sire of cow and sire of fetus provide a measure of the differences to be expected for the two effects.

The economic values determined by this procedure are true only if the genetic model is as described. If thecarry-over from one lactation to another is partial rather than being either complete or lacking, the procedure would have to be modified. If the service sire during the lactation as well as the sire of the fetus that initiated the lactation have effects, then a modification would be required also. Other factors may require modification although the procedure presented can be used as a guide in determining the economic values.

Prediction of Economic Value

The previous development to determine the economic weights for direct and fetal effects was based on the biology of transmission of a sample half of the genetic value to each succeeding generation, equal proportion of bull and heifer calves, influence of age on production, and various probabilities of survival. What resulted was a probabilistic definition of aggregate genetic value from which the economic values could be determined. The terms involved in the basic procedure (2) involve higher order powers and products of the $\hat{s}_i$ and $\hat{f}_i$. The best procedure for predicting H_i in such a case is not known. If only quadratic terms are included in the economic definitions, then the quadratic index procedure of Wilton et al. (6) would be best where predictions of $\hat{s}_i$ and $\hat{f}_i$ would be obtained from all available information using the appropriate covariances among the records and the $\hat{s}_i$ and $\hat{f}_i$ to be predicted. A reasonable approximation in other cases appears to be to substitute predictions of $\hat{s}_i$ and $\hat{f}_i$ in the equation for V_i.

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