PROFIT-MAXIMIZING DAIRY SIRE SELECTION PACKAGE

Robert W. Blake, C. Richard Shumway, Michael A. Tomaszewski, Greg P. Rickard, and John M. LaBore

Abstract

The Net Present Value Sire Summary Professional Package (NPVSS) is a microcomputer program designed for technical personnel to help dairy producers better manage investments in genetic improvement. NPVSS is written in C language, utilizes the MS-DOS operating system, and requires 256K of RAM. It is menu driven and includes parameter screens to define herd management characteristics of individual producers. Profit rankings of bulls can be generated to evaluate alternative: a) objective functions (selection policies for genetic merit in milk income and type scores), b) herd management performance factors (conception rate, calving interval, age at first calving), and c) economic factors (milk price, semen price, discount rate, planning horizon).

Key words: net present value, microcomputer, sire selection.

Dairy producers face a complex decision-making problem in selecting service sires for genetic improvement. Many artificial insemination (AI) sires are available for multiple trait selection with a wide array of semen prices ($4 to $300 per unit). Artificial insemination has been the major tool of genetic improvement of dairy cattle for the last 50 years, but economic benefits have not been fully realized. Selection of sires to increase future net income (i.e., from replacement female descendants) by considering milk price, semen price, discount rate, expected genetic gains in multiple traits, and alternative herd management situations has been only recently defined within a profit-maximizing framework (Wilcox et al.; McMahon et al.). Linear programming and selection index procedures with discounting have been applied to sire selection (Bakker et al.; McGilliard, 1978a, 1978b, 1979; McGilliard and Clay, 1983a, 1983b; Schneeberger et al.; Shanks and Freeman), but the cost of maximum genetic gain has not been assessed and profit-maximizing sires have not been identified. Maximizing net present value, however, permits such assessments by equating marginal factor cost (i.e., semen cost) with marginal product value (i.e., discounted net income earnings from descendants) of alternative investments.

The NPVSS Professional Package microcomputer software program has been developed to calculate expected net present values and confidence limits and to rank by profitability the semen purchases from all AI sires available to the dairy producer. Herd-specific parameters may be considered for each of the nine variables. These include: objective function (genetic selection policy based on potential net incomes from milk and type scores); conception rate; calving interval; age at first calving; age and season (mature equivalent) adjustments for fluid milk, milkfat, and protein yields; fluid milk, fat, and protein prices; discount rate; planning horizon; and semen price.

NPVSS SOFTWARE

NPVSS enables dairy science professionals (e.g., dairy researchers, extension workers, and consultants) to use current information from the USDA Sire Summary, breed association type summary, and stud service semen price lists, as well as characteristics of in-

dividual herds to economically evaluate AI sires for use in such herds. Basic sire data updated semiannually by USDA, breed associations, and stud services are available by telecommunication with the Direct Access to Records by Telephone (DART) program at the Dairy Records Processing Center at Raleigh, NC, or from the authors.

Calculation of Expected Net Present Value and Confidence Interval

The expected net present value (NPV) of semen when first breeding a cow of a specified breed is calculated as follows:

$$(1) \quad NPV_j = \sum_{g=0}^{G-1} 2^{-g} \sum_{t=1}^{L} (1+i)^a (M_{jt}+T_j)$$

$$-n \sum_{t=1}^{L} (1+i)^b P_j,$$

where
$$a = -[(t-1)(x/12)+y+gh]$$
$$b = -(t-1)(x/12)$$

and where

NPV_j = the net present value of genetic contribution of specified descendants of a cow bred to sire j (i.e., total worth of gene flow),

g = the generation number of descendent minus 1,

G = the planning horizon in number of generations of descendants,

2^{-g} = the decay in net income between subsequent generations of descendants (due to Mendelian halving of germ plasm),

i = the discount (or real interest) rate,

t = the lactation number,

x = the calving interval in months,

y = $[(L+2)x/2 + a - 1]/12$ which is the number of years after breeding the dam until the replacement daughter is expected to begin earning income, i.e., years from first insemination to expected birth of replacement, $[(L+1)x/2]/12$, plus age of replacement daughter at first calving, a/12, plus years to midpoint of daughter's first lactation, (.5x-1)/12,

L = the average number of lactations per cow (currently set at 3),

a = age at first calving in months,

h = xL/12 which is the number of years between generations,

M_{jt} = $(1-f)(PDM_j E_{mt} P_m + PDF_j E_{ft} P_f + PDP_j E_{pt} P_p)$ which is total milk income over feed cost due to genetic change for lactation t of a daughter of sire j,

f = the marginal feed cost as a proportion of marginal milk income,

PDM_j = predicted difference for fluid milk (in lbs.) of the jth sire,

PDF_j = predicted difference for milkfat (in lbs.) of the jth sire,

PDP_j = predicted difference for protein (in lbs.) of the jth sire,

P_m = price of fluid milk (in ¢/lb),

P_f = price of milkfat (in ¢/lb),

P_p = price of protein (in ¢/lb),

$E_{.t}$ = the reciprocal of the mature equivalent factor to adjust predicted difference for fluid milk, milkfat, or protein to predicted differences in the tth lactation (USDA),

T_j = w[(PDT_j/PDT) PD$] which is net income from type score for a daughter of sire j corresponding to the specified milk-to-type selection policy,

w = weighting on PDT relative to a weighting of 1.0 on total milk income over feed cost (e.g., for milk-to-type selection policy of 1:0, w=0; for a selection policy of 3:1, w=.33),

PDT_j = predicted difference for type score of the jth sire,

PDT = standard deviation for all sires with PDT's,

$PD$$ = standard deviation of predicted difference for gross milk income for all sires in the breed,

n = 100/CR(1−MR/100) which is the average number of units of semen for each calving of the dam for a specified conception

rate and mortality rate,

CR = conception rate in %,

MR = mortality rate in %, and,

P_j = price per unit of semen for the jth sire.

Confidence limits of NPV of bulls are calculated assuming a normal distribution using the following formula:

$$(2) \quad CL_j = NPV_j \pm Z_k[(1-R^2_{PDM(j)})S^2_{PVM} + w^2(1-R^2_{PDT(j)}) S^2_{PVT} +$$
$$2w(1-R^2_{PDM(j)})^{.5}(1-R^2_{PDT(j)})^{.5}$$
$$COV(PVM,PVT)]^{.5},$$

where Z_k = the standard normal deviate for probability k/2,

$R_{PDM(j)}$ = repeatability of PDM for sire j,

$R_{PDT(j)}$ = repeatability of PDT for sire j,

S^2_{PVM} = the variance of the milk income contribution to net present value,

S^2_{PVT} = the variance of the type score income contribution to net present value when w=1, and

COV(PVM, PVT) = the covariance between net present value contributions from milk and type score when w=1.

Software Use

The NPVSS software is menu driven. It includes screens to enter required parameters, change default levels, specify multiple sets of parameters to be used in sequence, and identify sorting criteria for the sire NPV listings. Documentation and user instructions are contained in Blake et al.

Since net present values are breed dependent, sire information must be first processed into a separate file for each breed to be used in the NPVSS program. Selecting the "change parameters" option of the opening menu calls the first of three screens that may be changed to calculate NPV for alternative management situations. Each screen has rows of descriptive names of parameters and default values. At the bottom of each screen is a menu of options for saving changes, abandoning changes, moving from screen to screen, and recalling default parameter values.

To change any parameter value, the cursor is positioned over the field to be changed. The new value is entered when the current one is highlighted. Parameter values may be entered in floating point representation, integer,

or scientific notation.

Multiple sets of parameter combinations may be specified in order to obtain NPV sire listings for alternative herd management situations. The user may input as many as five conception rates, five milk-to-type selection policies, and two planning horizons. The maximum number of combinations is 50. The appropriate milk-to-type selection policy (for determination of w above) depends on the sources of income and genetic goals of individual producers. For example, a 3:1 milk-to-type score selection policy implies that one standard deviation of PDT is economically as valuable as one-third standard deviation of gross milk income. Therefore, a producer choosing this selection policy believes that a large portion of future net income will come from the sale of breeding stock and/or substantial economic gains will be realized over time due to improvement of type score or corresponding decrease in cost of production.

Sires may be sorted either by expected NPV or by the lower limit of specified confidence intervals for NPV and printed using the NPVSS Report Writer. Output files contain the bull code number, bull name, NPV, and confidence interval for each parameter combination. In addition, sire data and semen price are also reported for each bull. These files can be transferred to a mainframe computer system or other microcomputer software for subsequent statistical analysis.

Software Information

The NPVSS software is written in C language, utilizes the MS-DOS operating system, and requires 256K of RAM. Speed of program operation is enhanced significantly by a mathematics co-processor chip and a hard disk. The program and user's manual are available for the IBM PC, PC-compatibles, and Texas Instruments Professional Computer. A diskette containing the NPVSS Professional Package and documentation are available for a handling fee of $25 from the Integrated Management Systems Group, Department of Animal Science, Texas A&M University, College Station, TX 77843-2471.

As of June 1987, NPVSS had been purchased by 20 universities and experiment stations. Questionnaire responses from early users indicated that it had met their expectations. Based on their suggestions, minor changes in the format of output screens have been incorporated into the current release.

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The program allows the user to rank AI bulls based on their expected NPV and/or lower limit of the confidence interval for NPV for a number of herd management alternatives. Evaluating the statistics associated with the program allows the user to estimate the opportunity cost of alternative sire selection options. This assists the user in determining the effect of misspecifying a selection parameter either because of an operator error or inadequate information.

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