# DECISION SUPPORT SYSTEMS FOR BEEF CROSSBREEDING PROGRAMS

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## SUMMARY

Decision support software (DSS) help people solve difficult problems well. This paper describes attributes of four different DSS that provide expertise in development and maintenance of beef crossbreeding programs. These programs have been used with varying degrees of success. The challenge for development and use of DSS in crossbreeding is commitment of time over the long-term to continuously upgrade and maintain the program and databases with up-to-date information.
**Keywords:** Crossbreeding, decision support software, beef cattle, genetics

## INTRODUCTION

Decision Support Systems (DSS) are computer programs that use specialised symbolic reasoning to help people solve difficult problems well. This is done by pairing the human with the expert system in such a way that the expert system provides some of the knowledge and reasoning steps, while the human provides overall problem-solving direction as well as specific knowledge not incorporated in the system. A specific subclass of DSS are Expert Systems, which can be used to preserve and disseminate scarce expertise by encoding all the relevant experience of an expert and making this expertise available as a resource for the less experienced person (Luconi *et al.* 1986).

Decision Support Systems are valuable for genetic decision making because (1) they combine information of different types; (2) they can handle abstract concepts; (3) they can handle uncertainty; (4) they can learn from prior solutions; and (5) they can be delivered electronically.

Various kinds of DSS in genetic improvement exist. At a most basic level, these include textbooks and fact sheets, and genetic evaluation schemes for most species of livestock, More advanced applications would be the combining of genetic and economic information into multi-trait selection indexes from STAGES (Stewart *et al.* 1991) and BREEDOBJECT (Barwick *et al.* 1993). However, there has been little development and use of more comprehensive multi-domain DSS in animal breeding. DSS would lend themselves to crossbreeding decision making in beef cattle because beef cattle are produced over a diversity of environments, management schemes and marketing arrangements. Because of this, no single breed of cattle will meet all criteria for efficient production. With the variety of breeds to choose from, and the number of ways these breeds might be combined to increase productivity, it seems only reasonable that DSS can help users make educated decisions about crossbreeding systems. With these thoughts in mind, the objective of this paper is to review available programs for crossbreeding decision support.

## PROGRAMS

At least five packages have been developed for use in beef crossbreeding decision making; four of those will be reviewed here, and are introduced in Table 1. The fifth program (Bandy and Stewart, pers. comm.) was developed in 1986 as part of post-graduate training. It was a rule-based system that matched breeding resources and market goals with appropriate mating plans. The program was never widely distributed because of lack of available computing resources to potential users. We also note the efforts of Savicky (1993) for sheep and pigs. This program is being updated to accommodate beef cattle as well (Nitter, pers. comm.)

**Table 1. Description of Four DSS for Beef Crossbreeding**

| Name | Language | Source |
|---|---|---|
| Simumate | FORTRAN IV | Minyard and Dinkel (1974) |
| X-Breed | Exsys Professional (C) | Hochman et al. (1991a, 1991b, 1994) |
| Cross-Choice | WinExp | Lamberson et al. (1997) |
| HotCross | Visual Basic | Newman et al. (1997) |

**Simumate:** Simumate allows the user to compare various crossbreeding systems and breed combinations for their own individual operations, as well production responses and net return to all segments of the beef industry. Simumate predicts how crossbreeding systems and particular breed combinations will work within an individual's own management regimen, using available feed. The program takes into account energy needs for cow maintenance, milk production and gain during gestation. It also considers reproductive rate, growth rate, selling prices at several stages and costs of production, both fixed and variable. The program calculates a carrying capacity (lbs TDN to carry a cow one year) relative to the first breed input.

Users filled out an input form, either by themselves or in conjunction with a local extension adviser. The forms were sent to South Dakota State University for processing, and possible interpretation. The program is presently inactive and experienced limited success. MacNeil *et al.* (1994) used a version of Simumate to derive economic values for a beef breeding objective. Simumate is presently being enhanced to examine issues related to variability in end-products, age distributions for cow herds, and improved carcass pricing based on carcass weight, grade, and yield (M. MacNeil, pers. comm.)

**X-Breed:** X-Breed is a true multiple domain (pasture agronomy and cattle breeding) expert system developed under the auspices of NSW Agriculture. It is a rule-based system of 660 rules, implemented on a PC using the Exsys Pro (C) shell (Hochman *et al.* 1991a). X-Breed is capable of choosing between eight breeding strategies and also recommends bull breeds from a list of 10 types of breeds. X-Breed is constrained to producers whose current breeding herd is made up of straightbred cows of a British breed. X-Breed's knowledge base includes information on the potential of each breeding system to contribute to the improvement of growth rate, maturity, calving ease, calf survival, disease resistance, milk production, temperament and fertility. It also contains relative performance values for each trait on 10 breed groups and how these values vary with pasture quality.

X-Breed is available through extension advisers in NSW Agriculture. X-Breed requires a minimum configuration of SVGA (800 x 600 pixels and 256 colours) and is not available commercially. It has likely experienced limited use in the field.

**Cross-Choice:** Cross-Choice helps the user identify systems best suited for particular sets of production circumstances (Lamberson *et al.* 1997). The Cross-Choice knowledge base utilises 94 rules to link answers to 13 questions on the production system to 11 crossbreeding systems. The questions asked of the user include market opportunities for calves, number of breeding cows, source of replacement heifers, use of artificial insemination, body condition scores for heifers and cows, use of supplementation, collection of performance data, and record keeping of breeding dates. Explanations are available with each question to aid in choosing the most appropriate answer. The recommended system is described, including possible breeds for use as sires and dams. The basis for recommendation of systems is maximisation of weaning weight within the constraints of the production system.

Cross-Choice has been available for only a short period of time, so its use has not been monitored. However, Cross-Choice is available on the World Wide Web as a free download at URL www.missouri.edu/~anscbeef. This will allow the developers an opportunity to gauge at the minimum the number of times the program has been down-loaded.

**HotCross:** HotCross was described in detail in a previous paper from this conference (Newman *et al.* 1997). Briefly, a major limitation to implementing crossbred mating programs in tropical areas has been the lack of information on the impact of genotype by environment interactions on specific breeds and crosses. HotCross was developed to predict differences in performance of alternative genotypes for 17 performance traits under tropical environmental conditions. The major descriptors of environmental stress used by the software are ambient temperature, ticks, worms and nutrition availability. The approach used to predict animal performance is to first predict performance in a benign (zero stress) environment. The combined impact of environmental stresses is characterised by determining the reduction in growth performance expected due to each source of environmental stress. The environmental regression equations are non-linear multiple regressions accounting for the level of environmental stressor and the percent of the animal's genotype that is a tropically adapted breed (zebu or adapted taurus populations). For maternally affected traits, the percent adapted genotype of the dam was also included in the regression equations. Performance of other traits are then predicted by regressing the trait on the stressed weight of the specific genotype. A database of 18 breeds was developed from published literature to characterise breed performance in a benign environment. Results of the USDA Germplasm Evaluation (Cundiff *et al.* 1993) is a major component of the database. The environmental regression equations for parasites were developed by pooling information in published reports relating animal performance to temperature, internal and/or external parasite levels. Nutritional stress is currently described as a percentage availability of nutrient requirements. Users must provide environmental descriptions for temperature, parasites and nutrition for breeding, growing and finishing phases of production. Default values for several regions of Queensland are provided. Users select a base genotype for their cow herd. They may then construct any mating plan using a graphical interface. The predicted performance can be displayed as a bar graph including all genotypes in the mating plan or a table listing performance of all traits for a genotype in both the benign and described environment. The software is PC windows based. An alpha-test version was released to selected users in November, 1996. Work is continuing to include economic inputs to combine the values of all traits and to allow inclusion of genetic evaluation information for individual sires or dams.

## CLOSING REMARKS

The success of any DSS will depend on a number of factors, including an assessment of user needs, commitment of the human expert(s), ease of use, commitment of the user to the project, and the amount of support the project receives from management. Various methods for planning, evaluation, and support have been used. Developers of HotCross use focus groups for screen design and available options. Developers of X-Breed used an international panel to evaluate decisions the program recommends (Hochman *et al.* 1991b). Cross-Choice developers used beef extension specialists around the US for evaluation of accuracy of decision-making and user-friendliness.

Likely the greatest challenges for the development and use of DSS include (1) commitment of time over the long-term to continuously upgrade and maintain the program and databases with up-to-date information; and (2) limited use of specialised hardware and software to allow wider availability.

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