APPLICATION OF CROSSBREEDING TO BEEF PRODUCTION : OPPORTUNITIES, OBSTACLES AND CHALLENGES

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SUMMARY

There has been rapid and widespread uptake of beef crossbreeding over the past 25 years in most temperate regions of developed countries. While there are still several important areas to be researched, these are generally not considered major obstacles to the effective use of crossbreeding. In these temperate areas, the main limitations to achieving effective crossbreeding programs appear to be, in order of priority: small herd size, and lack of resources given to cattle on mixed enterprise properties. These limitations cannot be overcome easily, though the use of composite breeds and simple crossing systems are recommended options. Other limitations include: lack of knowledge by cattle breeders, and a paucity of replacement F_1 females available for purchase. In tropical regions with extensive management systems there is a much lower use of crossbreeding. In tropical Australia, for example, only 10-30% of properties are practising crossbreeding. Herd size and competition for resources from other enterprises, are not such important obstacles to adoption in the tropics. Bigger obstacles involve: the need to use stress resistant cattle such as *Bos indicus* breeds, and the difficulties of using *Bos taurus* bulls for crossing; lack of facilities for controlled mating; and lack of knowledge by cattle breeders of appropriate systems.

It is suggested a higher proportion of resources should be allocated to extension programs. The design and targeting of extension programs will vary according to circumstances but the following principles will apply.

- Determine producers' information needs, and attitudes.
- Determine the most effective technology transfer agents.
- Develop comprehensive extension material, and deliver a targeted package, via various transfer agents.

An extension program using a whole herd approach, now operating in southern Australia and New Zealand, is given as one example. This extension program targets the need - 'Breeding systems to target markets,' - rather than the technology *per se*.

INTRODUCTION

Crossbreeding offers the opportunity to improve the profitability of beef production by utilizing heterosis and the additive genetic merit of different breeds. Numerous experiments have been conducted on crossbreeding (see reviews by Long 1980; Gregory and Cundiff 1980 Cundiff et al. 1986; Cundiff et al. 1994) providing a wealth of information. While there are still gaps in our knowledge that need further research, it is argued that effective crossbreeding programs can be developed in many instances from existing knowledge. The level of uptake of crossbreeding for commercial production varies greatly among different regions of the world and even within countries. In commercial herds where crossbreeding is being practised, the level of efficiency being achieved (though difficult to quantify) appears to be less than optimum.

This paper attempts to define the level of uptake, state of knowledge and research needs, obstacles to effective implementation, and opportunities and challenges for improved utilization of crossbreeding. The emphasis in this report is on temperate areas where cattle are under extensive grazing, particularly southern Australia, New Zealand, Canada and the USA, with reference made to tropical and other areas of the world. A small survey involving a sample of 41 research and extension personnel in the above-mentioned countries was conducted specifically as background for this paper ("Sundstrom 1994 Survey").

THE CURRENT LEVEL AND EFFECTIVENESS OF CROSSBREEDING

Simple estimates of crossbreeding frequency can be made from surveys of producers, saleyards and abattoirs. Several such surveys have been completed in southern Australia in recent years. A major saleyard survey showed 41% of cattle sold to be crossbred (Carter 1993). A higher proportion of crossbred cattle would be expected among those sold directly to abattoirs. Surveys of producers practising crossbreeding with at least part of their herd showed 62% in 1989 (Graham 1991), 74% in 1991 (Sundstrom and Barlow 1991) and 81% in 1993 (Deland 1993), with 50-60% of cattle turn-off being crossbred. These surveys are not directly comparable, but the trend is clear. Prior to 1969 cattle producers in these areas used British breeds mainly for straightbreeding with very little crossbreeding being practised (Barlow 1985).

In Alberta, the major Canadian cattle province, it was estimated from a provincial beef survey database (Basarab, pers. comm.) that 90% of commercial cattle breeders were practising crossbreeding in 1991. About 30% of the crossbreeders were using two breeds (different breed of sire over straightbred cows) and 70% were using three or more breeds. This compares with most herds being straightbred British breeds in the early 1960s. The incidence of properties practising crossbreeding in temperate USA appears to range from the levels reported in Alberta, to those for temperate Australia. In Alberta and the temperate areas of the USA however a higher proportion of cattle 'turn-off' is crossbred, at 80-90% (Sundstrom 1994). In New Zealand the situation is similar to temperate Australia (Sundstrom 1994). Cattle breeders in tropical Australia are mainly straightbreeding with high grade Brahman or derived *Bos indicus* breeds, with only 10-20% crossbreeding (Sullivon, pers. comm.) and the situation is similar in some of the more tropical parts of South America (Frisch 1993).

While the uptake of crossbreeding in temperate areas appears satisfactory, the effectiveness of programs also needs to be examined. What proportion of well intentioned programs is poorly planned or executed? A survey of commercial cattle breeders in Colorado (Simms, per. comm.) showed only 35% of cattle breeders had what the authors considered a "well planned breeding program". In the "Sundstrom 1994 Survey" participants were asked to estimate how close to optimum effectiveness the use of crossbreeding was in their region (taking into account herd sizes). A score of 100% indicates that given the herd size constraints, respondents considered cattle breeders were implementing effective crossbreeding systems. Results are summarized in Table 1.

Table 1. Estimated effectiveness (%) of crossbreeding system currently practised*

		Mean	Range
Australia	- Temperate	40	20 - 60
	- Tropical	15	10 - 25
New Zealand		45	30 - 60
United States	- Temperate	45	20 - 60

*100% indicates commercial breeders are using crossbreeding at optimum effectiveness.

In summary, there has been a major uptake of crossbreeding in temperate areas over the past 20-30 years, but even in those countries using crossbreeding most widely, there appears considerable scope to improve the effectiveness with which this is being implemented. In the tropics both the uptake and effectiveness are low.

STATE OF KNOWLEDGE AND FUTURE RESEARCH CHALLENGES

There has been a massive research investment in the past on the biological differences among breeds and heterosis effects, and their use in crossbreeding to improve traits of economic importance in beef cattle. A number of reviews have been published on crossbreeding in beef cattle (Mason 1966; Long 1980; Gregory and Cundiff 1980; Cundiff et al. 1986). In short, there is a large body of information which can be used to improve productivity in commercial herds. While the "Sundstrom 1994 Survey" was too small to give definitive research priorities, the areas it identified, and those from our review of the literature, that require further research, include:

- the linking of within breed selection with between breed utilization,
- additional information on additive and non additive effects on traits related to forage intake, intrinsic efficiency of nutrient use, meat quality, longevity, male fertility, and resistance to diseases and parasites,
- the advantages of crossbreeding in the context of whole herd profitability,
- development of adapted but productive genotypes for the tropics, and
- role of breeds with high frequency of double muscling.

The linking of within breed selection with between breed utilization is a logical extension of our current knowledge and requires a more focused research effort. The issues involved are discussed in more detail below.

LINKING WITHIN BREED SELECTION WITH BETWEEN BREED UTILIZATION

Crossbreeding experiments worldwide have sampled animals to represent breed averages, although large within breed variation exists for most traits of economic importance. Independently, major genetic improvements have been achieved through crossbreeding on one hand and within breed selection on the other. There is the need to link the two major genetic improvement strategies (crossbreeding and selection) in a single system. Simulations by Kinghorn (1986) indicate that under appropriate conditions crossbreeding systems could be optimized through multibreed index selection. Currently, opportunities which allow for the linking of crossbreeding with selection include, a) the use of estimated breeding value/estimated progeny difference (EBV/EPD) information when selecting parents for crossbreeding and b) employing selection in composite herds. Strategies need to be developed which allow for the utilization of both additive and non additive effects.

(a) Use of EBV/EPD Information when Selecting Parents for Crossbreeding

EBV/EPD information is usually generated within breed. The value of such information under a crossbreeding situation is not fully understood as there is a question about whether animals ranked through EBV/EPD from a straightbreeding system will be re-ranked under a crossbreeding scenario. Bell (1982) suggested the genetic correlation between straightbred and crossbred performance (r_{pc}) as the most reliable indicator. The limited information available for *Bos taurus* cattle in temperate areas suggest that re-ranking of sires will be minimal for growth traits (Dunn et al. 1970; Koger et al. 1975; Nunez-Dominguez et al. 1993). The r_{pc} values reported were > 0.7. Lower r_{pc} values were however reported in other studies (Swan and Kinghorn 1988; Tilsch et al. 1989). Vieselmeyer et al. (1994) indicate that there is minimal re-ranking for marbling. The expectation, as suggested by Cundiff et al. (1994), is that there would be less re-ranking for highly heritable traits. Given the paucity and at times contradictory nature of the information, precise estimates of r_{pc} are required before EBV/EPD information can be fully utilized in crossbreeding. This may involve the generation of EBV/EPD information on sires specifically for use in crossbreeding. Such information is also needed for breeds with small populations, in some countries, but used to a fair degree in crossbreeding.

A related issue which adds another level of complexity, but needs to be addressed, is the correlation of straightbred and crossbred performance in widely differing environments. A common genetic improvement strategy in tropical countries, is to use exotic (usually temperate, very productive) breeds and indigenous (well adapted) breeds in crossbreeding. The question is: how useful is the EBV/EPD information on the exotic sire?

(b) Employing Selection in Composite Herds

In an effort to combine in a single animal the characteristics of two or more breeds, utilize heterosis and at the same time avoid the complexities of structured breeding programs (e.g. rotation or terminal sire), composite breeds/herds are formed. These herds may be open to new genetic material from the parental breeds or closed. The breed composition of some of these herds has stabilized while that of others has not, and some of these herds have advanced to the stage of being considered new breeds, such as Santa Gertrudis and Australian Belmont Red.

Composites are gaining popularity in the USA and Canada (Sundstrom 1994). Improved productivity has been reported in advanced generations of composites (Berg et al. 1990; Gregory et al. 1993; Newman et al.

1993), but the relative contribution of retained heterosis and selection to this improvement has not been fully evaluated. Other issues which need to be addressed include the development of EBV/EPD for composite herds where both additive and non additive effects are confounded.

ISSUES RELATING TO THE CONDUCT OF RESEARCH

There is an almost complete lack of use of EBV/EPD information in the documentation of crossbreeding experiments. This is understandable for older experiments when these performance records were less available. With recent and current work however, this seems a major omission.

While well conducted experiments use breed average stock, it would be reassuring, and an assistance in extension, to have EBV/EPD information reported for those traits where available. This is less important for the carcass and fertility traits which have generally shown only small genetic trends. For the growth traits, trends in some breeds have been large. It is difficult for people to compare say Breed X sampled in the early 70's, with Breed Y in the mid 80's, without EBV/EPD information being reported for some key traits, and/or breed means being adjusted for genetic trends.

The trend in recent years has been a reduction in funding for on-station breeding research. Most within breed evaluations use industry data and are funded, at least in part, by the beef industry. An on going system of assessing breed differences through the use of industry data needs to be evolved, at least for traits measured in commercial herds. Opportunities will largely be restricted to the non-seedstock sector, and the methodology will evolve from the solutions required for combining within and between breed utilization.

OBSTACLES TO MORE EFFECTIVE ADOPTION

The rate and effectiveness of adoption of new technology have a major bearing on the eventual return on investment in research. Farquharson (1992) estimated the benefits and costs to society of a beef crossbreeding project in southern Australia. The costs included research, development and extension expenditure. The results indicated that the greater the aggregate (industry) adoption and the shorter the time to adoption, the greater the financial measures of project success. Only 20% of the costs to date was related to extension. While this percentage will differ depending on the stage of development of the project, it underscores the need for planning the total research, development and extension requirements. As part of this, the obstacles to effective adoption have to be identified and strategies evolved to overcome them.

IMPLEMENTATION DIFFICULTIES

The following are listed in order of priority identified by the "Sundstrom 1994 Survey".

Herd size - is a major constraint in most of the USA, New Zealand and temperate Australia. Small herds have difficulty in maintaining most crossbreeding systems. In the USA, for example, 55% of cattle and 93% of cattle breeders are on holdings with less than 100 cows (Gregory et al. 1993). The situation is similar in temperate Australia (Deland 1993). Herds in tropical Australia are considerably larger, but herd size is still a limitation in some areas (Vercoe and Burrow 1994).

Opportunities - Composite breeds; purchase of F_1 cows.

Allocation of Farm Resources and Managerial Priorities to Cattle - In many situations beef cattle are run as secondary enterprises. This can be with cropping (Australia, USA) or sheep (temperate Australia, New Zealand). Beef can also be a 'by-product' of dairying in some countries. In these situations straightbreeding becomes appealing, making it difficult to introduce any sophisticated crossing systems. Cattle managers are more difficult to attract to extension activities if they are not highly motivated.

Opportunities - Composites; commercial availability of F_1 females; simpler and better targeted extension.

Availability of F_1 Females - The use of F_1 females mated to sire breeds appropriate to the environment and markets, offers great potential in theory. However low reproductive rate of cattle - particularly in the tropics - limits the number of surplus F_1 females that can be made available for sale. To effect an F_1 production system, there need to be strong reasons to maintain a large straightbred population, such as the need to produce high quality wool from straightbred Australian Merino sheep. The need to run stress resistant cow breeds in the tropics is another example, even though the cows have low reproductive rates. The dairy industry is another potential source used to varying extents in many countries. In some countries, dairy females are highly valued, reducing the incentive to breed useful F_1 females for sale to the beef industry. As multiple ovulation and embryo transfer (MOET) technology advances, it may become economic to use dairy cows, for example, as recipients of beef embryos. These could include F_1 females. Other factors limiting F_1 female availability include: high slaughter value of F_1 females at young ages; the need for organization of F_1 sales; Breed Societies all promoting their F_1 females (including terminal sire breeds). Extension personnel noted encouraging signs of F_1 female sales developing in their countries (Sundstrom 1994), but felt more could be done within the current beef industry structure. Even if this is achieved, beef industries will have to continue without a major source of F_1 females, for the reasons outlined above.

Opportunities - Extension activities to promote the real value of F_1 females; MOET (in the longer term).

Lack of Adapted Genotypes in Tropical Areas - In tropical areas, environmental stresses can impose major limits to the uptake of some crossing systems. For example, in tropical Australia many cattle breeders run female herds with high *Bos indicus* content due to the need to use stress resistant cattle. At present, market signals encourage crossing these with *Bos taurus* or part *Bos taurus* sires to change carcass traits. In many areas however there are problems with the survival and fertility of these bulls. There is some progress in developing tick resistant *Bos taurus* cattle (Freer 1994), but it will be some time before a significant population becomes available. New vaccines and acaricides may also assist the running of *Bos taurus* breeds in some areas in the future. Lack of facilities for controlled mating, and lack of knowledge by breeders of appropriate systems are other obstacles.

Options - Evaluation of stress resistant breeds and composites with the desired carcass and fertility qualities. For example, the African Sanga and the Criollo breeds.

Commercial Use of Composites - Researchers responding to "Sundstrom 1994 Survey" were more supportive of the use of composites than did extension personnel. Concerns raised stem from past experiences where the initial productivity gains were lost when small herds were closed and treated as a breed. A second concern noted was the inclusion of terminal sire breeds in female composite lines.

Opportunities - Education of extension personnel and producers on benefits and use of composites.

Other Obstacles - The variability in the progeny from some crossing systems (such as breed rotation) presents problems with consistency of product particularly in smaller herds and where access to only a few markets exist. Requirements of certain markets, such as the highly marbled Japanese market, is encouraging some Australian cattle breeders to straightbreed using breeds with high propensity to marble, such as Angus. Requirements for consistent tenderness has created an aversion, in some areas, to crosses with high *Bos indicus* content.

KNOWLEDGE OF CROSSBREEDING PRINCIPLES BY COMMERCIAL CATTLE BREEDERS

A potential limitation to efficient crossbreeding uptake is lack of knowledge of existing research and the principles of breed utilization. While it is not as important as the implementation difficulties outlined above, this was noted by 80% of respondents to the "Sundstrom 1994 Survey" as significant. The two most deficient areas of producer knowledge are:

- The different roles of maternal and terminal breeds;
- How to use simple crossing systems in small herds.

In a more direct approach to determining cattle breeders' knowledge, a 1991 survey of cattle breeders in southern Australia (Sundstrom and Barlow 1991), sought responses to 11 questions testing their knowledge of crossbreeding practices. Cattle breeders averaged 65% correct answers, indicating a useful knowledge level, but exposed some gaps for extension to target. The lowest level of knowledge concerned differentiating between terminal and maternal breeds. In a later survey (Deland 1993), 30% of cattle breeders felt further information on "marketing, carcass quality and breed utilization" would assist their crossbreeding decisions.

Opportunity - Correctly targeted extension, based on sound market research and interactive extension methods.

OPPORTUNITIES AND CHALLENGES TO IMPROVING EXTENSION

As outlined earlier, there is sufficient research information available to allow a significant improvement in the application of crossbreeding in temperate regions. In the "Sundstrom 1994 Survey" respondents were asked to rate, on a 5 point scale (1 = most important), the relative importance of further research compared to extension of existing crossbreeding knowledge. Responses averaged 3.3 "of equal importance" for replies from research staff and 4.1 for extension personnel "extension a little more important". Historically there has been a much lower allocation of resources to extension than to research (Farquharson 1992), and this sample of opinion indicates this needs to be addressed. Against a backdrop of declining government involvement in extension in many countries, it may appear difficult to recommend increased extension of crossbreeding. However, there are positive signs, such as industry showing increased interest in funding technology transfer in some countries and Breed Societies increasingly employing qualified staff who often include crossbreeding in their breed promotion. Breed Society promotion does of course also have drawbacks, with most Societies promoting their breeds as suitable for most situations. The extension approach should vary in each country/region according to the stage of development of the beef industry, and the structures of the beef and dairy industries

The challenge is to identify the information needs of cattle breeders. The technology transfer agents most effective in each area must then be identified and extension packages developed. These packages should be comprehensive but simple. They should embrace a whole herd/farm approach and provide information not only on the potential increase in production efficiency, but also on the effect of adoption of the technology on both short and long term cash flow of the enterprise. Delivery can be via the mix of government and industry technology transfer agents most appropriate in each area. An example of such a project, currently being conducted in south east Australia, is given to show the principles which need to be applied.

Extension Program in Southern Australia - *BETTER BULL BUYING TO TARGET MARKETS*

This project began in 1991 with a survey of 550 commercial cattle breeders and separate surveys of technology transfer people including stock agents, veterinarians, meat company livestock buyers and government extension personnel (Sundstrom and Barlow 1991) to ascertain the processes cattle breeders use to make breeding decisions. From a list of 20 breeding issues, commercial cattle breeders ranked the following as their most important breeding needs:

How to produce cattle to meet market specifications, and
How to select best bulls;

as the most important, followed by:

How to improve fertility by breeding,
Breed characteristics that most influence profit,
How to reduce dystocia in heifers,
How to improve muscling, and
To know what is a good maternal line.

These results show the market awareness of cattle breeders, and suggested extension should be built around this, together with the need - "how to select bulls to meet breeding requirements". Other relevant results are presented in Table 2.

Table 2. Information sources used by commercial cattle breeders when making breeding decisions

	Usefulness ranking*		Frequency of use ranking**	
Opinion leader	NSW	Victoria	NSW	Victoria
Other cattle breeders	1	1	1	1
State beef advisers	2	6	5	7
Stud breeders	3	2	3	4
Veterinarians	3	4	3	3
Meat company staff	3	2	3	4
Family	3	4	6	5
Stock agent	7	6	2	2

*,**A rank of 1 indicates most useful or most frequently used, respectively.

Table 2 confirms the priority given to obtaining advice from other commercial cattle breeders and hence the need to ensure extension utilizes "networking principles", but within the context of people having participated in deciding their own needs. Table 2 also identifies the range of people involved in decision making and hence the need to include them in any program. Differences between states are of interest. In Victoria, state beef extension services were being reduced at the time of the survey with generalist extension staff being employed rather than beef specialists as in NSW. Where beef advisers are well regarded but less frequently consulted, it may be more effective for them to train and provide information to other more frequently used information providers.

Subsequent to the survey, a program was developed entitled - Better Bull Buying to Target Markets. This is currently being delivered in an interactive, participatory field day setting (best learning medium identified in survey). Participants reach a consensus on their markets of interest and the traits needed in bulls. Sessions are then conducted on buying appropriate bulls with performance records and on crossbreeding to target these markets. An introductory session on soundness and bull fertility is also included. The extension package, developed specifically for the program, includes a model bull (to demonstrate structural soundness), videos, posters and manuals. To date a trial run of 21 field days, involving some 900 cattle breeders has been successfully conducted. It is too early for formal evaluation, but preliminary feedback, and the numbers of people attending these user pay functions, are positive signs. It appears more effective to include crossbreeding in an integrated package targeting markets rather than to hold extension functions on crossbreeding alone. The concept is now spreading into other parts of Australia and New Zealand with some 40 days planned to be conducted during the remainder of 1994. The 'Network' should then carry the message much more widely. A logical next step in this program is to offer specialized crossbreeding workshops to participants. One of the steps which has already been taken is to develop a decision support system software package (Hochman et al. 1991) to serve as an extension tool. Similar principles should apply in other countries.

CONCLUSION

There has been significant uptake of crossbreeding in recent years especially in temperate areas of most developed countries. However the effectiveness with which it is practised can be improved. There are obstacles to more effective adoption which provide opportunities in both research and extension, as well as offer opportunities for development in areas such as, formation of composites and commercial production of F_1 females for sale. A challenge in research is to take the next logical step, which is to link within breed selection with between breed utilization. It is recommended that a higher proportion of resources be allocated to extension programs. The challenge is for the development of comprehensive, yet simple and effective extension programs based on a whole herd/farm approach.

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