DESIGN CONSIDERATIONS IN DEVELOPMENT OF BREEDING STRATEGIES IN A COMPLEX NATIONAL INDUSTRY CONTEXT

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SUMMARY
The Canadian sheep industry is characterised by highly diverse production environments, products, markets, and genetic resources. Exploitation of genetic resources for crossbreeding exists but is opportunistic rather than structured. Fluctuating markets and high input costs result in highly variable economic values for lamb and wool. Breeding objectives for the various production environments are numerous and would imply customisation of breeding objectives at the individual farm level. An integrated national approach could consider all genetic resources and production environments, heterosis and complementarity for development of an optimal number of breeding objectives and breeding strategies.

Keywords: breeding objective, crossbreeding

INTRODUCTION
The Canadian sheep industry is small by comparison with Australian, New Zealand and British sheep industries. It is characterised by a wide diversity of production environments, products, markets, prices and genetic resources, making derivation of a profit function appropriate to the industry as a whole difficult. High price variability exists due to the seasonal supply of lambs and the inconsistency of product quality (Moore 1992, Shafto et al 1989). Crossbreeding is utilised in an opportunistic way as breeds become favoured, and as such is unstructured, making the definition of breed roles difficult and breeding objectives vague. Non-linear merit and multiple decision makers also contribute to this lack of focus.

Harris et al (1984) suggest a series of steps for the development of a breeding program, the first step being to define the breeding objective. National genetic improvement systems have a national scope and have objectives which include genetic improvement of profit at the farm level through improved use of genetic and environmental resources nationwide. The development of multiple-trait selection indices for selection within pure lines should consider how and where these lines are used and with which other lines they may be crossed for maximum utility. Harris and Newman (1994) justify the use of different objectives for breeds dependent upon the crossing system used. Clarke (1982) points out the importance of future advancement through breed changes, crossbreeding strategies and selection. Banks (1988) suggests that taking a national approach to development of the utilisation and further improvement of genetic resources could include future market uncertainty and crossbreeding strategies, making better use of available resources. Some evaluation systems, including Breedplan through Breedobject (Graser et al 1995)
and PIGBLUP (Henzell 1995) include breeding objective customisation making allowances for selection of commercial sires on commercial objectives. Wilton (1986) examined the importance of structural effects on relative expressions in beef crossbreeding systems in Canada and on breeding objectives and suggested that genotype (breeds and crosses) by environment (market standards, nutrition and labour) interactions affect breeding objectives across varying intensities of production. Similar complexity of development of breeding objectives is common to Canadian beef and sheep industries and likely applies to extensive livestock industries worldwide.

INDUSTRY PROFILE
An examination of the complexity of the Canadian sheep industry follows. Opportunities for an integrated national approach to the development of an industry-wide breeding strategy employing optimisation techniques is explored.

A production environment is a combination of geographic/climatic region and management systems. Geographic/climatic regions influence costs of production by limiting the type of sheep production possible. Several environments often exist within a region. Management systems can be summarised as four major types depending upon the level of grazing, type of housing and intensity of production and these affect costs and returns differently. The production environment affects the type and quality of product produced.

The primary product from sheep production is lamb meat, classified into four distinct categories. The prices for these products differ across categories and markets. The availability of lamb is variable due to seasonal constraints on fertility and those imposed by climate. Many producers are, however, adopting accelerated breeding programs in order to supply lamb year round.

The production of wool is a secondary consideration for most sheep producers although in range operations wool production can contribute significantly to overall profit of the sheep enterprise. In farm flocks, particularly where smaller numbers of ewes are kept, wool for handspinning is considered important. Commercial markets for wool are limited and prices are often at levels which marginally cover costs of shearing and transportation of the product.

Sheep dairying has been identified as a new product sector of the sheep industry and now exists in several regions. It is difficult to estimate the economics of sheep dairying at this stage but it is clear that an increase in milk production per ewe is required if it is to become a viable industry.

44 sheep breeds are currently recognised under the Canadian Livestock Pedigree Act and several unrecognised breeds, unregistered synthetics and composites exist. Classifying similar breeds into groups of breeds for the definition of objectives and selection indices still results in a large number of breed by production environment by product by market combinations. Further determination of breeds suitable for crossbreeding, the type of crossbreeding system to be employed and the selection indices for those breeds is required.
SOLUTIONS

National genetic improvement schemes are faced with complex issues and generally two decision-making perspectives are considered: i) individual breeder, and ii) national. These perspectives arise from differing interests in investment into animal improvement and the anticipated returns (Smith 1978) and result in contrasting perspectives on the design and implementation of genetic improvement programs (Table 1). Both the national and individual perspectives of genetic improvement usually ignore the potentially useful interaction of breeds and environments in crossbreeding systems. Integrating the two perspectives and including additional considerations such as crossbreeding strategies increases the complexity of the problem substantially.

Table 1. Implications for design and implementation of genetic improvement strategies of contrasting perspectives

<table>
<thead>
<tr>
<th>Method of dealing with complexity</th>
<th>National</th>
<th>Individual</th>
</tr>
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<tbody>
<tr>
<td>Simplification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• system planning</td>
<td></td>
<td>producer “owned”</td>
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<tr>
<td>• number of traits/indices</td>
<td></td>
<td>total flexibility</td>
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<tr>
<td>• extension effort</td>
<td></td>
<td>objectives and traits tailored to farm</td>
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<tr>
<td>Information issues</td>
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<tr>
<td>Control of data integrity</td>
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<td>Ownership of data/direction of genetic change</td>
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<tr>
<td>• trait measurement</td>
<td></td>
<td>individual competitiveness</td>
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<tr>
<td>• estimation and prediction</td>
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<td>privacy</td>
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<tr>
<td>• central dissemination of</td>
<td></td>
<td>accessibility</td>
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<tr>
<td>information</td>
<td></td>
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<tr>
<td>Improvement desired</td>
<td></td>
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<tr>
<td>• long term, sustainable</td>
<td></td>
<td>short term, “competitive edge”</td>
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</tbody>
</table>

Computer search and optimisation techniques such as simulated annealing (Ingber 1993), neural nets (Wade and Laeroix 1994) and genetic algorithms (Goldberg 1989) have been shown to find optimal solutions to complex problems efficiently when the problem can be defined. The Canadian sheep breeding objective problem could be redefined in terms of optimisation of the use of resources which are presently available to an overall breeding strategy including breeds (genetic), management systems (human) and environment (physical). Such an approach could be employed to answer questions such as:

- What types of crossbreeding structures are most profitable?
- How many selection indices should a national program support?
- What are the selection indices which result in the most profitable crossbreeding structures?
- What production environments are most suited to straightbreeding? Crossbreeding?
- Which breeds should use which selection indices for which production environment?

For example, a single breed may be utilised in both straight breeding and crossbreeding in several ways which will depend upon the other resources with which it is combined and the production environments targeted. Optimisation of this type of genotype by environment interaction would
appear worthwhile and should result in better use of breeds across environments. This is akin to
developing a portfolio of stocks. A breeding strategy portfolio would thus include flexibility in
the entire system and in the national breeding goal (Banks 1988). When breed roles are clearly
identified, commercial producers are more likely to adopt particular crossbreeding systems and
purchase their stock from multiplier breeders, resulting in a more stable industry for all production
tiers.

Optimisation of genetic and environmental resources does not in itself guarantee or maximise
adoption of the breeding strategies found to be optimal, or ensure that the hoped for results are
achieved. Human and technical factors contributing to the successful implementation of the
scheme may include:
• clear and credible genetic evaluation system(s),
• clarity of financial reward for genetic improvement,
• efficient data and information transfer,
• on-line modelling, simulation and prediction of farm and population genetic progress,
• on-going research and readily-available extension,
• structure of the genetic service sector

These may be considered as variables in the optimisation process.

CONCLUSION
The Canadian sheep industry is complex and diverse and requires a design process which can
accommodate different perspectives on breeding strategies and genetic improvement structures.
These must reflect profitability in all key niches, through appropriate consideration of genetic,
environmental and human resources and opportunities. An approach currently under investigation
by the principle author into optimal use of breed resources and implementation of breeding
strategies represents the first stage of this optimisation process.

REFERENCES
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