DEVELOPING COMPOSITE CATTLE FOR BEEF PRODUCTION

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SUMMARY
A method is presented to optimise breed proportions in composite populations when the proportion of a specific breed in the composite is constrained to a desired level to reflect the production system and/or risk preference. A mate selection index (MSI) approach to create the desired composite using available animals is described. The MSI included the deviation of breed proportions averaged over all animals in the herd from desired composite breed proportions and deviations of breed proportions in individual animals from average herd breed proportions. In a simulation, implementing mate selection using the MSI successfully created a herd of animals all with the desired composite breed proportions, after five generations of breeding.
Keywords: Desired composite, mate selection, cattle

INTRODUCTION
Composite breeds provide a way of utilising both heterosis and within-herd selection. Newman *et al* (1998) described prediction of breed proportions in optimal composites for tropical environments using genetic growth parameters from a tropical crossbreeding experiment. Such an 'optimum' composite may not represent true economic optimal use of breed resources, particularly if no information on fertility and resistance traits is included in composite optimisation. For example, producers in tropical regions often feel composites containing greater than 50 % 'non-adapted' (e.g. British or European) genes incur unacceptable risk, particularly if parasite challenge is significant.

The objective of this paper is to present and illustrate a method for deriving the breed proportions in composites that maximise net merit, when the proportion of a specific breed in the composite is constrained to a desired level. Such a composite will be termed the *desired* composite. A mate selection approach to developing the desired composite from available animals is described.

METHODS
Derivation of optimum breed proportions in composites when proportion of a specific breed is constrained. Lin (1996) described equations to optimise breed composition for net merit, based on genetic parameters and selection index weights. These equations can be modified to restrict a specific breed in the composite to a desired proportion. If the proportion of the i^{th} breed in the composite is p_i, at equilibrium, mean net merit (μ) of a composite is

$$\mu = \sum_{i=1}^{b} \sum_{j=1}^{b} p_i p_j t_{ij} \qquad [1]$$

where t_{ij}= net merit for the combination of the i^{th} and j^{th} breeds (see Lin 1996 for derivation of t_{ij}). In matrix notation, $\mu = \mathbf{p}'\mathbf{T}\mathbf{p}$. Two Lagrange multipliers are used, to restrict sum of breed proportions to one, and to restrict the proportion of a specified breed to c. Then $\mu = \mathbf{p}'\mathbf{T}\mathbf{p} + \alpha(\mathbf{p}'\mathbf{u} - 1) + \beta(\mathbf{p}'\mathbf{v} - c)$, where $\mathbf{u}$ = a unit vector of dimension (b x 1) and $\mathbf{v}$ is a vector containing 1 for the restricted breed, and 0 for the others, dimension (b x 1). For simplicity, three scalars are defined, $x = \mathbf{u}'\mathbf{T}^{-1}\mathbf{u}$, $y = \mathbf{v}'\mathbf{T}^{-1}\mathbf{v}$, $w = \mathbf{u}'\mathbf{T}^{-1}\mathbf{v} = \mathbf{v}'\mathbf{T}^{-1}\mathbf{u}$. Hayes (1999) showed that the optimal breed composition with a specified breed restricted to c is,

$$\mathbf{p} = \mathbf{T}^{-1}\left[(cw - y)\mathbf{u} + (w - cx)\mathbf{v}\right]\left[w^2 - xy\right]^{-1} \quad [2]$$

Optimal composite as a target genotype for mate selection. Tactical approaches to breeding design use a mate selection index (MSI, Shepherd and Kinghorn 1999), describing economic gain as a function of mate selections, and a mate selection algorithm to identify the mating set from available sires and dams which maximises the MSI. If an optimal composite is the desired outcome from a breeding program, the optimal composite can be taken as a target genotype, and matings are evaluated on ability to produce progeny that contribute to this genotype (Swan and Kinghorn 1991). The appropriate MSI is,

$$-\left[\sum_{j=1}^{b}(\bar{p}_j - p_{opt\,j})^2 + \frac{q-1}{n^2}\sum_{i=1}^{n}\sum_{j=1}^{b}(p_{ij} - \bar{p}_j)^2\right] \quad [3]$$

where b is the number of breeds, n is the number of matings, p_{ij} is the proportion of the j^{th} breed in the i^{th} progeny, $\bar{p}_j$ is the proportion of the j^{th} breed averaged over all progeny, p_{optj} is the proportion of breed j in the desired composite, and q is the generation number for the current round of matings (1 when composite formation begins). The first component of the MSI aims to reduce deviation of herd average breed proportions from desired composite breed proportions. The second component aims to reduce the deviation of breed proportions in individual animals from the average herd breed proportions (within herd breed composition variation), with the objective of creating a herd of animals of uniform breed composition. No restriction is placed on within herd breed composition variation in the first generation - this allows sufficient imports to form the composite. The negative sign ensures deviations are minimised. In consecutive generations, increasing weight is placed on uniformity of progeny breed composition.

Example. The owner of an 800 breeder Brahman (B) herd wishes to import Belmont Red (AX) and Charolais (Ch) sires to establish a composite. The optimal composite, using growth parameters from Newman *et al* (1998), is 28 % B, 13 % AX, and 59 % Ch. Due to parasite challenge in the region, the producer wishes to keep the proportion of Charolais in the composite as low as possible. A curve describing net merit vs. Ch proportion in the composite was generated. Based on this curve a desired composite was chosen.

Mate selection, using Eq. [3] as the MSI, was used to derive mating plans for 5 generations to create the desired composite. An Exchange Algorithm (EA, Kinghorn and Shepherd 1994) was used to maximise the MSI. Mate selection algorithms which marginalise the value of each mating, such as Linear Programming (Jansen and Wilton 1985) could not be used, as knowledge of the whole mating set was necessary to evaluate average herd genotype in the MSI.

As no individual additive information was available, potential sires and dams were grouped by their genotypes, and a group mate selection strategy was used. The number of groups for each sex in each generation was restricted to eight. In practice, the number of genotype groupings could be chosen to reflect paddock constraints. In this case for example, no more than eight different dam genotypes can be produced each generation, which could reflect eight separate paddocks allocated to mating. Sires were mated to 50 dams.

RESULTS AND DISCUSION

Net merit vs. proportion of Charolais in the composite. Figure 1 describes the curve for net merit vs. proportion of Ch in the composite.

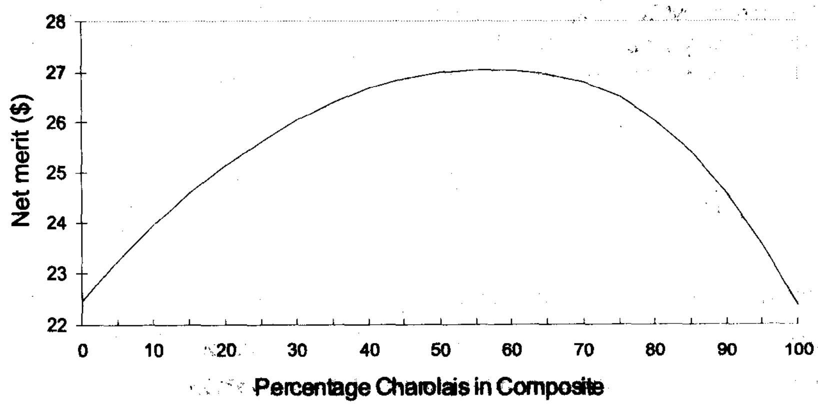

Figure 1. Change in net merit with increasing proportion of Charolais in the composite.

Net merit is quite flat between 50 % and 60 % Ch. Proportion of Ch in the composite can be reduced to 50 % with little drop in net merit - such a composite would have a net merit of $26.99, compared with 'optimal' composite merit of $27.05. With Ch restricted to 50 %, optimum proportions of B and AX in the composite are 33.9 % and 16.1 % respectively (Using Eq. [2]).

Composite development with mate selection. Table 1 shows average breed proportions of the home herd, within herd breed composition variation, and number of AX and Ch sires imported into the home herd, after implementing mate selection using Eq. [3] as the MSI. The number of different progeny genotypes in each generation is also shown.

Table 1. Herd average breed proportions, within herd breed composition variation, number of AX and Ch sires imported, and number of progeny genotypes in the herd at each generation

Generation	Herd average breed proportions			Within herd breed composition variation	Sires imported		Number of progeny genotypes
	B	AX	Ch		AX	Ch	
0	1.000	0.000	0.000		0	0	0
1	0.500	0.062	0.438	0.0893	4	8	2
2	0.344	0.156	0.500	0.0093	4	4	4
3	0.312	0.188	0.500	0.0015	0	0	5
4	0.366	0.164	0.500	0.0005	0	0	2
5	0.344	0.156	0.500	0.0000	0	0	1

By generation 5, the herd average breed proportions are very similar to those in of the desired composite. Within herd breed composition variation is high in the 1st generation, as the three possible F_1 crosses (B x AX, B x Ch and AX x Ch) are created. Within herd breed composition variation rapidly declines in subsequent generations until generation 5, when all progeny had the same breed composition as the desired composite. Two generations of importing AX and Ch sires were sufficient to establish the desired composite. Number of progeny genotypes declined rapidly after generation 3, so mating plans should require progressively fewer separate mating paddocks.

Mate selection generated mating plans to create a herd of animals with the desired composite breed proportions, from available animals. Methods described here can be used to develop composites for producers, customised for individual production systems and risk preference. Cost of Artificial Insemination, production parameters such as weaning rates, and additive variation could be easily modeled in the MSI, and would be necessary for practical implementation. In practice a round of mate selection would take place each year with overlapping generations. In this situation mate selection may take advantage of opportunities to generate favourable intermediate genotypes, reducing time required to attain the optimum composite.

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