MATE SELECTION FOR THE TACTICAL IMPLEMENTATION OF BREEDING PROGRAMS

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SUMMARY

Tactical implementation of breeding programs provides a means to properly integrate technical, logistical and cost issues facing animal breeders. Moreover, tactical implementation benefits from opportunistic use of prevailing animals and other resources, resulting in better outcomes.
Keywords: Mate selection, breeding program design, genetic algorithm

INTRODUCTION

The animal breeder must juggle many issues when s/he makes decisions resulting in implementation of the breeding program, including concerns about breeding objectives, genetic gains, crossbreeding, inbreeding, logistical constraints, and various types of operational cost.

One approach to solving these problems is to follow sets of rules recommended by geneticists and other practitioners. In individual cases these might include component recommendations such as:

- Use this set of economic weightings.
- Rank and select on estimated breeding value.
- Use ten rams mated to 40 ewes each.
- Set up a rotational cross.
- Use no more than two rams out of any one sire.
- Cull cows for age after 5 mating years.
- Buy bulls in the $2,000 to $3,000 price range.
- Don't mate full sibs.

Such rules are derived from generalised theories and concepts - and these are usually not well integrated with each other. For example, theories and rules about selection, crossbreeding and inbreeding have been developed largely in isolation from each other, such that when we mix them in real applications we are likely to miss the best overall strategy.

Moreover, there can be added advantage in making decisions ***tactically***, rather than following a pre-set ***strategy***. This is because a tactical approach will make use of knowledge of the full range of actual animals available for breeding at the time of decision making, as well as other factors such as availability of mating paddocks, current costs of specified semen, current quarantine restrictions on animal migration, current or projected market prices, etc. Tactical implementation of breeding programs gives the power to capitalise on prevailing opportunities - opportunities that would often be missed when adhering to a set of rules.

Mate Selection is an approach that can be used both to properly integrate all the key issues facing animal breeders, and to implement the program tactically. Mate selection incorporates decisions on animal selection and mate allocation. Because the best animals to select depends on pattern of mate allocation, and vice versa, we can best make these decisions simultaneously as mate selection - we just decide what mating pairs and groups to make.

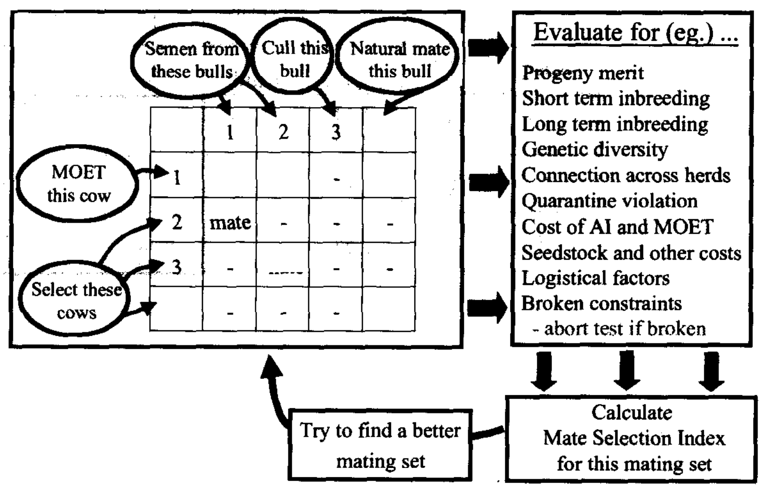
When we specify the implementation of the breeding program using this mate selection approach, we automatically incorporate decisions on breeding objectives, selection pressure, crossbreeding, inbreeding avoidance, which animals to take semen and embryos from, migration of sires between flocks, and how much to spend on seedstock purchase, transport etc. Moreover, we can also satisfy the logistical constraints we want to impose, such as the number of natural mating paddocks used, quarantine restrictions of animal movements, or even that we must use all 42 doses of semen on hand.

MATE SELECTION INDEX (MSI)

The MSI (Shepherd and Kinghorn 1999) quantifies the value to the breeder of matings made. In some cases, the consequences of a particular mating might be simple and quantifiable. For example, if the predicted merit of progeny from a mating is, say, 310 kg yearling weight, or +$12 in breeding objective units, then either of these figures constitutes an MSI *for that mating*. This can be done because the value of a mating in such a scheme is independent from what other matings might be made. However, in most progressive programs this is not the case - the value of a mating depends on what other matings are actually going to be made. For example, the value of a mating using a 'new blood' imported sire to help reduce inbreeding depends on how many other matings will be made using sires from the same outside source.

This means that for most applications the MSI cannot be specified at the level of individual matings - we can only calculate an overall MSI that characterises the combined value of all matings in the mating set. Examples of such an MSI are given by Kinghorn (1998), Shepherd and Kinghorn (1998) and Kinghorn *et al* (1999).

Figure 1. An outline for implementation of a mate selection index. The set of matings shown is an hypothetical test mating set. The matings specified imply the need for collection of semen, etc., as shown. The mating set is evaluated for all components in the MSI. An efficient algorithm for finding the best mating set is required.



IMPLEMENTATION OF MATE SELECTION

As implied above, the mate selection approach to breeding is driven by specifying desired outcomes. An outline of the approach is shown in figure 1. For each mating set tested, the component outcomes evaluated constitute the overall Mate Selection Index (MSI). Each component must be evaluated on the same scale, typically the scale of the breeding objective in units of, for example, dollars profit per breeding cow per year. The MSI can be set to an arbitrarily low and uncompetitive value (eg. minus 999999) for mating sets that break a constraint - for example mating sets that imply migration against a hard quarantine barrier, or greater use of liquid funds than a limit specified by the breeder or group.

The computing challenge is to find the mating set that gives the best MSI. For this purpose, an evolutionary algorithm was developed (Kinghorn 1998), based on Differential Evolution (Price and Storn 1997) . The mate selection driver shown in Table 1 was developed to conduct the search across all legal mating sets. The underlined figures in Table 1 drive the three matings noted, and these are the values to be optimised. "No. of uses" (second column for males, second row for females) is the number of matings for which each animal should be used, and this in turn drives selection, including extent of use of each animal. An animal is culled if this is set to zero. "Ranking criterion" is simply a real number. It is ranked to give the column "Rank". This in turn drives the mate allocation. The first ranked male mating is the single mating from male 3. He is thus allocated to the first available female mating (the one nearest to the left) - the one mating from female 1. The second ranked male mating is the first mating from male 1. He is thus allocated to the second available female mating (the one second nearest to the left) - the one mating from female 3. The third ranked male mating is the second mating from male 1. He is thus allocated to the third available female mating - the one mating from female 4.

Table 1. This table illustrates the components to be optimised for mate selection - they are underlined

			Female →	1	2	3	4...
Male↓	No of uses	Ranking criterion	Rank	1	0	1	1
1	2	5.32 2.16	2 3			mate	mate
2	0	-	-				
3...	1	7.64	1	mate			

DISCUSSION

We are lucky that the sharp end of decision making in animal breeding relies almost completely on just two elements - animal selection and mate allocation. The only key issue not covered by the combined mate selection approach is the choice of which traits to measure on which animals. This has to be handled by extension to the method. The mate selection approach outlined here has been implemented as Total Genetic Resource Management (TGRM, trademarked to LAMBPLAN). This is described at web site http://metz.une.edu.au/~bkinghor/matesel.htm.

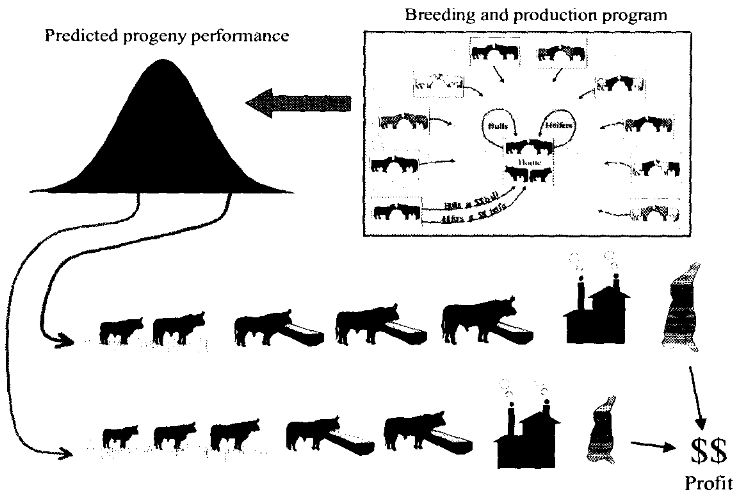


Figure 2. Tactical breeding program design could be extended to the full production system. "Total Genetic Resource Management" becomes "Total Resource Management".

TGRM could usefully be driven by a dynamic production model, rather than static breeding objectives. This means that breeding decisions (including dispersal of young bulls to commercial units) could be based on the optimal production and processing pathway(s) for prospective progeny. The result would account for eg. animal merit, variance in merit, prevailing feed and market conditions, and options for multiple pathways to multiple product end-points (Figure 2). Extension to give *ad hoc* tactical optimisation of the production systems themselves could prove very powerful.

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