BREEDING AND GENETIC IMPROVEMENT IN DEER

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INTRODUCTION

Defining the objectives is the first and most critical step in developing a rational breeding and herd improvement plan for any farm animal. It is no less important, and arguably even more critical with the red deer family, where there is enormous genetic diversity in the range of animals available to the breeder. Although there is much less diversity among the fallow deer, the importance of defining the breeding objectives cannot be understated. This paper is concerned mainly with red deer with reference to fallow deer where appropriate. However, the principles will also generally apply to improving fallow deer herds.

APPROACH

The first three steps in setting up a breeding programme are to:

* define the objectives

* decide on the most appropriate characters (traits) to be improved

* measure and compare the animals in terms of these characters

Following on from these first steps comes the important question of which pathway to improvement? Should it be selection within a strain or hybridisation between strains?

Objectives

Defining your objectives in farming deer sounds simple, and perhaps it is if you just want to breed deer to look at. However, there are other possible objectives such as breeding deer for sale, improving venison production, improving velvet antler production or breeding deer for trophy shooting. The real problems come when someone wants to breed the all purpose deer - this usually means that they do not really want to make a decision yet and therefore it is the easy way around the problem.

The Character

Having defined the objectives, the next stage is to select the character to be improved. For example, improving venison production, itself, sounds like a clear objective. However, when it actually comes down to deciding on the most appropriate characters to be improved in order to satisfy this objective, it is clear that it is potentially very complex. Do we select for weight gain? earlier calving? twinning? How important is carcass composition? Even if it is important can we work out how to measure it in the live animal or are there other ways?

Measurement

These questions highlight the importance of actually being able to measure the character we want to improve. In theory, improving venison production means improving the efficiency of venison production but unfortunately there is no easy way to measure efficiency. This point will be covered again later.

However, just measuring the character is not enough. There must also be variability between the animals in the breeding herd for the character. It is this variability which is the raw material for selection and herd improvement. As well, in order to make genetic progress, a reasonable proportion of this variability must be genetic and therefore be likely to be passed onto the offspring.

EFFICIENCY

Efficiency is an interesting concept - most people seem to have a very firm idea of what it means, yet very often it is rather difficult to find someone else who agrees with your definition.

This question of efficiency is a vitally important one in considering various breeding options in deer. Does bigger mean better? Should we be selecting the biggest animals for breeding? Should we be crossing wapiti with red deer or red deer with wapiti or just selecting within our red deer?

It is a fact of life that bigger animals are metabolically more efficient. For example a rat must eat more each day for its weight than a horse, simply because for its weight, the rat has a greater surface area and it is this surface area which is responsible for losing heat to the environment. In practice, this means that a 200 kg deer would lose heat at only 2.8 times the rate of a 50 kg deer even though it is four times the weight (see Table 1). Clearly this has repercussions in terms of the amount of feed required to maintain an animal.

Table 1: Relativities between weight and metabolic rate.

Weight (kg)	Relative weight	Relative metabolic rate
50	1.0	1.0
100	2.0	1.7
200	4.0	2.8
400	8.0	4.8

The wapiti of North America arrived there from Asia during the last Ice Age. In that cold environment, the relatively lower heat loss enabled the larger animal to eat proportionately less, a real selective advantage. However, as the wapiti moved south and the planet warmed, size alone was not such an advantage. This is apparent today when comparing the variation among the North American wapiti - e.g. the small Tule subspecies from California and the very much larger Roosevelt subspecies from further north. The fossil evidence from Alaska also indicates that the largest wapiti are a thing of the past (Guthrie 1966).

The recent decline in the size of the wapiti, as well as the example of sika deer and other island populations, suggest that size is not always equated with efficiency. When food, land or shelter becomes limited, new selective factors intervene. These are precisely the conditions in the farm situation. Consequently they point to a different equation to measure animal efficiency:

$$\frac{\text{Production}}{\text{Food intake}} = \text{Efficiency}$$

However, there are obvious problems in measuring efficiency using such a relationship. Practically, it is impossible to measure individual animal intakes on a large enough scale. Selecting on weight gain (or weight for age) may also have hidden costs as outlined in our discussion of evolution and size in wapiti. For example, selecting for weight gain will tend to increase weight at all ages and hence such selection will lead to animals of larger mature size. Because they are larger, there will be larger farm overheads in maintaining the same number of breeding females.

Having outlined the problem of defining and measuring efficiency, it is necessary to return to considering the raw material itself, the animal and the variability within the population.

DIVERSITY

Red deer

Red deer are members of an incredibly diverse group of cervids, ranging in size from the Japanese sika to the North American wapiti. This is the extreme example of the range in size, with the Japanese sika female weighing about 50 kg compared with the adult Roosevelt wapiti female, weighing about 300 kg. This 6-fold difference in size, although separated widely by geography, occurs under apparently similar environmental conditions. This difference is genetic, and no amount of feed or labour in selection, will produce a sika female of 300 kg. However, the genetic differences between sika and wapiti are not a sufficient barrier to prevent them from hybridising and producing fertile offspring, although no doubt the mechanics of such a mating and calving could be extremely difficult for those concerned. Therefore, from the deer farmer's point of view, where genetic improvement is the goal, sika deer may be regarded as small reds and wapiti as large reds. More practically, the red deer, being intermediate in size (Table 2 and Fig 1) is most suitable for hybridisation with other members of the red deer family. Although it is known that several of the crosses have produced fertile hybrids, as yet it is unclear with others.

Table 2: Species of the red deer family which may hybridise[1].

	Female body weight (kg)
Red deer	80–140
North American wapiti	140–300
Sika	40– 60
Pere David	120–150
Sambar	120–140
Rusa	50– 70

[1] Fertile hybrids have been reported for sika x wapiti; red x sika, red x Pere David and red x wapiti; and sambar x rusa.

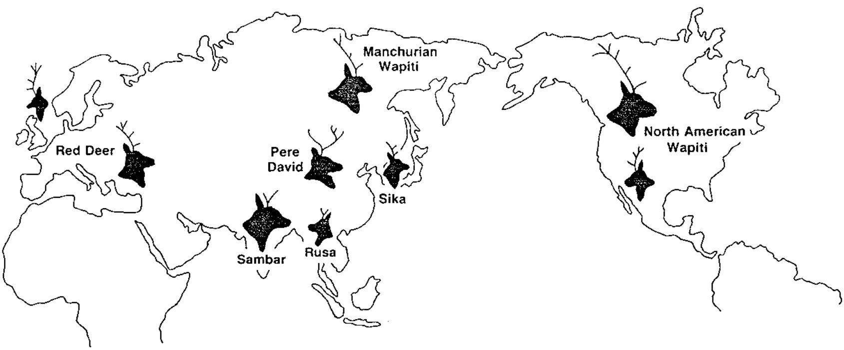

Fig 1. Common deer of the genus Cervus. The natural distribution of the species of deer which may hybridise with red deer are shown; the silhouettes indicate the approximate relative sizes of these deer.

Fallow deer

Compared with the red deer, there is much less diversity within the fallow deer family. Essentially there are only the two subspecies, namely the European and Mesopotamian (Persian) fallow deer. The latter deer is much larger and the two are known to interbreed and produce fertile offspring (Gray 1972). Recently some Mesopotamian fallow were imported into New Zealand with the intention of hybridising with the local fallow deer.

VARIABILITY WITHIN STRAINS

The discussion on diversity has highlighted the variability between the various strains and subspecies of deer. The other very important source of variability is that within strains.

Variation, so long as it is reasonably heritable, is the raw material for genetic improvement. Within a herd, the actual amount of variation is expressed by the mathematical concept of the standard deviation. Fig 2 shows the variability in velvet antler weight for a herd of 87, 3 year old red stags. An understanding of the concept of the standard deviation is critical in the design of sound genetic improvement programmes. While the data in Fig 2 are for velvet antler weight, the principle applies equally to weight gain or any other useful character.

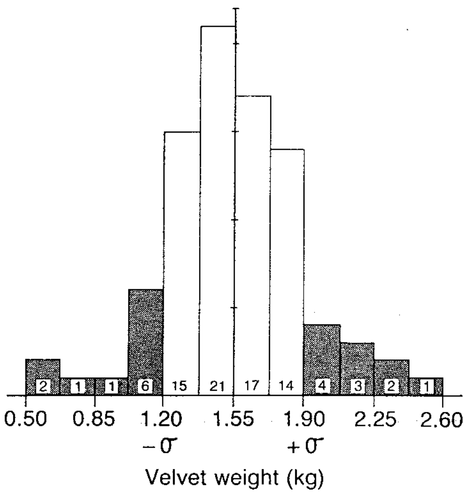

Fig 2: Distribution of velvet antler weight in a herd of 87, 3 year old red deer. The mean yield was 1.55 kg with a standard deviation (σ) of ± 0.35 kg. This means that about 2/3 of the stags would be expected to have yields between 1.20 and 1.90 kg (ie one standard deviation, either side of the mean). On the other hand, the top 2% of stags would be expected to yield more than 2.25 kg - 3 of the 87 actually achieved this.

PATHWAYS TO IMPROVEMENT

The considerations of diversity between strains and variability within strains highlight the two alternative pathways to genetic improvement in deer. Selection within a strain involves selection from among the individuals of one herd with a common background or from herds of a similar background. In contrast hybridisation involves breeding from animals which are genetically much further apart.

Hybridisation

The concept of genetic distance is a measure of the relatedness of two individuals or two groups. Put simply, there is less genetic distance between two brothers than between two second cousins. Similarly there is less genetic distance between European and Scottish red deer than between either of these and Pere David deer.

Before considering a practical use of hybridisation, namely wapiti x red hybrids, it is timely to add two cautionary comments. Firstly the greater the genetic distance between the potential mates, the greater the husbandry skills that will be required to successfully breed them. For example with Pere David x red deer hybridisation, it has been necessary to use artificial insemination because of the social difficulties between the potential mates. Secondly, hybridisation for rapid genetic progress in a highly valued character does not obviate the need for selection within the new herd, but only postpones it.

Selection within strains

The objective of recording the animals within a herd is to identify the top performers and breed from them. The relative superiority of any particular individual can then be calculated. When coupled with a knowledge of the heritability (ie the proportion of the variation which is heritable) the expected rate of improvement in performance of the herd can be calculated.

The major question in such selection relates to how should the animal's body weight be taken into account - do we want to go on just breeding bigger animals? If the real aim is improving efficiency of venison production, the answer is probably no. Therefore, the aim is to find some measure of efficiency - the best available is probably adjusting the weight of the progeny for the weight of its parents. For example, suppose there are two daughters of the one sire, each from a different hind. If one reaches 90% of its mother's weight at 15 months of age, and the other reaches only 70%, then it is logical that the first is likely to be a better bet.

EFFICIENCY - THE WHOLE SYSTEM

The diversity within the red deer family and the potential to breed deer of different sizes is evident from the hind weights for the various strains of red deer available to the New Zealand deer farmer (Table 3).

Table 3: Adult female body weights for members of the red deer group in New Zealand

Deer type	Adult female weight (kg)
NZ sika	75
NZ red	100
European red	100-150
Fiordland wapiti	170
Canadian wapiti	200-300

This potential carries it with the temptation to breed deer simply for size - this has been stimulated by the value of velvet antler in past years (bigger stags tend to produce proportionately bigger antlers than smaller stags). However, as the industry develops, and particularly as the emphasis shifts from the sale of live animals and velvet antler to venison, it will be more profitable to focus on efficiency rather than size. There will certainly still be a place for large sires and the females that can produce them. The most efficient system, though, will utilise the smallest hinds which can breed with large stags to produce offspring which reach the desired slaughter weights without getting fat.

When compared with an all large animal system, there are several advantages of a genetically large male x genetically small female combination, such as a Canadian wapiti bull across red hinds. Smaller females are easier to handle, requiring both less equipment and manpower. Per animal, they require less feed in winter, when pasture can be at a premium. In extreme cases, they can reach reproductive maturity a year earlier. Lastly the greater the genetic difference between the two parents, the greater the hybrid vigour - that is the superiority of the progeny over the average of the parents.

There are several possible large stag/small hind systems available to the New Zealand deer farmer. The wapiti bull x red hind is an extreme example and a great deal of managerial skill is required to achieve a satisfactory reproductive rate. If wapiti are to be used as the terminal sire, the red hinds will need to be larger than they are now to minimise managerial difficulties - these hinds will only be small in relation to the stags put across them. They could still be large by current New Zealand farm standards, averaging as much as 130 kg. To achieve hinds of this weight (megareds) will require systematic breeding programmes. Another option would be the mating of average New Zealand red hinds (about 100 kg) to wapiti x red hybrid stags. The large male/small female system would just be operating at a different level.

Eventually the success or failure of any system will depend on market requirements. The comparative efficiency of two systems will not matter if the produce from one achieves a ready market while the produce of the other does not. At this stage in the New Zealand deer farming scene, the place of wapiti x red hybrids is unclear - the market signals are not yet available. However, in the longer term technological developments in preparation of meat cuts may mean that actual size is not very important - the important criteria will be leanness.

PRACTICAL APPROACHES

Hybridisation between wapiti and red deer

The apparent advantages of a large male/small female system have been highlighted. Therefore at Invermay the practical requirements for and production from such a system are being evaluated (Moore et al., 1985, 1986). Initially, the comparisons were between red deer and Fiordland wapiti-type animals (a wapiti - red hybrid strain captured from Fiordland). However, now that Canadian wapiti are available the comparisons involve these and red deer.

The comparative bodyweights of the female deer of the two strains are about 105 kg for the reds and 240 kg for the Canadian wapiti. Consequently, the level of managerial skill required to ensure satisfactory performance is considerable especially at calving. To minimise calving difficulties, the feeding of the pregnant hinds is closely controlled through winter and right through to calving.

Birthweights and growth rates to weaning for hybrid and red calves are given in Table 4. The most interesting observation is that the growth rates of hybrids from birth to weaning are about 50% higher than reds, with both being reared by red hinds of the same weight. It seems certain that the hybrids are extracting a greater quantity of milk from their red deer dams than the straight red deer. The hybrid yearlings are apparently about 60% heavier than the straight red deer - the amount of hybrid vigour cannot yet be assessed accurately.

Table 4: Birth weights (n) and growth rates from birth to weaning for red and wapiti x red hybrid calves[1].

	Birth weight (kg)		Growth rate (g/d)	
	Male	Female	Male	Female
Red x red, 1985	9.6 (37)	8.4 (29)	384	330
Wapiti x red, 1984	13.6 (15)	13.9 (8)	592	561
Wapiti x red, 1985	14.3 (11)	12.9 (10)	560	510

[1] Moore <u>et al.</u>,1985, 1986 and Moore, unpublished.

The hybrids are being compared with red deer in all aspects of deer production - reproductive performance, growth rate, velvet antler and venison production, including carcass measurements, and animal health. In respect of health, it is interesting to observe that the wapiti and hybrids are apparently more susceptible to copper deficiency and ryegrass staggers than the red deer (Mackintosh <u>et al</u>., 1982; Mackintosh <u>et al</u>., 1986).

Selection within strains

The NZ Deer Farmers' Association are developing a recording scheme, Deerplan, to assist deer farmers with genetic improvement of their herds (Fennessy, 1985). Currently, the scheme is in the early stages of development, with records being collected by farmers and processed on a central computer. The scheme is planned to develop through three stages:

* recording
* ranking
* breeding scheme

The information required for hinds and their progeny is:

Calf: pedigree (sire and dam)
birth date
March or weaning weight
15 month weight

Hind: stag to whom mated (gives pedigree of offspring)
annual liveweight taken during autumn or winter.

When there is sufficient basic information from the recording scheme (after 2 or 3 years) it will be analysed to estimate any adjustments that need to be made (eg due to the sex of the calf, age of it's mother, etc). By using these adjustments on the farmer's records, animals will be given a ranking as to their position within the herd. These rankings will be very useful and enable a breeder to identify the top hinds and to compare the various stags used.

The breeding scheme stage will require a vast amount of data, as it involves the calculation of important genetic parameters such as the heritability of weaning weight and 15 month weight. The breeding values derived will give the breeder an estimate of the likely superiority of the offspring of a particular hind or stag comapred with the herd average.

A scheme such as Deerplan is worse than useless unless the farmer can collect the information simply and accurately. Therefore several farmers have worked well to develop practical schemes of deer recording (see Cowie 1985). With accurate information, we now have a good idea of what the important variables will be in making adjustments in weaning weight between progeny of various hinds. These are the sex of the calf (males grow faster than females), the weight of the mother (heavier hinds rear heavier calves), the sire of the calf, the age of the hind (2 year old hinds seem to rear smaller calves than older hinds) and the age of the calf at weaning. With the development of the ranking scheme, the farmer will be able to select out the superior breeding hinds.

CONCLUSIONS

The diversity among the red deer (and to a lesser extent fallow deer) offers tremendous opportunities for genetic improvement. The alternative pathways to improvement, namely hybridisation or selection within strains, highlight the importance of clarifying the objectives before starting into a breeding programme.

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FURTHER READING

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