GENETIC DISTANCE AND DEER BREEDING

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The aim of this paper is to look at developments in deer breeding from a genetics perspective. Deer breeding here has two branches: improvement within groups, such as red deer and fallow deer, and hybridization between more distantly related animals, for example the crossing of red deer and wapiti.

Breeding improvement within groups is already being practiced on many deer farms. Its principles were outlined at this meeting last year and in three issues of *The Deer Farmer* (Fennessy 1982, 1983 a and b). Its practice will be discussed by the speakers to follow. Hybridization is a deer farming practice just budding; some of its problems and benefits were also explained last year. Biochemical tests offer some tools which could aid in hybridization decisions and verification.

What unifies these two branches of deer breeding is the concept of genetic distance. Genetic distance is simply a measure of the degree of relatedness of two individuals or two groups. Put another way, the less the genetic distance the greater the common ancestry.

With breeding improvement programmes, our long-term concern is that the genetic distance between individuals does not become too low. If it does, genetic variation will be lost; variation that could prove valuable in eventual selection programmes. With hybridization, our immediate concern is whether the genetic distance between individuals is not so great that there will be problems obtaining viable offspring. By measuring genetic distance we have a predictor of breeding success.

What deer species are good prospects for advanced breeding programmes? Experience has shown that only social deer are suitable for intensive farming. With the notable exception of fallow and Pere David deer, this means using deer of the red deer and its relatives worldwide, Genus Cervus. Socialization refers to naturally occurring group size, i.e. the tolerance of deer for members of the same species, tolerance which has generally evolved in response to food resources. There are disadvantages in social deer:

1. They often have lower reproductive rates than solitary, territorial species.
2. Most are seasonal breeders as they evolved in temperature climates.
3. As the social structure is based on the stability of female groups, often composed of close relatives, the genetic distance between females in a herd is usually quite low. (Smith 1979.) Therefore in genetics terms, the effective size of a herd is significantly less than the actual number of animals.

The limitations of social deer must be recognised to be overcome, and through in some cases substantial, they are lesser obstacles than trying to select for sociality in white-tails or moose. For example, the first route suggested in genetic improvement is the use of a small number of superior stags. These are selected by recording body weights, growth rates, velvet antler yields on another valued trait. Part of such programmes must involve regularly replacing these high performers, following the natural outbreeding mechanism in social deer. This is particularly important on small farms, as inbreeding depression is well docummented in ungulates (Ralls *et al.*, 1979) and it may not show its effects for several generations.

On the female side, it has been shown that superior mothering ability, (lactation performance) results in larger calves and is heritable (Fennessy 1983). An extension of this is selection for twinning ability. Though the natural rate of twinning in New Zealand farmed deer is less than 1%, there is circumstantial evidence that within some herds, perhaps originating from specific localities, that rate may be 2-4% in some years. Selection for twins is likely to be a slow method of improving efficiency. In China, selection for twinning in sika deer has resulted in 5-8% of hinds producing twins.

The breakthrough between socialization and domestication lies in altering the seasonal breeding cycle and in selecting for docility. Selection for more and more tractable animals is likely to be a slow process, particularly while the value of individuals is so high. As the synchrony of calving in red has been reinforced by the pronounced seasons of Europe, genetic progress by assuring the early calves survive and breed is likewise liable to be slow. Both North America wapiti and Pere David's deer calve earlier than red deer. As with growth rates and velvet weights, the most rapid genetic progress in earlier calving lies in hybridization - if it can be successfully achieved.

By hybridization, we are referring to either crosses between recognised species, such as red/rusa or red/Pere David, or between animals where the divergence within species has been extreme, such as red/wapiti. In both cases we can measure the genetic distance between potential partners by electrophoresis. Electrophoresis - a long word for a relatively simple biochemical analysis -

looks at the amount of genetic variation from a random selection of proteins in an animal's blood or tissues (Gyllensten *et al.*, 1983). We can use these electrophoretic markers to compare the genetic variation between two individuals, groups, or species.

Below we outline three hybridization schemes and show how electrophoretic analysis might aid them. The programmes could refer to different types of deer farms, or they could be stags in the development of a particular deer farm.

The first step in creating any hybrid deer herd is the first cross, or F_1 generation. This may be as far as some deer farmers wish to go, as with putting a wapiti bull over red hinds and selling the progeny. Research at Invermay has shown that a Fiordland wapiti is much better suited for this type of terminal sire system, with a much higher percentage of hybrid calves reared, than a North American wapiti bull. It is a moot issue whether Fiordland wapiti are more successful because they themselves are hybrids, or simply because their reduced size represents 75 years of adaptation to a new habitat. (It is worth noting, however, that there are North American wapiti, that show reduced size without red deer hybridization - the Tulk elk of California.) By electrophoresis there is a good chance of determining whether hybridization has occurred, either inadvertantly in Fiordland or intentionally on a deer farm. In the latter case it serves as a source of verification, particularly when the wapiti or other desired sire is followed by a red deer chaser. The method has proved its use in court with dairy bulls and race horses.

The cost of a terminal sire system, and the reasons why models from the sheep and cattle system are not applicable, is that the genetic distance between partners is much greater than in domestic ungulate breeds and any incompatability is repeated each generation. More practical is the second system which retains hybrid females and high performance males and mates them to establish a stable interbreed. The advantages of this system or threefold are:

1. The development of a common mating behaviour pattern.
2. There is a closing discrepency in size between the mating pair, resulting in fewer mating and calving problems.
3. There is a more consistent predicatable progeny.

The cost in the stable interbreed is in a higher level of inbreeding, but this can be monitored with single sires or with electrophoretic markers, and it can be remedied by purchasing males, in this example either verified hybrids or wapiti.

This suggests the third hybridization programme, upgrading by breeding back to a larger terminal sire. North American wapiti is the most obvious example, but it may be possible that rusa or Pere David's deer could serve in this regard as well. Gradually the herd will show more of the character of the sire line, and with each generation of successfuly upgrading there should be fewer of the breeding and calving problems of the initial cross. Again electrophoresis could be used, in this case to quantify the progress of hybridization through a herd.

The benefit of hybridization, in more rapid genetic progress, is obvious. The cost is greater risk in breeding success and greater intensification of farming particularly at the rut and at calving. With red deer/wapiti hybridization some of those obstacles have been overcome by the sometimes disparaged Fiordland wapiti. Within most other types of hybridization, those problems are as yet ahead.

Domestication of red deer and its relatives is a worthy long-term goal for this industry. With the notable exception of reindeer, a grazing animal has not been domesticated for 2000 years. But it is in the interest of deer farmers and deer stalkers both that the genetic distance between animals behind fences and those in the wild be dramatically increased. The best prospect for success lies in genetically evaluating both an animal's ancestry and performance, and using those records in advanced breeding programmes.

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