Many deerfarmers are interested in improving deer production by the use of superior animals for breeding.

In this article, the first in a three-part series, Peter Fennessy of Invermay Agricultural Research Centre, suggests that considerable improvements in efficiency can be achieved by selection. Recording techniques and the practical application of selection principles will be the topics of articles in our autumn and winter issues.

First understand the basic principles

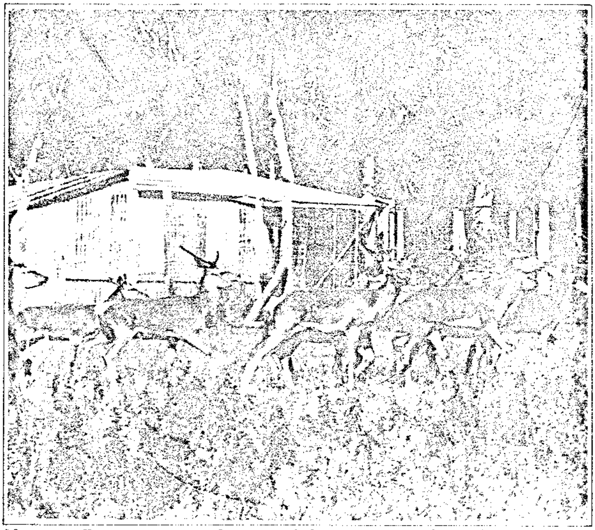

Photo: Nelson Charteris.

If genetically superior animals are used for breeding, each year's crop will be superior to the previous year's crop for the character selected.

IF ANIMAL efficiency is to be improved by breeding it is important to identify the characters which affect the efficiency of production and to understand some basic principles of genetics.

Calculations based on a knowledge of feed requirements and weight changes can provide an indication of the potential improvements achievable by selection. A summary of a series of such calculations is shown in Table 1.

For example, a 10 per cent increase in the weight of the breeding animals in the herd would be expected to result in a 10 per cent increase in the weight of their progeny at slaughter. According to the calculations, this would increase efficiency by about 2 per cent where efficiency is defined as the weight of carcase produced per unit of feed eaten.

A 50 per cent increase in weight would result in a 10 per cent increase in efficiency. However, if only the animals to be slaughtered are relatively heavier and the female breeding herd remains at the same weight, the relative increase in efficiency for a 10 per cent increase in weight of stock at slaughter is 4 per cent.

Increases in weight leading to increases in efficiency are potentially achievable by improvements in management e.g. nutrition), by the use of Wapiti or Wapiti hybrids and by selection of breeding stock.

At this stage, the use of Wapiti is speculative, but there is a considerable research effort being expended in this direction. However, the responses to selection of higher producing Red deer and their use in breeding programmes is not speculative and some farmers are already reaping the benefits from the use of superior animals.

The calculations suggest that selection and breeding from superior animals has the potential to contribute to increases in the efficiency of meat production from Red deer through improvements in:

- growth rate
- weaning rate (calves weaned on hinds to stag)
- reductions in wastage and death rate

Selection to improve velvet antler yield is also possible and is likely to ▷

Table 1

Factors affecting efficiency of meat production in a herd of Red deer, the expected response in efficiency to change in the factor, and possible means of changing the factors (from Fennessy, 1982).

Factor	Percentage change in factor	efficiency	Means of changing the factor
Weight for age of the herd	10	2	Selection, change of species (Red to Wapiti)
Weight of slaughter stock (2.1 years)	10	4	Selection, management, hybridisation (Wapiti x Red)
Weaning rate	10	6	Selection (for twinning and survival); management
Herd death rate	1	2	Management and disease control, selection

▷ be worthwhile for many farmers. This series of articles will be concerned mainly with selection for improved growth rates and for improved velvet antler yields.

Selection principles

The purpose of a selection programme is first, to identify the genetically superior deer within the herd and then, second, to use these animals as breeding stock. With ongoing selection and breeding, each year's crop will be, on average, genetically superior to the previous year's crop for the character selected. In this article, selection for velvet antler weight will be used to illustrate the selection principles.

Using a selection programme will result in the genetic merit of the herd increasing year by year. The expected rate of increase can be calculated using the following equation:

$$\text{Genetic gain per year} = \frac{\text{Heritability} \times \text{Selection differential}}{\text{Generation interval}}$$

Each of these terms will be considered in detail to illustrate the essential principles involved in improvements of velvet antler yield through selection.

However, the terms genotype and phenotype which are used frequently in discussions of animal improvements must be explained. The *genotype* refers to the whole set of genes carried by the animal for a particular character or trait, such as antler growth. The *phenotype* of the animal is its actual production of this character. The set of genes the animal carries, functions as a group in the expression of the phenotype. However, in breeding only half of any animal's genotype is passed onto its progeny. This is because half of the genes come from each parent.

Selection differential

For the purposes of this article, it is assumed that the productive characters of deer are the result of the action of many genes and are not the consequences of only one or two genes. For a character such as velvet weight, the yields for individual stags would therefore be expected to be distributed around the mean or average value. This appears to be the case with Figure 1 showing the velvet weight distribution for a group of 87 three-year-old stags. The mean velvet yield is 1.55 kg. It is the variation around this mean which provides the raw material for selection.

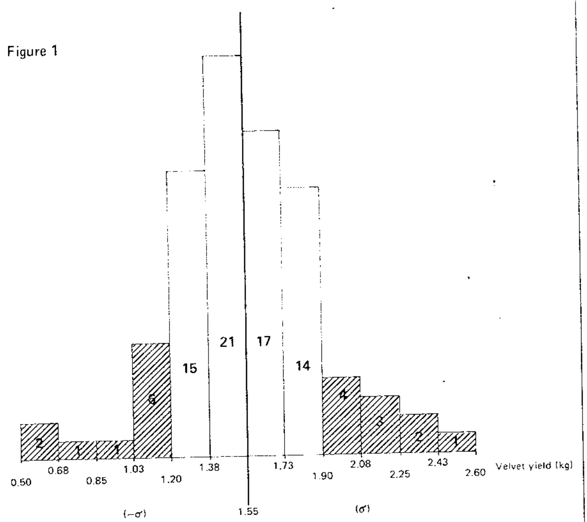

Figure 1

The variation is described by the standard deviation, which is denoted by the symbol, σ. The standard deviation of velvet weights for the 87 stags of $\pm$ 0.35 kg indicates that two-thirds of the stags would be expected to have velvet weights between 1.20 and 1.90 kg (i.e. 1.55 $\pm$ 0.35). On average about 16 per cent of the group of stags would have yields greater than 1.90 kg.

The selection differential is the difference between the performance of the animals used for breeding and the herd average from which they came. Selection differentials are given in

Table 2 and are applied to a group of 100 stags with a mean velvet yield of 1.55 ± 0.35 kg.

It can be seen from Table 2 that if only a few stags are used for breeding they can be very highly selected. The top stag in a group of 100 is expected to be 2.66 times the standard deviation better than average. This would represent a yield of 2.48 kg of velvet antler for the top stag in such a group of 100 stags. However, if the top 25 per cent of stags were selected the yield would be on average only 1.27 times the standard deviation above the mean (i.e. a yield of 1.99 kg in Table 2).

In applying such selection differentials in practice, we would have to assume that the hinds used for breeding are just average, since at this stage in deer genetics it is not possible to put numbers on hinds who do not normally grow antlers. However, in the long term it will be possible to assign breeding values to hinds based on the performance of their male relatives.

The *heritability* (h^2) is the proportion of the variation in a particular trait within the herd which is of genetic origin. Some Chinese work on Meihualu (Sika deer) suggests that the heritability of velvet antler weight is about 0.35 (Zhou and Wu, 1979, *Acta Genetica Sinica 6:* 434).

This means that about 35 per cent of the variation in velvet antler production within the herd of stags of the same age is of genetic origin. The remainder of the variation, in this case 65 per cent, is of environmental origin and would be due to factors such as the level of nutrition.

The *generation interval* is the average age of the parents when their progeny are born. In a deer herd in which the hind numbers are stable, the average age of the hinds will be about eight years (hinds culled at 15 years of age). If only three-year-old stags are used as sires, then the generation interval would be 5.5 years whereas if only eight-year-old stags are used, the generation interval would be eight years.

Therefore, it is apparent that if only older stags are used or the herd is made up mainly of older hinds, then the generation interval will be longer and the potential rate of genetic gain reduced.

Identification of superior animals

A good rate of genetic progress is dependent on a high selection differential. Since only a few stags are used in breeding compared with the number of hinds used, it follows that stags can be much more intensively selected. Therefore, they will contribute more to the selection differential than will the hind. Therefore, the top animals in the herd must be identified accurately so that they can be used for breeding. This is especially so with stags.

The *phenotypic deviation* is the term used to describe this superiority. It is the difference between the mean for the herd and the animal in question. Stag 622 was the highest velvet producer in the group of 87 shown in Figure 1. With a yield of 2.60 kg his phenotypic deviation was 1.05 kg (2.60 kg to 1.55 kg). The above average animals have a positive phenotypic deviation while those below average have a negative deviation.

Examples of the effects of different breeding programmes on the expected rate of genetic progress which illustrate the important points made in this article are given in Table 3.

Although the annual rate of improvement, which is the increased yield expected from this year's progeny compared with last year's, appears to be very small, the effect of 10 years of selection using only the top 1 per cent of stags compared with just average stags is substantial.

Using 1 per cent, the stags produced in 10 years time would be expected to be 0.30 kg higher in velvet antler yield than those produced if average stags had been used. Since this applies to each year of a stag's productive life, the benefit from selective breeding would amount to 2.4 kg during a productive lifespan of nine years (two to nine years of age). This is a substantial improvement for relatively little effort.

Summary

- Selection for improved animal performance can be expected to result in increases in efficiency in the conversion of grass to meat.
- The variation within the herd for the particular character or trait of interest, such as velvet antler weight, is the raw material of selection.
- The rate of genetic gain for a character is dependent on three factors: The heritability, which is the proportion of the variation which is of genetic origin; the selection differential, which is the difference between the animals used for breeding and the herd average; and the generation interval, which is the average age of the parents.

Superior animals must be accurately identified before they can be used. Therefore, records must be kept. Since only a few stags are used, they can be much more intensively selected than the hinds.

Although the annual rate of genetic improvement resulting from selection may appear to be small, the cumulative effects are substantial.

Table 2

Selection differentials and average yields for sub-groups of stags selected from a total group with a mean velvet yield of 1.55 kg and a standard deviation of 0.35 kg.

Stags selected		Selection differential		Selected stags average yield (kg)
Proportion	Percentage	Relative	Actual (kg)	
1.00	100	--	--	1.55
0.90	90	0.20[1]	0.07	1.62
0.75	75	0.42	0.15	1.70
0.50	50	0.80	0.28	1.83
0.25	25	1.27	0.44	1.99
0.10	10	1.76	0.62	2.17
0.05	5	2.06	0.72	2.27
0.01	1	2.66	0.93	2.48

[1] *Actual selection differential = standard deviation x relative selection differential*
= 0.35 x 0.20
= 0.07 kg

Table 3

Expected annual rates of genetic gain in velvet antler yield from following different breeding plans[1].

Stags used	Heritability	Selection differential of stag (Table 2)	Generation interval (years)	Expected genetic gain (kg/year)
Top 1%	0.35	0.93 kg	5.5	0.03
	0.35	0.93	8	0.02
Average stags	0.35	0	5.5	0
	0.35	0	8	0

[1] *It is assumed that the hinds are average and that their selection differential is zero, e.g. genetic gain =* $\frac{0.35 \times 1/2\ (0.93)}{5.5} = 0.03.$