Genetic improvement of farmed deer

Dorian J. Garrick

Abstract

Animals vary in their productivity and some of this variation is genetic in origin. The New Zealand deer industry can benefit from improving the genetic merit of the national herd with respect to characteristics that influence the quality, quantity and efficiency with which venison and velvet is produced. The national herd sources its genetic material from a subset of the industry involved in the production and sale of sire stags

At present, the attributes of the studmasters and managers of sire stag breeding enterprises, their farms and the individual physical appearance of sire stags collectively dictate the success of their businsesses In contrast, in a well-informed business-led industry it should be the likely economic contribution of future generations of offspring from sire stags that determines the relative success of the breeders of those stags

Breeding values and producing values are tools that can assist breeders in the selection of candidates that can be used for improving the genetic merit of the sire breeding herds in the first instance and the national herd in the second instance The use of these tools by breeders in New Zealand is very much in its infancy

Breeding values estimate the general combining ability of stags and hinds In theory, for traits that exhibit dominant gene action and marked heterosis, there can sometimes be significant deviations in performance from that predicted using breeding values for certain male and female pairings. These deviations result from so-called specific combining ability. Some breeders believe these factors are important in deer breeding although there is no scientific evidence from the analysis of pedigree and performance data to support this

The choice of a breeding scheme determines the accuracy of estimated breeding values, the timeliness of the information in relation to selection decisions, and the nature of use of selected individuals Together these factors influence the rate of genetic gain and the cost-effectiveness of the gain No formal comparisons of alternative breeding schemes for deer improvement have yet been undertaken in New Zealand

The exploitation of a well-designed and implemented genetic improvement scheme for the national deer herd remains an opportunity the industry has yet to harness.

Logical framework for genetic improvement

A structured approach to industry improvement would follow a number of well-documented and researched steps·

one must define the goal of the improvement programme Typically, the goal is profit oriented, such as increasing farm profit, or industry revenue

the selection objective is defined This involves two parts – determining the list of traits that influence the goal – then calculating the relative economic emphasis of each trait in the list

the selection criteria must be considered These are the animal characteristics that are measured in order to rank individuals for the selection objective

a breeding scheme must be designed for nucleus animals. This involves considering which animals should be measured, at what stage of life, and the fates of the selected and culled individuals Typically, it is desirable to limit the measurement of animals to a subset of the national herd and then to use the superior offspring over the unrecorded or commercial animals a dissemination scheme must be developed to transfer the improved genes from the so-called nucleus to the commercial sector of the population This may include a mating plan, to determine the manner in which the improved animals are used For example, a venison production system may involve out-crossing whereby hinds bred from stags selected for maternal characteristics are mated to sires bred for a terminal programme

an economic analysis should be undertaken to ensure that the costs of the entire scheme are less than the benefits and to consider alternative scenarios for each of the previously identified steps

This formal approach to animal improvement has and is continuously the subject of rigorous research in the dairy and other livestock and plant industries but for various reasons has yet to be undertaken with respect to farmed deer

Current structure of deer improvement

The industry consists of two tiers from a genetic viewpoint. a nucleus or sire-breeding tier and a commercial or sire-buying tier. Genetic improvement should originate in the nucleus sector and be passed on to the commercial sector through the sale of sires Ideally, the value of sires should be related to their ability to contribute to profit in the commercial sector. This requires a common language that sire breeders and buyers can understand to represent the value of a sire. Such a language is usually based on the concept of a breeding value (Garrick, 1997) In systems where a number of traits contribute simultaneously to profit, a measure of aggregate economic merit is typically constructed from an index of breeding values.

Unfortunately, such a language has yet to be adopted among breeders or buyers. Instead, phenotypic performance with respect to velvet antler and body weights are used for the sale animals and their sires are typically used as a basis for selling and purchasing herd sires. This paper demonstrates some of the inadequacies of this approach with respect to velvet production

Inspection of the performance of their animals has led some nucleus breeders to develop the theory that superior performance can be predictably generated, for example, by crossing sires of one family or so-called bloodline to hinds from a different family It is believed that some families go well together and others do not This approach is not conducive to achieving on-going systematic improvement and is not supported by any statistical analysis of velvet or venison performance records

Phenotypic performance

There is no doubt that comparing phenotypic performance is a straightforward method of ranking animals However, we are probably more interested in ranking animals for their expected future performance, or expected offspring performance, rather than their own retrospective performance Suppose I have two stags to choose from Echo cut 6 8 kg and Delta cut 8.7 kg Which is the best? Or perhaps I have two young stags to choose from – one born to Delta and one born to Echo – which would I prefer? How much more could I pay? Intuitively, it would seem that Delta is likely to be a better animal.

Phenotypic performance for repeatable traits such as velvet weight varies with the age of the animals. Average velvet antler weights typically increase each year until 8-10 years of age. Accordingly, the actual phenotypic performance tells us very little unless we also know the age of the animal

Figure 1 shows the velvet antler weights by age for a commercial deer farm in New Zealand in an average, and a very good production year The comparison of Echo and Delta will be more reliable if we can account for their age at the time of their velvet harvest and the nature of the year. Suppose Echo produced 6 8 kg as a 4 year old in an average year and Delta produced 8 7 kg as a 7 year old in a good year Relative to Figure 1, both stags produced 4 5 kg more than their contemporaries of the same age This suggests that the two stags may actually be quite similar in merit. Performance figures that are adjusted for systematic effects such as stag age, and environmental fluctuations such as due to year of measurement are known as adjusted deviations. Adjusted deviations are far more informative for ranking animals than are actual measures of phenotypic performance

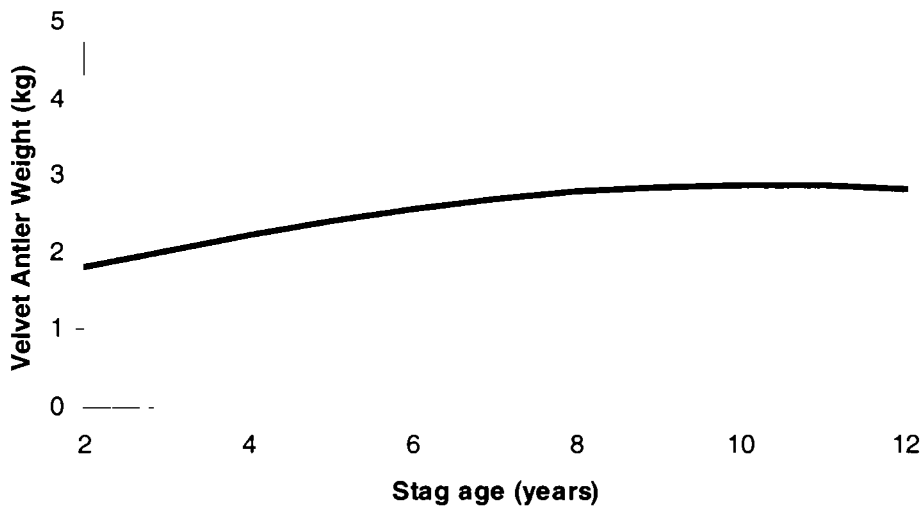

Figure 1 Velvet antler weight by age of stag in an average and a good year from a New Zealand commercial deer farm

Performance Deviations

The range of deviations in performance are often not constant from one year to the next or with changes in stag age The coefficient of variation in velvet antler weights is a measure of the standard deviation as a proportion of the average performance and seems to be more consistent across ages and years Figure 2 shows the average performance by age of red deer stags from several South Island deer farms (van den Berg and Garrick, 1997), along with the performance of animals that were one or two standard deviations superior or inferior to their herd mates The effect of this scaling is that a deviation of say 1 kg as a 4 year old is a much greater achievement than a deviation of 1 kg as a 5 or 6 year old With this in mind, it would seem that Delta may be inferior to Echo as both had the same deviation but Delta was an older animal

The presence of temporary environmental effects (Garrick, 1997) results in variation between the deviation of individual animals from year to year However, on average, animals with superior deviations in one year tend to be superior in subsequent years Figure 3 shows the deviations of actual stags as 2 and 3 year olds. Note that many of the inferior 2 year olds were culled and sold for venison accounting for the truncated nature of the distribution

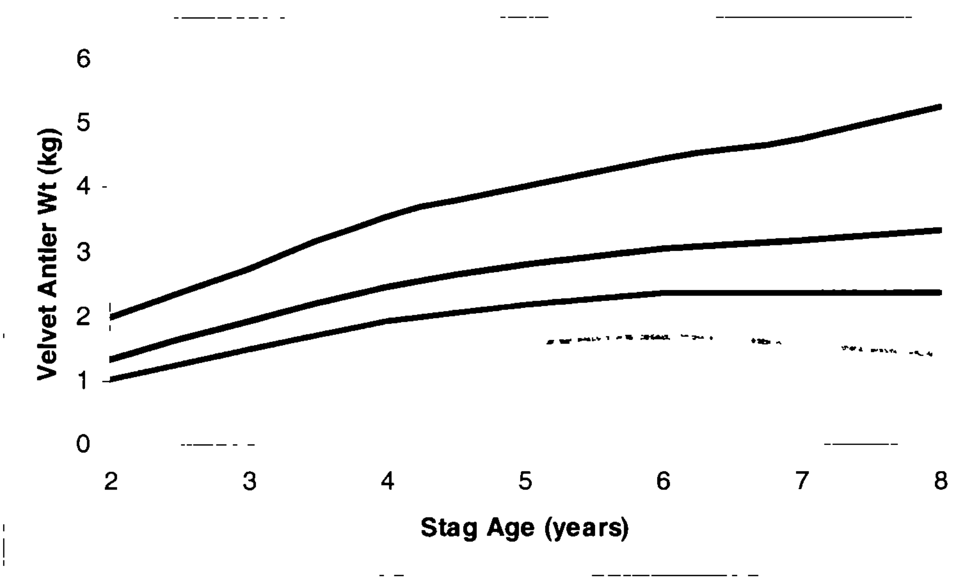

Figure 2. Velvet antler weights of red deer stags from some South Island farms, showing the average performance and the performance of animals that were 1 or 2 standard deviations from the mean

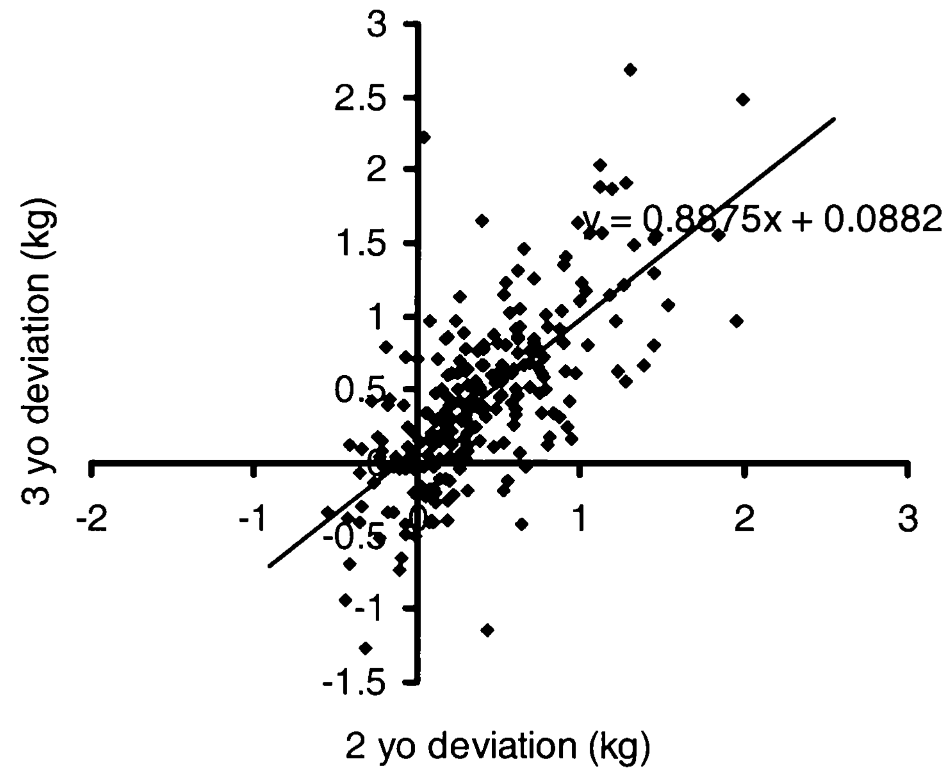

Figure 3. Relationship between deviations of individual stags for 2 year old and 3 year old velvet antler weights

In practice, most recorded stags are measured every year The actual deviations of Delta and Echo are shown in Table 1 On the basis of these results, pooling their individual deviations across the years of their records on an appropriate statistical basis, these two stags are of almost equal productive merit That is, they have equal producing values

Table 1. Actual velvet antler deviations of Delta and Echo

	3 yo	4 yo	5 yo	6 yo	7 yo	8 yo	9 yo	10 yo	11 yo	12 yo	13 yo
Delta			3 1	3 7	3 5	3 9	3 9	4 6	5 7	6 9	3 9
Echo	1 4	1.7	2 8	3 6	6 4	6 3					

Both Delta and Echo have been used as sires and have produced sons that have been measured for velvet antler production Delta had 74 sons measured as 2 year olds and these had an average deviation of 0.17 kg from their cohorts Echo had 73 sons and their average deviation was 0 63 kg. Despite the fact that these two sires had equal producing values, Echo produced more profitable sons. That is, Echo has a better breeding value than Delta.

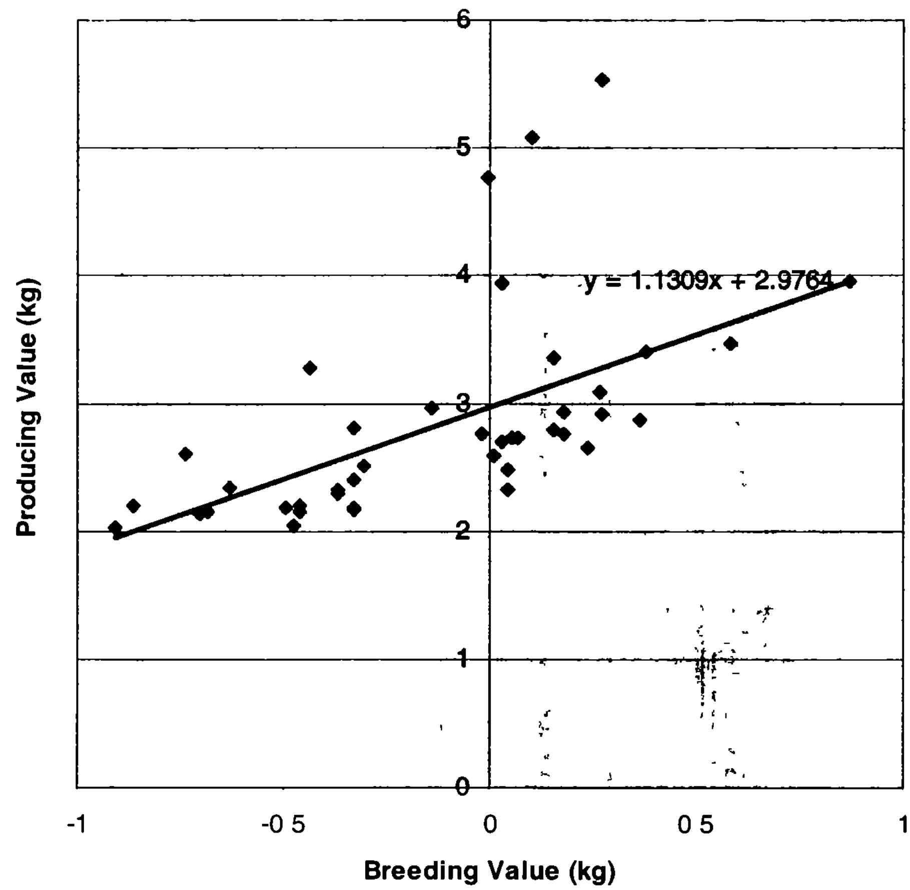

Figure 4 shows the relationship between producing values expressed in terms of expected 5-year-old velvet production and breeding values There is a tendency for animals with higher breeding values to have high producing values as breeding values are one of the determinants of producing value. However, the stags do not rank the same for producing value as they do for breeding value. The cause of these differences are non-genetic and are known as permanent environmental effects (Garrick, 1997)

Knowledge of the underlying causes of variation in performance between stags and between years leads one to understand and expect animals to rank differently for actual performance, expected future performance, and expected offspring performance Accordingly, the animals that are chosen for use in competitions are not necessarily the animals we would predict will perform best next year, or perform best as sires Unless stag breeders and stag buyers understand these distinctions, genetic progress in nucleus herds will be sub-optimal and buyers will be disappointed in the performance of offspring from their purchased sires.

Rate of genetic advance

Although phenotypic performance often improves with age, the genetic merit of an individual does not change. Genetic progress will be fastest when animals are identified and used at as young an age as possible, and then replaced by the best of their offspring The use of aged sires that have become industry icons is indicative of little or no genetic progress as such animals should have produced superior sons from their first mating season

The genetic progress per generation is determined by the genetic superiority of the parents and annual progress is determined by progress per generation divided by the generation interval Consider the rate of genetic gain in a simplistic improvement scheme

Suppose we have 200 breeding hinds kept for an average of five fawnings. The hinds will therefore fawn at 2, 3, 4, 5 and 6 years of age, with an average age at fawning (or generation interval) of 4 years Suppose the female replacements are chosen at random with respect to velvet antler merit. If sires are mated at 1 40, there will be 5 stags required Given an average fawning percentage of 85% (survival to weaning), there will be 85 young males available from which to select the best 5. Choosing the best 5/85 represents a proportion selected of 6%. Selecting the best 6% of a normally distributed population will provide a selection differential of 1 985 In the context of 2-year-old velvet antler weight, the selected stags velvet would weigh 0 22 kg more than the average of their unselected cohort If the stags were mated after their 2-year-old velvet had been harvested, their age when their offspring are born would be 3 years, giving a pooled generation interval of 7 years The gain per year is therefore 0.22/7=0 03 kg velvet antler. This may not seem like much, but an unselected nucleus with average 1.2 kg velvet antler harvested at 2 years of age would be producing 1 5 kg velvet after 10 years of selection This rate of gain does not require any pedigree recording. A greater gain could be achieved if pedigree records were collected and information on relatives was used to rank both stag and hind replacements on the basis of breeding values, also utilising antler weights from harvest taken after 2 years of age

Progeny testing

An alternative breeding scheme would involve the progeny testing of 2-year-old stags to commercial hinds, with the resulting sons used to rank the merit of the sires. This has the advantage of allowing the sires to be more accurately ranked than can be achieved on the basis of their own records alone, but the disadvantage of having to wait longer before the superior proven sires are used within the nucleus In this case, the increase in accuracy exactly balances the increase in generation interval and there is no change in the annual rate of gain However, such a scheme increases the costs of improvement as pedigree records are required for the progeny testing.

General and specific combining ability

The breeding value is formally defined as the sum of average effects of the genes an animal carries, in terms of superiority or inferiority of the animals offspring relative to the population mated randomly A sire with a breeding value of +1 kg will produce offspring with an average breeding value of +0.5 kg because deer are diploid (chromosomes are paired) and only one-half of the genes are contributed from the sire The concept of breeding value does not require knowledge of the merit or parentage of the mates of the animals

In some circumstances, such as in plant breeding for traits with sizeable dominant gene action, the performance of offspring varies according to the actual genotype of both parents In this case every sire and dam combination must be considered Superior offspring can be created through the exploitation of both general combining ability (breeding values) and specific combining ability (dominance deviations due to sire-dam combination) It is unlikely that specific combining ability is important in traits with high heritabilities, such as velvet antler weight and liveweights, and for traits with low heterosis. Furthermore, if specific combining ability is important, then commercial producers would need to keep track of their sire and dam bloodlines in order to exploit this effect. Purchasing stags with the correct genotype to perform well individually would be of little benefit as sires where their genotype is broken up during meiosis There are no livestock species where specific combining ability has been shown to be of commercial significance.

Conclusion

An opportunity exists for stag breeders to make systematic improvement in productive traits using existing technology. The deer industry is currently well behind best practice in other livestock industries In many respects this simply reflects the lack of maturity in the deer industry Education of both sire breeders and sire buyers will be crucial to the adoption of a systematic and informed approach to deer improvement. Veterinarians can play a valuable role in encouraging the adoption of soundly based improvement practices.

References

Garrick, D J. 1997 Genetic principles for deer farmers NZVA Deer Branch Conference Proceedings, 14 1-13

Van den Berg, G H J and D J Garrick 1997 Inheritance of adult velvet antler weights and live weights in farmed red deer Livestock Production Science, 49 287-295