Genetic Principles for Deer Improvement

Dorian Garrick

Introduction

Genetic improvement can be used to enhance farm profitability by mating the best stags to the best hinds. While this is straightforward in principle, in practice it involves three distinct endeavours. First, one must specify the characteristics that define what is best. This can be formally undertaken by defining a breeding objective relevant to a particular farming circumstance. A breeding objective comprises a list of traits that influence utility (usually profit) along with the relative emphasis that should be exerted on each trait in the list. A companion paper, introduces some considerations in the development of breeding objectives for farmed deer. Second, one must evaluate individuals for each of the traits in the objective. Genetic evaluations (known as breeding values) can be used to calculate a single index figure that reflects the overall breeding worth of the individual, balancing out desirable and any undesirable attributes of the animal according to their relative contribution to profit. Third, a mating plan or industry breeding structure needs to be developed to determine the optimal allocation of high ranking stags and hinds in order to obtain cost-effective improvement. In general, the greatest economic rewards come about from moderate rates of improvement achieved at low cost. Greater investments in identifying superior individuals can be rewarded in circumstances where the best animals can be used more widely in the industry than is the case with natural mating. This paper introduces some of the principles involved in genetic evaluation, and industry breeding structures as can be applied to farmed deer.

Principles of Breeding Values and Producing Values

Genetic information is stored on a compound known as DNA (de-oxyribose nucleic acid) as a sequence of chemical components known as bases. In animal species DNA is broken into separate units known as chromosomes, red deer usually having 34 pairs. An important feature of chromosomes in animals is that these occur in pairs (except for the sex chromosomes in males). Thus each animal has two copies of instructions for most biological processes; one copy having been inherited from the sire, the other copy inherited from the dam.

Recessive Genes

In some cases, the sequence of base pairs that comprise the genetic code may have been modified, such as by mutation, so that one copy of the instructions is defective. Provided that the copy inherited from the other parent is normal, it may be possible for the animal to live and behave normally. In this case the gene would be described as recessive, the animal only demonstrating the defective condition if both copies of the sequence are inoperative. In this case, the normal form of the gene would be described as dominant, because its effect dominates the recessive allele, masking its expression unless both alleles are recessive.

Polygenic Inheritance

In the case of production traits, (e.g. weight of velvet antlers, hind milk yields, liveweight gains), a considerable number of metabolic pathways within the deer's body are involved in the collection of raw materials (substrates) through to their processing into the relevant components. Each pathway could include genetic variants. It is likely that most production traits involve thousands of genes at different loci. At one locus on one individual, there can be, at most, two different alleles. However, over all individuals in a population, there can be a large number of different alleles. The presence of one allele may result in an animal performing at a different level from animals that do not have that allele. These alleles may be dominant or perhaps additive, where each allele adds to the expression of the trait.

A Breeding Value (or BV) is a description of the merit of an individual's genes in terms of their value when passed on to the next generation. The BV is the sum of the additive values of the pair of alleles carried by an individual at a particular locus, the summation occurring over *all* loci affecting the trait of interest. **Every animal has a true BV, representing the influence of that animal in terms of the contribution its genes can make to the next generation.**

Chromosomes occur in pairs, and meiosis results in the members of each pair separating so that gametes (sperm and ova) contain only half the number of chromosomes that are contained in a fertilised embryo. On fertilisation, the full complement of chromosomes is again achieved, a fertilised red deer embryo normally containing 68 chromosomes. **It follows therefore, that a parent can only pass on *half* of its genes to any one offspring, the other half of the offspring's genes being sourced from the other parent.**

Animals should be chosen as parents of the next generation on the basis of their BV's for the traits of interest. Ideally, the BV's are weighted by their respective relative economic values and selection would be based on this economic worth.

The units of BV's are usually the units of trait measurement (e.g. litres milk volume, kg milkfat or protein). The base value for comparing BV's is arbitrary. An "average" BV is often zero, therefore positive BV's represent animals that have above-average genetic merit whereas negative BV's are associated with animals having below average merit.

The superiority of the offspring of a parent will reflect *half* the BV of each parent as the offspring only have half of each parent's genes. That is, a stag with sons that produce 0.5 kg more velvet antler than the average stag in the population will have a BV that is 1 kg above average.

The sampling of chromosomes at meiosis is at random. Consider the events that lead to the formation of a particular sperm (or ovum) - it is a random event as to which member of the first pair of chromosomes ends up in the sperm (or ovum). Similarly for the other 33 pairs. Sampling of each pair is independent of the others. Accordingly, there are 2^{34} different sperm (or ova) (over 17,000,000,000) that can be formed with respect to chromosome assignment. Furthermore, a portion of one chromosome can swap over with a portion of the other chromosome in that pair, creating chromosome combinations that are mixtures of what was inherited from the previous generation. **This results in every sperm (or ovum) being different from every other sperm (or ovum). The process by which this occurs is known as *Mendelian sampling*.**

Properties of Breeding Values (BVs)

The previous two paragraphs lead to the following important principles of Breeding Values: **Progeny BV's are, on average, the mean of the parental BV's.** For example, a sire with velvet antler BV of 1 kg mated to hinds with average BV of 0.5 kg will have progeny with an average BV of 0.75 kg.

BV's of individual offspring can deviate from mid-parent average due to the effects of Mendelian sampling. A sire with velvet antler BV of 1 kg mated to hinds with BV of 0.5 kg might have progeny that range in BV from 0.25 kg to 1.25 kg.

It should be noted that the BV of an animal can be different depending on the population over which the animal is used. A stag passing a superior gene to a population without that gene will have offspring that have superior production relative to the offspring of stags not carrying that gene. However, if that same stag is used in a population where all animals already carry that superior gene, the offspring of the stag may only be average performers. This is one reason why it can be difficult to compare the merit of animals that have been sourced from different countries.

Scaling Breeding Values (BV's)

In practice, the amount of variation in performance between individuals is not the same in all herds. Evidence would suggest that some of the difference in variation is related to average performance. In other words, the difference between the best animals and the worst animals tends to be greater in herds with high average production as compared to herds with low production. Furthermore, differences between the progeny of two sires may be greater in years with favourable climatic seasons as compared to bad years. In respect to velvet antler weight, variation tends to increase with stag age, because the average performance increases with age. The coefficient of variation (standard deviation divide by the average performance) often tends to be relatively uniform.

Non-genetic influences on performance

In addition to genetic influences on performance, a range of non-genetic (environmental or residual) effects can also be important. The nature of these effects depends upon a number of factors, primarily related to the biology of the performance trait being considered. These include permanent and temporary effect, maternal effects, age effects and management influences. Some of these effects as impacting deer performance are briefly introduced below.

Permanent Environmental Effects

These effects influence the performance of traits that are expressed on a number of occasions over the lifetime of an animal, including velvet antler weight and hind lactation yields. In a given herd, stags with higher BV's for velvet antler weight produce, on average, more velvet antler than stags with average BV's. However, animals with the same BV, grazed and managed together, do not all produce to exactly the same level. Even identical twins (or clones), run together in the same mob, will produce at slightly different levels over their entire lifetime. **These differences result from permanent environmental effects which are, by definition, not genetic and not passed on to offspring.** These effects are common to every record an animal produces over its lifetime. Permanent environmental effects typically account for at least as much variation as genetic effects, for most repeated traits.

Crossbred animals often outperform expectations based on the BVs of the parents. This extra productivity is due to a phenomenon known as heterosis or hybrid vigour which is really a special type of permanent environmental effect. Hybrid vigour for various intercrosses can be predicted from knowledge of the parental breed composition provided prior knowledge is available on the additive breed effects and the level of heterosis. Such estimates are readily available for dairy cattle in New Zealand, and for beef cattle in the United States, but only a little information is available on deer in New Zealand (Fennessy 1992).

Management of young stags (or hinds) is likely to have permanent effects on the subsequent velvet antler (or lactational) productivity of the deer. For example; level of feeding during rearing; or liveweight at first mating; may well affect lifetime performance. In practice, performance records can be analysed to determine the relative importance of permanent environmental effects, although little is understood about the biological causes of these effects in relation to individual animals. Analyses of permanent environmental effects, in an animal breeding context, are undertaken *within* groups of animals that are managed and reared together (see later Section on Contemporary Groups) and therefore do not include the effects of management between herds and between years. Within a group of deer reared and managed together, some animals will receive above-average permanent environmental effects and some animals will receive below-average effects. Whether an individual receives a positive or negative permanent environmental effect is independent of the genetic merit of the animal. Farmers cannot alter the occurrence of negative permanent environmental effects within a group of replacement velvet stags or breeding hinds. However, farmers may subsequently cull some of those individuals with negative permanent environmental effects, after assessing their first performance (2 yo velvet antler or weaning weight of first fawn).

Animals with superior genetic plus permanent environmental effects are desirable for retention for subsequent seasons. The sum of a genetic and permanent environmental effect (including hybrid vigour) is known as the *Production Value (PV)*. In the same manner as BV's, these values are in kg or litres in accord with the measurement units. These PV values for each trait can be combined with economic information to provide farmers with a single production index figure for use in culling (as compared to the breeding index which would combine BV's to get a single index figure for breeding decisions).

Temporary Environmental Effects

Animals with the same producing value for velvet antler weights do not produce the same quantity of velvet, even when they are of the same age and pedicle casting date and are compared within one herd and one year. These differences in production can be attributed to temporary environmental effects, which are not genetic and therefore not passed on to progeny. These effects are unique to each animal for each individual velvet harvest. It is completely at random as to which individual animals receive above-average temporary environmental effects and which get below-average values. The values in one harvest are completely independent of values at the next harvest, because any common effects have been defined as permanent environmental effects. Temporary environmental effects are responsible for causing more variation in yield than either genetic effects or permanent environmental effects.

Maternal effects

A basic principle of animal production is that individual performance is determined by genetic makeup and environmental conditions. Individuals with above-average phenotypes can result from superior genotypes, favourable environments, or both. Prior to weaning, it is the prenatal and then milking and mothering ability of the dam that provides an important component of the young animal's environment. Although the milking and mothering ability of the dam is an environmental effect from the viewpoint of the young animal, it is affected by the genotype of the dam for milking and mothering ability. Thus, weaning weight is determined by individual fawn's genotype for preweaning growth (the so-called direct effect), genotype of the dam for milking and mothering ability (maternal effect) and effects of the environment (temporary effects).

Weaning weights can be modified by genetically increasing preweaning growth ability of fawns, using hinds with superior maternal ability, or by providing a better environment through improved management practices. Maternal effects can be a major determinant of performance up until weaning, but thereafter tend to diminish in importance with age as postweaning genetic and environmental factors dilute their effect.

There are several factors which complicate improvement programmes for traits with maternal influence. First, there may be a negative genetic correlation between direct and maternal effects. Second, the dam contributes both the maternal effect and half of the direct genes, leading to difficulties in accurately separating direct and maternal contributions. Third, the expression of maternal effects are sex-limited and occur late in life, a generation behind the direct effects.

Mass selection based on weaning weight is not suitable for customised improvement of direct and maternal genetic effects. Information on relatives is essential to accurately separate direct and maternal contributions. This requires individual animal identification, recording of parentage at mating (through artificial insemination, or single-sire mating groups) and relating fawns to hinds at calving, in addition to recording of individual weaning weights. DNA-based tests may be a practical alternative to allow parentage identification at weaning or at slaughter.

In beef cattle, commonly-used breeding values for maternally influenced traits are maternal grandsire effect (0.25 direct plus 0.5 maternal) or dam effect (maternal plus 0.5 direct). These weightings reflect the confounding of direct and maternal effects in maternal grandsires and in dams but are not necessarily appropriate weightings for selection programmes. The correct approach would be to calculate relative economic values for your particular production circumstances and base your selection on the index obtained by multiplying the BVs for direct and maternal effects by their appropriate relative economic values. Relative economic values for direct and maternal effects will depend, among other factors, on fawning percentage, replacement rates, and whether producers market offspring at weaning, yearling or older ages.

The value of a calf marketed at weaning is likely to be influenced by its direct genetic merit since calves with superior genotypes for direct effects will on average be larger than calves with average or inferior direct effects. In contrast, straight-bred calves carrying superior genotypes for maternal effects may not be identifiable by buyers to enable a premium return.

In a self-replacing herd, sires produce progeny that are finished and slaughtered in addition to progeny that are retained as breeding females. There is a greater time lag for realising benefits of superior maternal genotypes than benefits of superior direct genotypes. Appropriate economic weightings for direct and maternal contributions should account for the frequency of expression of direct and maternal genotypes and discount for time of expression.

Genetic and environmental relationships between direct and maternal influences complicates the inclusion of maternal effects in selection programmes. More sophisticated on-farm recording and data processing are required for genetic evaluation with maternal effects than for traits controlled solely by genes of direct influence.

Heritability and Repeatability

The heritability is a term used to describe the relative importance of genetic effects in determining variation in phenotypic expression. Within a herd of animals of the same age, grazed and managed together, differences in production can result from differences in the genetic merit of the animals (i.e. BV's) or differences in the permanent and temporary environmental effects. As each of these three effects are independent, the phenotypic variation can be calculated as the sum of variation in each of these three components. The genetic variation, expressed as a ratio of the phenotypic (or observed) variation, is known as *heritability*.

$$\text{Heritability} = \frac{\text{variation due to genetic differences}}{\text{total observable variation}}$$

Heritability values must lie between 0.0 and 1.0 (or 0 and 100%). A heritability of 25% for velvet antler weight indicates that, pooled across the whole population, 25% of the total variation in velvet antler weights between stags of the same breed, age and date of pedicle casting within a herd and year is due to genetic effects. For example, a group of 2 young stags reared on the same farm, is sorted into two mobs after velvet harvesting. Suppose one mob had produced an average of 2 kg velvet and the other mob had produced an average of 3 kg. The difference in velvet weight was 1 kg and will have been partly due to genetic effects and partly due to chance environmental effects. On average, 25% of this difference (equal to 0.25 kg) will be due to genetic differences, that is differences in BV's between the mobs.

The repeatability measures the extent to which variation in animal performance is a result of genetic *and* permanent environmental effects. The genetic plus permanent environmental variation expressed as a ratio of the total phenotypic variation is the repeatability.

$$\text{Repeatability} = \frac{\text{genetic and permanent environmental variation}}{\text{total observable variation}}$$

For a given trait, repeatability must be greater than heritability, but cannot exceed one. Repeatabilities are often between 50 and 60%. Consider the example with two mobs of first stags differing in performance by 1 kg in their first velvet harvest. A repeatability of 60% would indicate that this difference is expected to decrease to 0.6 kg (i.e. 60% of 1 kg) if these animals in the two mobs were put back together and all were retained for another velvet harvest. The difference shrinks because some of the original deviation was due to temporary environmental effects, and new temporary effects are sampled in the subsequent lactation.

A repeatability of 100% would indicate that temporary environmental effects do not contribute to observed variation. Accordingly, measured performance within a herd would be identical at each observation. A repeatability of 60% indicates that 40% (100-60) of the variation is due to temporary environmental effects. It is the presence of temporary environmental effects that result in the rankings of animals based on their measured performance changing from one observation to the next.

Some field data estimates of heritabilities and other variance components for velvet antler weight and liveweight in farmed Red Deer are in Garrick (1996) and Garrick and van den Berg (1996).

Contemporary Group Effects

The temporary and permanent environmental effects considered in the previous sections have been random effects. That is, within a group of animals treated the same way, some animals have positive environmental effects, some animals have negative effects. Exactly which animals end up with the positive effects cannot be predicted in advance, as these effects occur *at random*. In contrast, farm management can have systematic effects on performance across all animals in a group. For example, delaying the date of velvetting, or increasing the level of feeding will likely modify the performance of all animals in the herd. The effects of management common to a group of animals are described by animal breeders as *contemporary group effects*. A contemporary group can be defined in a number of ways, but most commonly it refers to a group of animals grazed and managed together in the same herd, and of similar age (ie, herd-year-age).

Some other factors also have systematic effects on production. For example, animals that cast pedicles earlier within the herd tend to produce more velvet if harvested at the same time as stags that cast at a later stage.

Heterosis and Breed Effects

The breed or strain of deer can have a considerable influence on velvet antler and venison production. Evaluation systems can ranks all animals *across* breed, provided sufficient records exist from pure-bred and cross-bred animals in the same contemporary group.

The BV of a progeny is, on average, the mean of the BV's of the parents, as described earlier. However, when animals with widely different genotypes are crossed (such as different breeds) the performance of the crossbred animal is sometimes greater than would be expected from the average of the parents. This effect is known as *heterosis* or *hybrid vigour*. Heterosis is greater in first-crosses than in later-crosses of animals, and greater when the differences between the parent strains are largest. The effects of heterosis would not be included in the BV of crossbred animals, but are included in their PV.

The additional performance that is sometimes observed as heterosis is simply making up for previously lost performance that resulted from inbreeding. The closer the level of inbreeding that has occurred within a breed or strain, the greater the extent of heterosis expected when the breed or strain is outcrossed to unrelated genotypes.

Estimating Breeding Values and Producing Values

Previous sections have described the factors that can affect a production record. In the case of velvet antler weights, these factors are breeding values, permanent environmental effects, temporary environmental effects, contemporary group effects, heterosis, date of pedicle casting. Animal breeders summarise these factors using model equations, as follows:

Measured velvet antler weight = genetic merit (including breed)
+ permanent envt. effects + temporary envt. effects
+ contemporary group effect (herd-year-age)
+ heterosis + date of pedicle casting

or

Measured weaning weight = direct genetic merit (including breed)
+ maternal milking ability + temporary environmental effects
+ contemporary group effects
+ heterosis + age at weaning

Given known values of effects on the right-hand side of the above equations, it would be easy to identify the best animals to breed from and the best animals to retain for production in a subsequent season. (Note that the chosen animals would not be identical in these two cases, as factors other than genetic merit affect lifetime performance). Unfortunately, all that can be actually measured is the velvet antler weight or the weaning weight. The objective of animal evaluation is to use the information available on the pedigree and performance of animals to obtain *estimates* for each of the above effects. The statistical techniques involved are beyond this paper, however, the philosophy behind the technique involves removing the systematic effects on production (the last three effects), and partitioning the remaining information into genetic and permanent environmental effects.

Most modern evaluation systems achieve this partitioning using a technique known as *Best Linear Unbiased Prediction (BLUP)*. Herd-year-age effects are removed by only comparing the performance among contemporaneous animals which are those of the same age, in the same herd and in the same year. The merit of every animal in the population is then obtained by combining information from three sources. These sources are: the average BV's of the parents; the average BV's of the progeny, adjusted for the merit of the "other" parent; and any individual information on the animal of interest relative to its contemporaries. The amount of emphasis (or weight) that is placed on each of these three sources of information varies with the number of records available.

An animal with no individual records or progeny is evaluated on the basis of its parent average BV. An animal with one record would be re-evaluated with reduced emphasis placed on the parent average BV and some emphasis placed on its individual performance relative to its contemporaries.

It is important that one realizes there is a distinction between "true" values and "estimates" of the various effects in the model equation shown at the start of this section. As the effects cannot be directly observed, their exact value will never be known. The estimates will not be perfectly accurate, the degree of perfection being assessed by a term known as *reliability (R)*. Animals with many progeny can be reliably evaluated.

Despite the fact that animal evaluation gives rise to *estimates* of effects, rather than *true values* of the effects, the principles of breeding values still remain. That is, the estimated merit of the offspring is, on average, the mean of the estimated merits of the two parents. However, individual animals with a particular value of estimated merit may have true merit that is either greater or smaller than the estimate, because of inaccuracies in the estimation of effects in the model. When averaged across a large number of individuals with a particular value of estimated merit, the average true merit will be the same as the estimated merit.

In practice, for a variety of reasons, the deer industry is currently making little, if any, use of formal evaluation to obtain BVs and PVs for ranking animals. Furthermore, little work has been done to establish formal breeding objectives to allow the BVs and PVs to be combined into single index values for selection and culling. A number of deer farmers routinely record performance and pedigree information, but little of this information is consolidated in a soundly-based statistical fashion. Based on experience with other species, this is likely to gradually change in future.

Mating plans

Deer farmers with a good understanding of the factors affecting performance (as described mathematically in the model equations given earlier) will recognise that the choice of breed or strain can enable exploitation of average breed effects and heterosis and selection within a breed can improve the BV of animals. In practice, improvement programmes can usually achieve 1-2% annual advances in performance as a result of selection. Greater progress is likely to be achievable in the deer industry.

The primary interest of breeders using evaluation and selection in practice is to generate genetically superior stock. Many of these breeders obtain a significant proportion of their income from the sale of breeding stock (particularly sires). That is, they sell genotypes. The sector of the industry comprising these breeders is often referred to by a variety of names including: stud, pedigree, seed-stock and, nucleus. However, in most industries the proportion of animals in this sector of the population is relatively small compared to the total. The majority of animals are typically contained in what might be called the commercial sector i.e. those breeders whose main source of income is obtained from the sale of products (e.g. velvet antler and venison). This sector could be thought of as selling phenotypes.

The rate at which genetic superiority among successive crops of animals born in the nucleus sector are dispersed to the commercial sector is dependent on structures or relationships between the herds that make up these two sectors. From an industry perspective, the breeding structure can have a large impact on the cost-benefit of genetic improvement.

Unstructured

At the initiation of any new industry, most will go through a phase where individual herds operate independently of each other i.e., each herd breeds all of their own replacements. Therefore, each herd develops its own rate of genetic progress in the traits that each breeder believes are important. These rates of genetic progress will vary from substantial gains made by farmers operating an effective selection programme to zero for a farmer not imposing any selection pressure or, sometimes even genetic losses. The beef and dairy cattle and sheep industries passed through this phase last century, but the deer and fibre goat industries have only recently been in this unstructured situation.

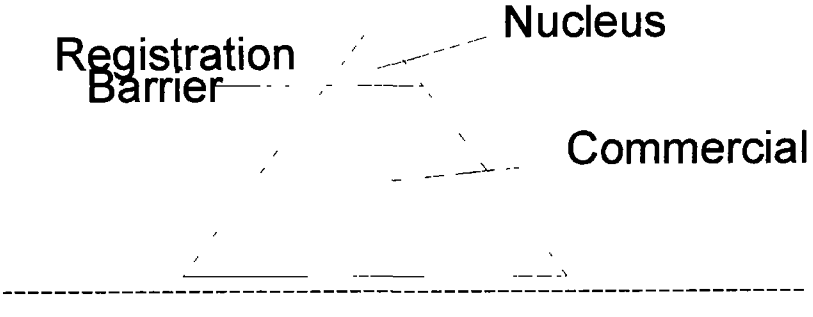
Two-tiered closed-nucleus structure

After some period of time in the unstructured phase, breeders will soon realise that there are costs and work associated with recording ancestry and performance that some operators would prefer to avoid. Some breeders with a particular interest in keeping and using animal records tend to be sought after as a sire source in preference to generating home-bred sires. In some cases, this is because the sire source herds are performing at higher (phenotypic) levels of production. Transfers of stock (generally males) from some herds to others gives rise to two layers in the industry. The top layer is often called the stud or **nucleus tier** and becomes charged with the responsibility of genetically improving traits important for profitability. These units have often become specialised and of small size and, the sale of sires becomes an important source of income. In contrast, the second tier concentrates on maximising efficient production through management; buying genetic gain from the nucleus tier through (in particular) the purchase of sires. This tier is often referred to as the **commercial layer**.

In many livestock industries, it is typical for the nucleus tier to become isolated (or **closed**) from the commercial layer by imposing a breed registration barrier between the two layers. This barrier is normally under the control of Breed Societies and is primarily an attempt to maintain genetic purity in the nucleus tier. In the traditional context, nucleus animals are registered and only animals with registered parents can themselves be registered. Sires sold to the commercial layer are usually sold unregistered. Thus, genetic material can only flow in one direction; from the nucleus to the commercial tier. Such a barrier involves the implicit assumption that, in a genetic sense, the poorest stock in the nucleus are better than the best in the commercial layer. However, this is unlikely to be true in the extensive livestock industries of New Zealand where the commercial tier contains 10 to 100 times more animals than the nucleus tier. Although the genetic mean in the nucleus layer may be superior to the commercial layer, the greater numbers in the commercial sector ensure some genetically elite animals will exist there. Of course, they may be difficult to cheaply identify. The effect of the registration barrier is to exclude some genetically desirable animals from contributing to genetic gain in the nucleus layer.

A problem with the registration barrier is that the nucleus tier may lose touch with the requirements of the commercial producers. This occurred during the 1960s and 1970s in the New Zealand sheep industry and resulted in many commercial producers breeding their own sires that met their objectives. Some of the producers went on to become major suppliers of sires thereby, creating a nucleus of "unregistered" animals.

Diagrammatically, the two-tier structure is often represented as a pyramid with the nucleus herds appearing in the tip of the pyramid. This is to show that for any breed only a small percentage of animal numbers are involved in the nucleus, probably less than 5% for most breeds. Thus, the rate of genetic gain for most of the livestock industry is dictated by only a small number of nucleus breeders imposing selection on a small percentage of the total stock numbers.



By consistently buying sires from one nucleus breeder, the commercial producer will within 2 or 3 generations (e.g. 10-15 years for deer) achieve the same rate of genetic gain as the nucleus breeder. This shows the importance of choosing the correct nucleus breeder to buy sires from. At any point in time though, the average genetic merit of the commercial herd will be inferior to that in than the nucleus herd by:

2 x generation interval x annual rate of genetic gain.

This quantity is typically referred to as the **genetic lag**.

If a nucleus herd is improving velvet antler weight at 30 grams per year, deer on commercial farms with a generation interval of 5 years buying from this nucleus will be about 300 grams (2 x 5 x 30) behind the nucleus in genetic potential for velvet antler weight. An alternative way of describing this lag is to say that the genetic merit of the commercial producers herd is 10 years (2 x 5 years) behind that of the nucleus unit e.g., the average genetic merit of the commercial unit in 1997 would be equivalent to the merit of the nucleus in 1987. Accordingly, if the nucleus herd has not progressed in average genetic merit over the intervening 10 years, there is no point in sourcing sires from that herd again - one would be better off retaining the best sons born in the commercial herd.

The above genetic lag calculations assume that the commercial producer is buying sires of average genetic merit from the nucleus, and doing no female selection. If the commercial producer buys above average genetic merit sires, or practices female selection, the average genetic merit of their herd will be closer to that of the nucleus at any point in time. However, the rate of genetic gain in the commercial herd will continue to parallel that of the nucleus, the genetic gain in the commercial herd cannot exceed that being achieved by the nucleus. In the event that above average genetic merit sires cost more, the commercial producer could undertake a cost-benefit analysis to see whether the reduced lag justifies the additional expense. In practice, sale of breeding males often reflects their phenotypic productivity rather than their genetic merit. In that situation, the high-priced sires may be genetically inferior to lower priced sires, despite their high individual performance which reflects favourable non-genetic influences.

New technologies

The introduction of new technologies (e.g., artificial insemination or DNA testing) to a livestock industry can influence genetic merit in two ways. First, it can impact the rate of progress that is achievable in the sire breeding sector. Second, it can impact the genetic lag between the sire breeding and the commercial sectors. Some technologies affect both components while others only affect one component. In considering the genetic improvement of a commercial deer herd in New Zealand, both the rate of gain in the herd providing sires, and the genetic lag will be of interest.

Summary

Farm profitability can be improved by identifying the best animals in order that these are preferentially used to parent the next generation, and to identify those individuals that will likely outperform their contemporaries in their remaining lifetime. A knowledge and understanding of the basic principles of genetics can assist in the development and introduction of objectively based improvement programmes. Such programmes can be cost-effectively provided by generating improvements within the minority of the industry responsible for breeding sires, and exploiting the superior males so generated as sires in the larger commercial sector of the industry. To date, the New Zealand deer industry has made relatively little use of well-proven techniques used in other plant and livestock industries for cost-effective improvement.

Further reading

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