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Genetic improvement of red deer

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ABSTRACT

Deer breeding has made significant progress in a relatively short time. However, opportunities exist to make further advances in several areas. Development and implementation of across-herd breeding value analyses could significantly benefit the deer industry through providing opportunity to accelerate rates of genetic gain, and by providing commercial stag purchasers with objective information on which to base stag selection. This will require the development of standard recording protocols and a central performance database, but the technical issues surrounding this are solvable and suitable models exist in other livestock industries. With changing composition of industry returns, deer farmers and breeders might re-evaluate whether they are best served by selection for specialist velvet and venison lines, or whether a dual-purpose animal remains the best option. There may also be value in broadening the traits objectively described to include aspects of venison production other than growth.

Keywords: deer; genetics; breeding objectives; breeding values; velvet; venison.

INTRODUCTION

The purpose of this paper is to review genetic improvement in the deer industry, and to identify opportunities and directions the industry can take to move forward. Several other authors have written excellent reviews in the recent past (e.g., Fennessy 1997; Garrick, 2001; Pearse & Amer, 2001), which discuss various aspects of genetic improvement and industry structure. It is not the intention of this paper to repeat these reviews, but rather to concentrate on areas which have not previously been covered in great depth. These include some industry structural issues surrounding taking objective breeding of deer to the next level, as well as a consideration of future directions for breeding objectives.

Historical perspective

To understand where the deer industry is going (in terms of genetics), it is useful to consider where it has come from. The industry is a very young industry (relative to other livestock industries), and has gone through a phase of rapid expansion of numbers. The base herd was essentially a wild population of deer with little selection pressure other than natural selection operating in the wild environment. It is important to note that success in the wild environment is not necessarily closely related to suitability in the farmed environment – one only has to look at high performing breeds of sheep and cattle in the farmed environment, and consider their likely ability to survive if released into a wild environment to see that artificial selection of farmed animals can differ markedly from natural selection in the wild. Thus, the deer industry has started with a genetic base of a different nature to the current genetic base of other livestock species.

During the early phase of expansion there was a shortage of animals, and consequently there was little selection pressure placed on females. Culling on temperament was the main priority during this period, and many people with experience in the industry from the early days will testify to the remarkable progress which has been made in temperament during this time, although this progress is likely due to components of environmental and learned behavioural influences as well as genetic selection.

The deer industry is in the fortunate position of farming a species which naturally inhabited a wide ranging environment, from Scotland across Europe and Asia to North America. Within this environmental range existed several sub-species with unique characteristics that had something to offer farmed deer in New Zealand. Consequently, during the early phase of industry development there were significant importations of new bloodlines which provided a significant and rapid improvement in the genetic base of farmed red deer. As a result of this, genetic improvement was largely driven by bloodline substitution through use of genetics derived from English and East European game parks until recently. However, the industry has now reached a point where most of the useful population resources available are now adequately represented in the New Zealand herd, and the importation of new genetics is increasingly difficult. Thus, continued improvement of red deer genetic resources is becoming (and will continue to become) increasingly reliant on generating genetic gain through selection within the national herd.

The use of wapiti and hybridisation on deer farming also had a significant impact. The ability of red hinds to hybridise with animals from another sub-species approximately twice the mature body size and produce live, fertile offspring with little calving difficulty is extraordinary among livestock species. Where wapiti are used as a terminal sire, the undisputed superior growth rates of hybrid progeny from red hinds and the ability to reach target weights earlier results in a very efficient system, both biologically (Fennessy & Thompson 1988) and economically. However, recent evidence has shown that over the last two decades there has been a significant introgression of wapiti genes into the red hind population, due to the retention of hybrid females into breeding herds (Asher, 2003). This introgression of wapiti into the national red deer breeding herd has significant implications. Size of hinds in the breeding herd has increased, which has consequences for the efficiency and profitability of the venison production system (these consequences may be positive or negative).

Industry breeding structures

Currently there are approximately 40-50 “seedstock” herds which regularly sell sire stags to commercial farmers by public auction or private treaty. The majority of these herds focus on red deer with genetics sourced from English or Eastern European game parks, with the remainder selling elk or Wapiti stags (a limited number sell both). However, the number of herds producing sires that are then used to breed other seedstock sires indicates that the seedstock sector consists of a small number of top-tier herds that influence genetic gain, with the remainder acting as multiplier herds to deliver genetics to the commercial sector.

The deer breeding sector is still relatively undeveloped in terms of industry structures, compared to other livestock species. Two breed societies exist (the Warnham-Woburn Society focused on deer imported from two particular English deer herds, and the Elk-Wapiti Society), but these societies do not cover the full range of deer genotypes commonly used (East European genotypes are a notable exception). Animal identification systems are not standardised across herds, and pedigrees are not held on a central register. No widely accepted standards for performance recording exist, although recent attempts have been made to suggest such standards through industry benchmarking programs. The industry has not yet developed central databases or infra-structure for recording of pedigree or performance information. However, objective information on velvet production and body weight is collected by most seedstock herds, and several breeders use specialised software packages to maintain pedigree and performance records on-farm.

Until recently, the use of objective information in breeding and selection was limited to comparison of phenotypic performance of individuals. However, a limited number of herds (generally at the top level of the breeding sector) are now starting to use breeding values calculated within-herd through a service provided by AgResearch, and provide this information to their clients (e.g. in sale catalogues). Breeding values use performance information on individuals and relatives (through pedigree information), together with knowledge about the heritability of a trait and its genetic relationship to other traits, to provide a more accurate assessment of the *genetic* merit of the animal compared to individual phenotypic performance alone.

Future developments in objective breeding

While within-herd breeding values are a useful advance in deer breeding, the development of across-herd breeding values would greatly increase the utility of breeding value technology in the deer industry, and is the logical next step in advancing deer breeding. Across-herd breeding values allow genetic comparisons to be made across all the animals within contributing herds, and have been successfully used in many livestock industries in New Zealand and internationally. The advantage of across-herd breeding values is a marked widening of the genetic pool evaluated on a common basis. This allows seedstock breeders to more accurately identify the most superior animals for breeding purposes, thereby increasing rates of genetic gain, and allows commercial breeders purchasing stags to compare animals from different herds and identify which herds and individual animals will best meet their breeding requirements.

Development of a national breeding value program requires additional structures to be set up to facilitate this. These structures include a set of recorded traits (and guidelines for recording standards) agreed to by participating herds, a national system for identifying animals (principally to ensure that the same animal used in two or more herds is given a common identification), and a centralised database which can hold information on pedigree and performance records of all herds contributing to the program. The deer industry is currently behind where other industries have been when they started to implement breeding value technology, as many industries already had recording structures and centralised databases in place prior to the advent of breeding value technology. However, the technical issues in developing these structures are relatively straight forward, and several models now exist in other industries to base these structures upon. Also the advent of industry-wide animal identification systems (through the animal health board) may assist the process.

The other vital component that is required to implement across-herd breeding value analysis is the development of “genetic linkage” across herds. Across-herd comparison relies on having genes shared across herds, so that the influence of different environments between herds (due to management, nutrition, etc.) can be separated from the influence of genetics. In practice, this is achieved by having sires represented with significant progeny numbers across two or more herds, thus, linking these herds. A network of linked herds can be constructed to facilitate across-herd breeding value analysis.

Currently the genetic linkage between deer seedstock herds is insufficient to implement across-herd analyses. While some exchange of genetics does occur between herds, this is often through purchases of young stags not used as sires in their herd of origin, and so does not provide adequate genetic linkage. While some semen from “master sires” is traded between herds, generally the quantities are relatively small and do not provide sufficient progeny to get an accurate assessment of the sire’s performance in the herd purchasing the semen. An alternative method to supplement genetic linkage is to develop sire reference schemes, whereby performance of stags used in their own herds is compared by using the stags (and recording progeny) in a commercial herd. This method may not be as desirable as direct across-herd linkage (due to increased expense and limiting resources), but can be used where seedstock herds are reluctant to trade semen due to commercial considerations. AgResearch has recently commenced a sire benchmarking project aimed at improving genetic linkage between industry herds. Results from this project will contribute towards developing a national across-herd breeding value program for the deer industry.

Breeding objectives for deer

Historically the breeding sector of the deer industry has been focussed largely on improving antler characteristics (velvet yield and hard antler weight and style), with some associated emphasis on bodyweight (Pearse & Amer, 2001). Significant genetic progress in has been made in a relatively short space of time, and this has been demonstrated by analysis of genetic trends for velvet weight of two-year-old stags in a number of leading herds. There are several likely reasons for the dominance of antler traits in current industry breeding objectives. The foremost reason is that velvet antler yields are a primary driver of profitability for velveting operations. Moreover, antler characteristics are moderately to highly heritable (van den Berg & Garrick, 1997; Pearse & Amer, 2001), and velvet yields are easily measured, meaning that significant genetic progress can be made through selection on phenotypic characteristics alone. Additional factors which have likely influenced the emphasis on antler in breeding objectives are the highly visual nature of antlers and their association with the mystique of deer.

To date, selection to increase body weight has received less emphasis than antler characteristics in the breeding objectives of most red deer breeders. This may be, in part, influenced by the availability of wapiti as an alternative to increase growth rates in the commercial situation. However, as a generalisation it is fair to say that most seedstock herds are currently aiming to produce a dual-purpose animal, suitable for both velvet and venison production, and so increasing body weight has received relatively less emphasis than might be the case where venison production was the main focus. Production of a dual-purpose animal suitable for both velvet and venison production was a suitable strategy in the early days of the industry, when export returns from velvet and venison were approximately equal. However, the industry has grown in size and the relative returns from velvet and venison have changed over time, venison now accounting for approximately 80% of export returns from deer (Deer Industry New Zealand). Moreover, the development of a market for trophy stags expressing good hard antler characteristics adds an additional significant factor to consider when developing breeding objectives. Thus, it is worth re-examining the issues and considering whether breeding lines of deer which specialise in velvet, venison or trophy production is a useful additional strategy to producing dual-purpose deer.

Specialist vs dual-purpose lines

In order to consider whether specialised breeding objectives for different production systems are justified, it is necessary to understand the drivers of enterprise profitability, and the relative balance between products in different production systems. A fundamental difference between deer and other dual-product livestock species (e.g., meat and wool from sheep, and milk and meat from cattle) exists in that the non-meat product from other species is produced by the female, whereas velvet in red deer is produced only by the male. However, although there is little (or no) opportunity for dual production of high-quality velvet and prime venison from the same animal, the velvet production system will always produce a quantity of venison as a by-product, as a breeding herd will always be required to provide replacements for the velveting herd. Likewise the venison system will always produce a quantity of velvet as a by-product, through velveting sire stags and spikers before slaughter. Thus, breeding objectives for systems specialising in either venison or velvet should include both venison and velvet components. However, the relative balance between traits to improve venison and velvet production may be very different if "specialist" lines of deer were to be produced. For example, the emphasis on velvet antler characteristics in a specialist venison breeding objective might be very small, whereas it will dominate a specialist velvet breeding objective.

With an increasing proportion of industry returns coming from venison production and a large number of commercial producers concentrating only on venison, it is worth deer breeders considering whether it is worth developing specialist lines focused on venison production? The answer to this question revolves around two major issues. Firstly, how superior (for venison production) would a "specialist" venison animal be compared to a dual-purpose animal? While growth rate is the main focus of venison production, selection for additional characteristics such as reproductive and maternal performance, early puberty, and possibly traits associated with seasonality, disease resistance and carcass characteristics could significantly improve venison production and might be usefully included in the breeding objective (McManus & Thompson, 1993). At this stage development of a broader breeding objective for venison is limited by a lack of knowledge about the genetics of these traits and a lack of recording systems.

The second question relevant to the specialist versus dual-purpose debate is whether the extra effort and expense required to breed a specialist venison animal is justified by the increased returns. In practise, the answer to this is largely determined by issues of commercial viability and market opportunity. Additional considerations might include the advantage of a dual-purpose animal in maintaining a greater level of flexibility to alter enterprise mix in the event of medium-term fluctuations in relative market prices of venison and velvet, or the increase in management complexity required were specialist lines to be used on properties running both velvet and venison enterprises. Thus, the issue is complex, but worth re-visiting from time to time.

The impact of the trophy market on breeding systems and selection for antler characteristics is of interest, as there are two factors in trophy production which differ significantly from traditional livestock breeding programs. The first of these is that the value of a stag as a trophy animal is driven by human perception, rather than a tangible measure such as weight of product. As such, trophy value could potentially be subject to the vagaries of fashion, with changes in desirable genotypes occurring. Secondly, the value of a trophy is determined by relative merit rather than absolute values. This is similar to breeding racehorses, where the objective is not to improve the overall population mean (which would simply mean that all horses would be faster) but to produce the winning horse – a fundamentally different goal.

Unfortunately, there is a low correlation between trophy potential and velvet production (Pearse & Amer, 2002), and farmer observation and scientific research both indicate that trophy merit can not be accurately predicted from observations of velvet antler in two-year-old stags. This means that without the development of alternative tools, selection to improve trophy merit carries a very significant cost (in sacrificing returns from harvested velvet antler) and will likely be slow as evaluation of trophy merit at older ages will produce very long generation intervals. Thus, making rapid genetic progress though traditional selection will likely be difficult. An alternative strategy may be to continue to evaluate trophy merit of stags selected primarily for velvet production, and to combine existing strains of deer with different antler characteristics in new and varied ways. This may well evolve to being a specialist role filled by a small number of herds which dominate the trophy market. It should be recognised that the trophy market uses only a relatively small number of stags per year (although stags are of high value), and a potential danger exists in distracting deer farmers from the main focus of achieving long-term genetic gain in the traits that determine profitability of their core enterprises, be it velvet or venison.

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