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Deer Improvement's breeding programme for venison production in red deer *(Cervus elaphus)*

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ABSTRACT

This paper describes the progress of the Deer Improvement breeding scheme that has been in place since 2004. The aim of the programme is to improve venison production through genetic selection for growth rate of lean meat with improved fertility, temperament and mature hind weight. The breeding programme currently comprises 500 hinds bred from stags selected for high growth rate with the intention of increasing hind numbers to over 1,000. This projected increase will be facilitated by the use of embryo transfer to multiply the genes of the top ranked yearling animals, thus shortening the generation interval. As part of the programme, all progeny are DNA parentage tested, weighed frequently during their first 12 months of life and temperament scored. Pregnancy and weaning rates are recorded in the nucleus and progeny testing herds. As a result of selection during the past six years, the average yearling weight has increased by 1.5 kg/yr over all farms involved in the breeding programme. In 2009, male fawns from the nucleus herd reached an average of 100 kg at seven months of age. This is greater than the current industry average of 75 to 78 kg for the same age.

Keywords: *Cervus elaphus*; red deer; breeding programme; venison production.

INTRODUCTION

Commercial deer production within New Zealand commenced in the 1960s, with the first export being feral deer to Europe (MAF, 2002). This was followed by the establishment of the first breeding herd in 1970, creating a steady supply of venison for the export market (MAF, 2002). The value of velvet was also realised at this time and export to the Asian market followed (MAF, 2002). Velvet is primarily used for medicinal purposes. Korea is currently New Zealand's biggest market (MAF, 2002). The New Zealand deer population was reported as 1.2 million in June 2008 and it is predicted to continue to rise (MAF, 2009) due to the retention of hinds on-farm. This was evident at August 2009 as measured by a decrease in hind numbers slaughtered compared to the previous year (Deer Industry News, 2009). Hinds are being retained to increase the breeding population due to the positive predictions for the venison schedule. Export revenue was reported as $320 million for the year ending 31 March 2009 representing an increase of 25% on the previous year, assisted by favourable trade conditions (MAF, 2009). As of the year ending 31 March 2009, 18,700 tonnes of venison was exported, with Germany importing the majority at 68%, whereas velvet exports earned $27 million over the same time period (MAF, 2009).

Deer Improvement started its breeding scheme in 2004 and the following year saw the introduction of DEERSelect. DEERSelect assesses the genetics of deer within its system and produces a breeding value (BV) for an animal from this appraisal. The software that carries out this genetic evaluation was created by AgResearch (Archer, 2006). Breeding values are calculated for a number of traits relevant to venison production to generate a 12 month and a mature weight index. A national sire summary is also available (Archer, 2006). DEERSelect has achieved cohesion in the breeding structure of the New Zealand venison industry (Archer, 2006) as previously there was no standard national, or across herd, comparison of phenotypic measurements. Breeders produced their own measure of genetic merit for their clients. Now farmers can use this information on the genetic composition of their herd in order to improve venison production and increase genetic gain by selective breeding (Archer, 2006). Furthermore, DEERSelect provides a national database of important traits, allowing progress of the industry to be monitored.

Deer Improvement provides high quality genetics for venison production. Since the start of the breeding scheme in 2004, genetic improvement has been made in a number of selected areas. This paper outlines the objectives of the programme and presents the progress in terms of genetic gain made to date, and the future direction of Deer Improvement.

MATERIALS AND METHODS

Deer Improvement's breeding objective is to produce an animal that improves on-farm productivity of venison. This is achieved through selection of animals for live weight, and more recently, carcass traits. Fawns located on the Balfour Research Farm (Northern Southland) and other progeny testing properties are weighed approximately seven times annually.

The first weigh occurs mid January, when fawns are weighed, tagged and DNA samples taken to determine parentage. Deoxyribonucleic acid (DNA) samples are processed at GeneMark laboratories and the resulting profiles are processed at Livestock Improvement Corporation (LIC). The second weighing takes place approximately four weeks later at the end of February, which coincides with weaning. From February through September, fawns are weighed approximately every six weeks. Weight data is sent to LIC for database input at each weigh date. BVs are calculated internally at LIC following each weigh date. Deer Improvement uses both BVs calculated at LIC, and by DEERSelect for selection and advertising purposes. DEERSelect BVs are made available for public use, whereas the BVs calculated by LIC are not. Each year, the aim is to have the LIC BVs available by mid to late February to enable decisions to be made on selection of 16-month-old stags for semen collection and subsequent progeny testing use. Superior stags are available for commercial use following progeny testing at 28 months of age.

Collection of lean meat measurements started in 2007. It involves 18-month-old male animals (spikers) selected for high live weight, undergoing a computed tomography (CT) scan prior to reaching 100 kg live weight. Traits such as fertility, temperament, mature hind weight and the timing of spiker growth are also measured. Fertility is assessed through pregnancy scanning. Scanning occurs once annually after the hinds are mated with the back-up stags. Back-up stags are stags that are naturally mated with hinds following artificial insemination (AI). Fetal aging occurs at scanning to determine an accurate mating date and thus birth date, resulting in a more precise BV estimate. Those hinds that are not involved in the multiple ovulation embryo transfer (MOET) programme and are not pregnant, are culled. Deer Improvement also measures temperament, which is defined as animal behaviour exhibited in the shed environment. This is scored on a 1 to 5 scale at each weighing. The repeatability of scoring is subjective and further research is required within this area. The industry recognises that continual selection for increased live

TABLE 1: The national ranking of all sires in DEERSelect in February 2010, sorted on breeding value for 12-month weight (W12BV). The corresponding accuracy for W12BV is listed as W12Acc. MWTBV is the breeding value for mature weight and its accuracy is MWTAcc (DEERSelect, 2009).

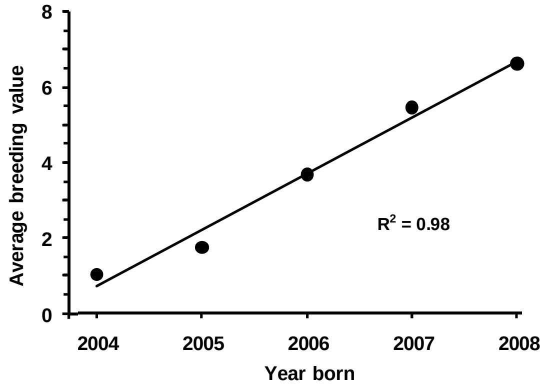
Birth herd	Birth tag	Current tag	Number of progeny	W12BV	W12Acc	MWTBV	MWTAcc	Current herd
Peel Forest Estate	03556/03	Atlas	60	25.1	0.94	22.2	0.79	Peel Forest Estate
Stanfield Eastern	03152/03	Megamilian	263	24.9	0.98	24.3	0.84	Wilkins Farming
Deer Improvement	06306/06	Czar	115	24.8	0.95	20.9	0.77	Deer Improvement
Deer Improvement	06259/06	Bremen	96	24.0	0.95	15.7	0.74	Deer Improvement
Doncaster Deer Partnership	06583/06	Corona	37	23.8	0.91	19.5	0.74	Deer Improvement
Doncaster Deer Partnership	05063/05	Corleone	25	23.4	0.89	17.8	0.73	Deer Improvement
Canterbury Imp Red Deer	31/04	Sonny Bill	25	22.7	0.88	24.5	0.75	Canterbury Imp Red Deer
Black Forest Park	02P162/02	Kurgan	50/98	22.1	0.95	22.7	0.85	Black Forest Park
Doncaster Deer Partnership	06549/06	Performer	33	21.9	0.91	20.0	0.74	Deer Improvement
Landcorp Stuart	259/06	259/06	12	21.7	0.83	15.3	0.67	Landcorp Stuart
Deer Improvement	06305/06	Commodore	76	21.7	0.94	15.7	0.76	Deer Improvement
Peel Forest Estate	04052/04	04052	7	21.7	0.83	21.4	0.72	Peel Forest Estate
Fairlight Station	05/3432	Stallone	174	21.5	0.97	14.0	0.78	Deer Improvement
Deer Improvement	06260/06	Franchise	37	21.3	0.91	16.0	0.74	Deer Improvement
Canterbury Imp Red Deer	02685/02	Cossar	288/302	21.2	0.98	23.5	0.86	Deer Improvement
Black Forest Park	03T649/03	Denzel	41	20.8	0.90	18.6	0.81	Totara Hills
Stanfield Eastern	97020/97	Maximilian	88/464	20.8	0.99	25.3	0.94	Stanfield Eastern
Remarkables Park Deer Farm	62/05	Luciano	94	20.6	0.95	14.1	0.74	Deer Improvement
Doncaster Deer Partnership	05073/05	05073	5	20.3	0.82	14.9	0.68	Doncaster Deer Partnership
Fairlight Station	063179/06	Mastermind	51	20.1	0.93	16.2	0.74	Deer Improvement
Peel Forest Estate	04034/04	Colt	46	20.1	0.86	18.4	0.72	Totara Hills
Peel Forest Estate	00264/00	Admiral	425/475	19.9	0.99	15.3	0.87	Deer Improvement
Peel Forest Estate	03315/03	3315/03	36	19.8	0.91	14.0	0.75	Wilkins Farming
Doncaster Deer Partnership	041943/04	Waipahi	34	19.7	0.90	16.8	0.73	Deer Improvement
Stanfield Eastern	011392/01	Colossus	118/150	19.7	0.97	18.3	0.84	Deer Improvement

weight may produce a heavier mature hind; an important issue for farmer customers. It is thought that heavier mature hinds result in a higher maintenance requirement affecting stocking rate. Therefore mature hinds are weighed annually. Data analysis will commence this year. The timing and the rate of antler growth is recorded for spikers as is the timing of spiker emergence. This is an important issue for those involved in supplying certain United Kingdom markets as venison from properties where velveting practices occur will not be accepted (P. Swinburn, Personal communication). Spikers with velvet must remain on farm once the velvet reaches 60 mm in length as they cannot be transported in accordance with the Animal Welfare Act (MAF, 1994). More time on farm results in an increase feed cost and a loss in schedule price due to slaughter outside of the prime season for sales of venison.

Formation of the breeding scheme started with the purchase of approximately 30 venison stags with growth data, from a range of New Zealand bloodlines. These stags were mated over hinds from four herds: AgResearch Invermay, Remarkables Park Stud, Fairlight Station and a commercial Canterbury property with a high proportion of Peel Forest genetics (Chardon & Gatley, 2006). Each stag sired approximately 20 to 40 progeny. The top two spikers and top six yearling hinds were selected from each of these four herds and transported to the Balfour Research Farm where they formed the nucleus herd. In addition to the selected spikers, seven two-year-old stags were included in the nucleus herd for the purposes of increasing genetic diversity. These seven stags had Maximillian, Kabul and outcross genes with high BVs, bringing the total number of stags to 15. These 15 stags were used in three progeny testing herds in conjunction with marker stags to establish a link across years, resulting in one thousand inseminations (Chardon & Gatley, 2006). A marker stag produces offspring across consecutive seasons and is used as a standard comparison for new stags entering the scheme.

Deer Improvement has formed a primarily closed female population on their Balfour Research Farm with the first hinds being introduced in 2006. The breeding population currently comprises approximately 500 hinds, with the intention to expand to over 1,000 in the future. The current hind population consists of two subgroups: the nucleus herd which consists of approximately 50 hinds used in a MOET programme, and approximately 450 hinds generated through AI. The Balfour Research Farm is split into two blocks by road. For bio-security reasons, the smaller block, known as the "quarantine" block, contains all animals from other properties. The larger "isolation" block has the original herd purchased with the property. These hinds serve as recipients for the MOET programme.

FIGURE 1: Average breeding values for 12-month live weight of the Balfour Research Farm and progeny testing herds.



MOET started in 2006 and was used on the nucleus herd to rapidly increase the elite female genetics within the breeding population. New genetics are introduced to the isolation block as both embryos and semen. This is to control the spread of disease, especially Johne's Disease, ensuring the isolation block remains Johne's Disease free.

Over the last three years, 50 nucleus hinds have been used in the MOET programme. Five to eight spikers are used annually in the MOET programme, with the programme generating between 150 to 200 fawns per year. All of the elite males selected for breeding within the Deer Improvement programme are generated from the nucleus herd. All hinds used in the MOET programme are replaced each year. On average, 75% of the nucleus hind replacements are generated from the MOET programme. The remainder of the hinds are selected from the hinds sired by AI on the basis of their BV.

RESULTS

The expected rate of genetic gain for live weight within the Deer Improvement breeding herd is 2.2 kg/yr. This is calculated using the following formula.

$$\text{Rate of genetic gain} = \frac{\text{Accuracy x Selection intensity x Genetic variation}}{\text{Generation interval}}$$

For the Deer Improvement breeding programme the trait of interest, yearling weight, has a genetic standard deviation of 5 kg, a heritability of 0.4 with an accuracy of 0.64. The selection intensity for the elite males is 8% as seven out of the 85 male fawns generated from the nucleus herd are selected. In the nucleus herd of elite hinds, 35 are selected from the 85 female hinds bred by MOET and 15 from the 200 generated by AI. The weighted average selection intensity for the female path is 1.23 units. Given a heritability of 0.4, the selection differential (accuracy x selection intensity) for the male path is $1.17\sigma_g$. For the female path it is $0.79\sigma_g$. The average age of the parents is 2 years for the males and 2.5 years for the females. Therefore for the Deer Improvement breeding scheme the theoretical rate of gain is:

$$\text{Rate of genetic gain} = \frac{(1.17 + 0.79) \times 5}{2 + 2.5}$$

$$= 2.2 \text{ kg /year}$$

The observed rate of gain within the Balfour Research Farm and the progeny testing farms is 1.5 ± 0.1 (standard error) kg/yr (Figure 1). This was calculated by fitting a regression to the annual average BV of the Balfour and progeny testing farms progeny.

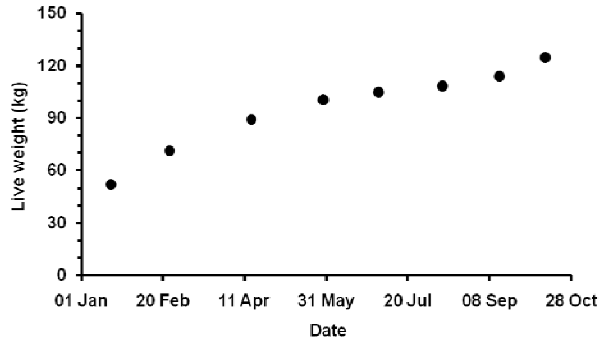
The success of Deer Improvement's breeding scheme can also be seen in the national ranking of stags provided by DEERSelect. In February 2010, Deer Improvement had 14 stags within the top 25 ranked stags (DEERSelect, 2009) (Table 1).

A recent accomplishment was the 2008 born male MOET progeny reaching an average live weight of 100 kg by approximately seven months of age (Figure 2). These fawns had an average daily gain of 372 g from mid-January until the end of May, with a median birth date of 15 November. Both sire and dam were selected on the basis of BV. A current estimate of an industry red deer male average in early June is 67 to 70 kg. It should be noted that there are a wide range of breeding objectives within the industry, including velvet and hard antler growth objectives, and weights from these properties are lower. Where breeding objectives target 12-month weight, earlier finishing, and some selection based on BVs, the average male fawn's weight at the same time is approximately 75 to 78 kg. When comparing weight figures, the average BV of the parents must be considered. On average, the industry has been slow to adopt growth rate BV selection to achieve more efficient finishing systems (A.J. Pearse, Personal communication). It is a Deer Improvement aim to have weaners at 100 kg live weight by winter, allowing them to be exported during the premium early spring market at peak weight. This aim fits in with the industry vision generated from the Deer Industry New Zealand (DINZ) industry productivity strategy of "more calves, heavier, earlier" (Deer Industry New Zealand, 2008).

DISCUSSION

The lower observed rate of genetic gain for live weight of 1.5 kg compared to the theoretical rate of 2.2 kg is due to the breeding programme being smaller in the formative years of Deer Improvement compared to the current scenario modelled for the theoretical rates of gain. That is, the model uses

FIGURE 2: Average live weight of the male stags born in 2008 within the multiple ovulation embryo transfer programme.



more animals than were available early in the breeding programme. Nevertheless, genetic gain is made annually and passed onto customers through semen. Currently, there are a number of ways farmers can utilise Deer Improvement's genetics. The top 10 to 20 percent of a herd's hinds can be artificially inseminated with semen sourced from Deer Improvement. This will produce elite male and female offspring, the males of which can be used as spikers to naturally mate the remainder of the herd. It is recommended that elite females generated are retained and naturally mated to ensure they can successfully get pregnant and raise a fawn. If these hinds are successful, they will be artificially inseminated the following season. Deer Improvement also provide spikers for those clients wanting a male animal on their property. These spikers do not have as high BV as the copmmercially available AI stags, but it is a single payment to purchase the animal and there are no AI costs.

Moving into the future, Deer Improvement will focus on a number of areas important to the industry. Firstly, carcass traits have been recorded for some time and will have a larger impact in the future Deer Improvement breeding scheme. This is due to the prediction that farmers may be paid different rates for different meat cuts. A number of meat processors in New Zealand have added technology that allows them to determine the composition of a carcass. Therefore, animals with a higher proportion of prime meat cuts will be of greater economic value. Deer Improvement CT scan a number of spikers that have been selected for a high live weight. The advantage of CT scanning is that although expensive, it is accurate. Alternatively, the eye muscles can be measured by external ultrasound, a less expensive method. Ward *et al.* (2010) investigated external ultrasound and concluded that this method of measuring the eye muscle in young deer is acceptable for raking deer within a herd. As animals do not need to be sedated for an external ultrasound scan, a higher proportion of the animals within a herd can be economically scanned increasing selection intensity. However, results may not be available year-round due to difficulties in scanning during the winter months on account of the thick double layer nature of the winter coat interfering with transmission of the ultrasonic signal.

Secondly, the technology surrounding parentage testing is relatively unstable, and will undergo a much needed update this year, with a single nucleotide polymorphism (SNP) panel being developed. This will increase the number of fawns successfully assigned parentage, thereby increasing the number of animals available for selection.

Thirdly, analysis of the age of emergence of antlers in spikers recorded last year at Balfour will be undertaken this year. Early antler emergence signifies a lost opportunity for farmers supplying markets where market regulations will not allow velveting practices to occur on-farm.

Deer Improvement will continue to provide improved genetics for its clients to increase their net profit.

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