
NEW ZEALAND SOCIETY
ANIMAL PRODUCTION
VOLUME 62 2002

Development of large scale commercial AI for genetic improvement in farmed red deer in New Zealand

W.H. MCMILLAN and G.W. ASHER[1]

LIC, Hamilton, New Zealand
[1]AgResearch, Invermay Agricultural Centre, Mosgiel, New Zealand

ABSTRACT

Experienced bovine AB technicians can be readily trained to successfully perform trans-cervical AI in red deer. Stags of all ages, including yearling spikers, can produce semen of acceptable quality and quantity at regular intervals from as early as February until mid-winter. Pregnancies rates to a single fixed-time insemination are typically 60-75% with unknown herd factors contributing much of the variation. Yearling hinds are capable of acceptable pregnancy rates when inseminated in late February, at least a month earlier than is current practice. Within broad limits, considerable flexibility appears to exist when hinds are inseminated relative to the end of synchrony treatment. A deer-specific intra-vaginal progesterone-releasing device has been shown to provide higher terminal levels of circulating progesterone compared with existing devices. Current field trials will determine its affect on pregnancy rates. We conclude that the genetic and reproductive technologies for increasing weight-for-age in deer have been successfully integrated and applied to commercial red deer in New Zealand.

Keywords: red deer; artificial insemination; genetic improvement; semen.

INTRODUCTION

Artificial insemination (AI) is the technique of choice for the widespread dissemination of desirable genetics in farmed livestock. This is most evident in dairy cattle where trans-cervical AI is used. This simple AI technique, when coupled with efficiently designed sire-proving schemes, has resulted in cumulative genetic progress rates in productivity of about 2 kg milk solids per head per year (Harris *et al*., 2007).

Early methods of AI in red deer involved highly invasive and labour intensive laparoscopic procedures (Asher *et al*., 1993). Success with trans-cervical AI in elk and larger elk hybrids were extended to red deer in the late 1990s. In general, much of the commercial AI undertaken has been of limited scale. However, recent developments have led to commercial-scale AI in New Zealand (Rhodes *et al*., 2003).

Although the quantitative genetic technologies to facilitate genetic progress in deer are simple adaptations from other livestock industries, it is not until recently that these have been sufficiently developed in the New Zealand red deer industry (*e.g.* Landcorp Farming, AgResearch Sire Referencing, DeerSelect). Industry-wide benefits from these recent parallel developments in genetic improvement and AI technologies are now available (Archer *et al*., 2007; Chardon, 2007).

Deer Improvement

Deer Improvement, a 100% owned subsidiary company of LIC (formerly Livestock Improvement Corporation) was established in late 2003 with the primary purpose of providing genetic improvement and AI services to the New Zealand red deer industry. The primary trait of interest is live weight-for-age, as a means of improving unit carcass weight (Chardon, 2007), along with improved temperament. A high genetic merit breeding herd has been established using embryo transfer and AI at their Balfour farm in Southland. Early season AI has been undertaken in young hinds. In addition, Deer Improvement is developing a red deer-specific intra-vaginal progesterone-releasing device to assist with the synchronisation of oestrus and ovulation for fixed-time AI.

The data reported in this paper have been collected during the commercial operations of Deer Improvement. Of necessity, this data is often unbalanced but nonetheless provides useful insight into the application to the deer industry of technologies well established in the dairy industry. At the formation of Deer Improvement there was a paucity of much of the technical information required to make commercial decisions in the context of a structured genetic improvement programme. In particular, factors affecting semen production in commercial quantities and factors affecting pregnancy outcomes were lacking.

This paper aims to provide data and information on AI training, semen production, insemination success and the development of a red deer-specific oestrus-synchrony device.

SELECTION AND TRAINING OF AB TECHNICIANS

Each year, LIC employs a resource of over 1,000 experienced bovine AB (artificial breeding) technicians. In early 2004, expressions of interest in training for deer AI were sought from this resource. There were 3 criteria for final selection: at least 15,000 bovine inseminations, at least 5-years continuous experience in cattle AI; above average 18-24 day non-return performance and the ability to comfortably pass their left hand through a metal ring of fixed diameter to at least a third of the way up their forearm. The later requirement was to ensure the comfortable trans-rectal manipulation of the deer cervix, a prime requirement during trans-cervical AI. In order to experience the full range of the rectal, vaginal and cervical anatomical variation in red deer hinds it was considered that about 30 animals would be required for each trainee (Dr Lee Morris, consulting veterinarian). Training was undertaken at the AgResearch Invermay deer farm under the supervision of a veterinarian experienced in deer AI.

Twelve technicians were finally chosen for training in trans-cervical deer AI from the list of volunteers. All except one of the chosen trainees was female. Most failed to meet the selection standard because of the size of their left hand or forearm. All trainees easily met the required AI standard. Between 4 and 22 animals were used in training, considerably less than expected. This contrasts with the training offered to first time bovine AB technicians where several hundred animals are used. This demonstrates the easy portability of the core skill from cattle to deer, at least in highly experienced and competent cattle AB technicians. Training of all new recruits in Deer Improvement is based on the criteria established during this first year.

SEMEN PRODUCTION

In contrast to the situation in many other farmed livestock (*e.g.* cattle, goats, sheep), red deer stags are virtually impossible to train to serve an artificial vagina for semen collection. As a result, electro-ejaculation using a probe *per rectum* is the method of choice (Asher *et al*., 2000). A subset of semen production data is presented to highlight significant improvements in performance, largely attributed to operator expertise. In 2004, data were collected on semen production following a frequent collection regime at several stages of the stag-breeding season. The 2006 data were collected early in the breeding season from stags of varying ages for Deer Improvements own breeding programme.

Semen Production (2004)

A total of 19 stags (13 were two-year-old, 4 were three-year-old and the remainder were adults) were used in the first year. Stags were routinely sedated during the autumn collections (February to April) undertaken by veterinarians from one company. These practitioners had previous experience with semen collection in deer, but were not specialists. The animals were scored on a 1 to 3 scale for 'ease of collection' and 'stress', with higher scores more desirable. At each collection, the incidence of bleeding or tenderness in response to the intra-rectal use of the electro-ejaculator probe was recorded. Stags were observed for signs of increased aversion behaviour to yarding and handling during semen collection. This behaviour was deemed to be a useful index of the level of obnoxiousness of the handling and semen collection protocol.

A specialist deer veterinarian from a second company was used for winter collections (June to July). There was no sedative used during these collections. The mean duration of stimulation with the electro-ejaculator probe at each collection from February to April was 233 seconds (3 minutes 53 seconds), ranging from 152 (2 minutes 32 seconds) to 294 sec (4 minutes 54 seconds). The coefficient of variation of the duration of stimulation for each stag was typically between 25 and 30% but ranged from 12 to 37%.

Seven stags were recorded with rectal bleeding or tenderness on one occasion and one stag on two occasions. All instances of rectal bleeding or tenderness were recorded during the first five collections and antibiotic was administered on each occasion. Rectal bleeding or tenderness occurred three times during the first two collections, four times during the third and fourth collections and twice during the fifth collections.

Semen collection was unsuccessfully attempted once on 10 of the stags in late February. Semen collection was attempted in all 19 stags in mid to late March (5 per stag), late April (1 per stag) and late June-early July (2 per stag). Over the 152 collection attempts the stags behaved well in terms of 'ease of collection' scores (overall mean scores ranging from 2.5 to 2.9 across collection periods) and 'stress' scores (overall mean scores ranging from 2.6 to 3.0 across collection periods) (Table 1). The mean number of straws per collection-attempt increased from 21 in March to 34 in April and 94 in June/July (Table 1). Concurrent with this increase was a decrease in the proportion of collections yielding no straws. There was no

Table 1: Semen production in 2004 (Range in individual stag performance in brackets).

Dates	Collection Attempts	Ease of Collection Score	Stress Score	Total Straws	Straws per Collection Attempt	Straws per Successful Collection Attempt	% Collections with No Straws
Mid to Late March	95	2.8 (2.0 to 3.0)	2.8 (1.8 to 3.0)	2308 (0 – 280)	24 (0 – 56)	62 (10 to 103)	61 (20 – 100)
Late April	19	2.5 (2.0 to 3.0)	2.6 (2.0 to 3.0)	637 (0 to 100)	34 (0 to 100)	49 (12 to 100)	32 (0 to 100%)
Late June – Early July	38	2.9 (2.5 – 3.0)	3.0 (3.0 – 3.0)	3581 (34 – 285)	94 (17 – 143)	99 (17 – 143)	5 (0 – 50)
All Dates	152	2.8 (2.3 to 3.0)	2.8 (2.1 to 3.0)	6526 (76 to 566)	43 (10 to 71)	76 (25 to 113)	43 (12 to 75)

Table 2: Semen production per collection in 2006 (Range in individual stag performance in brackets).

	Total Collections	Late Feb	Early-mid Mar	Late Mar	All Dates
Yearling Spiker (9 animals)	31 (2 to 4)	25 (13 to 36)	37 (19 to 56)	49 (10 to 143)	38 (16 to 64)
Two-year-old (6 animals)	17 (2 to 5)	136 (20 to 279)	111 (46 to 230)	72(60 to 103)	108 (89 to 201)
Mixed Age (7 animals)	13 (1 to 3)		173 (95 to 237)	129 (55 to 165)	142 (55 to 176)

evidence to support an increase in aversion behaviour during the collection period. On the contrary, stags were regularly backing into the collection crush with minimal assistance. This is interpreted to mean that stags did not find the repeated handling and collection of semen obnoxious. These results demonstrated that a team of stags could be easily and frequently handled for semen collection *per* electro-ejaculation at levels necessary for a large-scale commercial operation, without any apparent adverse behavioural outcomes.

A total of 6,526 straws of frozen semen were produced at an average of 43 per attempt at collection (Table 1). More straws were produced during collections in April compared with March (34 *vs*. 24 per attempt at collection, respectively). This was attributed to fewer unsuccessful collections (32 *vs*. 61%, respectively) rather than a higher yield in those animals with successful collections.

The production of straws during the autumn was much lower than the 70 expected and at the time was attributed to the level of experience of the operators, the stage of maturity of the animals and the stage of the breeding season. Mean straw production per attempt at collection was 94 during the winter, considerably higher than during the autumn. This increase over autumn performances was attributed to both a low proportion of unsuccessful collections (5%) and an increase in the straws produced from successful collections (99 *vs*. 49 in late April).

The increase in production of semen during the winter (post-rut) may be due to a number of factors including increasing sexual maturity of young animals and reduced incidences of natural ejaculation (Asher *et al*.2000). It may also relate to operator expertise.

Semen Production 2006

The specialist deer veterinarian employed for winter collections in 2004 carried out all collections in 2006. Semen was collected on 61 occasions from 22 animals of varying ages for a 6-week period during late February and March (Table 2). This semen was collected for Deer Improvement's own breeding programme where individual stags had a target number of straws to be produced. Viable semen was produced from late February in yearling stags ('spikers') and two-year-old animals (adult stags were not used in February). The mean number of straws per spiker collection almost doubled over this period (25 to 49 straws). Two-year-old animals produced high mean quantities of straws in late February (136) but these appeared to decline through March. The explanation for this apparent decline was that not all stags were collected on all occasions, and the decline reflects the performance of the lower yielding individual stags rather than a real biological decline. Mixed age animals were the most productive with individual stags producing from 55 to 237 straws at a collection. Commercial production of semen continued every 3 days during the AB season with considerably higher numbers of straws of fresh semen produced from older stags.

The semen production results in the autumn of 2006 for two-year-old animals was about twice as high as achieved in animals of the same age in 2004, and was higher than the average of 70 straws expected in 2004. In fact, the performance of spiker yearling animals in 2006 was not too dissimilar to the autumn performance of two-year-old animals in 2004.

It is difficult to be sure of the reasons for the higher performance in 2006 compared with 2004. Nonetheless, this high performance has continued with the specialist deer veterinarian, leading to our conclusion that this experience and specialisation is the most likely explanation.

The good performance of spikers is particularly heartening in a genetic improvement programme in that it allows a shortened generation interval and, therefore, faster genetic progress. This is particularly pertinent when the aim is to improve weight-for-age in that it allows animals with high-ranking yearling weights to be used during their first breeding season.

INSEMINATIONS AND PREGNANCIES

Pregnancy rates in hinds were determined using ultrasound from 5 to 8 weeks after AI. A total of 2,256 animals had insemination and pregnancy records in 2004. On average, each AB technician inseminated 188 hinds in 2004 (range 14 – 208 per technician) and the mean pregnancy rate was 67% (range 62%- 86%, Figure 1).

The pregnancy outcomes in 2004, although slightly lower than the mean of 74% reported for the 2002 season in over 2,000 adult red deer hinds (Rhodes *et al*, 2003), were highly acceptable for a number of reasons. First, all AB technicians were novices with deer AI and most had not handled deer at all until training. Second, most customers were also novices at deer AI and had accepted the commercial service at short notice (Deer Improvement was not formed until late 2003 and did not own any stags until January 2004. Contacts with customers did not take place until February 2004). Third, the team involved in semen collection and processing was not specialists with only moderate experience.

Nine of these AB technicians returned in 2005 and their performance in each year is shown in Figure 2. There is no relationship between technician performances in each of the two years.

Figure 1: Mean % pregnancy rate for 12 novice AB technicians in 2004 (Bars represent 95% confidence intervals).

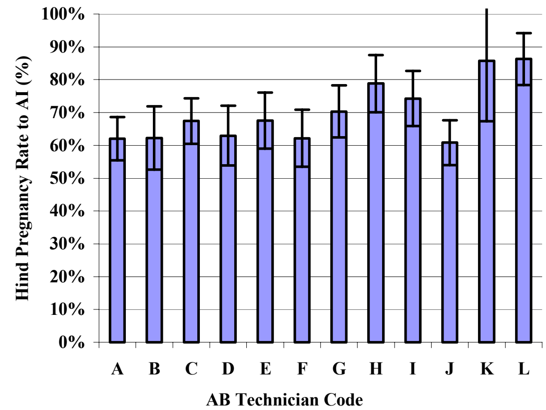
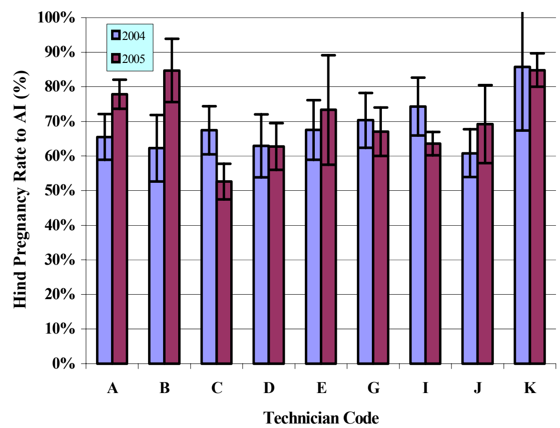


Figure 2: Mean % pregnancy rate for 9 AB technicians in each of 2004 and 2005 (Bars represent 95% confidence intervals).



Ease of Insemination and Pregnancy Rate

In order to understand the impact of ease of insemination on pregnancy outcomes, each technician scored their inseminations as a 1 (Difficult), 2 (Moderately Easy) or 3 (Easy) to pass the inseminator through the cervix during the 2004 to 2006 seasons.

The proportion of inseminations assessed as 'Very Easy' increased from 86% in 2004, to 92% in 2005 and reached 97% in 2006 (χ^2 = 58.7, P<0.001). Averaged over the 3 years, pregnancy rates progressively increased from 51% for 'Difficult' insemination to 57% for 'Moderately Easy' inseminations and 65% for Very Easy

Table 3: Pregnancy rates following inseminations classified as Difficult, Moderately Easy or Very Easy in 2004 to 2006.

	Difficult		Moderately Easy		Very Easy		All	
	N	% Pregnant	N	% Pregnant	N	% Pregnant	N	% Pregnant
2004	30	64	90	66	962	67	1116	66
2005	43	53	42	33	933	54	1018	53
2006	11	64	8	88	637	79	656	79
All Years	118	51	140	57	2532	65	2790	64

inseminations (Table 3, χ^2 = 12.9, P<0.001). This pattern was evident in each of the 3 years.

These results demonstrate, based on ease of passage through the cervix, that technicians are able to discriminate animals of differing fertility. It is not known if the differences in ease of passage are directly or biologically associated with fertility or the extra manipulation associated with difficult cervices leads to lower fertility.

Temperament and Pregnancy Rate

In order to understand the impact of temperament on pregnancy outcomes, each technician scored hind behaviour during insemination as a 1 (Difficult), 2 (Moderately Calm) or 3 (Calm) during the 2004 to 2006 seasons.

The proportion of hinds classified as 'Calm' was lowest in 2006 (83%), intermediate in 2004 (91%) and highest in 2005 (95%) (χ^2 = 58.8, P<0.001). Pooled across years pregnancy rates were not significantly affected by temperament scores (Table 4, χ^2 = 0.9, NS), although hinds with a 'Difficult' temperament in 2006 have lower pregnancy rates than 'Calm' hinds (68% *vs*. 79%, χ^2 = 3.9, P<0.05).

The relationship between temperament score and pregnancy outcomes is not straightforward, although the relationship can be expected to be weak in most years. This finding is not dissimilar to the situation in sucking beef cows in New Zealand where temperament score during AI had no relationship with pregnancy outcomes (Day, A.M. pers. comm.).

Order of Insemination and Pregnancy Outcomes

Inseminations commenced in each herd at about 50 hours after the end of synchrony treatment. The time of day of each insemination was recorded in several herds during the 2004 to 2006 seasons. Within each day of AB, hinds were classified as being inseminated during the first, second or third time periods of the AB visit. Depending on the elapsed time from the start to end of AB for each herd visit, a time period ranged from 1 hour (3-4 hour elapsed time) to 4 hours (12 hours elapsed time).

Approximately a third of the inseminations took place in each of the three time periods. The time period during which inseminations took place had no affect on pregnancy rates in 2004 and 2006. However, in 2005, inseminations taking place in the first and last time periods were less fertile than those in the second time period (47 *vs*. 50% *vs*. 64%, respectively, χ^2 = 23.6, P<0.001, Table 5).

The relationship between time period and pregnancy outcomes is not straightforward, although the relationship can be expected to be weak in most years. The collective data do not support a trend of reduced pregnancy rates over the duration of an AB visit to a herd. We have no explanation for the higher performance of inseminations carried out in the second time period in 2005.

Time of the Day of Insemination and Pregnancy Outcomes

Inseminations took place some time between 8 a.m. and 11 p.m. depending on the herd and the year. The time of day when at least some inseminations occurred in all years was between 2 p.m. and 8 p.m. when a total of 1672 inseminations took place. Overall, there was no difference in pregnancy rates for inseminations between 2 p.m. and 4 p.m., 4 p.m. and 6 p.m. and 6 p.m. and 8 p.m. (66% *vs*. 69% *vs*. 67%, χ^2 = 1.0, NS).

Within the limitations of this data, pregnancy rates of hinds appear independent of time of day at

Table 4: Pregnancy rates following inseminations with hind temperament classified as Difficult, Moderately Calm or Calm.

	Difficult		Moderately Calm		Calm		All	
	N	%	N	%	N	%	N	%
2004	9	68	87	70	1010	79	1116	69
2005	25	69	35	60	963	53	1018	64
2006	69	68	57	70	609	79	735	64
All Years	107	69	179	64	2582	64	2868	64

Table 5: Pregnancy rates following the first, second and third time periods of insemination.

	First Period		Second Period		Third Period		All	
	N	%	N	%	N	%	N	%
2004	312	63	363	61	303	63	978	62
2005	344	47	350	64	311	50	1005	54
2006	232	81	225	80	196	78	653	80
All Years	888	61	938	67	810	62	2636	63

insemination and a reasonably wide interval exists (at least 6 hours and probably 12 hours) over which so-called fixed-time inseminations can take place without compromising fertility.

Post-Thawing Percentage Live Sperm and Pregnancy Outcomes

Batches of previously frozen semen were assessed for the proportion of live sperm after thawing in water in 35 °Celsius during AB from 2004 to 2006. This data were then used to determine the relationship between the percentage of live sperm and pregnancy outcomes.

Fifty seven percent of the batches in 2004 were in the 40% to 50% live sperm range with an additional 30% of the batches above 50% live sperm. Pregnancy rate showed a non-significant increase with increasing percentages of live sperm (64% *vs*. 67% *vs*. 71%, χ^2 = 1.9, NS, Table 6).

In 2005, similar proportions of semen were in the two higher categories (47% and 50%, respectively). There was no significant relationship between the increasing levels of percentage of live sperm and pregnancy rate (40% *vs*. 66% *vs*. 58%, χ^2 = 3.6, NS, Table 6).

All semen was above 40% live sperm in 2006, and again there was no relationship between the increasing levels of percentage of live sperm and pregnancy rate (79% *vs*. 81%, χ^2 = 0.1, NS, Table 6).

In general, it appears that there is no consistent relationship between semen quality as assessed by the percentage of live sperm after thawing and pregnancy outcomes. This may be explained by the fact that high doses of semen were used in the current study (30 to 40 million sperm straw), and that the proportion of live sperm at insemination was not limiting fertility. We would expect that if the dose rates were much lower as in cattle straws (12 to 20 million), then the total number of live sperm could well become limiting at lower levels of percentage of live sperm. With time, we would expect that dose rates would need to fall for deer in order to allow the wider usage of smaller teams of elite stags, much as occurs in the dairy industry.

DEVELOPMENT OF AN OESTRUS-SYNCHRONY DEVICE

Oestrous synchronisation and fixed time AI is essential in deer since, unlike many other species of farmed livestock, they do not exhibit easily recognisable signs of oestrus (Fennessy *et al*., 1990; Asher *et al*., 1993). Current protocols are based on treatment with progesterone followed by a gonadotrophin. In practice, at least in New Zealand, red deer are treated with a progesterone-impregnated intra-vaginal device designed for sheep and goats (two devices are required) and a low dose rate of equine chorionic gonadotrophin is injected at device removal (Asher *et al*., 2000). Two devices are required because the surface area of one device is not sufficient to maintain levels of circulating progesterone at luteal levels (Fisher *et al*., 1989). It is particularly important that high levels are maintained to the end of treatment in a high proportion of animals, otherwise fertility may be compromised.

Deer Improvement has undertaken the development of a red deer-specific progesterone impregnated device to replace the need for the two devices currently used. A prototype device, similar to, but larger than, the current sheep device, has been developed. The surface area of the prototype is estimated at 3 times the area of a single sheep device. This was expected to result in high levels of circulating progesterone at the end of treatment.

On the 10th March 2006, 36 entire mixed-aged hinds were allocated at random to receive either a prototype device (N=15 hinds), two CIDR-G sheep devices (one inserted for 8 days and a second for 4 days, N=15 hinds); or a single pod from a Cue-Mate device (N=6 hinds). Animals were bled immediately prior to insertion of a device, and then 1, 4, 8, 9, 11, 12 and 13 days later. All devices were removed 12 days after insertion. Progesterone levels were determined using an ELISA assay.

The onset of heat was determined in the presence of entire stags by continuous observation from 24 to 72 hours after device removal. The interval from device removal to heat onset in individual hinds was estimated as the time difference from a standard removal time (2 p.m.) until the actual time of first standing oestrus.

Table 6: Pregnancy rates (%) for batches of semen assessed at three levels of percentage live sperm after thawing.

	Up to 35%		40% to 50%		Above 50%		All	
	N	%	N	%	N	%	N	%
2004	121	64	504	67	263	71	888	68
2005	10	40	193	66	204	58	407	62
2006	-	-	214	79	429	81	643	80

Table 7: Mean, shortest and longest intervals (h) from the end of treatment to the onset of heat.

	Number of Animals	Mean ± s.e. Interval to Onset of Heat (h)	Shortest and Longest Intervals (h)
CIDR-G (8-day + 4-day)	15	46 ± 1.7	36 to 57
Deer Prototype	15	45 ± 2.2	34 to 58
Cue-Mate Pod	6	50 ± 3.5	38 to 64
Total	36	47 ± 1.3	34 to 64

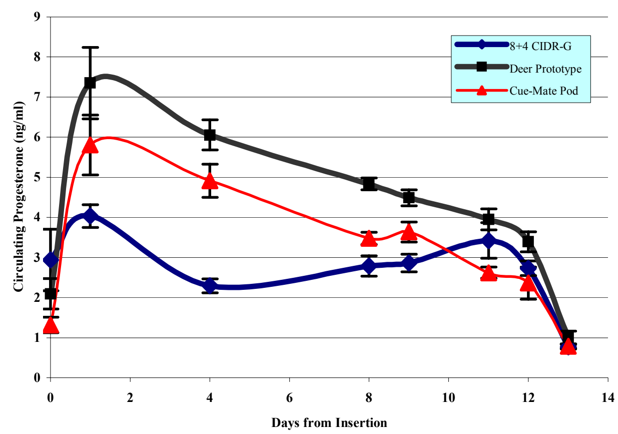
Circulating progesterone levels during treatment

Circulating progesterone levels for all three devices peaked within 24 hours of insertion (Figure 3). In hinds treated with the prototype and the pod devices these levels then declined in a linear manner until removal (decrease of 0.34 and 0.32 ng/mL per day, respectively, P<0.001). In contrast, hinds treated with the CIDR-G devices had declining levels until Day 4 and then levels varied between 2.7 and 3.4 ng/mL until device removal. At removal, levels were higher in hinds treated with the prototype but were similar in CIDR-G and Pod groups (3.4 *vs*. 2.7 *vs*. 2.4 ng/mL, respectively, P<0.05). Within 24 hours of removal, mean levels of circulating progesterone were at similarly low levels in all three groups of hinds (<1.0 ng/mL). In general, the correlation between circulating progesterone levels prior to insertion and each subsequent sampling date was low (typically <0.3). The correlation between peak circulating levels and each subsequent sampling date was similarly low. Although the mean level of circulating progesterone at device removal was higher in hinds treated with the prototype compared to the CIDR-G, they were also more variable (0.96 *vs*. 0.69 standard deviations). As a result, modelling using expected normal distribution show that the expected proportion of hinds with less than 1 ng/mL at device removal is similar at 1% in both groups. The expected difference between the two groups in the proportion of hinds with less than 1.5 ng/mL at device removal is still minor at 1.2% more of the CIDR-G treated animals.

Heat onset in treated animals

Only two hinds were not recorded in heat during the period of heat observation (1 from the prototype and 1 from the CIDR-G group). The overall mean interval to the onset of heat was 47 hours and was similar in the 3 groups of treated animals (Table 7). The shortest interval to the onset of heat was between 34 and 38 hours, and the longest interval between 57 and 64 hours depending on treatment.

Figure 3: Circulating levels of progesterone in ovariectomised deer treated with a sheep device for 8 days with replacement for a further 4 days (8+4 CIDR-G), deer prototype device (12 days) and a single Cue-Mate pod (12 days).



Pregnancy rate following synchronisation with the prototype device

A total of 588 hinds in 3 herds were treated with prototype devices and inseminated in the autumn of 2006. As a result of a misunderstanding, no control animals were treated. A total of 581 inseminated hinds were subjected to ultrasound scanning about 6-weeks later to determine pregnancy status, and 394 of these (68%) were pregnant to AI (Table 8). There was no difference in pregnancy rates amongst the 3 herds (67% *vs*. 67% *vs*. 78%, χ^2 = 1.7, NS, Table 8).

EARLY SEASON AI

One hundred and fifty four yearling hinds were treated with either two concurrent CIDR-G devices (N=78) or a single prototype device (N=76) for 12 days. In addition, 100 rising 3-year old hinds that had not reared fawns were allocated to the same groups (N=50 per group). Fixed time inseminations were undertaken on the 24-25th February 2007 starting 50 hours after the end of treatment. Pregnancies were determined by ultrasound scanning at 6-weeks after AI.

Table 8: Pregnancy rate to AI following treatment with a prototype device in three herds[1].

Farm	Number of Animals	Pregnancy Rate to AI (%)
Farm 1	350	67
Farm 2 - Herd 1	186	67
Farm 2 – Herd 2	45	78
Total	581	68

[1]Farm 1: Three-year-old hinds and hinds that did not hold to AI in 2005; Farm 2 – Herd 1: AI on the 23 Mar, herd management was poor; Farm 2 – Herd 2: AI was 2 weeks later and hinds were better managed
Although no control animals were used for comparison, the 68% pregnancy rate to a fixed time AI in animals treated with the prototype device is considered satisfactory.

Table 9: Effect of synchrony treatment on % pregnancy rate in yearling and rising 3-year-old hinds.

Age Group	Treatment	Number of Animals	Scanned Pregnant (%)
Yearling	CIDR-G	78	50
Yearling	Prototype	76	49
Yearling	Total	154	49
Rising 3-year-old	CIDR-G	50	34
Rising 3-year-old	Prototype	50	38
Rising 3-year-old	Total	100	36

The overall pregnancy rate in yearling hinds was 49% with no difference between the synchrony treatments (Table 9). Pregnancy rates were lower in the older hinds (36%, χ^2 = 3.9, P<0.05, Table 9), with no treatment difference.

These results demonstrate for the first time that late February AI in yearling hinds can yield satisfactory pregnancy rates using either the existing or prototype device. These earlier pregnancies would result in calving dates at least 4 weeks earlier compared to first matings in natural cycling yearlings. In turn, the live weights of the earlier-born progeny are expected to be heavier on any given date. A conservative increase in carcass value of 10% is expected from our modelling of the financial impacts (McMillan, unpublished). Although there may be potential carryover benefits to hind reproduction (*e.g.* early AI performance the following season) or reproduction in their offspring (*e.g.* earlier puberty), these are yet to be determined. The result in yearling hinds points to the possibility of using this high genetic merit age group to provide AI-sourced stags for natural mating within herds.

We have no explanation for the lower result in the older hinds but such a result would be commercially unappealing.

SUMMARY AND CONCLUSIONS

Experienced bovine AB technicians can be readily trained on less than a dozen animals to perform trans-cervical AI in red deer. Given the requirement for a small left hand and forearm, most successful trainees will be female. With a national resource of several hundred females trained in bovine AI, it is unlikely that the availability of AB technicians will limit the widespread use of AI in the New Zealand red deer industry.

These results demonstrate that red deer stags of all ages can be routinely subjected to electro-ejaculation (with or without sedation or anaesthesia) at 5-10 day intervals for at least a dozen times without apparent adverse effects on stag welfare or behaviour. Other results with regular collections of fresh liquid semen at 3-day intervals also support these findings (S. O'Sullivan, unpublished results).

Reasonable quantities of semen can be produced in yearling spiker and two-year-old stags as early as February. The result with spikers is particularly pertinent in that it allows animals with high-ranking yearling weights to be used during their first breeding season. By using such young stags, the generation interval is reduced and thus faster genetic gain is facilitated.

In the hands of experienced specialist operators, two-year-old and older stags are capable of reliably producing commercial volumes of semen from late February through until mid-late winter. In particular, fresh rather than frozen-thawed semen can be successfully produced during the commercial AI season (late Match to mid-April). We conclude, therefore that semen production need not be a factor limiting large-scale commercial AI in New Zealand red deer.

Highly experienced bovine AB technicians are capable of achieving acceptable pregnancy rates from their first year. Although factors such as ease of insemination, hind temperament, semen quality, AB technician and age of hind can influence pregnancy rates, unknown herd factors are the major source of variation in pregnancy rates. Compliance with recommended hind preparation protocols (*e.g.* O'Sullivan, 2006; Rhodes *et al.*,

2003) will go some way to reducing herd-to-herd variation.

Yearling hinds are capable of acceptable pregnancy rates when inseminated in late February, at least a month earlier than is current practice. Whether other age groups are capable of acceptable early conception performance and the size and impact of carry-over effects in subsequent seasons is yet to be determined. One benefit of earlier conception is heavier offspring earlier in the season. The result in yearling hinds points to the possibility of using this age group to provide stags for natural mating within herds.

A deer-specific intra-vaginal progesterone-releasing device has been shown to provide higher terminal levels of circulating progesterone compared with existing devices. Although acceptable pregnancy rates have been achieved, the comparative performance of this device will be known during the 2007 season.

In conclusion, the genetic and reproductive technologies for advancing weight-for-age in deer are now being successfully integrated and applied to commercial red deer in New Zealand.

ACKNOWLEDGEMENTS

The staff and management of the following are especially acknowledged: Deer Improvement Ltd (particularly Sean O'Sullivan); AgResearch Invermay (especially Ian Scott and the staff of the deer farms); Animal Breeding Services Ltd; Mike Bringans Consulting Ltd.

REFERENCES

Archer, J.A.; McEwan, J.C.; Hall, R. 2007: Genetic technologies for deer breeding. *Proceedings of the New Zealand Society of Animal Production* **67**: 91-94.

Asher, G.W.; Fisher, M.W.; Fennessy, P.F.; Mackintosh, C.G.; Jabbour, H.N.; Morrow, C.J. 1993: Oestrous synchronization, semen collection and artificial insemination of farmed red deer (*Cervus elaphus*) and fallow deer (*Dama dama*). *Animal Reproduction Science* **33**: 241-265.

Asher, G.W.; Berg, D.K.; Evans, G. 2000: Storage of semen and artificial insemination in deer. *Animal Reproduction Science* **62**: 195-211.

Fennessy, P.F.; Mackintosh, C.G.; Shackell, G.H. 1990: Artificial insemination of farmed red deer (*Cervus elaphus*). *Animal Production* **51**: 613-621.

Chardon, J. 2007: Genetic gain. *Proceedings of the New Zealand Veterinary Large Animal Convention 2007*: In press.

Fisher, M.W.; Fennessy, P.F.; Davis. G.H. 1989: A note on the induction of ovulation in lactating red deer hinds prior to the breeding season. *Animal Production* **49**: 134-138.

Harris, B.; Pryce, J.E.; Montgomery, W.A. 2007: Experiences from breeding for economic efficiency in dairy cattle in New Zealand. *Proceedings Australasian Association of Animal Breeders*: In press.

O'Sullivan, S. 2006: Deer Improvement – Breeding Hind Mating Management, 2006. Unpublished booklet.

Rhodes, L.; Pearse, A.J.T.; Asher, G.W. 2003: Approaches in developing a successful trans-cervical AI programme for farmed deer. *Proceedings of the New Zealand Society of Animal Production* **63**: 258-261.