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# Advancing calving date in New Zealand venison systems

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# Client Report

**Report prepared for DEEResearch**

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Advancing calving date in New Zealand venison systems

**February 2008**

**W.M. Griffiths, D.R. Stevens, J.A. Archer, G.W. Asher, R.P. Littlejohn**

**AgResearch Ltd**

## Disclaimer

### Client Report



Inquiries or requests to:

Wendy Griffiths or Jason Archer
wendy.griffiths@agresearch.co.nz or jason.archer@agresearch.co.nz
Agricultural Systems
AgResearch – Invermay Agricultural Centre
Private Bag 50034, Mosgiel, New Zealand

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## Summary

A major goal of the venison industry is to extend the shoulders of the current export chilled venison trade and to shift the supply from 47% to 65% over the August-December period. Supplying chilled venison earlier than the current season will require animals to be at kill weights in July/August and necessitate early calving combined with high growth rates to achieve kill weights at appropriate times.

Four key drivers that offer potential to advance conception and calving date have been identified from research spanning 15 years. However, it is relatively unknown if these drivers interact to influence calving date in an integrated farm systems context. These four drivers were;

1. Nutrition and management of the hind around weaning
2. Early introduction of a rutting stag
3. Nutrition of the hind in the third trimester of pregnancy
4. Genetics

A three year project was setup on a) AgResearch Winchmore deer unit, Ashburton to investigate interactions between management practices (drivers 1-3) on conception and calving date and b) Stanfield's Bushey Park, Palmerston to evaluate the role of genetics (driver 4) on conception date.

The treatments imposed in the Winchmore study were a factorial of 1) stag joining date in mid-late January, 2) early-February or mid-March weaning date and 3) high and medium planes of nutrition during lactation and around weaning, and again during the last trimester of pregnancy. High and medium were arbitrarily defined where medium represented the typical industry practices and high an enhanced plane of nutrition.

Across the three years there was no consistent effect of the treatment combinations on conception date. In Year 2, the practice of weaning calves in mid-March advanced hind conception date by approximately 3 days. However, in Year 3 the reverse held true and the practice of weaning in early February advanced day of conception by around 3 days. There was evidence that the enhanced plane of nutrition around weaning increased mean hind live weight but at a treatment level this did not translate to advances in conception date. In Years 1 and 2 individual hind live weight was well correlated with conception date. For example, in Year 2 there was a 6-7 day difference in conception date between a 90 kg and 130 kg hind, and when combined with late weaning practices this advantage extended to advanced conception dates of 9.4 days. DNA breed composition data revealed that hind genetics accounted for approximately 5 days of the observed advance in conception date. The breed composition of hinds (Eastern v English v Wapiti) was estimated using a limited range of DNA markers, and the 5-day difference, while showing a clear role for genetics in early calving, probably under-estimated the real breed differences (due to the imprecise measure of breed composition).

The intensive monitoring of hind live weight showed that there was a repeatable pattern of live weight loss following weaning for both early- and late-weaned hinds. Late-weaned hinds (mid-March) invariably did not regain their pre-weaning weight before the onset of winter. It was beyond this programme of research to determine the reason/s for the consistent post-weaning live weight loss and, therefore, clarification of the impact of the weaning process on reproductive performance.

There was no evidence that within the range of nutrition offered to hinds during the third trimester of pregnancy that the nutrition regimen influenced calving date. This probably reflected the absence of any change in hind live weight during late-pregnancy in response to nutritional status. There was evidence for a strong relationship between conception date and gestation length suggesting that gestation length is not entirely genetically controlled and is influenced by environmental factors. The push/pull phenomenon was evident with early- and late-conceiving hinds exhibiting longer and shorter gestation lengths respectively. For every 10 day advance in conception date calving date would be advanced by around 6 days or less. There was consistent evidence of a carry-over effect of nutritional feeding regimens during lactation on gestation length and thus calving date. This finding suggests that the nutritional status during lactation was a modifier of gestation length possibly through foetal growth as the driver. Evolutionary selection pressures have produced red deer that optimise their reproductive performance under their native northern hemisphere environment with the consequence being that there is some detraction from any gain in conception date to optimise calving date, or possibly birth weight, and this holds true in the southern hemisphere where selection pressures have yet to be sufficient to instigate any adaptation to New Zealand’s environment.

Although the nutritional regimens implemented during lactation did not impact on conception date at a treatment level, calf growth rates while suckling were significantly higher when the paired dam was grazing an enhanced plane of nutrition. Combined with the finding of a carry-over effect of nutrition during lactation on calving date it can be concluded from this research programme that nutrition during lactation is an important component of the management of red deer hinds and their calves to advance calving date and meet the industry’s goal of turning-out heavier weaners earlier.

The work undertaken on Stanfields’ Bushey Park demonstrated that the conception date for Eastern hinds (mated to Eastern stags) was 13 days earlier than that of English hinds (mated to English stags). It should be noted that this effect possibly under-expressed the real genotype differences as the Eastern stags were not joined with hinds until early-mid March. There were some indications that the driver of reproductive seasonality was the timing of female cyclicity as opposed to a ‘stag’ effect. This was supported by the absence of any clear effect from the joining date of a rutting stag on conception date in the Winchmore study.

The outcomes of the present studies indicate that management practices of early stag introduction, early weaning and enhanced hind nutrition around weaning and during late-pregnancy have minimal effect (<5 days) on advancing conception date and calving date in red deer hinds on well managed farms (i.e. where nutrition and weaning practices already meet industry standards, further gains through enhanced practices are unlikely, although in situations where hinds are under-fed a greater advancement may be achieved). Where management practices are already providing adequate nutrition, the most significant gains in calving date are likely to be achieved through herd genetics, with the Eastern genotypes offering significant opportunities to advance conception and calving date.

# 1.0 Introduction

New Zealand is the largest producer of farmed venison (50-55% of the world's traded product; I. Moffatt pers.com.), with much of the product exported to European markets. Premium prices for chilled product in Europe for animals of 50-65 kg carcass weight are attained during September-October, coinciding with the traditional European game season. Returns for frozen product or animals over the desired carcass weight are most notably lower within these markets. The industry remains committed to developing new markets to reduce the reliance on the highly seasonal European sector, and widening the shoulders of demand to enable New Zealand producers the opportunity of supplying premium quality product over a wider period. However, a high level of seasonality of demand and supply is likely to be a feature of our venison production systems for the foreseeable future. The challenge for the industry is to improve the biological productivity of farmed deer to enable a greater proportion of venison to be supplied as chilled product during the peak demand period. It has been stated on many occasions that one of the key opportunities for improving the supply of young stags in spring/early summer (8-11 months of age) is to advance the average calving date by 3-4 weeks to better align the feed demands of the hind during lactation with the grass production cycle, and provide greater opportunity for calf growth prior to seasonal peaks in schedule and market demand.

Reproductive function in temperate species of deer is strongly influenced by photoperiod. The mainstay of the national herd is the European Red deer (*Cervus elaphus scoticus, hippelaphus*) and the North American Wapiti (*C.e. nelsoni, roosevelti, manitobensis*). These subspecies all originate from northern cool-temperate regions and exhibit highly seasonal patterns of autumn conceptions and summer calving (Lincoln and Guinness, 1973) that reflects an adaptation to match nutritional requirements with seasonal forage abundance and quality to ensure reproductive success (Lincoln and Short, 1980). In New Zealand calving typically begins in mid-November and continues through until mid-late December. Summer calving in the predominantly pastoral environment of deer farms results in a poor alignment between the nutritional demands of lactation with seasonal nutrient supply as peak lactation coincides when quality (energy value) of traditional ryegrass/white clover pastures are at their seasonal lowest. This potentially decreases calf growth performance within the first three months of life and, combined with the subsequent pronounced seasonality of growth rates within their first year, presents considerable challenges to the industry for producing product that meets target weight to secure premiums in a timely and efficient manner.

The reduced returns and production efficiency from animals carried through a second winter was widely recognised some 15 years ago. A number of initiatives have focused on achieving greater weaner growth responses and these have included cross-breeding (particularly wapiti x red deer) to achieve higher birth weights and weaner growth rates, supply of particular special-purpose forages (e.g. chicory, sulla) over lactation, melatonin implants in hinds to artificially advance conception/calving dates, and attempts to introgress alternative cervid genotypes (e.g. Pere David's deer and Sambar deer). However, none of these strategies have provided the silver bullet and the venison industry fails to keep abreast with the productivity gains achieved in other livestock industries (Pearse and Fung, 2007).

The 'Holy Grail' of the New Zealand deer farming industry and deer researchers has always been to advance the average calving date of hinds to better align feed supply and lactation demand (Matthews *et al*., 1999). Data summarised by Stevens and Corson (2003) on the inter-relationships between weaner growth rate and calving date on achieving 'heavier weaners earlier' showed very clearly that achieving earlier calving within the national herd will be pivotal to increasing production efficiency. It would also better align the nutritional demands of lactation with pasture quality and availability, improving forage utilisation, and in doing so offer a longer window of opportunity to meet the premium weight.

Following a review of the research literature, four key drivers were identified as offering potential to advance calving date of farmed red deer. The supporting background for the four drivers will be briefly discussed below.

1. Nutrition and management of the hind around weaning

   It is widely acknowledged in all livestock industries that the nutritional demand of lactation places considerable stress on the dams' body resources. Beatson *et al.* (2000) summarising data collated as part of the DeerMaster programme found that hind condition, specifically body condition score prior to mating had the largest single effect on reproductive success. Hinds displaying a body condition score of <3 were found to have later conception dates than those with higher score (Beatson *et al.*, 2000). This highlights the importance of offering hinds a good allowance of a high energy diet during lactation.

   The practice of early weaning has been a further strategy to enhance the opportunity to prime or 'flush' the hind (i.e. increase live weight and body condition score) prior to mating. Data collected from a study on six Otago/Southland deer farms (Pollard *et al.*, 2002) showed that the mean conception date was 12 days earlier (28 March v 10 April) when hinds were pre-rut (11 March) compared with post-rut weaned (30 May). Most farms currently practice pre-rut weaning but can further opportunities be captured by shifting the date of weaning forward to February?

2. Early introduction of a roaring stag

   Clearly the timing of stag introduction will have an impact on conception date. Early work by Moore and Cowie (1986) reported that vasectomised (infertile but sexually active) stags introduced to hinds in early March could advance oestrus by up to 6 days. Likewise McComb (1987) showed that hinds exposed to 'roaring' vocalisations calved earlier than a control group. However, February mating practices have not been found to consistently advance conception date suggesting that red stags may be sub-fertile or disinclined to mate at that time (Moore and Cowie, 1986). Melatonin, a natural hormone that, if delivered artificially, alters endocrine responses entrained to photoperiod in red deer stags and can advance the sexual season by at least a month (Lincoln *et al.*, 1984). Studies by Fisher and Fennessy (1990) and Fisher *et al.* (1995) showed that the presence of an early rutting stag can influence hind cyclic activity and timing of onset of the breeding season in hinds.

3. Nutrition of the hind in the third trimester of pregnancy

   Across the sheep and cattle industries there has been considerable effort targeting late-pregnancy nutrition as foetal development appears strongly related to dam nutrition. Under conditions of nutritional deprivation sheep and cattle are known to decrease gestation length. However, work by Asher *et al.* (2005) reported the opposite with red deer. In this study, Asher and colleagues found that hinds on a high plane of nutrition reduced gestation length, calving on average 8 days earlier than cohorts on a restricted diet. This raised the concept that gestation length is not a genetic absolute, and that environmental factors may play a strong role in calving date beyond the influence of conception date. Specifically, improved nutrition to hinds during the third trimester of pregnancy may improve foetal growth rate and promote earlier parturition.

4. Genetics

   Red deer of Western European origin (e.g. *C.e. scoticus*) are the principle founding subspecies of the national herd but could it be that these subspecies are constraining the growth and efficiency within the venison industry. Anecdotal reports from within the industry have raised the possibility that red deer of Eastern European descent (e.g. imports from Hungary and Romania; *C.e. hippelaphus*) may exhibit significant physical and behavioural differences that offer promise of earlier calving. Furthermore, anecdotal comments suggest that some herds with predominantly Eastern hinds have a reputation for achieving earlier calving.

Despite the evidence that the above four drivers may be influential in advancing mean calving date it is important to note that these drivers have been studied in isolation (i.e. reductionist research) and it is unknown how they function in an integrated farm systems context. Are the effects additive or do complementary interactions exist?

This report documents the results of a three year project set up on a) AgResearch Winchmore deer unit to investigate interactions between management practices (drivers 1-3) both within and between years on conception and calving date, and b) Stanfield's Bushey Park to evaluate the role of genetics (driver 4) on conception date.

# 2.0 The influence of stag joining date, nutrition during lactation and weaning date on time of conception

## 2.1 Materials and Methods

### 2.1.1 Treatments

In this section we detail the experimental programme carried out during 2004-2007 on the AgResearch Winchmore deer unit, a 50 ha property located 12 km north of Ashburton in mid-Canterbury (43$^0$ 50' S 171$^0$ 45'E).

A group of 215 in-calf mixed-age hinds were sourced in August 2004 from the herd at AgResearch Winchmore. The hinds had been mated to wapiti-cross and red deer stags during the 2004 mating. Pedigree analysis following calving in January 2005 revealed that calf genotype was approximately 66% wapiti-cross and 34% red deer. In January 2005 dry hinds were removed from the group leaving a group of 202 hinds for experimental work.

The experimental treatments were structured from a randomised factorial design of 3 factors by 2 levels. The three factors evaluated over the period mid-late January to mid-June were;

1. Introduction of a melatonin-treated rutting red deer stag. The stag was introduced in mid-late January to half of the hinds and removed at the joining of the sire stag (untreated) in March (stag effect)
2. Arbitrarily defined high and medium levels of nutrition (nutrition effect)
3. Early February compared with mid-March weaning date (weaning effect)

For ease of farm management hinds were assigned randomly to one of four groups (stag x nutrition) of approximately 50 hinds balanced for preceding calving date (obtained from 2004 calving records) with the ethical restriction that any calf born after 1 December was assigned to a late weaning treatment. Hinds remained in the same treatment for the duration of the three year programme subject to the above restriction. Approximately half of the hinds in each group were weaned at each of the two prescribed weaning dates (1 February and 15 March) (Figure 1). From January 2006 all hinds set-stocked at calving in the preceding year remained in the experiment irrespective of lactation status.

At the time of set-stocking hinds for calving in October 2006 a random check on hind condition revealed considerable variation in hind dentition. Poor dentition was not correlated with age and the general level of wear possibly reflects, in part, the Lismore stoney loam soil type on the Winchmore unit. Nonetheless, to ensure that the project met animal ethical obligations and to remove risk of loss should the region be hit by a severe snowstorm as it was in 2006, a decision was made that animals with marginal dentition would be culled from the experimental programme. Hind numbers were subsequently reduced to 135 and the stag effect was removed for the final year (Year 3) of the study. All experimental work was pre-approved by the AgResearch's Invermay Animal Ethics Committee.

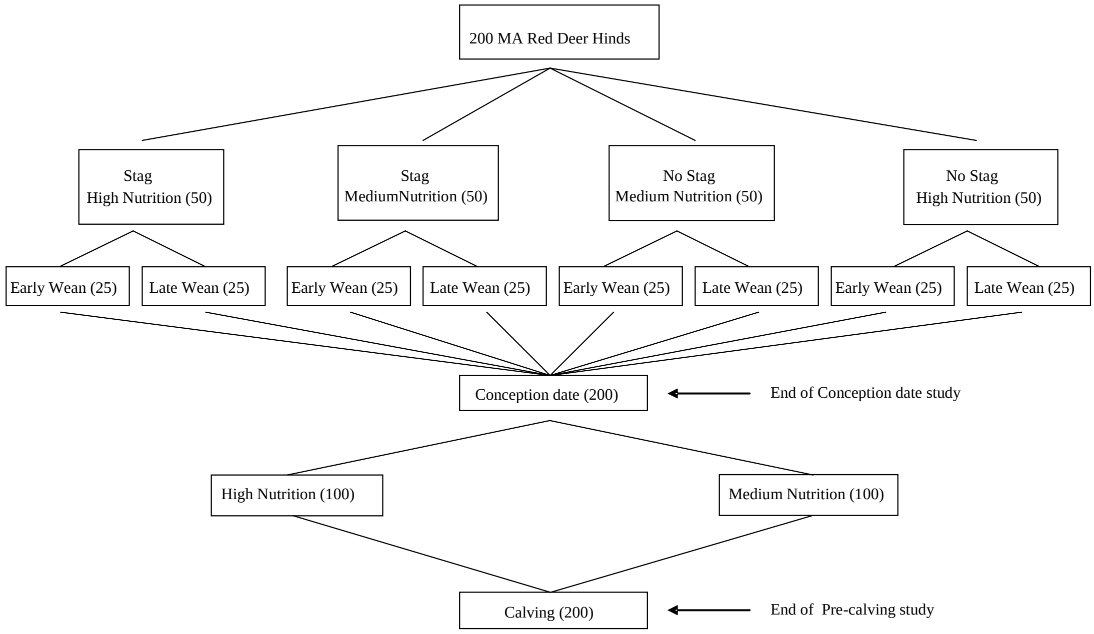


**Figure 1:** Experimental treatment design for evaluating the effect of stag joining date, lactation nutrition around time of weaning, and weaning date on conception date, and late-pregnancy nutrition on calving date.

### 2.1.2 Hind Calf parentage

All hinds and calves were yarded in early January of each year. Hair samples for DNA profiles were collected from all hinds in January 2005 by the pluck method; grasping the hair between thumb and forefinger. As there was uncertainty regarding the success of acquiring DNA from hair follicles from young animals, DNA was collected from each calf via a blood sample. Hair samples were collected in each year from the stags treated with melatonin at the time of the first implant and also from the sire stags following stag removal from each group in mid-May. The DNA profiles allowed for calves to be matched with dams (Tate *et al.*, 1998), and the hind profiles were also later used in evaluating hind breed composition.

### 2.1.3 Hind and calf monitoring

All hinds were weighed and assessed for body condition fortnightly from mid-late January until mid-June. Hinds were condition scored on a scale of 1 (low) to 5 (high) (Audige *et al.*, 1998). The regular live weight assessment enabled fine-tuning of the nutritional regimens (2.1.4) with the objective to achieve a minimum 5 kg contrast in mean hind live weight.

To facilitate the early weaning of calves, all hinds and calves were supplemented with barley (100 g/hind and calf pair daily) during the period mid-late January to early February. Following weaning, calves were grazed on good quality pasture and supplemented with barley as and when required, depending on pasture availability and quality at the time.

Calves were weighed every fortnight to monitor live weight change from mid-late January until time of weaning. At weaning the management of the calves was handed back to the farm. However, following 1 February the early weaned calves continued to be weighed fortnightly until 15 March to ensure the welfare of these animals was met. No contingency plans were activated in any of the three years. All calves were drenched at weaning and the early-wean calves received a second drench at the same time as the late-wean calves. Calves were vaccinated against Yersinia in early March.

### 2.1.4 Nutrition over lactation

The differential feeding period over lactation was initiated in mid-late January and continued until mid-March except for Year 3 when the regimens ceased in early-March. Two nutritional regimens were established to provide arbitrarily defined high and medium planes of nutrition. Two high plane and two medium plane groups were needed during this period to enable relative isolation of the early-stag and no (late) stag groups. All efforts were made to maintain as similar as possible nutritional regimens within both groups of the high and the medium plane treatments. The objective of the differential feeding regimens was to achieve a 5 kg contrast in mean hind live weight between the two nutritional regimens.

Regimens were designed around three concepts. The first was altering the availability of pasture by offering different amounts of feed to the hinds, as determined by pre-grazing herbage mass. The second was altering the feed quality that was offered to each group. These two methods were achieved through adoption of a leader-follower system of grazing so that the medium plane groups grazed the residual of the high plane group. Groups on the high plane of nutrition were offered pastures with pre-grazing covers between 2500 and 2800 kg DM/ha and shifted when pasture covers fell below 1800 kg DM/ha. The groups on the medium plane of nutrition grazed the covers down to approximately 1000 kg DM/ha. On average, hind and calf groups were shifted every two weeks. The third method was daily supplementation of barley to the high plane group. As previously stated hinds and calves were supplemented with barley between mid-January and early February to facilitate with the early weaning of calves. In Years 1 and 2, from early February until mid-March hinds on the high plane treatments received additional supplementation at 400 g barley/hind and calf pair per day. In Year 3 the corresponding quantity was 500 g barley/hind and calf pair per day.

Pasture cover was recorded pre- and post-grazing using a rising plate meter (Farmworks Electronic Plate Meter, Farmworks Ltd, Fielding, NZ) using the equation pasture cover = 200 + 159 x compressed height (cm). Samples of the herbage pre- and post-grazing were cut to ground level to determine pasture quality and composition. Pasture mass was visually monitored twice a week to assist decisions on when to shift the groups to new pasture. Pasture composition was determined by dissection of an approximately 400-piece sample into grass leaf, clover and dead matter, dried at 90°C and relative proportions determined by dry weight. Pasture quality was assessed by near infra-red reflectance spectroscopy and included acid detergent fibre (ADF), neutral detergent fibre (NDF), soluble sugars and starch (SSS), crude protein (CP), organic matter digestibility (OMD) and metabolisable Energy (ME).

### 2.1.5 Melatonin stag implants

To assess whether the introduction of a rutting stag would evoke early ovulation in hinds, a rutting stag was joined with two of the four treatment groups in mid-late January. Stags were induced into an advanced rut by the use of strategic melatonin implants (Regulin: Schering, Alexandria, Australia). From mid-October each stag received two implants (2 x 18 mg melatonin) each month for three months in Year 1, and in Year 2, from early October, 3 implants each month for five months. The stag treatment effect was not imposed in Year 3 due to hind availability (see 2.1.1). Stags were removed in early-mid March when one sire stag was joined with each group (approximately 1:50 single-sire mating ratio). In total four stags were selected for implantation so that a rotation policy could be applied and that at any one time two stags were with hind groups and two were resting in reserve. Stags were rotated on weeks three and five following joining. A different group of red deer stags were sourced each year owing to the long-term disruption by prior melatonin treatment to their subsequent reproductive activity and influence on velvet production (particularly noticeable with the timing of casting). The two groups of hinds joined with implanted stags and the two stags in reserve at any point in time were managed at one end of the farm (>350m separation) to minimise as much as possible social facilitation with the no-stag groups. Paddocks were also carefully selected to ensure welfare considerations (particularly water and shelter) were meet as the rut behaviour infringes on stag body condition, and the advancement of the rut coincided with the peak of the hot summer period.

Rutting behaviour for each of the four stags was assessed for 5 minutes each morning and evening on four occasions, two weeks apart. Stags were monitored for the number of roars over a 1-minute period and comments noted on other behaviours indicative of the rut (e.g. herding behaviour).

### 2.1.6 Sire stags

One breeding (sire) stag was joined with each group of hinds at an approximate ratio of 1:50 in mid-March in Year 1 and in early March in Years 2 and 3. Sire stags were removed in mid-May.

### 2.1.7 Rectal ultrasonography

The primary variable of interest was conception date and this was estimated from ultrasonographic foetal aging. All hinds were scanned ultrasonically on two occasions and hinds either exhibiting no visible sign of pregnancy or evidence of pregnancy <25 days old at the second scan underwent a third scan. The double-scanning procedure was carried out to minimise the operator error variance around the variable foetal age given its importance to the study conclusions.

A single operator using a 5MHz linear array transducer (Aloka SSD 500l Aloka Co. Ltd., Japan) performed the rectal ultrasonographic diagnoses for pregnancy assessment and foetal aging on each scanning occasion within an experiment and year. During ultrasonography, hinds were restrained individually in an upright position in a workstation crush. A liberal coating of carboxymethylcellulose lubricant was applied to the transducer, which was then inserted carefully into the rectum until an echo-image of the bladder was observed. The transducer was gently rotated $90^0$ clockwise and $180^0$ counter-clockwise while being moved forward until the uterus was located. Pregnancy was confirmed by identification of the chorionic vesicles, foetus or placentomes, and foetal age was estimated by the size of one or all of these identifying structures following the method of Revol and Wilson (1991). Foetal age was estimated in 5 day intervals.

In Year 1, the first scan was undertaken in early May to ensure that any conceptions to melatonin implanted stags were visualised. The sire stags were also removed on that day. The second scan followed four weeks after the first scan. In Year 2, the first scan was pushed forward to late April to allow for a better prediction from the double scan procedure (the optimum range for foetal aging is between 40 and 70 days post-conception). The second scan was four weeks later, which coincided with the date of removal of the sire stags. A third scan was performed on non-pregnant and late-conceiving hinds in late June. In Year 3 the first scan was carried out in early May and a second scan at the end of May when the sire stag was removed.

### 2.1.8 Statistical analysis

Statistical analyses were carried out for each year (or sample) using linear regression for the response variables conception day, hind live weight, hind body condition score and calf live weight and fitting the factorial interaction of the stag, weaning and nutrition treatments. Further analyses were performed with additional explanatory covariates for conception day added to the model. These variables included January live weight, mid-March live weight, preceding calving date and hind breed composition (proportion of English genes).

## 2.2 Results

### 2.2.1 Year 1 January – June 2005

Pasture covers pre-grazing were in excess of the targets of 2800 and 1800 kg DM/ha for the high and medium plane treatments respectively (Table 1). There was clear differentiation between pre-grazing and post-grazing pasture covers with significantly higher covers for high plane over medium plane groups (P=0.012). The medium plane treatment had a higher pre-grazing cover than the post-grazing cover of the high group because there was a two-week lag period before the leader-follower system was in sequence. The post-grazing cover target of 1800 and 1000 kg DM/ha were not met because of the large paddock sizes (2.4 to 3.9 ha), high pasture growth rates and small groups of deer.

**Table 1:** Means values for pasture cover, composition, quality and metabolisable energy concentration of the high and medium planes of nutrition offered to hinds during mid-January to mid-March 2005. Means with different subscripts between nutritional regimens are significantly different at P<0.05.

| | **Nutrition regimen** | | |
|---|---|---|---|
| | **High (n=8)** | **Medium (n=7)** | **s.e.d** |
| **Pasture cover (kg DM/ha)** | | | |
| Pre-grazing | $3911^{a}$ | $2244^{b}$ | 439 |
| Post-grazing | $2018^{a}$ | $1369^{b}$ | 205 |
| **Pasture composition (%)** | | | |
| Grass leaf | 72 | 76 | 10.2 |
| Clover | 3 | 3 | 2.3 |
| Dead matter | 25 | 21 | 11.0 |
| **Pasture quality (%)** | | | |
| Acid Detergent Fibre (ADF) | 32.9 | 35.8 | 1.55 |
| Neutral Detergent Fibre (NDF) | $59.3^{a}$ | $64.6^{b}$ | 1.49 |
| Crude Protein (CP) | $17.9^{a}$ | $13.1^{b}$ | 1.51 |
| Soluble Sugars Starches (SSS) | 8.9 | 7.8 | 0.96 |
| Organic Matter Digestibility (OMD) | 66.9 | 61.1 | 3.88 |
| **Energy concentration** | | | |
| MJME/kg DM | 10.01 | 9.41 | 0.52 |

The composition of the pasture on the high and medium plane treatments was similar and comprised predominantly grass leaf with little clover (Table 1) and subsequently there was minimal difference in the energy concentration between the two planes of nutrition. However, there were significant contrasts in the quality attributes of pastures. The pastures offered to hinds on the enhanced nutrition plane were found to contain significantly lower concentrations of neutral detergent fibre (NDF) and higher concentrations of crude protein (CP) (P=0.014 and P=0.002 respectively). Although not statistically significant, there was evidence that acid detergent fibre (ADF) was also lower (P=0.054) in pastures fed to hinds on the enhanced plane of nutrition (Table 1).

The nutritional regimen was structured with the objective of achieving a 5 kg contrast in mid-March live weight coinciding with the beginning of the mating season. In Year 1, the mean January live weight as a group was similar across both the high and medium plane of nutrition. By mid-March, hinds on the high plane had increased their live weight by 3.5 kg and hinds on the medium plane by 1.2 kg (P=0.002). Live weight gain over the period from January until the date of the first pregnancy scan in May was 0.2 kg for hinds on the enhanced plane of nutrition while the hinds on the medium plane of nutrition lost 2.6 kg (P=0.001) (Figure 2). Body condition score at mid-March was significantly correlated with nutritional status (P=0.001) with the condition of hinds on an enhanced plane of nutrition 0.5 ± 0.04 score units higher than those on the medium plane of nutrition. This effect carried through to May/June although the size of the significance of the nutrition effect declined and the weaning effect attained significance. The contrast in body condition between weaning groups was small (0.2 units) but highly significant (P=0.001)

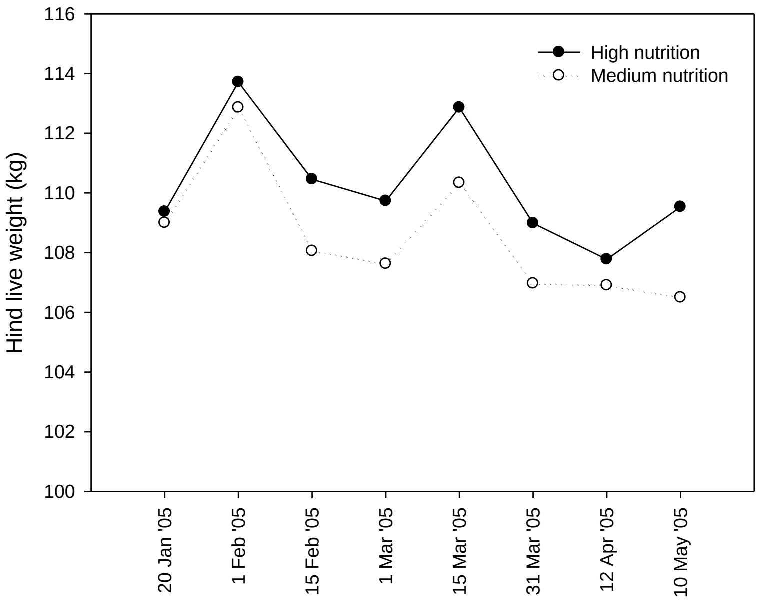


**Figure 2:** Change in hind live weight between January and May 2005 for each of the two nutritional regimens.

There was no consistent response in the mating behaviour of the stags treated with melatonin. Only on a few occasions were any of the stags observed roaring, and herding behaviour was not often observed. Further, the stags were not notably aggressive when yarded each fortnight for hind and calf live weight monitoring.

The mean conception date across the study in Year 1 was 24 March ± 0.9 day. There were no significant effects of weaning date (P=0.423), nutritional regimen (P=0.878) or stag joining date

(P=0.697) on conception date (as measured by foetal age) or of any interactions. Mean values for the eight treatments are given in Table 2.

**Table 2:** Effect of stag joining date, weaning date and nutrition regimen on conception day in Year 1 (mean ± s.e.m). Day 1 corresponds to 1 January; Day 80 corresponds to 21 March.

| | **Melatonin implanted rutting stag** | | | |
|---|---|---|---|---|
| | **Stag** | | **No Stag** | |
| | **Weaning** | | | |
| **Nutrition** | **Early** | **Late** | **Early** | **Late** |
| High | 80.4 ± 2.64 | 83.4 ± 2.42 | 88.2 ± 2.71 | 83.6 ± 2.47 |
| Medium | 84.0 ± 2.64 | 85.2 ± 2.47 | 79.0 ± 2.71 | 85.2 ± 2.47 |

Although there were no significant treatment effects a number of variables were added to the model as explanatory parameters. The analysis revealed that at the 10% level of significance, conception date was related to January live weight in 2005 (P=0.078). In this first year there was a 5.9 day advance in conception date between 90 and 130 kg hind (Figure 3a). Hind body condition score ranged between 1.5 and 5 but there was no evidence of any clear association between conception date and hind body condition score. Likewise, there was no evidence that mid-March live weight effected conception date. Preceding calving date was found to strongly influence conception date. For every 10 days earlier that the previous calving occurred, conception date was advanced by 4.8 days (Figure 3b). For hind breed composition, the proportion of English genes had a strong negative effect on conception date (P=0.033). Hinds with a low proportion of English genes (0.3) were predicted to conceive 7.5 days earlier than hinds with a high proportion of English genes (0.9) (Figure 3c). These effects of live weight, preceding calving date and genetics were essentially confounded and it was not possible to isolate the individual effects.

There was no significant difference in mean calf live weight between the treatments at the first weighing in mid-late January, following allocation of hinds and calves to their respective treatments. The weaning weight of the calves weaned early on 1 February was significantly higher (P=0.006) than the weight at the corresponding time for the calves in the late wean group (Table 3). Live weight gain between mid-late January and 1 February, when approximately half of the calves in each group were weaned, was similar and averaged 485 ± 16.7 g/day. Between 1 February and 15 March the late wean calves averaged 368 ± 7.5 g/day. Following weaning and handover of the early wean calves to the farm they were not managed as one group and so the direct comparison between the weight gain of the early and late wean calves over the period 1 February and 15 March should be treated with caution.

**Table 3:** Weaning weights of calves (mean ± s.e.m) for early and late wean treatments in Year 1. The corresponding weight for the late wean treatment at the time of early wean is also given.

| Weaning Date | Treatment | Live weight (kg) |
|---|---|---|
| 1 February 2005 | Early wean | 43.2 ± 0.91 |
| | Late wean | 39.8 ± 0.84 |
| 15 March 2005 | Late wean | 55.7 ± 1.00 |

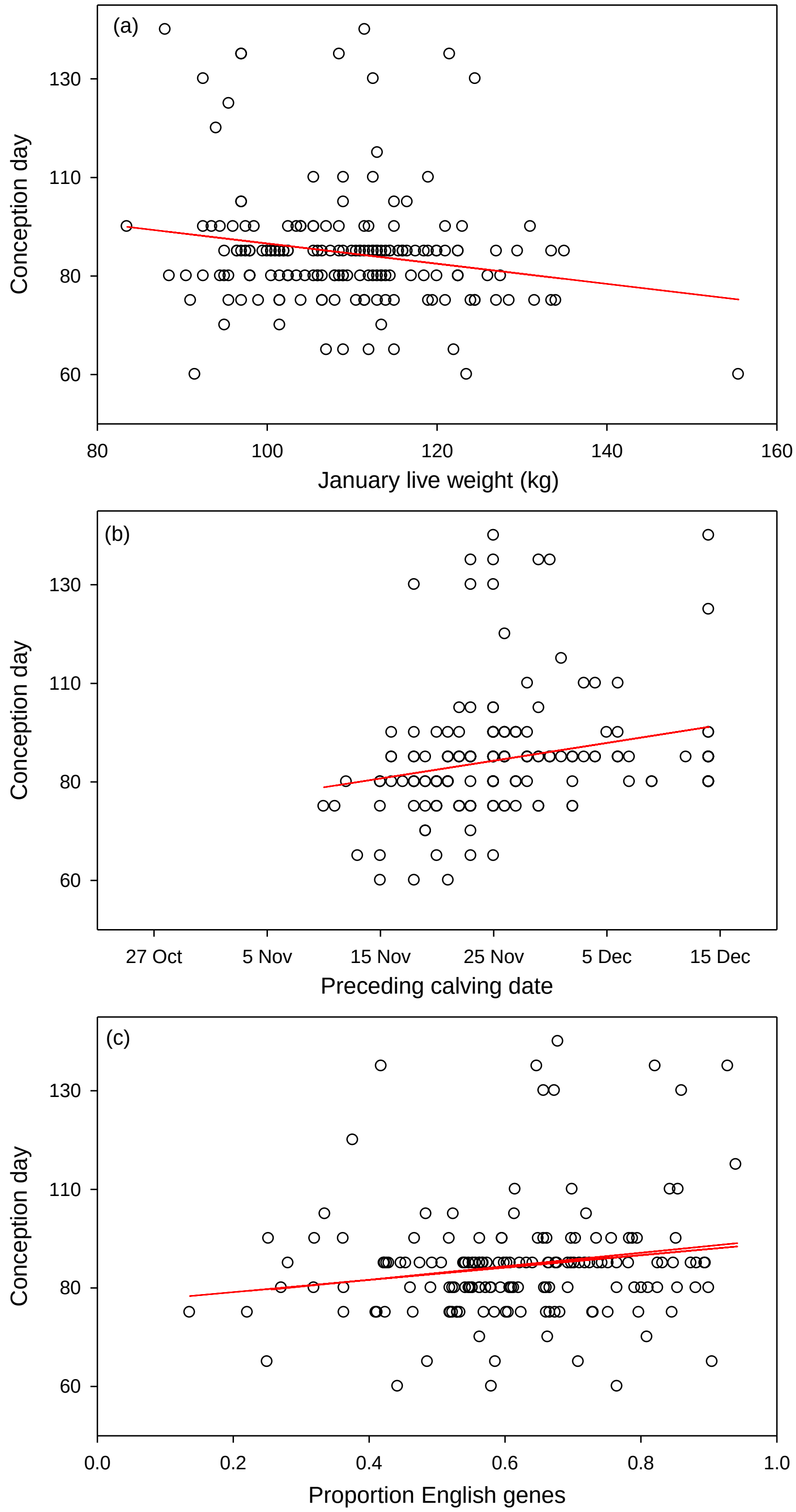


**Figure 3:** Relationship between conception day and (a) January live weight (n=164), (b) preceding calving date (n=163) and (c) proportion of English genes (n=164) in Year 1, 2005.

### 2.2.2 Year 2 January – June 2006

The pre-and post-grazing covers were significantly different across the two planes of nutrition although, once again, the covers exceeded the targets (Table 4). The high plane pastures comprised significantly more clover and less dead material than the medium plane pastures. Both acid detergent fibre (ADF) and neutral detergent fibre (NDF) were significantly lower, and crude protein (CP) and organic matter digestibility (OMD) were both significantly higher on the enhanced plane of nutrition, indicating that feed quality was significantly better on the high plane treatment. The apparent increase in quality was reflected in significantly lower metabolisable energy concentrations of the medium plane pastures (Table 4). Due to administrative complications the differential feeding period was curtailed earlier than intended at the end of February.

**Table 4:** Means values for pasture cover, composition, quality and metabolisable energy concentration of the high and medium planes of nutrition offered to hinds during mid-January to mid-March 2006. Means with different subscripts between nutritional regimens are significantly different at P<0.05.

| | **Nutrition regimen** | | |
|---|---|---|---|
| | **High (n=5)** | **Medium (n=6)** | **s.e.d** |
| **Pasture cover (kg DM/ha)** | | | |
| Pre-grazing | $3560^{a}$ | $2018^{b}$ | 355 |
| Post-grazing | $2133^{a}$ | $1442^{b}$ | 120 |
| **Pasture composition (%)** | | | |
| Grass leaf | 36 | 26 | 8.6 |
| Clover | $32^{a}$ | $6^{b}$ | 6.4 |
| Dead matter | $19^{a}$ | $63^{b}$ | 7.6 |
| **Pasture quality (%)** | | | |
| Acid Detergent Fibre (ADF) | $30.5^{a}$ | $37.0^{b}$ | 1.9 |
| Neutral Detergent Fibre (NDF) | $50.4^{a}$ | $58.1^{b}$ | 3.1 |
| Crude Protein (CP) | $18.2^{a}$ | $11.6^{b}$ | 2.3 |
| Soluble Sugars Starches (SSS) | 11.0 | 10.5 | 1.5 |
| Organic Matter Digestibility (OMD) | $67.8^{a}$ | $55.6^{b}$ | 3.0 |
| **Energy concentration** | | | |
| MJME/kg DM | $9.9^{a}$ | $8.5^{b}$ | 0.28 |

In Year 2 mean January group live weight across the main effects of high and medium nutrition was similar at 109 kg. By mating in mid-March there was a clear separation in mean live weight between the groups, with the hinds on the high plane of nutrition having increased their live weight by 5.6 kg and the hinds on the medium plane had decreased their January live weight by 1.1 kg (P=0.001). From mid-March until date of scanning, hinds on the high plane lost weight but were still 2.4 kg heavier than their January live weight (P=0.001) while the hinds on the medium plane of nutrition had held their mid-March live weight but were slightly lighter (1.1 kg) than their January live weight (Figure

4). By mid-March the body condition score of hinds on the enhanced plane of nutrition was significantly (0.45 ± 0.03 units, P=0.001) higher than for hinds on the medium nutrition. The impact of time of weaning on hind condition was stronger and significant in May/June although the nutrition effect remained the stronger of the two parameters.

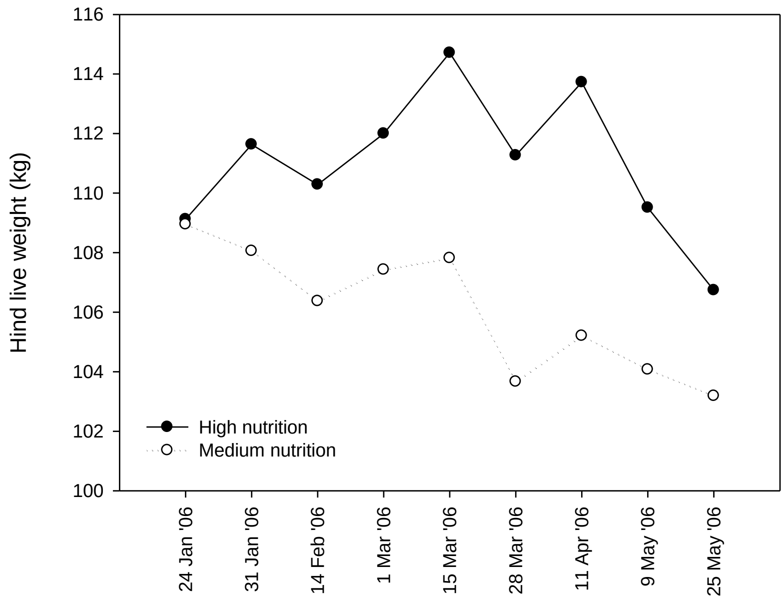


**Figure 4:** Change in hind live weight between January and May 2006 for each of the two nutritional regimens.

In a similar situation to Year 1, few recordings of consistent roaring behaviour were noted for the melatonin-treated stags. Stags were slightly more aggressive than in Year 1 but did not display the typical behavioural characteristics of a stag in full rut.

The mean conception date across the study in Year 2 was 26 March ± 0.7 day. There was no significant effect of the main effects of the nutritional regimen (P= 0.350) or stag joining date (P=0.524) on conception date (as measured by foetal age) or of any interactions. There was, however, a significant effect of weaning date at the 10% level (P=0.056) with a 2.8 day advantage for late weaning on 15 March as compared with early weaning on 1 February. Mean values for the eight treatments are given in Table 5.

**Table 5:** Effect of stag joining date, weaning date and nutrition regimen on conception day in Year 2 (mean ± s.e.m). Day 1 corresponds to 1 January; Day 80 corresponds to 21 March.

| | Melatonin implanted rutting stag | | | |
|---|---|---|---|---|
| | Stag | | No Stag | |
| | Weaning | | | |
| Nutrition | Early | Late | Early | Late |
| High | 87.2 ± 2.14 | 83.1 ± 1.78 | 86.2 ± 2.14 | 82.3 ± 1.84 |
| Medium | 86.9 ± 2.04 | 85.6 ± 1.81 | 86.0 ± 2.04 | 84.7 ± 1.84 |

Further analysis of explanatory parameters, adjusted for the late weaning effect, found that January live weight in 2006 (as with Year 1) was well correlated with conception date (P=0.022). There was a 6.6 day advance in conception date between 90 kg and 130 kg hinds (Figure 5a). Therefore, the advantage of a 130 kg hind weaned on 15 March extended to 9.4 days. In a separate analysis, due to the confounding effect between January live weight and hind breed composition (acknowledging that hinds with a high proportion of Eastern or Wapiti genes were generally larger animals), there was evidence that the proportion of English genes influenced conception date but narrowly missed significance at the 5% level (P=0.052). Figure 5b shows that the majority of the hinds in the study lie between 0.3 and 0.9 proportion English genes, and across this range this equates to a predicted advance in conception date of 5.1 days. This finding indicates that genetics were most likely responsible for a considerable proportion of the observed response in advanced conception date. There was no effect of preceding calving date (P=0.997) or mid-March live weight or hind body condition score (P=0.587) on conception date.

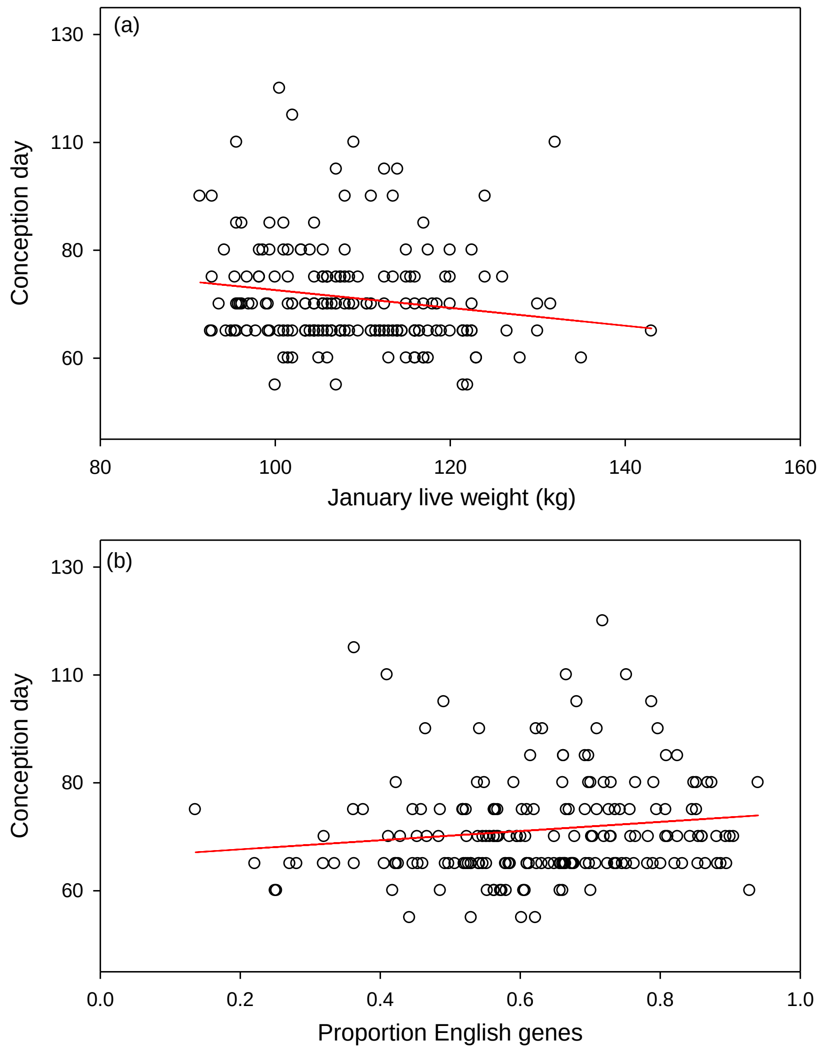


**Figure 5:** Relationship between conception day and (a) January live weight (n=190), (b) proportion of English genes (n=194) in Year 2, 2006 after adjustment for the significant weaning effect.

There was no significant difference in mean calf live weight between the treatments at the first weighing in mid-late January following allocation of hinds and calves to their respective treatments. Likewise there was no significant difference in live weight between the early and late wean groups at the time of early weaning. Calves weaned in mid-March were weaned at 50.9 ± 0.69 kg live weight (Table 6). However, within the late weaned group of calves there was a significant difference in the weaning weight (P=0.001) of calves paired with hinds on an enhanced plane of nutrition compared with those on the medium plane of nutrition (55.6 ± 0.97 v 46.7 ± 0.97 kg for high and medium nutrition respectively) (Table 6). Over the period mid-late January to 31 January, live weight gain was highly variable between the weaning x nutrition groups. The most significant result was for a significantly greater weight gain of calves assigned to a high plane of nutrition over the medium plane (444 ± 22.5 v 267 ± 21.1 g/day for high and medium respectively). A similar nutrition effect was found for the late wean calves over the period 31 January to 16 March, with calf growth rates on the high plane of nutrition averaging 367 ± 7.8 g/day, while the calves grazing the medium nutritional regimen grew at a rate of 217 ± 7.7 g/day. Following 31 January the early wean calves were managed as one group and supplemented with 100g barley/calf/day. This management allowed for a direct comparison of the weaning date on calf growth rate and during the period from 1 February and 16 March, the early wean calves collectively as a group averaged 11.8 ± 0.30 kg live weight gain while the suckling late wean calves gained 13.0 ± 0.25 kg.

**Table 6:** Weaning weights of calves (mean ± s.e.m) for early and late wean treatments, and late wean by nutrition in Year 2. The corresponding weight for the late wean treatment at the time of early wean is also given.

| Weaning Date | Treatment | Live weight (kg) |
|---|---|---|
| 31 January 2006 | Early wean | 39.3 ± 0.74 |
| | Late wean | 38.0 ± 0.62 |
| 16 March 2006 | Late wean | 50.9 ± 0.69 |
| | High nutrition | 55.6 ± 0.97 |
| | Medium nutrition | 46.7 ± 0.97 |

### 2.2.3 Year 3 January – June 2007

The leader-follow grazing system ensured significant differences between the pre- and post-grazing covers for the enhanced and medium planes of nutrition (Table 7). Clover content was lower and dead material was higher in the medium plane regimen when compared with the high plane regimen. Variation in pasture composition were reflected in lower metabolisable energy, organic matter digestibility (OMD) and crude protein concentrations and higher acid detergent fibre (ADF) and neutral detergent fibre (NDF) concentrations of the medium plane pastures (Table 7).

There were no significant differences between the mean January live weights or the mid-March live weights for the two nutrition groups. However, the 1.6 kg loss in live weight over this period was significant (P=0.006) for the medium plane group. Both nutrition groups lost live weight in the two weeks preceding May, thus yielding an overall weight loss since January of 2.5 kg for the high plane and 4.8 kg for the medium plane (P=0.004) groups (Figure 6). The nutritional regimens marginally but significantly influenced hind body condition score at mid-March by 0.2 score units in favour of the hinds on the enhanced plane of nutrition. The impact of weaning date on body condition increased in significance from mid-March to May, although the contrast in real terms was less than 0.3 score units.

**Table 7:** Means values for pasture cover, composition, quality and metabolisable energy concentration of the high and medium planes of nutrition offered to hinds during mid-January to mid-March 2007. Means with different subscripts between nutritional regimens are significantly different at P<0.05.

| | Nutrition regimen | | |
|---|---|---|---|
| | **High (n=6)** | **Medium (n=6)** | **s.e.d** |
| **Pasture cover (kg DM/ha)** | | | |
| Pre-grazing | 3460[a] | 1689[b] | 390 |
| Post-grazing | 1869[a] | 1474[b] | 155 |
| **Pasture composition (%)** | | | |
| Grass leaf | 61 | 53 | 7.1 |
| Clover | 24[a] | 12[b] | 5.8 |
| Dead matter | 6[a] | 27[b] | 6.5 |
| **Pasture quality (%)** | | | |
| Acid Detergent Fibre (ADF) | 30.9[a] | 35.1[b] | 1.9 |
| Neutral Detergent Fibre (NDF) | 48.5[a] | 55.4[b] | 2.9 |
| Crude Protein (CP) | 19.4a | 14.2[b] | 2.3 |
| Soluble Sugars Starches (SSS) | 8.7 | 7.3 | 0.8 |
| Organic Matter Digestibility (OMD) | 68.2[a] | 61.1[b] | 3.3 |
| **Energy concentration** | | | |
| MJME/kg DM | 10.0[a] | 9.1[b] | 0.44 |

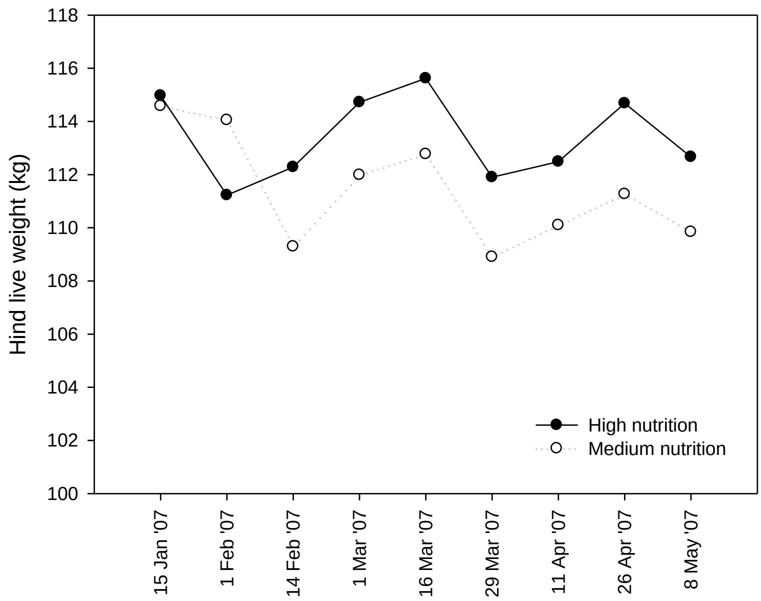


**Figure 6:** Change in hind live weight between January and May 2007 for each of the two nutritional regimens.

Mean conception date across the study in Year 3 was 25 March ± 0.5 day. In this year treatments were a factorial of weaning x nutrition and only the weaning effect reached significance (P=0.001), with a 3.4 day advance in conception date for hinds weaned on 1 February. Mean values for the four treatments are given in Table 8.

**Table 8:** Effect of weaning date and nutrition regimen on conception day in Year 3 (means ± s.e.m). Day 1 corresponds to 1 January; Day 80 corresponds to 21 March.

| | **Weaning** | |
|---|---|---|
| **Nutrition** | **Early** | **Late** |
| High | 83.4 ± 1.04 | 86.5 ± 0.92 |
| Medium | 83.6 ± 1.06 | 87.4 ± 0.92 |

Further analysis added explanatory parameters to the model and following adjustment for the early weaning effect the analysis showed that only the proportion of English genes reached significance at the 10% level (P=0.069). The regression analysis revealed that a decrease in English genetics from 0.9 to 0.3 advanced conception by 3.6 days (Figure 7) for a cumulated effect with early weaning of 7 days. January live weight in 2007, hind body condition score and preceding calving date did not attain significance (P=0.803, P=0.860 and P=0.576 respectively).

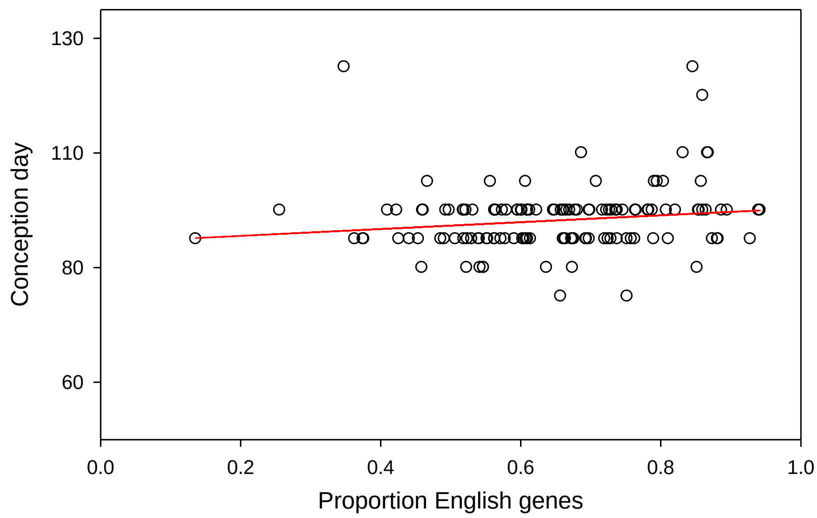


**Figure 7:** Relationship between conception day and proportion of English genes (n=131) in Year 2, 2006, after adjustment for the significant weaning effect.

No calf data was collected in mid-January at the time when hinds and calves were assigned to treatments and the differential feeding commenced. At the time of early weaning on 1 February there was evidence of a significant weaning advantage to the calves on early wean treatments (Table 9). Weaning weight for the late wean calves was 50 kg and there was no significant effect of nutrition on weaning weight. However, the nutritional status had a significant effect on the live weight gain of the late wean calves between 1 February and 16 March. Calves grazing on the enhanced plane of nutrition gained weight at an average rate of 312 ± 9.2 g/day (a total gain of 13.7 ± 0.40 kg) while the corresponding growth rate was 223 ± 9.7 g/day (a total gain of 9.81 ± 0.43 kg) for the calves grazing the medium plane of nutrition. The early wean calves grazing together as a group on a second year re-seeded pasture gained approximately 7.3 ± 0.34 kg at an average daily gain of 165 ± 7.7 g/day during the corresponding period.

**Table 9:** Weaning weights of calves (mean ± s.e.m) for early and late wean treatments in Year 3. The corresponding weight for the late wean treatment at the time of early wean is also given.

| Weaning Date | Treatment | Live weight (kg) |
|---|---|---|
| 1 February 2007 | Early wean | 43.9 ± 0.72 |
| | Late wean | 38.7 ± 0.62 |
| 16 March 2007 | Late wean | 50.6 ± 0.70 |

# 3.0 The effect of late-pregnancy nutrition on calving date

## 3.1 Materials and Methods

### 3.1.1 Treatments

The experimental treatments were two nutrition regimens arbitrarily defined as high and medium planes of nutrition. The regimens were imposed at the beginning of August and ceased in early-October when the hinds were set stocked for calving. Hinds were randomly assigned to one of two groups (high or medium) and a combination of crops, supplementary feed and a leader-follower grazing system on pasture was implemented (see Figure 1). An additional group of in-calf R3yo hinds (23 in 2005; 22 in 2006) were interspersed with the MA hinds at the time of set-stocking, and their inclusion maintained numbers at around 200 hinds.

Hinds were weighed and assessed for body condition fortnightly over the period of differential feeding.

### 3.1.2 Monitoring of calving

In each of the 2 years (and including the preceding calving in 2004) a daily calving beat was undertaken for 6 weeks beginning from the week prior to the expected arrival of the first calf based on foetal aging data. In the absence of such information for the lead-in 2004 calving, the calving beat began in early November. All calves were tagged and their birth weight recorded. A skin sample from any calf found dead before or following tagging was collected for DNA profiling.

### 3.1.3 Nutritional regimens

Regimens were designed around the three concepts adopted for the nutritional regimens during lactation (see 2.1.4). However, due to low pasture covers, supplements available on farm were incorporated into the diet as appropriate.

In Year 1, 2005 hinds on the high plane of nutrition were fed on a turnip and rape crop for four weeks beginning from early August and also offered silage *ad libitum*. Hinds assigned to the medium plane of nutrition were stocked in a paddock with low pasture cover and offered a restricted allowance of silage. From early September to mid-October the hinds on the enhanced nutrition were rotated ahead of the hinds on the medium plane of nutrition in a leader follower system. The target pre-grazing covers for hinds on the enhanced plane of nutrition were between 2000 and 2800 kg DM/ha, with hinds shifted when pasture cover fell below 1500-1800 kg DM/ha. Hinds on the medium plane of nutrition grazed the residual from the high plane group down to approximately 800-1000 kg DM/ha.

In Year 2, 2006 the leader follower system was again used with hinds on the high nutritional plane being grazed on pastures of between 2000 and 2500 kg DM/ha and shifted when pasture cover fell below 1500 kg DM/ha. Hinds on the medium plane of nutrition followed the high group and grazed the cover down to approximately 800-1000 kg DM/ha. The hinds on the high plane of nutrition were also supplemented with 500 g barley/head/day throughout the period. The hinds on the medium plane of nutrition were held on an all silage diet for the first 10 days of the differential period while the high plane hinds began the pasture rotation.

For both years the pasture cover offered, amount of silage offered and refused, and crop offered and refused, were measured during the period of differential feeding. Feed intake of the silage and crop supplements was estimated by disappearance. Pasture cover was recorded pre- and post-grazing using a rising plate meter (Farmworks Electronic Plate Meter, Farmworks Ltd, Fielding, NZ) using the equation pasture cover = 200 + 159 x compressed height (cm). Samples of the herbage pre- and post-grazing were cut to ground level to determine pasture quality and composition. Pasture mass was visually monitored weekly to assist with the decision to shift the groups to new pasture. Pasture composition was determined by dissection of an approximately 400-piece sample into grass leaf, clover and dead matter, dried at 90°C and relative proportions determined by dry weight. Feed quality assessments were made of the pasture, silage and crop offered throughout the period, and included acid detergent fibre (ADF), neutral detergent fibre (NDF), soluble sugars and starch (SSS), crude protein (CP), organic matter digestibility (OMD) and metabolisable energy (ME).

### 3.1.4 Statistical analyses

Statistical analyses were carried out for each year (or sample) using linear regression for the response variables calving date, gestation length and hind live weight and fitting the late-pregnancy nutrition treatments. Non-significant terms were dropped and further analyses were performed with additional explanatory covariates for calving date and gestation length. These variables included pre-calving live weight, preceding calving date, conception day, late-lactation nutrition and hind breed composition (proportion of English genes).

## 3.2 Results

### 3.2.1 Year 1 August – October 2005

The prescribed regimens of differential feeding provided significantly different estimated intakes from the supplements being added to the regimens and pasture covers were also markedly different, although low at 800 and 550 kg DM/ha for the high and medium plane respectively. Silage was offered to both high and medium planes of nutrition at approximately 0.97 ± 0.13 kg DM/head/day. The crop leaf yield was 6.2 ± 0.37 tonnes/ha and the bulb yield 0.9 ± 0.47 tonnes/ha. Crop quality assessments indicated that the feed quality was generally high. However, the dry matter concentration was only 8.6 % ± 0.18 in the tops (turnip leaf plus rape leaf and stem) and 7.5 % ± 0.72 in the turnip bulbs and the diet was supplemented with silage to avoid any possible reduction in intake.

During the period that hinds on the high plane of nutrition were on crop they consumed an estimated 0.87 kg DM/head/d as crop (75% utilisation) and 0.49 kg DM/head/day as silage (50% utilisation) compared with 0.93 kg DM/head/d consumed as silage (97% utilisation) by hinds on the medium nutritional plane (and not offered crop). The total supplement intake was 1.36 and 0.93 for hinds on the high and medium nutrition regimens respectively (Table 10). Unfortunately administrative problems led to data loss from the leader-follower rotation during the final six weeks.

**Table 10:** Hind feed intake on high and medium nutrition regimens pre-calving in Year 1, 2005.

| | Nutrition regimen | | |
|---|---|---|---|
| **Supplement intake (kg DM/head/day)** | **High (n=5)** | **Medium (n=5)** | **s.e.d** |
| Crop | 0.87 | - | - |
| Silage | 0.49 a | 0.93 b | 0.19 |
| Total | 1.36 a | 0.93 b | 0.18 |

Mean live weight between the two nutrition groups at the initiation of the late-pregnancy feeding was not significantly different (105.0 v 104.8, 1.36 s.e.d for high and medium planes respectively). Over the 10 week preferential feeding period hinds on the high plane of nutrition gained 8.1 kg while hinds on the medium plane gained 3.2 kg (P=0.001). However, the large majority of the live weight gain occurred during the final fortnight before hinds were set-stocked for calving (Figure 8) and the gain was not significantly different between the two nutritional regimens. The pattern of weight gain for the hinds on the medium plane of nutrition was strongly influenced by the weight loss in early September, which coincided with the transition to a leader-follower rotation on pasture (Figure 8).

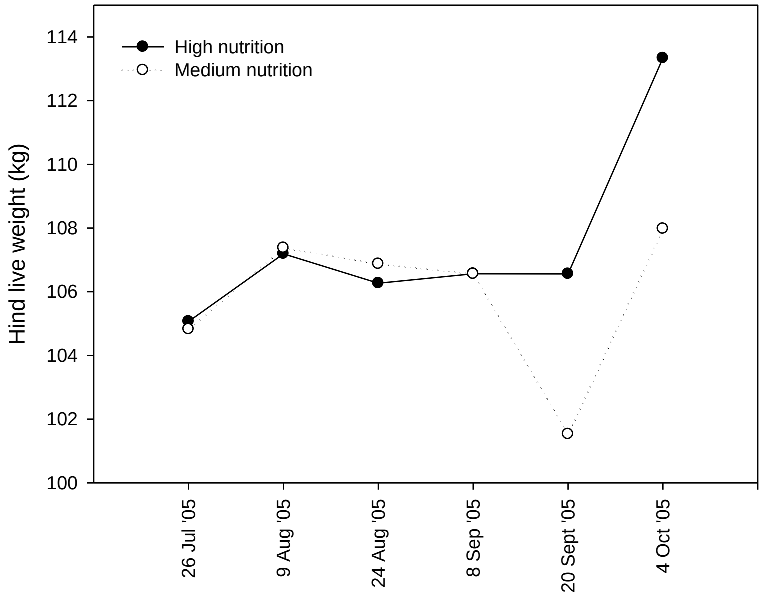


**Figure 8:** Change in hind live weight between July and October 2005 for each of the two nutritional regimens.

The mean date of calving across all hinds was 19 November (± 0.6 days). There was no effect of the nutritional regimen during late-pregnancy on calving date. Preceding calving date (P=0.001) and conception day (P=0.001) were both highly significant when added as covariates (Figure 9a). After adjustment for these effects nutritional regimen during lactation (see 2.0) was added to the model and found to have a highly significant effect (P=0.01) on calving date with a 3.2 ± 0.71 day advance for hinds offered an enhanced plane of nutrition during lactation (Figure 9a). Live weight at various strategic times over the period from January – October did not explain the response in calving date to summer nutrition. Deviation from the 234-day difference between conception and calving date implied variation around gestation length. The regression of gestation length against conception day showed a significant negative coefficient of -0.42 ± 0.046 (Figure 9b). Gestation length was significantly correlated with summer nutrition status with gestation lengths of 240 ± 0.7 and 244 ± 0.7 days for the high and medium nutrition regimens respectively.

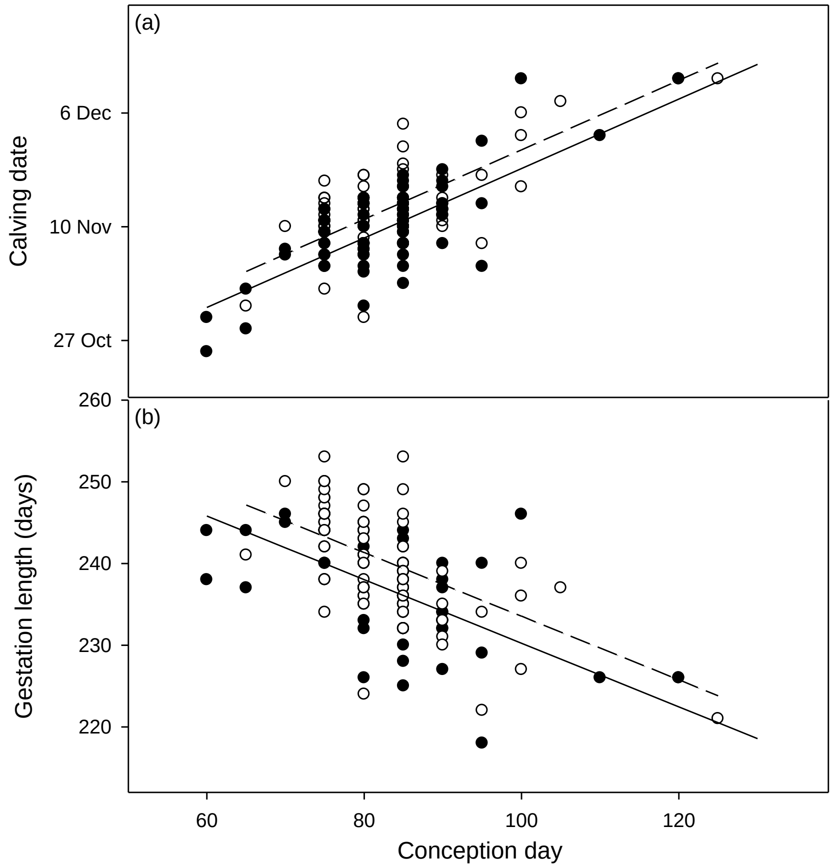


**Figure 9:** Regression of conception day against (a) calving date and (b) gestation length for hinds on high (solid circle) and medium (open circle) planes of nutrition in Year 1, 2005. Solid and dashed (high and medium nutrition respectively) lines represented fitted values.

### 3.2.2 Year 2 August – October 2006

The mean pre-grazing pasture cover for the hinds on the high nutritional regimen was 1790 kg DM/ha and the post-grazing residual was 1260 kg DM/ha. The hinds on the medium nutritional regimen grazed pastures down to 830 kg DM/ha (Table 11). Pasture composition was similar between nutritional treatments. However, the acid detergent fibre (ADF) and neutral detergent fibre (NDF) concentrations of the medium nutrition treatment were significantly higher than for the enhanced plane of nutrition, leading to slightly lower organic matter digestibility (OMD) and metabolisable energy (ME) concentration in the medium nutrition treatment (P=0.052 and 0.059 respectively), although the later was not significant. Crude protein concentration was significantly higher on the enhanced plane of nutrition. Nonetheless, the contrasts were unlikely to illicit any significant alterations in the feed intake of hinds during the third trimester of pregnancy as energy concentrations were high at 12.0 and 11.3 MJ ME/kg DM for both the high and medium nutrition treatments respectively (Table 11).

**Table 11:** Means values for pasture cover, composition, quality and metabolisable energy concentration of the high and medium planes of nutrition offered to hinds pre-calving in Year 2, 2006. Means with different subscripts between nutritional regimens are significantly different at P<0.05.

| | Nutrition regimen | | |
|---|---|---|---|
| | **High (n=7)** | **Medium (n=7)** | **s.e.d** |
| **Pasture cover (kg DM/ha)** | | | |
| Pre-grazing | 1794[a] | 1262[b] | 78 |
| Post-grazing | 1263[a] | 828[b] | 80 |
| **Pasture composition (%)** | | | |
| Grass leaf | 82 | 83 | 6.0 |
| Clover | 12 | 9 | 4.9 |
| Dead matter | 6 | 8 | 3.2 |
| **Pasture quality (%)** | | | |
| Acid Detergent Fibre (ADF) | 22.5[a] | 25.7[b] | 1.1 |
| Neutral Detergent Fibre (NDF) | 35.2[a] | 38.4[b] | 1.3 |
| Crude Protein (CP) | 28.7[a] | 25.1[b] | 1.6 |
| Soluble Sugars Starches (SSS) | 9.7 | 10.7 | 1.8 |
| Organic Matter Digestibility (OMD) | 83.1 | 79.5 | 1.9 |
| **Energy concentration** | | | |
| MJME/kg DM | 12.0 | 11.3 | 0.43 |

At the beginning of the late-pregnancy preferential feeding in early August 2006, live weight was not significantly different between the hinds assigned to the high and medium nutritional regimens (P=0.186). Mean group live weight decreased during the second fortnight, with the reduction in live weight slightly greater for hinds on the medium nutritional regimen than those on the high regimen (Figure 10). Thereafter, live weight increased with hinds on the high plane of nutrition, on average, 4.6 kg (± 1.1 kg) heavier than those on the medium plane of nutrition (Figure 10). Across the eight week period of preferential feeding, and prior to set-stocking for calving in early October, live weight gain for the hinds on the high nutrition regimen was 8.3 kg while the corresponding gain for the hinds on the medium nutrition regimen was 1.9 kg (P=0.001).

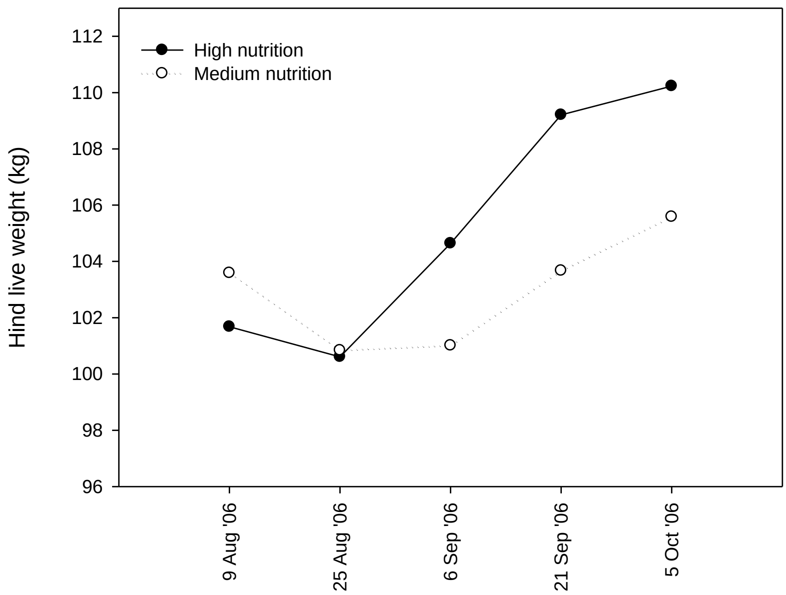


**Figure 10:** Change in hind live weight between July and October 2006 for each of the two nutritional regimens.

The mean date of calving across all hinds was 20 November (± 0.6 days). As with Year 1, 2005 there was no significant effect of late-pregnancy nutrition on calving date in Year 2, 2006. The covariate preceding calving date was not significant (P=0.99) but conception day was highly significant (P=0.001). The addition of nutritional regimen during lactation to the model was highly significant (P=0.018). Live weight prior to calving did not explain any of the variation around calving date (P=0.208). The relationship between conception day and calving date by lactation nutritional status is shown in Figure 11a. The relationship between calving date and day of conception implied that hinds modified gestation length (Figure 11b). For every 10 day advancement in conception date, gestation length was increased by 4.7 days (coefficient = -0.47 ± 0.059). Furthermore, for a given conception date hinds on an enhanced level of nutrition were found to shorten the gestation length by 2.5 days ± 0.98 compared to hinds on a medium plane of nutrition during lactation (Figure 11b).

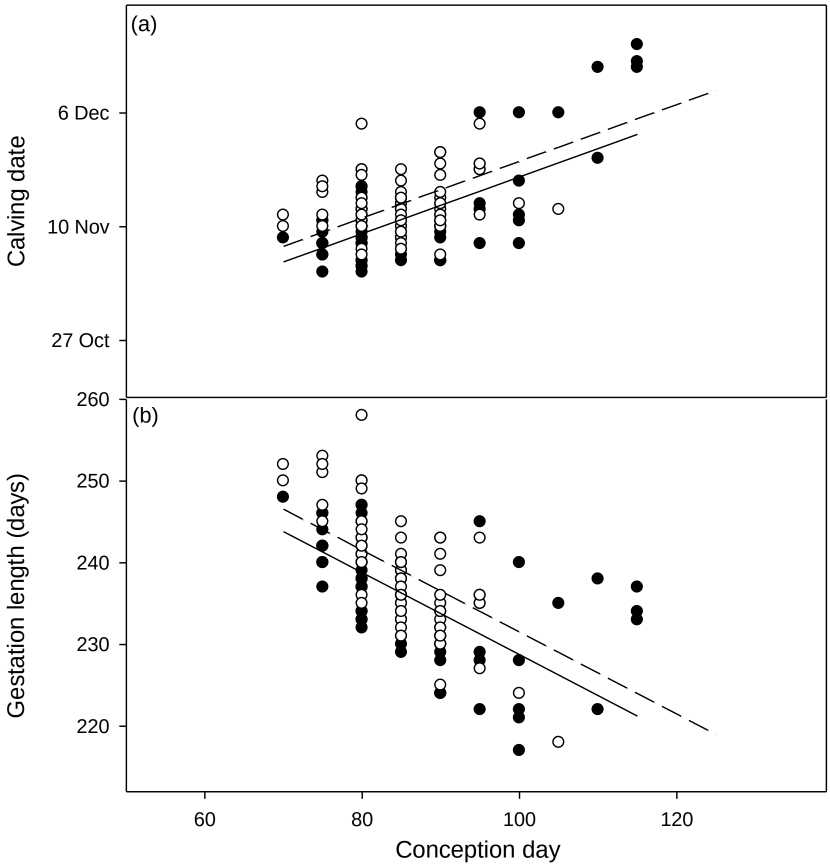


**Figure 11:** Regression of conception day against (a) calving date and (b) gestation length for hinds on high (solid circle) and medium (open circle) planes of nutrition in Year 2, 2006. Solid and dashed (high and medium nutrition respectively) lines represented fitted values.

# 4.0 Discussion

## 4.1 Nutritional regimens during late-lactation

In each of the three years the techniques used to provide contrasting herbage mass allowance to hinds and calves on the high and medium plane of nutrition were successfully implemented. However, some difficulty was experienced in controlling the feeding situation, particularly in Year 1 owing to the >2.5 ha paddocks carrying only 50 hinds and their calves. Due to the large paddock sizes and subsequent low grazing pressure hinds had the opportunity to selectively graze the more digestible herbage. This was greatly aided by their mouth morphology that allows for green leaf selection at a finer scale than for cattle (Gordon and Illius, 1988). Animal performance and intake is strongly sensitive and positively correlated with green dry matter content of the sward (Thomson *et al.*, 1986; Prache 1997). Consequently, at such high herbage allowances and given that herbage composition and quality was not significantly different across the two regimens, intake of green leaf was probably similar for all hinds. It is probable that this explains why there was minimal difference in hind live weight gain during the period of differential feeding.

Following Year 1, a number of paddocks were re-fenced to provide a number of more suitably sized 1-1.5 ha paddocks that allowed for a more restrictive regimen for the medium plane of nutrition to be imposed to achieve the desired contrast in animal productivity outcomes. During the following two years there was greater variation in the composition (clover and dead material) and quality of the pasture (ADF, NDF, CP, OMD, ME) offered on the two nutritional regimens, although paddock size was still too large to allow stricter control.

Despite meeting the targeted 5 kg contrast in hind live weight between the nutritional regimens, the apparent increase in hind live weight prior to mating did not translate into earlier conceptions at a treatment level. Had the programme of research targeted a more restricted nutritional regimen a more significant response in conception date to nutritional status may have been observed. However, the objectives of the research were to compare well-fed hinds on an enhanced plane of nutrition with hinds on a medium plane of nutrition (approximating industry practice), not to compare well-fed hinds with under-fed hinds. The outcomes indicated that there was little further benefit in conception date from higher levels of nutrition once an adequate level was attained.

## 4.2 Nutritional regimens during late-pregnancy

Evolutionary selection pressure has strongly influenced the seasonal reproductive activity of red deer so that the timing of calving coincides with ambient temperatures and the peak of readily available high-quality forage within the northern hemisphere environment. This has, for some time, been viewed as optimisation of calf birth date to ensure neonate survival and maximum growth rate before the onset of the first winter. Furthermore, gestation length was once considered to be genetically programmed and relatively fixed in term, supporting the notion that conception date timing was precisely controlled to ensure optimal birth dates. However, as apparent from Figures 11 and 13 and other studies with deer (Asher *et al.*, 2005), buffaloes (Usmani *et al.*, 1987) and alpacas (Davis *et al.*, 1997), gestation length is considerably variable in red deer. The range across both years of the current study was 218 to 258 days; a spread of 40 days.

Although there was clear differentiation in hind live weight between the two nutritional groups at the time of set-stocking in October in both years this did not translate into significant differences in calving date across nutrition groups. Within groups, there was a general pattern of increased live weight gain over the final weeks of the differential feeding regimens and probably reflected the exponential growth in foetal development where approximately 70% of the foetal growth occurs during the final 8 weeks of pregnancy (Rattray *et al.*, 1974). Data from both years was collated from field experimentation and the level of response in mean change in gestation length was no where near the magnitude of 8 days observed by Asher *et al.* (2005) in one of three years. This may reflect the much greater contrast in the nutritional regimens, with greater restriction of intake and greater magnitude of live weight change, in the study by Asher *et al.* (2005). Again it is worthy to point out that the nutritional regimens implemented in this study were typical of those that might be achieved on-farm and suggests that a nutritional regimen that restricts intake to the extent achieved by Asher *et al.* (2005) would not meet best practice on-farm.

In the absence of a gestational response to late-pregnancy nutrition it was of interest to find evidence of a consistent carry-over effect in 2005 and 2006 from the nutrition regimens implemented during lactation and around the time of weaning on gestation length and thus calving date. The regression equations showed that for every 10 day advance in conception, calving date would only advance by 6 days when hinds had been offered an enhanced plane of nutrition during lactation over the summer period, effectively mitigating some of the advancement in conception date in what has been termed the ‘push-pull’ phenomenon (Scott *et al.*, 2008). For hinds offered a medium plane of nutrition the advance in calving date would be reduced to approximately 3 days. This suggests that despite the fact that conception date was not sensitive to the observed contrast in pre-mating hind live weight and that the relative change in body condition score, while significant, was small, the nutritional status during lactation did biologically influence the ability of the hind to supply nutrients to the placenta during the final period of rapid growth of the foetus. This finding suggests that foetal growth may well be the driver of gestation.

The results presented from this 3 year programme have been one of several recent studies conducted by the AgResearch AgSystems deer team that has found supporting evidence on the relationship between conception date and calving date, and particularly the variability around gestation length. Emerging from these studies collectively has been the recognition that across a wide range of environments there are physiological mechanisms behind the environmental control of gestation length that are yet to be fully understood.

## 4.3 Weaning date

The results from this project suggest that there is limited response on conception day to weaning earlier than mid-March. In Year 2 there was a small advantage of approximately 3 days in favour of late weaning, whereas that effect was reversed in favour of early weaning in Year 3.

The phenomena around early weaning is that removal of a suckling calf reduces the hinds' energy loss (Loudon *et al.*, 1983) and allows the dam to maintain or increase condition prior to mating, a time that is considered to be critical for achieving early conception (Beatson *et al.*, 2000). There are no other published studies that have evaluated the impact of weaning date prior to March on conception day for comparison. The work by Pollard *et al.* (2002) evaluated the impact of pre- and post-rut wean on date of conception, and showed a five day variation in the evidence for an advance in conception date from pre-rut wean across two consecutive years. In the year that Pollard *et al.* (2002) found evidence for a 12 day advance in conception for hinds weaned early, farms were stricken with a drought the year prior. Adverse environmental conditions have been found to impact on hind live weight, and marked relationships have been demonstrated between body condition and fertility (Albon *et al.*, 1986). Therefore, it is probable that environmental conditions played a critical role in influencing the magnitude of the response in conception date for hinds weaned pre- and post-rut, across years in the study by Pollard *et al.* (2002).

The 3 day advance in the present study, whether favouring early or late weaned hinds, was small in comparison to the results reported by Pollard *et al.* (2002). However, Friedel and Hudson (1994), examining weaning date practices in Wapiti hinds in Canada, reported only a 5 day advance for hinds weaned early. This suggests that there is considerable variation in the response of conception date to the time of calf weaning supporting the notion that conception day is not strongly driven by hind body reserves once an adequate level of live weight and body condition is attained.

Across weaning treatments in each of the three years there was a consistent loss of live weight in hinds immediately post-weaning and hinds on both weaning treatments failed to re-gain their pre-weaning live weights in Year 1. In the first year of the study approximately 66% of the hinds reared wapiti x red deer calves and the failure to regain weight may have reflected the greater negative energy balance due to more vigorous suckling by crossbred calves (Ward *et al.*, 2007; 2008). There was no bias across treatments as crossbred calves were uniformly distributed across treatment groups. For Years 2 and 3, the early wean hinds regained their pre-wean weight by late May but the hinds on the late wean treatment did not always regain their pre-wean weight before the end of May (Figure 12a-c). The weight loss of around 5 kg following weaning was unexpected. For Years 2 and 3, there was minimal weight gain for the late wean group at the time the early wean group had lost considerable weight post-weaning, and following late weaning both weaning groups lost weight. The differential feeding regimens ceased at the time of late weaning in mid-March but dietary changes are unlikely to explain the full extent of the weight loss. The finding by Corrigall and Hamilton (1977) that hinds did not lose their appetite following the removal of calves suggests that the live weight loss would not be due to reduced intake, although this conclusion is hampered by few published studies in this area.

The composition of the weight loss is unknown and consequently there was no way of determining the impact on ovulation. Stress can also be a driver (Asher *et al.*, 1996) and if the weight loss was stress induced and associated with the breakdown of body fat, it may have important implications on ovulation. Negative changes in physiological processes at this time are known to delay the onset of ovulation in sheep and cattle. However, if this was the case it might be argued that the effect on day of conception would have been greater for late weaned hinds as their recovery period was shorter. An alternative theory is that the hind re-models the digestive tract following weaning. Work with other species has clearly shown that the mass of visceral organs change considerably in response to change in intake (Koong *et al.*, 1982; 1985). Removing the metabolic demand of lactation may induce changes in the digestive tract and other visceral organs. This may be reflected in live weight loss, but the impact on energy balance (and more specifically, energy available for reproductive functions) may differ from a more typical live weight loss scenario. Further explanation was beyond the scope of the current programme of research.

Weaning weights were heavier in Year 1 than in Years 2 and 3 and this reflected the dominance of crossbred (wapiti x red) calves in the first year. The slower growth rate of the early weaned calves, post-weaning was not unexpected given that calves of less than 100 days old are typically still highly dependent on the dams milk for a supply of energy (Loudon *et al.*, 1983). Similar depressed growth rates were also observed by Pollard *et al.* (2002) for calves weaned pre-rut compared with post-rut.

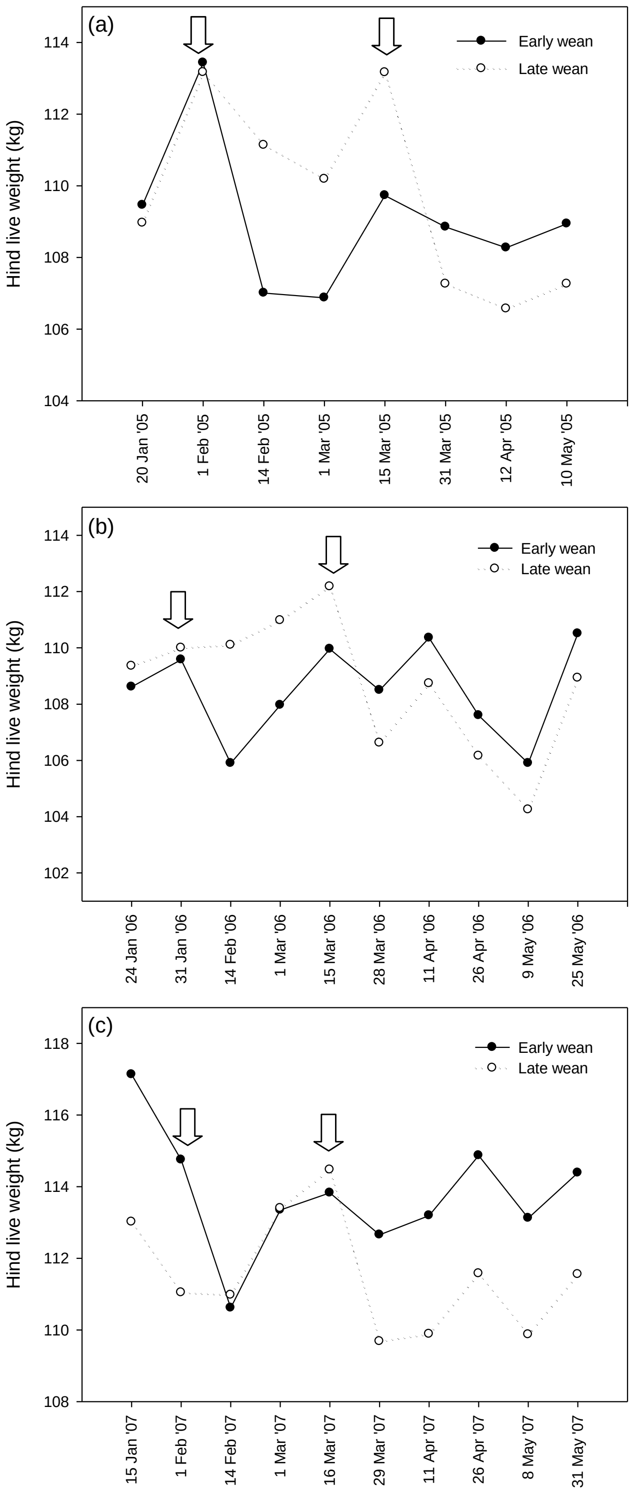


**Figure 12:** Change in hind live weight between January and May for each of the two prescribed weaning dates in (a) Year 1 2005 (b) Year 2 2006 and (c) Year 3 2007. Arrows indicate time of early and late weaning.

There was a consistent effect of hind nutrition during lactation on calf weight and growth rates, with calves reared by hinds on an enhanced plane of nutrition growing at a faster daily gain. The relationship between weaner growth rates and pasture energy concentration and green leaf is well established (Beatson *et al.*, 2000; Stevens 1999 cited by Nicol and Barry, 2002). Nutrition would also have had an impact on the lactation status of the hind. Geenty (1997) found that the onset of milk secretion was slower in ewes with a lower condition score and that the lambs had a less pronounced suckling drive. Loudon *et al.* (1983) reported that hinds fed on a poor quality pasture had lower milk yields, and that higher secretion of the lactation-related hormone, prolactin, was associated with greater calf suckling frequency. More recent research has shown that there was little significant difference in suckling duration or frequency between calves of different genotypes, although crossbred (wapiti x red) calves did suck with more vigour than red calves (Ward *et al.*, 2007), indicating that the calf was the primary driver of lactation. However, the finding from this project raises interesting questions concerning the drivers of lactation and the potential interaction with nutritional status, and deserves further investigation.

While the medium level of nutrition did not restrict the timing of conception there were clear downstream effects on calf growth. The earlier conception in Year 3 did not outweigh the depressed live weight gain of the early weaned calves in terms of producing product to meet market specifications.

The key point that emerged from this project was that the importance of good nutrition should not be under-estimated. Although an enhanced plane of nutrition did not deliver any further advantages in advancing conception day over a medium plane of nutrition, the nutritional status of the hind did influence calf growth rate. It is, therefore, of great importance to manage the interactions between herbage mass and herbage quality during lactation to ensure optimal hind live weight and condition prior to mating, and to produce calves at kill weights earlier in the season; in line with the industry's productivity strategy.

## 4.4 Conception profiles

On average, the late-March conception date was earlier than the industry average (Beatson *et al.*, 2000). The date was also similar to the mean date of the English red deer genotype stud hinds at Bushey Park (see 5.0). The absence of any impact of nutritional and weaning status on conception date argues well for the concept that hinds in this study were bordering on the conception date thresholds for red deer hinds.

Although the mean day of conception was relatively static across Years 1-3, varying by just 2 days, the conception date spread, or distribution, varied between years (Figure 13a-c). The spread was greatest in Year 1 due to a small number of hinds conceiving to the melatonin stags (i.e. conceptions prior to 16 March). Figure 13c shows a highly synchronous grouping of conception dates in Year 3. The analysis for Year 3 involved a smaller data set arising from the dentition cull, but a re-evaluation of data from Year 1 and Year 2 that excluded the hinds later found to have less than ideal dentition did not explain the significant reduction in the variance between Years 1, 2 and 3 (148, 91 and 34 for Years 1, 2 and 3, respectively). The greater synchrony could be a response to population density and social facilitation within smaller mobs. Subtle variations in photoperiod across years, influenced perhaps by climatic variations in actual sunlight hours, may also have relevance and deserves further investigation.

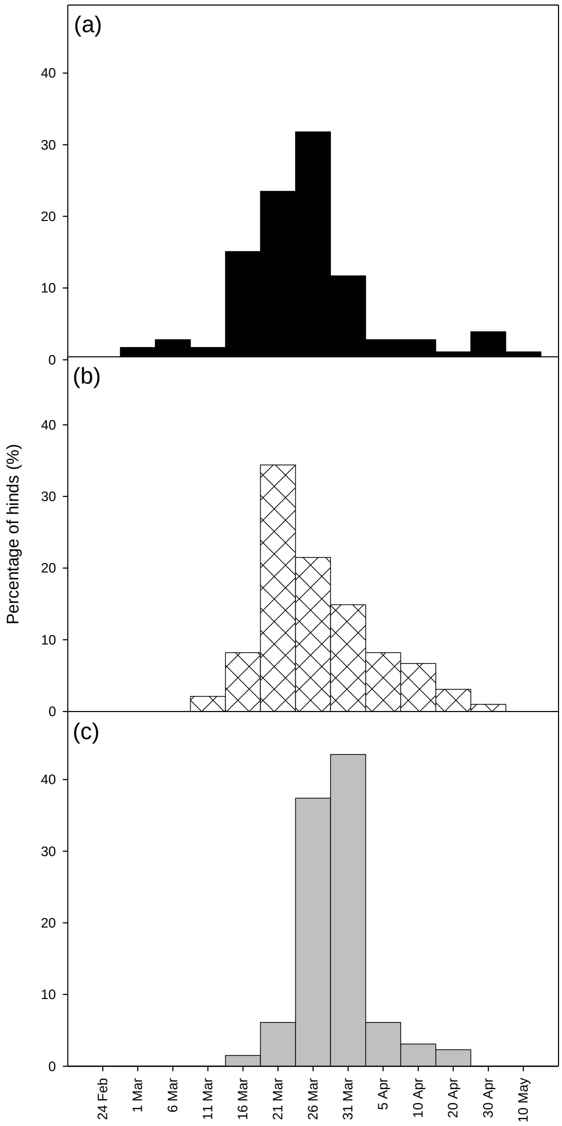


**Figure 13:** Histograms of the estimated conception date (± 5 days) across all treatments in (a) Year 1, (b) Year 2 and (c) Year 3.

## 4.5 Complementary and cumulative effects

At the outset of planning this project one of the goals was to assess the cumulative effects of the various treatments on advancing conception and calving date (treatment combinations from a two level factorial of stag, weaning and nutrition). However, the relative insignificance of the main effects made any attempt to assess whether the effects were complementary and cumulative or antagonistic difficult. Furthermore, evaluation of repeatability across years was difficult to ascertain because not all hinds remained in the same treatment each year; any hind in an early weaning treatment and calving following 1 December was re-assigned to a late wean treatment to ensure animal ethics obligations were met. Consequently, the analyses exhibited bias when hinds that met the above criteria were removed from the data-set. Year-to-year patterns were more consistent for the early wean treatments over and above the late wean treatments where the late conceiving hinds were not removed from their treatments.

Nevertheless, when using the criterion that considered all conceptions following 10 April as late (within the context of the histograms presented in Figure 13), approximately 12%, 19% and 12% of hinds in each year were categorised as late conceivers. However, between Years 1 and 2 only three hinds were late conceivers in each year and likewise between Years 2 and 3, only two hinds were late conceivers in both years. This indicates that, at least in this data set, the within-hind repeatability of conception date is low and that other environmental or genetic modifiers determine whether a hind is a late conceiver. Consequently, implementing management regimens to attain early conception are unlikely to lead to cumulative gains over a period of years. While this is somewhat disappointing given that the project was structured around achieving cumulative gains over years, it at least provides reassurance that when the conception profile is perturbed (e.g. through effects of drought, management decisions), the situation can most likely be recovered in following years without large carry-over consequences.

## 4.6 Population trends

The absence of consistent effects of management variables on conception day at the treatment level led to assessing relationships across a population of individuals. In Year 1 there was no evidence of any relationship between calf genotype and calving date. This finding contributed to conception day being unaffected by calf genotype despite the fact that hinds giving birth to crossbred (wapiti x red) calves are known to have a longer gestation (Asher, 2006). Furthermore, the absence of a similar association between preceding calving date and conception date in Years 2 and 3 suggests that this effect was confined to the variation introduced from the lead-in year from 2004. Once the hinds were in an established programme preceding calving date did not influence conception date.

Although hind live weight at the treatment level was not sufficient to illicit a response on conception date, there was a significant relationship in Years 1 and 2 between date of conception and January live weight but not mid-March live weight (i.e. at the cessation of the preferential feeding period). The slopes of the regression in Years 1 and 2 were significant (0.148 ± 0.084; 0.165 ± 0.071 for Years 1 and 2 respectively) and indicated that conception date could be advanced by around 6 days for a hind that was 130 kg when compared with a 90 kg hind. Live weight differences of this magnitude are likely due to a combination of both body condition and genotype influences, but it was not possible to separate out these factors in the analysis of live weight responses.

Due to the absence of treatment effects on the date of conception, particularly time of weaning in Year 1, a hind breed composition evaluation was undertaken to confirm the genetic baseline for each individual hind. Given industry trends for wapiti introgression to take advantage of rapid growth characteristics of cross-bred calves (Nicol *et al.*, 2003), there were suspicions of a strong influence of wapiti genes in the Winchmore herd. The results, however, discredited this thought and revealed considerable influence of Eastern genetics throughout the herd, with some minimal influence of wapiti. Breed composition analysis and its relationship with conception day were performed using the proportion of English genes as the principle variable and the regression coefficients were -12.52 (± 5.82), -8.51 (± 4.36), -5.98 (± 3.26) for Years 1, 2 and 3 respectively. These coefficients imply that an English dominant composite hind would conceive, on average, 5 days later than an Eastern dominant composite hind over the range of 0.3 to 0.9 proportion of English genes. It is interesting to note that the co-efficient for the association between genetics and date of conception was not consistent and declined across the three years. This probably reflected the greater synchrony in conception dates as shown in Figure 13. Furthermore, it is relevant to add that the breed composition of hinds (proportion of English, Eastern, Wapiti) was estimated using a limited range of DNA markers, and the approximate 5 day difference, while showing a clear role for genetics in early calving, probably under-estimated the real breed differences (due to an imprecise measure of breed composition).

The absence of any evidence for a stag effect on conception day indicated that either the rut was not sufficiently advanced in the stags treated with melatonin (despite altering the timing and number of implants in Year 2) or it is hind cyclicity, rather than stag presence, that controls day of conception (i.e. cause and effect are reversed, see section 5.0)

There was considerable evidence from the study to suggest that genetics has the potential to deliver more opportunity to the industry by way of advancing calving date than the management factors of nutrition and weaning. However, that does not negate the fact that nutrition is critically important to many other production system attributes and should not be over-looked.

# 5.0 The role of genetics in promoting earlier calving

This section summarises the results and conclusions from the research carried out on Stanfield's Bushey Park. A scientific proceedings paper submitted for the New Zealand Society of Animal Production Conference, 2006 is attached as an appendix.

The reproductive cycles of deer are strongly driven by photoperiod, but industry anecdotes suggest that there are some differences between genotypes in calving patterns, indicating a level of genetic variation in response to photoperiod. In particular, anecdotal evidence suggests that some deer from East European bloodlines calve earlier than the "NZ Red" deer descended from West European (English and Scottish) genotypes. As part of this programme we set out to provide objective evidence to test the anecdotal evidence and to determine whether genetics has a role to play in promoting earlier calving.

A series of observations were made on deer of different genotypes run on the one breeding property (Stanfield's Bushey Park at Palmerston). The genotypes observed consisted of:

1. English hinds mated to English stags (English)
2. Eastern hinds mated to Eastern stags (Eastern)
3. First cross (F1) Eastern x NZ red hinds mated to Eastern stags

All deer were mated in single-sire groups, with several groups representing each genotype. Stags were observed twice daily for roaring behaviour, and hinds were scanned to estimate conception date (to an accuracy of 5 days) at the end of the mating period.

For further details of the results please refer to the paper by Scott *et al.* (2006) as attached in the appendix. The Eastern stags showed significantly earlier rutting behaviour (as assessed by roaring frequency and body condition) than the English stags when in the same environment. Mean conception date for Eastern hinds was 13 days earlier than that of English hinds. In fact, this earlier conception may have under-expressed the true genotype differences as the stags were not joined with hinds until 7 March.

Interestingly, the F1 hinds showed a very similar conception pattern to that of the English, with the same mean conception date of 29 March. This was despite being run with Eastern stags. This result could be a reflection of the genetic control of the seasonality of conception date, and the fact that non-additive inheritance was observed (i.e. the F1s were not half way between the two parent breeds) might suggest that a small number of genes with a dominant inheritance pattern control the seasonal expression of reproductive traits. An alternative (although less likely) explanation is that the F1 hinds were sired by only a small number of Eastern stags, and these stags did not carry the genetics required for early calving.

The design of the study did not allow a definitive description of whether the early conception date of Eastern deer is driven primarily by male or female reproductive performance. However, observations of a very small number of English hinds which did exhibit early seasonality suggests that the English stags were capable of successfully inseminating hinds quite early in the season (before exhibiting full rutting behaviour), suggesting that the driver (or limitation) of reproductive seasonality is the timing of female cyclicity.

This study demonstrated clear genotype differences in conception date of hinds and rutting behaviour of stags, and confirms industry anecdotes about these breeds. This infers that there is genetic variation in the seasonal control over reproduction in red deer, and the results observed in red deer offer the intriguing possibility that this control is mediated by a small number of genes. This presents significant options to the deer industry in advancing calving via the use of genetics.

## 6.0 Acknowledgments

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# Appendix



## The influence of red deer genotype on conception pattern: Eastern vs Western subspecies.

I.C. SCOTT, G.W. ASHER, J.E. LACH AND R.P.LITTLEJOHN

AgResearch Invermay, Private Bag 50034, Mosgiel, New Zealand

### ABSTRACT

Advancing the calving pattern of red deer from November/December to October/November would better align the nutritional demands of lactation to pasture quality and availability. This study investigated the hypothesis that red deer of 'Eastern' (E) genotype (*Cervus elaphus hippelaphus*) have advanced reproductive seasonality traits compared to those of 'Western' (W) genotype (*C. e. scoticus*). Hinds of E (135) or F1 (E x W; 165) genotype were single sire mated to one of 6 E stags, while W (506) hinds were single sire mated to one of 11 W stags. Reproductive seasonality traits measured were stag roaring and body condition score (BCS), and conception date as estimated by fetal aging. Peak roaring frequency occurred earlier in E than W stags (mean March total roars observed 144 vs. 68 for E and W stags respectively; SED 33.4; $P<0.05$), and they also had a slightly lower BCS throughout the observation period. Mean conception date of the E hinds (16 March) was 13 days earlier than that of both the F1 and W hinds (29 March; SED E vs. F1 3.0 days; $P<0.001$). We conclude that red deer of E genotype have advanced reproductive seasonality traits compared to those of W genotype.

**Keywords:** red deer; subspecies; genotype; reproductive seasonality; conception

### INTRODUCTION

There has been much discussion within the NZ deer industry over several years about the desirability of advancing mean calving date as a tool to increase production by better aligning peak lactation with improved pasture quality and availability. To this end, some farmers have managed to shift from a November/December to an October/November calving pattern. There are probably a number of ways in which this has been achieved, including better feeding of hinds (Beatson *et al.*, 2000), earlier weaning (Pollard *et al.*, 2000) and earlier stag joining (Moore and Cowie, 1986). However, we also need to consider a potential role for genetics, particularly the option of introducing new genotypes into the national herd.

Red deer are the mainstay of the NZ deer farming industry, which was largely built up from wild captured stock and imports from British herds, with the predominant subspecies being *Cervus elaphus scoticus*. By contrast, many recent importations have been from Eastern Europe (e.g. Hungary and Romania) and are likely to be almost wholly of the *C. e. hippelaphus* subspecies. Essentially, these genotypes represent different subspecies of red deer that are part of the West-East 'cline' (gradual genetic change) from the smaller bodied Scottish red deer (*C. e. scoticus*), through to the larger Eastern European red deer (*C. e. hippelaphus)* (Whitehead, 1993). Irrespective of the finer detail of subspecies make-up, 'Western' and 'Eastern' red deer genotypes (for want of a better name) do demonstrate significant physical and behavioural differences.

The objectives of this study were: to compare the roaring pattern and body condition score (BCS) during the rut of 'Eastern' (*C. e. hippelaphus*) stags with those of 'Western' stags of English descent (predominantly *C. e. scoticus*); and to compare conception dates of 'Eastern' and F1 ('Eastern' x 'Western') hinds joined with 'Eastern' stags with those of 'Western' hinds joined with 'Western' stags. We tested the hypotheses that pure 'Eastern' stags commence the rut earlier, and hence lose body condition earlier, than 'Western' stags; and 'Eastern' hinds conceive earlier than 'Western' hinds, with F1 hinds being intermediate between the two parental genotypes.

### MATERIALS AND METHODS

#### Animals and treatments

This study was conducted on a commercial deer farm at Palmerston, Otago and approved by the AgResearch Invermay Animal Ethics Committee (Project 10487).

The hinds were weaned in the first week of March before joining with stags. Single sire mating groups were established as follows: 7 March - three purebred 'Eastern' (E) stags joined with 135 purebred 'Eastern' (E) hinds and eleven purebred 'Western' (W) stags joined with 506 purebred

'Western' (W) hinds; 14 March - three E stags joined with 165 F1 'Eastern' x 'Western' (F1) hinds. Because this study was carried out on a commercial farm we were unable to balance stag:hind ratios between individual stags, with the ratio varying between 1:12 and 1:69.

Roaring counts (the number of times a stag vocalised) were conducted for each stag for a period of five minutes in the morning and afternoon every Monday, Wednesday and Friday from 14 March until 27 April. Observations began within half an hour of sunrise and ended within half an hour before sunset and the same route was followed for each observation period so that animals would become used to a set routine. Body condition score (BCS: 1 - 5) of stags was also assessed in the field each day by a single observer (J.E.L.) with the aid of binoculars.

Hinds were scanned ultrasonically in mid-May, two-three weeks after stag removal, to establish pregnancy status and estimate conception date from fetal age. Hinds in which pregnancy could not be confirmed were scanned ultrasonically again mid-June.

### Ultrasonography

A single operator (I.C.S.) using a 5 MHz linear array transducer (Aloka SSD 500; Aloka Co. Ltd., Japan) performed all the rectal ultrasonographic diagnoses for pregnancy assessment and fetal aging. During ultrasonography, hinds were restrained individually in an upright position in a pneumatic crush. A liberal coating of carboxymethylcellulose lubricant was applied to the transducer, which was then inserted carefully into the rectum until an echo-image of the bladder was observed. The transducer was gently rotated 90° clockwise and 180° counter-clockwise while being moved forward until the uterus was located. Pregnancy was confirmed by identification of the chorionic vesicle, fetus or placentomes, and fetal age was estimated by the size of one or all of these identifying structures according to the method of Revol & Wilson, (1991).

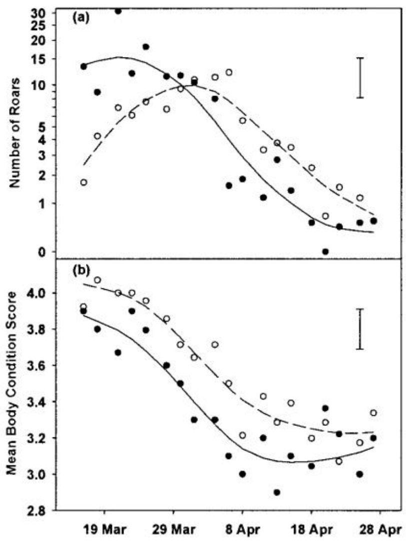
### Statistical analyses

The number of roars observed per day was log(1+x)-transformed to stabilise the variance. Along with body condition score (BCS), it was then analysed using residual maximum likelihood (REML), with stag as the random effect, genotype splines (smoothed curves) over day (Verbyla *et al.*, 1999), and genotype, day and their interactions as the fixed effects. Conception date data were analysed using REML, with stag as the random effect and hind genotype as the fixed effect. A further analysis included the number of hinds in each mating group as a fixed effect.

## RESULTS

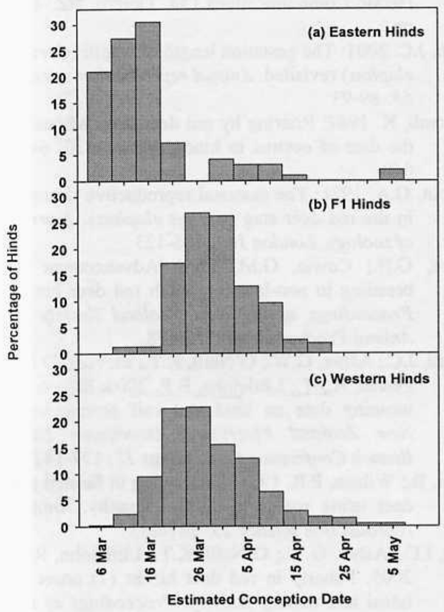
At the start of observations on 14 March the E stags were in full rutting voice, with the mean number of roars per observation day peaking around 19 March; thereafter roaring frequency declined rapidly such that they were virtually silent by mid-April (Figure 1a). By contrast, the W stags were relatively quiet at the start of observations and did not reach their peak roaring frequency until the beginning of April when, as with E stags, roaring activity declined rapidly (Figure 1a). The mean number of observed roars per stag totalled for the period 14 - 31 March was 144 for E stags and 68 for W stags (SED 33.4; $P<0.05$), while in April the respective means were 49 and 93 (SED 28.2; n.s.) observed roars. BCS for stags of both genotypes decreased over the observation period. Although BCS was lower for E than for W stags throughout the observation period and increased over the last two weeks of April (Figure 1b), there was no significant evidence that BCS or its slope or spline over time differed with genotype.

**FIGURE 1:** Scatter plots of mean and fitted smoothing spline of (a) number of roars per observation day and (b) body condition score of E (filled circles; solid line) and W (open circles; dashed line) stags during the observation period (March-April). The data has been log(1+x)-transformed to stabilise the variance.



The mean conception date for E hinds (16 March) was 13 days earlier than for the F1 hinds and W hinds (both 29 March; SED E vs F1 3.0 days; P<0.001) (Figure 2). There was no evidence (P>0.05) that conception date changed as the stag:hind ratio increased. Also, 80% of E hinds had conceived by 15 March, compared with 3% of F1 hinds and 12% of W hinds.

**FIGURE 2:** Density histograms of the estimated conception date to the percentage of (a) E (b) F1 and (c) W hinds conceiving in five-day periods.




## DISCUSSION

These data clearly show marked reproductive seasonality differences in both the hind and stag between 'Eastern' and 'Western' genotypes under the same environmental conditions. This is evident from the significantly higher roaring frequency of E stags in March, and the two-week difference between E and W hinds in mean conception date. Indeed, the early breeding characteristics of the E genotype may have been under-expressed due to being constrained to a 7 March joining date. We make this supposition because of two observations: firstly, the E stags were already close to their peak roaring frequency by the time observations began; and secondly, the conception profile of the E hinds indicates that nearly a quarter of the hinds were mated immediately the stags were introduced. This strongly suggests that some hinds may have initiated oestrus/ovulation before joining, and therefore would not be mated until a return to oestrus 18-19 days later. The F1 and W hinds had typical conception date profiles expected for hinds that had not initiated ovulatory activity before stag introduction (Scott *et al.*, 2005).

Body condition score of both the E and W stags decreased as the roar progressed, indicative of the increased physical activity and decreased appetite of a rutting stag (Lincoln, 1971). Although not significantly different, the BCS pattern of E stags is further evidence that E stags began and ended the rut earlier than W stags; their BCS was lower throughout the observation period, but began to increase from the second week of April, which coincides with the time that they virtually stopped roaring. However, assessing BCS from a distance is a limiting factor in the accuracy of our BCS data.

Previous studies (e.g. Fisher and Fennessey, 1990) have shown that seasonally advanced stags will induce hinds to cycle earlier than control stags. It is unlikely that the more intense roaring of E stags at the start of the present study induced an earlier mean conception date of pure E hinds; the F1 hinds were also joined with E stags, and their mean conception date was the same as W hinds (about two weeks later than E hinds). Also, the W hinds would have been able to hear the earlier roaring of the E stags and McComb (1987) has shown that auditory processes alone are sufficient to advance conception date in red deer hinds. Although the F1 hinds were joined with stags a week later than E hinds, their pattern of conception dates does not indicate that hinds were already cycling before the stag was introduced. Also, although the stag: hind ratio varied between mating groups, there was no evidence of stag:hind ratio having an effect on conception date. Therefore, we conclude that the limiting factor to early mating/conception was differential seasonality traits of the hinds and that expression of oestrous initiation was not altered by the early roaring of stags.

Interestingly, the F1 hinds had the same mean conception date as the W hinds, despite being 50% 'Eastern' genotype and run with E stags. This suggests that maybe only one or few genes control the seasonality traits studied and that these may be recessive for the 'Eastern' phenotype. If this is the case, then we would expect that the next generational cross (F2) obtained by mating F1 X F1 would produce individual hinds that expressed either early or late seasonal oestrus phenotypes. While this remains speculative, it opens up a huge array of opportunities to identify genes that may be responsible for early calving and to fix them into populations of red deer by selective breeding.

This study was carried out on a commercial farm and it was not practical to ultrasonically scan all of the hinds on two occasions to get a better estimate of fetal age, which is most accurate when the pregnancy is between 40 - 50 days. A single scanning date was set to coincide with the expected time that most hinds would be at that stage of pregnancy, as was indeed the case with W hinds. However, many of the E hinds in particular had a pregnancy of 70 days or more, sometimes making it difficult to visualise the fetus. In such instances, the less accurate method of estimating fetal age from placentome size was used. The conception profiles suggested that some of the hinds conceived in the five-day period before stags were joined with the hinds. This is clearly not the case and may reflect the inaccuracy of using placentome size to estimate fetal age. Alternatively, although we have no supportive data, it is possible that E fetuses grow more quickly, in which case fetal age would be overestimated.

Our data clearly demonstrate that *C. e. hippelaphus* hinds joined with *C. e. hippelaphus* stags conceive earlier than *C. e. scoticus* hinds joined with *C. e. scoticus* stags, but have yet to demonstrate that this leads to an earlier calving date. It is known that the larger wapiti subspecies (e.g. *C. e nelsoni*) has a longer gestation period than *C. e. scoticus* (Haigh, 2001) and this may also be the case for *C. e. hippelaphus*, thus cancelling out some of the benefit of an early conception date. However, anecdotal evidence from farmers using artificial insemination in their breeding programme suggests that there is no difference in gestation length between the two genotypes used in this study.

## CONCLUSION

Our data support the anecdotal evidence that introduction of pure 'Eastern' genetics into the deer herd will promote advancement of the mean calving date. However, it appears that this will not be expressed in F1 hinds, and further research is required to elucidate if reproductive seasonality is controlled by a single gene system.

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