Chapter 9

REPRODUCTIVE MANAGEMENT OF DEER

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OUTLINE

INTRODUCTION

Deer farming began in New Zealand in 1969 and has grown to be a significant livestock industry of approximately 1.6 million deer in 1997, with predictions of growth to 2.25 million by the year 2000. Initially, deer were captured from feral populations, but by the mid-1980s farmed deer population growth was largely a result of on-farm breeding. Research and experience has shown that the reproductive potential of farmed deer is high, but that management is a crucial factor in achieving optimum reproductive performance. All farmed deer species in New Zealand usually produce only single offspring and twinning is a rare event. Thus, for maximum reproductive efficiency, the goal of deer breeding management is to achieve as close as possible to 100% conception and weaning rates. Coupled with this goal is the need for genetic improvement, to adapt existing management systems to deer and to investigate new management possibilities to improve the overall reproductive efficiency of farmed deer.

There are seven species of deer farmed in New Zealand. Approximately 85% are Red (*Cervus elaphus scoticus*), 10% Wapiti (*Cervus elaphus nelsoni, rooseveltii and monitobensis*) also known as Elk, 4% Fallow *(Dama dama dama* and some *Dama dama mesopotamica)*, with a small number of Pere David's (*Elaphurus davidianus*), Sika (*Cervus nippon*), Rusa (*Cervus timorensis*) and Sambar (*Cervus unicolor*). There is a substantial amount of cross-breeding between Red and Wapiti. Table 9.1 summarises the major reproductive characteristics of the major species.

This chapter provides a summary of the important aspects of reproductive biology of the deer species farmed in New Zealand and discusses methods of reproductive management that will enhance the reproductive, productive and financial success of deer farming.

BREEDING SEASON

Red, Wapiti, Fallow, Sika and Pere David's deer, all of which originated from temperate regions, are distinctly seasonal breeders. They exhibit alternating periods of complete sexual quiescence and recrudescence. The photoperiodic control of reproductive cycles of temperate deer species has been demonstrated, and Red, Fallow, Sika and Wapiti deer are known as "short day breeders", with the breeding season in response to decreasing daily photoperiod, while Pere David's deer breed up to 3-4 months earlier. On the other hand, Sambar and Rusa deer may calve all year round, but calving tends to be concentrated in the autumn and spring. The comments that follow focus on the breeding season of the commonly

TABLE 9.1: REPRODUCTIVE CHARACTERISTICS AND PERFORMANCE TARGETS FOR THE SPECIES OF DEER COMMONLY FARMED IN NEW ZEALAND.

Characteristic	Deer species Red	 Wapiti	 Red x Wapiti[1]	 Fallow
Breeding pattern	Seasonally polyoestrus	Seasonally polyoestrus	Seasonally polyoestrus	Seasonally polyoestrus
Oestrous season begins:	Late March	Late March	Late March	Mid April
Gestation length (d)	224-242	247-265	233-248	225-242
Mean oestrous cycle length (d)	18	21	Unknown	21
Duration of oestrus (h)	18	15	Unknown	0.1 (terminated at copulation) or 12 if no copulation
Mean birth weight:				
males (kg)	9.9	19.2	13.8	4.4
females (kg)	8.9	16.8	12.0	4.1
Target weaning weight[2]:				
males (kg)	45	86	66	22
females (kg)	42	85	65	20
Target minimum liveweight at puberty:				
male (kg)	>80	>180	130	38
female (kg)	70	160	105	28
Target mature liveweight:				
male (kg)	>200	>400	>300	>100
female (kg)	>100	>240	>170	>50
Target calving/fawning pattern:				
1st calf/fawn	November 10	November 24	November 7	December 1
last calf/fawn	December 20	January 4	December 27	January 1
median calf/fawn	November 25-30	December 9-14	December 2-7	December 20
Target peri-natal mortality (%)	< 5	< 5	< 5	< 5
Target dystocia rate (%)	< 1	< 1	< 1	< 0.5
Target weaning %: 2-year-old	85	Few calve	50	75
Target weaning %: adult	90	85	90	85

[1] F1 hybrid = first cross Red deer x Canadian Wapiti.
[2] March 1st.

farmed temperate species in New Zealand.

The reproductive cycle

Male : The non-breeding season of males is characterised by complete spermatogenic arrest and a dramatic reduction in androgen secretion that coincide with antler casting and velvet antler growth. Conversely, the breeding season is characterised by an intensive period of mating activity, often termed the "rut" or "roar", during which males exhibit various forms of sexual behaviour and undergo a dramatic reduction in food intake and, consequently, bodyweight. The behavioural rut occurs from late summer to autumn, with the peak of rutting activity in Red deer commencing in late March through to April and in Fallow deer approximately 2 weeks later.

The reproductive changes associated with the annual rut include marked endocrine changes linked to photoperiodic cues and associated changes in testicular development, spermatogenesis, androgenesis and the development of secondary sexual characteristics e.g. antlers, neck muscle hypertrophy. These changes are directly influenced by LH secretion, which occurs in pulses of low amplitude and frequency during the non-breeding season and of high amplitude and frequency in late summer prior to the rut. As testes size increases toward the rut there is a concomitant increase in spermatogenic activity, such that by the onset

FIGURE 9.1: DISTRIBUTION OF BIRTH DATES FOR FARMED RED DEER AND FALOW DEER MONITORED ON SELECTED COMMERCIAL PROPERTIES IN THE WAIKATO AND BAY OF PLENTY REGIONS 1980-1984.

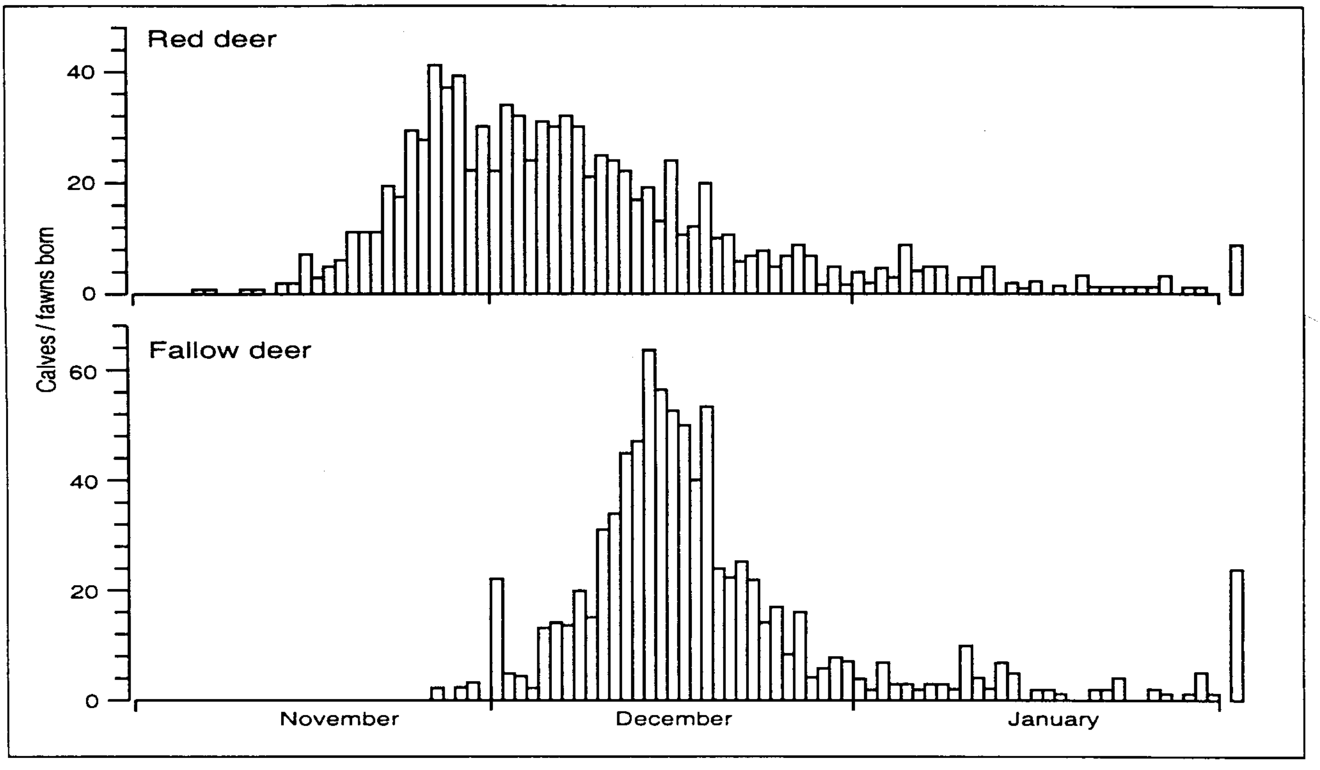
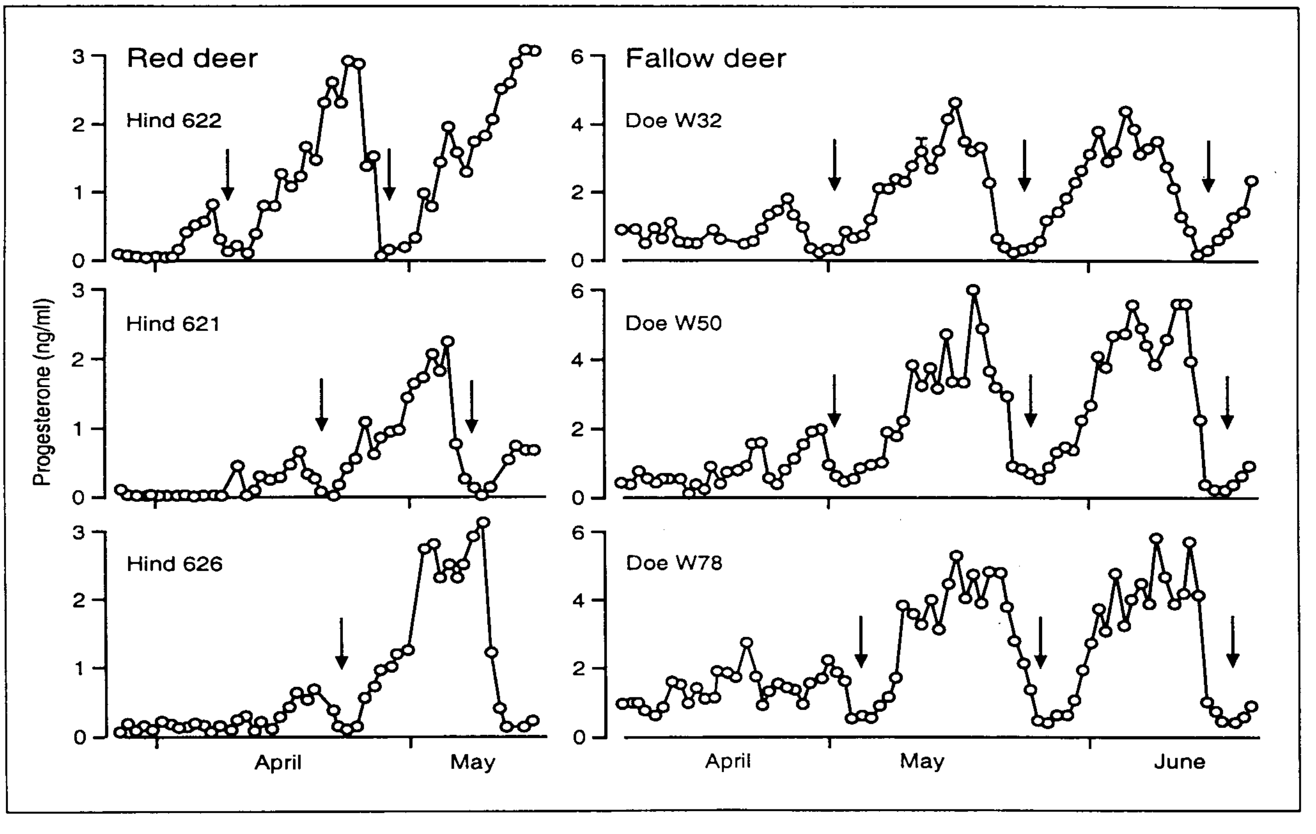


FIGURE 9.2: PLASMA PROGESTERONE CONCENTRATION PROFILES, FROM DAILY BLOOD SAMPLING OF RED DEER HINDS AND FALLOW DEER DOES DURING THE ONSET OF THE BREEDING SEASON,ILLUSTRATING LUTEAL CYCLES BEFORE AND AFTER OVERT OESTRUS.



Note that all animals exhibited one or more silent ovulations followed by a short-lived (8-10 day) luteal development. Arrows indicate overt oestrus detected by vasectomised males.

of the rut large numbers of viable spermatozoa are present in ejaculates. Testes remain active throughout winter, secreting modest levels of testosterone and producing large numbers of spermatozoa. Toward the end of spring, LH secretion diminishes and the testes regress in size and secrete only very low levels of testosterone. Spermatogenesis is completely arrested by early summer, and males remain infertile for approximately 2 months.

***Female*:** Female deer undergo a state of deep anoestrum, with the onset of the breeding season being in response to photoperiod changes. While deer are seasonally polyoestrous, their high fertility normally results in seasonal synchronisation of conception and a concise fawning (Fallow deer) or calving (Red deer, Wapiti) season (see Fig. 9.1).

Female Red deer generally commence seasonal oestrous cyclicity in late March, but may continue to cycle until August if conception does not occur. The breeding season of Fallow deer is approximately 2 weeks later, but synchrony of oestrus in this species is very pronounced, resulting in mean birth dates which are not significantly later than those of Red deer. The first overt oestrus of the breeding season in both Fallow and Red deer is preceded by a period of short-lived (8-10 d) luteal activity, which probably follows ovulation without behavioural oestrus (silent heat) (Fig. 9.2). These ovulations may be necessary for the expression of behavioural oestrus at the start of the breeding season and may play a role in the within-herd synchrony of first oestrus. The duration of the oestrous cycle differs between Red (18 d) and Fallow (21 d) (See Table 9.1), but cycle length becomes more variable toward the end of the breeding season.

In both Red and Fallow deer, the onset of overt oestrus precedes ovulation by 24 h. Luteal development following ovulation is associated with a progesterone secretory pattern that is typical of other domestic ruminant species (Fig. 9.2).

ADVANCING THE BREEDING SEASON

Deer usually give birth at a time of year when climatic conditions and an abundant, high-quality food supply are conducive to the survival of their young. In northern hemisphere regions where Red, Elk and Fallow deer have evolved, this generally means summer, a pattern they have still retained in pastoral environments.

However, in the New Zealand farming environment, the climate is milder and feed availability and quality are generally greater in spring than in summer. Therefore, advancing the timing of the mating, and thus calving or fawning seasons, would better align nutritional availability with requirements (Fig. 9.3), thus avoiding the occurrence of peak lactation during summer when both feed supply and quality may be limiting.

In addition to allowing better utilisation of pasture, the techniques may result in increased weaning weights (approximately 0.2-0.4 kg heavier at weaning for every day a Red calf is born earlier) and earlier attainment of acceptable carcass weights. Alternatively, being able to wean earlier may mean hinds can recover earlier from lactation and breed again earlier.

However, the induction of early breeding can be costly, and may reduce reproductive performance, particularly by spreading the calving or fawning seasons. In addition, advancing the timing of annual cycles in southern districts can result in the birth of young during unfavourable seasonal climatic conditions, while the associated enhanced growth rates may in some instances result in precocious puberty and an associated deleterious effect on growth. In the long term, genetic manipulation may prove to be a more suitable method of advancing the breeding season.

Techniques for advancing the breeding season

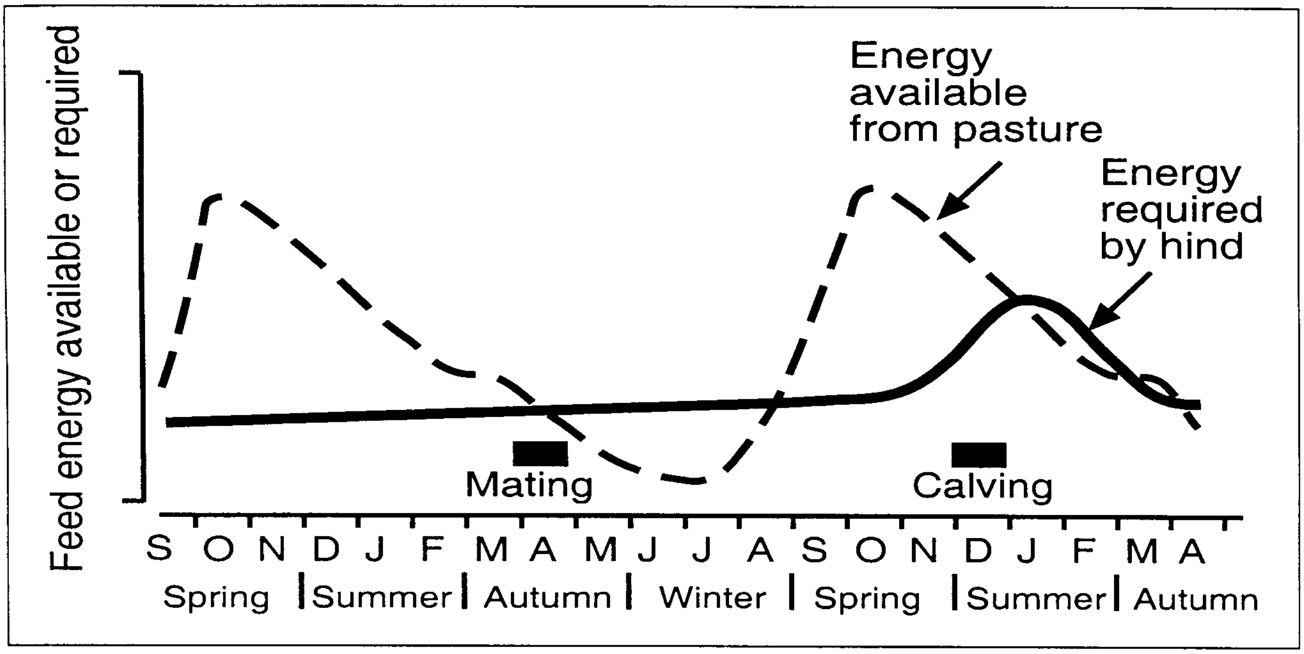
Advancing the timing of seasonal breeding can be achieved by stimulating the reproductive axis utilising hormonal or non-hormonal techniques (see Chapters 2 and 5) or by utilising animals with genetic traits for earlier seasonal reproductive activity.

Photoperiod and melatonin: Manipulation of the photoperiod or administration of melatonin can be used to modify the timing of the breeding season. Artificial darkness, which can be imposed by locking animals in a darkened room from mid-afternoon till after darkness for about 2 months after the summer solstice, or daily injecting or feeding of melatonin, results in an advancement of seasonal reproductive activity in hinds and stags. A more practical form of treatment is to use subcutaneous implants ("Regulin" Schering Agrochemicals Ltd.) containing 18 mg melatonin, thus providing a relatively constant pattern of melatonin release. Single implants are given to Fallow deer and double implants to Red deer to maintain elevated blood melatonin concentrations continuously for at least 30-40 days. The most practical and successful regimes involve three treatments at 30 day intervals or two treatments at 45 day intervals commencing late November, early December. It appears that in the annual photoperiod-entrained reproductive cycle an animal has to perceive a number of "long-days" (spring) after "short-days" (winter) before it is able to respond to melatonin treatment with advanced reproductive activity. Thus the melatonin treatment regime must be commenced from October through to December (Table 9.2). Within this period, earlier treatments may result in a greater advancement but may need to be of a greater duration.

Treatments commencing prior to October or after December may have little or no effect or may even delay reproductive activity.

Melatonin treated males may begin roaring or grunting

FIGURE 9.3: DAILY PASTURE ENERGY PRODUCTION AND ENERGY DEMAND FOR RED DEER HINDS FROM 8-28 MONTHS OF AGE DEMONSTRATING THE ASYCHRONY OF FEED SUPPLY AND DEMAND RELATED TO TIMING OF CALVING AND LACTATION.



earlier and display more aggressive, territorial and rutting behaviour when compared with untreated animals. In addition, seasonal changes in live weight, muscle development, testicular volume, scrotal circumference, semen characteristics, coat growth, and hormone secretion are evident earlier in treated animals. In the female, earlier ovarian activity and subsequent calving, as well as coat growth, occurs in treated animals. In addition, the effects of treatment can persist for a considerable time, as shown by an advancement in the timing of subsequent antler casting (Table 9.3) and velvet antler regrowth.

Melatonin implant treatment in late pregnancy has been shown in several studies to prevent the initiation of lactation in both Red and Fallow deer. Treatment after calving or fawning does not appear to affect lactation, but the necessity of yarding hinds or does with young at foot in the October to December period probably precludes its commercial use in adult animals. Thus melatonin treatment of females to advance the breeding season is practical only for first calving deer, with treatments commencing prior to puberty.

Progesterone, eCG and GnRH treatments: Direct hormonal stimulation of the ovaries with eCG or via the pituitary gland with GnRH, following a period of progesterone pre-treatment, can induce oestrus and ovulation in Red hinds and Fallow does. As little as 4 days (but usually 10-12 days) treatment with progesterone, usually in the form of an intra-vaginal CIDR device, ensures that behavioural oestrus accompanies ovulation and may also be important to subsequent corpus luteum and embryo development. While progesterone alone can induce oestrus and ovulation in a small number of animals, a low dose of eCG is injected at the time of progesterone withdrawal to induce oestrus and ovulation in the majority. It should be noted that the use of eCG may result in variable ovulation rates, with the possibility of excessive super-ovulation with higher doses in both Red and Fallow deer. While this may sometimes result in higher weaning percentages, it can also be counterproductive, particularly in Fallow deer, due to the higher incidence of mortality of offspring born as multiples.

GnRH can also be administered at or near the time of progesterone withdrawal and, while single ovulations only appear to be induced, the method of administration (via subcutaneous osmotic mini-pump or a series of injections) and the lowered success rate preclude its practical acceptance.

Progesterone and eCG/GnRH treatments both advance and synchronise mating so that nearly all females that respond are mated within a few days of progesterone withdrawal. However, fertility is frequently low and this may in part be due to the use of males which are likely to be subfertile or of low libido prior to the onset of the normal mating season. Fertility increases with proximity to the normal mating season or when melatonin-treated (seasonally advanced) males are used. Alternatively, spacing the time of treatments in a mob, so that only a proportion are mated every few days, can result in acceptable fertility.

Male/female interactions : There are several studies showing that untreated or control Red hinds and Fallow does can show oestrus, or conceive, up to about 3 weeks after progesterone/eCG treated females but still prior to the normal breeding season. This phenomena has been

TABLE 9.2: EFFECTS OF MELATONIN ON REPRODUCTIVE ACTIVITY IN RED AND FALLOW DEER.

Animal description	Treatment	Time treatment began	Peak testicular volume
Adult Red deer males	Melatonin	8 November	January
Adult Red deer males	Untreated	-	January-February
Adult Fallow males	Melatonin	22 November	January
Adult Fallow males	Untreated	-	March
Animal description	**Treatment**	**Time treatment began**	**Mean calving date**
Pubertal Red deer females[1]	Melatonin	2 October	24 October
	Melatonin	17 November	3 November
	Melatonin	30 December	21 November
Pubertal Red deer females[1]	Untreated	-	11 December
Pubertal Fallow females[1]	Melatonin	10 November	20 October
	Untreated	-	16 December
Adult Fallow females[1]	Melatonin	10 November	24 October
	Untreated	-	14 December

[1] Running with melatonon-treated or control males as appropriate.
(Data from recent trials at Invermay and Ruakura Research Centres.)

TABLE 9.3: MEAN DATE OF ANTLER CASTING IN UNTREATED CONTROL AND MELATONIN-TREATED RED DEER STAGS.

	Mean date of antler casting		
Age (years)	Untreated control	Melatonin-treated	Advancement (d)
5+	August 23 (4)	June 21 (5)	62
4	August 30 (2)	July 28 (3)	31
3	September 2 (2)	August 21 (3)	12

( ) Number of animals.
(Melatonin treatment was administered on the 16 December and the implants would have been exhausted during April.)

termed "social facilitation" or "sympathetic oestrus" and may involve a "stag effect" similar to the ram effect (see Chapter 7). Melatonin treatment of Red deer stags alone can result in advanced calving in untreated hinds (although both sexes need treatment for optimal advancement), while running a vasectomised "teaser" stag with hinds prior to joining with an entire stag may, although not always, also result in some advancement. However, while it is likely that these effects, when fully understood, will result in only modest (2-3 week) advances in the onset of the breeding season, they may contribute significantly to the synchrony of mating within groups of deer.

Genetic manipulation: Some of the natural variation in reproductive seasonality within a species of deer may be due to genetic variation. Selecting animals that have advanced antler growth cycles and rut or calve earlier than their herd mates may provide one opportunity to genetically advance the calving season. While there is evidence of such variation in Red deer, there may be less in Fallow deer.

Alternatively, hybridisation with species having more appropriately timed breeding seasons also offers the potential to genetically manipulate the breeding seasons of farmed deer. Consequently, the reproductive seasonality of the Red deer x Pere David's deer, Red deer x Sambar deer and European Fallow deer x Mesopotamian Fallow deer hybrids are being assessed. A Red deer X Rusa deer hybrid may also have the potential to breed earlier than Red deer.

OESTROUS BEHAVIOUR AND THE DETECTION OF OESTRUS

Behaviour in the different species

Red deer: The usual sign of impending oestrus is the close affiliation of the stag to the particular hind. Courtship often begins with the stag intermittently chasing the hind (short chase), with these chases gradually becoming more frequent and longer (long chase), often ending with the stag roaring. The stag may sniff the hind's vulva and show flehmen, especially when she urinates. As oestrus intensifies, the hind and stag spend more time together, sniffing and rubbing their chins and necks over each other's facial, back, rump and genital regions. The hind occasionally will circle the stag and wag her tail. Some hinds show a clear vulval discharge of mucus during oestrus. The stag usually mounts the hind about 5 times in a series of low, non-copulatory or incomplete mounts with penis extended. The final copulatory mount (high mount) results in intromission and, sometimes after a few mild pelvic thrusts, the stag performs a powerful copulatory or ejaculatory thrust, during which his head is held high and his rear legs leave the ground. At this point, the hind is pushed forward and the stag dismounts. The hind usually then crouches, appears to strain her abdominal muscles and urinates. This is only seen after copulation. The stag usually rests for a short while, may urinate and roar. A proportion of hinds may be served more than once, and up to five times, in a single oestrus.

Hinds in oestrus may also interact with other hinds, nuzzling and mounting them, and they are often more easily handled. A particularly quiet hind may exhibit standing heat in the presence of humans, whereby pressure on her back will result in the hind standing and arching her back (lordosis).

Elk: Little is known of the mating behaviour of farmed bulls and cows. However, from limited observations in the wild, it would appear that their behaviour very closely resembles that seen in Red deer.

Fallow: The earliest sign of impending oestrus, seen 12-24 hours before its onset, is when the doe dissociates from her herd mates, becomes restless and may show aggression towards other does. During this period, the buck may approach the doe, often displaying a high-gaited, goose-step-like walk, with flared pre-orbital glands and a raised tail. However, during such encounters the doe actively avoids the buck and is often chased or herded back into the group. The buck usually groans during and after the chase. This behaviour by the doe may continue to within a few hours of the onset of oestrus. It is followed by a period of resting during which the buck remains in close proximity and may sniff the doe's vulval region.

The initiation of fervent self-grooming or preening activity (continual chin-rubbing over the rump and back), or the absence of submissive or avoidance behaviour on the approach of the buck are indicative of the onset of oestrus. The buck may sniff or lick the does vulva, stand with his chin over her shoulder or back, groom the doe's face and ears or groan nearby whilst the doe remains standing or grooming. Within a few minutes, the buck tentatively mounts the doe. The buck usually mounts the doe about 10-20 times, each of which is non-copulatory, beginning with the penis unprotruded. As oestrus proceeds, the penis becomes more protruded and erect, and the doe continues grooming herself and occasionally grooms the buck as well. Eventually, the buck achieves intromission and performs a copulatory mount characterised by a powerful pelvic thrust during which his hind legs leave the ground and the doe is pushed forward. The doe usually then stands with her back arched and tail raised occasionally straining her abdominal muscles, and passing clear mucus from her vulva. The buck may urinate and groom his penile region, showing little further interest in the doe. Oestrus is usually terminated with copulation, but multiple matings at a single oestrus are occasionally seen. Does in oestrus do not often mount or interact with other does, nor do they mount the buck.

Detection of oestrus

Oestrus in Red, Wapiti and Fallow deer can be reliably detected by continuous observation throughout the breeding period but as yet there is no other completely satisfactory practical technique. Attempted methods of detection usually include a crayon colour marker attached to the brisket of the stag or buck. Crayon marks are transferred to the female's rump at mating. This technique is better suited to Fallow, which have a higher mount:service ratio and do not wallow in mud. Fallow bucks, particularly, are suited to fitting with ram mating harnesses containing soft red, blue or green crayons. Fitting the harness can easily be performed on unsedated deer in standard restraint systems (cradles), but crayon replacement needs to be performed at least every second day for optimum doe marking. Detection can be improved by bleaching the hair on the does hindquarters with hydrogen peroxide. Lengthening the straps on the harness also enables them to be fitted to red stags but the effectiveness of this method of oestrous detection in this species is highly variable, unlike its high degree of efficacy (90%) in Fallow deer.

An alternative technique, sometimes used on Red stags, involves applying dyed grease liberally over the stags underside, avoiding the penis and scrotum, and down the inside of the front and back legs. This usually requires sedating the stag. Since the grease dries, this technique is really only satisfactory for a few days, and when the hinds and stags cannot wallow or be marked inadvertently during yarding and handling.

Another technique of detecting successful mating is to take regular vaginal swabbings and examine the smears for spermatozoa. Although this method is generally impractical since it requires extensive yarding and handling, it does provide unequivocal evidence of mating, especially when used in conjunction with other techniques.

ARTIFICIAL BREEDING

Within the last 10 years there has been a rapid movement toward artificial breeding technologies for farmed Red, Fallow and Wapiti deer. Artificial insemination (AI) and embryo transfer (ET) have become commercially available in New Zealand and some other countries. Artificial breeding is not seen as an alternative to natural mating for commercial deer herds, but rather as a means of increasing the rate of genetic improvement. Cryopreservation of gametes/embryos enhances international transfer of genetic material, overcoming many of the risks associated with the international live deer trade.

Synchronisation of oestrus

Since detection of spontaneous oestrus in farmed deer is difficult, artificial synchronisation of oestrus has been adopted as a more cost-effective alternative for artificial breeding programmes. The most effective method is the administration of progestagens, which in Fallow deer also provide a high degree of synchrony at the next oestrus should the does not conceive at the first oestrus. Prostaglandins provide a less reliable form of synchronisation.

Most synchronisation programmes use the intra-vaginal CIDR (Controlled Internal Drug Release) device, using either CIDR type G for Red and Fallow deer or one CIDR type B device for Wapiti deer. Intra-vaginal insertion of the CIDR device for 12-14 days provides blood progesterone levels similar to those observed during the natural oestrous cycle of Fallow deer. In Red deer, a single CIDR results in a fall of progesterone to less than 1 ng per ml by day 14, prompting the use of CIDR device replacement on day 9 or 10, in many instances. The efficacy of synchronisation with the CIDR device appears optimal if they are timed to be withdrawn after the period of first normal spontaneous oestrus in Fallow deer. Oestrus occurs 48-58 h after CIDR device removal. At present the use of eCG at or near CIDR device removal is contra-indicated in Fallow deer due to excessive ovulatory responses leading to poor conception rates.

AI early in the breeding season is often associated with low conception rates in both Red and Fallow deer. However, for Red deer it has become routine practice to administer 200-250 i.u. of eCG at or near CIDR device removal. It is likely that this induces ovulation more reliably when CIDR devices alone are used prior to the natural breeding season. However, eCG may also counteract the suppressive effects of handling induced stress on ovulation and reduce the variance in timing of oestrus/ovulation synchrony. A slightly increased incidence of multiple ovulations has been observed following eCG administration to Red deer hinds and this has occasionally resulted in the conception and birth of twins to AI programmes.

Prostaglandin treatment may be used to induce premature luteal regression, and thus synchronise oestrus and ovulation with oestrus occurring approximately 36-48 h after treatment in both Red and Fallow deer. However, it may be ineffective in a proportion of animals during the first half of the oestrous cycle. Later in the cycle, it is a more effective means of inducing synchronisation. In practice, its use has produced lower conception rates than those observed after CIDR device synchronisation.

Semen collection and storage

Semen collection from male deer has been one of the major limiting factors to the widespread use of AI within the deer farming industry. Because of testicular quiescence during spring and summer, semen collection is limited to 4-6 months of the year commencing immediately before the rut. This presents time constraints for fresh semen distribution. Secondly, stag temperament during this period is not conducive to the use of natural semen collection methods. Therefore, semen collection from Red and Fallow deer has generally been performed by electro-ejaculation while the animals are under general anaesthesia/sedation. However, there are risks associated with the procedure and electro-ejaculation may produce semen of lower quality than would be obtained by more natural methods.

Generally, semen is extended in sodium citrate, egg yolk, glycerol diluent and frozen either as pellets on CO_2 ice or in 0.25 ml straws in liquid nitrogen. Fallow deer semen has been shown to be particularly resistant to the rigours of freezing/thawing procedures and post-thaw motility rates often exceed 70% of pre-freezing motility rates. Post-thaw motility rates of Red deer semen appear to be highly variable, both between stags and between consecutive ejaculates from the same stag.

Insemination procedures

Intra-uterine insemination using a laparoscopic technique is presently the preferred method of AI for both Red and Fallow deer, allowing precise placement of relatively small quantities of semen close to the site of fertilisation. Trans-cervical intra-uterine insemination has proven possible for Fallow deer, but is generally a slow procedure requiring long periods of chemical restraint. The standard regime presently applied to commercial laparoscopic intra-uterine insemination of Red deer in New Zealand involves semen disposition (20-40 x 10^6 spermatozoa, >50% motile post-thaw) between 54 and 56 h after CIDR device removal and following eCG administration. Studies on Fallow deer have indicated that the optimum protocol involves 25 x 10^6 spermatozoa (>70% motile post-thaw) between 65 and 70 h post-CIDR device removal. In the latter case, best results are achieved after 30 April in New Zealand. Conception rates following laparoscopic intra-uterine insemination of both species have generally ranged from 50-80%, although occasionally poor rates (less than 50%) have occurred on some farms, possibly as a result of poor semen quality, inappropriate timing of insemination and animal stress.

Intra-cervical inseminations for both Red and Fallow deer have resulted in highly variable conception rates (20-80%). However, recent studies on Fallow deer have indicated that consistently high conception rates can be achieved using this route where rates of greater than 100 x 10^6 motile frozen-thawed sperm are administered about 12 h before the mean time of ovulation (i.e. 60 h post-CIDR device removal). Fresh semen doses as low as 12 x 10^6 spermatozoa have resulted in conception rates greater than 75% following intra-cervical deposition of semen. While this holds promise for lower cost AI techniques, the development of a semen extender capable of maintaining spermatozoa viability for extended periods (i.e. greater than 3 days) is required.

Embryo transfer

Embryo transfer (ET) is practised on Red, Wapiti and, to a lesser extent, Fallow deer. Red, Fallow and Wapiti are mono-ovulatory, requiring administration of gonadotrophins to stimulate multiple ovulations. However, while a wide range of responses to eCG and FSH have been reported, the substitution of FSH for eCG probably will result in more consistent results. FSH is administered either as eight intra-muscular injections over a period of 4 days or by continuous infusion using osmotic mini-pumps implanted subcutaneously.

While there are few detailed published accounts describing embryo freezing for farmed deer, standard techniques have been applied commercially and have resulted in reasonable success rates. Thus pregnancy rates following embryo transfer to Red deer have ranged from 60-80% for fresh transplants and 55-66% for frozen/thawed transplants. Results have been similar for transfer of thawed Fallow deer embryos.

Generally recipient Red deer hinds are treated with intra-vaginal CIDRs for 12 days and given 200 i.u. of eCG at CIDR removal. The embryo is usually injected into the utero-tubal junction of the uterine horn on the same side as the ovary containing a CL using a glass pipette or a tom-cat urinary catheter. Recipient Fallow does are usually synchronised with an intra-vaginal CIDR device for 14 days.

In vitro fertilisation

The potential of *in vitro* fertilisation techniques for the deer farming industry has yet to be fully assessed. Oocyte recovery from pre-ovulatory follicles of slaughtered Red deer hinds is comparable to that of other domestic ruminants, with an average of six good quality oocytes per Red hind, while an average of only two oocytes have been recovered from Fallow does. Studies to establish successful techniques for *in vitro* maturation and fertilisation are needed before these techniques can be considered for commercial application.

PREGNANCY

The early development of the embryo following fertilisation has not been extensively studied in deer. However, limited observations in Red deer suggest that at least at about 6-7 days after mating they resemble cattle embryos of the same age.

Nineteen days after mating in the Red deer hind, the embryonic blastocyst begins to go through a period of rapid development with gastrulation (see Chapter 2) completed by day 27, by which time the trophoblast has elongated and extended through both uterine horns. The placenta is syndesmochorial (the chorionic epithelium is in contact with the endometrial connective tissue) and attachment of embryonic and maternal membranes or placentome formation occurs at the uterine caruncles (usually four or more in each uterine horn) from about day 24-41 onwards in Red deer and probably at a similar time in Fallow deer and Elk. There may also be some smaller accessory placentome formation between the main placentomes, at least in Red deer later in gestation. Elk and Red deer embryos weigh about 1g 40 days after mating. The comparative newborn weights of Red, Elk and Fallow deer are shown in Table 9.1.

The placenta grows throughout pregnancy in the Red hind, consistently comprising about 6% of the weight of the gravid uterus. Fluids account for about 30% of the 15 kg gravid uterus at term and the foetus 40%.

Pregnancy diagnosis and foetal ageing

Pregnancy diagnosis techniques are relevant to commercial farming to allow detection and culling of unproductive hinds, and as a tool for investigation of infertility problems. The optimum method needs to be 100% accurate for both pregnancy and non-pregnancy, it needs to be capable of diagnosis both early and late in gestation, and must be available at an acceptable cost.

***Blood progesterone*:** Blood progesterone levels during pregnancy range from 4-10 ng per ml. In order to distinguish the progesterone of pregnancy from luteal phase progesterone (1-6 ng/ml), repeat samples are necessary until late pregnancy, since a non-pregnant hind may cycle up to eight times (i.e. until mid-August). It is believed that progesterone measurements give a 10% over-estimate of pregnancy; this could be due to inappropriate sampling intervals, and/or persistent corpora lutea, or progesterone of adrenal origin possibly caused by the stress of handling and sampling the animals.

***Pregnancy-specific protein (PSP)*:** Pregnancy-specific protein B is produced by the trophoblast of several ruminant species. It can be detected in the plasma or sera of pregnant females, utilising a bovine radioimmunoassay technique, as early as 24 days after mating, but can be consistently detected only from 30 days gestation. This method is advantageous, as it is completely specific to pregnancy, but is currently unavailable in New Zealand. It is expensive.

***Manual methods*:** During the last 6-8 weeks of gestation, the foetus may be palpated abdominally, a technique which is usually difficult due to tension of the abdominal wall. During the last 2-4 weeks of gestation the udder develops progressively and may be visually observed or palpated manually to confirm pregnancy or to separate hinds into early or late calving mobs. Manual palpation per rectum is possible only in larger deer e.g. Wapiti, and foetal membranes, placentomes and foetal structures may be detected. Also during this time, abdominal distension and rapid weight gains are signs indicative of pregnancy.

***Ultrasonography*:** The most widespread and useful method of early pregnancy diagnosis in deer, and the only method available for foetal ageing, is real-time ultrasonography. A 3.5 MHz sector-scanner may be used externally, but is more suited to diagnosis later in gestation. The most satisfactory technique is the insertion of a 5 MHz linear transducer on a rigid metal extender into the rectum of suitably restrained deer. This technique gives an instant image of uterine and foetal structures. The first sign of pregnancy can be seen in some deer as early as 7 days after conception. The accuracy of pregnancy detection before day 20 is 35%, 71% between days 21 and 30 and 98% between days 31-42. Thereafter the accuracy of pregnancy diagnosis is 100% until late gestation, when foetal and uterine structures descend into the abdomen below the depth of penetration of a 5 MHz transducer.

Physical measurements of the foetus, membranes, placenta and uterus may be recorded from appropriate scans and age estimation undertaken. Foetal ageing will predict calving dates to within ±0.9 days on average. Accurate foetal ageing is not possible beyond 150 days gestation, when pregnancy can only be confirmed by the presence of placentomes or foetal extremities.

PARTURITION

Red deer: Hinds about to calve become restless and move away from their herd mates. This probably reflects the need for isolation, as in the wild, hinds disperse from their home range to calve. On farms, particularly in smaller paddocks, restlessness is commonly seen in two forms of fence pacing. The first, a period of light fence pacing may occur up to 7-10 days before calving. The second occurs 1-2 days before birth and is more intense, with the hind often running and panting, and during this time there is a marked swelling of the udder. The imminence of calving is characterised by a reddening and slight swelling of the perineal region and the hind frequently grooms her flanks, udder and perineal area. The calf is usually born within 45 minutes of the first appearance of the amniotic sac, during which time the hind may lick her teats, vulva and the emerging hooves and forelegs. The hind continues to be restless and usually alternates between lying down and standing and the calf may be expelled while in either position. The calf is licked clean immediately after birth and stands and sucks the hind about 30-45 minutes after birth. The placenta is expelled up to 90 minutes after birth and is immediately eaten by the hind. The surrounding grass is also eaten or cleaned of any membranes and fluids. The hind will graze and rest close to the newborn calf for periods of up to 4-5 h during which there are further periods of licking and grooming usually associated with suckling, between which the calf remains lying down, particularly in cover, in the characteristic hiding strategy. After about 4-6 days the calf begins to no longer stay hidden and tends to spend progressively more time with the hind and the rest of the herd.

Elk and Fallow deer: Little is known of the behaviour of farmed or even wild Elk cows and Fallow does around the time of calving or fawning. Casual observations suggest they generally resemble the behaviour patterns seen in Red deer.

Dystocia

The national prevalence of dystocia problems in Red deer is likely to be about 1%. Approximately 67% of dystocias are with male offspring, fewer than 50% of offspring are born alive after a dystocia and approximately one third of live offspring are rejected by their dam after a dystocia. Approximately two thirds of dystocias are anterior presentation (front first), with head back or down being the most common abnormality of presentation. Foetal oversize constitutes approximately 33% of anterior presentation dystocias. The other major presentational abnormality is front leg back. The remainder of dystocias are mainly normal posterior presentations (i.e. both hind legs presented first).

Important factors which pre-dispose to dystocia appear to be overfatness of the hind, lack of fitness (dystocia rates appear lower on hill country), relative foetal oversize dependent on breed of sire, and disturbance during parturition. It would appear that first calving hinds have a higher rate of dystocia than do mixed-age hinds.

The incidence of dystocia in Fallow deer is low, but may be increased slightly when using Mesopotamian sires. The

TABLE 9.4: GESTATION LENGTH, GROWTH RATE AND MORTALITY OF SINGLE AND TWIN RED DEER CALVES.

	Single	Twin
Hinds calving to an induced oestrus	39	19
Gestation length: males(d)	232	236
Gestation length: females(d)	235	233
Gestation length: male/female(d)	-	234
Birth weight: males (kg)	9.1	5.8
Birth weight: females (kg)	8.7	6.9
Birth weight: male/female (kg)	-	6.6/5.7
Peri-natal mortality (%)	15	25
Liveweight at 12 weeks: male (kg)	42	33
Liveweight at 12 weeks: female (kg)	39	32
Liveweight at 20 weeks: male (kg)	62	51
Liveweight at 20 weeks: female (kg)	56	48

(From Fennessy, P.F. et al., Anim. Prod. 51: 623-630, 1991.)

use of such sires result in an increase in birth weights by 40-50%.

Twins

The birth and rearing of natural twin (or multiple) Red, Elk or Fallow deer is a very rare occurrence, both in the wild and on farms. Thus, the induction of twin births would appear to be a means of readily increasing reproductive rate. However, in Fallow deer, the high incidence of low birth weights and the consequent increase in peri-natal mortality likely to be associated with multiple births, means that twinning is not necessarily a practical means of increasing reproductive rate or farm profitability. While there is no data on twinning in Elk, twin births have been successfully induced in Red hinds treated with progesterone and eCG prior to the onset of the normal breeding season. While twin Red calves have a lower birthweight and a higher incidence of dystocia and peri-natal mortality, increased production can result (Table 9.4). Theoretically, a 50% twinning rate (assuming 5% and 20% peri-natal mortality in singles and twins, respectively) increases biological efficiency (meat produced/food consumed) by about 12%, based on predictive models that have been developed for food intake and growth.

The incidence of freemartinism (sterility in females born co-twin to a male) has yet to be fully determined; this condition certainly occurs in some deer.

THE ANNUAL REPRODUCTIVE MANAGEMENT CYCLE

Mating management

Since the commencement of deer farming in New Zealand, mating management has improved with a consequent overall advancement in the onset of the natural breeding season. Calving patterns have become more condensed, weaning dates have been advanced and annual reproductive performance now averages approximately 86% calves weaned to adult hinds mated and about 70% to yearling hinds mated. Several management factors can influence the success of reproductive performance.

***The mating season*:** Red deer hinds rarely exhibit oestrus before late March. Consequently the commencement of calving is rarely earlier than November 10. The usual practice is to join stags with hinds in mid-March (post-weaning), partly in anticipation of a stag-effect inducing oestrus and ovulation in hinds. If single-sire mating groups are used, it is advisable to change stags at a date appropriate to allow the back-up stag one full oestrous cycle (18-21 days) in the event that the first stag exhibited sub-optimal fertility or libido. Conclusion of the mating season varies considerably in practice, but the tendency is now to conclude mating as early as May 1 to 10. Pregnancy rates of 95% have been achieved under optimum nutritional conditions with these short mating periods. Late born calves are considered to be largely unprofitable. It is often considered necessary to change stags during mating, even in multi-sire groups because of the harem formation that occurs with dominant sires.

Fallow deer tend to initiate oestrous cycles approximately 15 days later than Red deer, with breeding commencing toward mid-April. However, Fallow deer appear more synchronised in terms of their onset of oestrus, resulting in a tighter fawning pattern. Thus a shorter mating interval terminating mid-May appears appropriate for this species.

Pubertal (yearling) Red deer hinds tend to cycle approximately 10 days later than adult hinds, thus it may be appropriate to terminate mating a few days later for this age group. Given the social dominance patterns that occur between adult and pubertal Red deer, it may be advisable to mate yearling hinds in separate mobs. There is however, an indication that the mating period in large groups of yearling hinds is short, and that the addition of 10% of older hinds to the group may stimulate oestrus and therefore enhance conception rates. This may not be necessary for Fallow deer, which tend to exhibit less pronounced social dominance hierarchies.

Multiple vs single stag mating groups: Multi-sire mating is still practised on New Zealand farms. Where paddocks and herds are large enough for a number of stags to form individual, non-overlapping harems, this management is satisfactory. However, more aggression and fighting will occur if the area is not large enough for complete separation of harems, with one stag attempting to maintain dominance over all hinds. Defence of a harem exacerbates weight loss of dominant stags.

Single sire mating groups are more commonly used; they allow more control over breeding programmes and reduce the risk of injury to breeding stags by fighting. Furthermore, weight loss in stags is generally greater in multi-sire groups, increasing the risk of animal health problems during winter.

There has been an observation made with Wapiti that younger or subordinate bulls tend to be intimidated by near-by dominant or older bulls or more aggressive Red stags resulting in substantially reduced libido. It is therefore advisable to keep Elk mating groups well isolated from one another where possible. There is also a suggestion that Wapiti cows prefer to mate with mature rather than immature bulls.

Male/female ratios: The 'usual' male/female ratio at mating approximates 1:35. Some commercial units have a 1:80 ratio, and ratios of 1:180 have been attempted on occasion, apparently with success. It is suggested that such stag/hind ratios should be used only with mature, experienced males and in single sire groups. Further research is required to determine the ultimate breeding capacity of male deer.

The age of the sire is considered important and while 16-month-old male Red and Fallow deer are fertile, they are commonly used at ratios of only 1:10 to 1:15. Where yearling males are used, multiple sire groups are common. Only well grown yearling males should be used. Yearling Wapiti bulls are better not used as sires as they are generally later maturing than other species. Ratios of 1:50 have been used successfully with 2-year-old Red stags; a more conservative ratio of 1:30 may give more consistent results.

The recommended ratio for Wapiti-type deer is 1:25 to 35. Again further investigations are required to determine the mating capacity of Wapiti bulls.

Male fertility: Conception rate at a given oestrus in deer is usually 80-85% and for some sires has been as high as 100%, but occasionally the sire may be sub-fertile or infertile. Behavioural observations do not provide a good measure of fertility, but, if roaring and other rutting activity continue late into the rut, there is a possibility that females are continuing to cycle as a result of sire infertility. Ultrasound investigation of Red hinds approximately 15 days after the commencement of oestrous cyclicity should detect in excess of 30% of pregnancies. Thus, there is now a method for assessing fertility of stags early enough in the breeding season to effect management changes. The advantages of this would need to be weighed against the potentially negative effects of disturbing the mating group at that time.

Sire management: Given the dramatic bodyweight loss during the rut, sires should be fed to appetite during the spring and summer period to achieve high pre-rut bodyweights. Post-rut sires should be placed on high feed allowances to compensate for reduced body condition in the face of cold or adverse weather conditions. Failure to address this basic management requirement may result in the death of sires during winter due to exposure or starvation. In addition, anecdotal evidence suggests that high feed levels immediately post-rut enhance velvet antler production later in the year.

Weaning

While most farmers simply graze deer at pasture, many commence supplementary feeding (e.g. grain or deer nuts) 2-3 weeks prior to weaning. This quietens the calves in the paddock, and after weaning they are easier to handle (and muster), adapt more readily to supplementary feed and possibly suffer less stress.

***Weaning date*:** The majority of deer farmers now wean prior to the rut. The decision on weaning date depends on many factors. If feed supplies during late lactation are dwindling, as they often do in dry areas of New Zealand, farmers should consider early weaning (e.g. at mid-February) in order to allocate quality feed supplies to the weaners rather than the dams. Weaning during the first week in March, allows dams 3-4 weeks to overcome potential lactation-anoestrous effects and to recover some body condition prior to the onset of oestrus. Many commercial sale strategies rely on selling young stock at this time. Weaning should not take place at times of inclement weather because of the risk of stress-induced losses.

There are many practical advantages of pre-rut weaning including the ability to preferentially feed, undertake disease control (including anthelmintic drenching at regular intervals), frequent handling quietens deer at a young age, and mating management is simplified without the presence of calves at foot.

Some farmers, however, prefer to wean post-rut, believing that older deer suffer less stress at weaning. Further objective study is required to determine the influence of early and late weaning on productivity and reproductive efficiency in the farming environment.

Most Fallow deer farmers practise pre-rut weaning of fawns, with fawn removal occurring in late March.

There is a growing tendency amongst Wapiti farmers not to wean until after winter. Subjective observations suggest that elk cows and calves fret after weaning, with possible detrimental effects on the onset of oestrus.

***Feed management for weaners*:** To achieve optimum weight gains post-weaning, pasture should be green leaf type of a minimum 10 cm height. If that type of pasture is not available, supplementary feeding with concentrates is required. Soiled pasture is not readily accepted by young stock and should be avoided. Deer usually have a reduced growth rate 1-2 weeks after weaning, but recover rapidly.

Some deer farmers believe housing weaners indoors with concentrate feeding for up to 1-2 weeks after weaning is advantageous in quietening the animals and reducing stress.

Weaning weights: Target weaning weights (early March) are presented in Table 9.1. It would seem Red deer can be weaned at liveweights as low as 25 kg and Fallow as low as 12 kg. Weaning weights from first calving hinds and does are usually approximately 10-15% less than those of adults.

Weaning percentage: Target weaning percentages are given in Table 9.1. The target weaning percent for Red deer is 90% for mixed age hinds and 85% for first calving hinds. The national average Red deer weaning percentage approximates 86% of adult hinds mated. Similar targets are set for Fallow deer but actual weaning percentages on New Zealand Fallow farms are generally 80-85% for adult does and 70-80% for first fawners.

Peri and post-natal mortalities

Surveys have shown that mortalities prior to weaning range from approximately 2-17% (average approximately 10%). The major causes of Red deer calf losses were still-birth (28%), dystocia (23%), mis-mothering (20%), starvation (9%), trauma (6%), infections (4%), abortions (2%), other (8%). The most common cause of loss around weaning is injury (which can be largely avoided by quiet handling), or *yersiniosis*, often precipitated by underfeeding or inclement weather. There have been occasional occurrences of *leptospirosis* in newly weaned Red deer. Low birth weight Fallow fawns are termed non-viable because of their high mortality rate. This may be related to the level of nutrition of the deer during late gestation. Mis-adventure can be a common cause of Fallow fawn death, particularly if fencing materials are inadequate to prevent fawns from wandering away from the herd.

FEEDING FOR REPRODUCTIVE PERFORMANCE

Only a brief review of feeding management throughout the year is considered here - the reader is referred to the New Zealand Society of Animal Production Occasional Publication No. 10, (1987), for a more detailed account of the requirements for deer.

Autumn: Feeding of female deer between weaning and mating will depend on body condition. If females have lost significant body condition during lactation, an above maintenance ration is required immediately after weaning. An association between bodyweight and date of onset of oestrus has been reported for Red deer, with lighter and poor body condition hinds having a delayed onset of oestrus.

Newly weaned deer should be on *ad lib* pasture (>10 cm pasture height) or *ad lib* supplementary feed in order to achieve maximum growth rates, with the long-term objective of achieving the highest possible bodyweight at puberty. This is necessary to enhance female reproductive performance in the long term.

Male deer have a considerably reduced food intake during the rut irrespective of feed offered, but a maintenance ration must be provided.

Winter: Provided hinds and does are in good condition post-rut, they need be fed only to maintenance levels. It is normally inadvisable for hinds to lose condition over winter. If they are overfat post-rut they may be fed below maintenance to slowly reduce body condition with the long-term objective of preventing dystocia later. Stags and bucks require an above-maintenance ration in an endeavour to recover body condition post-rut. Weaners need to be on *ad lib* feed to achieve maximum growth potential.

Spring: It is important to prevent over-feeding of Red deer hinds, thus restricting body condition to avoid dystocia problems resulting from overfatness. This is especially important when larger breed terminal sires (e.g. Wapiti) are used over smaller breeding females (i.e. Red), where the foetus is disproportionately larger than normal. Restricting food intake of such hinds substantially reduces the dystocia rate. Conversely, severe feed restriction applied to pregnant Fallow does is counter-productive by compromising foetal development and fawn birth weights, resulting in a high incidence of fawn non-viability. The incidence of dystocia in this species appears to be substantially lower than in Red deer.

Summer (Lactation): Leafy green pasture of minimum 10 cm height is necessary to achieve optimum lactation and growth of offspring. The use of palatable alternative pasture species (e.g. red clover or chicory) will enhance growth of offspring and enable females to maintain or gain bodyweight during lactation, with likely positive consequences at the subsequent mating period.

MAIN POINTS IN CHAPTER 9

1. Of the seven species of deer farmed in New Zealand, Red, Wapiti, Fallow, Sika and Pere David's are temperate-origin seasonal breeders while Rusa and Sambar are less-seasonal breeders of tropical origin. The breeding season of temperate species is late March-May and calving (fawning) is mid-November-December.

2. Seasonal breeding patterns can be advanced to better match feed supply and demand patterns by manipulation of photoperiod, the use of melatonin or progesterone/eCG regimes, by stag:hind interactions, or possibly, by genetic manipulation.

3. Deer undergo a pattern of oestrous behaviour which differs between species. Red deer display short and long chases by the stag, sniffing and flehman, low mounts and finally, a distinctive copulatory mount (high mount). Fallow does become restless, self groom and are chased by the buck which eventually low mounts then copulates.

4. Oestrous detection is difficult in deer. Crayon harness or grease markers have been used, but with best results in Fallow deer.

5. Oestrous synchronisation is achieved using a progesterone/eCG regime in Red deer and progesterone alone in Fallow deer.

6. Semen collection is by electro-ejaculation. Artificial insemination with fresh or frozen semen is best achieved by the laparoscopic intra-uterine route, resulting in conception rates from 20-80%.

7. Embryo transfer techniques have achieved variable pregnancy rates averaging approximately 50-60%.

8. Pregnancy diagnosis may be achieved by manual or visual means, blood progesterone or pregnancy-specific protein measurement, but for practical purposes and foetal ageing, rectal real-time ultrasonography is the preferred method.

9. Red deer hinds fence pace 1-2 days before parturition. The birth is usually completed within 45 minutes. Thereafter the calf is cleaned, suckled and then concealed in available cover.

10. Dystocias average about 1% but are more common in fat deer, on flat land, following disturbance, and where large breed sires are used.

11. Twinning is rare naturally but can be induced by hormonal manipulation. Resulting problems of dystocia, lower survival, poorer growth of off-spring and the risk of freemartinism preclude its adoption on farms.

12. The reproductive management cycle is aimed at restricting the mating interval, maximising female:male ratios, and feeding both males and females in an annual cycle that optimises both the number and weights of offspring successfully weaned.

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