Reproduction of fallow deer

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Summary

Fallow deer exhibit highly seasonal patterns of reproduction controlled by annual photoperiod changes. Does are seasonally polyoestrous and have a 21-day oestrous cycle. First oestrus occurs in autumn and is preceded by silent ovulations.

Approximately 85% of does conceive to first oestrus, the remainder to later cycles. Gestation length is 234±5 days and the fawning is highly synchronised in December (southern hemisphere) or June (northern hemisphere). Late-born fawns pose management problems and should be avoided by appropriate buck:doe management.

Adult bucks exhibit marked annual cycles in liveweight, testis development and spermatogenesis.

Introduction

Reproductive performance is one of the main criteria of productivity on fallow deer farms. The number of fawns weaned annually (ie. weaning rate) is dependent on a number of factors associated with reproduction, including conception rate, embryonic mortality (abortion) and perinatal mortality. It is important that herd managers understand the principles of reproduction and reproductive management in order to optimise the weaning rate. Furthermore, recent advances in artificial breeding offer farmers the ability to increase the rate of genetic improvement of their fallow deer herds. Successful application of these technologies, such as artificial insemination, is dependent on a thorough appreciation of the principles of reproduction. This paper aims to combine the theory of fallow deer reproduction with practical aspects of reproductive management.

Photoperiodic regulation of seasonal reproduction

Fallow deer, like other deer of northern temperate origin, are highly seasonal breeders. Fawns are bom during summer months when climate and feed availability are normally most conducive to survival. The synchronous fawning season is a consequence of a short period of sexual activity in the preceding autumn when the bucks exhibit intense rutting activity and the does come into oestrus (heat), are mated, and conceive. The onset of these events in autumn is regulated by various environmental cues, the most important of which is the regular annual change in photoperiod (amount of daylight within each 24-hour period). Sexual activity in fallow deer is stimulated by decreasing day length as autumn approaches. While seasonal changes in climate and feed availability may influence marginally the onset of the rut (period of mating activity), these environmental cues are notoriously variable between years and are, therefore, unreliable predictors of a suitable fawning season. However, daily photoperiod changes are constant between years for any given latitude and are a very reliable seasonal cue. As temperate deer species breed in response to decreasing daily photoperiod they are often referred to as "short-day breeders".

Animals that breed in response to changes in photoperiod receive the vital information of day/night length via the eyes and optic nerve, to reach the pineal gland. This gland produces the hormone, melatonin, during periods of darkness, such that blood levels of melatonin are elevated only at night-time. When the nights are long (ie. days are short) the long period of melatonin secretion stimulates other hormonal secretion changes by various endocrine glands, eventually leading to full reproductive competence in both males and females.

Female reproductive cycles

Oestrus, ovulation and the oestrous cycle: Fallow does that accept the sexual advances of the buck, are sexually attractive to the buck, and are willing to mate, are described as being in oestrus (or heat). Such receptivity is a hormonally induced condition that occurs for only a very short duration (15 minutes - 24 hours, depending on copulation). The hormonal events leading to oestrus are very closely inter-related with those resulting in ovulation (release of an ovum from the ovaries), such that oestrus and ovulation normally occur within 24 hours of each other. Clearly, this has evolved so that sperm and ovum meet at exactly the right location in the female reproductive tract for successful fertilisation and conception.

When an ovum is shed at ovulation, the site of its origin within the ovary (ie. the follicle) gradually develops into a temporary gland that secretes the hormone progesterone. This gland, the corpus luteum, remains intact throughout pregnancy, secreting large quantities of progesterone to maintain the pregnancy. If, however, fertilisation and pregnancy do not occur, the corpus luteum is broken down (ie. luteolysis) with 21 days of ovulation and the subsequent drop in progesterone secretion triggers the chain of events leading to another oestrus and ovulation. The interval between two successive oestruses is referred to as the oestrous cycle. The length of oestrous cycles varies between species, being 21 days for fallow deer , cattle and goats, 18 days for red deer and sheep and 4 days for rats.

Seasonal occurrence of oestrus and ovulation: In the fallow doe, oestrus and ovulation can normally only occur during autumn and winter months. Does in New Zealand generally exhibit their first oestrus of the breeding season in mid April-early May. Within each herd, first oestrus is naturally synchronised to within a 12-14 day period (Figure1). Fallow deer does in the northern hemisphere exhibit first oestrus in mid October-early November.

First oestrus is always associated with ovulation and, as most does are mated at this oestrus, autumn represents the main time of conceptions. The spread of first oestrus in a herd of does corresponds essentially to the rutting period (the rut) of the bucks.

However, ovulations occur several weeks prior to first oestrus (or the rut) in most, if not all, fallow does (Figure 2). As these ovulations are not associated with oestrus and mating, they are referred to as silent ovulations and do not result in pregnancy. They are, however, a necessary prelude to the natural inducement of oestrous behaviour in autumn. The silent cycles (ie. interval between silent ovulations) are shorter (8-12 day duration) than true oestrous cycles (21 days) and this may be partly responsible for the high degree of natural synchrony of first oestrus within a herd.

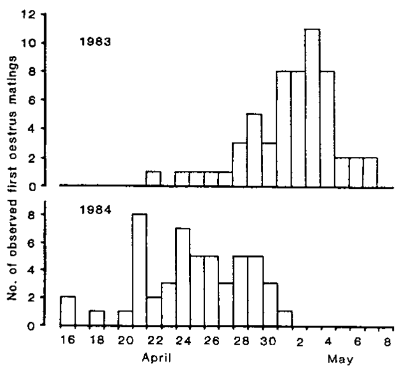

Figure 1: Occurrence of first oestrus of the breeding season in fallow deer does recorded on the Ruakura Agricultural Centre, Hamilton, New Zealand in 1983 and 1984 (Asher, 1986).

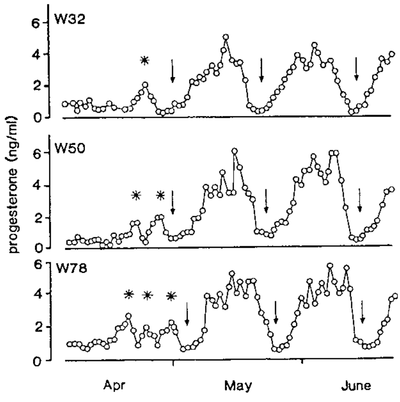

Figure 2: Plasma progesterone profiles of three fallow does showing evidence of a variable number of silent ovulations prior to first oestrus of the 1983 breeding season
(* indicates a silent cycle, ↓ indicates oestrus) (Asher, 1985).

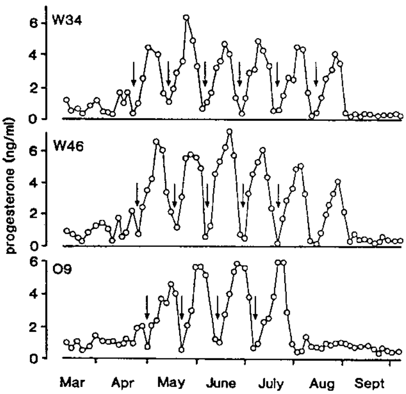

Figure 3: Plasma progesterone profiles of fallow does run continuously with vasectomised bucks in 1984. Continuous oestrous cycles are clearly indicated by the cyclic fluctuations in progesterone levels between periods of oestrus (↓) (Asher, 1985).

Oestrous cycle and potential breeding season: Most fallow does conceive to their first oestrus of the breeding season and, therefore, do not exhibit continuous oestrous cycles. This gives the impression that the female breeding season is less than 30 days duration and is virtually equivalent to the rut. However, in the absence of pregnancy, fallow does are quite able to exhibit continuous oestrous cycles for 3-6 months from the onset of oestrus in autumn (Figure 3). The potential breeding season is, therefore, 3-6 months duration, whereas, the actual breeding season is considerably shorter than this because pregnancy prevents subsequent ovulations.

The oestrous cycle length in fallow deer is remarkably constant, with the first cycle being 21 ± 0.64 (s.d.) days. Later cycles tend to become slightly longer and more variable (Table 1). Oestrous cycle length does not appear to be related to doe age or liveweight. By comparison to red deer the cycle of fallow deer is about 3 days longer but is more predictable (Table 1). The maximum number of oestrous cycles that has been recorded for fallow does is six. However, there is a significant age effect, with younger does on average having fewer cycles, and hence a shorter potential breeding season, than older does (Table 2).

As non-pregnant does cease cycling in spring, there is little opportunity to manipulate the fawning season usefully by strategic buck introduction dates. The latest possible dates of conception would only result in autumn/winter fawning; a far from desirable situation.

Table 1: Oestrous cycle lengths for fallow (Asher, 1985) and red deer (Guinness *et al.*, 1971).

Cycle No.	Fallow deer (NZ): No. of observations	Fallow deer (NZ): Mean cycle length (days)	Fallow deer (NZ): Standard deviation (days)	Red deer (UK): No. of observations	Red deer (UK): Mean cycle length (days)	Red deer (UK): Standard deviation (days)
1	33	21.0	0.64	29	17.8	1.7
2	33	22.0	0.66	21	18.2	1.7
3	33	22.9	0.97	14	18.8	1.7
4	28	23.0	1.11	7	19.1	1.1
5	12	23.5	1.45	4	18.3	-
6	3	25.7	1.53	2	19.0	-
Total	142	22.4	1.30	77	18.3	1.7

Table 2: Average number of oestrous cycles and duration of the potential breeding season of fallow does on the Ruakura Agricultural Centre, Hamilton, New Zealand (Asher, 1985).

Doe age (mths)	No. of does	Mean no. of cycles	Standard deviation	Mean date of first oestrus (s.d.)	Mean date of last oestrus (s.d.)
16	9	3.56	0.53	2 May (2.8)	20 July (12.4)
28	17	4.24	0.56	27 April (4.5)	30 July (12.5)
40+	7	5.43	0.54	24 April (3.3)	25 Aug (15.1)

Oestrous/mating behaviour: The rut represents the short period (12-14 days) in autumn when most does exhibit first oestrus of the breeding season and when most matings occur. However, few farmers observe such events as oestrus/mating activity account for only 2% of all activity during the rut. The average duration of oestrus is only 20 minutes because it is usually terminated at copulation. However, on rare occasions when copulation does not occur, a doe may exhibit oestrus for at least 8 hours (Asher, 1986).

Oestrous behaviour in does appears quite passive compared to that of other livestock species. For example, it is rare for oestrous does to mount, or be mounted by, other does (this occurs in red deer). In fact, the most obvious characteristic of fallow deer oestrus is simply that a doe will stand for the buck. A non-oestrous doe will generally avoid close contact with the rutting buck and will run short distances if a buck approaches. Characteristic lowering of the head below shoulder level and frequent bleats as the buck approaches also indicate that a doe is not in oestrus.

The transition from the non-oestrous state to full oestrus is often very abrupt, although oestrus is sometimes preceded by considerable fence-pacing (up to 24 hours prior to the onset of oestrus). The first indication of overt oestrus is normally the initiation of fervent self-grooming activity by the doe or a sudden approach by the buck that is not associated with submissive/avoidance behaviour by the doe. In the latter case, the buck generally shows considerable interest in the doe by sniffing or licking the doe's vulva, assuming a stance with its chin over the doe's shoulder, grooming the doe's face and ears, or groaning nearby. In response, the doe usually remains standing or continues grooming.

Such activity usually persists for only a few minutes before the first tentative mount is made by the buck. Throughout the subsequent courtship, repeated mounting of the oestrous doe is common but in most cases only the final mount is a copulatory mount. Between 8 and 31 mounts (mean ± s.d. = 16.4 ± 6.8) have been recorded during observed courtships, with the interval between the first mount and the final copulatory mount ranging from 4 to 50 minutes (mean ± s.d. = 14.8 ± 10.4). This gives a mount rate varying from 0.6 to 2.5 mounts per minute (mean ± s.d. = 1.3 ± 0.5).

The final copulatory mount is distinctly different from all other mounts. Following intromission, the buck gives a violent pelvic thrust, during which its hind legs leave the ground. The doe is generally propelled forward by the force of the thrust. The total interval from mount to ejaculation is less than 2 seconds.

Following copulation, the buck and doe move apart. The doe usually disassociates itself from other deer and stands motionless for between 5 minutes and 2 hours. Its back is arched and tail raised and it occasionally strains abdominal muscles, passing clear mucus from the vulva. Some does frequently lick their vulva region during the post-copulatory period. It would appear that does are in some pain following copulation and this may be the stimulus to terminate oestrus. The buck generally show no further interest in the doe.

Oestrous detection: The ability to detect oestrus/mating is fundamental for artificial breeding programmes in most species of livestock. Unfortunately, the very short oestrus/mating interval in fallow deer limits the ability of herd managers to observe the important behavioural events. For reliable oestrous/mating detection herd managers must rely on remote detection methods.

The high mount-to-service ratio during mating in fallow deer means that there is ample opportunity for bucks fitted with ram mating harnesses to mark does. The leather harness (various types available) is fitted around the neck and chest while the buck is restrained in a cradle. As the majority of fallow deer in New Zealand are melanic (black pelage), certain crayon colours are not always clearly visible on the does' hindquarters. Red, blue and green appear to be the best colours for dark animals.

Crayon smears are generally deposited on the doe's rump during the non-copulatory mounts, usually as the buck dismounts. Crayons may need to be replaced every 3 or 4 days depending on the weather and the number of does mated. Oestrous detection in fallow deer is labour intensive and most artificial breeding programmes now rely on artificial synchronisation of oestrus.

Pregnancy: Studies on fallow deer at the Ruakura Agricultural Centre showed that approximately 85% of does conceived and fawned to their first mating (oestrus) of the breeding season and that most of the remaining does conceive to a return oestrus 21 days later. The average gestation length (interval from successful mating to fawning) was 234 days, with a recorded range of 228-244 days. For Ruakura does, there was no evidence of any fawn sex, doe age or sire effects on gestation length. Recent studies indicate that does carrying hybrid fawns (ie. European x Mesopotamian genotype) may exhibit greater variation in gestation length, although the average duration of pregnancy appears similar (Asher, 1993).

Conceptus mass does not appear to influence doe liveweights until about 120 days gestation. Thereafter, pregnant does have a higher daily liveweight gain than non-pregnant does, such that towards the end of gestation (220-230 days) pregnant does are about 8 kg heavier than their non-pregnant contemporaries.

Blood progesterone levels of pregnant does remain elevated (4-8 ng/ml plasma or serum) for the entire gestating period of 234 days, whereas non-pregnant does tend to exhibit cyclic fluctuations in blood progesterone levels from autumn until the cessation of oestrous cycles in spring. Thereafter, progesterone levels remain very low until the start of the breeding season in the following year. Determination of blood progesterone levels of fallow does during the last 2 months before fawning will readily identify pregnant and non-pregnant does.

Pregnancy diagnosis: The most useful method of pregnancy diagnosis is ultrasonography. The foetus or gravid uterus can be detected using real-time ultrasound scanning equipment, either with 5 MHz rectal probes or belly scanners. Reliable diagnoses are possible from about 35 days of gestation, however, most scanning is performed at an average age of 60-70 days in order to detect pregnancy in late does. Whole herd testing is, therefore, usually performed in June/July in the southern hemisphere and in December/January in the northern hemisphere. Pregnancy to artificial insemination is usually performed at about 45 days, when the foetus is about 20 mm long (Mulley *et al.*, 1987; Asher *et al.*, 1990).

Fawning: The fawning season of fallow deer generally starts later than that of red deer, but tends to be more condensed (Asher & Adam, 1985). In the northern regions of New Zealand, the first fallow births usually occur in early December, whereas red deer births may start in early - mid November (Figure 4). However, fallow births are heavily concentrated within the 20 day period between 5 December and 25 December. Fawns born well before this period (eg. late November) have been observed but these may be premature births in some cases. Fawns born after Christmas day will generally include those conceived to return oestrus matings (ie. late May matings). In the northern hemisphere, the fawning season is essentially 6 months out of phase with the southern hemisphere. In all other respects, it appears similar to the New Zealand pattern.

The facts that fallow does exhibit high conception rates (~ 85%) to their first oestrus and that first oestrus is synchronised to within a 12-14 day period, explain the occurrence of a concise fawning pattern despite their being a certain amount of variation in gestation length.

Very late-born fawns do occur on some farms. This is particularly so if sire bucks remain with does throughout the autumn and winter months. This allows persistently cyclic does to conceive at their third, fourth or even fifth oestrus. As it is generally believed that fawns born in early autumn have low survival rates and complicate management, it is becoming common practice for managers to remove sire bucks from the breeding herds in early winter, effectively giving does only 2-3 chances to conceive. This will prevent fawns being born late but but will likely increase the number of non-pregnant does (at least within the first year of adopting the practice).

The fawning season of fallow deer coincides with deteriorating pasture quality in many regions of New Zealand. Attempts are usually made to optimise pasture quality in the period from December to March, when does are lactating. Failure to do so appears to result in poor fawn growth rates and severe decline in the doe's body condition. This may have carry-over effects on doe reproductive performance during the subsequent rut. In North America, pasture production is generally optimal at the start, and during, the fawning period. However, late summer droughts have been known to affect severely the milk yields of dams, resulting in low weaning weights of fawns. Pasture feed deficits are

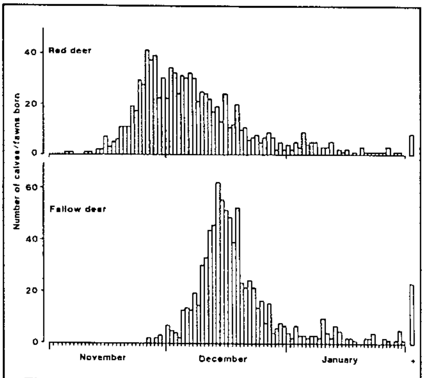

Figure 4: Frequency distributions of birth dates for red and fallow deer on several farms in northern regions of NZ between 1980 and 1984 (Asher & Fisher, 1990).

generally offset with supplementary grain/hay feeding during this period.

Parturient and maternal behaviour: Careful observation of doe behaviour during the fawning season may help farmers recognise problems should they arise. An understanding of the normal parturient and maternal behaviour patterns is necessary in order to detect abnormal situations requiring attention.

Fallow does tend to become restless about 48 hours before parturition. They will often disassociate from the main herd, pace the fenceline and, as birth becomes more imminent, frequently lick their vulval region. By the time labour has been initiated, does will often be completely segregated from the main herd. However, in small paddock situations this is not always possible and does may be observed fawning near other does. Under these circumstances, disturbance by other does can occur frequently.

At birth, presentation of the front hooves of the fawn through the vulva is usually preceded by the emergence of the waterbag. This may hang from the vulva for up to 30 minutes and the doe will frequently lick or bite it. Once the waterbag has ruptured and the doe has removed much of the membranes, the tips of the fawn's front hooves soon emerge, followed by the fawn's nose. Throughout this stage of labour the doe will probably exhibit noticeable abdominal contractions every few minutes. The fawn's hooves and nose may be the only visible signs of parturition for periods of up to 2 hours. However, once the rest of the fawn's head finally passes through the vulva, the rest of the birth process usually occurs within a few minutes. The torso of the fawn is often expelled at a single contraction.

During the entire period of parturition some does frequently lie on their sides, particularly during contractions. However, many does remain standing and it is not uncommon to see does grazing while giving birth.

Following parturition, the doe usually spends 30-60 minutes alternating between cleaning the fawn and removing the afterbirth. It is not uncommon for does to lie with their fawn for several hours following birth and they may even encourage the fawn to suckle during this time.

In the small paddock (0.25 ha) situation that exists at the Ruakura Agricultural Centre, it has been noted that young fawns may suckle their dams about 7-8 times during daylight hours for the first 10 days. Suckling activity was usually initiated by the dam. This behaviour may differ for deer kept under more natural surroundings (eg. larger paddocks, lower stocking rates, forest fringes) as it was noted on Ruakura that frequent disturbance of fawns by other does often led to suckling activity between the fawn and its dam.

Fawn birth weights and survival: The range of birth weights observed for both fallow and red deer in northern NZ are presented in Figure 5. Male fallow fawns average 3.8-4.2 kg and female fawns 3.6-4.0 kg; about one half the birth weight of red deer calves.

For adult does, the fawn birth weight is approximately 10% of their own rut liveweight (ie. the rut preceding the birth of the fawn). However, for first fawning does, the fawn birth weight is as little as 7% of their pubertal weight (ie. 16 months of age). As pubertal does are also generally lighter than adults during the rut, it is common to obtain very light birth weights (2.0-3.0 kg) from first fawners (Asher & Adam, 1985). Fallow fawn mortality rates are directly related to birth weights (Table 3).

Marked increases in mortality are observed in fallow fawns with birth weights 3.0 kg or less (~60% mortality). These fawns are frequently termed "non-viables" because they often have insufficient strength to walk and suckle. Those that are able to suckle are generally more susceptible to hypothermia or hyperthermia. Non-viable fawns can occur with all age classes of does but are considerably more common from first fawning does. (Asher & Adam, 1985; Mulley *et al.*, 1990).

Birth weights are also directly related to weaning weights of fawns. On any given farm, for every 100 g of additional birth weight, weaning weights increase by about 110 g (Asher & Adam, 1985) This effect is of minor consequence compared to the effects of feed quality during the lactating period.

While there are definite doe age effects on fallow fawn birth weights, little is known about the modifying effects of other environmental factors. For

Table 3: Relationship between birth weight and mortality of fallow deer fawns from four farms in the northern regions of New Zealand between 1980 and 1984.

Birth weight	≤3.0 kg	3.1-4.0 kg	4.1-5.0 kg	>5.0 kg
Fawns born	94	438	281	9
Fawn deaths	56	71	30	1
Mortality rate	59.6%	16.2%	10.7%	11.1%

example, little is known about the influence of nutrition during various phase of gestation. There is some suggestion that underfeeding does during the last third of pregnancy may reduce subsequent birth weights. Whereas feed restriction during this period is commonly practiced for red deer hinds in order to reduce the incidence of difficult births (dystocia), this cannot be recommended for fallow does for two reasons. Firstly, if such restrictions reduce birth weights, this will only serve to increase the incidence of non-viable fawns. Secondly, dystocia rates are generally lower for populations of fallow deer than for red deer (Asher & Adam, 1985). The current recommendation is to feed pregnant fallow does to appetite.

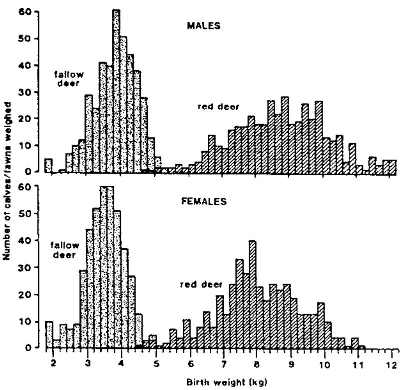

Figure 5: Frequency distributions of birth weights for red and fallow deer on several farms in northern N.Z. between 1980 and 1984 (Asher & Fisher, 1990)

Causes of fawn mortality: Data on causes of fallow fawn mortality have been collected from a number of northern NZ farms between 1980 and 1984 inclusive (Table 4).

While non-viability (low birth weights) was the single biggest cause of fawn deaths (25%), as discussed earlier, there were other important sources of fawn losses. Deaths due to difficult births (dystocia) accounted for 14% of mortalities. However, this is low compared to 34% for red deer (Asher & Adam, 1985). Typically, such fawns were found to have ruptured organs (eg. livers) due to the considerable pressures occurring at parturition. Interestingly, very few recorded dystocia cases required assistance at fawning. Dystocia rates were generally higher for first fawning does.

Starvation accounted for 19% of observed fallow fawn deaths. This may have been slightly inflated by interference effects leading to increased mismothering on the monitored farms. However, it is likely that a certain amount of mismothering will always occur irrespective of the proximity of people. This may be especially so with high stocking densities found on many intensive deer farms, where interference effects by other deer may contribute to abandonment of newborn fawns. Abnormal maternal behaviour has been observed occasionally in some groups of does; including "pirating" of new born fawns and "cross-mothering"; which could also lead to increased fawn mortality due to starvation.

The first few hours from birth is probably the most critical time during the dam/fawn bonding. Every attempt should be made to guarantee minimal disturbance during this period. If fawns are to be tagged within 24 hours of birth, avoid handling fawns within the first 2-3 hours, especially if they are

Table 4: Causes of mortality for 161 fallow fawn deaths recorded from four farms in northern regions of New Zealand between 1980 and 1984.

Diagnosis	n	%
Non-viability	40	24.9
Starvation	31	19.3
Dystocia	23	14.3
Misadventure	18	11.2
Gut infection	16	9.9
Throat /jaw infection	11	6.8
Lung infection	6	3.7
In-utero death	5	3.1
Liver infection	3	1.9
Severe hypothermia	2	1.2
Congenital/genetical abnormality	1	0.6
Unexplained	5	3.1
TOTAL	161	100

still wet. Walk away and allow the doe to return and finish cleaning the fawn.

Misadventure accounted for a significant proportion (11%) of fawn deaths on monitored farms. Generally, this resulted from fence "hang-ups" where fawns had become entangled in mesh fences. This problem is alleviated simply by providing fawn-proof netting around fawning paddocks. If this is not possible, attempts should be made to provide adequate cover within the fawning paddock and reducing the amount of visible cover immediately outside the paddock. This should reduce the fawn's desire to walk through fences.

Infectious agents can cause sporadic increases in fawn mortality on some farms. In the study described in Table 4, the total incidence of fawn deaths from infectious agents was about 22%, although the causative organisms differed between farms and years. Should a specific disease outbreak occur amongst fawns, it is important to quickly identify the causative organism. This will necessitate close liaison with the local veterinarian and veterinary diagnostic laboratories. If the organism is susceptible to specific antiobiotics (in the case of some bacteria) it is quite possible to treat fawns within the first 3-4 days from birth.

As gut infections have proven to be a problem on some farms, ensure that water supplies are not polluted by other animals (eg. ducks) that can transmit harmful bacteria such as *Salmonella*. Water supplies are possibly a common source of infection.

Weaning: There is considerable debate as to whether weaning of fawns is a necessary or desirable practice on farms. While pre-rut weaning may simplify management of mating groups over the rut period, suckling activity and lactation will not inhibit ovulation and conception per se (ie. lactational anoestrus does not appear to be common in fallow deer). However, if does become emaciated due to poor nutrition during lactation, it is probable that subsequent reproductive performance will be low if poor body condition is maintained throughout the rutting period. Under such circumstances, the continuation of lactation can only aggravate the situation and it would be wise to wean the fawns well before the rut, dry the does off and boost doe liveweights as rapidly as possible by increasing the level of feeding.

Such circumstances seldom occur under NZ conditions and it becomes arguable as to whether pre-rut weaning is necessary for better reproductive management. If the mating policy simply involves joining a number of bucks with the total breeding herd (ie. multi-sire mating), then fawns do not present a major problem. This form of mating policy approximates the natural herd situation during the rut. However, more controlled mating practices (eg. single sire mating; artificial insemination) may require considerable pre-rut sorting and handling of breeding stock. Under these circumstances, fawns are better removed from the breeding herd.

Weaning of fawns can also improve feeding management on intensive farms. It allows for differential feeding strategies to be implemented for different classes of stock. For example, it is common practice to offer growing weaners first access to a paddock and to follow behind with breeding stock to "clean-up" pastures. Weaning also reduces competition between adults and juveniles for feed resources, especially for supplements such as grain.

Doe puberty: Puberty in fallow does is regarded as the age at first oestrus, ovulation or mating. For most individuals it occurs at 16 months of age, with fawning occurring at 24 months of age. There are occasional reports of some does having ovulated and conceived at 4-6 months of age; these individuals usually being the largest and earliest born amongst their contemporaries.

There is a threshold liveweight that must be attained before yearling does will ovulate and conceive, but on most farms the majority of does are well beyond the threshold at 16 months of age. In one trial at Ruakura, in which doe liveweights ranged from 28-38 kg at 16 months of age, at least 55/56 (98%) of the does ovulated. Clearly, therefore, the threshold liveweight for first ovulation is at, or even below, 28 kg. This represents about 70% of average mature pre-rut liveweight.

However, while the majority of does reach puberty at 16 months of age, many do not successfully rear their fawns. It is likely that the lighter does of 28-32 kg at 16 months will be less successful in rearing fawns than heavier does, because their fawns are lighter at birth or the does have poor lactation abilities. Figure 6 presents data from a commercial farm in New Zealand in which the weaning rate from 2-year-old does was compared to their 16 month liveweight.

The weaning rate clearly increased with increasing pubertal weight. Whether these data represent differential conception rates or fawn mortality rates is unknown, but the overall message is clear. For maximal productivity from 2-year-old does, a respectable target liveweight should be attained by 16 months of age. These targets should probably be set at herd averages in excess of 38 kg.

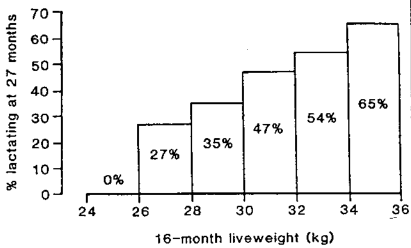

Figure 6: Relationship between 16 month liveweight and subsequent weaning rate from young fallow does on a commercial farm in New Zealand (n = 306 does born in December 1981).

In New Zealand studies, adult fallow does produce fawns with birthweights that were about 10% of their own pre-rut liveweight. However, two-year old does produced fawns with .birthweights that were only 7% of their own pubertal liveweight (Asher & Adams, 1985). Therefore, even if young does are well grown at puberty (ie. >38 kg) it is still likely that weaning rates will be slightly lower from first fawners than for adults, although fawning rates should be close to 100% in both cases. The higher fawn mortality from first fawners probably stems from lower birth weights (ie. non-viability) as well as some abnormal maternal behaviour amongst inexperienced dams. Weaning rates in excess of 75% for first fawning does are considered to be good.

Pubertal oestrus in fallow does tends to occur at about the same time as first oestrus of the breeding season of mature does. This appears to be particularly so if mature and pubertal does are run together during the rut. Some data suggest, however, that pubertal oestrus is about one week later on average if pubertal does are kept separate during the rut. This is reflected in slightly later fawning dates.

Male reproductive cycle

Annual growth and sexual cycle of adult bucks: Apart from siring offspring, fallow bucks contribute nothing to the growth and development of fawns. Yet their entire annual cycle centres around reproduction. Bucks invest incredible amounts of energy into mating activity during the rut, a period of only 2-3 weeks each year. The remainder of the year seems to involve recovery from the effects of the rut or preparing for the next rut.

The annual liveweight profile of adult fallow bucks (Figure 7) is typical for various temperate species of deer for which there is a definite rutting season during which males must compete for access to oestrous females.

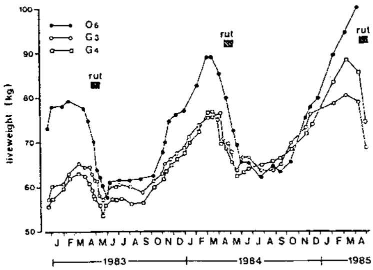

Figure 7: Seasonal liveweight profile of three sire fallow bucks (O6, G3, G4) at the Ruakura Agricultural Centre, recorded at fortnightly or monthly intervals from December 1982 until April 1985 (Asher, 1986).

Rapid liveweight gains occur during spring and summer months and bucks reach their peak annual liveweight immediately prior to the rut in autumn. The increases in liveweight mostly represent increased deposition of subcutaneous and depot fat, as well as increased neck muscle mass.

However, during the rut in autumn bucks drastically reduce their feed intakes and markedly increase mobile activity. The resultant negative energy balance leads to very rapid mobilisation of fat reserves and some catabolisation of muscle, such that bucks may lose up to 30% of total body weight in a 3-4 week period. For a 3-4 month period following the rut (ie. during winter) bucks regain very little of this lost weight even though they increase grazing activity. Bucks, therefore, overwinter in very poor body condition. It is not until the onset of spring that the growth and fat deposition cycle starts over again.

Testicular development in adult fallow bucks also undergoes annual cyclic changes. This is primarily controlled by marked changes in secretion of luteinising hormone (LH) from the pituitary gland in response to changes in photoperiod. LH is secreted in pulses. These pulses alter in amplitude and frequency during the year, being of low amplitude and frequency during the non-breeding season (summer) and of high amplitude and frequency leading up to the onset of the breeding season in autumn. These changes in LH secretion in late summer and autumn directly influence testicular activity by promoting testis growth and increasing the secretion of the androgenic hormone, testosterone (Asher *et al.*, 1989)

As testicular size increases in response to increased LH stimulation towards the rut, there is a concomitant increase in spermatogenic activity such that, by the onset of the rut, large numbers of viable spermatozoa appear in ejaculates. The testes remain active throughout the winter, secreting modest levels of testosterone and producing large numbers of spermatozoa. However, towards the beginning of spring, LH secretion diminishes and the testes regress in size; secreting only very low levels of testosterone. Spermatogenesis is completely arrested by early summer; the bucks becoming effectively infertile (Asher *et al.*, 1987).

It is during this phase of testicular regression that liveweights begin to increase rapidly. The animals remain infertile for about two months, gradually regaining fertility towards the end of summer.

The antler cycle of bucks is closely linked to the testicular-testosterone cycle. Old antlers are cast during early spring when the testes regress. Casting is in response to a marked decline in testosterone secretion. The new antler grows during the following period of low testosterone secretion through spring and summer. As blood testosterone levels increase in late summer and early autumn, the velvet antler mineralises rapidly and eventually the soft outer layer is stripped off. The hard antlers are retained throughout autumn and winter.

Annual changes in testosterone secretion also have marked effects on some muscles. In particular, rising testosterone levels in late summer and autumn cause hypertrophy of the neck muscles. This results in a massive increase in neck muscle mass by the start of the rut. Loss of liveweight over the rut results in a decrease in neck girth. However, when the testes fully regress and liveweights begin to increase in spring, neck girth decreases further in the relative absence of testosterone. This phenomenon of cyclic changes in neck muscle mass appears to be unique to deer.

Rutting behaviour: The fallow deer rut lasts for only a few weeks in autumn and is associated with profound and spectacular changes in the behaviour of the bucks.

The most characteristic behaviour of rutting bucks is the vocalisations. Bucks emit a series of low gutteral grunts, often referred to as groaning. Groaning appears to be confined largely to the period of first oestrus of the does and there is an apparent

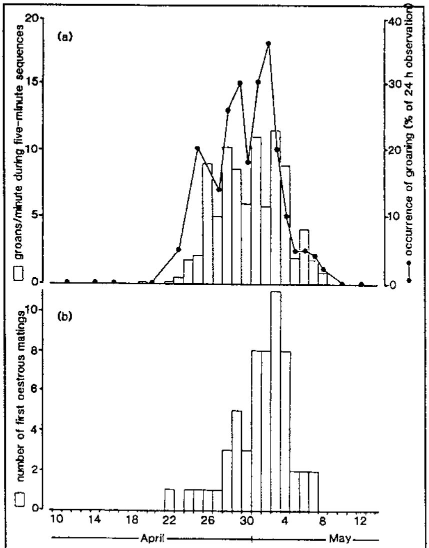

Figure 8: Frequency of groaning activity of bucks and the occurrence of oestrous does during the first oestrus mating period; Ruakura Agricultural Centre, Hamilton, NZ (Asher, 1986)

close relationship between the intensity of groaning activity and the occurrence of oestrous does on any one day of the rut (Figure 8). Groaning activity can occur throughout the day and night, but appears to be more intensive at dawn, dusk and at night.

The bucks' activity markedly changes during the mating period. Grazing activity has been observed to drop from 30-40% of total daily activity in early April to as low as 5% in late April in New Zealand. Associated with this are increases in mobile (walking/running) and surveillance (standing) activities. The net result is a severe loss of body fat reserves and a marked drop in liveweight (Figure7).

Multi-sire v. single-sire mating: Most fallow deer farmers presently introduce more than one buck per mating group (ie. multi-sire mating). As bucks are strongly territorial during the rut, it is important to allow the mating group sufficient area and topography for individual bucks to develop non-overlapping territories. Should the land area be too restrictive it is possible that bucks will expend too much energy fighting over territorial boundaries. Furthermore, younger bucks will be restricted from mating in the close proximity of larger dominant bucks. This could lead to a situation where the dominant buck is expected to do all or most of the mating.

Single-sire mating regimens are generally used when a farmer wishes to guarantee offspring from a particular buck. In fact, single sire mating is a key element in all genetic improvement programmes in which males are ranked against each other on the basis of progeny performance (ie. "progeny test").

Single-sire mating is particularly useful if very young sires (eg. 16 months old) are to be used. However, it is possible that even fence boundaries will not prevent intimidation of young bucks by more dominant older bucks. It may be necessary to separate mating groups by at least one paddock width.

Irrespective of whether multi-sire or single-sire policies are adopted, it is important that buck:doe ratios are not excessive. Too many bucks (eg. 1:5) could lead to excessive competition and fighting between bucks. Too many does (eg.1:50) could result in failure of mating if bucks become exhausted. The following buck:doe ratios may be a useful guide (Table 5).

Table 5: Recommended numbers of does per sire buck (multi-sire and single-sire situations).

Age of sire	Number of does
16 months	10-15
27 months	15-23
39+ months	30-35

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