REPRODUCTION OF FARMED FALLOW DEER (*Dama dama* L.)

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Introduction

Fallow deer are widespread throughout the world, being a popular game and park animal. Management of populations primarily for venison production has occurred in numerous countries including Germany (Reinken 1977), Italy (Rambotti 1985), Australia (Couchman 1980) and New Zealand.

The growth of the fallow deer farming industry in New Zealand has closely followed that of red deer farming, however, little emphasis was placed on velvet production. Initially, fallow farms were heavily concentrated around the major feral populations, particularly the northern herds at South Kaipara Heads and Wanganui. In recent years, farms have been established away from feral localities but are largely confined to the North Island. The high returns for venison and the low buying price of breeding stock relative to red deer, have been major factors behind a recent surge of interest in fallow farming.

The main factor holding back the growth of fallow deer farming is the limited availability of stock. As feral sources have been all but exhausted, more emphasis must be placed on natural recruitment within farmed populations. This paper summarises current understanding of fallow deer reproduction, an important aspect of farming the species.

(A) Photoperiodic Control of Reproduction

The generally accepted hypothesis that the strict seasonality of fallow deer reproduction is mediated by the prevalent photoperiod regime (Chaplin & White 1972, Eaton 1980) has largely been inferred from experiments on red deer (Jaczewski 1954) and sika deer (Goss 1983) in which artificial photoperiod regimes were observed to alter the annual antler and testes growth cycles of males. It has been further argued that an opposite photoperiod regime is responsible for the six month displacement in reproductive seasonality of fallow deer transferred from the northern to southern hemisphere (Chapman & Chapman 1975). Experimental testing of the hypothesis has not been attempted with fallow deer.

(B) The Fallow Doe

Puberty

The general age of fallow does at first mating has been variously assessed as 16 months (Harrison & Hyett 1954; Ueckermann & Hansen 1968; Armstrong *et. al.* 1969; Chapman & Chapman 1969, 1975; Baker 1973; Reinken 1977; Asher *et. al.* 1981; Asher & Adam 1985). Occassional well-grown individuals have conceived at 4-5 months of age (personal observation).

The threshold liveweight for attainment of puberty has been difficult to assess. Data on lactational status of 27 month old does (first weaning) on several NZ farms indicated that most does below 30 kg at 16 months of age failed to subsequently rear a fawn. However, direct observations of mating suggest that puberty weight, in terms of first oestrus, is probably around 28 kg. As average liveweights in NZ are between 34-38 kg at 16 months of age, most does are likely to be well above the critical puberty weight.

Chapman & Chapman (1975) and Reinken (1977) considered that pregnancy and fawning rates are usually lower for pubertal does than for older does. However, data from NZ farms indicate rates comparable to those of older does (Asher 1985). First fawning does (24 months of age) generally fawn about a week later than older does, presumably reflecting a slight lag in first oestrus at puberty.

Onset and synchrony of oestrus

The onset of the fallow deer breeding season is well defined in terms of first overt oestrus, which appears to correspond exactly with the onset of male rutting vocalisations. There is also little variation between years; on Ruakura the first oestrus doe can be expected between 15-20 April each year.

Oestrus is well synchronised within a herd. The spread of first oestrus on Ruakura in 1983 and 1984 was only twelve days, with pubertal does being later on heat than older does.

Silent ovulations preceding first oestrus

Progesterone profiles from daily blood sampling have indicated the occurrence of silent ovulations resulting in transient corpora lutea before first overt oestrus of the breeding season. This was confirmed by laparoscopic examination of does before first oestrus. Some does appeared to have two or more such ovulations in succession (Figure 1,a). The occurrence of short-lived corpora lutea (10-12 day cycles) during the transition of the breeding season helped to synchronise first oestrus, as the spread of first oestrus corresponded to the longevity of the short cycles.

Length of the oestrous cycle

Although originaly reported as being monoestrous (Harrison & Hyett 1954; Hamilton, Harrison & Young 1960; Asdell 1964), fallow does are now known to be seasonally polyoestrous (Cowan 1965; Armstrong et. al. 1969; Chapman & Chapman 1975). Cowan (1965) claimed the oestrous cycle length was 24-26 days for does in British Columbia and Baker (1973) estimated it to be 26 days in NZ. Both observations were based on only one or two individuals.

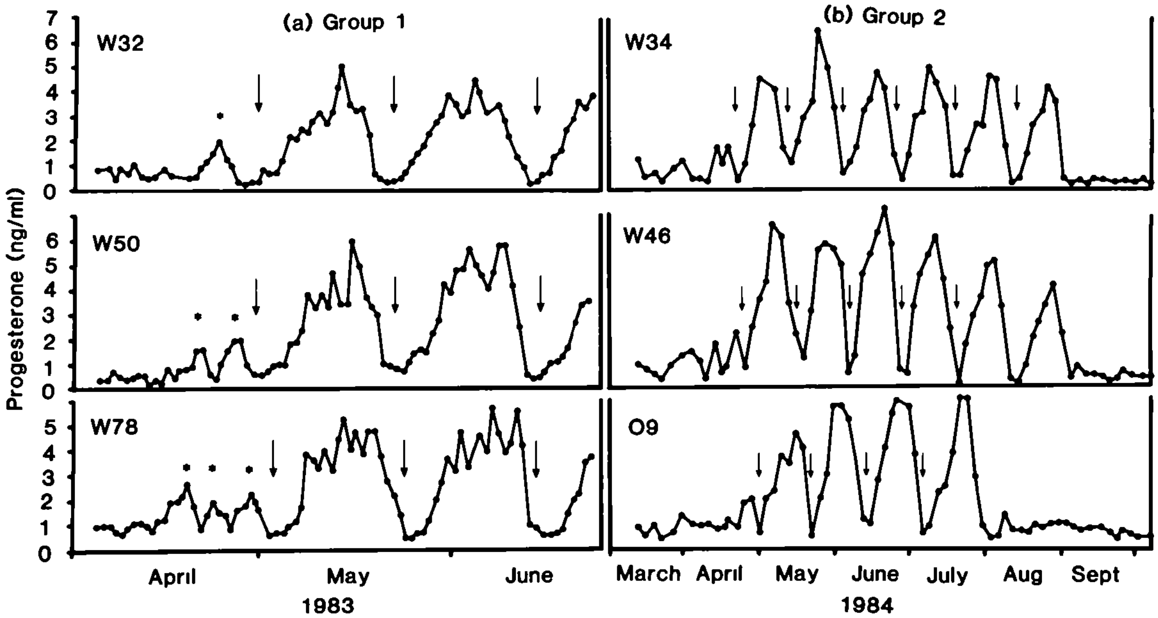

Figure 1: Selected typical progesterone profiles of (a) does showing single or multiple short-lived corpora lutea as indicated by transitory elevations of progesterone (*) before first oestrus and (b) oestrous cycles during the breeding season. ↓, oestrus.

A total of 34 does were run continuously with harnessed (Sire-sine) vasectomised bucks on Ruakura. Oestrous was detected on 177 occasions, resulting in a total of 142 valid oestrous cycle length observations. Mean oestrous cycle length was 22.4 days ± SD 1.3 with a range of 20 to 27 days. Cycle length increased as the breeding season progressed, with the differences between the means for the first, second and third cycles being significant ($P<0.05$), thereafter, they became more variable (Table 1). Year, doe age and doe liveweight did not significantly ($P>0.1$) affect oestrous cycle length (by cycle number).

Table 1: Fallow deer oestrous cycle length by cycle number

Cycle no.	Observations	Cycle length (days)	Standard deviation (days)
1	33	21.0	0.64
2	33	22.0	0.66
3	33	22.9	0.97
4	28	23.0	1.11
5	12	23.5	1.45
6	3	25.7	1.53

A noteable feature is the low variance encountered for the length of the first three oestrous cycles (Table 1) compared with respective data for red deer (Guinness, Lincoln & Short 1971).

Duration of the potential breeding season

In the absence of conception, cyclic activity of does continues throughout winter and into early spring. This is well illustrated by progesterone profiles of does run with a vasectomised buck (Figure 1,b). The number of observed oestrous cycles varied from 3-6 per doe, with the duration of the oestrus-bound breeding season varying from 65-135 days. Pubertal does had fewer cycles than older does and does in their second breeding season had fewer cycles than older does (Table 2).

Table 2: Duration of the potential breeding season (number of oestrus-bound cycles) by doe age.

Doe age (months)	No. of does	Mean no. of cycles (SD)	Mean date of first oestrus (SD days)	Mean date of last oestrus (SD days)
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)

The age effect was primarily due to the variation in occurrence of last recorded oestrus (Table 2). All does cycled beyond the shortest day, but younger does may have a more sensitive response pattern to increasing day length than older does, resulting in earlier anoestrus.

Conception rate at first oestrus and returns-to-service

The conception rate at first oestrus appears to be high for fallow does on the basis of the synchrony of fawning (Asher & Adam 1985). The conception rates and returns-to-service for fallow does observated mated on Ruakura are presented in Table 3.

Table 3: Summary of conception rates at consecuative oestrus periods.

	Observed 1st oestrus matings	Minimum conceptions at 1st oestrus	Minimum conceptions at 2nd oestrus	Minimum conceptions at 3rd oestrus	Non-pregnant does
1983	42	33 (78.6%)	6 (14.3%)	2 (4.8%)	1 (2.4%)
1984	56	48 (85.7%)	5 (8.9%)	(Buck removed early)	3 (5.4%)
TOTAL	98	81 (82.7%)	13(13.3%)		4 (4.1%)

The above data tend to support the fawning data, suggesting a high initial conception rate at first mating. Removal of bucks before third oestrus is likely to result in a slightly higher non-pregnancy rate, however, will prevent fawns being born after mid-January.

Gestation length

The gestation length of fallow does has been estimated at 229 days (Chapman & Chapman 1975). The gestation length of Ruakura does in 1983 and 1984, based on 88 observations, was 234.2 days (SD 2.7 days). There was no effect of doe age, fawn sex, fawn birth weight, year and sire upon gestation length (P>0.1, ANOVA)

Progesterone profile of pregnant and non-pregnant does

The progesterone profiles of 55 pregnant and 14 non-pregnant Ruakura does in 1983 are presented in Figure 2.

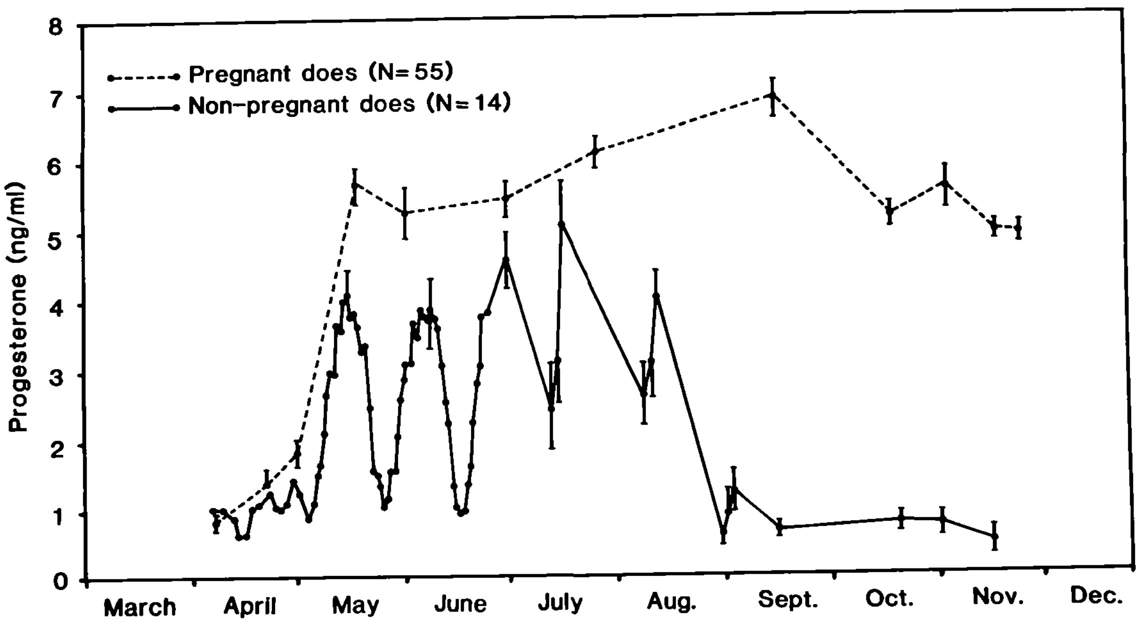

Figure 2: Progesterone profiles (mean $\pm$ SEM) of pregnant and non-pregnant does in 1983.

During the season of cyclic activity of the non-pregnant does, mean progesterone levels fluctuated, clearly showing individual oestrous cycles even though the data are not pooled by day of oestrus. Only at the cessation of all cyclic activity in late spring was there a significant differentiation of progesterone levels between pregnant and non-pregnant does. For valid pregnancy diagnosis, determination of progesterone levels in single samples will only be useful between mid-October (post-cycling) and mid-November (pre-fawning). Prior to this, extremely low progesterone levels (<0.5 ng/ml) may well indicate non-pregnancy, but high levels (>4.0 ng/ml) do not necessarily indicate pregnancy.

Fawning season

The fallow deer fawning season on four NZ farms (1980/81 - 1983/84 seasons) is illustrated in Figure 3. Birth dates were obtained by tagging all fawns within 12 hours of birth. The data are pooled between farms and years without adjustment for variation in the onset of fawning and median fawning date.

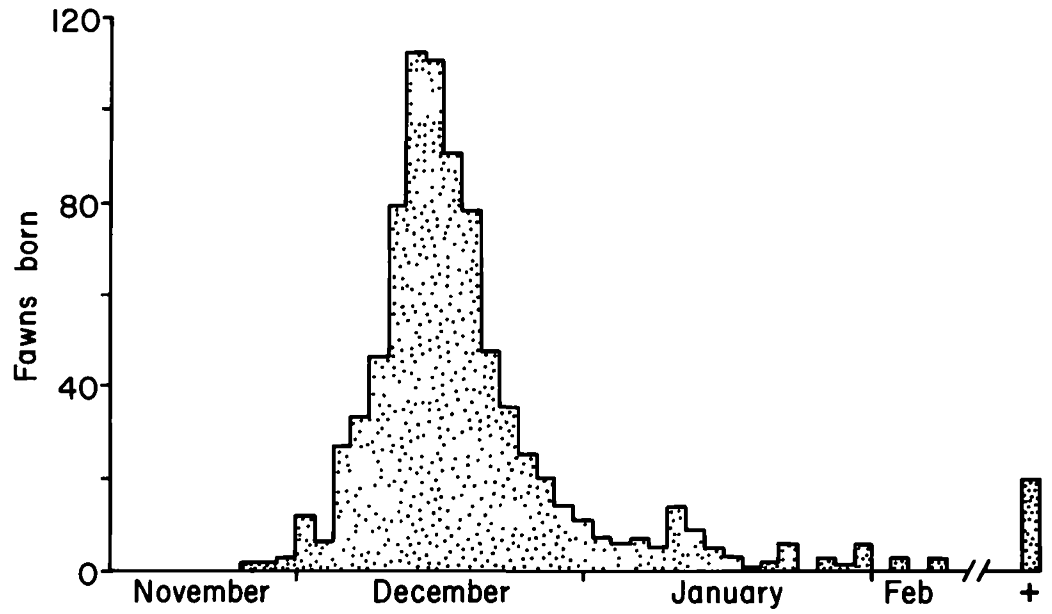

Figure 3: Frequency histogram of fawn birth dates from four Waikato/BOP fallow deer farms; 1980/81 - 1983/84 seasons.

The fawning season was more synchronised than that of red deer (Asher & Adam 1985) reflecting both a synchronised first oestrus and high conception rate at first oestrus. The distribution of births was, however, skewed to the right and it is probable that the small proportion of later born fawns were a result of return-to-service conceptions. Occasional fawns were born as late as March and were, therefore, conceived in July (fifth or sixth oestrus).

Reproductive rates

On-farm reproductive rates were obtained from a number of Waikato/Bay of Plenty fallow farms for the 1980/81 - 1983/84 fawning seasons. The data were obtained by postal questionnaire and from farms monitored daily during fawning (Tables 4 and 5).

Table 4: Reproductive performance of fallow does in some northern NZ regions.

Season	Farms (no.)	Does (no.)	Fawning Rate %	Weaning Rate %	Fawn Mort. %	Abortion Rate %	Assisted Fawning
1980/81	25	519	82.7	69.6	15.9	-	-
1981/82	29	525	84.2	72.8	13.6	4.2	1.1
1982/83	22	551	75.9	65.7	13.4	3.6	0.0
1983/84	27	752	80.9	69.5	14.0	0.7	0.3

Table 5: Reproductive performance of fallow does on monitored and survey farms.

	1981/82		1982/83		1983/84	
	Monitored	Survey	Monitored	Survey	Monitored	Survey
Farms (no.)	3	26	3	19	3	24
Does (no.)	210	315	222	329	236	516
Calving rate (%)	91.4	79.4	90.5	65.4	92.8	75.4
Weaning rate (%)	77.6	69.5	74.3	59.3	75.0	67.1
Fawn Mort. (%)	15.1	12.4	17.9	9.3	19.2	11.1
Abortion rate(%)	5.7	3.2	4.5	3.0	0.9	0.5
Minimum conception rate (%)	92.8	-	95.0	-	93.7	-

Overall reproductive rates (Table 4) were not as consistent between years as for red deer. Estimated fawning and weaning rates were lower, and fawn mortality rates higher than for red deer (Asher & Adam; MAF, Agricultural Research Division annual report, 1983/84).

Monitored farms collectively contained a large proportion of the total doe population sampled (Table 5) and also had higher reproductive rates, despite higher fawn mortality, than survey farms. It is likely that, without close supervision of herds during fawning, farmers on the survey farms under-estimated both fawn losses (and hence fawning rates) and abortions.

Combining fawning rates and abortion rates from monitored farms indicated that the herd minimum conception rates were high (Table 5), clearly showing that doe infertility (barreness) is unlikely to be a major cause of reproductive failure on most farms. This was further supported by data from recent slaughtering of 70 fallow does from a herd of 3000 does. These particular animals were assessed as non-lactating in March (weaning) for three years. Upon slaughter in June/July 1984, all but ten (0.3% of the total herd) were pregnant. The ten non-pregnant animals included five cycling does with encysted foetuses and five non-cycling does with vestigial reproductive tracts.

Clearly, more detailed investigations of fawn mortality and abortions are warranted.

Fawn mortality

The causes of fawn deaths on the monitored farms from 1980-84, as determined by post-mortem examination (after McFarlane 1965) are summarised in Table 6.

Table 6: Fallow fawn mortality (1980-84).

Cause of death	Number of deaths	%
Non-viability	40	24.9
Starvation	31	19.3
Dystocia	23	14.3
Misadvanture	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
Hypothermia	2	1.2
Abnormality	1	0.6
Unexplained	5	3.1

Non-viability (undersized fawns that failed to walk) accounted for a quarter of recorded deaths. This was further reflected in the relationship between birth weight and fawn mortality (Table 7).

Table 7: The influence of birth weight on fawn mortality.

Birth weight (kg)	<3.0	3.0-3.9	4.0-4.9	5.0+
No. of fawns	94	438	281	9
No. of deaths	56	71	30	1
Mortality %	59.6	16.2	10.7	11.1

Further investigation of the problem has shown that first fawning does (2 year olds) tended to produce lighter fawns at birth, relative to their own liveweight, than older does (Asher & Adam 1985). Mortality of fawns from first fawners was as high as 35%.

Fawn deaths due to starvation and fawning difficulties (dystocia), although accounting for 19% and 14% of fawn deaths respectively, were considerably lower than for red deer.

Death of fawns through misadventure (usually fence hangings) have been disappointingly high on some farms but were mostly overcome by techniques of fawn proofing paddocks.

Occasional outbreaks of infectious agents (enteritis, jaw infections) resulted in higher fawn mortalities on some farms in the 1983/84 season. In extreme cases of enteritis, new born fawns were effectively treated with broad-spectrum antibiotics prior to showing symptoms. This necessitated handling at birth, a practice not common on deer farms.

Abortions

There is some circumstantial evidence that third trimester abortions on some fallow farms were due to recurrent leptospirosis infection (hardjo & pomona). Several farmers appear to have overcome the problem by treating all stock with antibiotics (Streptopen) and a biannual vaccination (Leptovoid).

The abortions do not appear to relate to yarding activity, as has been suggested on many occasions.

(C) The Fallow Buck

Puberty

Puberty in fallow bucks has been defined as the period between the commencement of male hormone production and the formation of spermatozoa by the testes (Chapman & Chapman 1975).

Two principal androgens; testosterone and androstenedione; were measured from serum samples taken from entire and castrate bucks at 2-3 week intervals. The profiles (Figure 4) show that in the entires, androgens increased in concentration from January (12-13 months of age), reached peak mean levels in March (15 months) before the rut and declined appreciably at the start of the rut (mid April). Moderate levels were maintained through winter.

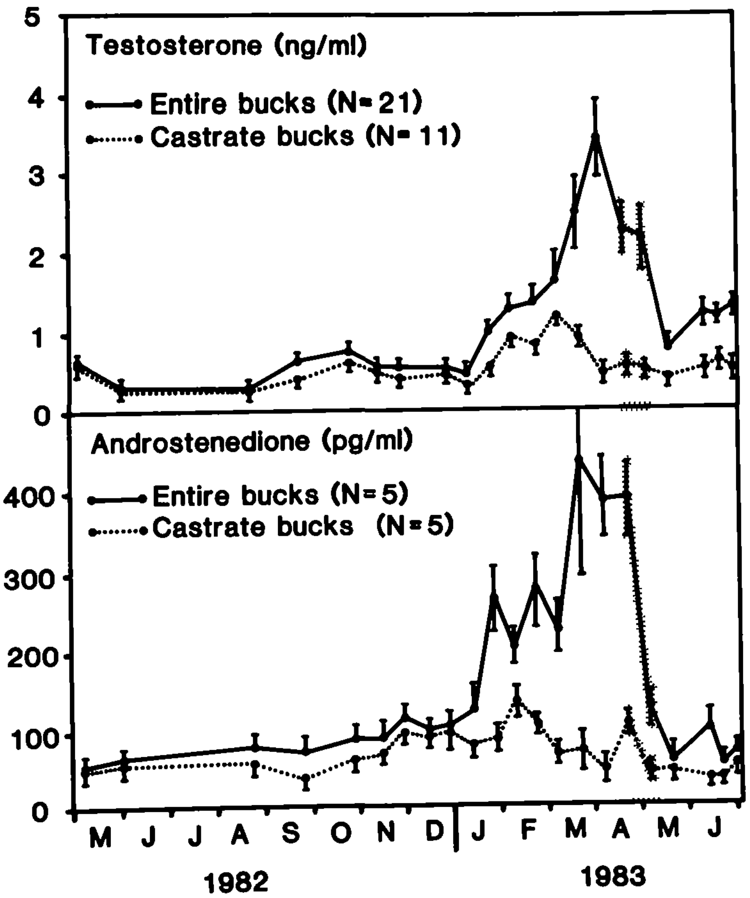

Figure 4: Testosterone and androstenedione levels (mean $\pm$ SEM) in the serum of entire and castrate fallow bucks from 5-18 months of age.

The castrates showed a small peak in both testosterone and androstenedione coincidental with that of the entires (Figure 4). As this peak did not occur in subsequent years it is probable that, not only were the androgens of extra-gonadal origin, but were linked with the onset of puberty, and may normally supplement gonadal androgens.

The morphology of the testes of variously aged bucks has been described in relation to puberty (Chapman & Chapman 1969, 1970, 1975, 1980; Chaplin & White 1970, 1972; Baker 1973). The accounts closely agree that primary spermatocytes became abundant between 6 and 10 months of age, secondary spermatocytes were evident at 11-12 months and all stages of spermatogenesis present at 13-14 months. In addition, Chapman & Chapman (1980) described the morphological development of the male accessory organ, and clearly showed that full functional development occurred by 16 months of age.

Reproductive seasonality of mature bucks

The dramatic annual liveweight cycle of mature male deer is well known. It is particularly pronounced in fallow bucks used as herd sires (Figure 5).

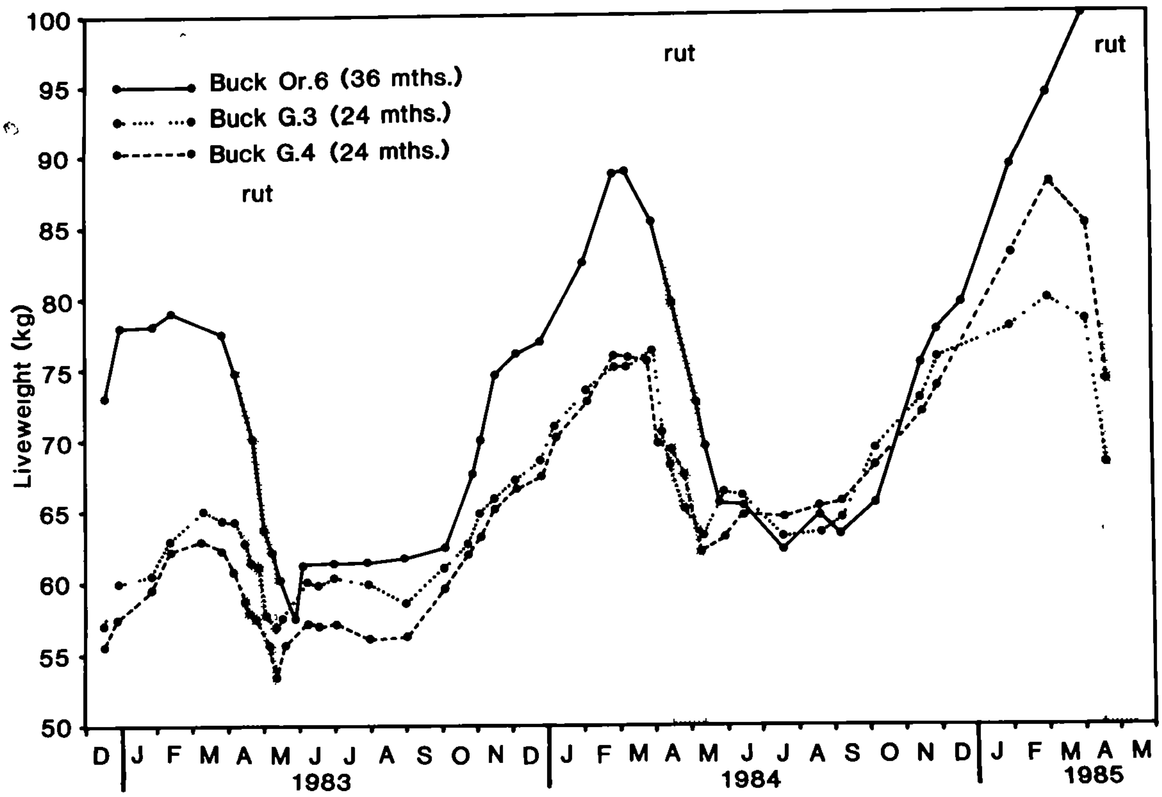

Figure 5: The annual liveweight cycle of entire fallow bucks used as sires on Ruakura in 1983 and 1984.

In the example above, liveweight showed a steady increase from October and peaked in March. Over eight weeks spanning the period of intensive rutting actively (late April/early May), individual bucks lost up to 25% of their March weight. Although there was some post-rut recovery the bucks continued through winter and early spring (June-October) at low liveweights and, presumably, with depleted fat reserves. Liveweight recovery did not start until October, about a month later than for red deer stags (Ruakura data).

The reproductive seasonality of a group of 21 polled (early pedicle cauterisation), entire bucks, run as a bachelor herd, was continually monitored from puberty (16 months) through to 40 months of age. A twelve month profile (22-34 months) of liveweight, testosterone, neck girth, testis diameter, sperm density and sperm motility was compiled for seven of these bucks (Figure 6). The semen was collected by electro-ejaculation of fully anaesthetised individuals.

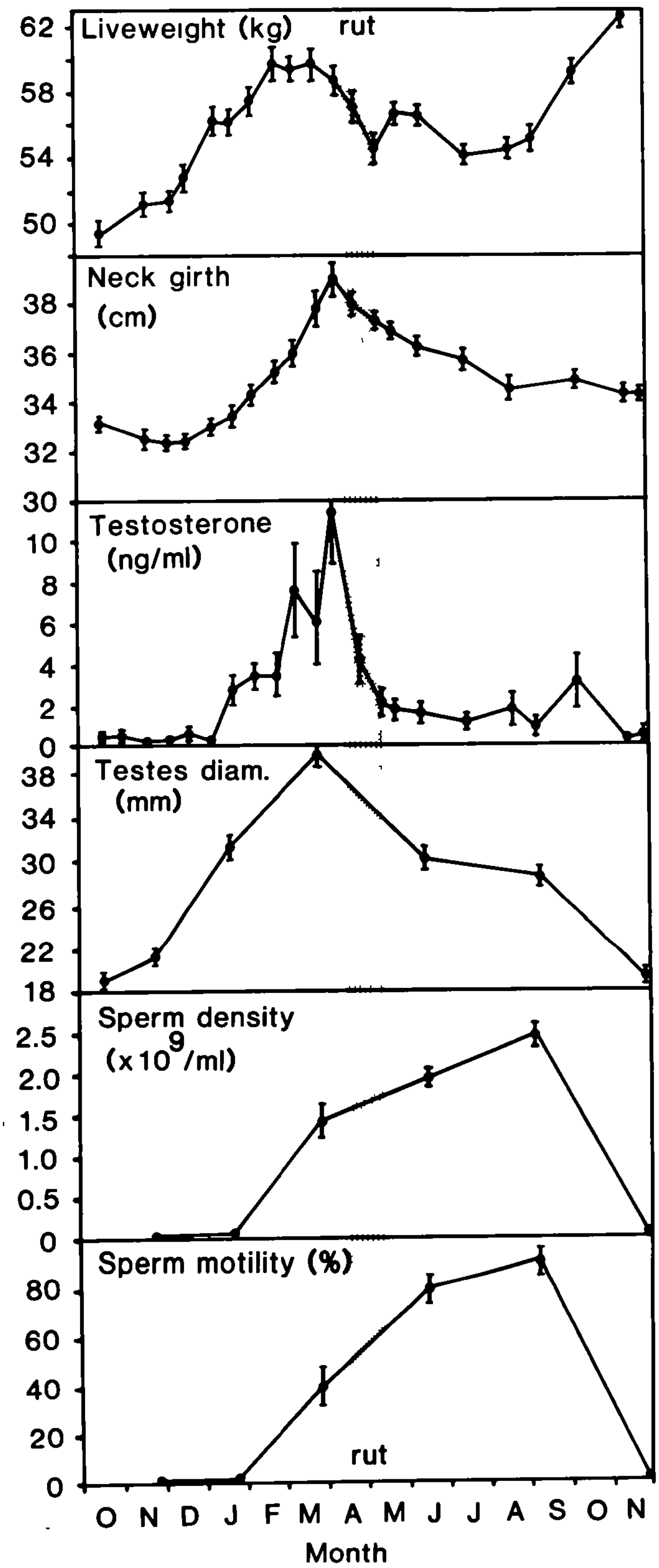

Figure 6: Annual profile (mean ± SEM) of reproductive characteristics of seven mature fallow bucks.

The annual cyclical pattern of liveweight was not as pronounced as for the herd sires and may be due to the absence of oestrous does. Testosterone levels were basal for the months of November and December and correlate with complete aspermatogenesis and testicular/neck regression. With antlered bucks, this period is characterised by antler casting, followed by rapid growth of velvet antler. Increasing testosterone levels through January-March (late summer-early autumn) were associated with progressive spermatogenesis (as reflected by sperm density and motility), testicular enlargement and neck expansion. Rapid calcification and stripping of antlers would normally occur in February.

Testicular activity (sperm production, testosterone secretion) continued throughout the period from April-October. Curiously, sperm density and motility were maximal after the rut (April/May), whereas, neck girth and testis diameter did not increase beyond the rut. This may represent early completion of maturation of secondary sexual characteristics in response to very high pre-rut testosterone levels, which may be partially inhibitory to maximal sperm production early in the breeding season. Similarly, in a recent trial a buck was observed to show poor mounting responses to does induced into oestrus (progesterone CIDR and PMSG) only three weeks before the onset of the natural rut. This may have important implications with respect to artificial manipulation of the breeding season of fallow deer.

Conversely, during studies on oestrous cycle length of fallow does, vasectomised bucks were observed mating oestrous does as late as October, although there is some suggestion that libido may have been declining at this late stage.

Buck activity during the rut

The term "rut" applies to the period of intense overt reproductive activity of the buck. The rapid loss of liveweight observed in rutting fallow bucks (Figure 5) is associated with major short-term changes in daily activity during this period.

Regular observations of activity were made on three sire bucks (as for Figure 5) in 1983. Spot observations of major activities (grazing, sitting, walking, running) were conducted every 15-30 minutes over 24 hour periods. Groaning (male vocalisations) was recorded additional to these major catagories as it occurred throughout all activities (even grazing!).

Figure 7 shows changes in both grazing and walking activity through the rut. The frequency of total observations in which groaning was observed, and the frequency of observed oestrus/matings, are included.

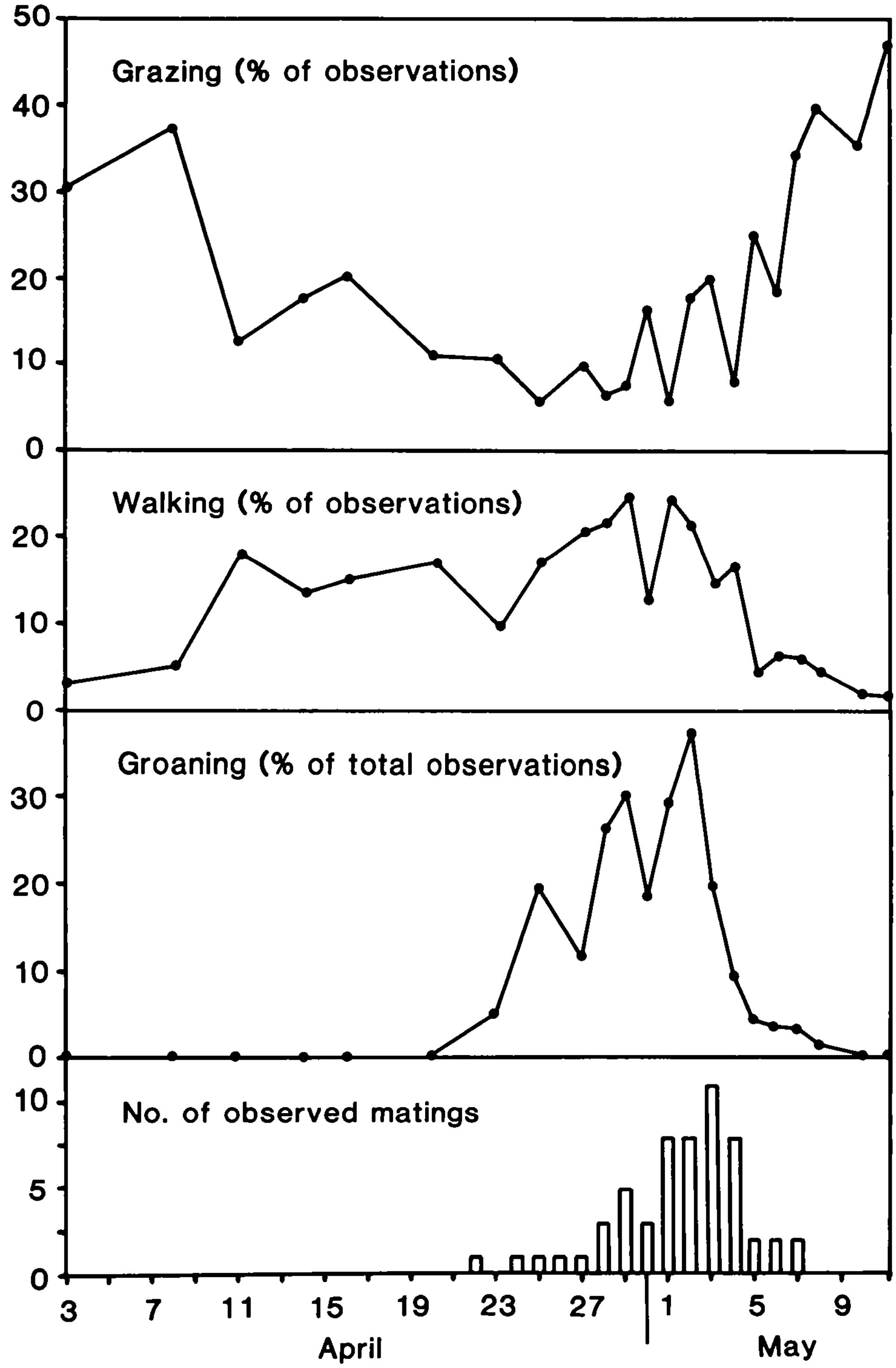

Figure 7: Changes in grazing, walking and "groaning" activity of bucks in relation to the spread of first oestrus of does.

The three bucks showed similar changes in their pre-rut, rut and post-rut activities. Clearly, groaning activity was closely associated with the presence of oestrous does. Grazing activity decreased from approximately 40% of pre-rut observations to as low as 5% by the start of the groaning/mating period. Correspondingly, the bucks became considerably more active, in terms of mobile activities (walking, running), as the frequency of oestrous does increased. This was due to considerable effort in the patrolling of territorial boundaries (usually fence-lines) and frequent chasing of does.

As the frequency of oestrous does decreased in early May, the groaning ceased and mobile activities returned to normal levels. However, there was a pronounced increase, compared to pre-rut levels, of grazing activity, presumably in response to intense hunger and severe depletion of energy reserves.

In all, the major rutting period lasted for only two weeks but had a profound effect upon the bucks' liveweight (Figure 5).

Effect of pre-pubertal castration on growth

Castration of bucks may be a useful tool for providing suitable slaughter animals when entires are normally difficult to handle due to aggression (eg. post-puberty). The growth between birth and three years of age of 21 entire and 11 castrate bucks is represented in Figure 8. Castration was performed using rubber rings at 5 months of age. The two groups were grazed together for almost the entire duration of the trial.

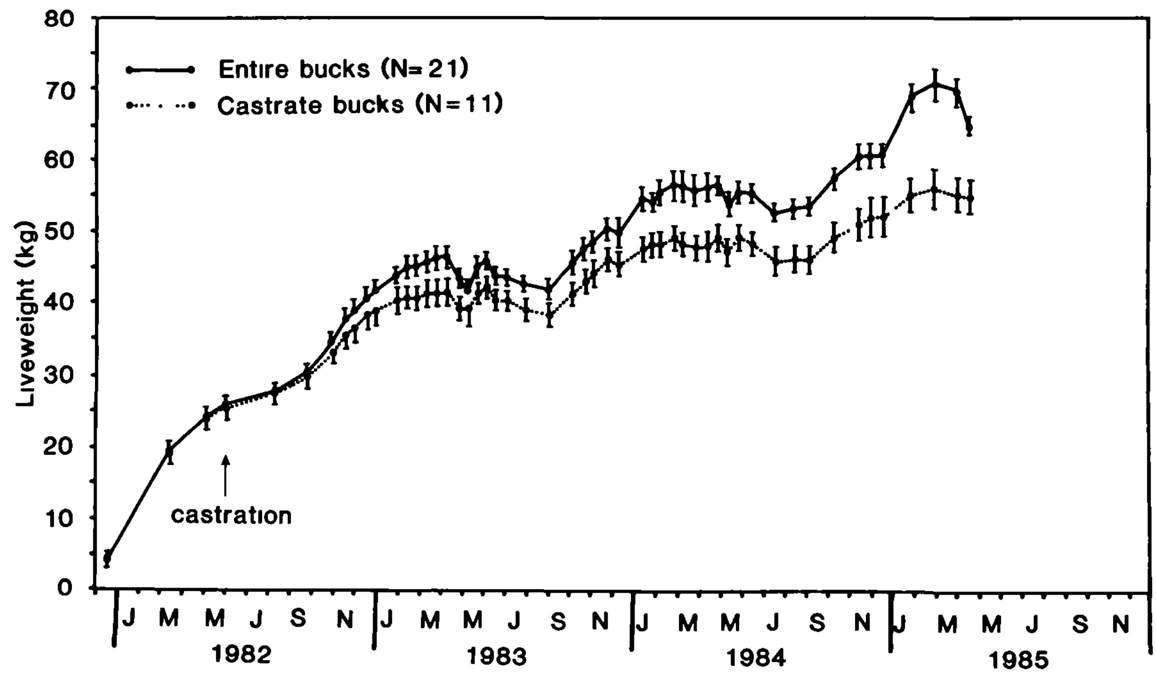

Figure 8: Growth (mean ± 95% CI) of entire and castrate fallow bucks from birth to 40 months of age.

By 15 months of age, the castrates were 9.8% lighter than the entires. The gap increased to 14.0% by 27 months and 20.5% by 39 months.

There was a tendancy for the entires and castrates to show similar fluctuation in liveweight for age. It is not possible at this stage to separate the effects of feed availability, peer pressure and castration upon liveweight. Trials are presently underway to measure feed intakes of entire and castrate bucks up to 20 months of age in order to assess the efficiency of growth of both groups.

(D) Control of Reproduction

Effect of the timing of buck introduction on the onset of oestrus in does.

The "ram effect" is well documented in the literature. Ewes can be induced to cycle earlier in the season by joining with a ram after a short period of ewe sensitisation to ram absence.

A possible "buck effect" was investigated by introducing single bucks to three widely spaced doe groups at different pre-rut times (ie. 15 March, 25 March & 4 April respectively) after a minimum period of 30 days in which there was no close doe contact with adult (>15 months) bucks.

There was no apparent difference in the onset of oestrous activity nor was there a significant ($P>0.1$) difference in the mean date of first oestrus between groups. This suggests that bucks may not be influential upon the onset of oestrous activity, however, the role of pheromones cannot be ruled out because of their potent nature. It is possible that few farms are capable of removing bucks from the presence of does at critical times.

Oestrus synchronisation

First oestrus of fallow does is naturally synchronised over a two week period. However, a greater degree of synchrony may be occasionally required on farms (eg. for artificial insemination).

A ten day treatment with 12% progesterone CIDRs (Alex Harvey Industries, NZ) inserted intra-vaginally is sufficient to synchronise first oestrus within the rut. In one trial with 6 does, oestrus was tightly grouped between 48 and 56 hours after CIDR removal on 30 April. All animals cycled exactly 21 days later, therefore the induced oestrus had resulted in an ovulation and viable corpus luteum.

Induction of earlier oestrus

Induction of earlier oestrus and ovulation in fallow does has been attempted using both PMSG (or HCG) and GnRH treatment after pre-treatment with 12% progesterone CIDRs.

Treatment with 500 iu PMSG (Folligon) upon CIDR removal three weeks before the start of natural oestrus, resulted in induced oestrus in 20/21 does between 48 and 60 hours. Laparoscopic examination at ten days revealed ovulation rates ranging from 1-4. Conception at induced oestrus was low (2/20 does) and may have been partly due to poor buck libido observed during the trial. The returns-to-service occurred between days 21-25 after first oestrus, showing considerably more variation in cycle length than untreated animals. This was presumably due to multiple corpora lutea from the induced ovulations. Further studies with PMSG will need to examine lower dosage rates in order to prevent multiple ovulations.

Treatment with low dose, 7-day infusion of GnRH via s.c. osmotic minipumps, (Alzet Corp) following CIDR removal, resulted in oestrus and ovulation in 7/14 does, as early as mid-February. Oestrus occurred between days 2-5 after CIDR removal. Only one doe conceived and produced a viable fawn in October, at least six weeks before the onset of natural fawning. The technique was very expensive and requires a careful investigation into treatment of bucks to ensure libido and fertility.

Control of reproductive seasonality of bucks

By comparison with does, the annual sexual development of bucks is a gradual process lasting several months. Therefore, short term treatments with reproductive hormones are likely to have little effect upon advancement of reproductive competence.

Longer term treatment of seasonally breeding male deer with the pineal hormone, melatonin, is being investigated. A trial was conducted with mature fallow bucks in which melatonin was incorporated into feed and orally administered daily in early summer to simulate short-day length. A 45 day treatment period from 1 December to 14 January resulted in a positive, but somewhat transitory, shift in several reproductive characteristics.

The results suggested that for this form of melatonin treatment to be fully effective, bucks need to be treated later in the season and, perhaps, for a longer period. Further trials are continuing.

Semen collection

Semen was collected from fallow bucks by electro-ejaculation. Between 0.5-1.0 ml of semen was obtained from fully anaesthetised animals, with best quality semen taken between March and September (refer Figure 8). Techniques of dilution, storage and thawing have not been evaluated.

Possible role of artificial insemination (AI)

The potential benefits of AI in fallow deer farming are primarily related to the importation of semen from exotic sources to introduce genetically different lines.

Two aspects of artificial breeding have been investigated to date; oestrus synchronisation and semen collection. Further studies are required on semen processing and insemination techniques before AI can be realistically considered as a farming tool.

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