Oestrous cycle and breeding season of farmed fallow deer, *Dama dama*

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Summary. Oestrus was detected on 177 occasions in 34 fallow does for the duration of the breeding season. A total of 142 cycles had a mean length of 22.4 (± 1.3, s.d.) days. Cycle length increased and became more variable as the season proceeded but was not affected by doe age or liveweight. First oestrus occurred within a 12-day period, but the length of the breeding season, and therefore the number of oestrous cycles, was related to doe age. Serum progesterone profiles suggest that silent ovulations, associated with short-lived corpora lutea, occurred before the first behavioural oestrus. Ovulations without oestrus may have also occurred at the end of the breeding season.

Introduction

Fallow deer (*Dama dama*) account for about 14% of the total farmed deer population in New Zealand (Ministry of Agriculture and Fisheries survey, 1980). They are seasonal breeders with mating coinciding with decreasing photoperiod in autumn and fawning occurring in summer (Chapman & Chapman 1975). The fawning season is well synchronized within a 3-week period in December (Asher & Adam, 1985) and coincides with deteriorating pasture quality, consequently reducing dam milk yields and fawn growth rates. Artificial manipulation of breeding may enable a shift in the fawning season to give a better match of feed requirements and feed quality, but to achieve this objective, a greater understanding of fallow deer reproduction is required.

Although originally 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, Chaplin, Chapman & Smith, 1969; Chapman & Chapman, 1969, 1975; Baker, 1973). However, the length of the oestrous cycle and the duration of the potential breeding season have not been investigated in detail. The aim of the present study was to measure the length and variance of oestrous cycles, to record the number of uninterrupted cycles in the potential breeding season, and to monitor serum progesterone concentrations throughout the breeding season.

Materials and Methods

*Animals and management.* Three groups of farm-reared fallow does of various ages (Table 1) were each grazed with a single mature vasectomized buck from 25 March to 10 October 1983 (Group 1), 25 March to 15 November 1984 (Group 2) and 15 April to 15 November 1984 (Group 3). Group 3 does had their first oestrus synchronized by use of a silicone elastomer intravaginal device impregnated with progesterone (AHI Plastic Moulding Co., Hamilton, NZ).

The three groups were contained in high-fenced paddocks (2500 m²), all within 150 metres of an enclosed observation platform. They were grazed on ryegrass–clover pastures. Meadow hay was provided *ad libitum* and occasional feeding of whole kernel maize was used to quieten the deer.
The bucks were polled by pedicle cauterization at 5 months of age to reduce aggression towards does during handling.

Detection of oestrus. Each buck was fitted with a ram mating harness (Fergus; Merck, Sharp & Dohme, NZ Ltd, Auckland, NZ). Red, blue and green crayons were the most effective and were replaced at least every 3rd day. Twice daily detection of crayon marks was aided by bleaching the hair on the does’ hindquarters with hydrogen peroxide solution. Oestrus was recorded to the nearest day of each observation.

Handling and blood sampling. When required, the deer were quietly mustered from the paddock into a covered handling shed. Deer were guided by controlled lighting into a cradle designed to restrain them. Liveweights were recorded at 2–3-week intervals using an electronic load cell (Tru-Test NZ Ltd, Auckland, NZ) supporting the cradle. Deer were not held in the handling shed for more than 1 h at a time before being returned to their paddock.

Blood (≈ 10 ml) was collected into serum Vacutainers by jugular venepuncture while deer were restrained in the cradle. Samples were chilled to ≈ 5°C and then centrifuged. The serum was transferred to glass vials and stored at −10°C until assayed.

The frequency of blood sampling was daily (08:00–09:00 h) from 5 April until 24 June 1983 (at least two complete oestrous cycles) for Group 1, every 3rd day (10:30–11:30 h) from 12 March (preceding the breeding season) until 10 October 1984 (cessation of cycling) for Group 2 and every 3rd day (10:30–11:30 h) from 16 April (insertion of intravaginal progesterone device) until 10 October 1984 for Group 3.

Progesterone radioimmunoassay. The assay used to determine serum progesterone concentrations for fallow does has been previously described and validated for bovine serum (Fairclough, Hunter & Welch, 1975). The antiserum was raised in a rabbit against progesterone-11–BSA conjugate and used at a final dilution of 1:3000. Cross-reactivity with major steroids was as follows; progesterone, 100%; androstenedione, 25%; cholesterol, 12%; 20β-hydroxy progesterone, <0.1%; 20α-hydroxy progesterone, <0.1%; 5-pregnen-3ß,17α-diol-20-one, <0.1%. All other steroids tested showed <0.1% cross-reaction with the antiserum. The only modifications in the assay procedure were the use of glassware for extraction and a change in solvents from petroleum ether to redistilled n-hexane.

All samples from an individual were included in a single assay. Low (castrated buck serum) and high (pooled pregnant doe serum) progesterone control samples were included in each assay. The inter-assay coefficients of variation were 11.5% for the low control (n = 95, mean = 0.77 ng/ml) and 10.6% for the high control (n = 72, mean = 4.39 ng/ml). The intra-assay coefficient of variation, calculated from 250 duplicates randomly selected across all assays, was 6.7%.

The recovery of progesterone added to charcoal-stripped serum from a castrated buck (10 determinations) was 90.0 ± 3.1 (s.d.)% at 1.0 ng/ml, 82.1 ± 4.2% at 5.0 ng/ml and 78.0 ± 5.9% at 10.0 ng/ml. Extraction efficiency of radioactive progesterone in doe serum was 94 ± 1.1%. The sensitivity of the standard curve, defined by Ekins (1970) as the variance of the control point at the 95% confidence limit, was 0.15 ng/ml after accounting for sample volume and extraction losses.

Statistical analysis. The data were analysed by analysis of variance or Student’s t test as appropriate except for the individual animal component of variation of sequential cycle lengths, which was examined by the χ² test on the frequency of individual differences between the first, second and third cycle lengths. The 95% confidence intervals for progesterone levels were constructed from the t-interval at n – 1 degrees of freedom.

Results

Liveweight changes

Generally, there was a small but continual loss in doe liveweight during the autumn and winter.
Text-fig. 1. Liveweight profile of fallow does during the study periods in 1983 and 1984. Values are mean ± s.e.m. for 14 does in Group 1, 14 does in Group 2 and 6 does in Group 3.

Table 1. Summary of numbers of does, ages, mean dates of first oestrus by group, and the number of does showing successive periods of oestrus

<table>
<thead>
<tr>
<th>Doe age (months)</th>
<th>Mean date of first oestrus (s.d. days)</th>
<th>No. of oestrous periods shown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Group 1, 1983</td>
<td>2 May (3-0)</td>
<td>14</td>
</tr>
<tr>
<td>Group 2, 1984</td>
<td>24 April (3-1)</td>
<td>14</td>
</tr>
<tr>
<td>Group 3, 1984</td>
<td>28 April* (0-6)</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>28 April (4-8)</td>
<td>34</td>
</tr>
</tbody>
</table>

* First oestrus artificially synchronized.
† Oestrus 2 and 3 not detected for Doe W41 (see text).

(Text-fig. 1) regardless of the amount of feed available. The liveweight differences between the three groups largely represented different age structures (Table 1).

Onset of the breeding season

Every doe was detected in oestrus, with the mean dates of first oestrus (Table 1) being significantly different between Groups 1 (1983) and 2 (1984) (P < 0.01). The first oestrus in Group 3 does, which had been artificially synchronized, occurred between the mean dates for the other two groups. The standard deviation of the date of first oestrus was only about 3 days for Groups 1 and 2 (Table 1).

One doe (W41, Group 1) was not detected in oestrus when its contemporaries had a second and third oestrus, although oestrus was detected at 68 days. The progesterone profile indicated that ovulatory cycles did occur between this period. A fourth oestrus was noted for all does (including W41); thereafter a declining proportion exhibited periods of oestrus (Table 1).

Length of the oestrous cycles

Through direct observation of mating and secondary observation of crayon marks, evidence of oestrus was detected on 177 occasions, resulting in a total of 142 valid observations of oestrous cycle length. Mean oestrous cycle length was 22.4 days (excluding Doe W41) with a range of 20 to 27 days (Text-fig. 2). 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 (Text-fig. 2). A significant proportion of does had increased cycle lengths between the first and second cycles ($P < 0.01$), first and third cycles ($P < 0.01$) and second and third cycles ($P < 0.05$). Year, doe age and doe liveweight did not significantly ($P > 0.1$) affect oestrous cycle length by cycle number.

**Table 2.** Duration of the potential breeding season (number of cycles between first and last recorded oestrus) by doe age

<table>
<thead>
<tr>
<th>Doe age (months)</th>
<th>No. of does</th>
<th>Mean no. of cycles (s.d.)</th>
<th>Mean date of first oestrus (s.d. days)</th>
<th>Mean date of last oestrus (s.d. days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>9</td>
<td>3.56 (0.527)</td>
<td>2 May (2.8)</td>
<td>20 July (12.4)</td>
</tr>
<tr>
<td>28</td>
<td>17</td>
<td>4.24 (0.562)</td>
<td>27 April (4.5)</td>
<td>30 July (12.5)</td>
</tr>
<tr>
<td>40+</td>
<td>7</td>
<td>5.43 (0.535)</td>
<td>24 April (3.3)</td>
<td>25 August (15.1)</td>
</tr>
</tbody>
</table>

**Duration of the breeding season**

The number of detected oestrous cycles varied from 3 to 6, with the duration between first and last oestrus varying from 65 to 135 days. Pubertal does (16 months) had fewer cycles than older does ($P < 0.05$; Table 2). Does in their second breeding season had fewer cycles than did older does ($P < 0.05$; Table 2). Within each age group, there was a positive but non-significant ($P > 0.1$)
relationship between pre-rut (late March) liveweight and the number of cycles observed. However, both doe age and liveweight may be confounded by year as there was an unavoidable unbalanced age distribution between 1983 and 1984 groups (Table 1).

**Progesterone profiles**

The composite progesterone profiles of daily and 3-day means about oestrus (Day 0) illustrate cyclic progesterone secretion of luteal origin (Text-fig. 3). Oestrus occurred only when progesterone concentrations were low (<1.0 ng/ml) and was followed by a gradual rise in progesterone concentration to reach peak values (3.0–8.0 ng/ml) between Days 12 and 16 after oestrus. Subsequent luteolysis, between Days 16 and 21, was rapid (Text-fig. 3a). This basic daily pattern for first and second cycles was repeated in Group 2 and 3 does for all cycles throughout the entire breeding season (Text-figs 3b, c & 4).

**The occurrence of silent ovulations before first oestrus**

A transitory increase in progesterone secretion preceded the first oestrus in 13/14 (93%) of does in Group 1 (Text-figs 3 & 4). A similar phenomenon was apparent for Group 2 does, but the 3-day blood sampling regimen was not adequate to monitor the event precisely.
Text-fig. 4. Selected typical progesterone profiles of (a) Group 1 does showing single or multiple short-lived corpora lutea as indicated by transitory elevations of progesterone (*) before first oestrus and (b) Group 2 does showing different events terminating the breeding season. J, Oestrus.
The magnitude of the maximum progesterone rise was generally 2–3 times the preceding basal values and frequently exceeded 1·5 ng/ml. Some does appeared to have more than one progesterone elevation in rapid succession (Text-fig. 4a).

The occurrence of silent oovulations after last recorded oestrus

Progesterone profiles throughout the entire breeding season for does in Groups 2 and 3 showed that the last recorded behavioural oestrus was followed by a luteal cycle of normal duration in 18/20 (90%) does (Text-fig. 4b, Doe W34). Five does continued to show cyclic patterns of progesterone at the end of the breeding season, without being detected in oestrus (Text-fig. 4b, Doe W46). Therefore, first and last dates of oestrus do not precisely define the seasonal period of ovulatory activity. One doe was still exhibiting progesterone cycles at the cessation of blood sampling, but no further oestrus was detected.

Possible short-lived corpora lutea were initiated immediately after the last full cycle in some does (Text-fig. 4b, Doe 0.9) as indicated by transitory elevations of progesterone. Thereafter, progesterone secretion remained low until termination of the sampling programme in early October.

Discussion

This study has confirmed that fallow deer are seasonally polyoestrous. The potential breeding season is considerably longer than is indicated by the 'rut' (overt sexual activity of the buck) which coincided with the spread of first oestrus in contemporary does (G. W. Asher, unpublished data).

The mean overall cycle length of 22·4 days is intermediate between that of red deer (18·3 days; Guinness, Lincoln & Short, 1971; 18·8 days; Krzywinski & Jaczewski, 1978) and Odocoileus spp. (22–29 days; Cheatum & Morton, 1946; West, 1968; Thomas, 1970; Thomas & Cowan, 1975) and similar to that reported for wapiti (21·2 days; Morrison, 1960a). It is less than the 24–26 days suggested for fallow deer by Cowan (1965) and Baker (1973).

A notable feature is the low variance encountered for the mean length (days ± s.d.) of the first (21·0 ± 0·64), second (22·0 ± 0·66) and third (22·9 ± 0·97) oestrous cycles of fallow does (Text-fig. 2) compared with limited data for red deer (Guinness et al., 1971).

Progesterone profiles over entire oestrous cycle (Text-figs 3 & 4) show a consistent pattern between does. Mean progesterone concentrations were lowest on the day of oestrus, with a gradual increase to reach luteal phase levels over Days 9–16. Luteal regression appeared to start 5 days before the next oestrus.

Silent ovulations precede overt oestrus in various cervids including wapiti (Morrison, 1960b), moose (Simkin, 1965) and black-tailed deer (Thomas & Cowan, 1975). Ovarian examination, by laparoscopy, of contemporary fallow does in 1984, about 1 week before first oestrus, revealed that all had ovulated and that a single corpus luteum was present in each. This strongly suggests that the transient elevations in progesterone before first oestrus, observed in Group 1 does, were in fact secretions from short-lived corpora lutea (Text-fig. 4) and occurred in the majority of does. Some does appeared to have had two or more such events in succession (Text-fig. 4a). The occurrence of silent ovulations during the onset of the breeding season helped to synchronize first oestrus, with the result that the spread of first oestrus corresponded to the approximate longevity of the short-lived corpora lutea. The onset of ovulatory activity appeared to be less synchronous than the onset of oestrus as variation occurred in the number of transitory corpora lutea. (Text-fig. 4a).

The onset of the first oestrus was significantly different between does in Group 1 (1983) and Group 2 (1984) (P < 0·05) and it is tempting to attribute this to the high proportion of pubertal does in 1983, although other potential modifying factors (e.g. social facilitation) have yet to be investigated.

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The occurrence of apparent silent ovulations during the breeding season was observed in only one doe (W41), the progesterone profile of which clearly showed that the apparent 68-day cycle comprised three normal length luteal cycles. For this reason, this multiple cycle was disregarded with respect to calculations of oestrous cycle lengths. Similar events have been observed with red deer hinds (Guinness et al., 1971). An apparent silent ovulation followed the last recorded oestrus of 5/20 does with the resulting corpora lutea being of normal longevity (Text-fig. 4b, Doe W46). In view of casual observations of declining libido of the vasectomized bucks towards the end of the breeding season, these events may reflect a failure of the bucks to detect or respond to oestrus. Only one doe apparently failed to develop a normal corpus luteum after final recorded oestrus. It was its seventh period of oestrus and the last detected oestrus of the 1984 season. A transitory rise in progesterone values was observed to terminate cyclic activity in some does (Text-fig. 4b, Doe 0.9). These events may represent short-lived corpora lutea and mirror the events occurring at the onset of the breeding season.

The increasing length and variability of the oestrous cycle as the season progressed (Text-fig. 2) also occur in red deer (Guinness et al., 1971). The progesterone profiles of some does in Groups 2 or 3 suggested that behavioural oestrus may have been increasingly delayed after the decline in progesterone concentrations following luteolysis, thus contributing to increasing cycle length. A more intensive blood sampling regimen over successive peri-oestrous periods would be required to validate the observation.

The apparent age effect upon the length of the potential breeding season of fallow does is in agreement with that observed for domestic sheep (Hafez, 1952; Dyrmundsson, 1973). This age effect in fallow does was primarily due to the variation in occurrence of last recorded oestrus (Table 2). The maximum duration of the breeding season, the period between first and last oestrus, was 6 cycles (7 periods of oestrus) or ~135 days, observed for 3 mature does. All does cycled beyond the shortest day, but younger does may have a more sensitive response pattern to increasing daylength than older does, resulting in earlier anoestrus.

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