BIOLOGY OF THE RED DEER FAMILY IN RELATION TO THEIR UTILISATION AS FARMED ANIMALS

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The red deer (Cervus elaphus) is a species of temperate origin, being a member of a family with a wide natural distribution from North America to Asia. In broad terms the red deer family covers a very large size range from the North American wapiti to the Japanese sika deer. These species can all interbreed to produce fertile offspring. The most important features of the biology of this family in relation to their use as farmed species are their seasonality, as apparent in their profoundly seasonal cycles of reproduction, body weight change and antler growth, and their social organisation.

This paper will summarise some of the important aspects of reproduction, body growth and antlers which are relevant to the farming of the red deer family. Some recent research will be highlighted while some of the main sources of information are listed in the bibliography.

REPRODUCTION

The red deer are short-day breeders with mating in the autumn leading to birth of progeny in the summer. The oestrous cycle is 18 days with a gestation period of 233 days in red deer. For the larger Canadian wapiti at Invermay, the values are about 21 and 255 days respectively.

Puberty in red deer females generally occurs in the autumn at about 16 months of age and is apparently bodyweight related, with a threshold weight of about 70 kg, or approximately 70% of the mature body weight. Wapiti females may not, however, attain puberty until a year later due to their relatively poorer growth rates. However, whether this is a management problem or a function of their biology as a later maturing species is not yet clear. Seasonality has been likened to a yearly puberty in females, with photoperiodic changes being implicated in the control of both events. For example, hinds subjected to earlier seasonal photoperiods by shortening day length or treatment with melatonin designed to mimic photoperiodic changes may ovulate and calve earlier in the season.

The males of the various Cervus elaphus strains are also seasonal breeders, the highlight for the male being the rut in autumn. The annual cycle of the adult male follows extremes characterised by a high voluntary feed intake and high bodyweight gain in spring-summer. Intake then declines under the influence of rising testosterone levels in the autumn as the stag goes into the rut, and then following the rut, when body fat reserves are virtually exhausted, intake increases so that bodyweight is maintained through winter.

Puberty in red deer stags is a continuous process which commences during the first autumn of life at about 3 months of age. However, the progress of pubertal development is more determined by the animals bodyweight than by daylength. The most obvious marker of puberty is initiation of pedicle development which occurs at about 30% of mature bodyweight. There is a conspicuous delay in pubertal development while the stag is growing his first velvet antler, but development resumes as this ceases. Although stags are generally fertile at 15 months of age, their use for breeding should be considered very carefully as their semen supply and behaviour can severely limit their effectiveness.

A simplified diagram of the hypothalamic - pituitary - ovarian regulation of ovulation and oestrus in the female as shown in Figure 1. Therefore an understanding of this indicates the possibilities for controlling reproduction in female deer. The regulation of the sexual cycle in males is also under daylength control with the pituitary LH and FSH acting on the testis resulting in spermatogenesis and the production of testosterone.

Consequently where the aim is to manipulate the oestrous cycle of the female deer, the possibilities may include the following:

a) reducing daylength
b) treatment with melatonin
c) treatment with gonadotrophin releasing hormone
d) treatment with luteinising hormone and/or follicle stimulating hormone
e) treatment with progesterone

In recent years, there has been a considerable amount of work mainly in New Zealand, but also in the United Kingdom and Canada, concerned with

manipulation of the oestrous cycle in red deer and wapiti. The major objectives of the work have been to devise practical methods for advancing the breeding season, to induce superovulation for embryo recovery and subsequent transfer, or to synchronise oestrus for artificial insemination or embryo transfer.

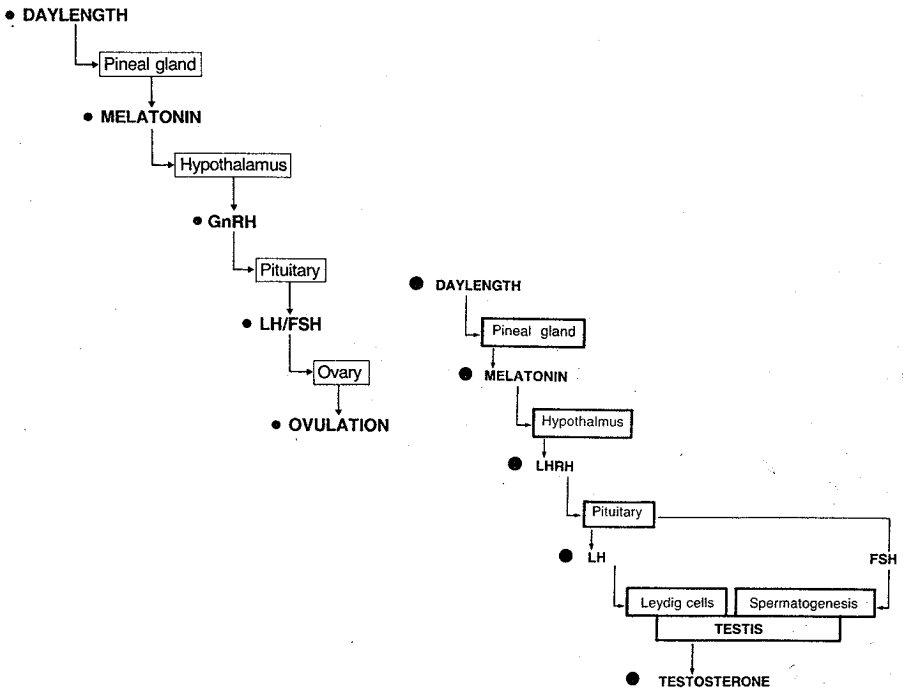

Fig. 1 Simplified description of the hypothalamic-pituitary-ovarian regulation of ovulation (and oestrus) in the red deer hind and stag.

While a progesterone/pregnant mares serum gonadotrophin (PMSG, which has both LH - and FSH-like activity) treatment has been used successfully to advance the date of ovulation and the onset of the breeding season in hinds, the fertility at the resulting oestrus has generally been poor. However, when treated hinds have been mated with stags treated with melatonin, fertility has been improved greatly. In one Invermay study, the

overall fertility to the induced oestrus (induced about March 1 to give calving about 21 October) was 57% (26/48 hinds) with treated stags in 1986 compared with only 13% (6/48 hinds) in 1985 when untreated stags were used in a virtually identical experiment (G.H. Moore and P.F. Fennessy, unpublished).

Observations suggest that prior to the normal breeding season (stags start mating in late March-early April to give calving in mid late November), stags copulate normally and appear to serve hinds on heat (M.W. Fisher and P.F. Fennessy, unpublished). However, they do not herd their hinds in the normal manner in marked contrast to their melatonin-treated counterparts. Consequently despite the obvious behavioural differences, it appears that fertility in untreated stags prior to the breeding season is limited by semen quality or supply rather than by behavioural deficiencies.

In the longer term, probably the most promising method for advancing the breeding season is the use of melatonin implants (Regulin, Regulin Ltd, Melbourne) both in hinds and stags. To this end, there has been a considerable amount of work particularly in New Zealand in the last 3 years. For example in one Invermay trial in 1985/86, 12 of 16 yearling hinds given melatonin implants had ovulated compared with 0/6 controls when examined by laparoscopy about a month prior to the onset of the normal breeding season. While some larger scale trials have been undertaken there are a number of questions relating to timing of treatment in both hinds and stags and its impact on the onset of the breeding season which need to be worked through to ensure its efficacy in the farmed situation.

The progesterone/PMSG treatment is used widely for the induction and synchronisation of oestrus for artificial insemination. Generally a double cervical insemination given on the second and third days following progesterone withdrawal/PMSG treatment gives about 50% fertility.

High levels of PMSG may also result in multiple ovulations and in some cases, multiple births. Since twinning is of considerable interest, some studies have been carried out. However, from comparison of different experiments it appears that while multiple births occur frequently in PMSG-treated hinds prior to the breeding season, they are much less frequent in hinds treated during the normal breeding season. This raises

the possibility that a type of embryo reduction mechanism may be operating in some situations.

Several groups in New Zealand are working on techniques for embryo transfer in red deer and wapiti. Treatments generally involve the use of follicle stimulating hormone with or without PMSG in hinds synchronised by progesterone therapy. The variability in ovulatory response means that the technique must still be regarded as experimental, although a number of calves have been born following embryo transfer.

No discussion of the regulation of the oestrous cycle would be complete without mention of the natural induction of ovulation or oestrus. There is evidence in deer of a "stag effect" akin to the well known "ram effect" in sheep. For example, a common observation in Invermay studies where ovulation has been advanced by progesterone/PMSG treatment is the synchronisation of calving in control hinds run with the treated hinds. Calving of the controls is coincident with ovulation approximately 18 days after the oestrus induced in the treated hinds. There is a possibility that pheromonal, visual and auditory components may all be involved.

GROWTH AND NUTRITION

The seasonal pattern of voluntary feed intake and as a consequence, bodyweight change is of critical importance in considering the farming of red deer as breeders and especially for meat production.

Red deer stags exhibit a very marked seasonal pattern of feed intake and liveweight change, even when fed ad libitum. Intake increases in the spring reaching a peak in late spring-summer, before the dramatic decline during the rut, even when the stag is not used for breeding. The pattern of bodyweight follows that of intake with large gains in weight over spring-summer followed by massive losses during the rut. With adequate feed, stags will maintain their post-rut bodyweight over winter. Studies of pen-fed stags have revealed that the intake pattern is actually a combination of two intake cycles, one probably mediated via daylength and the other responsive to the sexual cycle. The basic cycle, which is also evident in young animals of both sexes over the first year of life and in the adult female, is daylength related with increasing intakes in spring and decreasing intakes in autumn. The sexual cycle in stags results in

another intake cycle being superimposed over this basic cycle. The basic pattern from an indoor study at Invermay is shown in Figure 2.

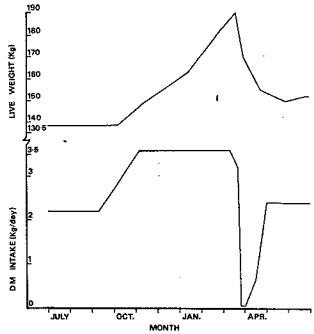

Fig. 2 The patterns of feed intake and liveweight gain for a red deer stag aged 2.5 to 3.5 years fed ad libitum on a high quality diet indoors (from Fennessy 1982).

Young deer in their first winter regularly exhibit a decline in food intake and weight gain even when fed ad libitum. Consequently while growth rates of 300 g/day are achievable for red deer stags over spring-summer (9-14 months of age) average growth rates over winter (6-9 months) seldom exceed 100 g/day. However, a study of the influence of latitude through its effect on daylength would prove very interesting since there is some evidence that the decline in winter intake observed in red deer in Queensland (Ritchie 1986) is less than that found in the Invermay studies.

Clearly, the seasonal pattern of intake imposes limitations and opportunities for the farmer in terms of how the animals are fed in the practical situation. The objective is to match up the nutritional demands of the animal with the natural supply of feed from the grassland, in order to avoid the use of expensive supplements so that the cost of production can be kept within reasonable limits (see Fennessy and Milligan 1987; Fennessy 1986). This seasonality of growth also has major implications in terms of producing a lean, high quality meat.

The pattern of growth of red deer indicates the obvious timing for the optimal slaughter of deer from the farmer's "producer" point of view, namely at the end of the spring-summer growth "spurts" in March at 15 or 27

months of age. Even though such stags will have reached 50-55% or 65-70% of their mature body weights at 15 and 27 months respectively, they are still very lean when compared with traditional livestock.

Despite the obvious advantages from the farmer's point of view in slaughtering stags at the end of their growth spurts, market requirements usually dictate otherwise. For the producer, methods for manipulating the growth patterns of young stags to ensure that they continue to grow during their second winter would be a major step forward. While hormonal manipulations, immunisation (eg, against LHRH) and castration, all have possibilities, the perception in the eyes of the final consumer of the venison may well limit their use.

ANTLERS

The antler growth cycle in the stag is linked to the sexual cycle, with the new antlers growing in the spring, followed by hardening and velvet stripping under the influence of testosterone in the summer-autumn so that the stag is in hard antler for the rut.

Antlers may be thought of as growing in four phases. Firstly, the pedicle develops under the influence of testosterone usually during the late winter-spring when the stag is six to nine months of age. When the pedicle has reached about 6 cm, the velvet antler develops (second stage). This is accompanied by a lowered testosterone secretion. In the third stage, the antler is cleaned of velvet while the testosterone levels are high. After testosterone levels have fallen in the early spring, the old hard antlers are cast (fourth stage) and the new antler growth starts with healing of the pedicle.

Although antlers are a unique and fascinating tissue there is relatively little research worldwide concerned with understanding how antlers grow or the regulation of their cellular growth. From the practical farming view, increasing velvet antler growth is important. However, apart from highlighting the importance of nutrition, especially during winter but also during the velvet antler growing period in the spring, research has not yielded any dramatic means of increasing antler growth. The importance of genetics cannot be overlooked and it appears that the major impact of selection has been to increase velvet yields particularly in two and three year old stags.

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