How to use Photoperiod to Increase Deer Growth during Winter

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Introduction

Temperate species of deer have a seasonal pattern of growth. This means that liveweight gain is greater in spring and summer compared with autumn and winter. During their first year of life red deer stag calves have the capacity to grow well after weaning, in autumn, at about 300 g/day but from May to August the maximum growth rate which can be achieved is about 150 g/day. In August growth rate increases and in spring and summer a growth rate of 350-400 g/day can be achieved, readily. The consequences of this winter reduction in growth rate are that the time taken to finish a stag is prolonged thus concentrating the killing season and resulting in seasonal over and under supply of deer carcasses for prime venison production. It would be desirable to `spread the kill' over the year but the tight seasonal pattern of growth limits the producer. A more flexible production system would be preferable

The seasonal pattern of growth is natural, innate to the animal and is independent of the availability of feed. Indeed when given access *ad libitum* to high quality food stags will voluntarily reduce their feed intake during winter. The seasonal pattern of growth has, however, some external control mechanisms Specifically daylength is known to have an influence on many seasonal cycles and it has been shown experimentally that seasonal changes in daylength can influence the expression of seasonal patterns of growth In the same way as the shortening days of autumn are needed to trigger the onset of reproduction so the lengthening days of spring signal to the deer to initiate the growing season.

It is possible to make use of the sensitivity to daylength to manipulate deer growth. During the period of low winter growth rate, deer can be induced to advance the onset of the rapid spring growth phase if they are exposed to the same amount of light as they would perceive in mid summer. Studies at Invermay (described below) have shown an unexpected further benefit of long daylength namely that deer calves grow at a more rapid rate than they would on natural daylength, even in summer under good pasture conditions Thus the advantages of manipulated daylength are two fold.

The aim of this paper is to describe the general conditions necessary for indoor housing of deer and to describe, using examples from our studies, how to use daylength manipulations successfully. The paper concludes with a section where examples from published studies elsewhere can be used to supplement Invermay work

General Conditions for Inwintering Deer

The overall reason to bring young deer indoors during winter is to improve animal welfare by increasing shelter thereby providing a dry, warm environment. Such an environment alone has been shown, in young deer, to improve growth rate, feed utilisation and efficiency. An additional benefit on heavier soils is that pasture damage in winter is lessened and overall stock carrying capacity can be increased In-wintered stock become very quiet and easily managed due to the close positive relationships which are built up with handlers over the winter period. Evidence suggests that this ease of management can persist over several years.

Housing

Most buildings currently used to house deer over winter are existing hay or wool sheds or parts of covered deer yards which have been adapted. Requirements are minimal. The building must be well ventilated so that the air is clean and the floor is kept as dry as possible. A semi-enclosed facility is ideal and this has the advantage that deer can experience natural sunlight during the day and feeding of conserved forage is facilitated. At Invermay red deer stag weaners are kept in pens with 2 m^2/animal. The actual size of the pen is less relevant than ensuring that animals have sufficient space. On farms it is prudent to allocate like sized animals to separate pens from those larger or smaller to decrease bullying. We have found that deer get bored easily and the provision of 'toys' such as rubber tyres and browse species lessen negative behaviour such as coat chewing. It is also advisable to release deer on fine days for several hours outside to permit exercise. These periods can coincide with pen cleaning and maintenance.

At Invermay we use un-treated sawdust as bedding, and this is replaced weekly. An alternative is the deep litter; that is, to add fresh saw dust every few days so that the floor level builds up. A front end loader can be used in spring to clean out the pens thoroughly. Bark chips or straw can also be used as bedding but straw is harder to keep dry.

Clean water must be available at all times, at best from several troughs, so that submissive animals cannot be prevented from access As deer enjoy playing with water care must be taken in designing facilities to ensure that pipes, ballcocks and fittings cannot be reached : floods are the inevitable results of a failure to comply with this necessity.

If deer are to be fed to appetite or if high quality hay is available at all times trough space need not be critical However deer will most likely be fed, commercially, on less concentrate feed than they could consume. To minimise competition and maximise access to feed it is important that all deer in a pen can comfortably feed at once. We recommend that deer are allocated 1½ times their breadth at the shoulders of trough space. For a red deer stag calf weighing 40-60 kg this is about 45 cm. Feed should be spread out evenly in the troughs both to prevent gorging and to ensure all animals have access to an even share.

Feeding

The quantity and quality of feed reflects cost, availability and desired growth rate, however maximum returns from the use of indoor housing with daylength manipulation cannot be achieved from poor feeding (see detail below) Conserved forages such as silage and hay can be fed successfully to indoor deer. In particular silage can be easily fed from a tractor to the front of a deer pen enclosed on three sides, with the deer given access to the silage via wooden slats. Barley can be fed on the silage or in troughs elsewhere in the pen It is outside the scope of this paper to describe feeding rates and food types in depth, but any feed normally available for deer is acceptable and the higher the feeding rate the higher the financial returns. Lucerne hay *ad libitum* has the advantage of reducing coat chewing. If high levels of concentrate diets or cereals are fed it is critical that the deer receive a gradual introduction to these feeds to prevent acidosis. At Invermay we have a period of 25 days from pasture to full concentrate feeding.

Lighting

Any electric lighting is suitable so long as an intensity of 250-300 lux, measured one meter above the floor level not directly under a light fitting is achieved. Strip-lighting is normally most efficient. Although at Invermay we use lights of balanced spectral quality there is no necessity for this. The lights should be controlled by an electric timer available from electrician and suppliers Without wishing to recommend a particular product at Invermay we use Orbis Alpha Products. There is no necessity to maintain the lights on at all times. Extra lighting can be used to supplement and add to natural light. Care must be taken to ensure that sufficient light enters the deer shed to provide at least 250-300 lux during the natural day when the electric light is off. In other words the deer must `see' the same quality of light over the entire wintering period whether this is natural or electric light. Power failures of a few hours duration do not impair the effectiveness of the procedure but care must be taken to reset electronic timers. In the event of a power failure, timers should be reset immediately. Do not attempt to `compensate' for any `lost hours' of light.

Animal Health

Mention has already been made of keeping animals of the same size together to minimise bullying. Once a group has formed it has a peer structure or dominance hierarchy and moving animals from one group to another will result in fighting until hierarchies become re-established Animals which are penned together should be exercised together. A close watch should be kept so that animals being bullied or the perpetrators of such behaviour can be separated.

All animals should be drenched before being put into inwintering pens with a suitable ant-helminthic as part of the farms post-weaning animal health programme. As deer indoors have been lost to *Yersinia* and clostridial diseases it is advisable to consider vaccination programmes. Foot abscesses occur in wintering pens and can be particularly damaging and hard to cure. Care must be taken to remove all rough surfaces and sharp edges at floor level. Tiny cuts can become infected especially in wet straw,

Deer can be slaughtered directly from the inwintering pen or can be released outdoors to take advantage of spring pasture. It is as important to `harden off' inwintered deer to outdoor feeding and environmental condition as it was to ensure they had adapted to indoors and concentrate feeding. Deer can be run outdoors on pasture during fine spring days to progressively accomplish this. As deer from daylength treatments often moult their winter coats, it is to be recommended that no deer be released outdoors permanently until a full summer coat has been grown This can be judged visibly

How to Manipulate Daylength

The approach we have adopted here is to use our data to answer the questions we have been asked by veterinarians and producers or to describe the ways we have replied to the pitfalls and problems which have been reported to us.

1. <u>When can you start daylength manipulations</u>?

Typically red deer stag calves are weaned from late February to late March. Growth rates post weaning can remain high until late May when winter inappetance begins. Inappetance

and low growth continue until late August. To obtain an advantage by using a daylength manipulation, the treatment could potentially start from late March onwards. We have started, in successive years, studies in mid April, early June and late June where red deer stag calves were exposed to a daylength of 16 hours of light followed by eight hours of darkness during each 24 hour period (16L.8D) (Figure 1). All three start times gave positive growth responses. Although the starting liveweight of the calves differed, this had no effect on the response to 16L.8D.

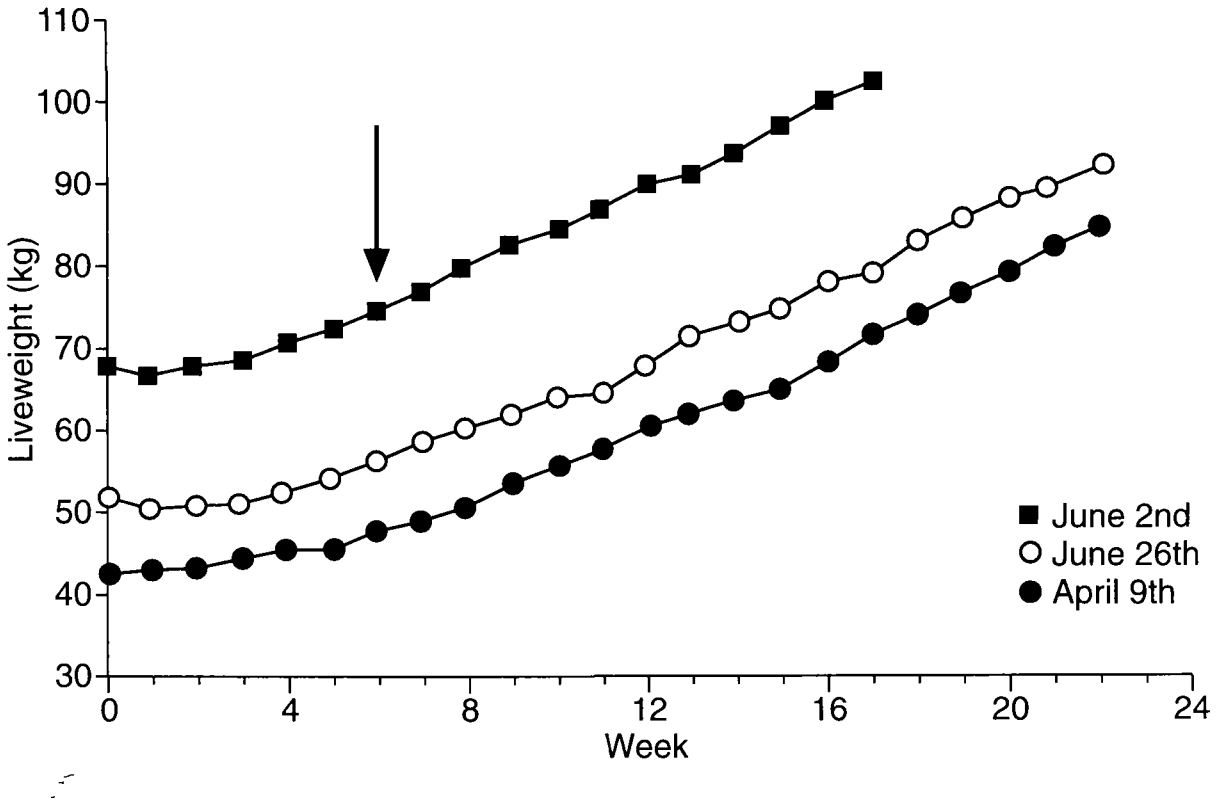

Figure 1 Mean liveweight (kg) of red deer stag calves exposed to a daylength of 16L:8D (16 hours of light followed by eight hours of dark during each 24 hr period) at different months of the year from April to June (n = 10 stags/group). The vertical arrow at six weeks represents the typical timing of the onset of rapid growth.
So a start date from April to June will result in an increase in growth.

2. How long will it take to get an effect?

All the animals take time to adjust to the signal which indicates to them that they should begin growth; an immediate effect of additional daylength should not be expected. From Figure 1 it is clear that a change in growth rate took place about six weeks after exposure to 16L:8D at all three start times irrespective of body size. Food intake typically also increases at this time.

3. How much additional daylength is necessary?

At 45° South there are about eight daylight hours on the shortest day and 16 hours on the longest day. Scientists studying daylength control systems typically consider the absolute number of hours of light is a more relevant signal to the animal than the direction of the prevailing daylength change. (In fact both probably provide separate information). To

To determine how much daylight was required to reverse the effects of low winter growth rate in deer, a study was carried out at Invermay where stag calves were kept either at the winter solstice daylength (8L:16D) or were given one of a range of daylengths with longer amounts of daylight (Figure 2). It is clear that only 16L:8D successfully increased the timing of the increase in growth and the rate of growth. None of the remaining treatments prevented the normal spring rise in growth, which occurred in late August. Notice that the 16L:8D group decreased rapid growth at week 25 when they had reached a mean liveweight of 114 kg. This means that fixed daylength prematurely stops growth if the deer are left on it for a long time.

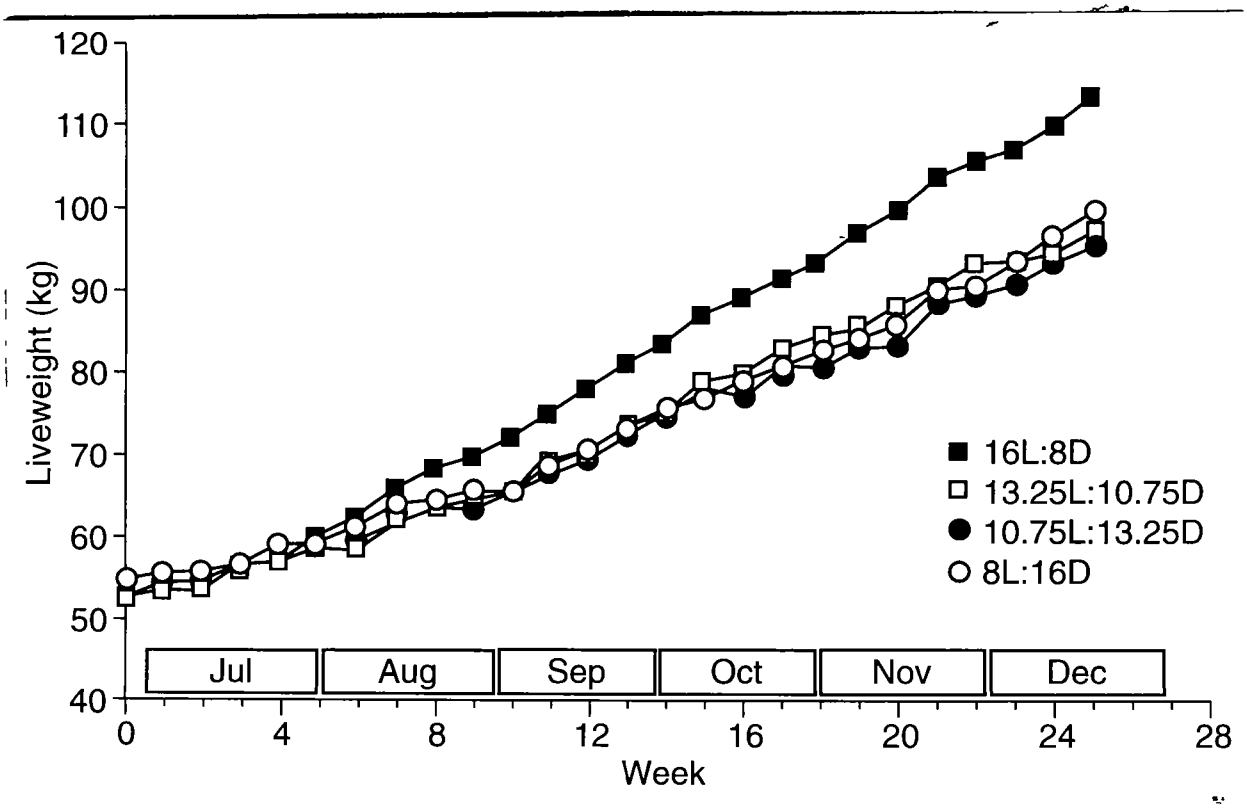

Figure 2 Mean liveweight (kg of red deer stag calves exposed to one of a series of daylengths from the winter solstice (n = 10/group).

In this study the deer were kept in pens for much longer than normal (about six months) to evaluate fully the potential for growth. The possibility nevertheless exists to keep deer on a manipulated daylength until slaughter weight is achieved, if this is a desirable economic outcome. 16L:8D is a successful daylength to increase both the timing of increased growth and its rate.

4. How best should increased daylight be presented to the deer?

Daylength changes follow a sine function so that maximal rates of change take place at the equinoxes when daylength is 12L:12D and zero rates of change take place at the summer and winter solstices when daylength is 16L:8D and 8L:16D respectively. Intuitively it appeared that by providing a more naturally changing daylength then growth enhancement could be optimised. A study was carried out (Figure 3) which convincingly showed that the technique of providing a fixed daylength of 16L:8D was considerably more effective than other treatments.

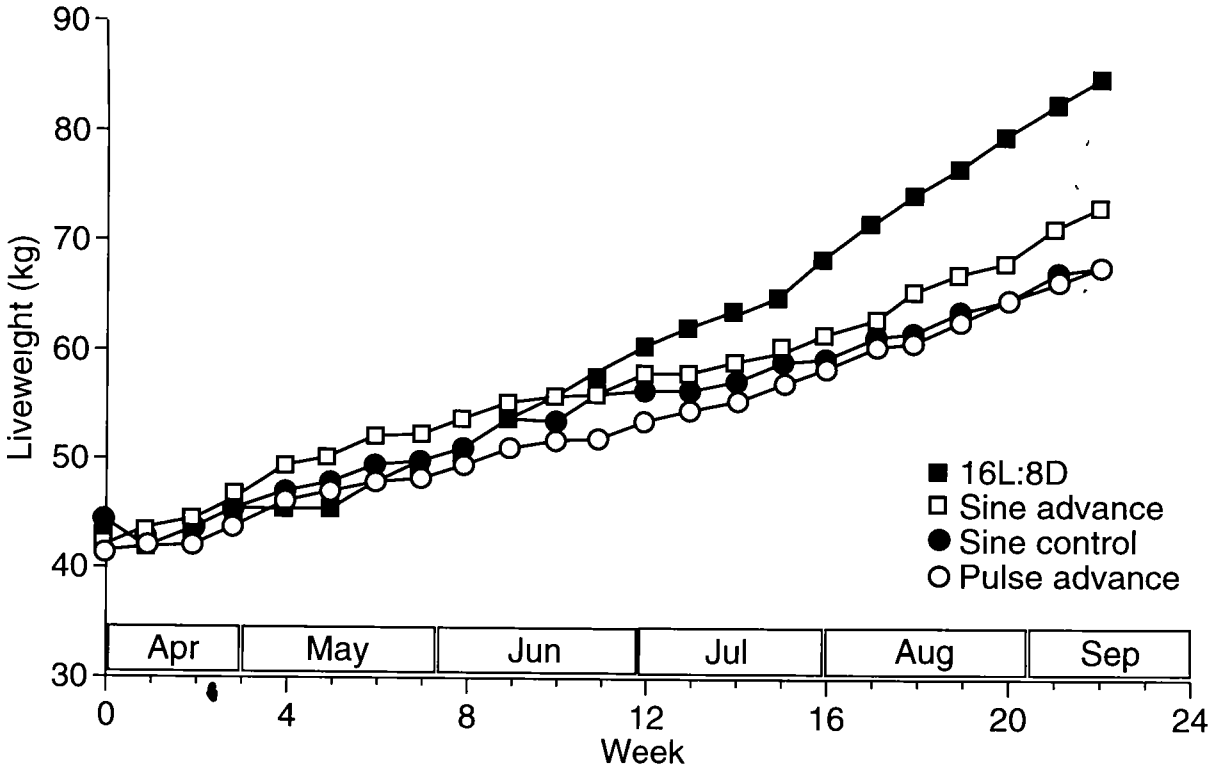

Figure 3 Mean liveweight (kg) of red deer stag calves exposed to one of the following daylength from mid April (n = 8/group).

(1) 16L:8D - abrupt change from natural photoperiod to that of the summer solstice.

(2) Sine Advance - abrupt change to the winter solstice daylength (8L.16D) followed by a gradual increase following a sine function.

(3) Pulse Advance - abrupt decrease in photoperiod to that of the winter solstice for a period of six weeks followed by an abrupt increase to 12L:12D.

(4) Sine Control - a daylength which mimics the changes occurring outdoors.

At Invermay we have arbitrarily designated 8 00 am each day as our 'subjective' dawn when lights are switched on. Consequently lights off on a daylength of 16L:8D is at mid-night. In a practical situation we recommend that additional lighting is timed to come on at natural sunset and go off at mid-night. This recommendation is dependant on sufficient ambient 'daylight' being available in the pen from at least 8.00 am until sunset. If daylight is below the threshold level of 250-300 lux, supplement light during the day may also be required. The aim is to achieve a minimum of 16 hours of daylight above the intensity threshold each day.

The daylight is best presented as a block of 16 hours, although natural light and artificial light can be added together to achieve this

5. What happens if you give more than 16 hours of daylight?

In a study at Invermay we exposed red deer stag calves to 20L:4D (Figure 4) All deer responded but neither the pattern nor size of the response varied with the extra light over and above the 16 hours.

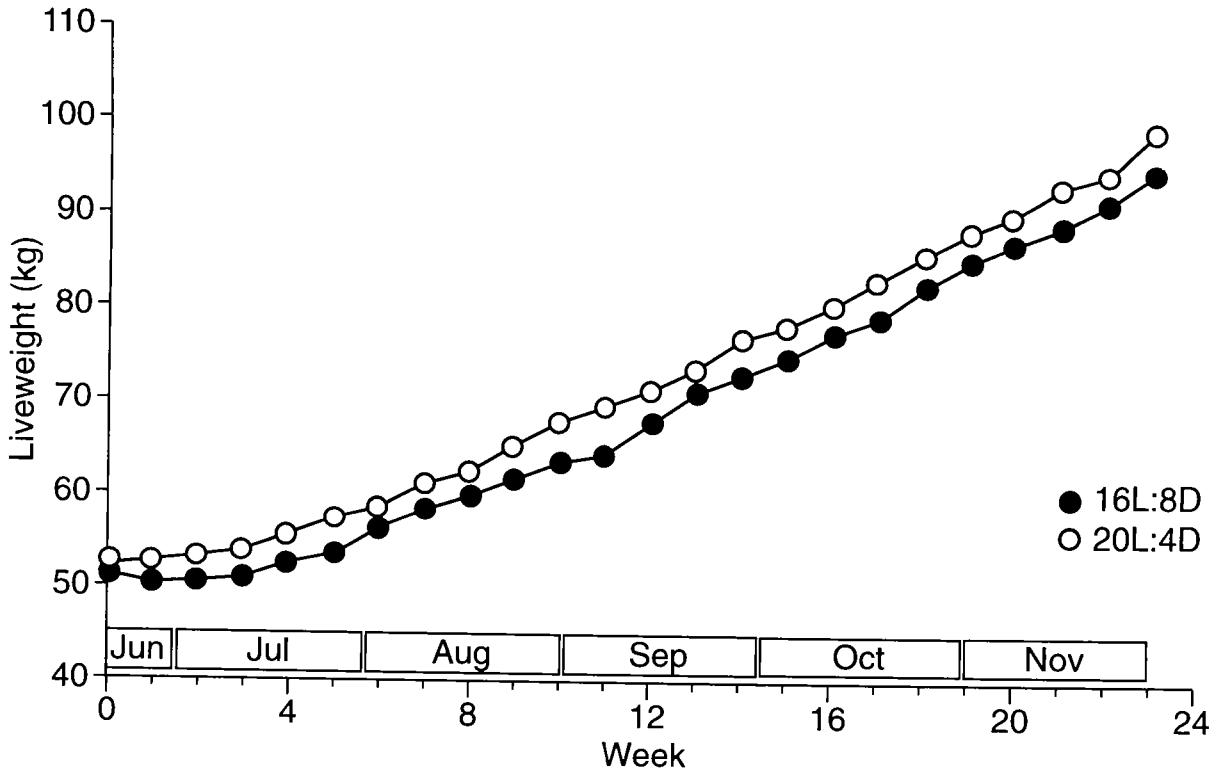

Figure 4 Mean liveweight (kg) of groups of red deer stag calves exposed to either 20L:4D or 16L:8D from mid Jhne (n = 8/group).

The extra light would be more costly and would not be economically worthwhile. It must be stated firmly that leaving the light on permanently i.e. for 24 hours each day would not be successful.

6. What happens when I want to stop the daylength treatment and put the deer outside?

From above it is clear that it takes six weeks exposure to 16L:8D in order to see an effect on growth. If deer are exposed to 16L·8D for shorter than this period it is highly unlikely that any positive effects would be apparent. In a study at Invermay we exposed deer to 16L:8D for six weeks from mid April then placed them back on natural daylength. Consequently daylength was still decreasing at the time when the 16L:8D treatment ceased (Figure 5). After the initial six week period the deer showed a growth increase despite the cessation in the stimulatory 16L:8D However this increase was not sustained. After about six weeks re-exposure to natural daylength the stags began to grow at a rate similar to the Control animals. Thus short term (six week) exposure to 16L·8D resulted in a short term increase, but no growth penalty. The stags were however kept indoors during this study. It is not possible to say that stags would have performed in the same way if they had been turned outside after the initial exposure to 16L.8D. We consider it likely, however, that if food availability were sufficient then growth enhancement would take place at least for a period of six weeks. The advantages of daylength treatment will not be lost at turn out time whenever it takes place, if food availability is sufficient We recommend that deer be turned out to good clean pasture in spring Access to shelter should be available during a hardening off process.

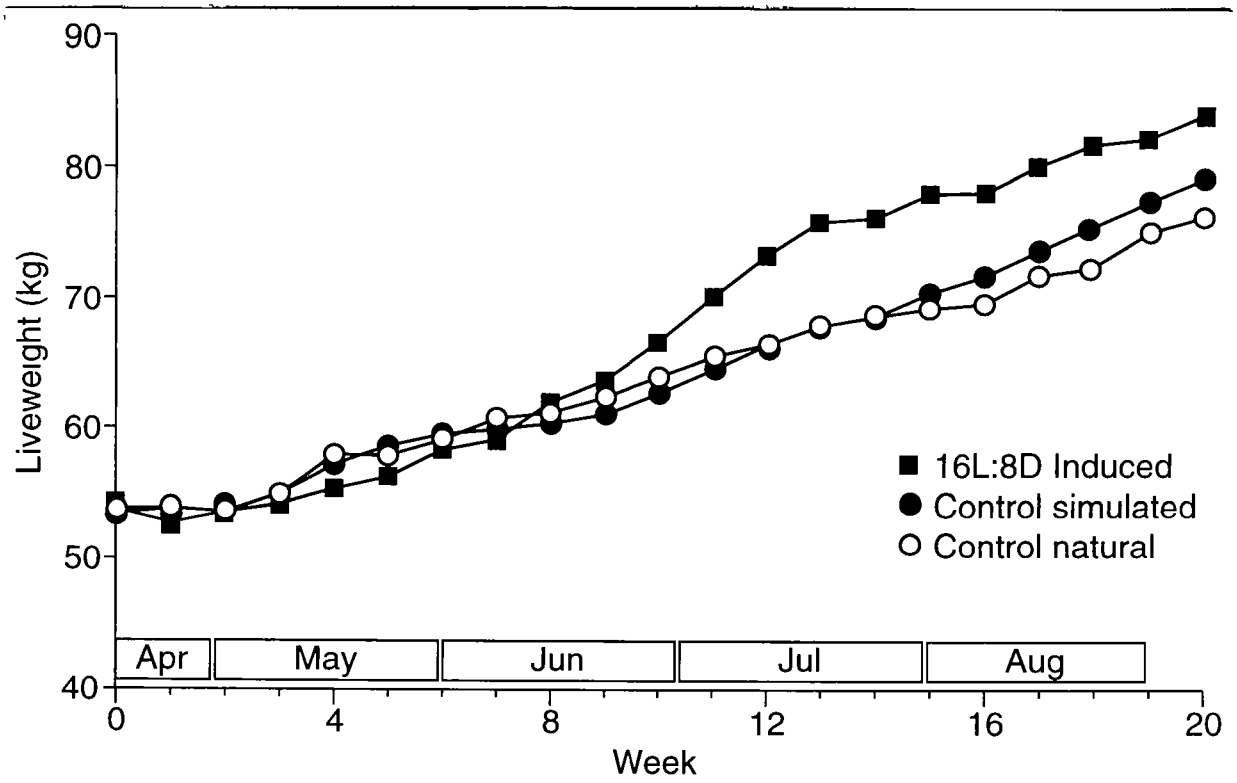

Figure 5 Mean liveweight (kg) of gropus of eight red deer stag calves exposed to either one of two control daylengths or 16l 8D for six weeks only in April and May.

It is vital to ensure that the deer receive the full 16 hours of light each day every day when growth enhancement is desired. It is not sufficient to rely on manual switching of the lights or expect deer to perform if the daylength is only increased to 16 hours inconsistently. The use of an automatic clock and a consistent approach is emphasised.

7. How do I feed deer indoors on 16L.8D?

Food intake increases when deer begin to grow rapidly after exposure to 16L:8D. In addition efficiency of utilisation of feed also increases In order to test the extent to which restricted nutrition prevented the expression of rapid growth, stag calves were exposed to 16L:8D for a period of six weeks and their *ad libitum* food intake was measured (Figure 6) After six weeks one group was allowed to continue to eat *ad libitum* but a second group had their food restricted to the same amount that they had eaten during the initial six weeks.

The well fed group grew optimally and initially the restricted group did as well but after 4-6 weeks of food restriction their growth ceased. This illustrates well the necessity to provide consistently high quantities of high quality food to realise daylength induced growth potential.

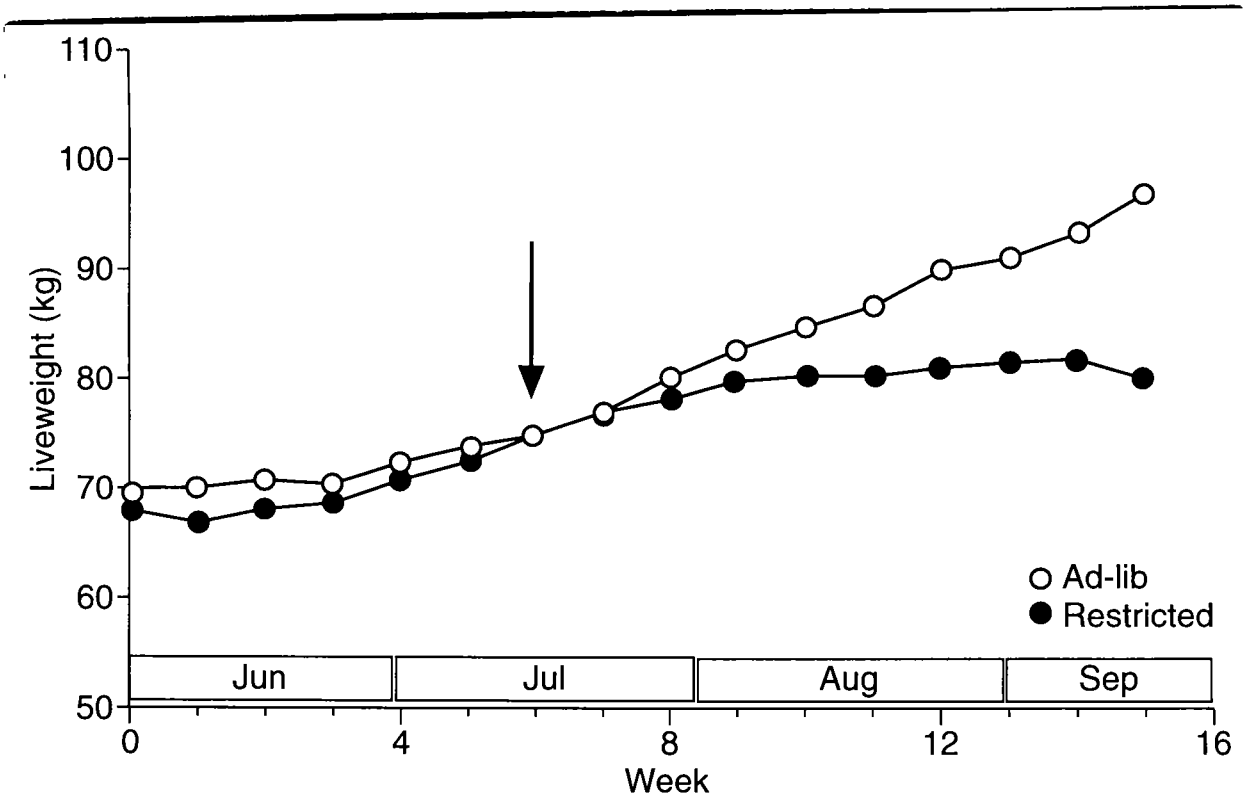

Figure 6 Mean liveweight of groups of eight red deer stag calves exposed to 16L:8D and either fed *ad libitum* throughout or *ad libitum* for the first six weeks, than restricted to this level for the remainder of the study. The arrow indicates when food restriction began

8. Do deer have to stop growing in autumn?

As frequently mentioned in this review deer naturally cease growing in autumn. This natural cessation takes place in late May We consider that deer need about six weeks to respond to a daylength change by altering a physiological parameter, in this case, growth. This means that they probably perceive a daylength stimulus in late March which is around the time of the autumnal equinox. What happens if deer are exposed to 16L.8D before this time? We have studied deer which have been exposed to 16L:8D from the summer solstice onwards, that is, they have never experienced a short or decreasing day (Figure 7). These deer not only failed to show winter inappetance, they also failed to show a rapid natural resumption of growth in spring compared with control animals on natural daylength throughout. The net effect was that all animals were about the same size in early summer. It would appear that there is no advantage by preventing deer from undergoing winter inappetance. Advantage accrues by ensuring an early resumption of growth.

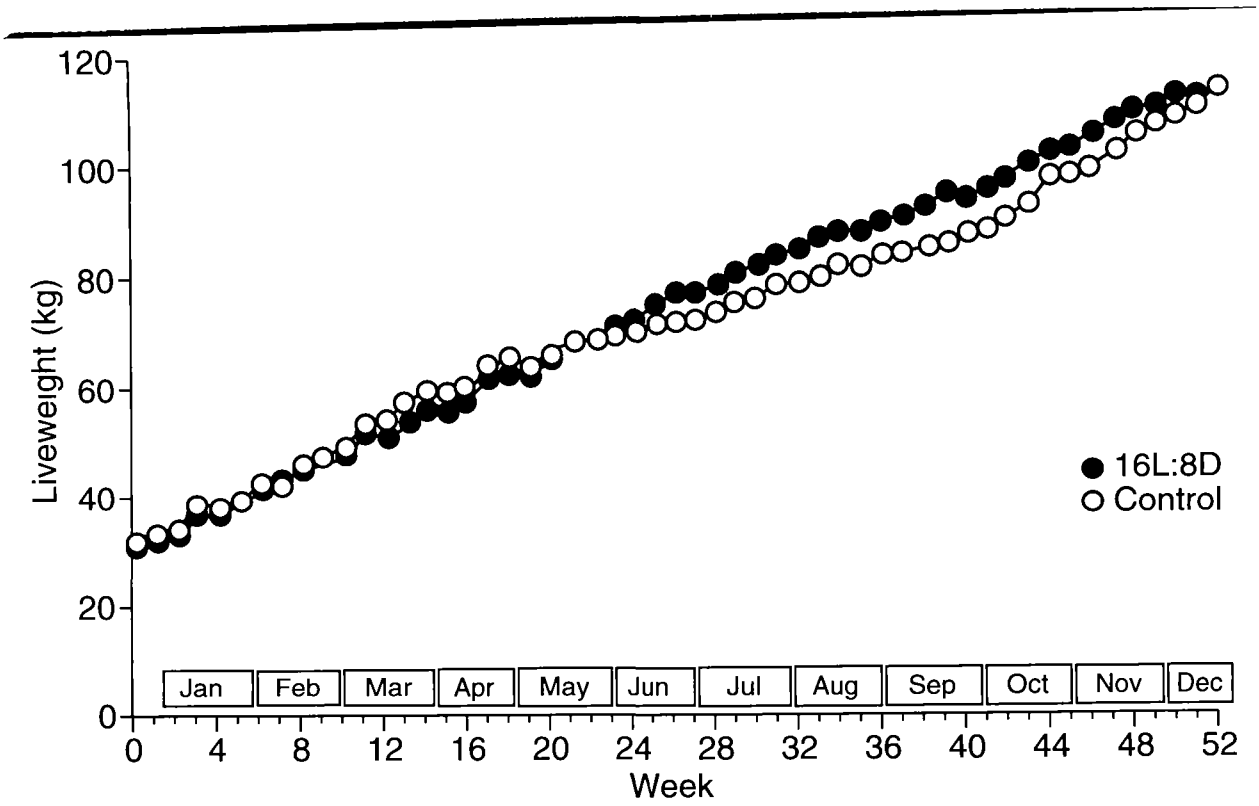

Figure 7 Mean liveweight (kg) of groups of four red deer stag calves maintained on 16L:8D from the first summer solstice of life or on a simulated natural control daylength.

Supplementary Studies

At Invermay we have studied red deer stag calves only. We have no information of our own on red deer females or other species of deer of either sex. This gap in our knowledge can be supplemented by published studies from elsewhere. Vigh-Larsen (1993) exposed groups of fallow bucks to a daylength of 16L.8D during winter in an enclosed shed or to natural daylength. Growth rate was 163 g/day and 130 g/day respectively. Suttie *et al* (1991) kept two groups of male reindeer calves on 16L:8D or 8L:16D during winter. The calves on 16L·8D grew faster than those on 8L 16D. From comments raised by veterinarians and farmers it is clear that hinds respond to 16L:8D by increasing growth rate. In conclusion the practice of using 16L:8D during winter to enhance growth appears to be widely successful in both sexes and across a wide range of species. The responses of tropical species of deer to daylength manipulation are unknown. Intuitively they would be expected to be less or even non responsive.

Prospects for future work at Invermay include use of strategically placed lighting pulses during the dark period to enhance growth and the use of supplemental lighting to increase growth rate in spring after the natural daylength cue has been received by the deer. Daylength treatments might also be integrated into systems which use pasture better by night-time housing.

Economic Consideration

The success of this treatment to induce and maintain rapid growth in young deer depends on some considerations other than biological. Costs of lighting and housing may be high but can partly be offset by superior food utilisation. These high costs can also be recovered if the schedule price for venison is high during spring as a premium is paid for 'out-of-season' meat.

Market access is also an issue. We sell venison against a background of a `clean, green image'; is it ethical to indoor house when the complaint of factory farming could be levelled? In defence of indoor wintering the Europeans are exponents of the technique as indeed indoor wintering is part of their sheep, beef and dairy farming. It can fairly be argued that indoor housing improves welfare thus the ethical question, while not being forgotten must be viewed in perspective.

Conclusion

16L:8D daylength during winter is a variable technique to improve winter growth rate in deer. It requires attention to detail to be successful, but has great potential in the hands of a competent producer

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