Photoperiodic Control of Appetite, Growth, Antlers, and Endocrine Status of Red Deer

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J. M. Suttie* and A. M. Simpson

Physiology Department, Rowett Research Institute, Bucksburn, Aberdeen AB9 2SB, Scotland

Abstract

The responses of seasonal cycles of red deer (*Cervus elaphus*) to fluctuations in day length were investigated in 2 experiments.

Four stag calves were subjected for 18 months to an artificial light regime with changes in day length following a 6-month cycle. Cycles of antler casting, growth and cleaning, appetite, body growth, testis size, and testosterone concentration were shown to follow 6-month rhythms in response to photoperiod.

Two yearling hinds subjected to a regime similar to the stags' showed pronounced cycles of food intake and weight gain in response to photoperiodic rhythms, although of lower amplitude than those of the stags. Peaks of the clear 6-monthly rhythms of prolactin did not coincide with peaks of growth and food intake. Hinds' food intake and weight peaks occurred relatively later in the photoperiodic cycle than those of stags.

Keywords: Cervus elaphus, *photoperiod, growth, appetite, antlers, prolactin*

Introduction

Circannual cycles of growth, food intake, and reproduction are shown by all boreal and arctic cervids studied including white-tailed deer (*Odocoileus virginianus*, French *et al* 1956), mule deer (*O. hemionus*, Wood *et al* 1962), red deer (*Cervus elaphus*, Kay 1979; Suttie 1980), and reindeer (*Rangifer tarandus*, McEwan and Wood 1966; McEwan 1968). Goss (1969) demonstrated that by changing the frequency of day length cycles up to 3 sets of antlers (effectively an index of male reproductive status) could be grown by adult sika bucks *(C. nippon)* in 1 calendar year. Supplemented artificial light partly reduced winter loss of appetite in white-tailed bucks (French *et al* 1960). These studies would predict that deer, like sheep (reviewed by Sadleir 1969), respond to fluctations in day length to control seasonal cycles. The present study examines this hypothesis as applied to male red deer and also investigates the influence of photoperiod on growth and food intake in red deer hinds.

Materials and Methods

Experiment 1

Four stag calves born in June 1972 were penned individually from August 1972 until February 1974 in a room with an artificial light cycle of normal amplitude for Aberdeen at 57°N, but the frequency was doubled to provide 2 complete cycles per year. Light intensity was 400 – 470 lux at 1 m from the floor. The deer were offered a high-concentrate ration (84% barley, 13% fish meal, and 3% minerals and vitamins) to appetite. Food intake and antler status were recorded daily, and at 3-weekly intervals each animal was weighed, the testes and antlers were measured, and a blood sample was taken. Plasma testosterone was measured by radioimmunoassay (A. H. Klopper *pers. comm.*).

Experiment 2

Two red deer hinds born in June 1977 were penned individually from March 1978 until March 1980 in the same room on the same light cycle as calves in Experiment 1, and they were offered the same diet to appetite. Food intake was recorded daily, and at 3-weekly intervals each animal was weighed and a blood sample taken for measurement of plasma prolactin (Chesworth 1977). In February 1980, 1 of the hinds died of malignant catarrhal fever.

Results

Experiment 1

During the 1.5-year study there were 3 cycles of photoperiod with 3 corresponding cycles of food

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* Present address: *Invermay Agricultural Research Centre, Private Bag, Mosgiel, New Zealand*

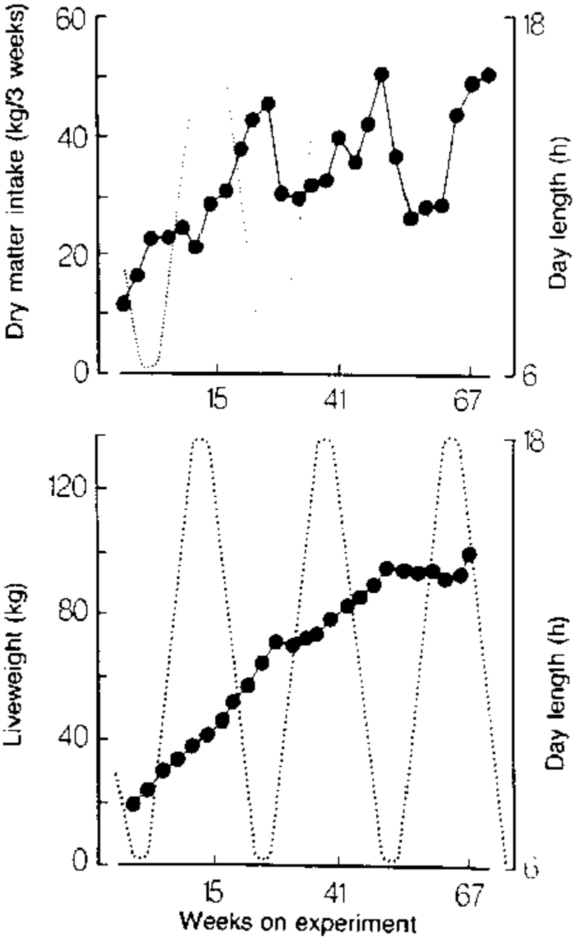

Fig. 1: Mean dry matter intake and liveweight for 4 red deer stags (•, mean ± s.e.m.; . . . . day length in hours).

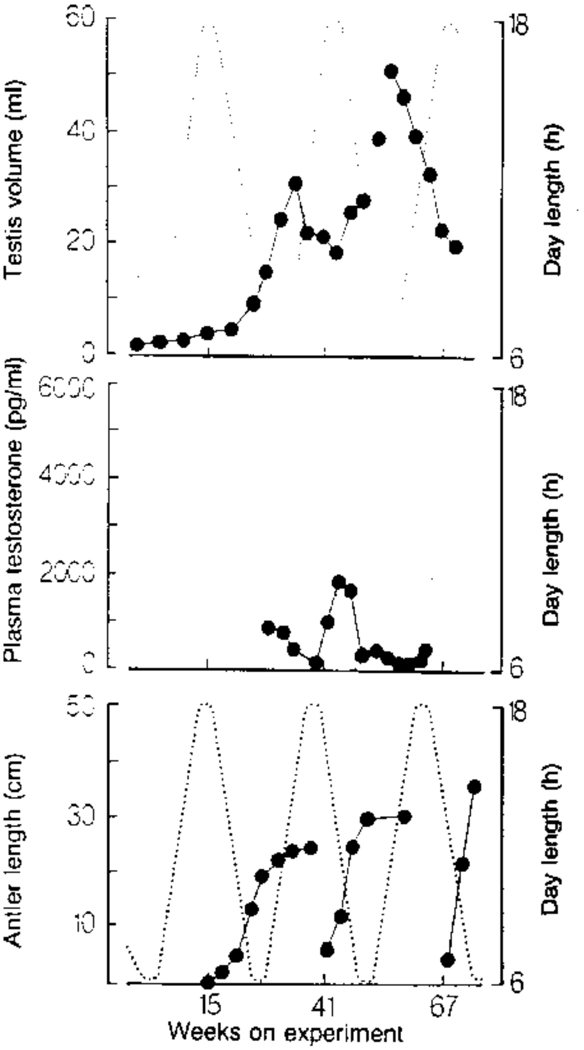

Fig. 2: Mean values for testis volume, plasma testosterone, and antler length for the 4 stags.

intake (Fig. 1). Peak food intake occurred when day length was almost at its shortest and the trough of intake when day length was just beginning to increase. The depressions in food intake led to zero weight gain or weight loss at these times (Fig. 1). Otherwise the stags grew rapidly during periods of high food intake. Periodicity of body growth reflected periodicity of day length.

Pedicle development began in December 1972 and antler development in March 1973 (Fig. 2). This first set of antlers were clean of velvet by May and were cast in June. Thereafter periodicity of antler growth mirrored periodicity of day length. Maximal antler growth occurred at the same time as high levels of food intake and body growth. Casting coincided with peak day length.

Antler weight, length, number of points, and rate of growth in general increased with successive cycles (Table 1). For comparison, the third set of antlers grown by a stag fed an identical diet but kept on natural photoperiod had 10 points which were 70 cm long and grew at 2.57 cm/week.

Both testes volume and plasma testosterone level reflected photoperiodic fluctuations (Fig. 2). Peak values for testes volume occurred at about the time of the apparent winter solstice, following the peak of appetite.

Table 1: Antler parameters for 4 stags on 6-month photoperiod (mean ± s.e.m.)

	Cycle 1	Cycle 2	Cycle 3
Antler weight (g)	70 ± 10.5	NM	492 ± 97.9[a]
Length (cm)	22.5 ± 1.03	30.8 ± 4.39	41.8 ± 2.13[ac]
No. of points	1.0 ± 0.00	2.6 ± 0.11[a]	3.3 ± 0.13[ab]
Rate of growth (cm/week)	1.8 ± 0.10	3.0 ± 0.29[a]	3.8 ± 0.14[ab]

NM not measured; a, different from cycle 1, $P<0.01$; b, different from cycle 2, $P<0.01$; c, different from cycle 2, $P<0.05$

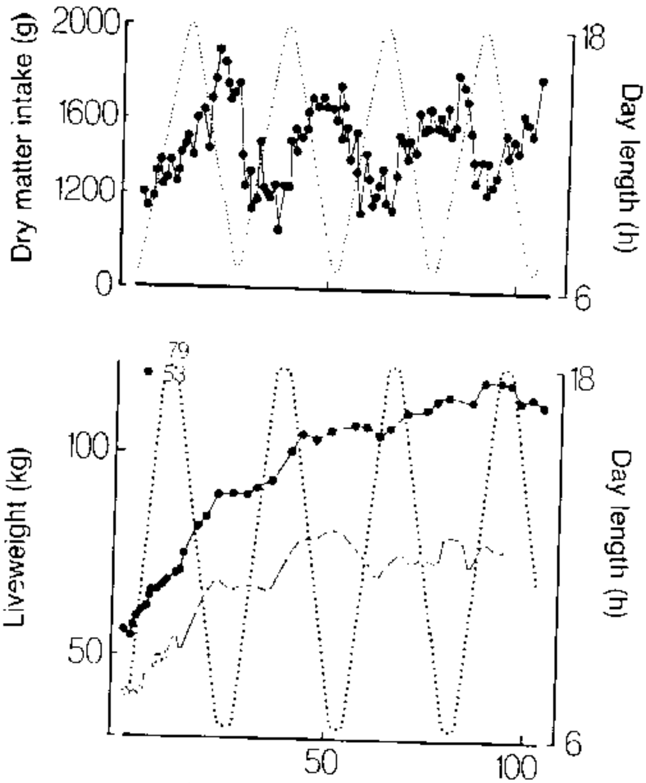

Fig. 3: Mean food intake for 2 red deer hinds and liveweight for each hind.

Experiment 2

The periodicity of food intake of the hinds (Fig. 3) followed the artificial day length cycle. Peak food intake occurred after the artificial summer solstice and trough food intake after the artificial winter solstice. In addition, liveweight paralleled intake (Fig. 3), with periods of rapid growth being followed by periods of weight maintenance or weight loss. After the third cycle both hinds reached their probable genetic potential weight, and cycles of weight gain and loss in response to photoperiod became less apparent.

Both hinds showed clear 6-monthly rhythms of plasma prolactin levels (Fig. 4). Peak plasma concentration tended to occur near peak day length, and was not coincident with peak intake.

Discussion

Increasing the frequency of day length cycles influenced body weight, food intake, gonadal activity, and antlers in young male red deer. The order in which these events occurred relative to the photoperiod was as reported for deer on normal photoperiod (Kay 1979; Suttie 1980), although with the increased frequency of cycles the events tended not to coincide with the day length at which they would have been expected to occur, but rather lagged behind. For example, peak food intake occurred when day length was almost at its shortest, whereas in stags on natural photoperiod, peak food intake occurred at or near the longest day (Suttie 1981). We consider that this lag of some 2 – 3 months was due to an endogenous rhythm which the altered photoperiod could not completely entrain to the doubled frequency, at least over the period of the experiment.

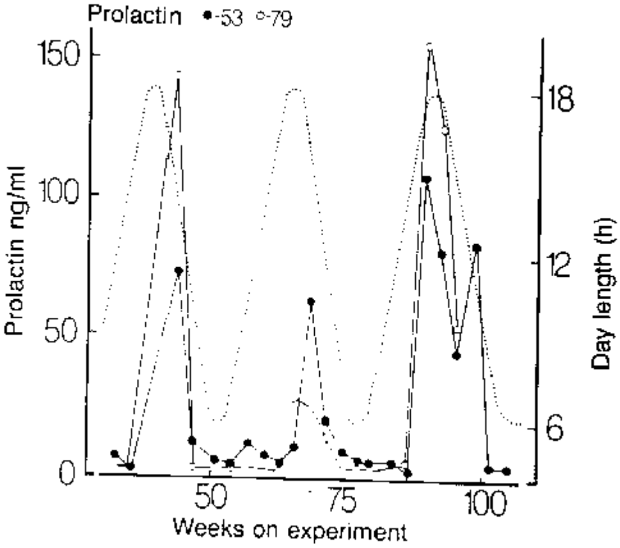

Fig. 4: Plasma prolactin concentrations for each hind through the 1.5 years.

Broadly speaking, antlers increased in size as the study progressed but were smaller than the antlers grown by stags on natural photoperiod. This agrees with Goss (1969) who found that increased day length cycle frequency resulted in smaller antlers. The antlers frequently had rounded tips which we consider to have been due to premature high levels of testosterone causing ossification before the cartilage matrix was complete.

The hinds showed cycles of reduced amplitude compared with the stags. Thus they conformed to the pattern shown by male and female black-tailed deer (*O. h. columbianus*, Bandy *et al* 1970), where adult non-pregnant females showed less marked seasonal cycles of growth and intake in comparison with bucks. The phases of the food intake cycles in the 2 sexes were not coincident. Peak food intake of the stags occurred 7.0 ± 0.82 (mean ± s.e.) weeks after peak day length, whereas it was 10.3 ± 0.96 weeks after for the hinds (unpaired 2-tailed t-test $t = 2.62$, $P < 0.05$). Therefore not only were the hinds cycles of lower amplitude, but they occurred later relative to the day length cycle than those of the stags. This discrepancy merits further discussion.

Red deer hinds at pasture or on the hill reach peak annual weight in November some 2 months after the stags reach their peak annual weight (Blaxter *et al* 1974; Mitchell *et al* 1976) and by inference their food intake must remain high until that time. This means that hinds continue to have a high voluntary intake during the rut and for a few weeks after. Thus they may increase their chances of conceiving by increasing their weight (Hamilton and Blaxter 1980), compensate for any loss of condition due to lactation (which would be declining around that time), and accumulate reserves of fat to maximise their survival potential during the ensuing winter and spring (periods of low food quality and quantity). In November the food intake is reduced in response to the endogenous cycles entrained by the photoperiod.

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