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489

INFLUENCE OF NUTRITION ON GROWTH AND SEXUAL MATURATION OF CAPTIVE RED DEER STAGS

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ABSTRACT

Scottish red deer *Cervus elaphus scoticus* are smaller in size and mature later than many continental subspecies. Previous investigations at the Rowett Research Institute have shown that when Scottish red deer are penned indoors and fed well they grow almost as large as European deer: the differences betwenn subspecies appear principally environmentally determined. To test this one group of 6 stag calves was maintained on *ad libitum* feeding regime, while a second group was offered 70% as much (on a metabolic body weight basis) during the winter but *ad libitum* during the summer. After the first winter the restricted group were 27 kg lighter and skeletally smaller than the *ad libitum* group. Despite remarkable catch-up growth in summer some difference was still apparent at the end of the growing season in September. This pattern was repeated during the second year. Good nutrition caused precocious sexual maturation. Many of the unrestricted group rutted in spring and autumn both as calves and as yearlings. Undernutrition is considered to be responsible for undersized Scottish deer.

1. INTRODUCTION

Scottish red deer stags are smaller in size and mature later than many continental subspecies of *Cervus elaphus*. Fig. 1 shows a range of carcass weights from Europe: Scots deer are among the smallest (Huxley 1931, Mystkowska 1966). Previous investigations by Blaxter et al. (1974) and Simpson (1976) have shown that if Scots red deer are penned indoors and fed well they grow almost as large as European deer. Fig. 2 shows the growth curve of a stag fed to appetite indoors compared with the mean of a group of stags of similar genetic stock from the Glensaugh Experimental Deer Farm, (Blaxter et al. 1974), who had access only to hill vegetation. The difference between the two is striking: the captive stag resembles a European stag in size. Skeletal growth in terms of hind foot length is illustrated in Fig. 3, where a well fed stag is compared with a group of hill fed stags. Clearly the well fed stag matured earlier and at a larger size than the hill fed stags.

Differences in size between subspecies appear to be principally environmentally determined. One theory which has been put forward to explain this is that poor nutrition during the long winter particularly in the first years of life restricts the animal to a small frame which prevents attainment of its true genetic potential size.

This study set out to test this theory and also to investigate the effects of nutrition on cycles of growth and reproduction which have been described for red deer, Lincoln (1971), Blaxter et al. (1974), Pollock (1975), Brown et al. 1979), caribou and reindeer (*Rangifer tarandus* L.), Meschaks and Nordkvist (1962), McEwan and Wood (1966), McEwan (1968), McEwan and Whitehead (1970), Whitehead and McEwan (1973) and many other species of deer.

2. MATERIALS AND METHODS

In June 1977, 12 stag calves were collected from a Scots estate within three days of birth, and brought to the Rowett Institute. The animals were penned individually although they could hear, see and smell each other. Lighting was via a window and no manipulations of photoperiod or temperature were made. They were weaned at nine weeks of age onto a pelleted barley diet. After ten weeks on 16 August 1977 the calves were allocated into two groups of six such that mean body weight was the same for each. One group was fed to appetite while the second was restricted to 70% of the first groups intake on a body weight$^{0.75}$ basis. Between 22 May 1978 and 19 November 1978 the restricted group was fed to appetite in order to investigate the extent of any com-

REGION	$\bar{X}$ CARCASS WEIGHT (KG)
Scotland	94
England	137
Hanover	133
Hesse	151
Hungary	207
Bukovina	235
Poland	138
Russia	180
Norway (Hitra)	95
Norway (continent)	145

Fig. 1. Body size of European Red Deer Stags.

pensatory growth. From 20 November 1978 until 14 May 1979 this group was returned to the same restricted feeding regime as in the previous winter. Since May 1979 they have been fed to appetite to investigate to what extent compensatory growth is possible in the second summer of life. The first group represents a population of deer in an environment where food supply is never limiting, the second represents a population in a Scottish environment where food is limiting for six months of the year.

At weekly or three weekly intervals each animal was weighed, the hind foot length measured and blood sample taken by jugular venopuncture. The blood samples were kept on ice until centrifuged and the plasma was stored at –20°C until assayed for testosterone, Corker and Davidson (1978) and prolactin, Chesworth (1977). Food refusals were weighed daily, so that food intake could be measured.

3. RESULTS

The mean changes in weight of both groups are given in Fig. 4. The unrestricted group grew well from weaning,

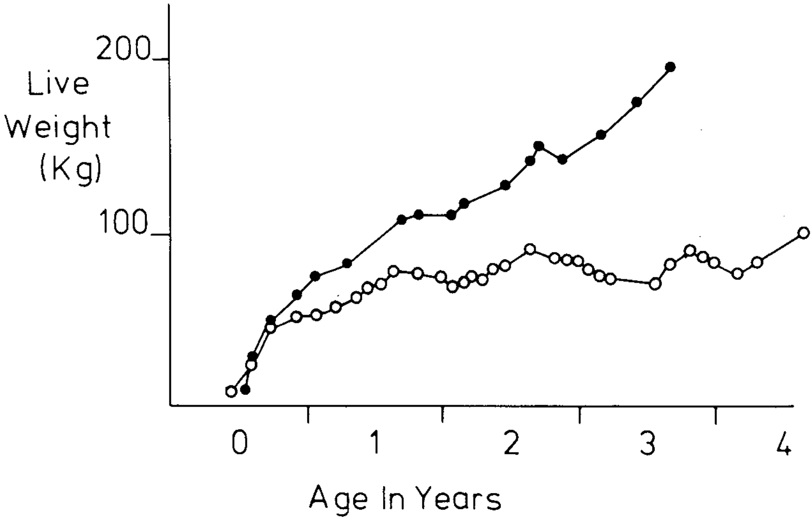

Fig. 2. Live Weight (kg) v Age in Years.

Pen fed stag ●–●

Deer farm stags ○–○

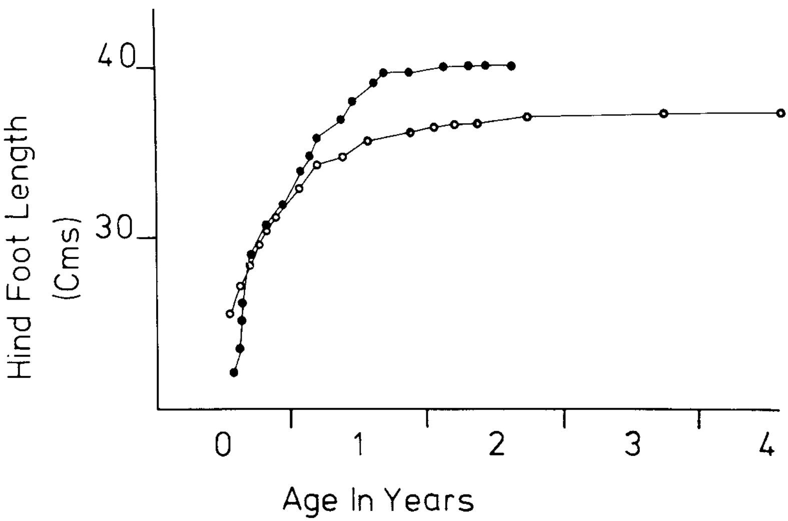

Fig. 3. Hind Foot Length (cm) v Age in Years

Pen fed stag ●–●

Deer farm stag ○–○

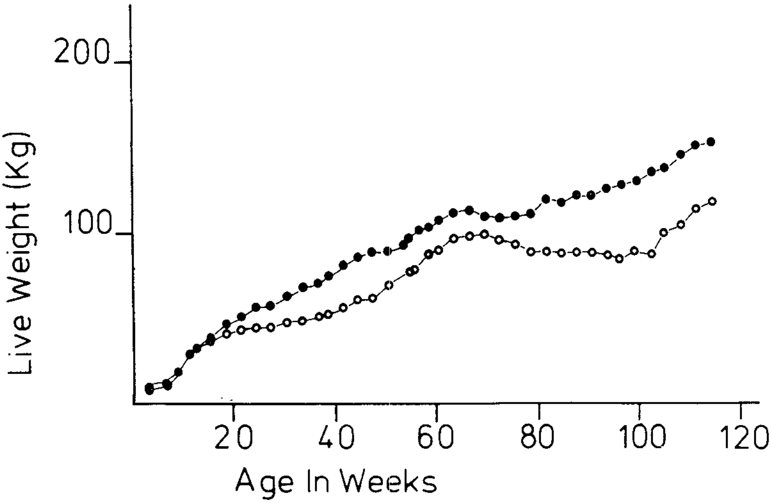

Fig. 4. Live Weight (kg) v Age in Weeks

Unrestricted group ●—●

Winter restricted group ○—○

showing only a slight weight loss during the rut at weeks 66–69 and a decrease in growth rate for 8 weeks following it. The winter restricted group grew slowly during the first period of restriction, then showed remarkable compensatory growth during the period of realimentation. At week 66, the difference in mean live weight between the groups was significant ($P < 0.01$). There was a marked weight loss during the rut in both groups and also during the subsequent period of winter restriction. Compensatory growth was evident again in the second summer of realimentation. Fig. 5 shows the skeletal growth curve of both groups. The unrestricted group grew at an approximately linear rate from birth until an asymptote was reached at around weeks 70–75. The winter restricted group grew more slowly but showed acceleration of growth between weeks 47 and 75 when they too reached an asymptote. However despite some compensatory growth, the means of hind foot length were significantly different ($P<0.02$) at this time.

The voluntary food intake of the unrestricted group expressed as mean weekly dry matter in grams per day is given in Fig. 6. Voluntary food intake increased from weaning until it reached a plateau at around 1300 g/day during the first winter. It rose to 1900 g/day in spring before falling to 1400 g/day in May and June. In July and August it was again high (2200 g/day) before it dropped to 1100 g/day during the rut. This pattern was repeated during the second year. Fig. 6 also includes the mean food intake of the winter restricted group expressed in the same units. Their ability to compensate for the enforced restriction by increasing their food intake to above that of the controls during the unrestricted summer is very marked, however they also reduce their food intake voluntarily during the rut.

The testosterone and prolactin curves of a representative stag from the unrestricted group are shown in Fig. 7. The two hormones showed reciprocal cycles. There are four peaks of each hormone indicating thar this animal has rutted four times during the study. Fig. 8 illustrates the testosterone and prolactine curves of a representative stag from the winter restricted group. Reciprocal cycles are evident except that this stag only rutted twice during the study.

Figs 9 and 10 show mean testosterone and prolactin curves for unrestricted and winter restricted groups respectively, with food intake in kg dry matter superimposed. Peaks of food intake are preceded by peaks of prolactin, with approximately a ten week lag, troughs of food intake coincided with peaks of testosterone. Prolactin increased in the restricted group before they were given the opportunity to feed to appetite.

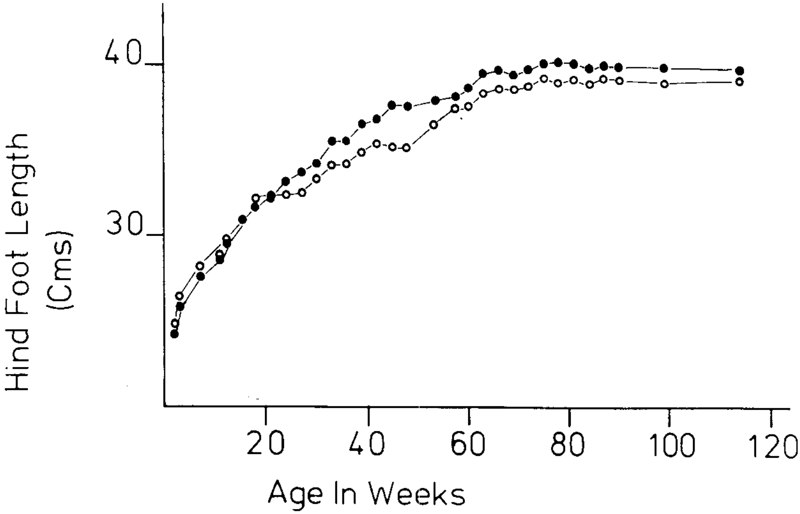

Fig. 5. Hind Foot Length (cm) v Age in Weeks

Unrestricted group ●–●

Winter restricted group ○–○

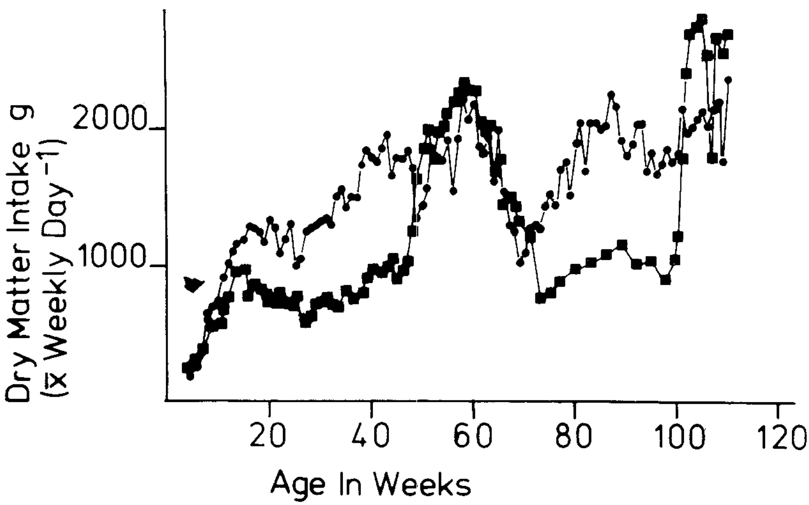

Fig. 6. Dry Matter Intake g (x̄ weekly day^{-1}) v Age in Weeks

Unrestricted group ●–●

Winter restricted group ■–■

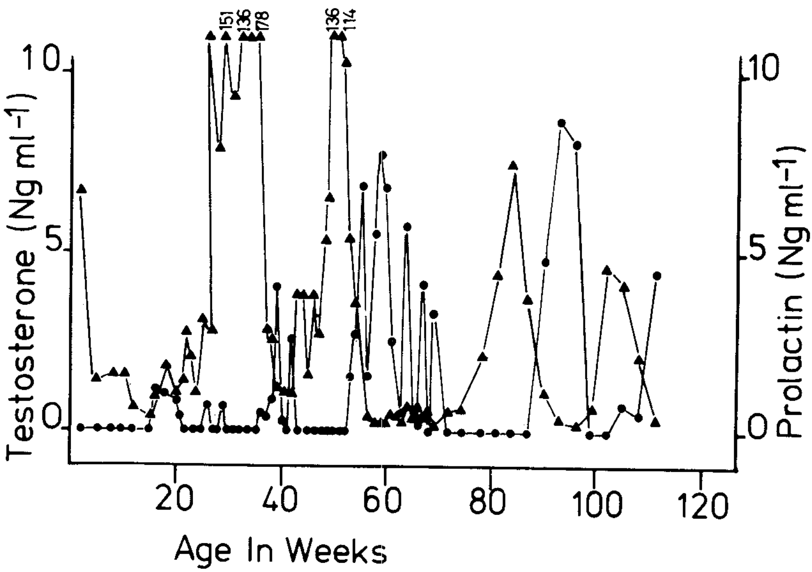

Fig. 7. Testosterone (ng ml^{-1}) (● — ●) and Prolactin (ng ml^{-1}) (▲ — ▲)

Levels of a representative unrestricted stag v Age in Weeks

4. DISCUSSION

The live weight growth curves closely resemble those already described for barren ground caribou *(Rangifer tarandus)* by McEwan (1968), white tailed deer *(Odocoileus virginianus)* by McEwan et al. (1957) and black tailed deer *(Odocoileus hemionus)* by Wood et al. (1962) and Bandy et al. (1970).

Increased appetite after a period of undernutrition is consistent with studies on cattle and sheep reviewed by Allden (1970). However no long term study has been carried out on the effects of seasonal food restriction. The failure of the compensatory mechanisms to permit the restricted group to completely catch up over either their first or second summer indicates that poor winter nutrition may be responsible for the failure of Scottish red deer to reach their genetic potential size. This is further illustrated by the failure of the restricted deer to catch up skeletally – they have a smaller frame to build on, during periods of better nutrition.

The effects of nutrition on sexual maturation are shown by the earlier development of reproductive function by the unrestricted group. The exact relevance of the spring period of sexual activity is hard to understand but it has been noted previously in red deer by Gillett (1904) and Petzsch (1959) and in reindeer by Whitehead and McEwan (1973). It used to be a common occurence in Pere David deer *(Elaphurus davidianus)* (Bedford 1951).

The relationship between high levels of testosterone and low levels of food intake has been described by Simpson (1976). Forbes et al. (1975) described the relationship among daylength, level of feeding and prolactin in sheep, this relation is confirmed here for red deer. Prolactin is considered to mediate the effect of daylength on growth rate. However in this study the restricted group showed an increase in prolactin before they were fed to appetite. If prolactin secreted in response to increasing daylength affects appetite to increased daylength then deer on the restricted plane of nutrition will be metabolically stressed until allowed to feed to appetite. This period of stress lasts approximately six weeks between late March until mid May when metabolism is active yet food to satisfy the appetite is not available. This period coincides closely with periods of high natural mortality of red deer in Scotland (Low 1969, Mitchell et al. 1973).

In conclusion it may be said that poor and prolonged winter nutrition prevents stags from reaching their

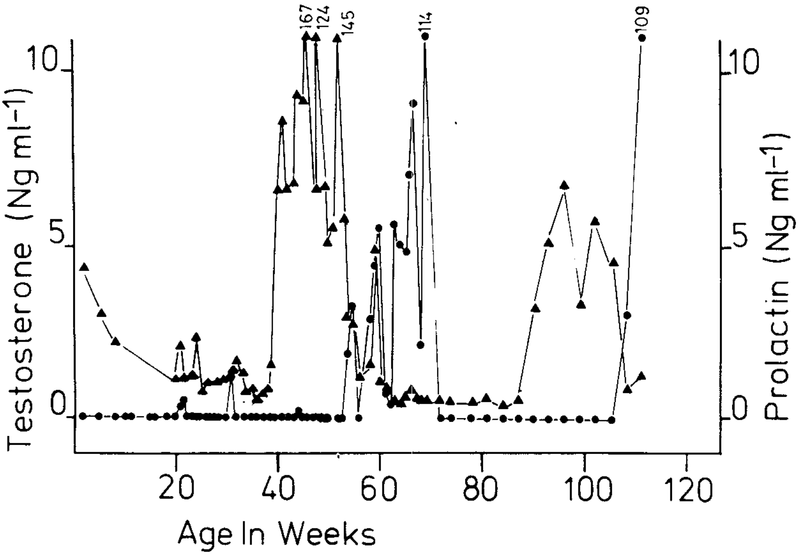

Fig. 8. Testosterone (ng ml^{-1}) (● — ●) and Prolactin (ng ml^{-1}) (▲ — ▲) of a representative winter restricted stag v Age in Weeks.

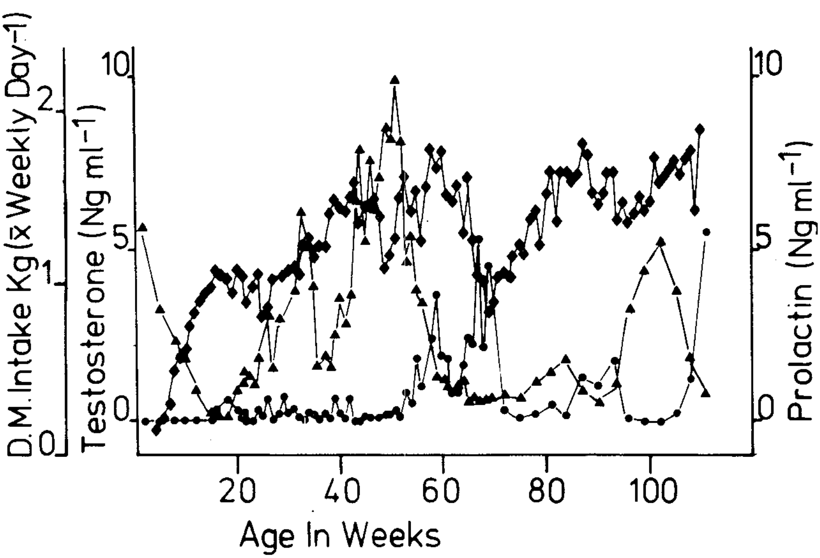

Fig. 9. Mean Testosterone (ng ml^{-1}) (● — ●). Mean Prolactin (ng ml^{-1}) (▲ — ▲) and Mean Dry Matter Intake kg ($\bar{x}$ weekly day^{-1}) (◆ — ◆) of unrestricted group v Age in Weeks.

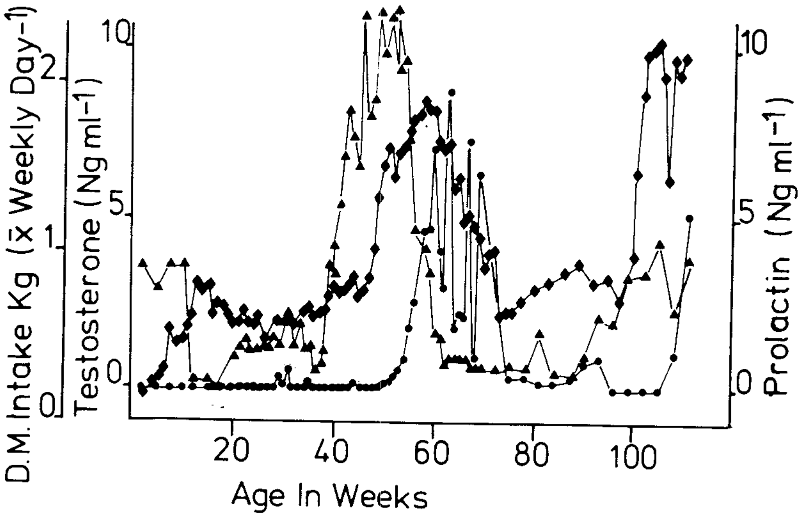

Fig. 10. Mean Testosterone (ng ml^{-1}) (● — ●). Mean Prolactin (ng ml^{-1}) (▲ — ▲) and Mean Dry Matter Intake kg ($\bar{x}$ weekly day^{-1}) (◆ — ◆) of winter restricted group v Age in Weeks.

genetic potential size, slows sexual and skeletal maturation and may enhance metabolic stress which can lead to high mortality within a natural population.

Acknowledgements

I wish to thank Mr E.D. Goodall and Mr S.J. Miller who assited with sampling and handling of animals and Mr G. Henderson who performed the prolactin assays. Dr. R.N.B. Kay read an earlier draft of this paper.

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