CIRCANNUAL RHYTHMS OF GROWTH, METABOLISM AND FOOD INTAKE AND THEIR ENDOCRINE CONTROL IN RED DEER STAGS

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Introduction

Boreal and temperate deer show marked seasonal rhythms of growth such that rapid increases of body weight occur in the spring and summer yet does not occur during the autumn and winter when weight is lost, (1,2). Controlled studies indoors, where food has been available to appetite throughout the year, reveal that this growth rhythm is not due to feed insufficiency. Rather the deer have a rhythm of food intake and consume more during the summer than the autumn and the winter, (2,3). The extent to which the growth rhythm is truly endogenously circannual, entrained by the environment, and the extent to which it is driven by the environment, is not yet known. However it is known that photoperiodic manipulations are capable of altering the growth and food intake rhythms, (4,5). The increasing daylength of spring tends to stimulate food intake and growth, while the short daylength of autumn reduces food intake. It is known that the pineal hormone, melatonin, mediates the effects of changing daylength on rhythms of reproduction, (6). This presentation describes the effects of melatonin on growth rhythms and develops testable hypotheses about the hormonal control of seasonal growth.

Materials and Methods

Experiment 1. Melatonin implant effects on the seasonal growth rhythm: Adult red deer stags (n=6 per group) were allocated to either exogenous melatonin treatment during the summer from November to February or were unmanipulated as controls. They were kept on pasture and weighed monthly.

Experiment 2. Effect of melatonin implants during the spring on the seasonal growth rhythm: Adult red deer stags (n=6 per group) were allocated to melatonin treatment beginning either on the winter solstice (June 22), August 4, September 16, October 23 or were unimplanted as controls.They were kept on pasture and were weighed monthly. Melatonin treatment continued for a period of 6 months.

Experiment 3. Seasonal rhythms in Insulin-like growth factor 1 (IGF 1) secretion: IGF 1 is believed to mediate many of the growth promoting effects of growth hormone on growth. Plasma levels of IGF 1 were measured for 1 year in young red deer stags kept indoors and fed a concentrate diet to appetite.

Results

Experiment 1. The seasonal peak of bodyweight in the control stags occurred in February, but the melatonin treated stags reached their peak body weight one month earlier in January. The seasonal weight loss in the autumn occurred two months earlier in the melatonin treated stags than the control stags.

Experiment 2. The stags treated with melatonin beginning in June and August were delayed in reaching their peak weight compared with controls, but the stags treated with melatonin in September and October were advanced compared with controls in reaching their peak bodyweight.

Experiment 3. Plasma levels of IGF 1 showed a seasonal rhythm in the deer with peak concentrations in the summer when growth was most rapid and food intake was highest. IGF 1 concentrations were reduced in autumn and winter.

Discussion

In Experiment 1 the fact that melatonin treatment advanced not only seasonal weight gain but also weight loss indicates that melatonin is neither "stimulatory" nor "inhibitory" for growth, but instead is involved in the mechanism whereby daylength influences the growth rhythm. In Experiment 2 melatonin treatment beginning during late winter delayed the seasonal growth spurt. It is considered that melatonin treatment during this time prevented the stags from perceiving a photoperiodic cue which stimulates the growth spurt. Stags which received this presumably "long-day" cue were capable of having their growth rhythms advanced by melatonin. The fact that melatonin treatment did not prevent the seasonal growth spurt is evidence that this is due to an endogenous rhythm, which is capable of being entrained by the photoperiod. The assumption made is that the pharmacological administration of melatonin prevents the stags from perceiving photoperiodic cues, but whether the stag perceives the implant as an ultra short day or perceives nothing is unknown.

In view of the fact that IGF 1 is a natural growth promoting hormone, it is tempting to speculate that it is responsible for the growth with which it is so closely related in time. Were this the case then there must be a link between photoperiod, melatonin and IGF 1. It is hypothesised that this link must be in the brain, probably mediated by hypothalamic and pituitary hormones. Whether the drive to grow, a metabolic drive, stimulates the seasonal increase in food intake or whether the seasonal increase in food intake stimulates the growth rhythm is currently under study.

References

1. Bandy,P.J., Cowan,I.McT. & Wood,A.K.(1970) Can.J.Zool. 48, 1404-1410.
2. McEwan,E.H & Wood A.K.(1966) Can.J.Zool. 44, 401-411.
3. Suttie,J.M., Goodall,E.D., Pennie,K. & Kay,R,N,B.(1983) Br.J.Nutr. 50, 737-747
4. Suttie,J.M. & Simpson,A.M.(1985) in Biology Of Deer Production P.F.Fennessy and K.R.Drew eds Royal Society of New Zealand Bulletin#22 429-432.
5. Suttie,J.M., Fennessy,P.F. and Corson I.D.(1984) Procs.N.Z.Soc.Anim.Prod. 44, 167-170.
6. Karsch,F.J., Bittman,E.L., Foster,D.L., Goodman,R.L., Legan,S.J. & Robinson, J.E.(1984) Rec.Prog.Horm.Res. 40, 185-232.