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Does nutritional status during the latter stage of pregnancy mediate the effect of conception date on gestation length in red deer hinds? I. Voluntary food intake of hinds during gestation

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ABSTRACT

Efficient farmed venison production under New Zealand lowland conditions requires early calving to better align lactation with pasture availability. However, hinds that conceive early in the breeding season have a longer gestation length than those conceiving later, negating some of the gains achieved by early conception. This variation in gestation length may relate to seasonal imbalances in hind nutrient uptake influencing foetal growth. However, little is known about food intake cycles of pregnant hinds and whether they exhibit the photoperiod-induced voluntary food intake (VFI) reduction over winter seen in younger age classes and adult stags. This study investigated the effect of pregnancy status on VFI of red deer hinds. In addition, concentration of leptin and ghrelin circulating in the body was measured throughout the study to ascertain if these hormones are indicative of hind energy status. Seven pregnant (P) and seven non-pregnant (NP) hinds were housed indoors in individual pens from April to November where they were offered daily an *ad libitum* pelleted ration. On average, P hinds gained 75 g/day and NP hinds lost 27 g/day ($P=0.02$) in autumn. Mean live weight (LW) of both groups then steadily increased for the remainder of the study with no significant difference between groups. Mean body condition score (BCS) change of P and NP hinds was similar in autumn and winter, but whereas that of P hinds decreased in spring, that of NP hinds increased ($P=0.02$). Pregnancy status of the hinds had no significant effect on mean VFI throughout the trial except for the last 5 days before parturition when VFI of P hinds decreased dramatically ($P=0.001$). VFI of both groups of hinds was significantly higher in autumn ($P=0.03$) and spring ($P=0.01$) than in winter and for every 0.1 MJME/kg $LW^{0.75}$/day increase in mean VFI during the study period, gestation length decreased by 6.4 days ($r^2=0.51$; $P=0.04$). Pregnancy status had no significant effect on plasma concentration of either leptin or ghrelin at any of the sampling times and there was no significant association of either leptin or ghrelin with VFI. However, leptin plasma concentration was positively associated with BCS ($r^2=0.41$; $P=0.008$). This study showed that VFI of pregnant hinds was depressed during winter and early spring, and was negatively associated with gestation length. A reduction in BCS of pregnant hinds indicated that they were in a moderate energy deficit during the final third of gestation.

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1. Introduction

To maximise the productivity of farmed venison supply systems food availability needs to match energy demands at all times. For the hind and its rapidly growing calf, energy demand is highest from late pregnancy through to weaning. Red deer (*Cervus elaphus*) evolved in temperate regions of Europe (Whitehead, 1972) where seasonal extremes in temperature and feed availability strongly influence animal survival. The prevailing conditions have dictated a highly seasonal pattern of autumn conception and early summer calving for survival of the species (Lincoln and Guinness, 1973). Calves born very early or late in the season are less likely to survive as neonates than those born at the peak of the calving period (Iason and Guinness, 1985). Furthermore, conception earlier or later than standard dates affects milk production and composition and therefore has important implications for calf growth (Landete-Castillejos et al., 2000). Thus, the reproductive cycle of red deer has evolved to match perfectly food availability in the temperate regions of Europe. However, under New Zealand lowland farming systems, pasture quality and feed availability are often low during summer and autumn (Litherland et al., 2002), limiting the genetic potential for calf growth. Early summer calving has resulted in a misalignment between peak pasture quality in spring and the nutritional demands of a lactating hind and her offspring during summer and autumn (Asher et al., 1996).

Although significant research effort has been expended to advance the calving date of red deer hinds (Asher et al., 1996), such efforts appear to be partly offset by robust and complex adaptations of reproductive processes in deer that have evolved to ensure offspring are born at the optimal time for survival. Only a few generations of red deer have been exposed to the New Zealand farming environment, so there has been insufficient time for selection pressure to have modified their inherent seasonality. Heritability of conception date has recently been estimated as 0.2 ± 0.06 from 2500 mating records (Archer et al., in press) and breeding values for conception date are now included in the New Zealand Deer Industry genetic evaluation database (DeerSelect). This will enable farmers to make significant advances in conception date through selective breeding. Insufficient data has been collected to make heritability estimates for gestation length.

Recent research has shown that hinds conceiving early in the breeding season have a longer gestation length than those conceiving late, and conversely, those conceiving late in the breeding season have a shorter gestation length (García et al., 2006; Scott et al., 2008a). For every 10 days change in conception date there will likely be 2–4 days change in gestation length. Scott et al. (2008a) hypothesised that a photoperiod-induced reduction in hind food intake during winter may impact on the ability of early-conceiving hinds to meet the increasing energy demands of the rapidly growing foetus during the last third of pregnancy. Thus, the ensuing moderate energy intake imbalance between seasons mediates the observed variation in gestation length. This hypothesis was based on the observations of Asher et al. (2005a) who reported that a moderate energy intake imbalance during the last third of pregnancy in red deer was compensated for by varying gestation length to ensure optimal birth weight at the time of parturition.

Seasonal animals are assumed to maintain an appropriate body mass which varies depending on circumstances such as age, reproductive status or season (Kay, 1988). A model of how intake of ruminants is regulated to maintain an appropriate body mass was first proposed by Montgomery and Baumgardt (1965). They proposed that ruminants are able to regulate dry matter intake over a range of feed digestibilities so that their energy intake remains equal to their need. Such a model has since been validated in three cervid species: white-tailed deer (*Odocoileus virginianus*; Ammann et al., 1973), reindeer (*Rangifer tarandus tarandus*; Ryg, 1983) and red deer (*Cervus elaphus*; Scott et al., 2008b; Webster et al., 2000). As an adaptation to living in temperate zones with predictable seasonal cycles of food abundance in summer and scarcity in winter, many animals exhibit seasonal variations in voluntary food intake (VFI), body mass and energy metabolism that do not reflect actual changes in food availability, but are a function of physiological changes in response to predictors of the seasonal environment (Loudon, 1994). A photoperiod-mediated reduction in VFI during 'short days' has been well documented for young growing red deer of both sexes and for adult stags and non-pregnant hinds (Loudon et al., 1989; Pollock, 1975; Suttie and Simpson, 1985), but there appears to be an absence of such data for pregnant red deer hinds.

Pregnancy is a dynamic state and to ensure reproductive success the energy demands of the developing foetus must be met at all stages of gestation. Nicol and Brookes (2007) calculated the total energy requirement for the entire pregnancy of a red deer hind to be 55 MJME/kg birth weight above maintenance. During the last third of pregnancy the foetal and maternal components of pregnancy gain about 70% of their final mass in red deer (Adam et al., 1988a), and it was estimated that the additional energy requirements of pregnant above non-pregnant hinds increases from 1.7 to 5.0 MJME/day during that time (Adam et al., 1988b). This raises the question of whether pregnant red deer hinds have reduced VFI during late-winter and spring, at the time when energy demands of a rapidly growing foetus are increasing.

The advantages of a mechanism whereby VFI matches that of food supply in animals living in highly seasonal environments are well recognised. Such an adaptation is thought to have evolved so that less energy is expended on foraging for food during times of scarcity (Kay and Staines, 1981), but precisely how food intake is regulated has yet to be fully elucidated. However, it is known that two peptide hormones, leptin and ghrelin, play a major role in maintaining metabolic homoeostasis in mammals. Synthesis and secretion of ghrelin are regulated by nutritional state; blood levels rise in anticipation of food, promoting hunger, and then decrease after meals. Plasma factors indicative of nutritional status that are released at the time of food intake, such as glucose, amino acids and insulin, stimulate leptin secretion and promote satiety (Gao and Horvarth, 2007). Feeding is thus partly modulated by the antagonistic effects of leptin and ghrelin.

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