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Reproductive responses to sexually active buck of does treated with melatonin when body weight/body condition is increasing or decreasing

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ABSTRACT

When the sexual activity of bucks is minimal, there is a minimal male effect on does regardless of their body weight (BW)/body condition (BC) and whether does are treated with melatonin or not. The study examines whether sexually active bucks can induce an adequate male effect in does with an increasing or decreasing trajectory of change in BW/BC when does are or not treated with melatonin. During natural anoestrus, 46 Blanca Andaluza does were assigned to two groups: 1) low BW/low BC group in which does were fed 1.9 times maintenance requirements for dietary energy for gaining BW/BC (LLg group; $n = 23$); or 2) a high BW/high BC group in which the does were fed 0.4 times maintenance requirements for dietary energy that resulted in a loss of BW/BC (HHl group; $n = 23$). There were similar numbers of does in each group that were treated or not treated with melatonin (MEL). Following 48 days of isolation from bucks, four sexually active individuals fitted with marking harnesses were transferred to the paddock containing the does of each group. Blood samples were collected by jugular venipuncture (before the distribution of concentrate) twice per week. The effect of the treatments (increasing or decreasing BW/BC and melatonin) on the different variables that were assessed were analysed using an ANOVA or the Fisher-Freeman-Halton exact probability test as necessary. During the 35 days after treatments were applied, the percentage of females expressing oestrous and having an ovulation were greater in the LLg + MEL than HHl-MEL subgroup ($P < 0.05$). The interaction of nutrition × melatonin treatment had a significant effect on reproduction of does ($P < 0.05$). This could be explained by the greater plasma glucose and IGF-1 and lesser plasma non-esterified fatty acid concentrations in does with increasing BW/BC ($P < 0.01$), and the greater IGF-1 concentrations of MEL-treated females ($P < 0.01$). The LH concentration and pulsatile release of this hormone from the pituitary were also modified by the presence of the males ($P < 0.01$). Furthermore, the LLg + MEL-treated does were responsive to the presence of bucks ($P < 0.05$). The present results indicate sexually active males cannot induce an adequate reproductive response in females with decreasing BW/BC even when does are being treated with melatonin. The presence of bucks enhanced the doe reproductive response when does were treated with melatonin and a pattern of increasing BW/BC.

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1. Introduction

Reproductive seasonality is common in goat breeds of temperate latitudes with photoperiod being the main environmental cue (Shelton, 1978; Ortavant et al., 1985; Chemineau et al., 1992a; Zarazaga et al., 2011a,b,c). Other environmental stimuli, such as social interactions and food availability, represent potential modulators of physiology in small ruminants (Walkden-Brown et al., 1993; Mani et al., 1996; Piccione et al., 2009).

The introduction of a buck to anovulatory females previously separated from bucks can induce oestrous activity within a few days and this is termed the "male effect". The practice of placing bucks in the presence of does helps optimize the sexual response of does during the anoestrous period, leading to a greater synchronization of oestrous onset (Delgadillo et al., 2009), and is widely used in extensive and semi-extensive goat production systems in Mediterranean countries. The intensity of the male effect depends greatly on factors such as breed, type of previous female isolation, stage of anoestrus, postpartum stage, parity number, nutrition and body condition (Walkden-Brown et al., 1993; Cerbito et al., 1995; Urrutia et al., 2003; Veliz et al., 2009; Delgadillo et al., 2009; Gallego-Calvo et al., 2015b), and the sexual behaviour of the males (Flores et al., 2000).

With Spanish conditions, female and male goats had less sexual activity and less productivity during the long days of February to September (Zarazaga et al., 2005, 2009; Gallego-Calvo et al., 2014, 2015a). Goats are recognised as "short-day" breeders because a) the period of sexual activity in goats occurs during autumn-winter, and b) transition to short days (8 h light per day) and long days (16 h light per day) is followed by the stimulation and inhibition of reproductive activity, respectively (Zarazaga et al., 2011a,b,c). The hormone melatonin is a chemical messenger synthesized by the pineal gland during darkness. It functions as a physiological messenger of the alternation between light and dark periods. Its circadian periodicity is believed to serve as an endogenous synchronizer of circadian rhythms and as a coordinating signal for other physiological patterns (Giannetto et al., 2016). The administration of slow-release melatonin implants during the spring advances the onset of the breeding season by mimicking the stimulatory effect of short days (Chemineau et al., 1992b; Williams et al., 1992). Such implantation in males at around the spring equinox results in stimulation of the increased reproductive activity in the spring (Zarazaga et al., 2010). For females, it is usually accompanied by separation from bucks for 45 days, before transferring bucks back into the paddock with does to induce the "male effect".

Under extensive or semi-extensive systems, food availability in spring, when the "male effect" is used for reproductive management, can vary widely, and animals may have increases or reductions in body weight (BW) and body condition (BC) that can modify the reproductive response to the "male effect" (Gallego-Calvo et al., 2015b). Variations in food availability may, for example, affect the intake of feed sources that when digested and nutrient absorption occurs can be metabolically converted to glucose (involved in energy homeostasis) and non-esterified fatty acids (NEFAs − indicative of the adipose reserve or energy balance) and consequently modulate insulin-like growth factor-1 (IGF-1 − which provides a related metabolic signal) concentrations. The interaction between nutrition and exogenous melatonin may also affect luteinizing hormone (LH) secretion (Zarazaga et al., 2011b). Moreover, access to food during specific times of day has profound effects on the behaviour and physiology of animals (Piccione et al., 2010).

This is the third in a series of studies performed to address the experimental topic that is focused on in the present study. The first study (Gallego-Calvo et al., 2015b) examined the reproductive response and performance of does with an increasing or decreasing trajectory of BW/BC change in the presence of sexually active bucks (treated with melatonin), and it was reported that those with decreasing BW/BC had a lesser reproductive responsiveness. In the second study (Zarazaga et al., 2017), exogenous melatonin implants were used in an attempt to improve the reproductive performances of does with increasing/decreasing BW/BC while using bucks expressing typical sexual activity in the spring of the year. With these conditions, reproductive responses were minimal, and administration of melatonin implants did not result in an improvement of the reproductive performance of does having a decreasing trajectory of BW/BC. To complete this series, this third study examines whether sexually active bucks (made so *via* melatonin implantation) can induce an adequate "male effect" in does with a decreasing trajectory of BW/BC, change when these does are or not treated with melatonin. Metabolic/nutritional factors that might explain the observed responses were also considered.

2. Material and methods

2.1. Study conditions

All procedures were performed by trained personnel in strict accordance with Spanish guidelines for the protection of experimental animals (RD 53/2013), and in agreement with European Union Directive 86/609. The study was conducted at the University of Huelva experimental farm (latitude 37° 20′N and longitude 6° 54′ W), which meets the requirements of the European Community Commission for Scientific Procedure Establishments (2010/63).

2.2. Animals and management

This study was of a 2 × 2 factorial design, *i.e.*, two nutritional amounts, and exogenous melatonin was or was not administered to does in which the other two treatments were imposed. On 25 March, 46, 4 year-old (adult), non-pregnant does in anoestrus were divided into two groups depending on their BW and BC (nutrition): 1) low BW (36.0 ± 1.3 kg)/low BC (2.42 ± 0.03), defined as the LLg ('g' for 'gain') group (n = 23) because these animals were fed 1.9 times the maintenance requirements; and 2) high BW (40.5 ± 1.6 kg)/high BC (2.83 ± 0.04), (HH-l group; 'l' for 'loss') (n = 23) because these animals were fed 0.4 times the maintenance requirements. The dietary treatment regimens that were imposed on does were consistent with INRA standards (Morand-Fehr

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