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Effect of photoperiod and heat stress in the third trimester of gestation on milk production and circulating hormones in dairy goats

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ABSTRACT

The influence of photoperiod manipulation in the dry period was examined in dairy goats experiencing environmental heat stress. Multiparous Israeli Saanen goats were blocked at dry off (~60 d prepartum) into 2 groups of 4 goats each based on body weight, previous milk production, and detected embryo number. Treatments consisted of long-day (16 h light:8 h dark) and short-day (8 h light:16 h dark) photoperiods (LDPP and SDPP, respectively). Heat-stress conditions were applied by manipulating the environment of metabolic rooms to reach a maximum temperature of 37°C between 1000 and 2200 h, and a minimum of 23°C and 70.3% relative humidity. All goats were returned to ambient photoperiod after kidding, milked twice daily, and milk yield was automatically recorded. Dry matter intake during the dry period was similar between treatments, averaging 1,114 g/d. Milk production was significantly higher in the SDPP than the LDPP group (2,172 vs. 1,550 g/d) during the 12-wk experimental period. Milk protein and fat contents were similar in both groups and averaged 3.63 and 4.34%, respectively, whereas milk lactose was higher in the LDPP group (4.77 vs. 4.67%). Heart rates were similar between treatments and averaged 112.6 beats per minute (BPM). Respiration rates were lower in the morning (58.4 BPM) compared with the afternoon (91.2 BPM) and were not influenced by photoperiod. Rectal temperature was higher for the LDPP than the SDPP group (40.4 vs. 39.6°C). The thyroid hormone level (mean ± SE) was similar in both groups during the dry period, but higher during lactation in the LDPP goats up to 40 d postpartum (110 ± 6.59 vs. 156 ± 8.76 ng/mL). Plasma IGF-1 (mean ± SE) was higher in the LDPP group (279 ± 62 vs. 162 ± 27 ng/mL in SDPP) during the dry period but was similar postkidding, averaging 132 ± 24 ng/mL. Plasma prolactin level (mean ± SE) was higher in the LDPP than the SDPP group during the dry period (17.2 ± 1.6 vs. 10.6 ± 0.99 ng/mL), whereas it was similar throughout lactation (0.61 ± 0.28 ng/mL). These data support the idea that SDPP manipulation during heat load in dry goats can be used as an abatement strategy to reduce the carryover effect of heat stress observed during the subsequent lactation. The higher milk production in SDPP goats is explained by changes in circulating prolactin profile rather than differences in feed intake or secretion of insulin-like growth factor 1.
Key words: dairy goat, heat stress, photoperiod, prolactin

INTRODUCTION

Dairy goat farming is on the rise in Israel and the Mediterranean region. Caprine milk production is gaining importance worldwide due to its health benefits for individuals suffering from allergies and intolerance to cow milk (Haenlein, 2004). In contrast to dairy cows, goats have seasonal reproductive cycles, but little information is available on the effects of environmental stressors such as heat and photoperiod on milk production and quality.

Dairy animals in Israel are exposed to heat stress for 3 to 4 mo a year. In recent years, most dairy goat management has turned to intensive regimens in which at least 2 breeding cycles are used: in one of these, the goats are bred in the early summer and suffer from heat stress during the third trimester of gestation under relatively long-day photoperiod (**LDPP**). We recently showed that dairy goats exposed to short-day photoperiod (**SDPP;** 8 h light:16 h dark) during the dry period produce more milk in the next lactation compared with LDPP goats (Mabjeesh et al., 2007). However, the effect of heat stress on goats during their third trimester in gestation has not been studied, in contrast to extensive studies of this phenomenon in dairy cows showing depressed milk yield, DMI, and reproductive performance (Beede and Collier, 1986; Wolfenson et al., 1988; do Amaral et al., 2009). Moreover, analy-

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ses of Israeli national records of Holstein cows have revealed that those exposed to heat stress in the summer months during the dry period (Barash et al., 2001) have the lowest annual milk yield. The prevailing view is that the reduction in milk yield under heat stress is a consequence of reduced appetite and DMI (Beede and Collier, 1986; Wolfenson et al., 1988; McGuire et al., 1989; West, 2003). However, this view has been challenged by evidence of a direct effect of heat stress itself on the process of milk secretion (Wayman et al., 1962; Bandaranayaka and Holmes, 1976): for example, force-feeding of hyperthermic cows to the level recorded in normothermic cows (Wayman et al., 1962) or restricting the intake of normothermic cows to the level recorded in hyperthermic cows (Bandaranayaka and Holmes, 1976) did not abolish the differences in milk yield between the two.

Both dairy cows and goats exposed to SDPP during the dry period produce more milk than their counterparts exposed to LDPP (16 h light:8 h dark) during the subsequent lactation (Dahl et al., 2000; Mabjeesh et al., 2007). The photoperiod effect observed in both dairy animals is mediated through the prolactin (**PRL**) signaling axis, in particular through the inverse relationship found between circulating PRL and its receptor (**PRL-R**) expression in multiple tissues, including the mammary gland (Auchtung et al., 2003, 2005; Dahl, 2008). Similar to LDDP during the dry period, heat stress increased the concentration of circulating PRL in dairy cows compared with cows under the same environmental conditions cooled by sprinklers and fans (Tao et al., 2011). Further, it was observed that cows experiencing heat stress during the dry period had increased circulating PRL and reduced mRNA gene expression of PRL-R in lymphocytes and hepatic tissue (do Amaral et al., 2009, 2010). Based on the data from Auchtung et al. (2003, 2005), mRNA gene expression of PRL-R in the mammary gland and lymphocyte tissues changes in the same direction; it can be concluded that heat stress has an effect similar to that of LDPP on mammary gland development and performance in subsequent lactations. Indeed, Tao et al. (2011) recently concluded that in dairy cows, experiencing heat stress during the dry period affects mammary gland development before parturition by showing a decrease in epithelial cell proliferation during the transition to lactation and, hence, decreased milk production.

Therefore, we hypothesized that dairy goats suffer from the same effects as dairy cows that are heat stressed during the dry period. We also hypothesized that the use of photoperiod manipulation would minimize the effect of heat stress during the dry period in dairy goats. To the best of our knowledge, no data are available regarding the influence of photoperiod and heat stress effects during the dry period in dairy goats. Photoperiod management is of great interest because it is a safe, noninvasive, and effective method of increasing milk production. The objectives of the current study were to evaluate the effects of heat stress under controlled photoperiod (LDPP vs. SDPP) during the dry period on subsequent milk production and plasma hormonal profiles in dairy goats.

MATERIALS AND METHODS

Goats and Treatments

All procedures were approved by the Hebrew University (Rehovot, Israel) Institutional Animal Care and Use Committee. Multiparous Israeli Saanen goats (n = 8) in mid to late lactation were synchronized and inseminated to ensure their pregnancy. These goats were blocked at dry-off (~60 d prepartum) into 2 treatments of 4 goats each based on BW, previous milk production, and the number of detected embryos in utero. Treatments were LDPP (16 h light:8 h dark) and SDPP (8 h light:16 h dark) at hyperthermic ambient temperature to induce heat stress (maximum of 37°C between 1000 and 2200 h, minimum of 23°C, and 70.3% relative humidity). All goats were maintained under ambient photoperiod until the onset of treatment. During the experimental period, goats were housed in separate metabolic rooms with fully controlled environmental conditions in metabolism cages equipped with automatic feeders. The photophase light intensity was 350 lx at goat eye level, with photoperiod adjusted according to treatment. Goats were fed a diet that adequately met their nutritional demands for maintenance and gestation stage. Feed was offered in 12 equal meals by automatic feeder. The diet consisted of commercial pellets containing 16% CP, 29.1% NDF, and 1.6 Mcal of NE_L on a DM basis (mixture 1471; Ambar Ltd., Hadera, Israel), and chopped clover and vetch hay with 14.9% CP, 47.5% NDF, and 1.1 Mcal of NE_L. The hay supplied 60% of the daily DMI. Rectal temperature and heart and respiration rates were measured twice daily at 0700 and 1500 h by the MP 100 System (BIOPAC Systems Inc., Santa Barbara, CA).

Dry matter intake was monitored while the goats were in the metabolism cages and was adjusted to allow 10% refusals. At kidding, all goats were returned to ambient photoperiodic conditions and a normal management regimen. Goats were milked twice daily at 0700 and 1900 h. Daily milk production was recorded by automatic milk meter for 12 wk in lactation (**WIL**; Free-flow; S.E.R., Netanya, Israel). Pellets were offered in the milking parlor ad libitum and hay was then offered in the yards to supply 35% of total daily DMI.