THE EFFECT OF HIGH ENVIRONMENTAL TEMPERATURE ON DOE PERFORMANCE DURING LACTATION

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ABSTRACT

The general objective of this research was to study the effect on doe performance during lactation of high ambient temperature exposure from early development stages. Specifically, the effect on following traits was analyzed: daily milk yield; milk composition [dry matter (DM), crude protein (CP) and gross energy (GE)]; average daily feed (ADFC) and water (ADWC) consumptions, and doe live weight (LW). The study was performed comparing the performance of two groups of contemporary does reared under the same management and feeding but different environmental temperature. At 60 days of age, 80 females (and 15 more for reposition) were randomly distributed in two identical and adjoining rooms. In one room, the temperature was permanently kept within the thermo-neutral zone (between 18° to 22°C), which was considered as comfort conditions (C). In the second room, the environmental temperature pattern attempted to simulate the characteristic daily temperature cycle of summer in Mediterranean countries (minimum 24°C and maximum 30°C for at least 2 hours), which was considered as heat conditions (H).

Despite both rooms differed in temperature being H room out of the boundaries of the thermo-neutral zone at any time of day, no significant differences were found for daily milk yield, milk composition and ADWC during the lactation period. However, the high environmental temperature led to a lower average daily feed consumption (-9.4%) and live weight (-6.2%) with respect to results obtained under C conditions. Based on these results, it could be concluded that both milk yield and composition seems not to be affected when animals are exposed to heat stress from early stages of development, despite there is a relevant decrease of doe feed consumption during lactation. High environmental temperature in this period seems not to affect average daily water consumption. Thus, reducing feed intake rather than increasing water intake could be the main animal's mechanism to overcome high environmental temperature, at least for the pattern of temperature applied in this study, which could only produce moderate stress in the doe.

Key words: Feed consumption, Heat stress, Milk Yield, Milk Composition, Water consumption

INTRODUCTION

Livability and growth performance of kits up to 18-19 days of age mainly depend on their mother's milk production and composition. Therefore, all the factors affecting doe performance during lactation will have a big influence on pre and post weaning growth and survival of kits, and consequently, on meat production and profit of commercial farms. Environmental temperature is one of the most important factors because rabbits are very sensitive to heat (Marai et al., 2002).

The negative effect of heat stress on rabbit milk production has been demonstrated in several studies (Maertens and De Groote, 1990; Fernández-Carmona et al., 1995 and 2003; Pascual et al., 1996). Most of these studies were performed under constant environmental temperature in climatic chambers (Rafai and Papp, 1984; Szendrö et al., 1998; Fernández-Carmona et al., 2003). However, common farm environmental conditions encompass seasonality as well as varying temperature between day and night, reaching minimal temperatures during the night and early in the morning, when rabbits feed (Prud'hon, 1975); under this situation, the impact of heat stress on doe performance could be alleviated. Only two studies have considered the effect of heat stress on milk production under farm conditions (Maertens and De Groote, 1990; Pascual et al., 1996) but in both cases the effect of environmental temperature was not estimated from data obtained from contemporary animals but from the same group of animals in different seasons or periods. In this case, the effect of other environmental factors, such as changes in management, light, diet, etc, can be confounded with the temperature effect. Moreover, in most of the experiments, animals changed from comfort to heat stress conditions just at the beginning of their reproductive period (Maertens and De Groote, 1990; Fernández-Carmona et al., 2003), or the effect of temperature was studied with data from commercial farms where animals born during the hot season usually begin to produce in the cold one, and the opposite (Pascual et al., 1996; Piles et al., 2012). Thus, the effect of heat on animals which were born and/or grew up also under high environmental temperature remains unknown.

The general objective of this research was to study the effect of daily temperature cycle characteristics of summer in Mediterranean countries on doe milk production and quality as well as on other related traits such as doe feed and water consumption during lactation, which might condition the former traits.

MATERIAL AND METHODS

Animals and experimental design

At 2 months of age, 80 rabbit females (and 15 more for reposition) were randomly distributed in two identical and adjoining rooms. In one room, temperature was kept permanently within the limits of the thermoneutral zone (between 18 to 22 ^{o}C; comfort conditions, **C**). In the second room, animals were continuously exposed to heat conditions (**H**) following a daily temperature cycle with a minimum of 24 ^{o}C and a maximum of 30 ^{o}C which was maintained for 2 hours. Animals were fed *ad libitum* with a commercial concentrate pelleted diet containing 15.5% CP, 18.7% CF, 3.8% EE and 8.5% ash. Water was always available and supplied through a graduate plastic bottle (2 L) connected to the drinker. The amount of evaporated water was also weakly measured in each room and used to correct the water consumption records. Females followed a semi intensive reproductive rhythm during all the experimental period: first AI at approximately 4.5 month of age, with subsequent 42-d reproductive cycles, and weaning at 32 days. Live weight of doe (**LW**), average daily feed consumption (**ADFC**) and water consumption (**ADWC**) were recorded weekly.

Daily milk yield (**DMY**) was recorded three times per week as the difference in body weight of doe before and after suckling This measure was taken after 24 hours of separation of the kits from their mother to avoid free suckling. At 10 days of lactation, a total of 41 milk samples were obtained from 36 multiparous does (third and later lactations). Milk samples (20 mL) were obtained after oxytocin injection (5 IU) by gently manual milking. After that, samples were weighed and stored at -80 ^{o} C until subsequent chemical analyses. Milk samples were lyophilized (Liodelta Telstar), and weighed after freeze-drying. After that, samples were analyzed for dry matter (**DM;** 3 h at 50ºC), crude protein (**CP**; N by Dumas method multiplied by 6.38) and gross energy (**GE**) with an adiabatic calorimeter (IKA C-2000 basic).

Statistical Analysis

Mixed models were fitted to the data. All the analyses were conducted using *lmer* function from *lme4* package of R. The model for ADFC and ADWC included the effects of environmental conditions (**EC**, 2 levels: C, H), parity order (**PO**, 3 levels: 1, 2 and ≥3), gestation-lactation overlapping (**GLO**, 2 levels: overlapping and not overlapping), number of sucking kits (**SK**, 8 levels), week of lactation (**WL**, 4 levels), and the random permanent effects of doe and lactation. The model for DMY included the effects of EC, PO, GLO, the interaction terms between those factors, a fixed quadratic polynomial regression on day of lactation, a fixed quadratic polynomial regression on SK, a random quadratic polynomial on day of lactation nested within doe (which encompasses the permanent effect associated to female which is common to all its lactations), a random quadratic polynomial on day of lactation resulting from the combination between doe and PO (which encompasses the permanent environmental effect of lactation, which is common to all records of the doe in each lactation) and the random residual. Additionally for DMY, a second model including the interaction between environmental conditions and the quadratic polynomial regression on day of lactation was also considered in order to assess whether there were differences in the shape of the lactation curve across environmental conditions. The model for each of the major components of milk (DM, CP and GE) included the effects of EC, PO and the interaction between them. The model for LW included the effects of EC, GLO, a linear regression on doe age in days (covariate) and a random linear regression on age nested within doe (which encompasses the permanent effect associated to female, common to all its records).

RESULTS AND DISCUSSION

The ADFC was about 36 g/day (9.4%) higher for does under C conditions than in those under H conditions. This result is in agreement with results from previous studies. Thus, the difference in ADFC observed here is close to the one obtained by Maertens and De Groote (1990), who reported that feed intake of does kept in farm conditions at high environmental temperature (27-31˚C in daytime and 21-25 ˚C during the night) was 11% lower than when they were reared at 14-19 ˚C, in a previous period of time. However, in other studies (Cervera et al., 1993; Fernández-Carmona et al., 1994 and 1997; Szendrö et al., 1998; Mousa-Balabel, 2004) feed intake of does in climatic chamber at constant temperature (30-33 ˚C) was 23 to 33% lower than in does housed under normal environmental temperature (18-20 ºC). Maertens and De Groote (1990) indicated that variation in daily temperature probably increased does' tolerance to heat, which resulted in higher milk yield and feed consumption than the expected values at constant temperature in climatic chambers. This is due to the fact that rabbits feed during the night and early in the morning (Prud'hon, 1975), time when, even in the warmest season, temperature is closer to the thermo-neutral zone. Thus, a reduction in heat during this period of the day would allow animals to recover their activity and feed properly, which leads to a reduction in the observed heat effect on this trait. The difference in ADWC under C and H was very small and not significant (-7.60 ± 60.0 mL/day). This surprising result seems not to be in agreement with other previous studies. Water consumption of does kept at high temperature (30-33 ˚C) was increased by 30-45% relative to that of does kept at 18-20˚C (Mousa-Balable, 2004). Also, in growing rabbits, Manzano and Torres (2005) found a 30% higher water consumption for rabbit housed under 30˚C with respect to those housed under 18˚C. On the contrary, Szendrö et al. (1998) found 16.5% lower water consumption during the lactation period for does kept at 30˚C than for does kept at 15 ˚C. Panting is a way for animal's heat loss by water respiratory vaporization when it is subjected to severe heat stress (Marai et al., 2002). These water losses need to be compensated by drinking more water, which would explain the results obtained by other authors (Mousa-Balable, 2004, Manzano and Torres, 2005). However, a previous study that analyzed animal behavior measurements by video-recording of does from our experiment found no differences between C and H pregnant does in drinking behavior, and no panting behavior was observed (Dalmau, not published results). We suggest that in a constant thermal cycle, like the one applied in this work, animals could behaviorally compensate the heat treatment by staying longer resting and in a prostate position, reducing some secondary behaviors, such exploration or sitting, but with few differences in other important behaviors for the animals, such as grooming, feeding or drinking. The lack of panting is also seen as a sign that confirms that the thermal stress applied in the current study was not excessive.

Doe LW was 308.13 g greater (6.2 %) under C than under H conditions. Cervera et al. (1993), Fernández Carmona et al. (1995 and 1997) also found a negative effect of constant 30 ºC on LW relative to does under 18-21 ºC or standard farm conditions. The interaction between EC and doe age was no significant, meaning that growth pattern is similar under both EC.

The interaction between EC and the three terms of the polynomial regression of DMY on day of lactation was not significant (P-value = 0.13). Therefore, it seems that there was no difference in the shape of the lactation curve of the does under the different environmental conditions. The estimated regression coefficients were: 13.78 ± 0.87 for the linear term and -0.33 ± 0.04 for the quadratic term. According to formulas shown by Casado et al. (2006), the lactation peak was at day 21 and the yield at the peak was 207.6 g/day. Despite temperatures inside the two rooms were clearly distinct and the temperature in H conditions was up the boundaries of the thermo neutral zone at any time of day, the difference in DMY between the two rooms was very small and not significant. This result seems not to be in agreement with other previous researches. Maertens and De Groote (1990) found that DMY was nearly 10% lower during the hot period than during the cold period, but they also noted that this difference was about the 50% of the expected value from previous studies in climatic chambers at constant temperature (Wittorff et al., 1988). Fernández-Carmona et al. (1995) found a difference of 36 g/day in the average milk yield during the third week of lactation between does under farm conditions and does in a climatic chamber at constant 30 ºC. Szendrö et al. (1998) observed a decreasing trend in DMY with high environmental temperature especially during the third week of lactation. Animals in these experiments either were kept under farm conditions or they were placed in a climatic chamber at constant temperature at the beginning of the reproduction period (around 5 months of age) or just after kindling. However, in our experiment animals were allocated in the two rooms at 2 months of age, when they were still growing up. Hence, it would be possible that animals under H conditions become adapted to these environmental conditions.

The differences between DM, CP and GE content of doe milk under C and H conditions were no significant (Table 1). This result is in agreement with the results obtained by Kustos et al. (1998).

Table 1: Effect of environmental temperature on average daily feed consumption (ADFC), average daily water consumption (ADWC), doe live weight (LW), daily milk yield (DMY), and milk composition: dry matter (DM, crude protein (CP) and gross energy (GE).

Trait	Least Squares Means		Number of data (Number of does)	
	Comfort	Heat	Comfort	Heat
ADFC (g/day)	383.11 ± 7.17	347.26 ± 7.59	267 (42)	209 (39)
ADWC (mL/day)	793.73 ± 26.24	780.75 ± 26.67	273 (41)	223 (41)
LW (g)	4947 ± 84	4639± 85	519 (41)	562 (41)
DMY (g/day)	172.24 ± 5.24	172.14 ± 5.30	551 (42)	433 (38)
DM (%)	34.02 ± 0.80	35.22 ± 1.05	26 (21)	15 (15)
CP (%)	13.37 ± 0.30	13.65 ± 0.41	26 (21)	15 (15)
GE (MJ/Kg)	9.07 ± 0.29	9.50 ± 0.38	26 (21)	15 (15)

CONCLUSIONS

Constant daily temperature cycles out of the boundaries of the thermo-neutral zone at any time, seems not to affect daily milk yield, the lactation curve, and milk composition at 10 days of lactation, when does are kept under these conditions from early stages of development, despite both feed consumption and doe weight decrease. The average daily water consumption seems not to be affected, indicating that reducing feed intake rather than increasing water intake could be the main animal's mechanism to overcome high environmental temperature, at least for the pattern of temperature applied in this study, which could only produce moderate stress in the doe.

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