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Environmental Temperature Influences Diet Selection and Growth in Early-Weaned Lambs

Research Article

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ABSTRACT

The objective of the present study was to trace the influence of environmental temperature on growth and feed consumption in early-weaned lambs from dairy sheep breeds. The experiment was conducted in 2015 at the experimental farm of the Institute of Forage Crops, Pleven, Bulgaria using 36 lambs of the Blackhead Pleven sheep breed. The animals were divided into three groups (12 animals per group). Each group was divided into 6 sub groups (2 lambs per pen and divided into three experimental premises, each with a different environmental temperature. The lambs reared at an average temperature of 12.6 ˚C grew significantly faster (P<0.01), than the lambs reared at 5.1 ˚C and -3.0 ˚C. The animals grown at an average temperature of -3.0 ˚C, consumed a larger quantity of maize (P<0.01) and a lower amount of pelleted protein concentrate (PPC, P<0.01). In the animals grown at an average temperature of 12.6 ˚C, the tendency for consumption is reversed (higher PPC consumption and less maize). In this case, when the lambs were grown at a temperature of 12.6 ˚C the percentage of crude protein in the dry matter chosen is the highest at 22.0%.

KEY WORDS body weight, lambs, nutrition, temperature.

INTRODUCTION

Environmental conditions affect the health and welfare of animals. Low environmental temperature can affect the frequency and severity of certain endemic diseases, the thermal com for, the growth rate, milk production and indoor air quality (Seedorf *et al.* 1998; Seinfeld and Pandis, 1998). Environmental temperature is often considered as a "stress factor" which can be divided into heat and cold stress. According to Grzych (2010) the animals are more sensitive to cold stress, but it depends on the breed and the life cycle. West (2003) found that heat stress is the limiting factor in sheep. However, if sheep were previously adapted to high temperatures the losses will be minimal. Cold stress increases energy expenditure in ruminants (Young, 1981) the result of which is increased use of lipids as an energy substrate (Blaxter and Wainman, 1961).

Sheep are seasonally polycyclic animals and the birth and weaning of lambs is generally during the winter months (January-February). During this period there may be poor efficiency of feed use. One reason for this is the low temperatures, which will lead to food intake, low digestibility and high requirements for maintenance of body temperature (Delfino and Mathison, 1991). According to Christopherson and Kennedy (1983), the low temperature influences the absorption of nutrients: the reason is their rapid passage through the rumen of animals. Lambs are sensitive to cold and hypothermia, which is one of the main reasons for the high death rate at an early age. In the presence of cold stress there is a loss of heat and energy, the metabolism of the lambs increases, thereby mobilizing the use of so-called 'brown fat' (Vázquez-Vela *et al.* 2008). According to von Von Keyserlingk and Mathison (1993), if ruminants are exposed to low temperatures the energy requirements are increased due to the additional energy requirements for thermoregulation. Ames and Brink (1977) found that the temperature of the premises where the animals were kept influenced feed consumption. According to NRC (2007) lambs' energy and protein requirements depend not only on sex, age and physical activity but also on the environmental temperature. The low temperatures at which lambs are raised affects the growth rate (Schanbacher *et al.* 1982) and average daily gain (Li *et al.* 2000; Moibi *et al.* 2000).

Values for prediction of temperature-feed intake interactions for farm feeding of sheep are limited, mainly because the vast majority of sheep are kept under extensive grazing conditions. In this study, we aimed is to trace how environmental temperature influences diet selection and growth in early-weaned lambs.

MATERIALS AND METHODS

The experiment was conducted in 2015 with 36 lambs of the of Blackhead Pleven sheep breed at the experimental farm of the Institute of Forage Crops, Pleven, Bulgaria. The animals were divided into three groups (12 animals per group). Each group was divided into 6 sub groups (2 lambs per pen measuring 3 m×1.5 m) and divided into three experimental premises, each with a different environmental temperature. The microclimate (temperature) in the rooms is controlled by electric stoves with a relay for regulating the temperature. During the test period, the temperature was monitored continually as the outside temperature dropped to -20 ˚C. During the test the animals were divided into three rooms with controlled temperature, namely: In the animals from the first group, the temperature varied from 10 ˚C to 15 ˚C (moderate temperature); in the animals from the second group the temperature varied from 0 ˚C to 10 ˚C (low temperature) and in animals from the third group from -5 ˚C to 0 ˚C (lower temperature). The average temperatures and humidities in the premises during the test period are shown in Table 1. The lambs involved in the experiment were allotted according to age (days), live body weight (kg), sex (male and female) and type of birth (single and twins). At the beginning of the experiment, the average age of the lambs was 35.8 days. At the beginning and at the end of the experiment the lambs' body weight was determined after 12 hours of water deprivation and 24 hours of food deprivation. The duration of the test was 28 days. During the experimental period, the animals were offered pelleted protein concentrate for lambs (PPC), maize grain and alfalfa hay (*ad libitum*).

The PPC used in the experiment was of the following composition: sunflower meal (32.5%); soybean meal (25.5%); rapeseed meal (29.5%); molasses (5.0%); vitamin premix (2.5%); calcium carbonate (2.0%); sodium chloride (1.5%); sodium bicarbonate (1.5%). The feed ingredients were separated from each other so that the animals could freely choose and consume each, independently. Feed intake was determined every day (morning at 6:30 by collecting feed refusals and estimating the new amount of feed equal to previous days plus 10%). The temperature and humidity in each room was recorded hourly using mobile stations. The aim of this was to ensure that the temperature did not drop and did not exceed the set temperature values for each of the groups. The chemical composition of the feed (Table 2) was determined by the Weende method following the description of AOAC (2007). The data were analyzed using the General Linear Model (GLM) as a completely random design with pen (n=6) as the experimental unit using the software Statistical for Windows (Statistica, 2006). Groups were compared using a t-test, and differences at $P < 0.05$ were considered significant.

RESULTS AND DISCUSSION

The results showed (Table 3) that when the lambs are raised at a temperature from 10 ˚C to 15 ˚C they have a higher growth rate, compared with lambs raised at a temperaturata from 0 ˚C to 10 ˚C and from -5 ˚C to 0 ˚C ($P<0.01$). The lambs raised at a temperature from -5 ˚C to 0 ˚C, consumed larger quantities of maize ($P<0.01$) and lower amounts of PPC ($P<0.01$, Table 3 and Figure 1). In the animals raised at a temperature from 10 ˚C to 15 ˚C, the tendency for consumption is reversed (the lambs consumed more PPC and less maize grain).

Differences were found between the groups for the composition of diet consumed ($P<0.01$). The percentage of selected CP (on a DM basis) is the highest in the lambs raised at a temperature from 10 ˚C to 15 ˚C (22.0%) and the lowest in the lambs raised at a temperature from -5 ˚C to 0 ˚C (16.9%, Table 3). This allowed us to derive the following regression equation ($CP=0.1868+0.0037\times T^{\circ}$; Figure 2), whereby the correlation coefficient is high ($r=0.923$).

Animals have an optimum temperature range for growth and comfort, which depends on the species, age, physiological condition, humidity, etc. When animals are in the optimal temperature range, they have higher productivity and efficiency in the of feed utilization. If temperatures are too low, the metabolism of adolescent animals increases to support heat production, reducing their growth. When animals are kept at low temperatures, they increase feed intake to meet increased energy needs for life support (NRC, 2007).

Table 1 Average temperature and humidity during of the experiment

Item	Temperature ˚C		
	Moderately	Low	Lower
Average temperature (˚C)	12.6	5.1	-3.0
Air humidity, %	69.5	67.8	67.2

Table 2 Composition and nutritive value of feedstuffs (g.kg^{-1} at natural moisture)

Analytical composition, g.kg^{-1}	Alfalfa hay	Maize	Pelleted protein concentrate (PPC)
Dry matter	899	886	887
Forage units for growth (FUG)[1]	0.65	1.57	0.97
Crude protein	150.8	87.2	328.6
Digestible protein in the intestine	74	68	145.82
Balance of the protein in the rumen	47	-37	128.0
Crude fats	19.4	34.7	17.3
Calcium, g	11.2	0.41	15.53
Phosphorus, g	1.68	2.56	8.12

[1] 1 FUG= 6 MJ NE.

Table 3 Growth of the lambs and feed consumption

Indicators	Temperature ˚C			SEM
	Moderately	Low	Lower	
Age, days	36.3^{a}	35.5^{a}	35.7^{a}	0.207
Initial body weight, kg	13.9^{a}	13.7^{a}	13.9^{a}	0.179
Final body weight, kg	21.8^{c}	19.6^{ab}	17.3^{a}	0.196
Gain, kg/day	0.282^{c}	0.211^{b}	0.121^{a}	0.007
Feedstuff intake, kg/day				
Pelleted protein concentrate (PPC)	0.408^{c}	0.349^{b}	0.238^{a}	0.012
Maize	0.267^{a}	0.321^{b}	0.442^{c}	0.078
Alfalfa hay	0.126^{b}	0.112^{a}	0.109^{a}	0.055
Total	0.801^{b}	0.782^{a}	0.789^{a}	0.012
Intake of energy and nutrients per day				
Dry mater, kg	0.712^{c}	0.694^{a}	0.701^{b}	0.012
Feed units for growth (FUG)[1]	0.897^{a}	0.916^{b}	0.996^{c}	0.028
Crude protein, g	156.7^{c}	150.5^{b}	118.3^{a}	4.056
CP % of DM	22.0	21.7	16.9	-
Feed conversion				
Feed consumption, kg	2.84^{a}	3.72^{b}	6.52^{c}	0.176
Feed conversion ratio (FCR), g feed/g gain	36.7^{a}	39.9^{b}	45.6^{c}	0.814

[1] 1 FUG= 6 MJ NE.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

In our study we found the highest feed consumption and the highest growth rates when the lambs were reared at moderate temperatures (Table 3). Exposure to cold stress for adolescent animals impairs growth and feeding efficiency (Ames *et al.* 1980) and when temperatures are higher than 31 ˚C in sheep it can lead to increases in rectal temperature and heart rate (Cezar *et al.* 2004). Low winter temperatures and exposure of adolescent animals to cold stress, causes a metabolic acclimatization, which leads to reduced growth and productivity (Birkelo *et al.* 1991).

According to Salam *et al.* (2016), at low temperatures, the animals must be given a high energy ration which is in support of our research.

According to Jassim *et al.* (2015) the level of total blood glucose is significantly affected by cold stress, that probably involves more intensive energy metabolism to maintain body temperatures. When animals are subjected to cold stress and the ration is low in energy, a process of excessive protein breakdown begins to form in the body as an alternative to covering energy shortages. This was not noticeable in our study because the lambs that were raised at low temperature (from -5 ˚C to 0 ˚C) received maize grain as an energy source, which covers their needs for energy. The quantity of maize grain consumed by lambs, grown at a lower temperature is 39.6% more than the lambs grown at a moderate temperature (Table 3 and Figure 2).

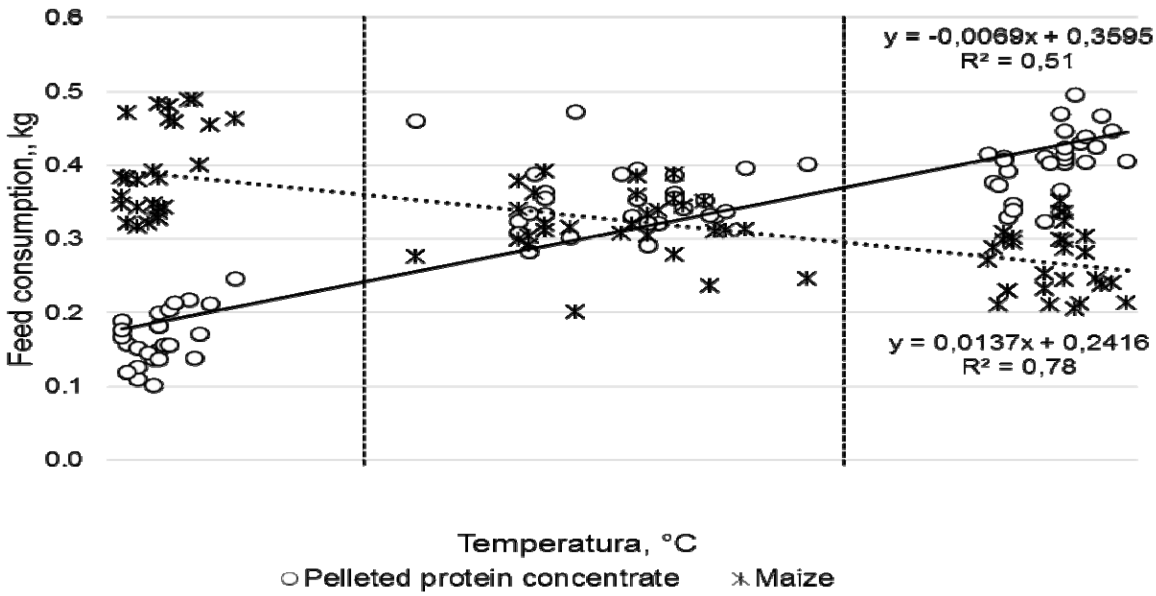

Figure 1 Feed consumption at different temperature variations

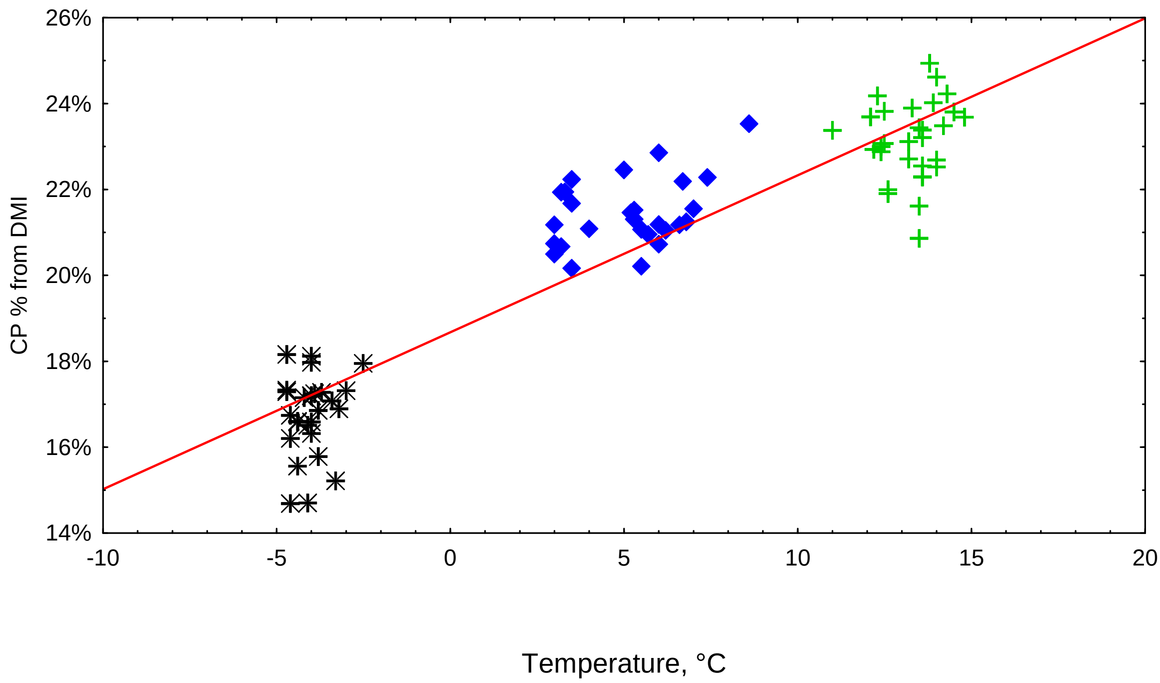

Figure 2 Crude protein consumption at different temperature variations (r=0.9277; r^2=0.861; CP % from DMI=0.1868+0.0037*x)

Despite the higher consumption of maize grain, growth of the animals was limited (Table 3), indicating that the received energy is going for heat production. Increased degration of protein reserves by animals is common in winter, when the sheep are underfed and the corresponding high levels of blood urea have been reported (Mohamed, 2012).

When animals are subjected to low temperatures, the need to increase heat production, to maintain body temperature, through shaking and other thermoregulatory processes is significantly increased (Young, 1983). In the study of Kang *et al.* (2016) they indicated higher feed consumption and higher calf growth when the temperature was higher, which is consistent with our results (Table 3).

In our study, growing lambs at a temperature of 10 ˚C to 15 ˚C indicates that the lambs fall within the temperature comfort zone (Ames and Brink, 1977) and the average daily gain of 282 g/day approximates the values reported from NRC (1985) for early weaned lambs with potential achieved near optimum growth. This in contrast the study of Vachon *et al.* (2007) where a tendency for cold environment (from –7.49 ˚C to –4.74 ˚C) lambs to have a higher gain and to take less time to reach market weight, than those raised in the warm environment (from 6.25 ˚C to 10.50 ˚C). Schanbacher *et al.* (1982) reported higher gains and feed efficiency for lambs raised at 5 ˚C compared with lambs raised at either 18 or 31 ˚C. According to NRC (1985) the temperature for maximum gains is 13 ˚C for shorn lambs and lower for lambs with fleece. Moibi *et al.* (2000) reported lower growth rate with wether lambs were raised at 0 ˚C compared with lambs raised at 20 ˚C to 23 ˚C which is a confirmation of our results. The feeding system may also have an impact on the differences between the current study and previous studies. In the current study, PPC, maize grain and alfalfa hay were given separately to evaluate the effect of ambient temperature on protein and energy consumption. This approach may impact the performance at different environmental temperatures compared with a uniform concentrate feed. Thus, Şahin *et al.* (2003) and Keskin *et al.* (2007) stated that the lamb's feed preferences and behaviors during the fattening may change according to the hours of day and months, and the environmental temperature has an effect on this. According to NRC (1985) dry matter intake increases as ambient temperature decreases in which it was established linear relationship was established between ambient temperature (from –5 to 35 ˚C) and dry matter intake for shorn lambs. The following relationship is reported by NRC (1985).

$$\text{DMI (g kg}^{-1}\text{ BW}^{0.75}) = -111.3 - 0.52\ \text{T ˚C}$$

The separate placement of the feed, so that animals have selectivity shows that at low temperature (-5 ˚C to 0 ˚C), lambs, preferrad maize grain to the PPC (P<0.01, Table 3 and Figure 1).

The resulting FCR in the lambs grown at a low temperature (45.6) was relatively higher than that in the animals grown at moderate temperature (FCR=36.7, Table 3). This is indicative that the temperature influences the FCR and the same is the lowest when the temperature ranges from 5 to 15 ˚C (Ames and Brink, 1977), although the feed is of high quality. According to Christopherson *et al.* (1979), the higher the FCR, the lower the efficiency of the feed used when the temperature is below 0 ˚C. The reason for this can be explained by the reduced digestibility (Christopherson and Kennedy, 1983) and higher energy requirements for life support (Von Keyserlingk and Mathison, 1993). However, the lambs of the third group have the lowest growth rate and the highest FCR because of the low temperatures increased metabolic processes (Yamamoto, 1989). This has been coupled wuth, increased heart rates (Christopherson *et al.* 1979) when the animals are kept at low temperatures indicating increased energy metablosm. In this case, energy intake is also increased to maintain the body temperature of the animals. Kennedy and Milling (1978) indicated that at low temperatures, decreased digestibility of dry matter, which supports the above-mentioned authors.

CONCLUSION

Lambs raised at an average temperature of 12.6 ˚C gained significantly more body weight (P<0.01) compared to lambs raised at a lower temperatures (P<0.01). Lambs at low temperature (-3.0 ˚C) consumed significantly more maize and less PPC (P<0.01). By the means of free choice feeding, it was determined that lambs at low temperatures (-5 ˚C to 0 ˚C) selected maize instead of PPC (P<0.01).

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