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# Thermal Status in Three Breeds of Newborn Lambs during the First 24 Hours of Postnatal Life

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## Abstract

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Rectal temperature (RT) dynamics during the first 24 h after birth was studied in Pleven black head (PBH), Bulgarian fine wool (BFW) and Bulgarian fine wool x East-Friesian breed crosses (FC) lambs. Data were collected from a total of 137 lambs. For each breed group all lambs were paternal half sibs and born at term, without assistance. The ewes were housed in a sheep barn throughout the lambing period, which occurs in winter. Rectal temperature was recorded at 1, 3, 12, and 24 h after birth, within 0.1 °C. The newborn lambs were weighed within 1 h after birth. Skin fold thickness and fleece depth were measured on mid side. Time taken of each lamb until it first sucking was also recorded.

The lambs of the studied breeds had similar pattern of RT dynamics throughout the first 24 h after birth. Fall of RT was observed in all breeds up to 12 h postpartum followed by an increase at the 24$^{th}$ h. Bulgarian fine wool lambs had lower RT than the lambs of the other two breeds over the first day of postnatal life, but the difference was only significant at 1 h after birth ($P<0.001$). Lamb sex had no significant effect on the rate of RT decline during the first 12 h following birth. Single lambs had higher RT values at 1 h ($P<0.01$) and at 12 h ($P<0.05$) after birth than those in twins. Time to first sucking was similar in all breeds. In PBH lambs RT at 3, 12 and 24 h of postnatal life tended to be lower at ambient temperature 4.1 – 8.0 °C compared to that at 0.0 – 4.0 °C.

The results suggest that under prevailing management system and specific conditions in the barn the newborn lambs of the studied breeds were able to maintain successfully their body temperature at a range of ambient temperature 0.0 – 8.0 °C without any incidence of hypothermia.

*Key words*: breeds, lambs, newborn, rectal temperature dynamics
*Abbreviations*: RT = rectal temperature; PBH= Pleven black head breed; FC= Friesian crosses, BFW= Bulgarian fine wool breed

## Introduction

Numerous studies have investigated various aspects of thermoregulation in newborn lambs. However the majority of these studies have been performed in laboratory conditions where lamb's cold resistance was evaluated by the use of water bath or climatic chamber. The observations on thermal status of lambs born in field conditions are limited. Despite the differences in the intensity and duration of the cold stress, experienced by the lambs under field and laboratory conditions, sizable between and within breed differences in cold resistance in both cases have been found. These differences may well be related to lamb's physical and physiological characteristics, such as birth weight, type of hair coat, skin fold thickness, endocrine activity and rate of activation of the thermogenic potential (Samson and Slee, 1981; Slee et al., 1980; Slee, 1981; Slee, 1984). These investigations have been designed to assess the relation between the rate of decline of rectal temperature to a given point during cold exposure and the ability of newborn lambs to survive in field conditions, which are typical for sheep production systems prevailing in Australia and New Zealand.

Sheep breeding in Bulgaria and other European countries is based mainly on sheep confinement during winter months when pasture is meagre. This period usually coincides with lambing. The investigations on the ability of newborn lambs to maintain body temperature during the first day of neonatal life under practical conditions are scarce and do not allow a reliable assessment of the adaptive responses in different breeds during the early postnatal adaptation. On the other hand the results may be used for evaluation of different types of sheep buildings in terms of animal production and welfare.

The objective of this study was to investigate thermal status during the first 24 h after birth in different breeds of lambs, born in confinement during winter months.

## Materials and Methods

The experiment was carried out at the research farm, near the town of Razgrad, North Eastern Bulgaria. All ewes were raised in a single herd and were artificially inseminated in June-July using fresh semen from the corresponding breed. Thus, for each breed group all lambs were paternal half sibs. During summer month's sheep grazed on natural pastures and in the end of October were housed in a sheep barn and fed according to their physiological state - 0.6 kg ground grain (equal quantities of maize, barley and wheat) maize silage and alfalfa hay. The diet was calculated to meet the maintenance and pregnancy requirements.

When the first signs of the forthcoming delivery appeared the ewes was separated from the flock and placed in individual pens where an area of approximately 2 $m^2$ per ewe was ensured, and where the observations and measurements were performed. Clean straw bedding was regularly supplied

The observations were made on 48 Pleven black head (PBH) lambs, 41 Bulgarian fine wool breed x East-Friesian (FC) crosses-$F_2$ and 48 Bulgarian fine wool breed (BFW) lambs. The experiment comprised healthy lambs, born at term, without shepherd's, assistance and from ewes which manifested good maternal behaviour and actively groomed their lambs immediately after birth. The ewes, which gave birth for the first time, were excluded from surveillance because of the possible delivery problems, requiring additional help by the shepherd. Prior to lambing the wool around the udder was removed by scissors in order to allow rapid lamb access to the teats and early suckling.

Lamb weights were measured within 0.1 kg, during the first hour after birth following the complete removal of placenta. Skin fold thickness and fleece depth were measured on the mid side, with an accuracy of 0.01 and 0.1cm respectively by means of calliper-square. Rectal temperature of the lambs was recorded within 0.1°C by means of digital clinical thermometer ALP K2, model NOFT-7D, inserted to a depth of 6 cm. Data were collected at 1, 3, 12 and 24 h postpartum, assuming this period as a critical for the body temperature maintenance in newborn. The time from birth to successful suckling was determined via observation on obvious suck signs and a check-up of dam᾽s udder and teat if needed. All measurements were taken in individual pens, avoiding as far as possible the animals´ anxiety. Time to the first successful suckling was determent by the observer stayed out of the pen scrutinizing mother-offspring behavior. The observations were made throughout the day independently of the time of birth. More than a month before lambing time ewes was fed in the barn and was habituated to men's presence.

Air temperature, relative humidity and air velocity were registered at various locations in the barn by the use of thermometers for air temperature, whirling psychrometer and katathermometer respectively. Relative humidity and air velocity were registered every day. Ambient temperature was registered at each measurement of RT. All environmental measurements were conducted at dam height with the exception of air velocity that was registered both at dam and lamb height.

Data were analyzed taking into account the effects of time after birth, breed, sex, type of birth effect for the whole range of ambient temperatures and separately for the range from 0.0 to 4.0 °C and for 4.1 to 8.0 °C. LS-means were obtained with SPSS set of programmes. They were presented with the corresponding standard errors (SE). The differences were tested with Student T-test.

## Results and Discussion

Relative humidity of the air at different locations in the barn ranged between 64 and 76% throuhout the experiment. Air velocity ranged between 0.05 and 0.11 m/sec at lamb height and between 0.10 and 0.17 m/sec at ewe height. Ambient temperature in the barn over the lambing period ranged between 0.0 and 8.0°C. This temperature interval is typical for the local sheep barns in winter. Round-the-clock temperature deviations in the barn were in a narrower limits and rarely exceeded 3°C as compared to outdoor temperature magnitude, which sometimes exceeded 10 °C.

Body weight at birth, fleece depth, skin fold thickness and time to first sucking of single and twin lambs of different breeds are shown in Table 1. Pleven black head and FC single lambs had similar body weights. Bulgarian fine wool lambs, unlike the other two breeds, had significantly lower body weights in singleton ($P<0.01$) in comparison with PBH lambs, although some of these differences may be due to the quantity of detained fetal fluid (Table 1). The twins had in all occasions significantly lower birth weight ($P<0.05$, $P<0.01$, $P<0.01$) compared with single lambs.

**Table 1**

**Birth weight, wool depth, skin fold thickness, and time to first sucking in lambs of different breeds and type of birth**

| Type of birth | Single | | | Twins | | |
|---|---|---|---|---|---|---|
| Breeds | PBH | FC | BFW | PBH | FC | BFW |
| Number of lambs | 34.00 | 29.00 | 32.00 | 14.00 | 12.00 | 16.00 |
| Live weight, kg | 5.00±0.14 | 4.70±0.14 | 4.52±0.15 | 3.88±0.22 | 3.88±0.24 | 3.80±0.21 |
| Wool depth, mm | 13.7±0.08 | 12.9±0.09 | 5.9±0.09 | 12.4±0.13 | 11.8±0.14 | 4.8±0.20 |
| Skin fold thickness, mm | 5.03±0.03 | 4.95±0.03 | 3.98±0.03 | 4.41±0.05 | 4.33±0.05 | 3.44±0.05 |
| Time to first sucking, min | 41.7±0.5 | 39.8±0.6 | 41.8±05 | 44.5±0.5 | 43.1±0.5 | 48.2±0.8 |

Values are LS-means ± sem

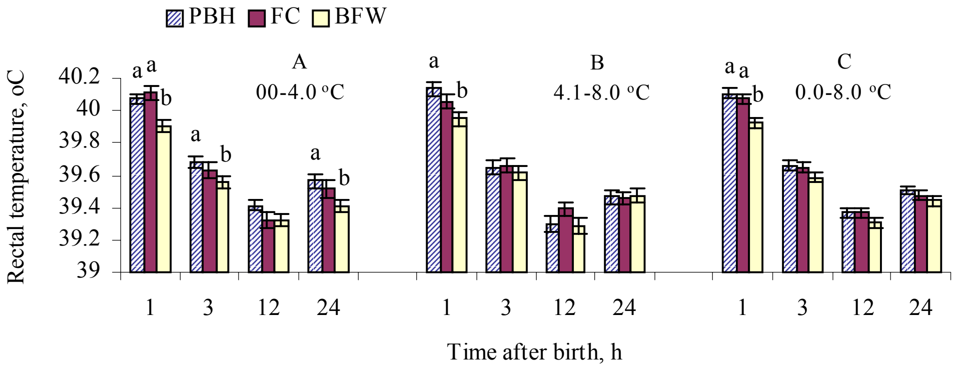


**Fig. 1. Rectal temperature dynamics during the first 24 h of postnatal life in three breeds of lambs at different ambient temperatures:**
**A (0.0-4.0 °C); B (4.1-8.0 °C); C (0.0-8.0 °C). Values are LS- means ± sem.**
**Denote bars represent sem. Different letters denote significant differences**

There were no significant breed differences between twin lambs concerning their body weight.

Bulgarian fine wool lambs had significantly lower fleece depth (P<0.001) and skin fold thickness (P<0.001) compared to PBH and FC lambs (Table1). There were negligible but significant differences (the levels of significance varied between P<0.05 and P<0.001) between breeds and type of birth concerning the time elapsed to first suckling (Table1).

Rectal temperature dynamics at a range of ambient temperatures between 0.0 to 4.0 °C (A); 4.1 to 8.0 °C (B) and 0.0 to 8.0 °C (C) respectively are presented in Figure 1. Time after birth had the most pronounced effect on RT dynamics. Rectal temperature fluctuations over the first 24 h following birth had similar pattern in all groups of lambs regardless of the range of ambient temperature, sex and type of birth (Figures 1, 2, 3 and 4). Age associated differences concerning the

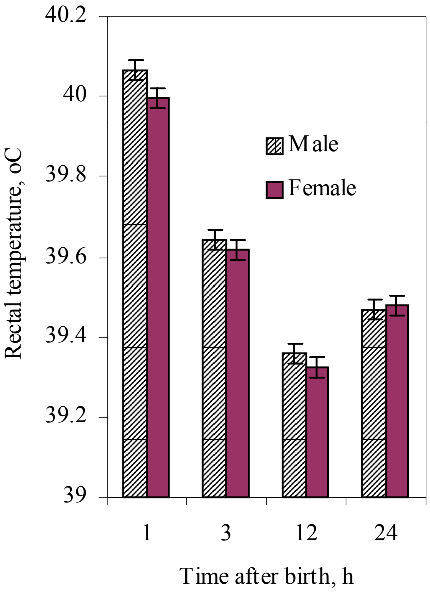


**Fig. 2. Rectal temperature dynamics over the first 24 h of postnatal life in male (n = 67) and female (n = 70) lambs at ambient temperatures between 0.0 and 8.0 °C. Values are LS-means ± sem. Denote bars represent sem. Different letters denote significant differences**

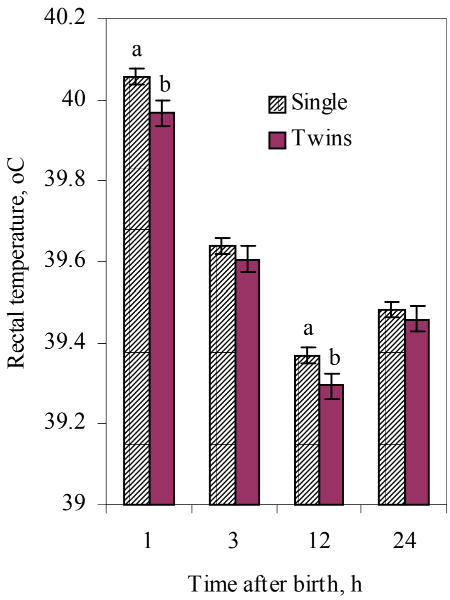


**Fig. 3. Rectal temperature dynamics over the first 24 h of postnatal life in single (n = 95) and twin (n = 42) lambs at ambient temperatures between 0.0 and 8.0 °C. Significant at 1 h (P<0.01). Values are LS-means ± sem. Denote bars represent sem. Different letters denote significant differences**

fall of RT were significant (P<0.001) in all breeds, at all time points and at all temperature ranges up to 12 h postpartum. The enhancement over the period between 12 and 24 h after delivery at studied temperature ranges was significant as follows: A-in PBH and FC lambs, (P<0.05); B-in PBH P<0.05), and BFW lambs (P<0.01); C-in PBH (P<0.01), FC (P<0.05) and BFW (P<0.01) lambs. Pleven black head and FC lambs had similar RT over the 24 h period after birth, whereas in BFW lambs it remained lower throughout this period, but the differences were in all exposures significant at 1 h after birth (Figure 1). There were not any recognizable differences in the pattern of age related RT changes in lambs of different breeds exposed to different ambient temperatures during the first day of postnatal life. At different temperature ranges the differences between BFW and the other two breeds were significant (P<0.01) at 1 h after birth, and at 3h and 24 h respectively at the lowest ambient temperature. The data obtained suggested no considerable effect of sex on RT dynamics (Figure 2). Single lambs at all time points had measurably higher RT than twins but the differences were significant at 1 h (P<0.01) and at 12 h (P<0.05) after birth (Figure 3).

The rectal temperature values in PBH lambs were higher under lower ambient temperature (0.0-4.0°C) at 3, 12, and 24 h

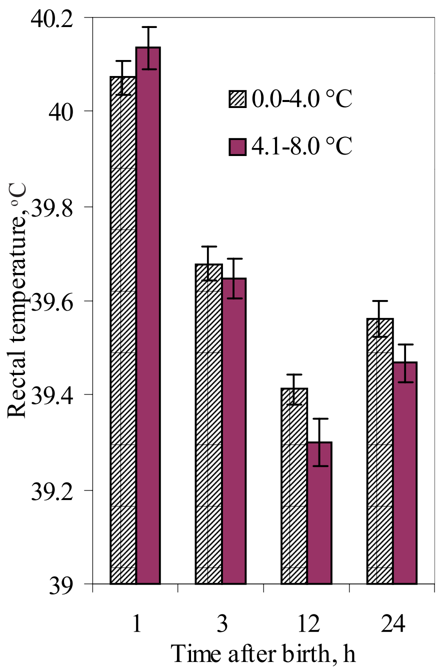


**Fig. 4. Rectal temperature dynamics over the first 24 h of postnatal life in PBH lambs at different ambient temperature ranges (0.0-4.0 °C and 4.1-8.0 °C). Values are LS-means ± sem. Denote bars represent sem. Different letters denote significant differences**

of neonatal life, compared to those registered at higher ambient temperatures (4.1-8.0 °C) although the differences were not significant (Figure 4). The lowest rate of decline in RT up to 12 h after birth was observed in BFW lambs but the differences between breeds were only significant (P<0.01) at 1 h and 12 h postpartum (Table 2).

It is known that RT dynamics during the first hour of postnatal life is influenced by the thermal gradient, physical characteristic of the lamb and its ability for quick activation of endogenous heat production. The latter, according to Gunn et al. (1991); Gunn et al. (1993); Gunn and Gluckman (1995) require a combination of the removal of the placental inhibitors of lipolysis from the circulation, abundant oxygen supply and stimulation of cutaneous cold receptors.

Our data concerning the comparatively high RT values at 1 h after birth in all groups of lambs (Figures 1, 2, 3, 4) indicate fast thyroid and adrenal-sympathetic activation (Doubeck et al., 2003) which presumably influences considerably brown adipose tissue function and genera-

**Table 2**
**Rate of decline of rectal temperature (°C) in lambs of different breeds up to 12 h after delivery and elevation (values in the last row) during the next 12 h of postnatal life at ambient temperature range 0.0-8.0 °C**

| Periods after birth, h | Breeds | | |
|---|---|---|---|
| | PBH | FC | BFW |
| | n = 48 | n = 41 | n = 48 |
| 1 – 3 | 0.44±0.03 ** | 0.43±0.03** | 0.34±0.03 |
| 3 – 12 | 0.29±0.03 | 0.28±0.03 | 0.26±0.03 |
| 1 – 12 | 0.74±0.03 ** | 0.71±0.03** | 0.60±0.03 |
| 12- -24 | 0.15±0.03 | 0.13±0.03 | 0.12±0.03 |

Values are differences between LS-means means ± s e m, corresponding to the separate periods. The negative differences in the last row. ** P<0.01

tion of adequate amount of heat .This period, when the lamb cools like a physical body, coincides with commencement of vasomotor function, increased motor activity of lambs in quest for the udder and enhanced muscular tone, often accompanied by visible shivering. These factors are among the major contributors to heat production in lambs (Clarke et al., 1994).

The rectal temperature measured by 3 h following birth was still relatively high in all breeds (Figure1) despite of the increased heat losses, associated with drying of the amniotic fluids during this period. A number of studies have suggested that these changes in RT stem from increased endocrine activity and secretion of calorigenic hormones, related with non-shivering thermogenesis in brown adipose tissue (Mellor and Cockburn, 1986; Slee et al., 1987; Symonds et al., 1995). All lambs began to suck within 1 h after birth (Table 1) and sucking is known to stimulate heat production. Eales and Small (1981) reported increased basal and summit metabolism (46 and 20% respectively) following colostrum intake, compared to lambs that were deprived of colostrum. Differential thermoregulatory response in colostrum fed and deprived of colostrum lambs has been observed within 1 h after birth (Hamadeh et al., 2000). These findings coincide with the established inhibition of thyroid stimulating hormone surge when the first milk intake was delayed (Gabello and Wrutniak, 1990). Symonds et al. (1995) noted that the colonic temperature of newborn lambs, separated from their mothers at ambient temperature 3-8 °C and deprived of food, decreased up to 1 °C during the first 6 hours after birth. During the next 6 hours of postnatal life the colonic temperature showed recovery, which however coincided with the intake of milk replacer? According to Clarke et al. (1997) and Clarke and Symonds (1998) feeding of colostrum and even of 50 ml water to pre-term lambs cause an elevation of thermogenic activity in brown adipose tissue. Mercer et al. (1979) also pointed out that the postnatal rise in metabolic rate was associated with both parental feeding and the concomitant hormonal dynamics. These findings suggest that the early colostrum intake not only recover the energy reserves of the body but appears to have a triggering effect on brown adipose tissue thermogenesis and presumably on neonatal metabolic adaptation.

Rectal temperature declined by 12 h after birth (Figures 1, 2 and 3) when the fleece was presumably dry and external insulation improved. It is known that the postnatal metabolic adaptation in newborn lambs occurs earlier compared to that of other species, and indicate higher level of thermoregulatory maturity at birth which largely determines the ability of adaptation to the extra-uterine environment. Our data suggest that during the first hours of the neonatal development the thermoregulatory mechanisms were not fully mature yet in spite of the advanced level of homeothermy.The appreciable elevation ($P<0.01$; $P<0.05$; $P<0.01$) in rectal temperature of lambs of all breeds between 12 h and 24 h of postnatal life is seemingly a result of fully activation of adaptive thermo genesis and improved peripheral insulation. Redistribution of the blood flow alters the temperature gradient contributing for the reducing the rate of heat dissipation. Mercer et al. (1979) also remarked that by 17 h postpartum the lower critical temperature fell by 8 °C due to increase of metabolic rate and fleece drying, and further reduction has been observed up to

31 h after birth. We did not find any measurable effect of different ambient temperatures on RT changes after birth (Figure 1). Under both ambient temperatures, the lambs of different breeds had similar RT dynamics although between breeds and age related differences persisted at the same extent. These findings witness that the temperature ranges studied have not been strong enough to induce any remarkable between group's differences in the rate of metabolic responses.

Lamb sex had no significant effect on RT dynamics (Figure 2) The possible explanation of this finding could be due to the absence of differences in birth weights between male (4.43±0.07 kg) and female (4.37±0.08 kg) lambs. Single lambs at all time points measured had recognizably higher RT and the differences were significant at 1h ($P<0.01$) and at 12 h ($P<0.05$) after birth (Figure 3). It is known that surface area to mass ratio is partly related to RT. Consequently the level of heat losses in twins, which had lower birth weight (Table 1), would be higher because of the presumably larger body surface (Muller and McCutcheon, 1991). The gradual fall in RT during the observed period (Figure 3) indicates that the importance of surface to mass ratio for maintenance of the thermal balance declines with age regardless of the type of birth. In this respect our results are in agreement with the opinion of Sykes et al. (1976) that birth weight has significant effect on body temperature maintenance only in cases when heat losses approach the capacity for maximal heat production. We assume that the cooling effect of ambient temperature in our experiment was not strong enough to induce maximal thermogenic response.

The lower RT values observed in BFW lambs (Figure 1) could be due to various reasons related with lamb ability to produce heat by activation of the respective thermoregulatory mechanisms on the one hand, and the ability for heat preservation by reduction of heat losses and improvement of body insulation on the other hand (Slee, 1978; McCutcheon et al., 1983a, b). With age advancement all this mechanisms could be activated in different combinations. Another possible reason for the lower RT in BFW lambs could be the type of fleece that affects at least partly heat losses, since many factors like body insulation, quantity of the detained fetal fluid, the site of evaporation and the energy needed for drying of the fluid are related to fleece type. Rectal temperature differences between breeds may also be due to between breed differences in the level of basal and summit metabolism. The lower rate of RT decline in BFW lambs over the period 1-12 h following birth (Table 1) may indicate both an increase of heat production and improvement of body insulation.

There is considerable evidence that rectal temperature maintenance in lambs during the first hours of the neonatal life is well related to the level of sheep feeding over the prenatal period that is acting through the influence of birth weight and its effect on RT. Lamb birth weight affects positively the body temperature maintenance which may be attributed to the smaller relative surface area, related with reduced heat losses, on the one hand, and the higher level of energy reserves in heavier lambs, on the other hand (Dwyer and Morgan, 2006). Feed intake in our experiment was not controlled during summer grazing. However over the last part of pregnancy the ewes were housed in a sheep barn and fed according to their nutritional requirements. It is well known that during this period occurs an enhancement of fetus growth and accumulation of perirenal-abdominal fat (Alexander, 1978; Symonds and Clarke, 1998). The high level of feeding during the last months of pregnancy has a certain effect on brown adipose tissue quantity and maturation and the both factors have a significant effect on thermoregulation (Symonds and Lomax, 1992). It has been shown that fetus brown adipose tissue in sheep fed on diets exceeding nutritional requirements by150% has higher content of uncoupling protein-1 and higher calorigenic activity than that in fetus of sheep fed on diets calculated to meet 100% of their requirements. It has been suggested that the mechanism which regulate uncoupling protein content in brown adipose tissue is related to the nutritional flow reaching the fetus (Budge et al., 2000). It seems that dietary sufficiency in our experiment contributed to better fetus development and production of adequate quantity of colostrum that ensures continuous supply of badly needed energy for heat production during the first hours after birth.

Another noteworthy point was that RT at 3, 12 and 24 h after birth in PBH lambs tended to be permanently lower at ambient temperature 4.1-8.0°C compared to that at ambient temperature 0.0-4.0°C (Figure 5).The lower RT at higher ambient temperature, although not significant, could be due to reduced endogenous heat production. Consequently it can be presumed that PBH lambs did not mobilize non-shivering thermo genesis at ambient temperature 4.1-8.0°C to the same extent as they did at ambient temperature 0.0-4.0°C. This assumption is further supported by the fact that shivering thermo genesis, that in our case was rarely observed during the first 24 h after birth, occurs when RT drop to a certain critical point. Clarke et al. (1994) found out that the delivery into a cool environment (15°C) causes an increase of plasma concentration of thyroid hormones which affects neonatal thermoregulation enabling in preterm lambs a greater thermogenic responses via shivering thermo genesis compared with the lambs delivered into the warm (30°C) Rectal temperature values in BFW lambs, unlike those in PBH lambs, did not show any trend at both levels of ambient temperature-0.0-4.0 and 4.1-8.0 °C respectively (Figure 1), and were probably due to increased rate of non-shivering thermo genesis, because of the lower body insulation (Table 1) and expected higher heat losses in comparison with PBH lambs. Based on these results we assume that the maintenance of RT in BFW lambs at ambient temperature 4.1-8.0°C was related with higher rate of non-shivering thermo genesis when compared to that in PBH lambs.

The similarity of RT pattern in the 3 breeds of lambs demonstrates the ability of all lambs to maintain the body temperature during the critical 24 h after birth under the prevailing environmental conditions in the sheep barn. It is likely that the mild environmental conditions in the barn, indicated by the lower magnitude of ambient temperature, the low speed of air velocity and the presence of straw litter, contributed for reduction of heat losses and better tolerance to cold stress. It is also known that over the first hours following birth, lambs spend most of the time flat ways with tucked in legs, which decreases the effective surface area. Thus, changing the body posture and choosing the proper lying area within the straw bedded pen, the lamb achieves its own microclimate, which contributes to a reduction of heat loss and elevation of the effective ambient temperature. This, together with an activation of appropriate thermoregulatory responses, supports the ability of lamb for body temperature maintenance.

## Conclusion

This study showed that the lambs of all three breeds studied had similar age associated patterns of RT dynamics between 1 and 24 h after birth at ambient temperature between 0.0 and 8.0 °C. Fall of RT was observed in all lambs up to 12 h postpartum followed by an increase at the $24^{th}$ h. Bulgarian fine wool lambs had lower RT values from 1 h up to 24 h of extrauterine life compared to those in PBH and FC lambs, but the difference was only significant at 1h after birth ($P<0.001$). Bulgarian fine wool lambs had the lowest rate of decline of RT between 1 and 12 h after birth ($P<0.01$). Lamb sex had no significant effect on RT dynamics during the first day of neonatal life. Single lambs had significantly higher RT values at 1 h ($P<0.01$) and 12 h ($P<0.05$) after birth than those in twins. In PBH lambs RT at 3, 12 and 24 h of postnatal life tended to be lower at ambient temperature 4.1 – 8.0 °C compared to that at 0.0 – 4.0 °C. Rectal temperature of lambs in all three breeds was maintained within normal physiological range at all temperature levels studied.

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