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Effects of housing systems on physiological and energetic parameters in comisana ewes

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Abstract: *The pattern of some physiological parameters (rectal temperature, respiratory rate and heart rate) and some energetic parameters (glucose, triglycerides, total cholesterol and total lipid) has been investigated with the purpose to assess the influence of shearing on thermoregulation. Thirty-six Comisana ewes were divided into two groups of 18 subjects and were allowed to two different housing systems: animals of group A were housed in an open-front barn with a paddock and animals of group B to a paddock equipped with shading net. After a period of adaptation to the experimental conditions, individual rectal temperature, respiratory and heart rates were measured. The serum concentrations of glucose, triglycerides, total cholesterol and total lipid were also assessed. All parameters were recorded, with an average interval of eleven days during 90 days, from July 15th to October 11. The statistical analysis, the ANOVA followed by the Bonferroni's test, showed a significant effect of the time for respiratory rate, heart rate and glucose and it showed that during experimental period the type of housing system influenced glucose, triglycerides, total cholesterol and total lipid. These results confirm that different micro-environmental conditions can influence thermoregulatory mechanisms with effects on the productivity and on the welfare of ewes.*

Key words: *Housing systems, Physiological parameters, Energetic parameters, Ewes*
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Introduction

Some housing and management practices can be a source of stress for ewes and domestic animals (Lynch *et al.*, 1992; Vandenheede and Bouissou, 1993). The relationships between behavioural and physiological indicators can be used to evaluate the adaptive capacity and consequently "welfare" of these animals in relation to different types of housing and management (Broom and Johnson, 1993). This is done with particular attention to possible stressors of some systems, detectable as modifications of respiratory or heart rates, which are a valid index of social stress (Guyton, 1995). Also, rectal temperature is an indicator of thermal balance and may be used to assess the adversity of the thermal environment which can affect the growth, lactation and reproduction in dairy cows (Hahn, 1999; West, 1999).

It is well known that to maintain a constant body temperature, an animal has to satisfy the condition of "stationary equilibrium", in which the metabolic production of heat is equal to its loss. In these conditions an increase of the metabolism allows the animal's adaptation to the various environmental conditions (Piccione *et al.*, 2002). Many studies have carried out to evaluate the effect of shearing and sheltering on the energy metabolism of ewes, in particular, some researchers evaluated the modifications of some physiological and haematological parameters and showed the adaptive responses in the organism (Piccione *et al.*, 2006). Instead other Authors evaluated the effect of maintenance system on the reproduction of sheep as well as the level of some morphological and biochemical blood indicators (Patkowski *et al.*, 2006).

The ability to regulate temperature is an evolutionary adaptation that allows homeotherms to function in spite of the variation of the ambient temperature. This ability also allows body temperature to be used as a signal to control physiological processes (Piccione *et al.*, 2006). Some authors investigated the effects of the climate on physiological status of sheep (Roda *et al.*, 2002) and heat tolerance in Brazilian sheep (McManus *et al.*, 2009). Some studies were carried out in order to assess the influence of the type of shelter on the homeostatic balance of sheep: the authors showed the important role of shelter's microclimate on animal's welfare (Biondi *et al.*, 2003; Pennisi *et al.*, 2004; Piccione *et al.*, 2002).

On the basis of that some physiological parameters (rectal temperature, respiratory rate and heart rate) and some energetic parameters (glucose, triglycerides, total cholesterol and total lipid) have been investigated with the aim of comparing the effect of two different housing systems on thermal homeostasis maintenance in comisana ewes.

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Materials and Methods

The trial was carried out in a farm located in Sicily (37° 28' N; 14° 37' E), at an altitude of about 450 meters above sea level. The climate of this area is Mediterranean, with rainfall mainly distributed in late autumn and in winter. External environmental temperature and relative humidity for each experimental day were continuously recorded with a data logger (Gemini, Chichester, West Sussex, UK) placed exterior to the barn under shade and whose sensor was placed at animal level.

Thirty-six pregnant comisana ewes, average age 3±0.6 years, average body weight 52.1±3.2 kg, were used in the experiment. All housing and care conformed to the standards recommended by the Guide for the Care and Use of Laboratory Animals and Directive 86/609 CEE. The animals, well-fed and in good conditional status, were divided into two groups of 18 subjects and were allowed to two different housing systems from July 15th to October 11th. Group A was housed in an open-front barn with a paddock and group B was assigned to a paddock equipped with shading net. The net allowed about 80% of shading compared to the total shading offered by the roof of the barn. The animals of two groups were fed daily on hay (1 kg), wheat straw (0.4 kg), wheat concentrate (0.3 kg) and water *ad libitum*.

After 10 days of adaptation to the experimental conditions, physiological parameters were monitored and blood samples were collected. Rectal temperature was recorded using a digital thermometer (HI92704, Hanna Instruments Bedfordshire, UK) with the probe being inserted 9 cm inside having a sensitivity of 0.1°C, respiratory rate was recorded visually using a stopwatch over a 2 minutes period by counting flank movements and heart rate was measured by means of an oscillometric apparatus (Argus TM-7, Schiller, Barr, Switzerland).

Two individual blood samples were collected through jugular venipuncture, using two vacutainer tubes (Terumo Corporation, Japan), the first without any additive and the second with K_3-EDTA. Blood samples collected in tubes without additive were centrifuged at 3000 r.p.m. for 10 minutes and sera were stored -4°C until analysis. In each sample serum concentrations of triglycerides, total cholesterol and total lipid were assessed. Sera were analysed with commercially available kits by means of a UV spectrophotometer (model Slim SEAC, Firenze, Italy). Blood samples collected in tubes with K_3-EDTA, were used to assess glucose concentration by means of Blood Glucose Meter (Glucotrend 2, Roche), immediately after the collection. All parameters were recorded, with an average interval of eleven days during 90 days, from the July 15th until October 11. All the measurements were performed in the same time on each animal and begun always at 2.00 p.m.

The statistical elaboration of the data for each parameter was based on the average values obtained.

Two-way repeated measures analysis of variance (ANOVA) was used to determine the significance of the two experimental factors, housing system and time. $p<0.05$ were considered statistically significant. Bonferroni's test was applied for post-hoc comparison. Data were analyzed using STATISTICA 5.5 (Stat Soft Inc.) software package.

Results and Discussion

External environmental temperature remained almost constant with an average value of 28°C, while relative humidity level showed average values of 54% with high peak of 74% in September.

The average values (± SD) of studied parameters for the two housing systems, group A ewes in the barn and groups B in the net-shaded paddock, together with statistical significances between groups A and B, are presented in Tables 1,2. Two–way ANOVA showed a significant effect of the type of housing system only on energetic parameters: glucose ($F_{(1,272)}$=5.97, p=0.0199), triglycerides ($F_{(1,272)}$=15.21, p=0.004), total cholesterol ($F_{(1,272)}$=29.86, p<0.0001), and total lipid ($F_{(1,272)}$=62.49, p<0.0001). The effect of time was highly significant for respiratory rate ($F_{(8,272)}$=12.93, p<0.0001), heart rate ($F_{(8,272)}$=8.00, p<0.0001) and glucose ($F_{(8,272)}$=31.02, p<0.0001).

The results obtained in the two experimental conditions, ewes stabled in a modern and efficient barn compared to ewes stabled in a net-shaded paddock, showed a very interesting effect of the type of housing system on the energetic metabolism in dairy ewes during summer period in a Mediterranean area.

Ewes share with all mammals their capacity to keep body temperature within certain limits. Concerning the defence against heat, farm animals use two thermal dispersion system, sweating and polypnea. Sheep are in an intermediate position between horses and cattle, species in which sweating prevails, and swine and dogs, in which polypnea is the main means of defence against heat (Ruckebusch, 1986).

Ewes in environments with high temperatures are subjected to different stressful climate conditions than ewes in temperate zones (Johnson, 1987). Heat stress occurs when the combination of air temperature, relative humidity, air movement and solar radiation cause the effective temperature of the environment to be higher than the animal's thermo-neutral zone or comfort zone. This comfort zone identifies a range of environmental temperatures where heat production and heat loss from the body are the same (Srikandakumar *et al.*, 2003). In late spring and summer wide areas of the Mediterranean basin, where dairy sheep are very common, often present ambient temperatures that exceed the thermo-neutral zone (5 to 25°C) for ewes (Sevi *et al.*, 2001).

In our experimental conditions the external environmental temperature, monitored in the hottest hours of the day, was almost constant and it exceeded the thermal neutral zone.

As previously observed by other Authors, the type of housing system does not affect respiratory and heart rates (Pennisi *et al.*,

Table - 1: Average values (± SD) of rectal temperature (RT), respiratory rate (RR) and heart rate (HR), together with statistical significances relatively to time, between group A and B in comisana ewes

Parameters	15 July	26 July	06 Aug	17 Aug	28 Aug	08 Sept	19 Sept	30 Sept	11 Oct
Group A									
RT(°C)	39.26±0.20	39.12±0.20	39.45±0.44	39.08±0.30	39.21±0.25	39.55±0.34	39.57±0.34	39.33±0.31	39.20±0.27
RR (breaths min^{-1})	57.78±20.54	59.29±16.76	71.06±24.60$^{\Delta}$	53.65±15.71$^{\blacktriangle}$	54.00±15.15$^{\blacktriangle\bullet}$	71.50±22.12$^{\Delta\bullet}$	74.75±23.11$^{\Delta\bullet\dagger}$	54.75±12.33$^{\blacktriangle\square\blacksquare}$	48.75±10.73$^{\blacktriangle\square\blacksquare}$
HR (beats min^{-1})	88.28±10.45	96.71±11.82	88.35±18.89	100.00±15.46$^{\Delta\blacktriangle}$	95.00±15.00	93.50±11.47	95.75±15.73	93.75±10.97	97.75±8.67
Group B									
RT(°C)	39.37±0.24	39.37±0.21	39.06±0.30	39.08±0.38	39.56±0.29	37.92±6.98	39.41±0.42	39.31±0.16	39.27±0.17
RR (breaths min^{-1})	64.25±15.66	88.00±22.21$^{\Delta}$	67.33±19.61°	50.22±14.21$^{\Delta\circ\blacktriangle}$	74.22±24.86°	88.78±29.86$^{\Delta\blacktriangle\bullet\dagger}$	56.71±12.14$^{\dagger\square}$	55.87±8.41$^{\circ\dagger\square}$	53.81±10.57$^{\circ\blacktriangle\dagger\square}$
HR (beats min^{-1})	77.29±14.40	91.78±11.68$^{\Delta}$	86.22±9.72	99.33±20.41$^{\Delta\blacktriangle}$	108.00±14.71$^{\Delta\circ\blacktriangle}$	98.77±18.37$^{\Delta\blacktriangle}$	99.76±15.12$^{\Delta\blacktriangle}$	101.37±12.66$^{\Delta\blacktriangle}$	100.13±12.28$^{\Delta\blacktriangle}$

Significance: $^{\Delta}$vs 15 July, $p<0.0001$; $^{\circ}$vs 26 July, $p<0.0001$; $^{\blacktriangle}$vs 06 Aug, $p<0.0001$; $^{\bullet}$vs 17 Aug, $p<0.0001$; †vs 28 Aug, $p<0.0001$; $^{\square}$vs 08 Sept Aug, $p<0.0001$; $^{\blacksquare}$vs 19 Sept Aug, $p<0.0001$.

Table - 2: Average values (± SD) of glucose, triglycerides, total cholesterol and total lipid, together with statistical significances relative to time, between groups A and B in comisana ewes

Parameters	15 July	26 July	06 Aug	17 Aug	28 Aug	08 Sept	19 Sept	30 Sept	11 Oct
Group A									
Glucose ($mmol\ l^{-1}$)	2.84±0.34	2.79±0.48	3.20±0.47$^{\Delta\circ}$	3.49±0.45$^{\Delta\circ}$	3.35±0.47*$^{\Delta\circ\blacktriangle}$	2.89±0.45$^{\bullet\dagger}$	3.47±0.54$^{\Delta\circ\square}$	3.70±0.52$^{\Delta\circ\blacktriangle\square}$	3.76±0.53$^{\Delta\circ\blacktriangle\square}$
Triglycerides ($mmol\ l^{-1}$)	0.94±0.06	0.95±0.05	0.94±0.05	0.92±0.05*	0.92±0.06*	0.93±0.08	0.93±0.07*	0.95±0.06	0.96±0.06*
Total cholesterol ($mmol\ l^{-1}$)	2.31±0.19*	2.29±0.17*	2.32±0.19*	2.25±0.20*	2.28±0.20*	2.34±0.19	2.36±0.17*	2.36±0.13*	2.40±0.14
Total lipid ($mg\ dl^{-1}$)	322.72±3.79*	321.67±4.29*	322.39±4.49*	323.56±4.75*	322.44±4.72*	320.28±3.66*	321.28±3.98*	325.00±4.07*	322.56±5.03*
Group B									
Glucose ($mmol\ l^{-1}$)	2.65±0.45	2.46±0.50	2.97±0.53°	3.36±0.54$^{\Delta\circ\blacktriangle}$	3.07±0.54$^{\Delta\circ}$	2.75±0.46$^{\bullet}$	3.15±0.54$^{\Delta\circ\square}$	3.94±0.57$^{\Delta\circ\blacktriangle\bullet\dagger\square\blacksquare}$	3.61±0.45$^{\Delta\circ\blacktriangle\bullet\dagger\square\blacksquare}$
Triglycerides ($mmol\ l^{-1}$)	0.98±0.07	0.98±0.07	0.97±0.06	0.96±0.05	0.97±0.05	0.96±0.07	0.99±0.06	0.98±0.06	0.99±0.05
Total cholesterol ($mmol\ l^{-1}$)	2.49±0.24	2.48±0.22	2.47±0.23	2.42±0.21	2.46±0.19	2.46±0.20	2.48±0.16	2.51±0.14	2.49±0.16
Total lipid ($mg\ dl^{-1}$)3	345.94±4.17	346.33±4.31	346.33±4.59	349.44±4.73	342.72±4.92	345.28±3.99	347.06±3.44	348.33±3.58	349.00±4.06

Significance: *vs Group B, $p<0.05$; $^{\Delta}$vs 15 July, $p<0.0001$; $^{\circ}$vs 26 July, $p<0.0001$; $^{\blacktriangle}$vs 06 Aug, $p<0.0001$; $^{\bullet}$vs 17 Aug, $p<0.0001$; †vs 28 Aug, $p<0.0001$; $^{\square}$vs 08 Sept Aug, $p<0.0001$; $^{\blacksquare}$vs 19 Sept Aug, $p<0.0001$

2006), but over time reveals a significant effect probably due to the environmental conditions, particularly to high environmental temperature and to variable relative humidity levels. In hot climates, high ambient temperatures are the main environmental stressing factors that impose strain on animals (Silanikove, 2000).

All the energetic parameters were influenced by the housing system. The open-front barn provides a total degree of protection from sun direct radiations compared to the 80% offered by the net. Consequently the direct solar radiation could be responsible for the metabolic variations observed in group B ewes, according to other authors (Cascone *et al.,* 2005; Piccione *et al.*, 2004). These results also agree with those obtained by Piccione *et al.* (2006, 2008a, b) who observed a different trend in the energetic metabolic parameters after shearing both shearing and sheltering induce adaptive responses in the organism. In conclusion, our results confirm that different micro-environmental conditions can influence thermoregulatory mechanisms with effects on the productivity and on the welfare of ewes.

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