Effect of Heat Stress on Production in Mediterranean Dairy Sheep

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***Abstract** - Sicilian Valle del Belice dairy sheep were investigated with the following aims: 1) to establish the relationship between production and weather conditions using information from weather stations 2) to locate the heat stress point for dairy sheep and 3) to determine a heat stress function suitable for studying genetic tolerance against heat stress. The data consisted of 59,661 test-day records belonging to 6,624 lactations in 17 flocks. The traits investigated were daily milk and fat+protein yield. The two models shown, included the fixed effects flock × year of test-day, days in milk × parity-class, and furthermore maximum temperature and relative humidity or the temperature-humidity index (THI). Results shown pertain to daily productions and weather of the current and the preceding day. Milk and fat+protein production showed negative phenotypic correlations with maximum temperature of -0.36 and -0.38 for the current day and -0.35 and -0.38 for the preceding day respectively. Furthermore milk and fat+protein productions had positive correlations with relative humidity of 0.38 and 0.39 for the current day and of 0.39 and 0.41 for the preceding day respectively. Daily productions started to decline above a THI of 23. For THI≥23, phenotypic correlations of THI with milk and fat+protein production were -0.30 and -0.32 for the current day and of -0.28 and -0.31 for the preceding day respectively. The preceding day showed the highest decrease of production; in fact this resulted in a decrease of milk and fat+protein production of about -68.5g (-7%) and -9.1g (8%) respectively per unit of THI increase. These results indicate that Valle del Belice sheep, although originating from a hot environment, are affected by heat stress resulting in a decrease of production*

Introduction - European Mediterranean countries (Portugal, Spain, France, Italy and Greece) account for almost 11% of the world sheep population. World sheep milk production is estimated around 8,000,000 tons, quite a small amount compared to the almost 500,000,000 tons of milk produced by dairy cattle. Sixty-seven percent of all dairy sheep production is concentrated in the Mediterranean region, whereas the same area accounts for only 15% of the dairy cattle production (FAO, 1997). This shows the importance of dairy sheep production in the Mediterranean area. This area is also characterized by exposure to considerable heat between three and six months annually. High ambient temperature with high direct and indirect solar radiation, wind speed and relative humidity, cause the effective temperature of the environment to be above the thermo-neutral zone of the animals (5 to 25ºC; McDowell, 1972) and therefore heat stress occurs (Bianca, 1962; Finch, 1984; Hayes et al., 2003). Heat stress is one of the limiting factors in dairy production in hot climates (Johnson et al., 1962) and is hard to account for by management in the extensive grazing-based farming system of Mediterranean dairy sheep where animals are rarely kept indoors. In addition to milk quantity also milk quality might be affected. This is important considering that sheep milk production is mainly intended for cheese making. The interest of our study was to investigate if in the Mediterranean area heat stress has an effect on dairy sheep performance. Some studies (Ames et al., 1971; Lowe et al.,

2001; Sevi et al., 2001; Srikandakumar et al., 2003) on sheep heat stress investigated changes in rectal temperatures, respiration rates or volumes of air inhaled and other physiological functions. Unfortunately, such measurements are costly and not feasible on a large scale in practical farming circumstances, which leads to insufficient data quantity, especially for genetic studies. A novel approach was developed by Ravagnolo et al. (2000) where data from the national dairy cattle recording system was combined with weather information obtained from numerous weather stations across the state Georgia (USA). In the present paper the methodology of Ravagnolo et al. (2000) was applied to dairy sheep. The study was performed on Valle del Belice dairy sheep reared in the Sicily. The Valle del Belice dairy sheep were investigated with the following aims 1) to establish the relationship between production and weather conditions using information from a weather station 2) to locate the point at which heat stress starts for dairy sheep and 3) to determine a heat stress function suitable for studying genetic tolerance against heat stress.

Material and Methods - Data consisted of 59,661 test-day records belonging to 6,624 lactations of 4,428 lactating ewes in 17 flocks. Production information included daily milk production, milk fat content, and milk protein content. Subsequently daily fat plus protein (F+P) yield (g) has been calculated. The meteorological data set consisted of daily maximum temperature ($\mathbf{T}_{Max}$) and daily average relative humidity (RH). The temperature-humidity index (THI) has been calculated as proposed by Kelly and Bond (1971) by combining maximum temperature, in degrees Celsius, and average relative humidity. The THI is commonly used as an indicator for the degree of stress on animals caused by weather circumstances. In addition to the effects of the weather conditions of the current day also the preceding day has been considered. The two model applied, included the fixed effects flock × year of test-day, days in milk × parity class (1^{st}, 2^{nd} and $\geq 3^{rd}$), and $\mathbf{T}_{Max}$ and RH or THI, respectively.

Result and Discussion - Table 1 shows a summary of the basic statistics of the final data set.

Table 1: Description of production and weather data.

Daily measurement	Mean±SD	Range
Milk yield (g)	1361.3±703.3	200-4000
Fat+protein yield (g)	165.8±78.7	14-567
Maximum Temperature (^{o}C)	22.5±7.5	8.7-43.7
Average Temperature (^{o}C)	15.1±6.1	3.3-31.4
Minimum Temperature (^{o}C)	7.8±5.3	-3.7-24.0
Relative Humidity (%)	72.6±15.7	22.7-100.0
THI	20.7±5.5	9-32

Table 2 shows Pearson correlations between daily milk and fat+protein yield, the weather conditions including $\mathbf{T}_{Max}$, RH, and THI on the same and preceeding day.

Only days with heat stress (THI≥23) were considered. Above THI≥23 production started to decline. Milk and fat+protein productions always showed negative phenotypic correlations with $\mathbf{T}_{Max}$ and THI. In particular the same day showed more negative correlations in both daily milk and fat+protein production. Furthermore the production traits showed a positive phenotypic correlation with relative humidity. For THI≥23, phenotypic correlations with milk and fat+protein production were -0.30 and -0.32 respectively for the same day; and -0.28 and -0.31 for daily milk and fat+protein production respectively for the preceding day. These preliminary results indicate an effect of the weather conditions on dairy sheep performances. Further this confirms that weather stations can be useful for the detection of heat stress in dairy sheep production.

Table 2: Pearson correlations between daily milk and fat+protein (F+P) yield and the weather conditions including maximum temperature ($\mathbf{T}_{Max}$), average relative humidity (RH) and the temperature-humidity index (THI) on two days, including only days with heat stress (THI≥23).

			Same day			1 day lag		
	Milk	**F+P**	T_{Max}	**RH**	**THI**	T_{max}	**RH**	**THI**
Milk	**1**	0.93	-0.36	0.38	-0.30	-0.35	0.39	-0.28
F+P		**1**	-0.38	0.39	-0.32	-0.38	0.41	-0.31

Table 3 presents the coefficients of determination and the mean square errors for the model used in on the same and preceding day, for milk and fat+protein productions. Two data sets have been used, one considered the entire data with THI from 9 to 32, and a reduced data set with THI≥23, which was found to be the starting threshold for heat stress in Valle del Belice dairy sheep.

Table 3: Coefficients of determination (R^2) and mean square errors (MSE) for daily milk yield in Model 2 with THI (9-32) and THI≥23 in two days (Same day and 1-d lag).

	Daily milk yield (g)			
Model term	**9£THI£32**		**THI³23**	
	R^2	**MSE**	**R^2**	**MSE**
THI (Same day)	0.540	475.96	0.539	477.77
THI (1-d lag)	0.545	475.30	0.542	476.55
	Daily fat+protein yield (g)			
THI (Same day)	0.501	55.47	0.501	55.62
THI (1-d lag)	0.511	55.12	0.508	55.23

Figure 1 shows least square means for the entire data set (9≤THI≤32) for test-day milk and fat+protein productions, in the two days considered. All the curves show a similar shape for daily milk and fat+protein production; respectively, however it

seems that 1-d lag results in a smoother curve with less variability. The production appears to decline starting at THI=23.

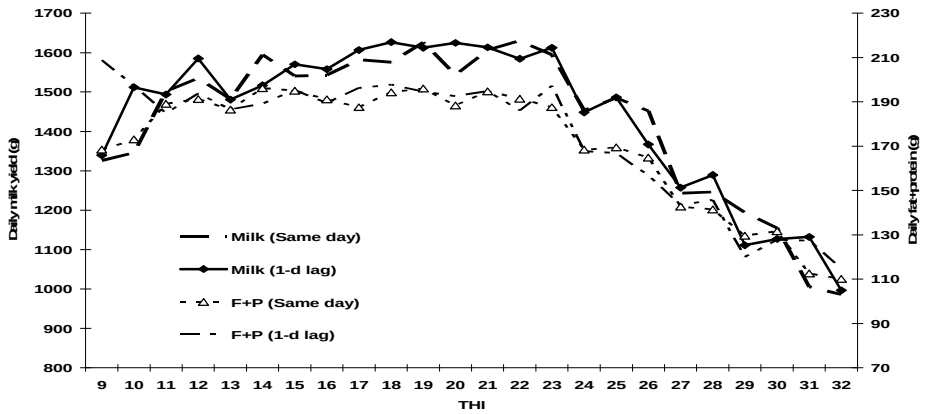

Figure 1: Relation between the daily milk and fat+protein yields and the temperature-humidity index (9≤THI≤32) for maximum temperature and average relative humidity in two days (Same day and 1-d lag).

Table 4 shows in detail the drops in production, both for daily milk and fat+protein yields for the two days considered. In particular 1 day lag showed to have a slighter higher drop of production. In fact it resulted, in a decrease of milk and fat+protein production of about -68.5g (-7%) and -9.1g (-8%) respectively per unit of THI increase above 23. These results indicate that Valle del Belice sheep, although originating from a hot environment, are affected by heat stress resulting in a decrease of production. In contrast, Sevi and colleagues (2001) reported heat stress for the Comisana dairy breed sheep starting at THI≥27.

Table 4: Production decline per unit of THI (THI≥23) in the same and the previous day analysed for daily milk and fat+protein yields.

	Daily milk yield (g)	**Daily fat+protein yield (g)**
THI (Same day)	-67.6 (-7 %)	-8.6 (-8 %)
THI (1-d lag)	-68.5 (-7 %)	-9.1 (-8 %)

References

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