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Preliminary Findings On Seasonal Heat Stress Of Sheep

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Abstract. *This paper studies the heat stress conditions imposed onto sheep housed in a naturally ventilated sheep barn during the four seasons of a year. The barn is located near the east coast of central Greece. Heat stress is assessed by means of the hourly temperature-humidity index (THI). The analysis shows that animals were exposed to heat stress in 11%, 80% and 17% of spring, summer and autumn hours, respectively, whereas no heat stress was identified during winter. As expected, animals are more prone to severe heat stress during summer, as the daily maximum hourly values of THI remained higher than the extreme severe heat stress threshold (i.e. THI = 25.6) in 90% of the summer days. Additionally, THI remained higher than 25.6 during the vast majority of the summer daytime hours. Measures have to be taken so as to improve the indoor climate conditions and to alleviate animal's heat stress.*

Keywords. Welfare, heat stress, sheep, sheep barn, temperature-humidity index

Introduction

Climate conditions within a livestock building affect animal health and welfare. An inadequate thermal environment can affect the incidence and severity of certain endemic diseases, the animals' thermal comfort and growth rate, and the milk yield, while it can influence indoor air pollution levels (Seedorf et al., 1998; Seinfeld and Pandis, 1998). It is well documented (Thwaites, 1985) that a combination of high ambient temperatures and high relative humidity is unsuitable to sheep. As heat stress affects the body growth, the biological functions and the productive and reproductive characteristics of sheep (Sevi et al., 2001, 2002), it is considered as a serious threat for their thermal welfare. Additionally, the economic importance of the sheep sector must be pointed out, as Greece is included among the main producers of sheep milk and meat in European Union (EU), accounting for the 10% of the total EU production (Theocharopoulos et al., 2007).

This study aims at investigating seasonal heat stress imposed onto sheep housed within a naturally ventilated barn having no thermal insulation.

Material and Methods

Facilities and animals

The barn (fig. 1) is located 91 m above sea level near the east coast of central Greece (latitude 39^{o} 20´ N, longitude 22^{o} 53´ E). It occupies an area of 879 m^2 and a volume of 4,777 m^3 and has an N-S orientation. As it is shown in figure 1b, there are two big doors at the south and the north wall of the building (D1 and D2; fig. 1b) and six smaller doors at its east and west wall (D3 – D8; fig. 1b). The dimensions (width × height) of D1 and D2 are 4.25 × 4.6 m, of D3 are 0.9 × 1.89 m, while the width of D4 – D8 is 1.7 m and their height ranges between 1.85 and 2.05 m. Additionally, there are 10 west and five east windows. The dimensions of every window are 4.6 x 1.85 m, except W1 and W2 (only these are marked in fig. 1b), which are 0.2 m narrower. There is no ridge opening. The control of ventilation rate was performed manually by the simultaneous opening and closing of openings, through which the air exhausts. Approximately 500 sheep were housed. A detailed description, as well as an analysis of the indoors climate conditions are provided by Papanastasiou et al. (2011).

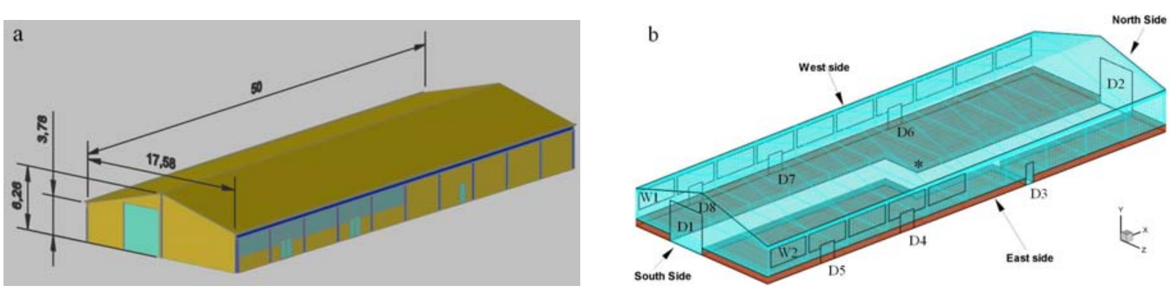

Figure 1. Description of the sheep barn: barn's dimensions (a) and positions of ventilation openings (b) (Papanastasiou et al., 2011). In (b): D and W stand for doors and windows, respectively.

Data

A miniature device (model Hobo Pro, Onset, USA) was used to monitor air temperature and relative humidity inside the sheep barn. Mention of trademark is for information purposes only, no endorsement implied. The device was placed in a white plastic shield with lateral slots for protection, which was fixed at ~1.5 m above the ground in the middle of the building. The measuring point is marked with an asterisk (*) in figure 1b. Climatic variables were observed every 15 min from 14 August 2008 to 29 July 2009. Hourly averaged values are used in the present analysis.

Sheep heat stress assessment

Heat stress is assessed by means of the hourly temperature-humidity index (THI) (Marai et al., 2007; Panagakis and Chronopoulou, 2010). THI combines two climatic variables as input, namely dry-bulb temperature (T, in ^{o}C) and relative humidity (RH, in %) (eq. 1). Four heat stress categories, presented in table 1, are defined (Marai et al., 2007).

$$THI = T - (0.31 - 0.0031 \cdot RH) \cdot (T - 14.4) \quad (1)$$

Table 1. Heat stress classes as defined by THI values

THI value	Heat stress condition
THI < 22.2	absence of heat stress
22.2 ≤ THI < 23.3	moderate heat stress
23.3 ≤ THI < 25.6	severe heat stress
THI ≥ 25.6	extreme severe heat stress

Results and Discussion

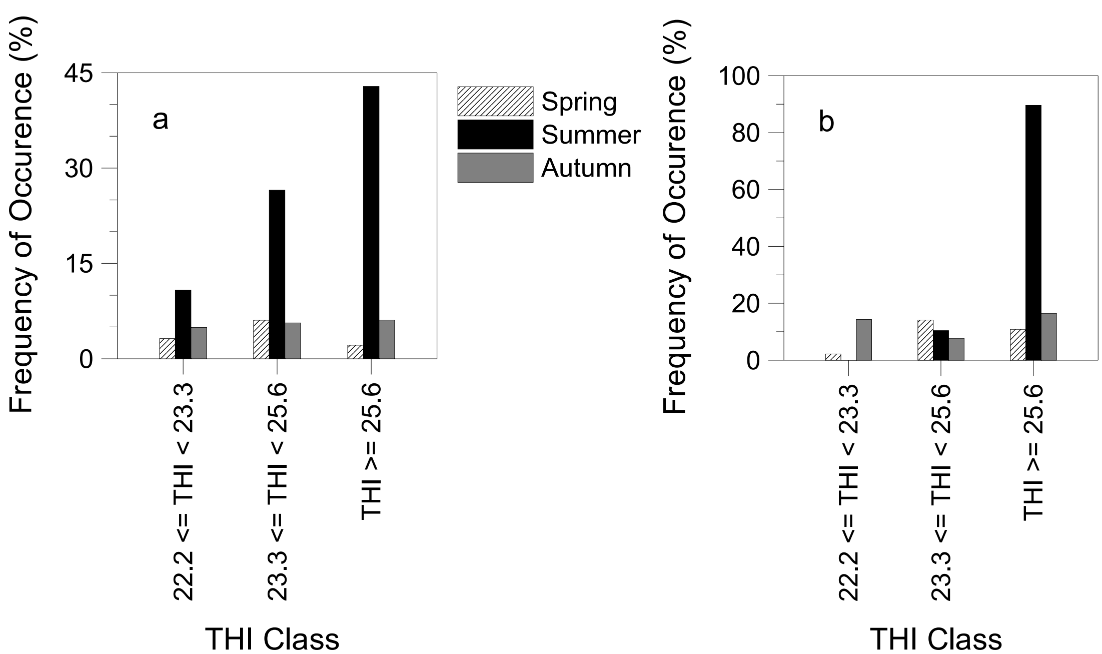

Figure 2. Frequency of occurrence (%) of THI classes. Figure 2a refers to the hourly THI values, while figure 2b refers to the daily maximum hourly THI values.

The analysis of the THI values revealed that animals were exposed to seasonal heat stress, which greatly varied between winter and summer. The THI ranged from 28.2 to 7.7, 32.7 to 16.6, 29.3 to 9.8 and 20.9 to 6.1 during spring, summer, autumn and winter, respectively, whereas the corresponding mean values were 16.9, 25.0, 18.4 and 13.0. Figure 2a shows that heat stress (THI ≥ 22.2) was identified in 11%, 80% and 17% of spring, summer and autumn hours, respectively, whereas no heat stress was present during winter. Furthermore, severe heat stress (THI ≥ 23.3) was identified in 8%, 69% and 12% of spring, summer and autumn hours, respectively. Figure 2b refers to the daily maximum hourly values of THI. Figure 2b reveals that animals experienced extreme severe heat stress (THI ≥ 25.6) in 11%, 90% and 16% of spring, summer and autumn days, respectively. It is worth mentioning that the minimum daily maximum hourly THI value that was observed during summer was 24.3, a fact that shows that during all summer days sheep experienced severe heat stress (THI ≥ 23.3).

The average diurnal variation of THI during the four seasons is presented in figure 3. It is obvious that during summer, THI dropped below the heat stress threshold (i.e. 22.2) only between 03:00 h to 07:00 h, while it remained higher than the extreme severe heat stress threshold (i.e. 25.6) during almost all daytime hours (10:00 h – 21:00 h). Additionally, figure 3 shows that the difference between the higher and the lower THI value within a day is higher during summer than during the other seasons, its average value being 6.4.

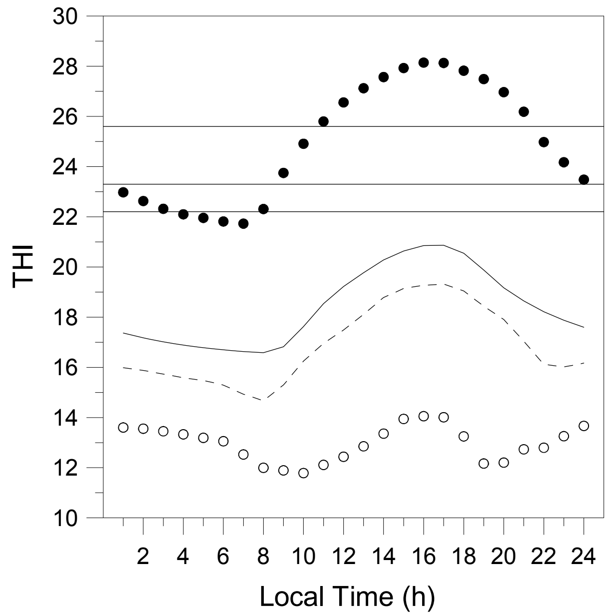

Figure 3. Average diurnal variation of THI classes. Black circles: summer; solid line: autumn; dashed line: spring; white circles: winter. The horizontal solid lines correspond to THI thresholds (i.e. 22.2, 23.3 and 25.6)

It is evident that under summer conditions animals are apparently exposed to severe heat stress potentially burdening their welfare, whereas because of the lack of thermal insulation animals were partially exposed to severe heat stress during autumn and spring. The situation will probably be worse in the future as the summer temperatures are expected to rise due to climate change. Additionally, heat waves are more frequently observed during the last decades and their duration exhibits an increasing trend (Papanastasiou et al., 2012). The above results call for protective measures so as to improve the indoor climate conditions and consequently, to improve animals' thermal comfort. These measures can include interventions to the barn, as well as short- and long-term actions. The roof of the building could be painted with white reflective die in order to reduce the absorption of solar radiation. Additionally, the building shell could be thermally insulated so as the indoor thermal microenvironment is not significantly affected by the outdoors climate conditions. Moreover, short-term actions could be adopted, such as fogging during strenuous conditions, which could maintain indoor temperature and relative humidity within acceptable limits. Furthermore, long-term actions, which require detailed preliminary design and obviously are more expensive and inconvenient, could be planned, such as the change of building's orientation to E-W. Finally, concentrated international research is required to update current engineering approaches and to explore novel solutions aiming to achieve efficient control of the thermal environment in livestock buildings under climate change conditions (Kuczynski et al., 2011).

Conclusions

This study investigated the seasonal heat stress of sheep, which are housed in a barn located near the east coast of central Greece. The ventilation of the barn is natural and is applied manually, while the barn is not thermally insulated. The analysis of the hourly values of the temperature-humidity index revealed that animals were prone to severe heat stress during most of the summer daytime hours. Heat stress was also identified during spring and autumn but to a much less degree, while no heat stress was identified during winter. The results of this study underline the need to improve the indoor climate conditions by implementing short- and long-term interventions in order to ameliorate animals' thermal comfort, taking also into account the climate change conditions.

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