Spraying effects on some physiological and behavioural traits of goats in a subtropical climate

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ABSTRACT

Heat stress is one of the major factors adversely affecting animal welfare and thus economic benefits of farms. This study was designed to determine the effects of two different spraying methods on goats exposed to high air temperatures. Thirty goats were divided into three groups for the trial (sprayed once per day, OTS; sprayed twice per day, TTS; and non-sprayed, Controls). Respiration and pulse rates, rectal and surface temperatures (from head and udder skin) were taken three times a day (08.00 - 09.00; 16.00 - 17.00 and 00.00 - 01.00) on hot summer days in July 2005 in a Mediterranean climate. Some behavioural aspects such as eating, ruminating, drinking, walking and resting, and daily feed and water consumption were regularly measured. Rectal temperatures, pulse and respiration rates, udder and head temperatures differed between the three groups. Rectal, head and udder temperatures and respiration and pulse rates increased at 16.00 relative to 08.00, and at 00.00 had returned to the same level as at 08.00. TTS goats showed smaller increases in all physiological measurements at 16.00 than the other groups. TTS goats spent more time than OTS and Control goats eating (P=0.002), ruminating (P=0.032) and walking (P=0.021), but less time drinking (P=0.041) and lying (P=0.001). TTS goats consumed more concentrate feed (P=0.001) and alfalfa hay (P=0.024) than the other two groups, whereas Control goats consumed more water (P=0.003) than the other groups. Ultimately, the spraying had positive effects on yearling goats for alleviating heat stress and improving animal welfare.

Key words: Goat, Thermal stress, Spraying, Animal behaviour, Physiological features.

RIASSUNTO

EFFETTI DELLA NEBULIZZAZIONE SULLA FISIOLOGIA E IL COMPORTAMENTO NELLE CAPRE IN CLIMA SUB-TROPICALE

Lo stress da caldo è uno dei fattori principali che influisce negativamente sul benessere dell’animale e quindi anche sul reddito dell’allevamento. Questo studio è stato condotto al fine di determinare gli effetti di due diversi metodi di nebulizzazione su capre esposte a temperature elevate. Lo studio è stato eseguito su 30 animali divisi in tre gruppi: nebulizzati 1 volta al giorno OTS; nebulizzati 2 volte al giorno TTS; privi di nebulizzazione: gruppo di controllo. In giornate calde estive del Luglio 2005 in un clima mediterraneo sono stati registrati tre volte al giorno (08.00 - 09.00; 16.00 - 17.00 e 00.00 - 01.00) i seguenti parametri: frequenza respiratoria, frequen-
Introduction

Heat stress in animals causes decreases in feed intake and efficiency; in extreme cases, it can even cause death. These losses amount to millions of dollars each year. A subsequent analysis of the death losses was performed to identify the risk factors attributed to loss of the individual animals (Brown and Brandl et al., 2006).

Alleviation of the heat load by providing suitable feeding, housing and management could help heat-stressed animals to express their genetic potentialities in tropical and subtropical areas (Abdel and Samee et al., 1992). There are several means available to reduce heat stress on livestock. Providing plenty of clean and available water, enough shaded areas and good ventilation should be routine. These areas are the first to concentrate on if a heat stress problem is evident in the herd. Some types of cooling systems can be considered after the more routine practices have been managed (Collier et al., 2003; Turner et al., 2004). Housing and management technologies that can reduce climatic impacts on livestock are available, but the rational use of such technologies is crucial for survival and prof-

ity of the livestock enterprise (Hahn et al., 2003).

The most economical cooling method is evaporative cooling using spray jets or mini sprinklers and fans (Turner et al., 2004). Darcan and Guney (2002) reported that the economic benefits of spraying were estimated at 2.56 USD for each kid during the fattening trial in hot and humid conditions in a subtropical Mediterranean climate. From the point of view of barn ventilation and spraying management, July and August are difficult periods of the year in the east Mediterranean region of Turkey because of frequent significant changes in air temperature and relative humidity. This study was designed to determine the effects of two spraying regimes on cross-bred goats in order to decrease heat stress. Therefore, the objective of this initial study was to evaluate strategies aimed at helping cross-bred goats to cope with hot climates under Mediterranean climate conditions.

Material and methods

Thirty cross-bred dairy goats (75% German Fawn +25% Hair) were studied in the Dairy Goat Research Farm of Cukurova
University, located in Adana Province in the east Mediterranean region of Turkey. The principal climatic characteristic of Adana Province is high air temperature and humidity in the summer season. The average daily temperature was 34.2°C, while the highest and lowest temperatures were 42°C and 23.1°C in July, respectively. Average relative humidity and wind speed were observed as 68.2% and 1.2 km/h during the trial, respectively. The climatic data such as air temperature, relative humidity and Thermal Heat Index (THI) of each of the experimental pens during the fattening trial were given in Table 1.

Thirty maiden one and a half year old goats were randomly allocated into three equal groups as one time sprayed (OTS), two times sprayed (TTS) and non-sprayed control groups (C) during the experimental period. Every two goats were kept in pens of 1.30 m x 1.30 m. The first group (Group OTS) was sprayed once a day (from 11.00 to 12.00), the second group (TTS Groups) was sprayed twice a day (at 10.00 – 11.00 and 14.00 – 15.00) while the third group was not sprayed (C). The Kentucky system was performed for cooling (Bucklin et al., 1991). Parallel sprinkler pipelines were mounted 2 m above the ground. In total, 24 sprinklers supplied 2.5 litres water/min. Two axial fans were mounted (45 cm diameter) in the middle of the paddocks for experimental goats. Every day at the same time, the goats were allowed to pass the open side of the paddock where sprinkler pipelines were mounted. All goats were forced to be sprayed for one hour. Then, they were put back into their pens.

The physiological data (rectal temperature, respiration and pulse rates, and skin temperatures from head and udder) were recorded at morning 8.00 – 9.00; midday; and midnight 24.00 – 01.00. Rectal temperatures were detected by digital thermometer, and the respiration and pulse rates were recorded using a stethoscope. Skin temperatures were measured via infrared thermometer (Testo BP-960) at a distance of 10 cm from the head and udder skin. Additionally, daily food consumptions were detected, and some of the activities of these animals were observed and classified, such as eating, ruminating, drinking, resting, walking and others. “Others” includes such

| Traits             | Hours        | Average values |
|--------------------|--------------|----------------|
| Air temperature    | 08.00–09.00  | 32.25 ± 0.16   |
|                    | 18.00–19.00  | 36.15 ± 0.21   |
|                    | 00.00–01.00  | 34.23 ± 0.12   |
| Relative Humidity  | 08.00–09.00  | 61.88 ± 0.56   |
|                    | 18.00–19.00  | 67.43 ± 0.98   |
|                    | 00.00–01.00  | 64.89 ± 0.56   |
| THI                | 08.00–09.00  | 84             |
|                    | 18.00–19.00  | 89             |
|                    | 00.00–01.00  | 86             |
activities as playing and examining, which are less significant. Behavioural observations were recorded for 24 hours, twice a week, by portative camera system linked directly to a computer. All animals were subjected to group fed feeding on concentrate (12% crude protein and 2300 kcal/kg ME), corn silage, alfalfa hay and oats. The experiment lasted 32 days; from 1 July to 1 August 2005. Panting behaviour of the goats was observed as well. Panting score is an effective management tool to assist in the assessment of stress levels due to heat in grain fed cattle, and should be used as part of summer management. It has the potential to be used in the assessment of the welfare status of animals (Gaughan, 2003).

The panting scores were assigned on the basis of visual observation of behaviour. A description of panting scores is given in Table 2 (Brown-Brandl et al., 2006).

At the end of the experiment, rectal temperature, udder and head skin temperature data were analysed using the following model, a completely randomised block design; \( \hat{Y}_{ijk} = \mu + \alpha_i + \beta_j + \alpha\beta_{ij} + e_{ijk} \); where, \( \hat{Y}_{ijk} \): observed value, \( \mu \): mean of population, \( \alpha_i \): the effects of treatments, \( \beta_j \): the effects of time, \( \alpha\beta_{ij} \): the effects of interaction, and \( e_{ijk} \): residual error. The differences were tested using Duncan’s Multiple Range Test (SPSS 10.0 version, 1999). Respiration and pulse rates were analysed using Friedman’s test, and any significant findings were further subjected to post-hoc pair-wise comparisons performed by Dunn’s Test.

**Results and discussion**

Mean diurnal rectal, udder skin and head skin temperatures, pulse and respiration rates, and panting score of experimental goats were indicated in Table 3. There were no significant differences between groups regarding rectal, head and udder temperatures of morning records (P > 0.05). TTS and OTS goats had significantly lower respiration, pulse rates and panting score than Control goats (P < 0.05). However, there were significant differences between udder, head and rectal temperatures, pulse and respiration rates, and panting scores in afternoon and midnight measurements of the experimental goats (P < 0.05). Non-cooled (Control) goats tended to have higher rectal, head and udder temperatures, respiration and pulse rates, and panting score than that of cooled goats in the afternoon and midnight hours of the day. Interaction effects of groups and times were found to be significant in rectal, head and udder temperatures, panting score, respiration and pulse rates (P < 0.05), as well. Rectal, head and udder temperatures, panting score, respiration and pulse rates of TTS were much lower among the three groups.

**Table 2.** Description of panting scores (Brown-Brandl et al., 2006).

| Score | Description |
|-------|-------------|
| 0     | Normal respiration, 60 or fewer breaths/min. |
| 1     | Slightly elevated respiration, 60–90 breaths/min. |
| 2     | Moderate panting and/or the presence of drool or small amount of saliva, 90–120 breaths/min. |
| 3     | Heavy open-mouthed panting, saliva usually present, 120–150 breaths/min. |
| 4     | Severe open-mouthed panting accompanied by protruding tongue and excessive salivation. |
Table 3. The average measurements and daily trends for physiological parameters.

| Parameters          | RT (°C)          | HT (°C)          | UT(°C)          | RR (Per/min.) | PR (Per/min.) | Panting Score |
|---------------------|------------------|------------------|-----------------|---------------|---------------|---------------|
| Control             |                  |                  |                 |               |               |               |
| 08.00-09.00         | 38.77 ± 0.04     | 34.48 ± 0.19     | 34.72 ± 0.08    | 46.68 ± 2.00  | 57.26 ± 1.11  | 1.25 ± 0.03   |
| 16.00-17.00         | 39.65 ± 0.08     | 37.50 ± 0.17     | 37.29 ± 0.18    | 54.40 ± 2.12  | 65.20 ± 1.87  | 2.00 ± 0.03   |
| 24.00-01.00         | 39.37 ± 0.07     | 32.60 ± 0.34     | 33.34 ± 0.10    | 47.60 ± 1.31  | 58.50 ± 1.04  | 1.00 ± 0.02   |
| OTS                 |                  |                  |                 |               |               |               |
| 08.00-09.00         | 38.51 ± 0.05     | 34.74 ± 0.18     | 34.94 ± 0.24    | 44.48 ± 0.79  | 56.08 ± 1.03  | 1.00 ± 0.01   |
| 16.00-17.00         | 39.10 ± 0.07     | 36.79 ± 0.16     | 37.26 ± 0.14    | 51.14 ± 0.74  | 63.19 ± 1.45  | 1.25 ± 0.01   |
| 24.00-01.00         | 38.63 ± 0.05     | 31.72 ± 0.20     | 32.63 ± 0.27    | 41.88 ± 0.53  | 55.49 ± 1.08  | 0.04 ± 0.01   |
| TTS                 |                  |                  |                 |               |               |               |
| 08.00-09.00         | 38.70 ± 0.04     | 34.66 ± 0.17     | 34.82 ± 0.15    | 43.06 ± 1.31  | 55.70 ± 0.95  | 0.99 ± 0.03   |
| 16.00-17.00         | 38.93 ± 0.06     | 34.94 ± 0.17     | 36.78 ± 0.20    | 48.00 ± 1.32  | 61.87 ± 1.11  | 1.06 ± 0.02   |
| 24.00-01.00         | 38.73 ± 0.05     | 31.67 ± 0.13     | 32.71 ± 0.12    | 39.76 ± 1.20  | 54.22 ± 1.01  | 0.02 ± 0.01   |
| SEM                 | 0.053            | 0.214            | 0.192           | 0.431         | 0.468         | 0.023         |
| Treatment           | **               | ns               | ns              | **            | **            | **            |
| Time                | **               | ns               | ns              | **            | **            | **            |
| Interaction (Tr. x time) | *          | *               | *               | *             | *             | *             |

1: Differences were illustrated on treatments for RT, RR and PR as a, b, c.
2: Differences were illustrated on time for HT, UT, RR and PR as a, b.
*: P < 0.05, **: P < 0.01, ns: not significant.

RT: Rectal temperature, HT: Head skin temperature, UT: Udder skin temperature, RR: Respiration rate, PR: Pulse rate.
Rectal temperature is an important indicator of thermal balance and might be used to evaluate the impact of heat stress (Spiers et al., 2004). Rectal temperatures of Control goats increased rapidly until afternoon (almost +1°C) and slightly decreased at midnight, while OTS and TTS increased between 0.2 – 0.5 at day time and returned to morning levels at midnight time. The TTS and OTS goats maintained their rectal temperatures during the day while Control goats' midnight rectal temperatures were recorded +0.6°C more than morning measurements. Head and udder temperature of Control goats increased until afternoon (+3.2 and +2.5) and returned to normal level at midnight hours. The trends of skin temperatures of cooled goats were recorded almost the same. However, the head and udder temperatures of both cooled goats were significantly lower than non-cooled ones (P<0.05). The udder temperatures were increased more than the head temperatures for morning measurements in all groups. This observation may be attributed to surface radiation effects of the earth, because the goats are subjected to heat the whole day by way of both convection and radiation. These data demonstrated that spraying application minimizes the effect of increasing air temperatures during the day and non-cooled goats would suffer from heat stress. Silanikove (2000) and Avendano-Reyes et al. (2006) reported that the homoeothermic ability of dairy goats starts to be compromised when the Thermal Heat Index (THI) exceeds 80%. Silanikove (2000) reported that, McDowell et al. (1976) suggested that the THI is a good indicator of stressful thermal climatic conditions. THI values of 70 or less are considered comfortable, 75 – 78 stressful, and values greater than 78 cause extreme distress and animals are unable to maintain thermoregulatory mechanisms or normal body temperature. Based upon the THI values, the goats were subjected to stressful conditions (i.e. 84 to 89, see Table 1) in this experiment. According to Avendano-Rayes et al. (2006), Yousef (1985) reported that increased body temperature is a normal mechanism by which animals diffuse heat from their bodies to maintain thermoregulation in hot ambient conditions. In the present experiment, the rectal temperatures of the control groups exceed over 39°C. Only goats can maintain their rectal temperatures below 38.5°C, which is considered as normal (Devendra, 1987; Avendano-Reyes et al., 2006). It can be suggested that the non-cooled goats were affected by high ambient temperatures more than cooled goats, because it is impossible to maintain normal body temperature in such conditions.

During morning measurements, respiration and pulse rates were found to be similar in cooled and non-cooled goats, while the difference was higher in the Control group for afternoon measurements. However, respiration rates of the goats were detected as similar at night in all groups. The differences between morning and afternoon respiration rates exceed 5-8 units among the three groups, whereas diurnal difference varied by 10-18 units of breaths. In spite of increasing environmental temperatures in the daytime, there were no significant changes regarding diurnal respiratory rates in sprayed goats. A recent study (Darcan, 2000) showed that under the same conditions, the pulse and respiration rates increased when the ambient temperature rose up to 30°C and the differences between morning (06.00 - 07.00) and afternoon (18.00 - 19.00) pulse and respiration rates of the goats were found to be almost 20-65 breaths. Basal
respiration rate is about 25-30 breaths per min. (Silanikove, 2000) and basal pulse rate is about 65-80 beat per min. (Devendra, 1987) in goats. Breath rate measurement can provide reliable and practical information in estimating the severity of heat stress for farm animals (low: 40–60 breaths per min.; medium high: 60-80 breaths per min.; high: 80-120 breaths per min.; and severe heat stress above 150 breaths per min.) (Silanikove, 2000). In the present experiment, cooled goats had shown normal panting values (65 to 73 breaths per min.) while goats of the Control group had high respiration rates (82 breaths per min.) in afternoon measurement. This response was further emphasized during the peak ambient temperature of the day time when compared to the night-time (Al-Tamimi, 2007). The cooled animals had normal rates as a result of the shower.

The panting scores are used especially for cattle. However, they can be useful for goats; these results indicate that non-sprayed goats were stressed more than the other two groups, which might indicate that they were stressed in an extreme temperature situation. Considering the average daily panting score, significant differences were detected between experimental groups (P<0.01). The daily panting scores of TTS goats were more satisfying compared to the other groups. Both panting score and respiration rate showed that the TTS goats had less stress in the daytime than that of the other groups. Panting scores obtained from sprayed goats showed an increase in daytime and turned to morning levels at midnight. As to Control, these values were invariably higher than those of sprayed ones. Especially in daytime measurements, panting scores were found to be at their highest in Control, as well. All groups had the same trend in panting score during a day. Silanikove (2000) similarly states that as the temperature drops below 21°C for 6 - 7 hours between 22.00 - 05.00, the animal has sufficient opportunity to lose at night all the heat gained from the previous day. This is the reason of lower physiological data of midnight hours.

As indicated in Table 4, TTS goats spent more time than OTS and Control goats during the activities of eating (P=0.002), ruminating (P=0.032) and walking (P=0.021) but less time drinking

| Table 4. Daily activities and daily feed and water consumptions of experimental goats. |
|-----------------------------------------------|-----------------|-----------------|-----------------|-----|
| Traits            | TTS             | OTS             | Control         | P   |
| Eating hr/day     | 3.4±0.6a        | 2.8±0.2ab       | 2.3±0.6b        | 0.002 |
| Ruminating        | 4.8±0.2a        | 4.2±0.6a        | 3.2±0.7b        | 0.032 |
| Drinking          | 1.5±0.4b        | 1.8±0.4a        | 2.7±0.3a        | 0.041 |
| Walking           | 7.1±0.6a        | 5.9±0.3b        | 5.5±0.5b        | 0.021 |
| Lying             | 6.4±0.4b        | 7.8±0.8a        | 8.5±0.5a        | 0.001 |
| Others            | 0.8±0.7b        | 1.5±0.3a        | 1.1±0.3ab       | 0.035 |
| Concentrate consumption g/day      | 983.3±12.9a     | 876.4±10.9a     | 678.5±12.9b     | 0.001 |
| Hay consumption   | 1116.7±9.8a     | 978.9±7.2ab     | 870.2±16.1b     | 0.024 |
| Water consumption | 450.9±6.1b      | 570.3±11.0b     | 890.5±8.9a      | 0.003 |
(P=0.041) and resting (P=0.001). During heat stress, eating and resting behaviours decreased, whereas drinking and standing behaviours increased. Spraying had positive effects on activities and feeding behaviour of goats. During heat stress, eating behaviour (21 - 48%), ruminating (31 - 50%) and walking (7 - 33%) decreased, while drinking (50 - 80%) and lying (18 - 43%) increased. During hot weather, farm animals tend to reduce their activity during the day (Silanikove, 2000). Our findings seem to match reports from Brown-Brandl et al. (2006) and Silanikove (2000).

Mitlöhner et al. (2002), reported that multiple behavioural adaptive mechanisms play a major role, including, but not limited to, seeking of shade and cooler surfaces, change in posture and reduced muscular activity in addition to changing the pattern of feed and water intake (Al-Tamimi, 2007). Yousef (1985) also reported that in the standing animal, conductive heat loss is minimal because of the presence of a layer of air against the skin, which means that most of the heat transfer in the animal takes place to air, and air has a poor thermal conductivity (Silanikove, 2000). Furthermore, in a standing animal, transfer of heat to the ground only takes place through the feet with a small area of contact, and in animals the distance between the blood vessels and surface is much greater in the feet than it is the skin (Silanikove, 2000). As seen in Table 4, Control goats were lying more than the cooled goats. They were attempting to increase the heat dissipation by conduction. The high ambient temperatures push the efforts of animals like goats to dissipate the extra heat load, resulting in the increase of respiration rate, rectal temperature and water consumption while feed intake decreases. According to Beede and Collier (1986), the water requirement of the animal was highly influenced by the demands of maintaining homeothermy during heat stress. At this time, the water requirement of animals increases, leading to more frequent drinking in response to rising ambient temperatures. Also, Albright and Alliston (1972) reported that heat stress caused the rostral cooling centre of the hypothalamus to stimulate the medial satiety centre which inhibits the lateral appetite centre, resulting in reduced dietary intake (Silanikove, 2000). Our findings matched the above-mentioned findings. The daily feed and water consumption of experimental goats were also given in Table 4. Significant changes between the groups were ascertained in terms of feed and water consumptions. TTS goats consumed more concentrate feed (P=0.001) and alfalfa hay (P=0.024) than the other two groups, while Control groups consumed more water (P=0.003) than the others.

**Conclusions**

The studies concerning the effects of the cooling methods on physiological and behavioural aspects were limited in goats. Especially climatic changes resulting in elevated ambient temperatures during the last decade require specific solutions for cooling farm animals. Among domestic ruminants, goats are best adapted to hot ambient conditions. Thus, the present study provides some basic clues on the cooling strategy of the goats raised in a hot and humid region. It was found that non-cooled goats had higher physiological traits, and behaviour observations revealed that non-cooled goats decreased eating and walking while increasing water consumption and lying behaviour. This shift in behaviour, along with the physiological data, indicates that non-cooled goats are more stressed under hot climate...
conditions, and the current experiment, offering spraying to goats, represents an efficient tool to dissipate heat loads. Especially spraying goats twice resulted in better performances than that of the once-sprayed and non-sprayed goats. We could suggest that under hot weather conditions spraying has positive effects in alleviating heat stress and improving goat welfare. It should be performed at least once a day to maintain the comfort of dairy goats.

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