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ORIGINAL ARTICLE

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Evaluation of different shades to improve dairy cattle well-being in Argentina

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Abstract Two tree shades (TS1 and TS2) and an artificial shade structure (AS) were evaluated using black globe temperatures (BGTs) to assess their effectiveness in reducing heat load. The artificial structure consisted of a black woven polypropylene cloth providing 80% shade, mounted on 2.5-m-high eucalyptus posts. The work was carried out at Rafaela Experimental Station, Argentina, during the summer (January and February) 1994. BGTs and floor temperatures were measured in concrete floor holding pens with and without artifical shade. The results showed no difference between TS1, TS2 and AS, their average BGTs being 30.2 (SD 0.58), 29.0 (SD 0.70) and 30.2 (SD 0.74)°C, respectively. BGTs under all three shades were significantly lower (P<0.01) than the average BGT recorded outside: 35.5 (SD 1.12)°C. Average BGTs in holding pens were 32.4 (SD 1.38) and 39.9 (SD 1.91)°C for shaded and non-shaded areas (P<0.01). The corresponding average floor temperatures were 27.8 (SD 0.68)°C and 47.7 (SD 2.13)°C (P<0.01). To assess the effects of shade on animal well-being, afternoon rectal temperatures (RT) and respiratory rate (respirations per minute, RR) of lactating cows were recorded twice a week. Rectal temperatures were significantly higher for non-shaded cows (P<0.01), mean RT being 40.1 (SD 0.65)°C vs 39.3 (SD 0.42)°C for the shaded animals. Corresponding RRs were 78.9 (SD 18.0) and 60.7 (SD 10.6) (P<0.05). It was concluded that: (1) tree and artificial shades produced similar effects, (2) shading the holding pen with an 80% shading cloth was effective in reducing heat load and floor temperatures, and (3) access to shade in our pasture-based system improved animal well-being.

Key words Dairy cows · Floor temperature · Black globe temperature · Animal well-being

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Introduction

Homeothermic animals maintain their thermal equilibrium with the environment through heat transfer processes as determined by radiation, wind speed and air temperature and humidity (Buffington et al. 1981; Armstrong 1994). In hot weather, heat stress occurs if equilibrium is not achieved, thus provoking production declines (Fuquay 1981; Morrison 1983; Davison et al. 1988) and reproductive failures (Stott and Williams 1962; Vicentini et al. 1991).

The main radiation source is the sun, emitting high energy thermal radiation, thus usually becoming the most important route for heat gain by animals kept outside.

The objectives of the present work were to evaluate the effectiveness of different kinds of shade to improve comfort characteristics in the field, to determine the effects of an 80% shading material in the holding pen, and to assess the impact of shade management on well-being of dairy cows in a pasture-based feeding system.

Materials and methods

The work was conducted in the experimental dairy unit at Rafaela Experimental Station, National Institute of Agricultural Technology (INTA), Santa Fe, Argentina, during January and February 1994. Rafaela Experimental Station is located at 31°11′ S latitude and 61°33′ W longitude, in the most important industrial milk supply area of Argentina. Average and maximum temperatures for the hottest months (December – January – February) are 25.0° C and 31.3° C, respectively, while mean relative humidity reaches 72%.

Twice a week from 0900 to 1900 hours black globe temperatures (BGTs) were recorded every 2 h under two elm tree shades (TS1 and TS2) and under an artificial shade structure (AS) built in a pen near the milking parlour. Structure characteristics are described elsewhere (Valtorta et al. 1996). Essentially, it consisted of a black woven polypropylene cloth providing 80% shade mounted on 2.5-m-high eucalyptus posts, with an east-west orientation. Control measurements were performed outside, over a grass-covered soil surface (OG). All measurements were taken by means of black globe thermometers (model K1q5.050, SUGESA, Argentina, accuracy+0.2° C), held at 1.5 m above the surface (Bond and Kelly 1955).

BGTs over the holding pen concrete floor, both under an 80% shade material (SC) and in a non-shaded location (NC) were recorded at the same times and on the same days, in order to evaluate the effect of shading the holding area.

Shaded (SF) and non-shaded (NF) concrete floor temperatures were measured twice a week every 2 h, between 1100 and 1700 hours with an infrared thermometer (PYROVAR, Model HpR, Germany, accuracy±0.2° C, response time 6 s). Measurements were taken during that period of the day because most dairies in the area begin their afternoon milking between 1400 and 1500 hours.

In order to determine the effects of shade on animal response, 36 milking cows were randomly assigned to two groups: shaded and not shaded. The shaded group was in a diurnal confinement system, with no access to pasture between 0900 and 1600 hours, while the non-shaded cows were on pasture with no access to shade. A previous study (Valtorta et al. 1996) had shown no effect of these two management systems on total gazing time, the grazing patterns being quite similar. Twice a week, rectal temperatures (RTs) were recorded with clinical veterinarian therometers (accuracy±0.1° C), and respiratory rate (respirations per minute, RR) were determined by counting flank movements, immediately before the afternoon milking, carried out at the end of the confinement period of the shaded group, at 1600 hours.

Statistical analyses were performed by the least-squares method.

Results and discussion

Average daily BGTs for TS1, TS2, AS and OG are shown in Fig. 1. No differences were detected when comparing TS1, TS2 and AS, while OG was significantly higher ($P<0.01$), overall means and standard deviations being 30.2 (SD 0.58, 29.0 (SD 0.70), 30.2 (SD 0.74) and 35.3 (SD 1.12)°C, respectively. It is probable that the BGT for TS2 averaged 1.2° C lower than that for TS1 because, while both tree shades were selected for BGT evaluation, there were no animals under TS2.

Generally, trees have been considered to provide a better shade environment than shading structures made from artificial solid materials, since evapo-transpiration consumes energy and releases moisture, processes which can theoretically provide a cooler environment (Hahn 1982). Artificial shading materials also vary in effectiveness (E; Bond et al. 1961), for example: a 15-cm-thick hay-covered shade (best; E=1.203); corrugated aluminum (E=1.000); 90% plastic shade (E=0.839) and 50% wood slats (E=0.589). The current results based on average daily BGTs, indicate no practical difference between trees and the 80% artificial shade material which supports observations showing this material to be as effective as tree shades on the basis of effects on milk production (Comerón et al. 1985; Davison et al. 1988; Valtorta et al. 1996).

The time spent by lactating cows in the holding pen before afternoon milking is quite important, since they can be subjected to an excessive head load as a result of solar radiation and the hot concrete surface of the pen. Shading the holding pen with the same woven cloth material resulted in a much less stressing environment as determined by overall mean BGTs for situations SC and NC ($P<0.01$), which were 32.4 (SD 1.91) and 39.9 (SD 1.91)°C, respectively. Shading the holding pen also produced a significant decrease ($P<0.001$) in floor temperature (Fig. 2). Overall daily mean floor temperatures were 27.8 (SD 0.68)°C and 47.7 (SD 2.11)°C for SF and NF, respectively. Shading was particularly effective in reducing floow temperature during the hottest hours of the day.

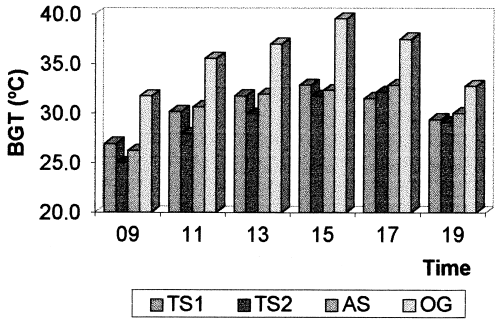

Fig. 1 Daily black globe temperature (*BGT*) under two tree shades (*TS1* and *TS2*), under an artificial shade structure made with an 80% shading material (*AS*) and outside over a grass-covered surface (*OG*) (n=17)

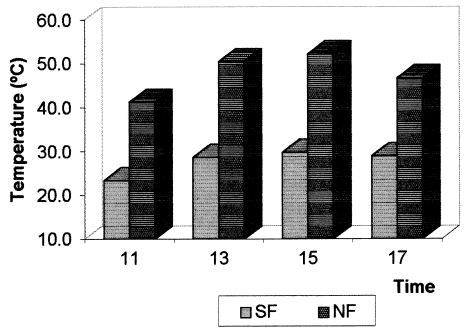

Fig. 2 Average daily temperature of shaded (*SF*) and non-shaded (*NF*) concrete holding pen floors (n=17)

In terms of animal responses to the treatment environments, average RTs were 39.3 (SD 0.42)°C for the shaded cows, and 40.1 (SD 0.74)°C for the non-shaded group, while RR averaged 60.7 (SD 10.57) and 78.9 (SD 18.04), respectively, both differences being significant ($P<0.01$). During the experimental period the temperature humidity index (THI) averaged 73.1±3.2 and the mean wind speed was 7.2±2.1 km/h. Wind speed was within the limits considered to be acceptable for animals on a pasture-based system (McDowell 1972). On the other hand, the average THI was above the critical value of 72 (Armstrong 1994).

Higher body temperatures are associated with a greater amount of stored head (Ingram and Mount 1975). Thus, higher afternoon temperatures in the non-shaded cows indicate that they store more heat during the day. At high ambient temperatures, evaporation is the most effective way to dissipate heat, and the increased RR of the non-shaded group indicates their need for respiratory evaporative cooling. This coincides with results reported by Davison et al. (1988) and Valtorta et al. (1996) in

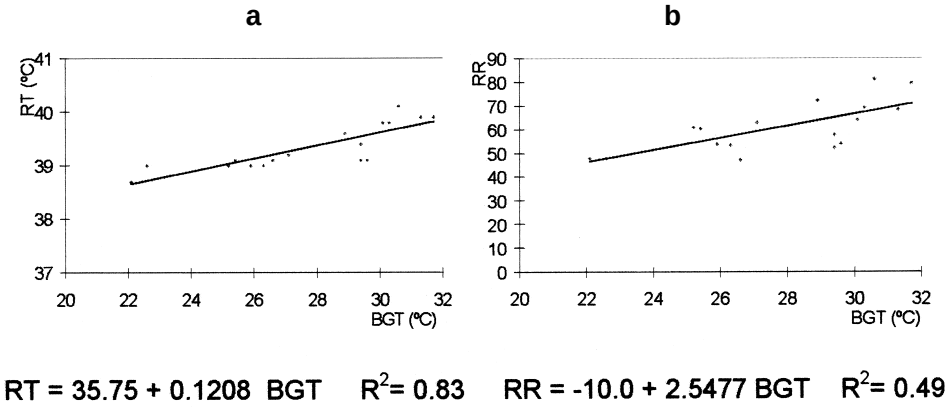

Fig. 3 Rectal temperature (*RT*, **a**) and respiratory rate (*RR*, **b**) as a function of mean black globe temperature (*BGT*) for the shaded group (measurements from 18 animals taken over 17 days). BGT was measured between 0900 and 1900 hours, while RT and RR were measured at 1600 hours

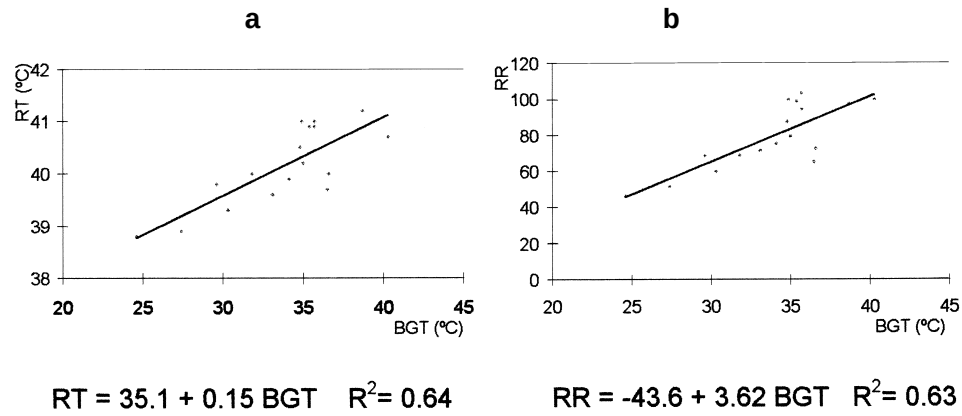

Fig. 4 Rectal temperature (*RT*, **a**) and respiratory rate (*RR*, **b**) as a function of mean black globe temperature (*BGT*) for the non-shaded group measurements from 18 animals taken over 17 days). BGT was measured between 0900 and 1900 hours, while RT and RR were measured at 1600 hours

grazing animals. The latter, using a management system similar to the one described in the present paper, also reported a 12% higher milk production for animals in diurnal confinement.

Correlation analyses were performed between RT and RR as functions of mean BGT to evaluate the predictive ability of BGT for responses of animals in a pasture-based system (Fig. 3, 4). There was a very good correlation of RT and RR with average BGT, especially when correlating RT with BGT for shaded cows. BGT is thus suggested as a good indicator of the stress imposed by the environment, either for animals kept outside or under shade during the hottest hours of the day.

BGTs under the artificial shade structure and trees were similar; the 80% shading cloth, was quite effective in lowering concrete floor temperatures in the holding pen; providing lactating animals with shade during the hottest hours of the day was effective in reducing both RT and RR; and BGTs were a good indicator of the level of heat loads imposed by the environment in hot weather.

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