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THE EFFECT OF FREE OR RESTRICTED ACCESS TO ARTIFICIAL SHADE ON RESPIRATION RATE, BEHAVIOUR AND PERFORMANCE OF GRAZING STEERS

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ORIGINAL ARTICLE

ABSTRACT: *The effect of access to artificial shade on respiration rate, performance and behaviour of grazing steers was determined during summer. Forty-two yearling steers were randomly assigned to 3 treatments without replication: 1) no shade, 2) free access to shade, and 3) restricted access to shade. Animals with restricted shade were daily removed from the grazing paddocks and enclosured in a resting area with shade and water between 10.00 and 16.00 h while animals of group 2 had both shade and water available ad-libitum in the grazing area. The respiration rate of control steers (69 breaths/min) was significantly higher than that of shade steers without differences between free and restricted access to shade (58 and 56 breaths/min, respectively). Total grazing time during daylight hours was not affected by shade availability (515 min). Between shaded treatments, animals with restricted access to shade spent significantly ($P< 0.05$) more time grazing during the morning than animals with free access to shade to compensate the lack of grazing between 10.00 and 16.00 h (241 and 168 min, respectively). The amount of time steers with free access to shade spent in the shade structure was strongly related to air temperature (R^2=0.85). When air temperature averaged 23.1ºC between 06.00 and 20.30 h steers spent on average 50 min in shade; while when temperature averaged 29.6ºC steers spent 422 min in shade. No significant difference was found in overall average daily gain among treatments (538 g/a/day). The provision of shade either ad-libitum or restricted reduced respiration rate of steers without affecting diurnal grazing time and animal performance.*

Keywords: *Cattle, behaviour, respiration rate, shade*

INTRODUCTION

There has been a trend towards more intensive forage-based beef production units in Uruguay. Cattle are managed in rotational grazing systems all year around, even during summer when combinations of temperature and humidity can result in conditions that present considerable challenged to farmed livestock. Increase animal productivity may also increase the susceptibility to heat stress and the response to mitigation strategies. One of the first steps that should be taken to moderate the stressful effect of a hot climate is to protect cattle from solar radiation. Mature trees are the more convenient and simplest way of providing shade to grazing animals. However, trees are not often conveniently placed for rotational grazing systems as often some paddocks have shade while others do not (Turner, 2000) and trees can be killed by high cattle density (West, 2003). To overcome those issues, the provision of artificial shade is the most cost-effective way of alleviating cattle heat stress by changing the radiation balance of the animal (Ames and Ray, 1983; Mader et al., 1999; West, 2003).

Research has extensively addressed the issue of shade and heat stress mainly on feedlot cattle (Gaughan et al., 2004; Mader et al., 1999, 2002 and 2006; Mitlöhner et al., 2001). The response in pastoral systems may be different as cattle are not confined which increase air circulation and ventilation. Although studies have been conducted overseas examining the effect of shade on pastoral systems many of these have been conducted in dairy cattle (Tucker et al., 2008; Schütz et al., 2009, Schütz et al., 2010) which is known to be more susceptible to heat stress. Growing and fattening steers would have lower heat production and usually higher thermal insulation being less influenced by a hot climate (Vandenheede et al., 1995).

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Ideally, the shade structure should be moveable in grazing systems but in practice is difficult to provide portable shades to meet the desired amount of shade for adult cattle in large herds on pastures (Turner, 2000). A practical approach is to build a permanent shade structure in a resting area and to move cattle from the grazing paddock to the shaded area during the warmest hours. However, as animals are kept under zero-grazing conditions in the resting area the benefits of providing shade could be offset by a decrease in animal performance. On the other hand, there is the perception among producers that providing shade *ad-libitum* in the grazing area may reduce the time that cattle spend grazing affecting pasture intake and animal performance. The objective of this experiment were to evaluate the effect of restricted or un-restricted access to artificial shade on respiration rate, behaviour and performance of grazing steers during summer and to discuss the overall cost-benefit of implementing a shade structure.

MATERIALS AND METHODS

This study was carried out from January 4th to March 12th 2007 at the INIA-Treinta y Tres Research Station (latitude: 33° 14' S, longitude: 54° 15' W) in Uruguay. Forty two growing 15-month-old Angus x Hereford steers (average initial weight ± standard deviation (SD): 278±26 kg) were randomly assigned to 3 treatments of 14 animals each without replication: 1) no shade, 2) free access to shade, and 3) restricted access shade. Each treatment group was kept separately in 2 hectares of Sudangrass (*Sorghum sudanense*) sub-divided into 3 paddocks of 0.67 ha which were rotationally grazed changing the grazing area based on forage allowance. The artificial shade structure consisted of a black woven polypropylene cloth occluding 80% of the incoming radiation mounted on 3.0-m-high eucalyptus posts with the long axis north/south. The length and width of the cloth were 12.0 and 4.0 m (48 m^2) corresponding an average space of 3.4 m^2 of shade per animal. Shade in the free access treatment was available 24-h per day in the grazing area. Animals with restricted access to shade were daily removed from the un-shaded paddocks at 10.00 h and taken to a zero-grazing resting area with a shade structure until 16.00 h when they returned to the grazing paddock.

Dry bulb temperature (ºC) and relative humidity (%) were recorded each day hourly during 24 hours placing automatic weather stations (HOBO Pro Series Model) exposed to sun and under the shade structure at a height of 2.0 m above ground level. A Temperature-Humidity Index (THI) was calculated hourly to characterize the climatic heat load experienced by the animals based on the equation developed by Thorn (1959): [(0.8 x temperature) + (relative humidity/100) x (temperature-14.4) + 46.4]. Pasture allowance was estimated before and after grazing each paddock by cutting ten 0.125 m^2 quadrants. Respiration rate (breath/min) was measured weekly by counting the flank movements in 60 seconds in four steers randomly selected per treatment in 9 different days 5 times per day (10.00, 12.00, 14.00, 16.00, and 18.00 h) as practical indicator of heat stress risk (Silanikove, 200). Steers were weighed on days 1, 20, 35, 55 and 67. Animal behaviours (grazing, standing, lying, walking and head in the water trough) were measured in five days by live observations of all animals per treatment every 15 minutes from 06.30 to 20.30 h.

Statistical analyses were performed using the SAS System v. 6.12 (SAS Inst. Inc., Cary, NC). The main effect of shade on climatic, pasture and animal-related variables was analysed using the PROC GLM procedure. In all the variables, where the *F*-test was significant ($P<0.05$) the differences between treatments were determined using Tukey's test.

RESULTS AND DISCUSSION

Climatic variables

The provision of shade did not affect climatic variables registered by automatic sensors (Table 1). Mean THI was in the category of "no stress" according to the five comfort zones for milking cows reported by Wiersama (2005) to assign the risk of environmental heat stress (no stress THI<72; mild stress 72≤THI≤78; severe stress 79≤THI≤89; very severe stress 90≤THI≤98; risk of death THI>98). According to the THI value recorded hourly during the experimental period cattle were exposed to no stress, mild and severe risk of heat stress during 51, 36, and 13% of the time, respectively.

Table 1 - Climatic conditions during the study (mean±SD)

	Sun	Shade
Average air temperature, ºC	23.0±5.8	23.1±6.0
Minimum air temperature, ºC	16.2±3.8	16.4±3.7
Maximum air temperature, ºC	31.5±3.5	30.7±3.7
Relative humidity, %	77±27.0	76±25.0
Temperature-Humidity Index	70±8.0	70±7.0

Row means with different superscripts differ significantly at P <0.05.

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Pasture characteristics

Shade had no effect either on herbage mass or plant height (P>0.05) (Table 2). Numerically, herbage utilization was greater in shaded treatment than in the control group (55% and 40%, respectively). Averaging over treatments, values of organic matter digestibility (59.3%), crude protein (7.65%), acid detergent fibre (44.3%), neutral detergent fibre (68.5%), and ashes (7.95%) of Sudangrass reflected the excessive accumulation of herbage mass which affected its nutritional value.

Table 2 - Mean (± SD) herbage mass and plant height for each treatment before and after grazing

	Treatment		
	No shade	Restricted shade	Free shade
Before grazing			
Herbage mass (DM kg/ha)	5199±418	5478±1629	5473±1696
Plant height (cm)	137±29	134±29	134 ±32
After grazing			
Herbage mass (DM kg/ha)	3116±1146	2424±1315	2539±1159
Plant height (cm)	84±16	77±19	80±14
Herbage utilization, %	40	56	54

Row means with different superscripts differ significantly at P<0.05.

Respiration rate

Shaded animals had lower (P<0.05) overall mean respiration rate (RR) than un-shaded animals averaged over day of evaluation (57 and 69 breaths/min, respectively) (Figure 1). This is consistent with several studies that have also found that average RR was lower in shaded animals than in animals with no shade availability (Mitlöhner et al., 2002; Gaughan et al., 2004; Eigenberg et al., 2005).The differences in RR were significant throughout the day except in the first measure at 10.00 h which averaged 54 breaths/min over treatments (P>0.05) indicating that climatic conditions registered during the night were cool enough to allow animal recovery from the heat load encountered during the day (Igono et al., 1992; Muller et al., 1994a; Silanikove, 2000). Between shaded treatments, shade-restricted animals had a significant higher RR than animals with free access to shade only at 14.00 h (P<0.05). Maximum RR rate was registered at 14.00 h (61 breaths/min) and 16.00 h (77 breaths/min) for shaded and un-shaded treatments, respectively.

Only in 2 out of the 9 days in which RR was evaluated there was no significant difference (P >0.05) in RR among treatments. In those days, the average air temperature was 26.5ºC between 10.00 and 18.00 h compared with an average of 29.7ºC registered in the days with significant differences in RR. This is consistent with results reported by Muller et al. (1994b) and Eigenberg et al. (2005) who found that the provision of shade had no effect on RR on days when the ambient temperature was less or around 25ºC.

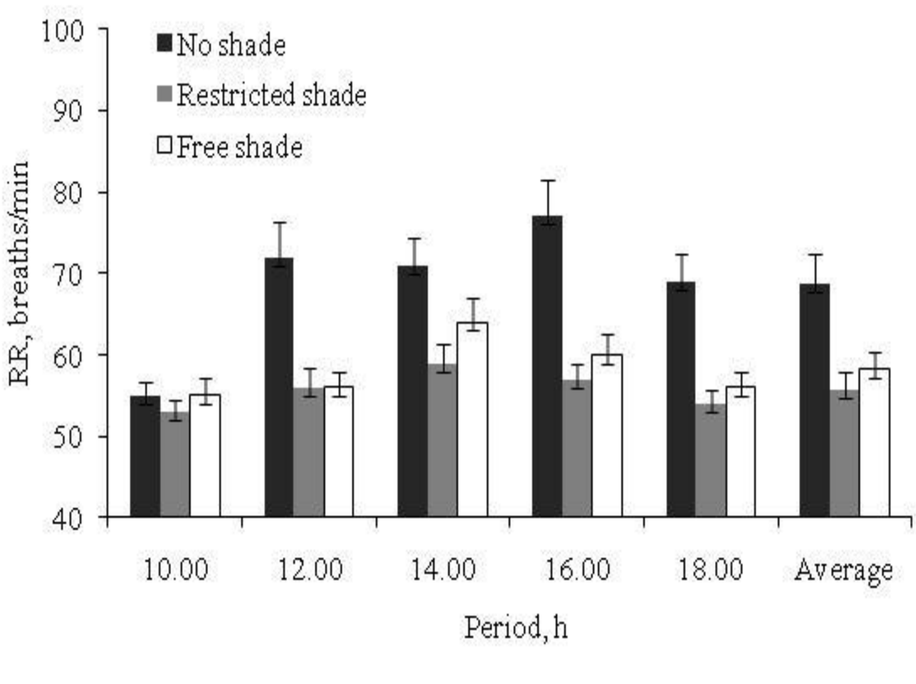

Figure 1 - Mean (± SEM) respiration rate (breaths/min) of steers per treatment and period of day.

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Animal behaviour

The provision of shade did not affect diurnal grazing time (P>0.05) (Table 3). Between shaded treatments, grazing activity of restricted steers was increased during the morning (+43%) and evening (+20%) hours compare with those with free access to shade. This was a mechanism to compensate the lack of grazing between 11.00 and 16.00 h when animals were taken to the resting area. In recent studies, it has been reported that cattle can react to a time constraint at grazing through an increase in the proportion of time spent grazing and in pasture intake rate (Perez-Ramirez et al., 2008; Kennedy et al., 2009). In addition, the grazing behaviour of steers was not registered during the night (20.30–06.00 h) being recognized that a decrease in dry matter intake during the hottest hours of the day can be compensated for longer grazing periods at night when climatic conditions are cooler (Igono et al., 1992).

Table 3 - Mean (± SD) behaviour of steers (min) between 0600 and 2000 h

	Treatment		
	No shade	Restricted shade	Free shade
Total grazing time	524±60[a]	528±39[a]	478±109[a]
06.00-11.00 h	225±28[a]	241±39	168±31[a]
11.00-16.00 h	117±17[a]	43±21[b]	106±22[a]
16.00-20.00 h	182±53[a]	245±44[b]	204±40[a]
Standing	120±75[a]	90±16[a]	99±56[a]
Lying	138±45[a]	198±26[a]	230±85[a]
Walking	17±07[a]	15±21[a]	21±17[b]
Head in the water trough	25±21[a]	9±05[a]	13±10[a]
Total use of shade	-	130±111[a]	199±206[a]
Standing	-	43±25[a]	72±62[a]
Lying	-	87±88[a]	126±148[a]

[ab] Row means with different superscripts differ significantly at P <0.05.

Free-shaded animals decreased their grazing time and spent more time in the shade during the morning and afternoon hours compared with un-shaded steers. The preference for steers to lie as opposed to stand in shaded areas in the present experiment is consistent with results reported by Muller et al. (1994c) and Rovira and Velazco (2010) but contrary with other observations (Mitlöhner et al., 2001; Kendall et al., 2006). When increased standing behaviour is observed during summer it is likely an effort to maximise the animal surface area exposed to the environment to regulate body temperature in extreme environments (Kendall et al., 2006). Drinking, walking, lying and standing behaviours did not differ among treatments (P>0.05).

Animal performance

Average daily gain (0.538±0.138 kg/a/day) and final body weight (314±28 kg) were not affected by treatment (P>0.05) even though restricted and free shaded animals showed an average daily gain 8% and 14% greater than un-shaded steers, respectively. The moderate rate of growth of animals could decrease the sensitivity to heat stress as the comfort line depends on the level of production being more sensitive animals presenting higher level of production as dairy cows and feedlot cattle (Berman, 2005). The difference in body weight between shaded and un-shaded animals was maximum between d 34 and d 51 (9 kg) (Figure 2). In the last period (51 day to finish) compensation through increased daily gain by cattle provided no shade tended to be evident and is generally expected to occur after periods of heat stress in cattle (Mader et al., 1999; Mitlöhner et al., 2001).

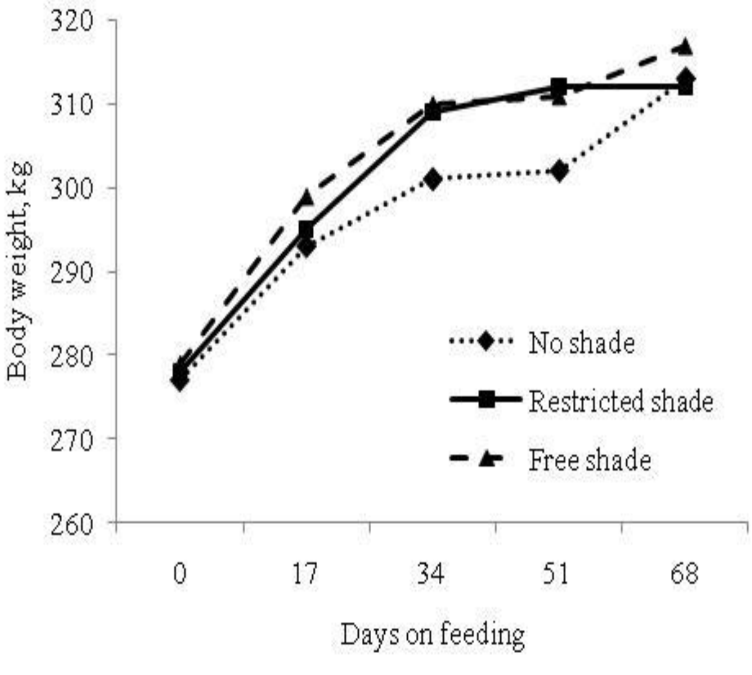

Figure 2 - Means of body weight (kg) of steers during the 68-day grazing period

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CONCLUSION

The results of the present study support the use of shade either *ad-libitum* or restricted during summer to decrease animal respiration rate reducing the risk of heat stress in grazing cattle without compromising productivity.

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