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Physiological and Productive Performance Responses of Horro Cows to Shade

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ABSTRACT

Twenty eight Horro cows were used to determine whether shade influences milk production and composition, days open, some physiological and hormonal traits. Cows grazed on natural pasture predominantly, *Cynadon dactylon* for about 7 hours/day. During grazing, one of the groups had access to shade where as the other group was not allowed to have any shade including trees. Cows were supplemented with concentrate feed during milking in the morning, evening and after grazing. Data on physiological, productive and reproductive parameters between the two groups were compared. Significant differences were observed in respiration rate, rectal temperature, pulse rate and live weight of cows between the two treatments. But there were no significant differences in average daily milk yield, days open and services per conception. Hence it is suggested that a form of shade should be made available for grazing Horro cows.

Key words: Horro-cow, shade, production, days open, services per conception, physiology.

INTRODUCTION

Milk production and reproduction are products of animal genetic and environmental interactions. In tropical environments, milk production for specific genotype is the result of climate and its indirect influence on the quantity and quality of feed available, diseases and parasites and management skills. Increasing air temperature, temperature-humidity index and rising rectal temperature above critical thresholds are related to decreased dry matter intake and milk yield; modifications including shade, barns and fans which enhance passive ventilation increase body heat loss and will lower body temperature and improve dry matter intake (West, 2003). Different workers (Shultz, 1984; Mitlohner *et al*., 2001, 2002) demonstrated that shade modified the quantity of feed and water consumption, physiological and behavioural response to heat, which will in turn has effects on productivity. In the choice of the type of shade, Valtorta *et al*. (1997) indicated that trees and artificial shades produced similar effects and access to shade in pasture-based system improved animal well-being.

Cattle production remained to be an important component of the agricultural sector in Ethiopia. Low productivity resulting from inadequate nutritional status, prevalence of diseases and parasites, poor genetic potential, traditional husbandry practices, inadequate infrastructure characterize the production of cattle.

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Adopting a relatively improved husbandry practices is expected to improve the performance of the animals. Hence this experiment is designed to assess the response of Horro cows in milk production and reproduction to improved management, with main emphasis on shade management.

MATERIALS AND METHODS

Location

The study was carried out at Bako Agricultural Research Center (Longitude = 37° 09' E, Latitude = 09° 06' N and Altitude = 1650 m above sea level), Ethiopia. The center is located 257 km West of the capital city, Addis Ababa. Mean minimum, mean maximum and average temperatures are 14°C, 28°C and 21°C, respectively. The rainfall pattern is bimodal with short rains in March/April. The rainy season covers May to September. The mean annual rainfall is about 1243.7 mm with peak rains in August. The soil type is predominantly nitosols.

Materials

Animals

Twenty eight cows (Purebred Horro cows, *Bos indicus*) of second and third lactation number were assigned to grazing with or without access to shade by stratified random sampling on the basis of milk production. The cows were first checked for any abnormality and diseases before they were taken into the experiment. Cows were taken into the experiment on the seventh day after parturition and stayed for five and half months. All required veterinary services were given to the animals.

Feed

Animals were grazed outdoor at 09:00 h on natural pasture, predominantly *Cynadon dactylon* , for about 7 hours. Both groups were supplemented with concentrate feed (1 kg/head) in the afternoon when immediately back from grazing. Additionally during milking in the morning and evening they were supplemented with concentrate feed (50% ground maize, 48% noug cake (oil seed cake), 1% salt and 1% bone meal), 1 to 1.5 kg/head/day depending on how long the milking took. The milking was done by hand, to be made by same 4 milkers, supervised for uniformity of milking at the beginning, mid and towards the end of the experiment. The composition of the ration fed to animals is given in Table 1.

Equipment and facilities

Cattle scale for weight measurement, thermometers, stopwatch and facilities for measuring weather/climate, laboratory to undertake hormonal and hematological tests.

Shade

The shade was made from dry grass and wood from eucalyptus trees for cows to be kept under shade. The shade was constructed in the grazing field in such a way that the two groups

Table 1 Mean composition of feeds fed to experimental cows.

	Cynadon dactylon	Bone meal	Maize grain	Noug cake
DM%	91.8	92.6	89.2	92.0
Ash%	9.0	69.7	1.7	11.0
CP%	8.3	25.2	8.4	31.7
OMD%	56.1	94.6	97.5	69.2
NDF%	74.6	53.6	5.6	32.3
ADF%	46.6	-	2.4	29.8
Lignin%	11.8	-	2.4	10.0
Cellulose%	32.4	-	-	18.7

graze close together but separated by wire fencing to access only the group assigned to shade. The shade has an estimated area of 5 m × 7 m and height of 3.5 m at the center.

Methods

There were two groups of Horro cows, namely Group 1: 14 cows were grazed on natural pasture for about 7 hours during the day with access to shade at their own free will during the daytime. They were enclosed in barns at night. Group 2. 14 cows were grazed similarly as group 1; but did not have any access to shade during the daytime but they were enclosed in barns at night.

The available natural pasture reserved for the experimental animals was almost 5 hectares. Grazing was controlled by herdsmen to be continuous and forward, so that what has been grazed properly would not be regrazed. Drinking water was available in the nearby stream/river in addition to what they were provided at barn.

Measurements

The daily dry and wet bulb, minimum, maximum and black globe temperatures were taken indoor and outdoor.

Physiological data, which include respiration rate (RR), pulse rate and rectal temperature (RT) were taken twice a month at 14:00 h in the field.

Milk samples from morning and evening milking sessions were taken from each cow for measuring fat percentage, protein, and solid non-fat using lactoscope spectrophotometer (Delta Instruments, Netherlands). The actual milk yield of cows was standardized to 4% fat corrected milk yield using the formula, fat corrected milk yield= (0.4×milk yield) + (15×fat yield) (Nevens, 1951)

Blood sample (8 ml) was taken at 14:00 h at the middle and end of the experiment from the jugular vein of the animals; plasma was harvested from the blood samples and stored below -4°C until assayed for cortisol, glucose and blood urea nitrogen (BUN), and hematocrit, hemoglobin, and white blood cells count determined. Hematological parameters, hematocrit, hemoglobin and white blood cell contents (WBC), were determined by Microhematocrit, Hemometer and Hemocytometer methods, respectively (Voigt, 2000). Plasma cortisol concentrations were determined by ECL (Electrochemiluminescene; Elecsys Analyzer 2010, Roche Diagnostic) at National Health and Nutrition Research Institute, Ethiopia. Cortisol determination was from a single assay, hence only intra assay coefficient of variation could be determined. To assess the nutritional status of the cows, blood urea nitrogen (BUN) and glucose levels were determined by using Du-40 spectrophotometer (Beckman model, USA); using enzymatic calorimetric test and enzymatic calorimetric test without deproteinisation methods.

Feed samples were taken from concentrate and roughage for dry matter, protein and fiber analysis at Holetta Agric. Research Center, Ethiopia. Crude protein (CP), dry matter (DM), total ash (TA) and organic matter (OM) were determined as described by Association of Analytical Chemists (AOAC, 1990). Neutral detergent fiber (NDF), Acid detergent fiber (ADF) and lignin were determined using the method of Goring and Vansoeust (1970). Percentage organic matter digestibility (OMD%) was determined by the method of Tilley and Terry (1963). Hemicellulose content was obtained as the difference between NDF and ADF.

Statistical Analysis

A t-test using PROC TTEST of SAS for Windows V. 8.1 (SAS , 1999) was applied to test if treatment differences were significant for meteorological data, physiological reactions, milk yield and reproductive performance. For conception rate a Chi Square technique was used (SAS, 1999).

RESULTS

As given in Table 2 maximum, average and black globe temperatures out of shade were significantly (P<0.01) higher than that of inside the shade. There were no significant differences between minimum temperature and relative humidity of the no shade and that of the shade. The results (Table 2) revealed that the thatched roof which was made from grasses, has significantly protected the cows from solar radiation and lowered the ambient temperature under the roof. The grass roof also has a property of an insulator. Therefore re-radiation under the roof should be at a minimum value.

Mean rectal temperature (RT), respiration rate (RR) and pulse rate (PR) of Horro cows kept under no shade and shade conditions are given in Table 3. Measurements on the physiological reactions were taken around 14:00 h and it was before 14:00 h that the group that had access to shade went under shade. It was after their stay in shade that the measurements were taken. Since the meteorological results (Table 2) were significantly more stressful for the no shade than the shade, the cows under no shade showed signs of more physiological stress than the counterpart cows under the shade treatment. It can be seen (Table 3) that rectal temperature, respiration rate and pulse rate of the cows under no shade conditions were significantly (P<0.05) higher than that of cows under the shade.

Furthermore, the results from Table 2 revealed that although the environmental conditions of the no shade was more stressful than that of the shade but the cows were not heat-stressed as such. This is may be due to the fact that both treatments have cows of the same breed of high heat tolerant type. Therefore, the physiological responses of the cows in both treatment were still remain within thermoneutral zone but the physiological responses of no shade cows were closer to the upper critical temperature than the shade cows. This mean that more energy is required to keep the cows in the no shade treatment at homeostasis than their counterparts in the shade treatment.

Means of live weight, body condition score, days open, services per conception, hemoglobin, hematocrits and white blood cells counts of Horro cows under no shade and shade conditions are given in Table 4. On one hand, the

Table 3 Mean ± S.D. rectal temperature (RT), respiration rate (RR) and pulse rate (PR) of Horro cows kept under No shade and shade conditions.

Parameter	Group	
	No shade	Shade
RT (°C)	39.0 ± 0.3[a]	38.8 ± 0.4[b]
RR (breaths/min)	33.8 ± 2.7[a]	32.2 ± 2.8[b]
PR (pulses/min)	46.8 ± 4.8[a]	45.1 ± 5.3[b]

Means within a row with different superscripts are significantly different (P<0.05).

Table 2 Maximum, minimum, average, and black globe temperatures, and relative humidity, Mean ± SD, of no shade and shade treatments.

Parameter	Group	
	No shade	Shade
Maximum temperature (°C)	33.2 ± 3.0[a]	31.4 ± 2.6[b]
Minimum temperature (°C)	14.9 ± 1.6	14.7 ± 1.5
Average temperature (°C)	24.0 ± 1.4[a]	23.0 ± 1.4[b]
Black globe temperature (°C)	39.3 ± 6.4[a]	33.2 ± 3.3[b]
Relative humidity (%)	34.5 ± 11.5	43.2 ± 11.2

Means within a row with different superscripts are significantly different (P<0.01).

results Table 4) showed that the live weight and body condition score of the no shade cows were significantly (P<0.05) lower than that of the shade cows. On the other hand, the results (Table 4) showed that there were no significant differences between days open, services per conception, hemoglobin, hematocrits and white blood cells counts of Horro cows under no shade and shade conditions.

Means of milk yield, fat percentage, milk protein, milk lactose and total solids of Horro cows under no shade and shade conditions are depicted in Table 5. The results (Table 5) showed that there were no significant differences (P>0.05) in fat corrected milk yield, fat content, milk protein, milk lactose and total solids of Horro cows under no shade and shade conditions.

Mean of plasma cortisol, blood urea nitrogen (BUN) and plasma glucose concentrations of Horro cows under no shade and shade conditions are shown in Table 6. The results (Table 6) showed that there were no significant differences in plasma cortisol, blood urea nitrogen (BUN) and plasma glucose concentration of Horro cows under no shade and those under shade conditions. That is, both group of cows have the same nutritional status and were stressed equally. In the determination of cortisol, the within coefficient of variation was 13 %.

Table 4 Live weight, body condition score, days open, services per conception, hemoglobin, hematocrits and white blood cells counts, Mean ± S.D., of Horro cows under no shade and shade conditions.

Parameter	Group	
	No shade	Shade
Live weight (kg)	223.5 ± 2.7[b]	232.4 ± 1.5[a]
Body condition score	3.1 ± 0.1[b]	3.5 ± 0.1[a]
Days open (days)	86.1 ± 6.9	87.7 ± 6.8
Services per conception (time)	1.6 ± 0.2	1.5 ± 0.2
Hemoglobin (gm%)	9.8 ± 1.4	10.1 ± 1.3
Hematocrits (%)	24.4 ± 2.4	25.2 ± 3.3
White blood cells counts (cells/mm^3)	7306.8 ± 2066.9	7319.4 ± 1787.3

Means within a row with different superscripts are significantly different (P<0.05).

Table 5 Fat corrected milk yield, fat percentage, milk protein, milk lactose and total solids, Mean ± S.D., Horro cows under no shade and shade conditions.

Content	Group	
	No shade	Shade
Fat corrected milk yield (kg/hd/d)	2.7 ± 1.5	2.8 ± 1.6
Fat percentage (%)	6.2 ± 1.1	6.5 ± 1.5
Milk protein (%)	4.4 ± 0.4	4.3 ± 0.7
Milk lactose (%)	4.3 ± 0.3	4.1 ± 0.5
Total solids (%)	16.6 ± 1.5	16.8 ± 2.1

Table 6 Plasma cortisol, blood urea nitrogen (BUN) and plasma glucose concentrations, mean ± S.D., of Horro cows under no shade and shade conditions.

Parameter	Group	
	No shade	Shade
Plasma cortisol (ng/ml)	13.4 ± 2.2	10.8 ± 1.6
BUN (mg/dl)	21.3 ± 3.3	21.7 ± 4.7
Plasma glucose (mg/dl)	55.2 ± 2.5	54.4 ± 2.1

DISCUSSION

Fertility rates in zebu cattle raised traditionally under less than ideal management is low. Mulugeta *et al*., (1991) and Legesse *et al*., (1987) reported that both production and reproduction in Horro cows varied between improved research center's management conditions and the traditional husbandry practices of the farming community. Average milk production/day (kg), lactation length (days), age at first calving and the calving interval were 0.4-0.8, 210, >60 and 19.5, respectively, whereas under relatively improved feeding, housing and health care conditions these figures were 2.41, 230, 55.3, and 14.5, respectively.

In this study days open and services per conception were improved considerably than any work reported for the breed. This is attributable to the feeding regime that the experimental animals were exposed to. In shade accessed and nonshade accessed groups days open were 87.7 and 86.1, respectively. Optimum days open was indicated to be 85-110 (Varner and Majeskie, 1998). Values of services per conception greater than 2 are reported to be poor (Mukasa-Mugerwa, 1989), hence the values of services per conception obtained in this study for both treatment groups would be well acceptable. But milk production did not change much, a reflection of the genotype (low milk yielder).

The composition of milk is influenced by genetics (breed & individuality of the cow) and environment (interval between milkings, stage of lactation, age, health and feeding regime) (O'Connor, 1995; Stallings, 1998). In her work on Horro cows on-farm, Alganesh (2002) found that their mean milk composition in percent was 3.31, 14.31, 6.05, and 4.51 % in protein, total solids, fat and lactose, respectively. Compared with what was obtained in this study, these figures were low; and this would be attributed to the management differences between on-farm and the research center and the procedures followed in the milk analysis. The absence of significant differences in the milk composition of the two groups of cows is attributed to the similarity of feeds that cows consumed.

In this study cows in both treatments were equally accessed to the same pasture and supplemental diets which in turn contributed to the similarity in the levels of BUN and glucose. BUN and glucose levels were within the range reported for cattle (Oregon State University, 2004); the normal ranges were indicated to be BUN 8-27 mg/dl and glucose 51-77 mg/dl..

The results (Tables 4 and 5) revealed that the Horro cows with shade have better production ($P<0.05$) in term of live weight than the counterpart group of cows with no shade treatments. There was no significant ($P>0.05$) advantages in terms of milk yield of the Horro cows with shade over the counterpart group of cows with no shade treatments.

Different works have demonstrated that significant differences existed in respiration rate, rectal temperature and pulse rate between the shaded and unshaded dairy type animals (Valtorta *et al.*, 1997; Mitlohner *et al.*, 2002). Elevated environmental temperatures were also reported to increase rectal temperature, respiration rate and plasma cortisol and decrease milk yield in lactating cows (Elvinger *et al.*, 1992).

When challenged by high environmental temperature, cows can adjust physiologically, behaviorally and immunologically to minimize adverse consequences; under normal conditions the physiological reactions of an animal to its environment depend on the adaptation of the animal (Hahn, 1999). Since level of heat stress, principally, depends on the value of the upper critical temperature which varies positively with heat tolerance. The value of upper critical temperature is specific for each breed. Hence, a known high heat tolerant cattle such as *B. indicus* (the Horro cattle) will have relatively higher upper

critical temperature value than the known less heat tolerance cattle such as *B. taurus* and *B. indicus* × *B. taurus* crossbreds (Holstein Friesian and Holstein Friesian crossbreds, for instance).

CONCLUSION

During the warm-dry season accessing cows to shade significantly ($P<0.05$) lowered physiological reactions and improved the live weight of Horro cows significantly. It did not significantly ameliorate the milk production or reproductive performances. Hence provision of shade constructed from grass under low heat stress conditions would lower the respiration rate pulse rate and rectal temperature of Horro cows. It is suggested that a form of shade should be made available for grazing Horro cows.

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