



Effects of Water Deprivation and Environmental Temperature on Physiological Performance of Sudanese Desert Goats

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Abstract Twenty eight Sudan Desert goats were used in these trials. The objective was to study the effects of some management factors (Water Deprivation and Environmental Temperature) on physiological responses of Desert goats. The trial was laid out as randomized complete block design (RCBD). The experimental period lasted for 10 months. The result showed that lowest average goat Respiration rate was at 12:00 pm while the highest Respiration rate was at 18:00 pm ($P < 0.001$). Rectal temperature, on the other hand, was highest ($P < 0.001$) at the evenings (18:00 pm) and lowest ($P < 0.001$) at the morning (8:00 pm). Goats with access to drinking water everyday had slightly lower ($P > 0.05$) Respiration rate and Rectal temperature compared with goats watered every other day, Goats had the lowest Respiration rate during the summer season and the highest Respiration rate during the rainy season ($P < 0.001$), with winter season, but Respiration rate, Rectal temperature was lowest during the winter season. Dry goats had comparatively higher Respiration rate and Rectal temperature compared with pregnant ones. Goat consumed comparatively more feed during winter and had slightly more water consumption during summer. Goats recorded the highest ($P < 0.001$) live body weights during winter, followed by rainy season and the lowest weights were recorded during the summer season. The results clearly indicated that goat performance is greatly influenced by changes in climatic factors either directly or indirectly.

Keywords Desert Goats, Water Deprivation, Physiological responses, feed, water consumption, Respiration rate and Rectal temperature

Introduction

Animal performance plays a vital role in the monitoring of physiological responses of animals to their environment [1]. Some of the important responses measured are feed and water intake, heat production, hormone levels, heart rate, respiration rate, body weight, body temperature, and behavioral changes [2]. Proper understanding of how climatic and management factors affect the physiological responses of goats provides a firm basis for improving their husbandry and productivity. In comparison with other livestock, there is paucity of information regarding seasonality in physiological responses of goats. Goats are said to have favorable characteristics and capacity to adjust to harsh environmental (arid, semi-arid, tropical, sub-tropical, etc.) conditions throughout the world. In tropical and sub-tropical regions high ambient temperature is the major constraint on animal production [3]. This is aggravated when heat stress is accompanied by high humidity. Excessive heat stress may cause hyperthermia and have several physiological side effects and economic impacts on the livestock [4]. The ability of livestock to grow and produce to their maximal genetic potential is strongly related to the thermal environment where body temperature, pulse and respiration rate are important physiological responses commonly used to assess adaptation responses to environmental stresses in goats [5-6].



Most of goats in Sudan are of the Desert type. Sudanese desert goats are mainly found in Western region of the Sudan which including Darfur and Kordofan states. Desert goats are mainly raised for meat production especially in rural area and they also provide milk for family needs.

This work was undertaken with an ultimate objective of studying the effects of some management factors on physiological responses of Desert goats. Specific objectives are to study, Seasonal performance trends Goats' responses to different watering and shading regimes.

Materials and Methods

Study Area

This study was conducted at El-Obeid, Sheikan locality, North Kordofan State (latitudes 11°:15'-16°:30'N; longitudes 27-32°E; altitudes 560 meters. Average temperature varies between 30-35°C during most of the year with peaks of above 40°C during April, May and June. The rainy season extends from July to October with maximum rainfall in August. Long-term average annual rainfall is about 280 mm (Technoseve, 1987; El-Tahir *et al.*, 1999). Soils varies from sandy in the north to heavy cracking clay in the south. Sandy soils cover about 60% of the cultivable area, while clayey and sandy clay soils cover only 30%. The sandy soil is stabilized sand dunes locally known as "goz". These soils are very deep, coarse to fine sand with low organic matter. "gardud" soils are prevalent in the area, covering about 10%.

Experimental animals and trials layout

Twenty eight (28) Sudan Desert goats (3-4 month old, average body weight 11.8±1.35 kg) were used in these trials. Goats were, vaccinated against, parasites. All goats were allowed a one week adaptation period before the start of experiment.

The goats were randomly divided into equal two groups based on their initial body weight and age. One group was randomly allocated to a shaded condition while the other group was left on the open with no shade. All goats were provided with individual feeding and watering troughs. Each group was again randomly subdivided into two similar groups based on initial body weight and age. One received water every day whereas the other one was watered every other day. And consisted of grass straw and hay (Table (1) shows feed ingredients and chemical composition on DM-basis).

Feed and water consumption:

Feed offered was measured every morning. Refusals were weighed next morning before offering the next day meal. A single pan balance (Cap. 500g) was used for weighing feeds. Water offered was measured using a measuring cylinder (2 liters volume).

Body weight measuring:

Every goat body weight was recorded at the beginning of the trial, then monthly until the end of experimental period which lasted for 10 months.

Table 1: Ingredients and Chemical composition of experimental rations percentage

Item	Ration 1	Ration 2	Ration 3	Ration 4
Rations' Ingredients:				
Straw	50	50	50	50
Groundnut hulls	29	29	19	19
Grawia tenax	20	-	-	30
Dichriostachys cinerea	-	20	30	-
Common salt	1	1	1	1
Total	100	100	100	100
Ration chemical composition (%DM-basis):				
DM%	94.36	93.89	95.51	95.37
OM%	80.30	78.84	81.38	79.00
Ash %	14.05	15.05	14.13	16.58
CP%	9.94	11.10	11.74	10.86
CF%	26.69	15.85	18.75	19.88
EE%	21.20	18.20	12.00	12.50



NFE%	22.47	33.69	38.89	35.76
IVOMD%	53.20	58.18	52.43	52.68
Ca%	1.45	0.77	1.53	2.20
P%	0.9	0.15	0.13	1.04

Respiration rate (RR) and rectal temperature (RT):

Respiration rate and rectal temperature were measured on monthly-basis and were done in each month. At that day respiration rates and rectal temperatures were measured at the morning (at 08:00 am) and then every two hour until evening at (06:00 pm). Respiration rate was done through counting the flank movement for one minute while RT was determined by using clinical thermometer insert in the rectum for one minute with an accuracy of $\pm 0.1^{\circ}\text{C}$.

Statistical Analyses

The experimental data was analyzed as a completely randomized block design. Analysis of variance test (ANOVA) two- way interactions. Snedecor and Cochran (1980) [7] used to evaluate the effect of shade condition and watering regime on goats performance. Time of the day was included as a factor with season, shade condition and watering regime to test their effect on respiration rate and rectal temperature using the general linear model (GLM) procedure of (SPSS software version 16, 1999)

Results

Desert Goat Physiological Responses to Seasonal and Management Practices:

Respiration rate (RR) and Rectal temperature (RT)

The effects of time of the day, housing condition and water regime on respiration rate (RR) and rectal temperature (RT) are presented in Table (2). Time of the day had significant main effects on both RR and RT. The lowest average goat RR was at 12:00 am while the highest RR was at 18:00 pm ($P < 0.001$). On the other hand Rectal temperature, was highest ($P < 0.001$) at the evenings (18:00 pm) and lowest ($P < 0.001$) at the morning (8:00 am) Figure 1. Housing condition and watering regime had no main effect ($P > 0.05$) on Respiration rate and Rectal temperature. Nonetheless, Respiration rate and rectal temperature were comparatively higher under direct sunlight conditions in comparison with those for goats under shade (Table 2). Goats with access to drinking water everyday had slightly lower ($P > 0.05$) RR and RT compared with goats watered every other day (Table 2). No significant ($P > 0.05$). Furthermore, monthly average RT was comparatively higher for goats under direct sunlight than that for goats under shade. The effects of season, housing condition and water regime on respiration rate (RR) and rectal temperature (RT) are displayed in Table (2). Seasonal main effects on goat RR and RT were highly significant ($P < 0.001$). Goats had the lowest RR during the summer season and the highest RR during the rainy season ($P < 0.001$), goat RT was highest during the rainy season, but unlike RR, RT was lowest during the winter season, with no differences in goat RT between summer and rainy seasons (Table 2). Nonetheless, goats under direct sunlight had relatively higher RT and RR throughout the experimental period compared with those under shade). Interaction effects among the different factors (Table 2) were not significant ($P > 0.05$).

Table 2: Main effects of time of the day (T), Housing Condition (HC) and watering regime (WR) on respiration rate (RR) and rectal temperature (RT) of Desert goat

Factor	Respiration Rate (R R) (Breaths/Minute)	Rectal Temperature (R T) ($^{\circ}\text{C}$)
Time of the Day (T):		
08: 00	32.5a	38.8a
10: 00	30.8ab	39.5b
12: 00	28.8b	39.0c
14: 00	35.8c	39.3d
16: 00	35.4c	39.4b
18: 00	37.8c	39.5b
SE \pm	1.39***	.051***



Season (S):		
Summer	27.0a	39.1a
Rainy	36.3b	39.4b
Winter	34.5c	39.0a
SE±	0.575***	0.045***
Housing Condition (HC)		
Shade	32.8	39.2
Sunlight	34.1	39.3
SE±	0.57 ^{NS}	0.31 ^{NS}
Watering Regime (WR):		
Daily	32.7	39.2
Every other day	34.3	39.3
SE±	0.574 ^{NS}	0.32 ^{NS}
Interaction effects of T, HC and WR:		
HC×WR	33.5	39.2
SE±	0.81*	0.045 ^{NS}
HC × T	35.8	39.4
SE±	1.30 ^{NS}	0.073 ^{NS}
T × WR	30.7	39.4
SE±	1.31 ^{NS}	0.69 ^{NS}
HC × WR × T	29.8	39.0
SE±	1.86 ^{NS}	0.087 ^{NS}
Interaction effects of S, HC and WR		
S x HC	32.7	38.1
SE±	0.815 NS	.065 NS
S x WR	22.5	38.1
SE±	0.820 NS	.057 NS
S x HC × WR	22.3	38.0
SE±	1.160 NS	.090 NS

^{abcd} Means in the same column with no letter in common are significantly different according to Duncan Multiple Range Test (DMRT) (** Highly Significant at $P < 0.01$, *** very highly significant at $P < 0.001$, ns = not significant at $P > 0.05$)

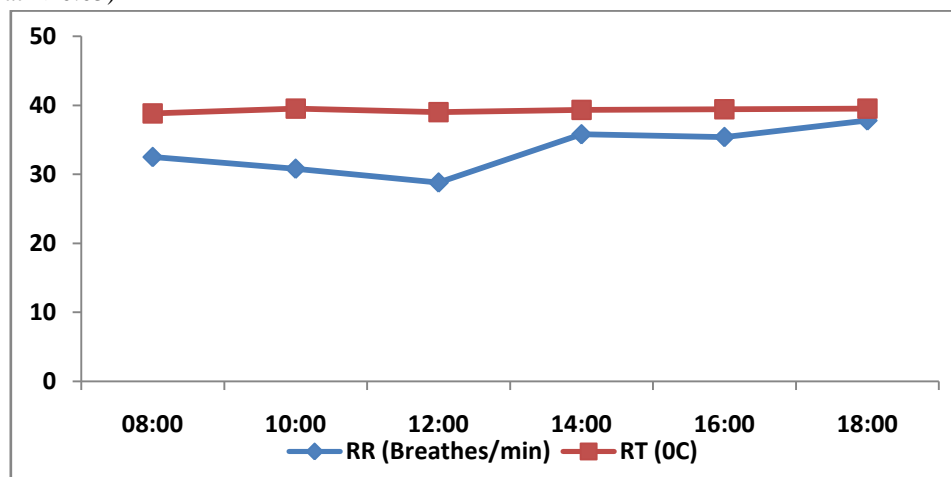


Figure 1: Average goat respiration rate (Breathes/minute) and rectal temperature ($^{\circ}$ C) during different times of the day

Effects of goat Physiological State on Respiration Rate and Rectal Temperature

The main effects of physiological state and interaction effects of physiological state with season, housing condition and watering regimen on respiration rate (RR) and rectal temperature (RT) of goats are shown in Table (3). Physiological state seemed to exert no main effect ($P > 0.05$) on goat RR and RT. However, dry goats had comparatively higher RR and RT compared with pregnant ones.. Interaction effects between physiological state, season, housing condition and watering regimen and their combinations were not significant ($P > 0.00$).



The effect of season, housing condition and water regime on goat feed intake, water consumption and body weight are presented in Table (4). Feed intake and water consumption were measure for summer and winter seasons only. Seasonal main effects on feed intake and water consumption were not significant ($P > 0.05$). However, goat consumed comparatively more feed during winter and had slightly more water consumption during summer Seasonal main effects on goat average body weight were highly significant ($P < 0.001$). Goats recorded the highest ($P < 0.001$) live body weights during winter, followed by rainy season and the lowest weights were recorded during the summer season. goats under shade had comparatively higher feed intake and slightly lower water consumption and recorded relatively higher average live body weights in comparison with goats maintained under direct sunlight. No significant ($P > 0.05$) season x housing condition, season x watering regimen, housing condition x watering regimen, season x housing condition x watering regimen were found (Table 4).

Table 3: Main effects of physiological state (PS) and interaction effects with season (S), housing condition (HC) and watering regime (WR) on Desert goats respiration rate (RR) and rectal temperature (RT)

Factor	respiration rate (RR)	rectal temperature (RT)
Physiological State (PS):		
Pregnant	32.238	39.060
Dry	32.896	39.168
SE±	.688 ^{NS}	.077 ^{NS}
Interactions: SE±		
PS × HC	34.328	38.827
SE±	.8100 ^{NS}	.109 ^{NS}
PS x S	27.370	39.115
SE±	.9757 ^{NS}	.109 ^{NS}
PS x WR	32.192	39.180
SE±	.9502 ^{NS}	.106 ^{NS}
PS x S× WR x HC	34.212	39.042
SE±	1.358 ^{NS}	18.63 ^{NS}

^{NS} Not Significant $P > 0.05$

Table 4: Main effects of season (S), Housing Condition (HC) and watering regime (WR) on feed intake, Water intake and body weight (W) of Desert goat

Factor	Feed intake/g/week	Water intake /m L/ week	Weight/Kg
Season:			
Summer	2084.73	5402	10.8a
Rainy	-----	-----	13.3b
Winter	2311.85	4970.75	15.6c
SE±	432.388 ^{NS}	1053.893 ^{NS}	0.25***
Housing onditions:			
Shade	2232.275	5185.38	13.5
Sunlight	2164.3	5187.275	13.1
SE±	432.311 ^{NS}	1059.230 ^{NS}	0.21 ^{NS}
Watering Regime:			
Every day	2294.	6165.25a	13.3
After day	2102.1	4208.4b	13.2
SE±	434.791 ^{NS}	1059.230***	0.21 ^{NS}
Interactions:			
HC × WR	8915.8	17135.6	13.4
SE±	618.355 ^{NS}	1497.977 ^{NS}	0.29 ^{NS}
HC × S	8422.7	21616.1	15.4
SE±	546.835 ^{NS}	1490.392 ^{NS}	0.34 ^{NS}



WR × S	8508.6	26053.6	13.3
SE±	633.020 ^{NS}	1640.952 ^{NS}	0.35 ^{NS}
HC × WR × S	9509.9	22319.0	14.8
SE±	901.129 ^{NS}	2107.332 ^{NS}	0.50 ^{NS}

^{abc}, Means in the same column under the same factor with different letters are significantly different according to DMRT (^{NS}, Not Significant P>0.05, ** Highly Significant P<0.01)

Discussion

Time of the day had significant main effects on both RR and RT. The lowest average goat RR was at 10:00 am while the highest RR was at 18:00 pm. Differences in RR at 14:00 pm up to the evening (18:00 pm) were not significant. RR showed a rise from the morning (8:00 am) up to 10:00 am then slowed down up to noon time (12:00 pm) and rose again up to the evening. This was in line with Shalaby (1985) [8] and Maria *et al.* (1997 and 2000) [9-10], in their study on Egyptian Rahmani, Ossimi and Ossimi × Suffolk crossbred ewes, who found that respiration rate was markedly lower at 8:00 than at 12:00 and 16:00. However, these workers reported that rectal temperature was found to markedly lower levels at 8:00 than at 12:00 and 16:00, differing from the results of this study where rectal temperature was highest at the evenings (18:00 pm) and lowest at the afternoon (12:00 pm), with minimal diurnal variations [8, 11]. Seasonal main effects on goat RR and RT were highly significant. These results were in agreement with Marai *et al.* (1997) [10], El-Darawany, (1999) [12] and Abdel-Hafez (2002) [14] who observed significant variation in rectal temperature throughout the year. Nonetheless, their reported values showed markedly lower RT during winter than during summer in rams unlike goats in this study where RT was highest during winter season. Unlike RT, RR was highest during winter season and lowest during rainy season with summer recording intermediate values, which was in close accord with the findings of Fahmy (1994) [14] and Marai *et al.* (1997) [10] who reported higher RR during summer in sheep. Respiration rate was not affected by housing condition or watering regime. On the contrary, Ahmed and El Kheir (2004) [15] reported that goats restricted to 40% of their daily *ad libitum* water intake showed increased respiration rates and Aganga *et al.* (1990) [16] found that respiration rates decreased with increased water deprivation and that RT was not affected either by housing condition or watering but time of the day had significantly (P<0.05) higher effect on both RR and TR. Mengistu (2007) [17] found that Ethiopian Somali goats' rectal temperature increased over the course of the day and that significant variations were observed in RR and RT when goats were watered once every fourth day. Dry goats had comparatively higher RR and RT compared with pregnant ones.

Feed intake and water consumption were measured for summer and winter seasons only. Goats consumed comparatively more feed during winter and had slightly more water consumption during summer. Schoenian (2010) [18] found that intake of DM usually declines with hot weather. Goats recorded the highest live body weights during winter, followed by rainy season and the lowest weights were recorded during the summer season. This could probably be due to that high ambient temperature during summer time reduced feed intake and resulted in reduced body weight. Hadjipanayiotou (1995) [19] reported that water consumption of goats was greater in summer than in winter. Some signs of heat stress are usually reflected in continual panting, rapid breathing, elevated rectal temperatures and reduced feed intake [20].

Goats under shade had comparatively higher feed intake and slightly lower water consumption and recorded relatively higher average live body weights in comparison with goats maintained under direct sunlight whereas goats on a daily watering regime recording higher water consumption and feed intake in comparison with those on every other day watering. On the contrary, in the Saudi Arabia indigenous goats (Hipsi, Aardi and Zumri) kept in a shaded pen, feed intake was sharply reduced starting from the first day of water. However, similar results were obtained by Misra and Singh (2002) [21] who found that feed intake of adult Indian male Sirohi, Marwari and Kutchi goat breeds, housed in a semi-open shade and watered once every two days and allowed to drink water once daily, were not different but with relatively higher feed and water intakes for those watered daily. In contrast, El-Hadi (1986) [22] maintained adult Nubian bucks housed in unshaded pens on a three day water deprivation regimen reported that the Nubian bucks had consumed only 82% of their pre-water deprivation feed intake. These findings were supported by Dmi'el (1986) [24] and Mousa *et al.* (1983) [25] who



observed that water restriction in sheep, goats and camels for five days caused a decrease in dry matter intake in the three species,. No significant season x housing condition, season x watering regimen, housing condition x watering regimen, season x housing condition x watering regimen were found. This was in disagreement with El- Hadi (1986) [22] who reported a loss in body weight of 14 and 18% in desert- adapted ram and Nubian bucks, respectively, on the third day of water deprivation. A higher percentage of weight loss of 20% was reported by Alamer (2006) [25] who subjected Saudi Arabia indigenous goats to three days water deprivation.

Conclusion

Goat performance is greatly influenced by changes in climatic factors either directly or indirectly. Seasonal effects are reflected on goat general performance and condition in terms of live body weight, and respiration rates

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