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Physiological, biochemical and endocrine responses of goat kids maintained on two different floor types in hot-dry weather conditions

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ABSTRACT

This study investigated physiological, biochemical and endocrine responses along with nutrient intake and growth of goat kids kept on either wooden slatted or soil floor in hot-dry weather conditions. Twenty kids (age 208 ±1.7 days; live weight 26.2±0.6 kg) were divided into two equal groups and allotted to either soil or slatted floor. After 14 days of adaptation, physiological responses, serum metabolites, enzymes and hormones were estimated at weekly intervals for 28 days. All the physiological responses increased from morning to afternoon with increase in temperature-humidity index. Type of flooring did not significantly influence physiological and growth variables. The serum biochemical, enzyme and endocrine responses were similar between both the groups. Due to lack of significant effect of slatted floor on growing kids, the provision of such floor in goat shelter could be appropriate only if it is economically feasible in terms of initial inputs and labour cost in hot-dry tropical environment.

Key words: Biochemical variables, Jakhrana kids, Physiological and endocrine responses, Slatted floor

Suitable housing for goats is more desirable during the peak summer and winter as it protects animals from challenging environments. Types of housing affect different physiological and endocrine responses of farm animals during normal and stressful weather conditions (Nunes *et al*. 2014). Floor type, among others, is an important housing feature that affects not only manure handling, but also dampness, greenhouse gas emission inside pen and overall health of the animals (Ahrens *et al*. 2011, Cai *et al*. 2015).

Rectal temperature (RT), heart rate (HR) and respiration rate (RR) are shown to be good indicators of stress, and may be used to assess the adverse effects of the inclement weather conditions (Brown-Brandl *et al*. 2009, Minka and Ayo 2012). Heat stress increases body temperature, RR and HR that lead to marked reduction in feed intake and alteration in endocrine and biochemical functions (Marai *et al*. 2007). Increase of body temperature is associated with reduction in thyroid gland activity resulting into a decreased thyroid hormone [Triiodothyronine (T3) and thyroxin (T4)] concentration in blood circulation (Silanikove 2000). In contrary to this, during stressful conditions, activation of adrenal gland increases cortisol concentration in blood. Therefore, these hormones and some enzymes such as alanine aminotransferase (ALT), aspartate aminotransferase (AST) and alkaline phosphatise are commonly used as indicators for physiological stress to the animals (Gupta *et al*. 2013).

Goats are usually housed on soil or concrete floor with deep straw bedding. Research on alternative flooring solutions in goat production are limited, probably mainly because of the initial cost of this type of floor for goat houses. The main advantages with fully-slatted floor in goat housing are animals may be kept relatively clean without any bedding material, high stocking density at a low space allowance and minimum labour input for manure disposal (Boe *et al*. 2007). Considering these advantages, use of slatted floor is widely used for goat houses in areas with cool, high rainfall or hot-humid weather conditions (Hamito 2009). Similarly, its use is also increasing in large scale commercial goat farms in areas with hot-dry arid and semi-arid conditions (Mowlem 2011). The information pertaining to the provision of slatted floor on physiological responses, level of comfort and welfare of goat kids during hot-dry weather conditions is not available. Therefore, the present research was conducted with the aim to investigate the effect of floor type (soil floor vs wooden slatted floor) on the physiological, endocrine and biochemical variables of Jakhrana goat kids during hot-dry weather in semi-arid conditions of India.

MATERIALS AND METHODS

Experimental site and thermal environment data: This study was carried out at the Central Institute for Research on Goats, Makhdoom, Mathura, Uttar Pradesh, 169 m above

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mean sea level and 10°N, and 78°02' E with a semi-arid climate. The annual rainfall in the area averages 750 mm, while the average daily temperature varies from 2°C (winter) to 48.5°C (summer).

The wet- and dry-bulb temperatures (WBT and DBT, °C) (sling psychrometer), relative humidity (RH, %), sunshine/hour/day and temperature humidity index (THI) were recorded at the experimental site at 7:00 AM and 2:00 PM on the day of recording of physiological variables (day 7, 14, 21 and 28). Moreover, maximum-minimum temperature (maximum-minimum thermometer), WBT, DBT, RH and THI were measured three times (9:00 AM, 12:00 noon and 5:00 PM) daily for entire experimental period. The THI, a measure of heat stress to animals, was calculated according to the formula given below

THI = DB-{(0.55-0.55 RH) (DB-58)} (Marai *et al.* 2001)

where DB, dry bulb temperature (°F), RH, relative humidity (%). The obtained THI values were categorized as <82 (absence of heat stress), 82 to <84 (moderate heat stress), 84 to <86 (severe heat stress) and over 86 (extreme severe heat stress).

Animals and management: Twenty healthy Jakhrana male kids aged 208±1.7 days and weighing 26.2±0.6 kg were served as subjects of the study. The Jakhrana goat is an important large size milch goat breed of India characterized by its black coat colour with white spots on muzzle and ears. The breed is known for its very good adaptability in the semi-arid region of the country. Equal number of animals were randomly assigned to well-ventilated experimental pen with either soil flooring (Pen 1; n = 10) or wooden slatted flooring (Pen 2; n = 10) and maintained under uniform feeding and management conditions.

Animals were offered concentrate pellets, dry fodder (gram straw, *Cicer arietinum*; Arhar straw, *Cajanus cajan*), green fodder (cow pea, *Vigna sinensis*; berseem, *Trifolum alexandrinum*) and drinking water *ad libitum.* The animals were allowed for an adaptation of 14 days in the respective pens prior to the recording of physiological variables and collection of blood samples, at specified period of time. Prophylactic measures against goat diseases like goat pox, *peste des petits ruminants*, enterotoxaemia, and endoparasitic and ectoparasitic infestations were carried out as prescribed by the institute. A feeder and a waterer were placed in each pen and animals were given access to drinking water *ad libitum.* All the experiments were conducted strictly in accordance with the guideline of Institutional Animal Ethics Committee (IAEC).

Measurements of physiological variables: All measurements of physiological variables (RT, RR and HR) were done under relatively calm and quiet conditions twice daily at 7:00 AM and 2:00 PM, at weekly intervals (day 7, 14, 21 and 28). The measurement of RT of kids was done using a digital clinical thermometer, inserted about 3–4 cm into the rectum for about 1 min and represented in °C. The RR was measured before the HR and RT. The HR (presented as beats/minute) and RR (presented as breath/minute) were recorded using a medical stethoscope at the fourth left inter-costal space behind the animal's left elbow and above the animal's left elbow over a period of 1 min, respectively.

Blood collection and serum separation: Blood samples from all animals were collected after feeding on day 7, 14, 21 and 28 at 2:00 PM by direct jugular venepuncture. The days of blood sample collection were different from the days of recording of physiological variables to avoid possible effect of handling or human presence on the cortisol level in the blood. Serum was separated at room temperature for 4 h, which was centrifuged (600×*g* for 5 min at room temperature) using table top centrifuge and samples were collected, stored at –20°C until assayed for biochemical and endocrine variables.

Endocrine and biochemical variables: Serum concentrations of endocrine variables such as thyroxine (T4, µg/dl), tri-iodothyronine (T3, ng/ml), thyroid stimulating hormone (TSH, µIU/ml) and cortisol (ng/ml) were estimated using commercial ELISA kits. The assay procedure was done according to the manufacturer's instructions and absorbance was recorded on a spectrophotometer.

Biochemical variables such as alanine transaminase (ALT) [IU/l; 2,4-DNPH (Reitman and Frankel method)], aspartate transaminase (AST) [IU/l; 2,4-DNPH (Reitman and Frankel method)], alkaline phosphatase (KA units; Kind and King's method), albumin (g/dl; Bromocresol Green method), total protein (g/dl; modified biuret, end point assay), total cholesterol (mg/dl; CHOD-PAP, end point assay) and triglyceride (mg/dl; GPO-PAP, end point assay) were measured using commercial kits according to the manufacturer's instructions.

Statistical analyses: Data were first tested for normal distribution using the Kolmogorov–Smirnov's test. Homogeneity of variances was tested using the Levene's test. If data fulfilled both criteria, parametric tests were applied and if one criterion failed, non-parametric tests were used. The mixed model procedure was used each for serum endocrine and biochemical variable as a dependent variable. Type of flooring (soil floor or slatted floor) was considered as fixed factor, sampling days as repeated effects, and their respective interactions were included into the model. The covariance structure autoregressive (first-order autoregressive structure with homogenous variances) followed by Bonferroni correction were used for serum endocrine and biochemical data. Differences at each time point between the groups were also compared by either Student t-test or Mann–Whitney U test. Pearson's correlations (2-tailed) were calculated between THI and physiological variable (RT, RR and HR). Statistical analyses were performed using SPSS (version 16.0). All data are presented as arithmetic means ± standard error of the mean (Mean ± SEM) and probability value (P) lower than 0.05 was considered to be statistically significant.

RESULTS AND DISCUSSION

New types of flooring are now being introduced for loose housing in goats but there are almost no studies regarding

the effect of different types of flooring on kid's welfare and level of comfort. The present study demonstrated the comparison of the basic biochemical, hormonal and physiological variables in goat kids under different floor types during the hot-dry conditions.

Thermal environmental data during the study period: Thermal micro-environmental observations at the time of recording of physiological variables (7:00 AM and 2:00 PM) are presented in Table 1. Minimum temperature, maximum temperature and sunshine/h/day during the experimental period were 27.9±1.7°C, 45.6±1.6°C and 9.8±1.7 h, respectively. No significant differences were observed in the meteorological conditions of both the pens (Table 1). In both the pens, meteorological observations (AT, DBT, WBT and THI) in the morning were significantly lower ($P \leq 0.05$) compared to the afternoon and mean observations. Whereas, RH recorded in the morning was significantly higher compared to the values of afternoon. The mean DBT (°C), RH (%) and THI at different time points daily of the experimental days (9:00 AM, 12:00 noon and 5:00 PM) were 38.0±1.2, 42.8±1.4, 42.0±1.8; 41.0±5.0, 27.5±4.5, 25.3±5.6 and 86.5 ± 0.8, 88.5±1.0, 86.9±0.6, respectively.

Temperature-humidity index is an important indicator for estimating severity of thermal load to animals. Values of THI over 86 are considered as severe to extreme heat stress, while less than 82 indicate absence of heat stress (Marai *et al*. 2001). Kids of present study were under severe heat stress during afternoon as THI varied between 87.2 ± 1.1 and 88.1±1.3 and under adequate climate in the morning where THI was between 78.9±1.9 and 79.0±1.5 (Table 2). The thermal environmental observations during the afternoon were characterized by high AT and THI, typical of the hot-dry period in the semi-arid region of Northern India during the month of June. The values of AT and RH were markedly outside the reference thermo-neutral zone (AT, 22–35°C and RH, 58–65%) for goats in the tropical regions (Richardson 2002). Similarly, the mean THI value of 87.8 was above the normal comfort zone of 70–75 (Brown-Brandl *et al*. 2009). Thus the meteorological conditions during present experiment were unfavourable to the goats, particularly during the hot hours of the day when the THI attained the peak value of more than 87. At this period of the day, heat stress was apparent and posed significant changes in the thermoregulatory mechanisms of the goats.

Physiological variables: Table 2 shows the variation in basic physiological variables [RT (°C), RR (breath/min) and HR (beats/min)] of goat kids (morning and afternoon) of both the groups. All the physiological variables were significantly ($P \leq 0.05$) lower in pen 2, when compared to the pen 1 in the afternoon of d 21 of experiment. However, there was no significant difference in overall mean of all

Table 1. Variables indicating thermal environment of both the experimental pens

Pen	Time	AT (°C)	DBT (°C)	WBT (°C)	RH (%)	THI
Pen 1	7:00 AM	29.8^{a}±1.3	30.4^{a}±1.6	22.5^{a}±1.3	51.1^{a}±6.7	78.9^{a}±1.9
	2:00 PM	42.9^{b}±1.7	42.2^{b}±1.7	26.1^{b}±1.1	28.2^{b}±4.8	88.1^{b}±1.3
	Mean ± SEM	36.4^{c}±2.7	36.3^{c}±2.5	24.3^{c}±1.0	39.6^{c}±5.8	83.5^{c}±2.0
Pen 2	7:00 AM	30.1^{a}±0.8	30.4^{a}±0.6	22.5^{a}±1.4	50.3^{a}±5.2	79.0^{a}±1.5
	2:00 PM	42.5^{b}±2.0	42.5^{b}±1.3	24.9^{b}±1.3	24.0^{b}±6.2	87.2^{b}±1.1
	Mean ± SEM	36.3^{c}±2.5	36.5^{c}±2.4	23.7^{c}±1.0	37.2^{c} ±6.2	83.1^{c}±1.8

AT, ambient temperature; DBT, dry bulb temperature; WBT, wet bulb temperature; RH, relative humidity; THI, temperature humidity index. Mean values with different superscripts (a, b, c) in the same column are significantly different ($P<0.05$).

Table 2. Basic physiological variables of goat kids (n=20) during experiment, recorded at fortnight interval

Days	Time	RT (°C)		RR (breaths/min)		HR (beats/min)	
		Pen 1	Pen 2	Pen 1	Pen 2	Pen 1	Pen 2
d 8	M	37.8 ± 0.2	38.0 ±0.2	28.8 ± 3.0	27.6 ± 2.8	112.2 ± 4.3	111.0 ± 2.1
	A	39.1 ± 0.1	39.2 ±0.1	46.0 ± 2.7	51.0 ± 3.0	112.0 ± 2.6	112.8 ± 2.7
d 15	M	38.3 ± 0.1	38.3 ± 0.1	35.2 ± 4.3	27.6 ± 3.6	104.4^{a} ± 2.8	90.8^{b} ± 2.7
	A	39.2 ± 0.0	39.2 ± 0.1	66.2 ± 5.1	61.8 ± 4.1	132.8^{a} ± 4.6	118.0^{b} ± 2.9
d 22	M	38.9 ± 0.1	38.9 ± 0.1	33.2 ± 3.5	33.0 ± 2.8	110.1 ± 3.8	105.7 ± 3.6
	A	39.1 ± 0.1	39.2 ± 0.1	69.6 ± 6.2	76.0 ± 6.1	113.0 ± 3.1	115.6 ± 3.2
d 29	M	39.3^{a} ± 0.1	38.8^{b}±0.1	53.2 ± 5.6	43.6 ± 3.6	103.6 ± 2.8	108.0 ± 3.3
	A	39.1^{a} ± 0.1	38.9^{b}±0.1	81.4^{a} ± 4.2	57.2^{b} ± 6.4	125.8^{a} ± 2.4	120.4^{b} ± 1.9
Overall mean	M	38.5 ± 0.1	38.6 ± 0.1	37.6 ± 2.5	32.9 ± 1.9	107.6 ± 1.8	103.9 ± 1.9
	A	39.1 ± 0.0	39.2 ± 0.0	65.8 ± 3.0	61.5 ± 2.9	120.9 ± 2.1	116.7 ± 1.4

Pen 1, Pen with soil floor; Pen 2, Pen with slatted floor; n = 10 in each pen; M, Morning (7.00 AM); A, Afternoon (2.00 PM); RT, rectal temperature; RR, respiratory rate; HR, heart rate. Means with different superscripts (a, b) within rows are significantly different ($P<0.05$).

Table 3. Relationships between temperature humidity index and rectal temperature, respiratory and heart rates of goat kids in both the experimental pens [pen 1 (soil floor) and pen 2 (slatted floor)]

Correlated parameter	Pen 1 (n = 10)	Pen 2 (n = 10)	Overall (n = 20)
Temperature humidity index and mean rectal temperature	0.791**	0.544*	0.674**
Temperature humidity index and mean respiration rate	0.938**	0.933**	0.916**
Temperature humidity index and mean heart rate	0.781**	0.626**	0.677**

*P<0.05, **P<0.01.

the physiological variables in both the groups. Temperature humidity index was highly correlated with RT, RR and HR of goat kids in both the groups (Table 3).

A change in RT indicates the change of a similar magnitude in deep body temperature, therefore, RT is considered as an ideal indicator for the assessment of thermal stress to animals (Lefcourt *et al*. 1986). Similarly, RR and HR are good indicators of heat stress and are used to estimate the undesirable effects of the high AT (Alamer and Al-Hozab 2004).The physiological variables of the kids in the morning were within the normal physiological range (Souza *et al*. 2014) and no difference was observed in both the groups indicating absence of stressful condition in the morning. However, the significant increase in the physiological variables during afternoon compared to the morning is due to increase in AT and THI at afternoon. The mean RT, RR and HR values of the kids recorded during afternoon were above the normal range of 38.5–40.0°C, 16–30 breaths/min and 70–80 beats/min (Ayo *et al*. 1998) for RT, RR and HR, respectively. This is mainly because the THI during afternoon was outside the normal comfort zone. The results agree with the findings of earlier researchers (Minka and Ayo 2012, Al-Samawi *et al*. 2014).

Biochemical and endocrine variables: Type of flooring did not influence serum concentrations of biochemical variables included in the study (Table 4). Endocrine variables of both the groups during experimental period are presented in Table 4. Serum concentrations of all endocrine variables including serum cortisol did not differ between the groups (P>0.05).

The variability in THI is known for the modulation of physiological mechanisms due to shift in metabolic reaction through enzymatic regulation. Shaffer *et al*. (1981) explained that increased activity in some enzymes with rising temperature may be due to the accelerated reactions at higher temperature. Serum levels of ALT and AST are helpful in diagnosis of comfort level to the animals (Gupta *et al*. 2013). Thus, the level of these enzymes reflects the metabolic activities during stress conditions. Serum ALT increased whereas AST remain unchanged during heat stress in goats (Ocak *et al*. 2009), whereas heat stress lowered the alkaline phosphatase activity in goats (Helal *et al*. 2010).

Table 4. Biochemical and endocrine variables of goat kids (n=20) of both the experimental pens [pen 1 (soil floor) and pen 2 (slatted floor)]

Variable	Group	Days				Overall mean	P-value
		1	2	3	4		
GOT (IU/l)	Pen 1	46.2±5.5	57.6±12.1	104.7±11.4	183.4±46.9	98.0±14.8	0.132
	Pen 2	49.7±7.4	57.6±12.7	91.2±9.6	292.0±52.4	124.3±21.1	
GPT (IU/l)	Pen 1	20.3±4.0	20.7±7.0	13.5±4.2	12.1±5.9	17.1±2.6	0.084
	Pen 2	31.6±15.1	29.8±6.0	24.7±7.7	20.1±3.9	26.1±4.3	
AKP (KA)	Pen 1	40.0±8.6	45.1±8.9	52.8±16.8	44.8±10.6	46.0±5.8	0.164
	Pen 2	62.9±13.1	56.4±11.1	97.4±22.2	43.4±9.4	65.1±7.9	
Albumin (g/dl)	Pen 1	3.63±0.07	3.90±0.06	4.20±0.19	3.83±0.07	3.9±0.1	0.937
	Pen 2	3.61±0.08	3.99±0.10	3.96±0.06	3.98±0.09	3.89±0.05	
Total protein (g/dl)	Pen 1	6.9±0.2	6.8±0.2	7.1±0.2	7.0±0.2	7.0±0.1	0.558
	Pen 2	6.6±0.3	7.5±0.5	7.0±0.3	7.2±0.2	7.1±0.2	
Total cholesterol (mg/dl)	Pen 1	36.4±4.6	37.5±4.8	39.7±6.1	25.8±2.5	34.8±2.4	0.446
	Pen 2	41.7±6.7	26.8±2.8	45.6±4.2	35.9±4.4	37.4±2.5	
Triglyceride (mg/dl)	Pen 1	36.7±2.6	40.7±3.9	33.5±2.6	33.4±4.1	35.9±1.7	0.578
	Pen 2	33.2±3.8	36.3±5.6	38.6±6.0	44.2±5.0	38.1±2.6	
T3 (ng/ml)	Pen 1	2.50±0.20	2.80±0.20	2.56±0.30	2.74±0.34	2.65±0.13	0.337
	Pen 2	2.37±0.14	2.41±0.08	2.37±0.19	2.31±0.31	2.36±0.10	
T4 (µg/dl)	Pen 1	8.15±0.60	7.93±0.62	6.62±0.78	7.36±0.49	7.51±0.32	0.151
	Pen 2	6.98±0.41	6.76±0.36	6.22±0.32	6.29±0.54	6.55±0.21	
TSH (µIU/ml)	Pen 1	0.17±0.07	0.25±0.05	0.15±0.02	0.12±0.03	0.18±0.03	0.618
	Pen 2	0.21±0.03	0.15±0.04	0.15±0.03	0.10±0.03	0.15±0.02	
Cortisol (ng/ml)	Pen 1	42.98±4.40	37.72±4.1	45.24±4.53	40.54±6.63	41.62±2.45	0.281
	Pen 2	38.07±5.48	30.76±2.5	41.35±6.23	36.56±3.38	36.65±2.30	

The mean values of AST ranged from 46.2 to 183.4 IU/l in kids were in close agreement with the reference range for goats (66.0 to 230.0 IU/l) (Fraser *et al*. 1986). The mean serum ALT of 12.1–32.7 U/l observed in kids of both the groups was within the reported range of variation for goats (15.3 to 52.3 U/l) by Fraser *et al.* (1986) even though it is towards the lower end. Decrease in the activities of these enzymes and others such as alkaline phosphatase might be due to reduction in thyroid hormone concentration and reduced metabolic activity that occurred during heat stress in the kids (Hooda *et al*. 2014).

Blood biochemical variables such as total protein, total cholesterol, albumin and triglyceride may be important indicators to identify the effects of stress on the animals (Sejian and Srivastava 2010). Prolong exposure to heat stress can cause increase in plasma total protein and albumin to goats that might be due to decreased plasma volume during heat stress (Helal *et al*. 2010). Total protein concentration observed in the present study failed to indicate a higher stress response, since concentrations in both the groups (pen 1 and 2) were within normal physiological range of 6–7.5 g/dl, reported for goats (Jones *et al*. 2007). On the contrary, blood total cholesterol level decreased during summer season and increased during winter season in goats (Ocak *et al*. 2009). The marked decrease in total serum cholesterol levels may be associated with the decline in blood acetate (primary precursor for the cholesterol synthesis) concentration due to decreased feed intake during period of stress. Nazifi *et al.* (2002) observed significantly lower triglyceride levels in goats during hot and cold stress than in animals kept at optimum temperatures. The observations of serum triglyceride concentration in the present study were similar to the findings of Pandey *et al.* (2012) who reported significant decline in triglyceride concentration in goat kids exposed to heat stress.

Ambient temperature is one of the main regulators of the activity of various endocrine organs including thyroid gland. To our knowledge, no evidence for endocrine changes has been described in kids kept on slatted flooring. Some earlier reports suggest that T3, T4 concentration decreases, while cortisol concentration increases in kids during the summer season after exposure to high temperature (Silanikove 2000, Al-Samawi *et al*. 2014, Hooda *et al*. 2014).This reduction may be due to effect of heat on hypothalamus-pituitary axis to decrease thyrotropin releasing hormone which enable animal to reduce basal metabolism (Johnson 1987).This is an adaptive physiological mechanism to reduce the metabolism, decrease heat production from the body and thus reduce the heat load on the animal (Al-Samawi *et al*. 2014).

When animals are exposed to stress, activation of the hypothalamic-pituitary-adrenal axis leads to increase in blood cortisol concentration, thus basal cortisol level in blood is used to evaluate effect of stress in goats (Silanikove 2000). Cortisol secretion stimulates physiological modifications that enable animals to neutralize the adverse effects caused by stressful condition including increased gluconeogenesis in the liver (Adenkola and Ayo 2010). The mean concentration of cortisol observed in kids was slightly higher than reported (3 to 15 ng/ml) in earlier studies in different goat breeds (Al-Busaidi *et al*. 2008, Aoyama *et al*. 2008). However, higher concentration of cortisol (82.74±4.33 nmol/l) was observed in other study on goats exposed to heat stress (Sejian and Srivastava 2010).

Lack of significant differences in blood cortisol concentration, nutrient intake and growth variables between the groups indicates absence of added benefit of wooden slatted floor to minimize level of stress to goat kids during hot-dry conditions.

In conclusion, our results showed that fully-slatted floor furnished similar results to the soil floor in terms of level of comfort as well as physiological and blood (biochemical and endocrine) variables of goat kids. Therefore, it is concluded that slatted flooring can be considered as an alternative floor only if it is economically feasible and if the aim is to improve the hygiene of goat shelter in dry-hot tropical conditions. This finding is particularly interesting in view of the commercialization of goat farming and warrants further work also with the restricted feeding schedule to set recommendations for the use of alternative slatted flooring materials such as plastic or any other available material exclusively or in combination.

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REFERENCES

Adenkola A Y and Ayo J O. 2010. Physiological and behavioural responses of livestock to road transportation stress: A review. *African Journal of Biotechnology* **9**: 4845–56.

Ahrens F, Platz S, Link C, Mahling M, Meyer H H and Erhard M H. 2011. Changes in hoof health and animal hygiene in a dairy herd after covering concrete slatted floor with slatted rubber mats: a case study. *Journal of Dairy Science* **94**: 2341–50.

Alamer M and Al-Hozab A. 2004. Effect of water deprivation and season on feed intake, body weight and thermoregulation in Awassi and Najdi sheep breeds in Saudi Arabia. *Journal of Arid Environment* **59**: 71–84.

Al-Busaidi R, Johnson E H and Osman M. 2008. Seasonal variations of phagocytic response, immunoglobulin G (IgG) and plasma cortisol levels in Dhofari goats. *Small Ruminant Research* **79**: 118–23.

Al-Samawi K A, Al-Hassan M J and Swelum A A. 2014. Thermoregulation of female Aardi goats exposed to environmental heat stress in Saudi Arabia. *Indian Journal of Animal Research* **48**: 344–49.

Aoyama M, Negishi A, Abe A, Maejima Y and Sugita S. 2008. Short-term transportation in a small vehicle affects the physiological state and subsequent water consumption in goats. *Animal Science Journal* **79**: 526–33.

Ayo J O, Oladele S B, Fayomi A, Jumbo S D and Hambolu J O.

1998. Body temperature, respiration and heart rate in the Red Sokoto goat during the harmattan season. *Bulletin of Animal Health and Production of Africa* **46**: 161–66.

Boe K E, Andersen I L, Buisson L, Simensen E and Jeksrud W K. 2007. Flooring preferences in dairy goats at moderate and low ambient temperature. *Applied Animal Behaviour Science* **108**: 45–57.

Brown-Brandl T M, Eigenberg R A and Nienaber J A. 2009. Water spray cooling during handling of feedlot cattle. *International Journal of Biometeorology* **54**: 609–16.

Cai L, Yu J, Zhang J and Qi D. 2015. The effects of slatted floors and manure scraper systems on the concentrations and emission rates of ammonia, methane and carbon dioxide in goat buildings. *Small Ruminant Research* **132**: 103–10.

Fraser C M, Mays A, Amstutz H E, Archibald J, Arnour J, Blood D C, Nawberne P M, Snoeyenbos G H and Huebner R A, editors. 1986. Merck Veterinary Manual. 6th ed. Rahway, NJ: Merck; p. 906.

Gupta M, Kumar S, Dangi S S and Jangir B L. 2013. Physiological, biochemical and molecular responses to thermal stress in goats. *International Journal of Livestock Research* **3**: 27–38.

Hamito D. 2009. Technical Bulletin No.32. Shelters and Housing for Sheep and Goats. Ethiopia sheep and goat productivity improvement program. http://www.esgpip.org/pdf/Technical%20Bulletin%20No.32.pdf

Helal A, Hashem A L S, Abdel-Fattah M S and El-Shaer. 2010. Effects of heat stress on coat characteristics and physiological responses of Balady and Damascus goat in Sinai Egypt. *American Eurasian Journal of Agriculture and Environmental Science* **7**: 60–69.

Hooda O K and Upadhyay R C. 2014. Physiological responses, growth rate and blood metabolites under feed restriction and thermal exposure in kids. *Journal of Stress Physiology and Biochemistry* **10**: 214–27.

Johnson H D. 1987. Bioclimate and livestock. *Bioclimatology and the Adaptation of Livestock.* pp. 3–16. (Ed.) Johnson H D. Elsevier Science Publisher, Amsterdam, Netherland.

Jones M L and Allison R W. 2007. Evaluation of the ruminant complete blood cell count. *Veterinary Clinics of North America: Food Animal Practice* **23**: 377–402.

Lefcourt A M, Bitman J, Wood D L and Stroud B. 1986. Radiotelemetry system for continuously monitoring temperature in cows. *Journal of Dairy Science* **69**: 237–42.

Marai I F M, Ayyat M S and Abd El-Monem U M. 2001. Growth performance and reproductive traits at first parity of New Zealand White female rabbits as affected by heat stress and its alleviation, under Egyptian conditions. *Tropical Animal Health and Production* **33**: 457–62.

Marai I F M, El-Darawany A A, Fadiel A and Abdel-Hafez M A M. 2007. Physiological traits as affected by heat stress in sheep-A review. *Small Ruminant Research* **71**: 1–12.

Minka N S and Ayo J O. 2012. Assessment of thermal load on transported goats administered with ascorbic acid during the hot-dry conditions. *International Journal of Biometeorology* **56**: 333–41.

Mowlem A. 2011. Goats. *Management and Welfare of Farm Animals.* pp. 365–389. Wiley-Blackwell – UFAW Animal Welfare series.

Nazifi S, Gheisari H R and Shaker F. 2002. Serum lipids and lipoproteins and their correlations with thyroid hormones in clinically healthy goats. *Veterinarski Archive* **72**: 249–57.

Nunes M L A, Miranda K O da S, Faria João M B A de, Vieira, Afrânio M C and Arcaro Júnior Irineu. 2014. Physiological evaluation of heat stress in gestating sows under different housing systems in bedding and concrete floor. *Engenharia Agricola* **34**: 1–7.

Ocak S, Darcan N, Cankaya S and Cinal T. 2009. Physiological and biochemical responses in German Fawn kids subjected to cooling treatments under Mediterranean climate conditions. *Turkish Journal of Veterinary and Animal Science* **33**: 455–61.

Pandey N, Kataria N, Kataria A K and Joshi A. 2012. Ambient stress associated variations in metabolic responses of Marwari goat of arid tracts in India. *Journal of Stress Physiology and Biochemistry* **8**: 120–27.

Richardson C. 2002. *Lowering Stress in Transported Goats.* Ontario Ministry of Agriculture and Food–Livestock Technology Branch, Northern Ontario Regional Office.

Sejian V and Srivastava R S. 2010. Effects of melatonin on adrenal cortical functions of Indian goats under thermal stress. *Veterinary Medicine International* Article ID 348919.

Shaffer L, Roussel J D and Koonce K L. 1981. Effects of age, temperature-season and breed on blood characteristics of dairy cattle. *Journal of Dairy Science* **64**: 62–70.

Silanikove N. 2000. Effects of heat stress on the welfare of extensively managed domestic ruminants: a review. *Livestock Production Science* **67**: 1–18.

Souza P T de, Salles M G F, Lima da Costa A N, Carneiro H A V, Souza L P de, Rondina D and Araújo A A. 2014. Physiological and production response of dairy goats bred in a tropical climate. *International Journal of Biometeorology* **58**: 1559–67.