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Effect of North and South Faced Housing System on the Physiological Performance of Growing Foals in the Semi-Arid Regions of Rajasthan

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A B S T R A C T

Good housing is one of the key to success in management. Housing always remains to be a significant challenge in health regulation of horses. Direction of the animal house determines the amount of sunlight, wind and humidity entering the house, which thereby exerts some influence on the health of the animal. This study was conducted to quantify the effect of north and south faced housing system on the physiological indices (heart rate, respiration rate, rectal temperature) of growing foals, during summer, (May-June 2017) with ambient temperature and relative humidity as factors. A total of 12 foals, divided into two groups, six in north facing house and six in south facing house was placed. Ambient temperature (°C) and Relative humidity (%) were recorded daily at 08:00h and 14:00h and all the physiological parameters of the foals placed in both houses were recorded simultaneously; With ambient temperature as a factor, at 08:00h, all the physiological indices increased significantly ($p<0.01$) in the south facing house. Whereas, by 14:00h, there was a significant rise ($p<0.01$) in all the physiological indices of foals placed in both the north and south facing house. With relative humidity as factor, no significant changes were observed on both the sides at 08:00h, whereas by 14:00h, only the north facing house recorded significant changes. From the present study it was evident that exposure of sun was more in the north facing house than the south facing house and thus south facing was conducive for the foals. Also it was evident that factors like ambient temperature and relative humidity has significant influence on the performance of foals.

Introduction

Horses (*Equus ferus caballus*), an extraordinary athlete, is an odd-toed ungulate mammal belonging to family Equidae (Grubb, 2005). Domestication of horses began around 4000 BC. They hold an honourable place in mythologies of many cultures (Tozer and Basil, 1908). They are also used in work, sport and warfare. They are often considered as a symbol of endurance, self-confidence and independence. The athletic capacity of a horse is attributable to a number of physiological adaptations. Some physiological processes are malleable, able to adapt in response to conditions to which the animals are exposed. Body heat is produced by metabolism 2 and is also gained from the environment. In homeotherms, the temperature is normally within the range of 37-40°C, by an integrated

neurophysiologic mechanism that balance heat production and heat loss. Horses maintain their body temperature within the thermoneutral zone, through the process of thermoregulation. Anecdotally, horses have been reported to survive in environments with the temperature reaching 58°C (Hafez, 1968). Any elevation in core body temperature will limit the performance capacity of horses, and will also have an effect on their basal metabolic rate (BMR). Availability of water, when exposed to the hot or cold environment will also influence the heat production. It has been suggested that solar radiation can contribute up to 15 percent of the heat gain in horses during exercise in sunny conditions. Evaporative cooling is one of the mechanisms for heat loss, in optimum conditions, where the relative humidity is low. The evaporation of sweat is a very efficient mechanism of heat loss (Jill McCutcheon, 2008). Sweat gland is an organ of thermoregulation in a limited number of species, like bovidae, primates and equidae. In horses, sweat glands are found in both haired and hairless skin with regional variation in the density of glands. Typical areas of sweat patches after exercise include neck, chest, flank and hind quarter region. Studies have demonstrated that, when exposed to high temperatures horses show thermoregulatory and stress responses, including elevated rectal temperature, respiration rate, neutrophil to lymphocyte ratio, serum cortisol concentration and haematocrit percentages (Marlin *et al.,* 1995; Friend, 2000; Stull and Rodiek, 2000).

Thus, housing is one of the biological challenge to the normal mechanism of health regulation in the horse. (Jackson *et al.,* 2000; Holcombe *et al.,* 1998) have suggested that even in an apparently healthy animal, a greater level of upper and lower airway inflammation is seen when housed and this subsidized when animals are turned out. The housing may both psychologically and physically stress the horse. Location and direction of an animal house are the main factors which determine the internal environment of the house. Orientation, layout and location of a house will influence the amount of sunlight the building receives and therefore its year-round temperature and comfort. Climatic factors are the other parameters that influence the orientation of an animal house.

Temperature is the most important single bioclimatic factor known to influence the air and immediate surroundings. The direction of animal house also plays a major role in determining the amount sunlight entering the animal house, which on the other hand influences above mentioned physiological and haematological parameter. Heat stress is known to affect the physiological indices in animals, including goats, lamb and equines (Karim and Patnayak, 1999; Yousef, 1990).

Thermal stress is one of the most important stressors in the hot regions of the world and it is one of the important factors which will affect the working capacity of all animals including equines (David, 1980; Altan *et al.,* 2003). Henceforth, the Objective of this study is to find the effect of north and south faced housing system on the physiological indices of foals.

Materials and Methods

Study animals

Twelve growing foals, of age group 1-1½ years were included in the study conducted at the Equine Production Campus, NRCE, Bikaner. The twelve foals were divided into two groups; six foals were placed in the North facing house and six in the South facing house respectively. The study took place during the summer (May-July 2017) when there is an expected rise in the ambient temperature and relative humidity.

Study design

Physiological parameters like rectal temperature, respiration rate and heart rate were recorded daily, in all the foals placed in the north and south facing house at morning 08:00h and afternoon 14:00h during the experimental period.

Ambient temperature, relative humidity during the experiment were recorded at 08:00h and 14:00h using zeal maximum and minimum thermometer and wet and dry bulb thermometer (Mason's type).

Data management and analysis

Uni-variate general linear models (GLM) were used to explore the effect of ambient temperature and relative humidity (RH) on each physiological parameter of foals with ambient temperature, relative humidity and temperature-humidity index as fixed factors. The significance of mean difference was tested by Waller-Duncan multiple range test. The analysis was carried out using SPSS software version 24 as described by Snedecor and Chochran (1994).

Results and Discussion

The various physiological indices were studied to quantify the effect of North and South facing housing system on the performance of growing foals under the hot semi-arid conditions characterized by high temperature and humidity are presented in the following section. The physiological responses (rectal temperature, respiration rate and heart rate) were studied in growing foals during summer (May-July 2017). Animals were placed in north and south facing house which was well ventilated and was given free access to water and feed. To study their performance under north and south faced housing system, physiological parameters were recorded daily at 08:00h and 14:00h, taking ambient temperature and relative humidity as factors.

Effect of ambient temperature on the physiological indices of foals placed on the north and south facing house at 08:00h.

Rectal temperature (RT °C)

Rectal temperature (Mean ± S.E) recorded in growing foals placed in the north and south facing house at 08:00h is presented in table 1 and 1a and Figure 1. Rectal temperature (37.70±0.02) increased significantly ($P<0.05$) in the foals placed in south-facing house when they were exposed to a ambient temperature ranging from22-36°C, whereas there were no significant changes observed in the rectal temperature (37.74±0.02) of foals placed in the north facing house when they were exposed to the same ambient temperature ranging from 22-36°C.

Heart rate (HR, beats per min)

Heart rate (Mean ± S.E) recorded in growing foals placed in the north and south facing house at 08:00h is presented in table 1 and 1a) and Figure 1. Heart rate increased significantly ($P<0.01$) in the foals placed in south-facing house when they were exposed to ambient temperature ranging from22-36°C, whereas there were no significant changes observed in the heart rate of foals placed in the north facing house when they were exposed to the same ambient temperature ranging from 22-36°C.

Respiration rate (RR, breaths per min)

Respiration rate (Mean ± S.E) recorded in growing foals placed in the north and south facing house at 08:00h is presented in table 1 and 1a and Figure 1. Respiration rate did not show any significant rise in the foals placed in

south and north facing house when they were exposed to ambient temperature ranging from 22-36°C.

Effect of ambient temperature on the physiological indices of foals placed in the north and south facing house at 14:00h

Rectal temperature (RT °C)

Rectal temperature (Mean ± S.E) recorded in growing foals placed in the north and south facing house at 14:00h is presented in table 2 and 2a)and Figure 2. Rectal temperature increased significantly (P<0.01) in the foals placed in the north facing house (37.81±0.02) and was significant (P<0.05) in the south facing house (37.77±0.02) when they were exposed to ambient temperature ranging from 32-46°C.

Heart rate (HR, beats per min)

Heart rate (Mean ± S.E) recorded in growing foals placed in the north and south facing house at 14:00h is presented in table 2 and 2a and Figure 2.

Heart rate increased significantly (P<0.01) in the foals placed in both north (54.12±0.34) and south (54.51±0.35) facing house when they were exposed to ambient temperature ranging from32-46°C.

Respiration rate (RR, breaths per min)

Respiration rate (Mean ± S.E) recorded in growing foals placed in the north and south facing house at 14:00h is presented in table 2 and 2a) and Figure 2.

Respiration rate did not show any significant rise in the foals placed in the north facing house (27.14±0.19), whereas there was a significant (P<0.01) rise in respiration rate in foals placed in the south facing house (27.50±0.21) when they were exposed ambient temperature ranging from32-46°C.

Effect of Relative Humidity on the physiological indices of foals placed in the north and south faced house at 08:00h

Rectal temperature (RT °C)

Rectal temperature (Mean ± S.E) recorded in growing foals placed in the north and south facing house at 14:00h is presented in table 3 and 3a) and Figure 3.

Rectal temperature with regard to relative humidity (RH) as a factor increased significantly (P<0.01) in the foals placed in south facing house (37.81 ±.02) and did not show any significant change in the north facing house when they were exposed to an RH ranging from23-88percent.

Heart rate (HR, beats per min)

Heart rate (Mean ± S.E) recorded in growing foals placed in the north and south facing house at 08:00h was presented in table 3 and 3a and Figure 3.

Heart rate with regard to relative humidity as a factor did not show any significant rise in foals placed in the north facing and south facing house when they were exposed to RH ranging from 23-88percent.

Respiration rate (RR, breaths per min)

Respiration rate (Mean ± S.E) recorded in growing foals placed in the north and south facing house at 08:00h was presented in table 3 and 3a and Figure 3. Respiration rate with regard to relative humidity as a factor did not show any significant rise in the foals placed in north and south facing house when they were exposed to an RH ranging from23-88percent.

Table.1 Least square means ± SE value of the effect of ambient temperature on the physiological indices of foals in north facing house at 08:00h

Ambient temperature	n	Rectal temp	Heart rate	Respiration rate
Overall mean(µ±S.E)		37.74±0.02	54.51±0.38	28.13±0.21
(°C)		NS	NS	NS
T1 (22-30°C)	105	37.78±0.04	53.63±0.76	28.19±0.43
T2 (30-32°C)	105	37.69±0.04	55.21±0.77	28.68±0.44
T3 (32-34°C)	105	37.78±0.04	55.40±0.77	28.43±0.44
T4 (34-36°C)	105	37.71±0.04	53.78±0.73	27.23±0.42

n – Number of observations; NS – Not significant

Table.1a Least square means ± SE values of the effect of ambient temperature on the physiological indices of foals in south facing house at 08:00h

Ambient Temperature	n	Rectal temp	Heart rate	Respiration rate
Overall mean(µ±S.E)		37.70 ±0.02	55.01±0.38	28.21±0.22
(°C)		*	**	NS
T1 (22-30)	105	37.60^{a}±0.04	52.86^{a}±0.76	27.61±0.44
T2 (30-32)	105	37.70^{ab}±0.04	54.64^{ab}±0.76	28.22 ±0.44
T3 (32-34)	105	37.74^{ab}±0.04	55.86^{b}±0.75	28.32±0.44
T4 (34-36)	105	37.78^{b} ±0.04	56.66^{b}±0.76	28.68±0.44

n – Number of observations; *– Significant (P<0.05)
** – Highly significant (P<0.01); NS – Not significant
Means with at least one common superscript within classes differ significantly with each other.

Table.2 Least square means ± SE values of the effect of ambient temperature on the physiological indices of foals in north facing house at 14:00h

Ambient temperature	n	Rectal temp	Heart rate	Respiration rate
Overall mean(µ±S.E)		37.81±0.02	54.12±0.34	27.14±0.19
(°C)		**	**	NS
T1 (32-36 °C)	105	37.63^{a}±0.04	52.11^{a}±0.69	26.90± 0.38
T2 (36-40 °C)	105	37.77^{ab}±0.04	55.37^{b}±0.69	27.39± 0.38
T3 (40-42 °C)	105	37.94^{c} ±0.04	55.10^{b}±0.69	27.29±0.38
T4 (42-46 °C)	105	37.91^{bc}±0.04	53.92^{ab}±0.70	26.99±0.38

n – Number of observations; *– Significant (P<0.05)
** – Highly significant (P<0.01); NS – Not significant
Means with at least one common superscript within classes differ significantly with each other

Table.2a Least square means ± SE values of the effect of ambient temperature on the physiological indices of foals in South facing house at 14:00h

Ambient Temperature	n	Rectal temperature	Heart rate	Respiration rate
Overall mean (µ±S.E)		37.77±0.02	54.51±0.35	27.50±0.21
(°C)		*	**	**
T1 (32-36 °C)	105	37.66^{a}±0.04	51.83^{a}±0.70	26.50^{a}±0.41
T2 (36-40 °C)	105	37.76^{ab}±0.04	54.71^{b}±0.71	26.81^{a}±0.42
T3 (40-42 °C)	105	37.85^{b}±0.04	55.01^{b}±0.72	28.37^{b}±0.43
T4 (42-46 °C)	105	37.83^{b}±0.04	56.51^{b}±0.69	28.33^{b}±0.41

n – Number of observations; *– Significant (P<0.05)
** – Highly significant (P<0.01); NS – Not significant
Means with at least one common superscript within classes differ significantly with each other.

Table.3 Least square means ± SE values of the effect of relative humidity on the physiological parameters of foals in north facing house at 08:00h

Relative humidity	n	Rectal temperature	Heart rate	Respiration rate
Overall mean (µ±S.E)		37.74±0.02	54.47±0.38	28.12±0.21
(%)		NS	NS	NS
H1 (23-45%)	105	37.70±0.04	53.98±0.76	28.28±0.43
H2 (45-55 %)	105	37.71±0.04	53.90±0.78	28.53±0.44
H3 (55-67%)	105	37.80±0.04	55.18±0.74	27.85±0.42
H4 (67-88%)	105	37.67±0.04	54.82±0.76	27.80±0.43

n – Number of observations; NS – Not significant

Table.3a Least square means ± SE values of the effect of relative humidity on the physiological parameters of foals in south facing house at 08:00h

Relative humidity	n	Rectal temperature	Heart rate	Respiration rate
Overall mean (µ± S.E)		37.70±0.02	55.02±0.38	28.22±0.22
(%)		**	NS	NS
H1 (23-45%)	105	37.75^{ab}±0.04	54.35±0.76	27.35±0.43
H2 (45-55 %)	105	37.79^{b}±0.04	55.47±0.76	28.16±0.44
H3 (55-67%)	105	37.68^{ab}±0.04	55.14±0.78	28.33±0.44
H4 (67-88%)	105	37.60^{a}±0.04	55.11±0.78	29.05±0.45

n – Number of observations; *– Significant (P<0.05)
** – Highly significant (P<0.01); NS – Not significant
Means with at least one common superscript within classes differ significantly with each other.

Table.4 Least square means ± SE values of the effect of relative humidity on the physiological parameters of foals in North facing house at 14:00h

Relative humidity	n	Rectal temperature	Heart rate	Respiration rate
Overall mean (μ ± S.E)		37.81±0.02	54.13±0.34	27.14±0.19
		**	**	NS
H1 (8-22%)	105	37.99^{c}±0.04	54.76^{a}±0.69	26.72±0.38
H2 (22-34%)	105	37.83^{bc}±0.04	54.03^{ab}±0.67	27.39±0.37
H3 (34-44%)	105	37.80^{b}±0.04	55.94^{b}±0.70	27.25±0.38
H4 (44-73%)	105	37.62^{a}±0.04	51.80^{a}±0.69	27.21±0.38

n – Number of observations; *– Significant (P<0.05)
** – Highly significant (P<0.01); NS – Not significant
Means with at least one common superscript within classes differ significantly with each other

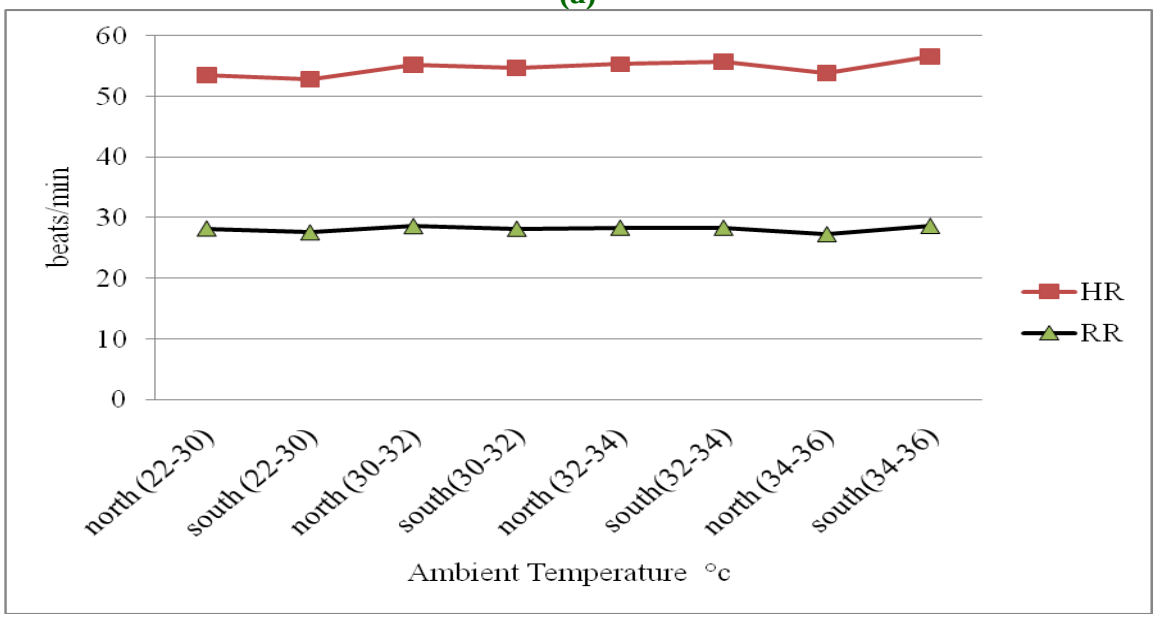
Table.4a Least square means ± SE values of the effect of relative humidity on the physiological parameters of foals in South facing house at 14:00h

Relative humidity	n	Rectal temperature	Heart rate	Respiration rate
Overall mean (μ ± S.E)		37.77±0.02	54.54±0.36	27.50±0.21
		*	NS	*
H1 (8-22%)	105	37.86^{b}±0.04	54.03±0.72	26.44^{a}±0.42
H2 (22-34%)	105	37.80^{ab}±0.04	54.82±0.73	27.56^{ab}±0.43
H3 (34-44%)	105	37.77^{ab}±0.04	55.48±0.73	28.15^{b}±0.43
H4 (44-73%)	105	37.66^{a}±0.04	53.82±0.69	27.84^{ab}±0.41

n – Number of observations; *– Significant (P<0.05); NS – Not significant
Means with at least one common superscript within classes differ significantly with each other.

Fig.1 Effect of ambient temperature on the physiological indices of foals placed in the north and south facing house at 08:00h

(a)



(b)

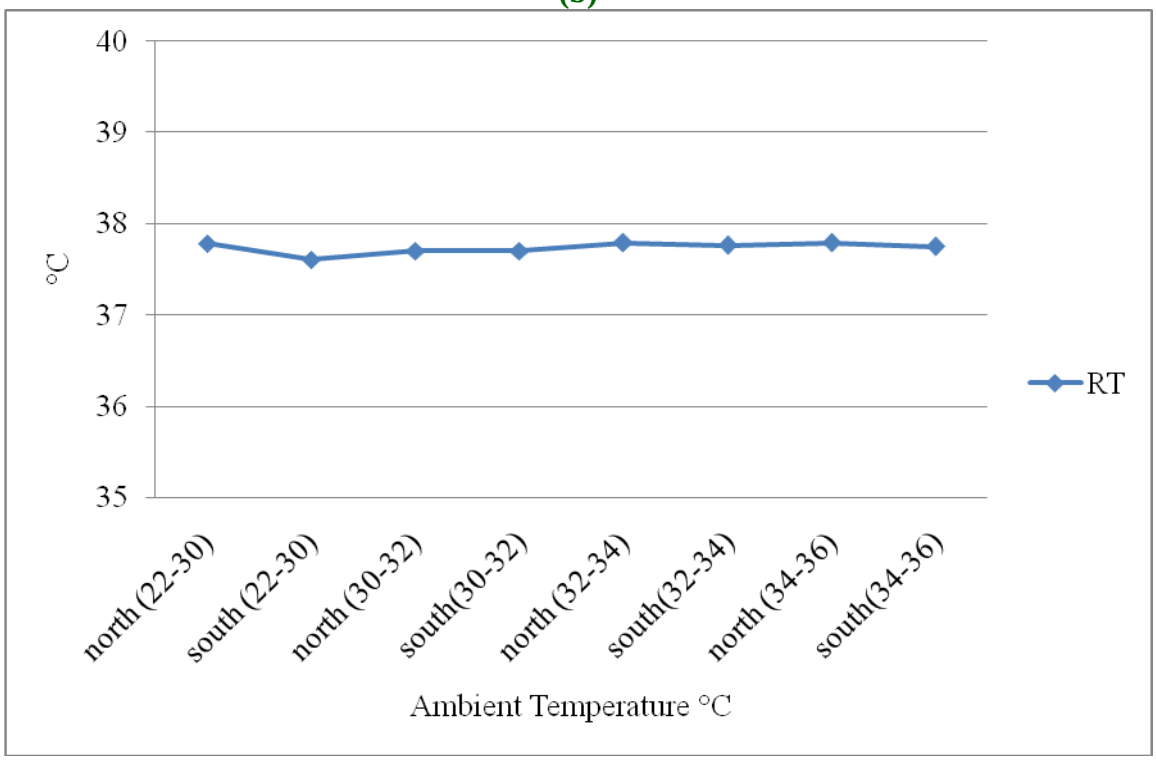
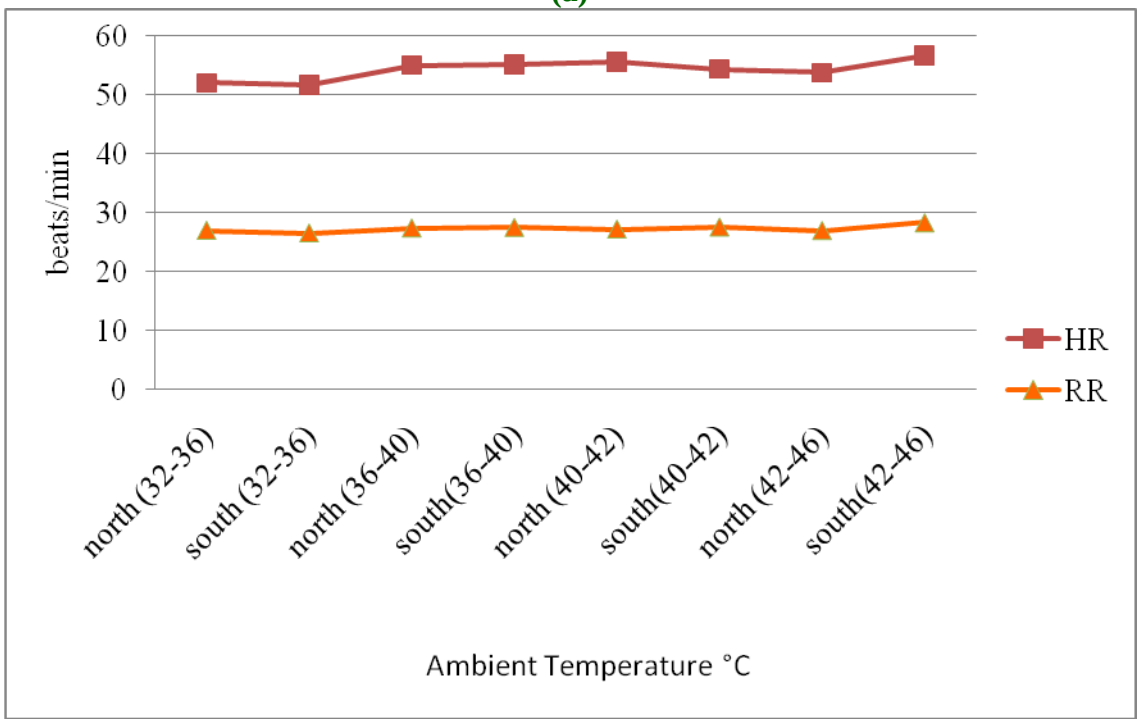


Fig.2 Effect of ambient temperature on the physiological indices of foals placed in the north and south facing house at 14:00h

(a)



(b)

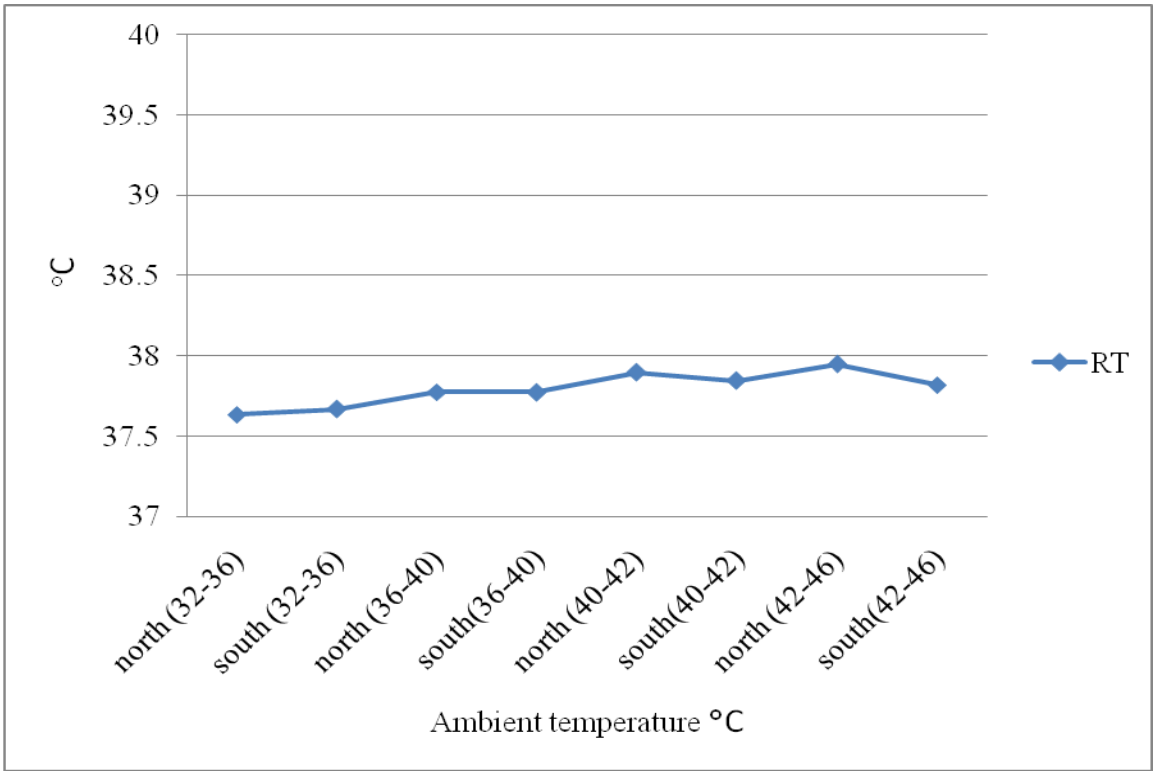
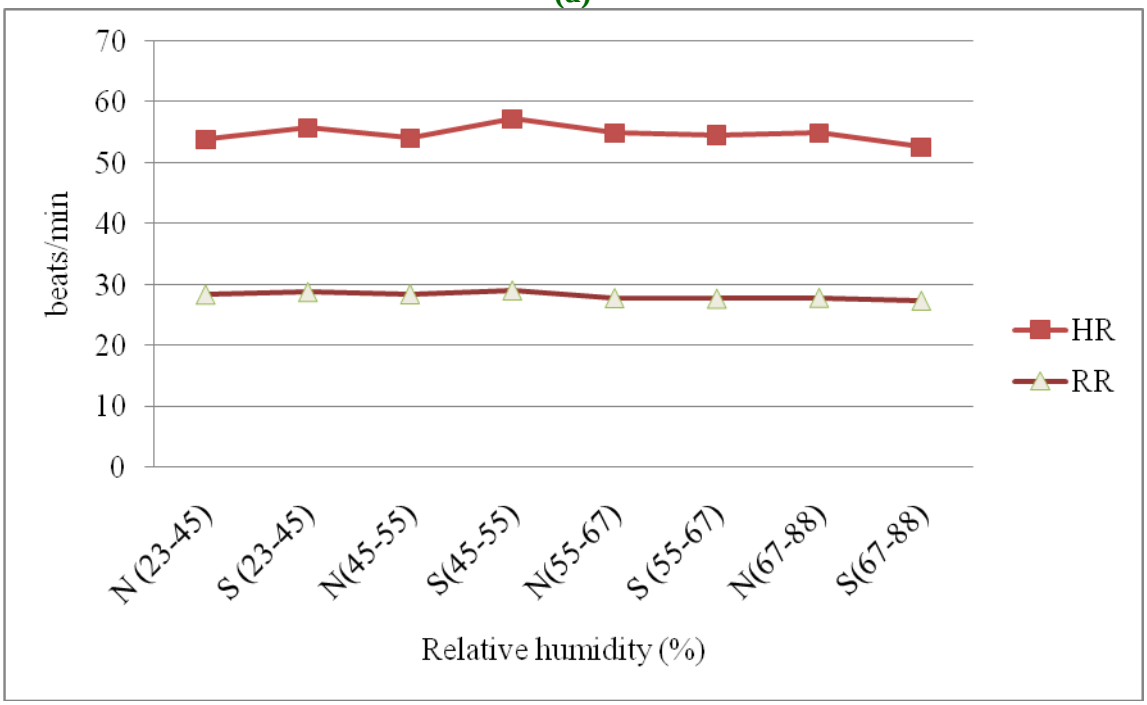


Fig.3 Effect of Relative Humidity on the physiological indices of foals placed in the north and south facing house at 08:00h

(a)



(b)

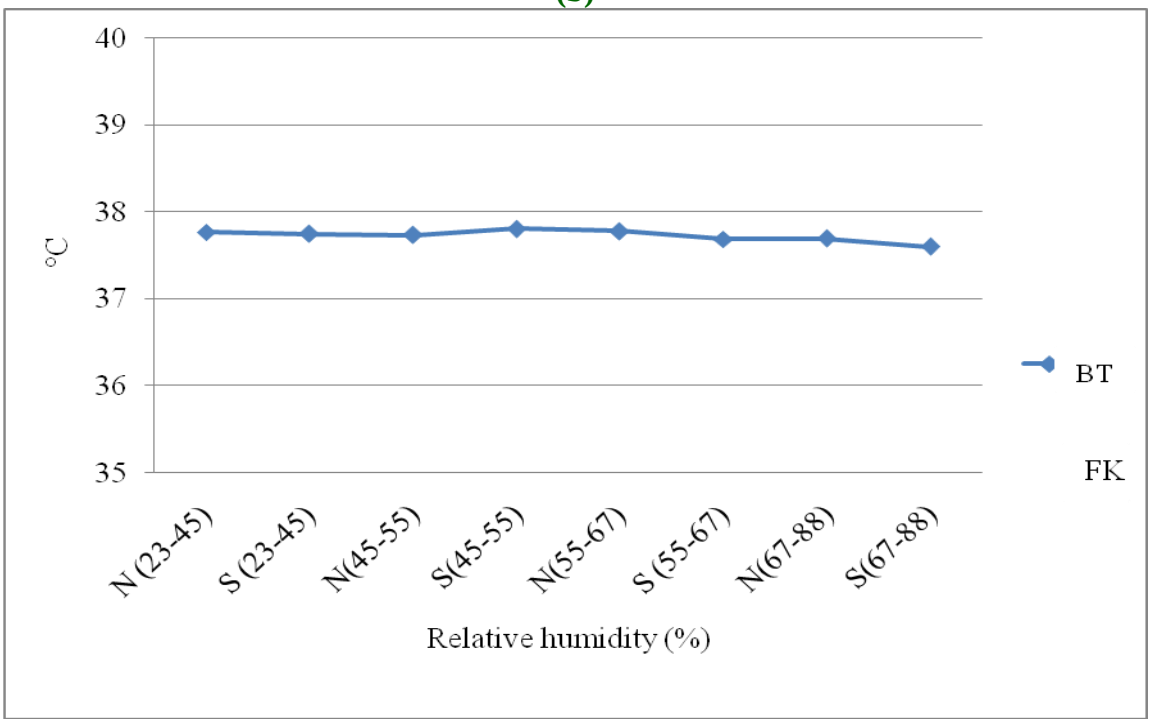
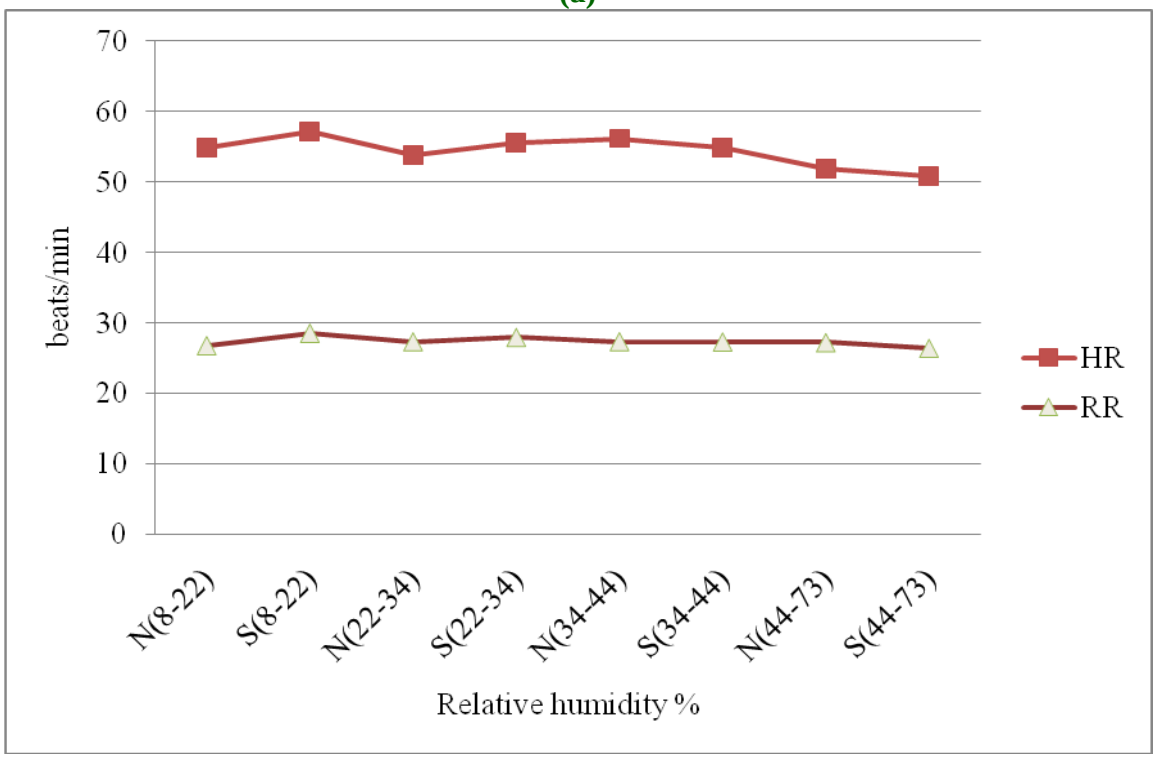
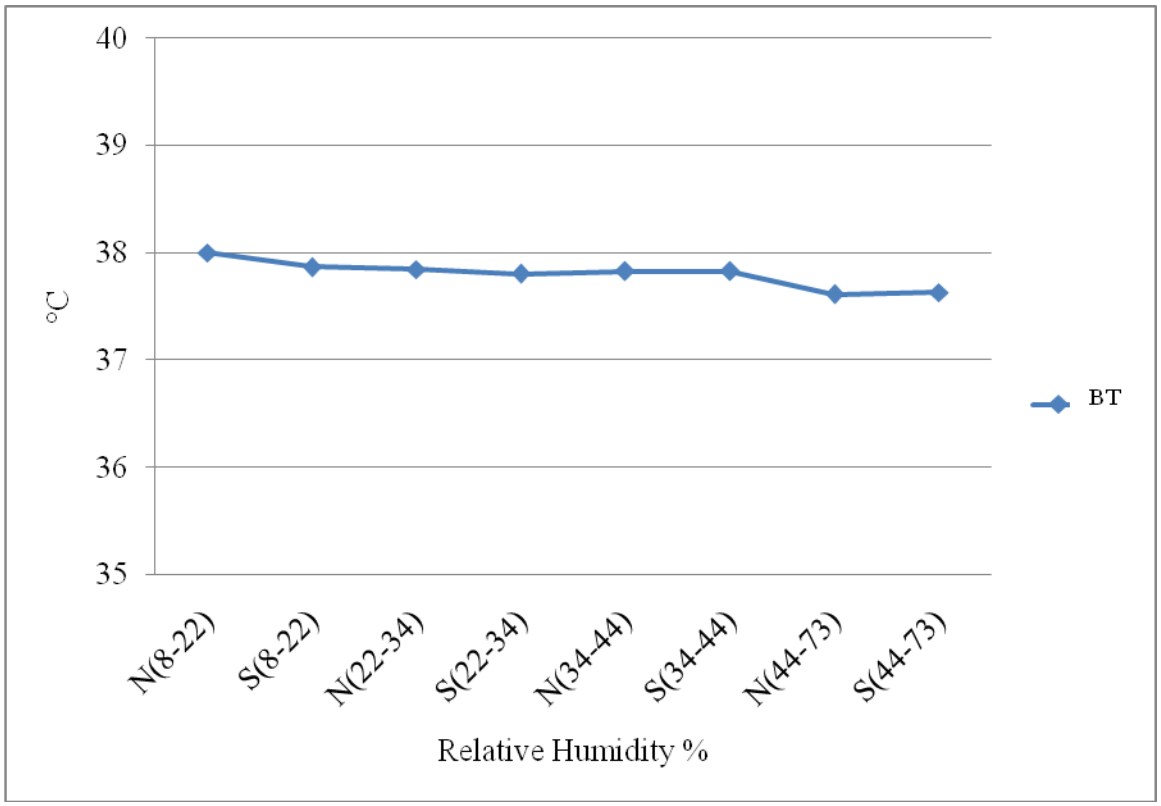


Fig.4 Effect of relative humidity on the physiological indices of foals placed on the north and south facing house at 14:00h

(a)



(b)



Effect of relative humidity on the physiological indices of foals placed on the north and south faced house at 14:00h

Rectal temperature (RT °C)

Rectal temperature (Mean ± S.E) recorded in growing foals placed in the north and south facing house at 14:00h is presented in table 4 and 4a and Figure 4. Rectal temperature with regard to relative humidity (RH) as a factor was highly significant (P<0.01) in the foals placed in the north (37.81±0.02) and (P<0.05) in south facing (37.77±0.02) house when they were exposed to RH ranging from 8-73percent.

Heart rate (HR, beats per min)

Heart rate (Mean ± S.E) recorded in growing foals placed in the north and south facing house at 14:00h is presented in table 4 and 4a and Figure 4. Heart rate with regard to relative humidity as a factor increased significantly (P<0.01) in the foals placed in the north (54.13±0.34) facing, whereas there was no significant rise in the south facing house when they were exposed to RH ranging from 8-73percent.

Respiration rate (RR, breaths per min)

Respiration rate (Mean ± S.E) recorded in growing foals placed in the north and south facing house at 14:00h is presented in table 4 and 4a and Figure 4.

Respiration rate with regard to relative humidity as a factor did not show any significant rise in the foals placed on facing in north facing house, but there was a significant rise in RR in foals placed in a south facing

house (27.50±0.21) when they were exposed to RH ranging from 8-73 percent.

As there is a paucity of information with regard to the work on the facing / orientation of the animal house and their effect on animals performance, factors like heat stress, transportation stress was taken as reference. Having said that, previous works by Cwynar *et al.*, (2014) evaluated the effect of heat stress on physiological parameters and blood composition in Polish Merino rams. He reported decreased respiration rate and rectal temperature due to thermal stress. Padalino *et al.*, (2012) reported that rectal temperature remained within the normal levels every time after loading before and after transportation and heart rate increased to considerable levels each time after loading and unloading, whereas Hulugulla *et al.*, (2012) conducted a study on response of basic physiology to exercise in horses and concluded that bathing reduced the rectal temperature while exercise did not Minka and Ayo (2007) conducted a study on the effect of shade provision on some physiological parameter and indicated that heart rate recorded pre and post packing indicated that un-shaded donkeys have significantly higher values compared with shaded donkeys, pre and post packing. Padilla *et al.*, (2006), also described that the rectal temperature was higher in summer (39.83°C) than autumn (38.30 °C) in lactating cows. The above references were corroborating to the results of this study. Sapkota *et al.*, (2016) reported, with Acute Heat exposure skin surface temperature had increased at all locations and also the Core Body temperature is in agreement with our finding. To the best of our knowledge, this is the first report which has described the changes with regard to the direction of the animal house. Hence it can be concluded that foals placed in the south facing house experienced considerable stress with regard to ambient temperature at 08:00h than the north facing house. It also can be due to the rising pattern of sun and rays falling on the horse. If the sun rises in South East during that time, there are more chance of rays falling directly on horse facing south so there can be extra stress compared to North facing horses.

With regard to 14:00h, foals on both north and south facing house experienced considerable stress in the present study, all the physiological parameters (RT, HR) except RR showed highly significant changes in north facing house, whereas the south facing house recorded significant changes in all the physiological parameters as the north facing house, including the RR. Pal *et al.*, (2000) also reported similar findings in donkeys, where their respective rectal temperature and respiration rate, increased in the afternoon.

When exposed to the direct solar radiation skin is the first organ to experience the heat load. As they absorb the maximum heat and when the heat load is more, core body temperature starts elevating gradually. Such an increase in temperature helps to dissipate the heat and may help in keeping the body temperature in a thermo-neutral zone (Aggarwal and Upadhayay1997; Hahn 1999; Das *et al.*, 1997; Silanikove, 2000; Beatty *et al.*, 2006, Kumar and Kumar 2013). On the other hand, this overall effect may be the other cause for an increased respiration rate and heart rate, when the temperature ranges between 32-46°C.

The increased respiration rate is a heat dissipation mechanism, it helps in cooling down the blood running from lungs to the heart (Aggarwal and Upadhayay, 1997; Hahn, 1999; Das *et al.*, 1997; Beatty *et al.*, 2006, Kumar and Kumar, 2013). Increased pulse rate provides a cooling effect, that greater heat is dissipated by sweating and by another mechanism, by increasing the blood flow to peripheral organs and skin (Aggarwal and

Upadhayay, 1997; Hahn, 1999; Das *et al.*, 1997; Beatty *et al.*, 2006, Kumar and Kumar, 2013).

The effect of north and south faced housing on the performance of foals has been studied in the semi-arid area, of Rajasthan. When exposed to the variables of climate like ambient temperature and relative humidity, the foals have shown significant responses in their physiological indices. With ambient temperature as a factor, the foals placed on the south-facing house exhibited increased rectal temperature, heart rate at 08:00h, whereas by 14:00h foals on both north and south facing house exhibited increased rectal temperature, heart rate. Hence, it was evident that the temperature has a greater influence on the foals. With relative humidity as a factor, no significant changes were observed on the physiological indices of the foals placed in north and south facing house at 08:00h whereas significant changes in the physiological indices of foals were found only in the north facing house at 14:00h.

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