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REGULAR ARTICLES

Different ambient management intervention techniques and their effect on milk production and physiological parameters of lactating NiliRavi buffaloes during hot dry summer of subtropical region

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Abstract
In tropical countries, one of the major threats for diary animal production is climate change. Ambient management interventions are beneficial and are the dire need of animal production in tropics. Ambient management intervention and its effect on physiological performance of lactating NiliRavi buffaloes were investigated during the hot dry months (April to June) of Pakistan. Fifteen lactating NiliRavi water buffaloes of similar size, age, and same parity were randomly stratified into three groups, comprising of five animals in each group, designated as group S, SF, and SFS. Animals of group S (control) were kept just under the shade while the animals in group SF were provided shade plus fan, animals in group SFS were provided the shade, fan as well as sprinklers during the hot day hours between 10:00 AM to 6:00 PM. Shed conditions were same for all animals, isonitrogenous and isocaloric feed was provided to all animals. Milk production decreased with the increase in ambient temperature. Average dry matter intake in group S, SF, and SFS were 75%, 80%, and 90% of the total feed offered to the experimental animals, respectively. The mean rectal temperatures (°F) were 101.69, 101.19, and 100.85 in group S, SF, and SFS, respectively. Heat stress had pronounced effect on blood glucose level as indicated by the mean glucose concentration in group S and SFS being recorded at 78.04 mg/dl and 90.47 mg/dl, respectively. It is concluded that the buffaloes should be provided with sprinklers and fans to minimize heat load and maximize the production during hot dry season.

Keywords Production · Buffalo · Shower · Hot dry summer

Introduction

Buffaloes (*Babalus bubalis*) are widely used as dairy animals in developing and developed countries. Use of buffalo milk is increasing in dairy industries because of higher concentration of milk constituents as well as higher economic returns and great deal of opportunities for the manufacturing of valueadded dairy products (Mane and Chalti 2015). Buffalo farming has been shifted from traditional to intensive farming techniques that were initially developed for cattle (De Rosa et al. 2005).

Heat stress is known to be a problem causing huge economic losses to the dairy animals' 30–40% as well as dairy industry (Pragna et al. 2016). Heat stress occurs when animal's body means fail to control its internal temperature. Heat stress has a direct effect on productive efficiency of female buffalo during summer and during heat stress period 35 to 50% milk is lost (Singh et al. 2013, Conte et al. 2018).

The high environmental temperature and relative humidity are major physical factors that cause heat stress in dairy animals (Dash et al. 2016). Furthermore, radiant heat from the sun adds stress to animals, if not properly shaded (Berman and Horovitz. 2012). Heat stress is a complex process that brings about

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various challenges in the animals' homeostatic mechanism and causes some alterations in the normal physiological mechanisms, therefore, evokes a stressful response. Heat stress is the most limiting factor affecting animal's production and farmer income in the subtropical regions. Nonevaporative cooling is less in animals when environmental temperature rises above the thermoneutral zone (Ahmad et al. 2018). During heat stress period some physiological mechanisms activates like increase skin blood flow to the extremities, high sweating rate to avoid the heat storage and increase in body temperature to cope up with the external environment to decrease the heat load burden. Warm air and heat stress are major concerns for all dairy animals and for all livestock production systems and their effects have profound and readily apparent negative impact on production and health, and in some case heat stress leads to mortality (Pragna et al. 2016). In hot climatic areas, exposure to higher ambient temperature from thermoneutral zone is the major constraint on dairy animal's productivity. An increase in body temperature of around 1 °C may result in detectable, deleterious effects on tissue integrity, metabolism, and a significant depression in production (Das et al. 2016). When dairy animals are exposed to thermal stress conditions for extended period, animals try to adjust in the changing adverse environment (Haque et al. 2015).

During the hot dry period, if heat load persists for extended period, heat acclimation is achieved through an acclamatory hemostasis process (Horowitz, 2001), which are partially characterized by a lowered glucocorticoid, albumin, globulin, total protein and cholesterol concentration and other hormones such as T3 and T4. Increased temperature humidity index (THI) markedly suppress the glucose and total protein level due to lowered DMI. Voluntary decrease in DMI is the physiological mechanism to reduce the internal heat load (Polsky et al. 2017). Some hormones alter the basal metabolic rates along with some other hormones and reduce the heat production (Burnabucci et al. 2010). There exists seasonal variation of different hormone glands' activities, which in turn reduces the heat production within the body of animals by different physiological and hormonal activities. Changes in the concentration of different hormones in the blood reflect the metabolic and nutrient status of the animal body (Aleena et al. 2016).

Buffaloes being different in physiological aspects than cattle, demands different cooling management strategies to minimize the harmful effects of heat stress. Although cooling through fan, mist or foggers (AvendanoReyes et al. 2006, Aggarwal and Singh, 2008, Rahangdale et al. 2010), are previously done in buffalooriented countries but most of the studies have been done using the controlled chamber conditions. Information of cooling buffalo during the hot dry summer in the environmental open condition is scarce in the literature. Therefore, present study was undertaken to investigate the effect of strategic ambient management on productive and physiological reaction of NiliRavi buffaloes during the hot dry summer in subtropical region of Punjab (Pakistan).

Materials and methods

Location of study

The present study was performed at Dairy Animals Training and Research Centre, University of Veterinary and Animal Sciences, Ravi campus, Pattoki, located 31.02° N latitude and 73.84° E longitude, and 635 ft. above the sea level, Pakistan. The experiment was conducted during the hot dry summer months (April to June, 90 days). The average rainfall during the months of April, May, and June is around 14, 2.6, and 9.3 mm, respectively. Average minimum (maximum) temperatures in April, May, and June were 19.9 °C (34.9 °C), 24.3 °C (39.7 °C), and 27.9 °C (41.2 °C), respectively. Data of average rainfall and environmental temperatures were obtained from the metrology department of Pakistan. The weather was hot dry throughout the experimental period.

Experimental animals

Experiment was planned in a completely randomized design, 15 lactating NiliRavi water buffaloes of similar size and age and same lactation were randomly stratified into three treatments, comprising of five animals in each treatment, designated as treatment S, SF, and SFS. Animals of treatment S were kept just under the open shade and this treatment was considered as control. Animals in SF were provided with shade and fan (Fan works from10:00AM to 6:00PM) while the animals in SFS were provided the shade, fan as well as sprinklers during the hot day hours between 10:00AM to 6:00PM.

The sloped floor of stall was constructed with concrete while the roof was built with hard metal covered with insulation material while the shed walls were open for ventilation. The slopes on the floor were properly kept towards the drain to avoid dampness. The animals were housed in modified head to head housing system. All the experimental animals were provided oat grass silage at 8:00 AM. A total of 5 kg concentrate allowance was offered daily to each animal, out of which 2.5 kg at the time of morning feeding (8:00 AM) while the remaining 2.5 kg was provided to lactating buffaloes before the start of evening milking (4:00 PM). Concentrate feeding was provided in partition to avoid the selective feeding behavior. Water was provided ad lib in five frequencies in rubber tubs for 24 h.

Recording of parameters

The chemical composition of oat silage was estimated in the Animal Nutrition laboratory, Ravi Campus, University of Veterinary and Animal Sciences (AOAC, 2000). Oat grass silage pH was 3.9, dry matter (DM) (%) 41, crude protein CP (%) 7.7, and ash (%) 14.2 while gross energy (kcal/kg) was 3612 and concentrate DM (%) was 91.10, crude protein (%) 13.75, ash (%) 7.10, Fat (%) 1.6, crude fiber (%) 8.2. Lactating NiliRavi animals were drenched at the start of experiment against internal parasites. Animal in all groups were provided measured quantity of *adlib* silage and measured quantity of concentrate (5 kg per animal per day). In the next morning, the leftover silage was weighed to calculate the DMI of each animal. It was done for three consecutive days for 7 days interval. Animals were given measured quantity of water ad lib five times daily and it was recorded twice every week. Total water intake was measured by subtracting the leftover water from the offered.

The shed temperature, Tdb, and relative humidity were measured by the LCD digital temperature humidity thermometer HTC1 at 12:00 PM and 6:00 PM daily to calculate THI (power supply 1.5 V × 1, storage condition: −20 °C to 60 °C, 20–80% RH, Shenzhen DSC Tools Co., Ltd., China). THI was calculated by Mader et al. (2006),

$$\mathrm{THI} = (0.8 \times \mathrm{Tdb}) + \Big[(\mathrm{RH}/100) \times \Big(\mathrm{Tdb}{-}14.4 + 46.4 \quad (1)$$

Whereas, Tdb = dry bulb temperature; RH = relative humidity

One temperature humidity thermometer was used in each shed. It was placed on the wall of shed at 6 ft. height. The milk production was recorded daily at the morning and evening milking by electrical weighing balance (05:00 AM and 05:00 PM) throughout the experiment period. The composition of milk (fat%, protein%, SNF%, and lactose%) was estimated by the mixing morning and evening milk through Lacto scan, Funke Gerber (Lacto star type, year 2012, Ser. No. 3510–144,703, voltage frequencies 230 V, 50–60 Hz, Power input/current 0.4 KW/2A) on weekly basis.

The physiological parameters, i.e., respiration rate (RR), pulse rate (PR), skin temperature (ST), and rectal temperature (RT) were recorded twice a week. All physiological parameters were recorded between 1:00 pm to 2:00 pm of the day and physiological parameters were measured under the shed where experimental animals were kept. The RR (minutes) were measured by observing the flank movement after one complete inward and outward movement through the hand. The PR (beats per 10 s) was recorded from the coccygeal artery. The ST was recorded at forehead of buffalo for about 6 s by the 1.2” LCD noncontact digital infrared thermometer laser temperature gun sensor (−50 °C⁻ to approximately 380 °C) whereas the RT was observed with the help of digital thermometer (CTA302 digital thermometer, Citizen Systems Japan Co. Ltd) in the rectum and waited until the buzzer. The blood samples were collected from juggler vein on fortnightly basis, in sterile vials containing disodium salt of ethylenediaminetetraacetic acid (ETDA, 2 mg/ml) as anticoagulant under aseptic condition for estimation of White blood cells (WBC), red blood cells (RBC), hemoglobin (Hb), hematocrit (HCT), and serum was collected by centrifuging at 5000 rpm for 5 min. Hematological parameters were analyzed through automated hematological analyzer (Stac Abacus Junior 5 Hematological Analyzer, STAC Medical Science & Technology Co., Ltd., China) at the University Diagnostic Laboratory, UVAS, Lahore, on fortnightly basis, while the blood serum was frozen at −20 °C till further analysis. The blood serum was analyzed by kit method through spectrophotometer (IRMECO UVVIS, Model U2020, Serial No. 20A1133, IRMECO GmbH, Geesthacht, Germany). The blood serum was analyzed through commercially available kits; serum total protein was analyzed by Zaia et al. (2005); albumin by Tietz et al. (1995); glucose by Burtis et al. (2008); cholesterol by Mignarri et al. (2015) while globulin was calculated by subtracting albumin from total protein.

Statistical analysis

Data of mean THI, DMI, milk production, average RR, PR, ST, RT, blood hematology, blood biochemistry and behavioral responses of lactating NiliRavi buffaloes were calculated on different intervals. The data collected were subjected to Oneway ANOVA to test the difference between the three treatment groups. Multiple comparisons among means were carried out through LSD test (Steel et al. 1997). All the statistical analysis was performed using the statistical software SAS 9.1.3 (SAS, 9.1.3, 2005). Statistical confidence level was 95%.

Results

Meteorological recoding of sheds

The daily mean ambient temperatures in the experimental period were 33.90, 33.56, and 31.09 °C, in treatment S, SF, and SFS, respectively. Daily mean relative humidity values were 39.27%, 38.37%, and 39.07% in treatment S, SF, and SFS, respectively. Daily mean THI values were 81.10, 80.52, and 77.69 in shed S, SF, and SFS, respectively (Table 1).

Feed intake, water intake, milk production, and composition

Average dry matter intake in SFS and SF was higher ($p < 0.05$) 17.34% (14.61 kg), 5.40% (13.12 kg) than 12.45 kg of S (Table 2). Water intake was highest ($p < 0.05$) in treatment S

Table 1 Meteorological data of microclimate of NiliRavi buffaloes in hot dry summer

Parameter	S	SF	SFS
Environmental temperature (°C)	33.90 ± 0.85a	33.56 ± 0.75a	31.09 ± 0.55b
Humidity (%)	39.27 ± 2.84a	38.37 ± 3.28a	39.07 ± 3.71a
THI	81.1 ± 0.73a	80.52 ± 0.67a	77.69 ± 0.47b

Different letters within the same row indicate significantly different result ($p < 0.05$)

S shade only (control), *SF* shade and fan, *SFS* shade, fan, and shower

(108.29 l) followed by treatment SF (98.81 l) and SFS (95.04 l) Table 2. Milk production was highest ($p < 0.05$) in treatment SFS (8.74 kg/d) followed by treatment SF (6.3 kg/d) and lowest in treatment S (5.60 kg/d) respectively.

Milk composition showed significant ($p < 0.05$) changes in different treatment. Fat percentage was highest ($p < 0.05$) in S (6.50) followed by SF (6.25) than SFS (5.76) during the hot dry period. Milk protein (%) was high as ($p < 0.05$) 3.79, 3.59, and 3.39 in SFS, SF, and S, respectively. Solid not fat (%) was high as ($p < 0.05$) 8.76, 8.65, and 8.58 in SFS, SF, and S, respectively. Milk lactose content in buffalo milk was significantly higher as ($p < 0.05$) 4.52, 4.32, and 4.11 in SFS, SF, and S, respectively.

Physiological parameters

Daily mean respiration rate (breaths/min) was highest ($p < 0.05$) in S (34.73) followed by SF (26.15) and lowest in SFS (19.98). Similarly, pulse rate (beats/min) was highest ($p < 0.05$) in S (62.53) followed by SF (56.05) and lowest in SFS (47.95). Skin temperature (°C) were high ($p < 0.05$) 4.61 followed by 33.74 than 32.52 in S, SF, and SFS, respectively. Rectal temperature (°F) was recorded highest ($p < 0.05$) in S (101.69) than SF (101.19) than SFS (100.85) during the hot dry period.

Blood hematological parameters

White blood cells (10^{-3}/μl) were highest ($p < 0.05$) in SFS (8.57) followed by SF (7.78) than S (6.63) during the hot dry period. Red blood cells (10^{-6}/μl) were ($p < 0.05$) highest in SFS (8.34) followed by SF (7.85) than S treatment (7.07) during the trial period. Hb (g/dl) was 9.20, 8.80, and 7.78 in SFS, SF, and S, respectively. HcT (%) showed nonsignificant ($p > 0.05$) 36.52, 36.10, and 36.06 in SFS, SF, and S treatment, respectively.

Blood biochemistry

Blood metabolites of different treatment of animals were also determined during the hot dry period. The total protein (mg/dl) was highest ($p < 0.05$) in group SFS (8.55) followed by SF (7.76) than S (6.78). Blood albumin (mg/dl) was highest ($p < 0.05$) in S (46.61) followed by SF (44.28) and lowest in SFS (39.62). Blood globulin (mg/dl) showed similar pattern as blood albumin. Highest ($p < 0.05$) globulin concentration (mg/dl) was found in S (39.83) followed by SF (36.51) than SFS (31.07). Blood glucose concentration (mg/dl) was highest ($p < 0.05$) in SFS (90.47) followed by SF (82.03) than S (78.04). Blood cholesterol concentration (mg/dl) was highest ($p < 0.05$) in S (212.63) followed by SF (211.04) than SFS (204.97).

Discussion

During the study period, the thermal stress was typical in the plain area of Pakistan, which is characterized by the hot summer with little fluctuations in environment. Value of THI 73 is considered quite above the comfort zone for animal

Table 2 Productive performance of NiliRavi buffaloes during hot dry season

Parameters	S	SF	SFS
Dry matter intake (kg/day)	12.45 ± 0.39c	13.12 ± 0.29b	14.61 ± 1.18a
Water intake (liter/day)	108.29 ± 3.95a	98.81 ± 5.49ab	95.04 ± 1.8b
Milk yield (kg/day)	5.60 ± 1.19b	6.30 ± 1.2b	8.74 ± 1.15a
Fat (%)	5.76 ± 0.07c	6.25 ± 0.04b	6.50 ± 0.04a
Protein (%)	3.39 ± 0.06c	3.59 ± 0.05b	3.79 ± 0.07a
SNF (%)	8.58 ± 0.04b	8.65 ± 0.05ab	8.76 ± 0.04a
Lactose (%)	4.11 ± 0.03c	4.32 ± 0.04b	4.52 ± 0.069a

Means of triplicate analysis, different letters within the same row indicate significantly different result ($p < 0.05$), $n = 5$ per group production (Tullo et al. 2017) but as a whole THI values remain well above from the TNZ during the experimental period which was critical for production. Based on mean THI values, THI were over the comfort level during the trial period, animals were in great heat stress when kept in the sheds. However, it could be said that buffaloes from the SFS experienced favorable welfare conditions during the experimental duration than other treatments.

Threshold of THI for dairy animals is 72. Heat stress caused 15–35% reduction in milk yield (Chanda et al. 2017). Milk production decreased with the increase in ambient temperature. The decline in milk production can also be connected to the lower DMI. Higher milk production in SFS was due to the cooling effects caused by sprinklers which helped in higher DMI in SFS treatment (Chen et al. 2016). Increase in ambient temperature decreased the dry matter intake which resulted in lower milk production (Marai and Habeeb, 2010). Environmental temperature has great impact on milk production (Hussain et al. 2006; Marai et al. 2009). Climatic changes have great impact on specific biological functions, which led to the lower milk production (Tanaka et al. 2007, Javed et al. 2009).

DMI decreased with increase in ambient temperature (Ahmad and Tariq, 2010). The DMI decreased due to increase in the THI to reduce the heat load to lesser the heat production in the animal's body produced by the metabolic process, importantly it is the one of the major sources of heat production in ruminants which leads to decreased DMI (Pejman and Shahryar, 2012). Reduction in heat load of the animal body by decreasing DMI has been reported by the many previous studies (Lough et al. 1990, Rhoads et al. 2009). Moreover, the water fill effect may also decrease DMI in heatstressed lactating buffalo during the hot dry period. ElShwey (2017) reported that the sprinkling increased DMI 17% over control group whereas in the study of Garner et al. (1989) the DMI increased up to 20% in sprinkling group during hot dry period.

Water intake (WI) increased in S treatment as a strategy to decrease metabolic heat of the body and it decreased the DMI. Water intake in buffaloes was found to increase with increase in environmental temperature (Daniel et al.1981, Kamal et al. 1982, Khongdee et al. 2013). Similar results were reported by Kamboj et al. (2000) and Das et al. (2011) in NiliRavi buffalo heifers, Singh et al. (2005) in lactating NiliRavi buffaloes, and Davis and Mader (2002) in crossbred steers. DMI (kg per day) increased due to the cooling effect by sprinklers in SFS compared to fan (SF) and only shade (S) animals while the WI decreased in sprinkler group (SFS) followed by fan (SF) than controlled treatment (S).

The increase in milk fat (%) might be due to the factor that animals were comparatively in better microclimate which was produced by sprinklers and their THI value was 77.69 (treatment SFS) compared to 81.10 (treatment S) and animals in SFS treatment showed mild heat stress as compared to S treatment. Cooling during the hot environmental temperature significantly ($p < 0.05$) increased milk fat, protein, and SNF. Milk fat (%) decreased in heat stressed animals due to increase in environmental temperature while milk fat (%) increases in cooled cows during the hot dry summer months (Bailey et al. 2005). The difference in the fat (%) may be due to the difference in fatty acid synthesis of lactating animals due to difference in ambient temperature. When environmental temperature increases, the fatty acid synthesis decreases, and it decreases the milk fat contents (Yasmin et al. 2012). Another major factor is that during the period of increased temperature the dry matter intake decreased which decreased the milk quantity and quality (Butler et al. 2008). The present study results are in line with studies of Yadav et al. (1994), Voltorta and Gallardo (2004), and Yasmin et al. (2012) who reported decreased milk fat (%) during hot summer as compared to cooler months.

The decrease in milk protein concentration might be due to the advances in stage of lactation in buffalo animals. Reduced feed intake might be another factor which decreases the milk protein contents in heat stressed animals compared to cooled animals. Milk protein (%) decreased in heat stressed animals due to increase in environmental temperature while milk protein (%) increases in cooled animals (Bailey et al. 2005). During summer months the milk protein contents decreased due to reduction in case in contents which might be another reason of decreased milk protein concentration (Bernabucci et al. 2002). Result of our study are in according to the study of Yasmin et al. (2012) in cow, Voltorta and Gallardo (2004) in Holstein cow, and Sevi et al. (2001) in ewe, who reported decreased milk protein contents during hot summer months in lactating animals. However, lower lactose contents were observed in heat stressed buffaloes which might be due to decrease in health condition and might be due to increased physiological stress on animal's body (Bruckmaier and Blum, 2004). Our results are in line with the studies of Yasmin et al. (2012) and Dobranic et al. (2008) found decreased milk lactose contents during marked seasonal variation during summer months.

The mean rectal temperature was 38.71, 38.43, and 38.25 (°C) in treatment S, SF, SFS, respectively. In the thermal stress period, the rectal temperature was higher in control treatment as compared to shower treatment animals ($p < 0.05$). The number of breaths per minute was 42.47% and 24.70% lower in SFS and SF as compared to controlled S. RR were significantly ($p < 0.05$) higher in heat stressed animals as compared to fan and shower treatment. Higher RR was the result of discomfort and it was also noticed that increase in RR might be due to exposure to greater THI values. With the increase in environmental temperature the respiration rate was increased in dairy cows because cows were in above TNZ (Das et al. 2016). Increased RR might be due to the result of more heat accumulation within the body of animal which was to be get

Table 3 Physiological parameters of NiliRavi buffaloes during hot dry season

Parameter	S	SF	SFS
Respiration rate (breaths per minute)	34.73 ± 1.17a	26.15 ± 1.18b	19.98 ± 0.76c
Pulse rate (beats per minute)	62.53 ± 1.24a	56.05 ± 1.7b	47.95 ± 0.83c
Skin temperature (°C)	34.61 ± 0.23a	33.74 ± 0.05b	32.52 ± 0.5c
Rectal temperature (°F)	101.69 ± 0.09a	101.19 ± 0.06b	100.85 ± 0.06c

$n = 5$/group; different letters within the same row indicate significantly different result ($p < 0.05$)

For the detail of groups, see Table 1

rid of by higher pulmonary evaporative cooling via respiratory tract (Ganaie et al. 2013). RR of heat stressed calves was more than cooled calves (Soly and Singh, 2001, Khongdee et al. 2013). The skin temperature (°C) showed significant difference ($p < 0.05$) between the different treatments. In the present study, the significant high ($p < 0.05$) skin temperature suggested that highambient temperature affects the skin temperature in NiliRavi buffaloes. Result of present study is in line with the study of Chaudhari and Singh (2015) in Murrah buffalo. The pulse rate was 23.32% and 10.36% lower in treatment SFS and SF than controlled treatment (S). The increased pulse rate was observed in S treatment, which were provided only shade and it showed great stress due to high THI values well above the normal values for dairy animals which is 72. Results of present study are in harmony with the studies on Murrah buffalo (Das et al. 1999) and crossbred male calves (Soly and Singh, 2001), who reported increased physiological responses during inclement hot weather (Table 3).

The WBC (cells/μl) reduced in heatstressed group and increased in sprinkler group. Significant difference ($p < 0.05$) was observed in the serum WBCs, in cooled animals compared with the thermalstressed animals. The possible reason might be the higher load of heat accumulation within the body and might be due to low resistance against the diseases because heatstressed animals have low threshold to withstand against the diseases (Koubkova et al. 2002). This decrease might be the result of increase in hemodilution effect and increase in erythrocyte destruction (Zhang et al. 2017). The RBC decreased in heat stressed animals as compared to cooled animals in present study. RBCs of thermal exposed dairy cattle were lesser than the group of animals kept under normal conditions (Koubkova et al. 2002). The Hb values also showed significant decrease in heatstressed animals while Hb value increased in SFS treatment. In heat stress period, Hb level decreases because thermal stress leads to hemolysis which results in loss of hemoglobin. Results of present study are in accordance with the study of Todorovic et al. (2011) in dairy cows and Ganaie et al. (2013) in cows who reported decreased Hb concentration in heat stressed animals (Table 4).

The glucose (mg/dl) concentration was 15.92% higher in cooled treatment (SFS) compared to heat stressed animals (S). During the heat stress period the glucose concentration decreased ($p < 0.05$) in heat stress NiliRavi animals. Heat stress had pronounced effect on blood glucose level. During heat stress period, the basal insulin level increases and due to increased insulin concentration, the glucose concentration decreases (Wheelock et al. 2010). The effect of heat on blood glucose level has been extensively reported elsewhere (Shwartz et al. 2009, Bahga et al. 2009, Singh et al. 2012). During the hot dry summer, serum protein concentration significantly differed ($p < 0.05$) between the groups of lactating buffaloes. However, contradictory result was reported by Sejian et al. (2010) in goats who reported increased values of total protein during heat stress period. Albumin concentration was increased significantly ($p < 0.05$) during the hot dry summer period (Table 5). These finding are relevant with the findings of Hooda and Upadhyay (2014) in buffalo calves and Koubkova et al. (2002) in cattle, who reported higher level of albumin during heat stress period. Albumin are major

Table 4 Hematological values of NiliRavi buffalo during hot dry summer

Parameters	S	SF	SFS
WBC (10^{-3}/μl)	6.63 ± 0.16c	7.78 ± 0.26b	8.57 ± 0.18a
RBC (10^{-6}/μl)	7.07 ± 0.11c	7.85 ± 0.18b	8.34 ± 0.08a
Hb (g/dl)	7.78 ± 0.17b	8.80 ± 0.19a	9.20 ± 0.10a
HcT (%)	36.06 ± 0.24a	36.10 ± 0.28a	36.52 ± 0.21a

Different letters within the same row indicate significantly different result ($p < 0.05$)

WBC white blood cells, *RBC* red blood cells, *Hb* hemoglobin, *HcT* hematocrit

Table 5 Effects of heat exposure on blood biochemical indices in lactating NiliRavi

Blood metabolites	S	SF	SFS
Total protein (mg/dl)	6.78 ± 0.63c	7.76 ± 0.44b	8.55 ± 0.49a
Albumin (mg/dl)	46.61 ± 2.13a	44.28 ± 0.81a	39.62 ± 2.03b
Globulin (mg/dl)	39.83 ± 1.88a	36.51 ± 1.48a	31.07 ± 2.03c
Glucose (mg/dl)	78.04 ± 3.24b	82.03 ± 3.48b	90.47 ± 5.37a
Cholesterol (mg/dl)	212.63 ± 9.08a	211.04 ± 1.01a	204.97 ± 5.59b

$n = 5$; different letters within the same row indicate significantly different result ($p < 0.05$)

extracellular source of thiols and it function as antioxidant, and this increase of serum albumin concentration might be the result of loss of extracellular fluid due to heat stress (Rasooli et al. 2004, Ganaie et al. 2013).

Conclusion

It is concluded that productive and physiological performance of lactating NiliRavi buffalo can be improved by providing facility of sprinklers assisted with fan under the shade during hot dry summer in subtropical regions.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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