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Research Article

CAN BATHING AMELIORATE THE EFFECTS OF HEAT STRESS ON MILK YIELD AND QUALITY OF DAIRY CATTLE?

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ABSTRACT
Heat stress is a major factor that reduces milk production, feed intake and reproductive performance in dairy cows. Water is commonly used to cool cattle in summer. The objective of this research is to evaluate the effect of frequency of bathing on milk yield and milk quality parameters viz percentage milk fat, SNF, lactose and protein in crossbred Jersy cattle during hot summer.A total of 16 crossbred Jersey cattle were used in this experiment in randomized complete block design. The experiment was conducted at National Cattle Research Programme (NCRP)'s cattle research farm during May to July while the milk quality parameters were tested in dairy laboratory in Bharatpur, Chitwan. The crossbred cattle were subjected to four bathing frequencies viz; once at 12:0 hours, twice at 12:00 and 15 hours, thrice at 09:00, 12:00 and 15:00 hours for a total of 90 days during hot summer days from May till July. Routine assessment of the microclimate within the experimental shed wand daily milk yield and fortnightly assessment of milk quality parameters (Fat, Solid-not-Fat (SNF), Protein and Lactose percentage) were made. The maximum and minimum temperatures in the shed over the experiment duration were 35.4^{0}C and 27.4^{0}C respectively. The results from the experiment inferred that frequency of bathing did not have any significant impact on milk yield and any of the milk quality parameters. The effect of heat stress during the mild summer with an average maximum of 35.4^{0}C and minimum of 27.4^{0}C did not reveal any significant impact in terms of milk yield and quality parameters ruling out the necessity to explore coping strategies.

Keywords: *Heat stress, Milk Yield, Milk Fat, SNF, Lactose, Protein, Jersey Crossbred*

INTRODUCTION
Nepal has, on an average, witnessed an annual increment in average temperatures of 0.06^{0}C from 1977 to 2000 and of 0.04^{0}C increases in the terai and 0.08^{0}C increases in the Himalayas (Malla, 2009). These patterns have indicated that the pattern of such increment and their detrimental consequences are more pronounced at higher altitudes and more so during the winter months as opposed to the monsoon season. In the meantime, it has also been reported that the western half of the country is more affected than in the eastern half (Chhetri and Easterling, 2010).
The climatic conditions of Nepal vary from place to place in accordance with the geographical features. In the north summers are cool and has winter it is severe, while in south summers are very warm and winter is mild. In the terai, summer temperatures exceed 37^{0}C and higher in some areas (Anonymous, 2015). About two-third of the total population of cattle are raised in such areas (Paudel and Perrera, 2009). The climatic conditions of the tropics during affect the performance of dairy cattle in a variety of different ways more than other species of livestock (Paudel and Perrera, 2009). To attain the fullest genetic performance, environmental conditions and diets should be modified. Thermal factors consist of air temperature, humidity, air movement, and radiation rate. In lactating Holstein cows, the comfortable temperature is within the range 4- 24^{0}C (Hahn 1981). The effects of heat stress on the cows begin to be observed above 24^{o}C, and milk yield decreases markedly above 27^{o}C (Johnson 1965).
Stress as the magnitude of forces external to the body which tend to displace its systems from their normal physiological condition. In this light, heat stress for the dairy cow can be understood to indicate all high temperature related forces that induce adjustments occurring from the sub-cellular to the whole animal level to help the cow avoid physiological dysfunction and for it to better fit its

environment (Yousef, 1985). The endeavor by homeotherms to stabilize body temperature within fairly narrow limits is essential to controls biological reactions and physiological processes associated with normal metabolism (Shearer and Beede, 1990). In order to maintain homeothermy, an animal must be thermal equilibrium with its environment, which include radiation, air temperature, air movement and humidity. Lactating dairy cows prefer ambient temperatures of between 5 and 25^{0}C, the thermoneutral zone (Roenfeldt, 1998).

MATERIALS AND METHODS

The study area and period

The experiment was conducted during the summer months of 2015 (May-July) at experimental station of National Cattle Research Program (NCRP) in Rampur, Chitwan (27º39'N and 84º21'E), 10 km west of district headquarters, Bharatpur. Climatically, Chitwan harbours the tropical climate and yet is one of the most important dairy pockets of Nepal, largely due to the high demand of fluid milk, easy availability of feeds, straw, veterinary services favouring commercialization of dairy farming.

Sample size, design and treatment groups

All together sixteen lactating cattle were used for the study and fit into completely randomized block design (RCBD). Blocking was done on the basis of the parity of the animals selected for the study. The following list explains the treatment arrangement of the experiment.

Treatment group

T_1: Bathing once in a day (12:00 hours)
T_2: Bathing twice (12:00 and 15:00 hours)
T_3: Bathing thrice (9:00, 12:00 and 15 hours)
T_4: Control (no bathing)

Data collection and analysis

Meteorological data (maximum, minimum, dry bulb and wet bulb temperature in centigrade) were collected from inside the shed every morning at 9:00 hours. Likewise, vital signs were collected three times daily (at 9:00, 12:00 and 15 hours) every fortnight during the trial period. Any aberrations to the vital signs and animal behaving other than their normal behavior were closely monitored. Provisions were made in a way that any animal distressed due to the experiment will be treated and taken out of the experiment considering the study's alignment with the standard animal ethics protocol.

The milk sample were collected on a fortnightly basis starting from day zero. The collected samples were analyzed for fat, solid-not-fat (SNF), protein, lactose etc. milk analyzer (Ekomilk, Total Ultrasonic Milk Analyzer, Bulltech 2000, Stara Zagora, Bulgaria). Milk production records were recorded daily two times morning and evening during the research period. Collected data were assembled and processed and cleaned with the use of MS Excel (version 16.16.4) and differences among the means using different models has been carried out using SPSS™ Statistical Software (version 23). All the recorded data were subjected to analysis of variance and Duncan's multiple range test (DMRT) for mean separation. The significance differences among the means were tested using least significance difference (LSD) at 5% level of significance (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Microclimatic condition inside the cattle shed

The climatic conditions inside the shed are presented in table 1. The average of maximum, minimum, dry bulb and wet bulb temperature are tabulated as 35.4, 27.4, 30.7 and 26.1 ^{0}C respectively. Environmental temperature at which the respiration rate started to increase was lower (17^{o}C) for high-producing cows (>35 kg milk/day) than that (22^{o}C) of low producing cows (Hagiwara *et al.*, 2002). Some studies indicated that lactating dairy cows from European breeds, the thermos-neutral zone ranges between -5 and 25°C, and are called lower critical temperature (LCT) and upper critical temperature (UCT) respectively meaning animals require no additional energy above maintenance to cool or heat their body (Johnson, 1987).

Table 1: Meteorological data inside the cattle shed during the experimental period

Variable	No. of observation	Temperatures (^{0}C)		
		Mean	Minimum	Maximum
Maximum temperature	90	35.4±0.3	30.0	39.0
Minimum temperature	90	27.4±0.2	23.0	33.0
Dry bulb temperature	90	30.7±0.2	27.0	35.0
Wet bulb temperature	90	26.1±0.2	22.0	28.5

Milk production performance

The milk production performance of experimental animals was recorded on every milking (morning and afternoon) and daily yield is calculated for the use in the experiment. To work-out the difference due to the difference in frequency of bathing were again calculated to give fortnightly milk yield in kilograms and are presented in table 2. The minimum bathing effects were recorded in experimental animal (crossbred Jersey cattle) during the experimental period. The results were found statistically non-significant.

Table 2: Effect of bathing frequency on fortnightly milk production performance

Treatments	Fortnightly milk yield (in Kgs)					
	1st	2nd	3rd	4th	5th	6th
T1	121.0±17.8	121.2±20.3	110.9±20.4	102.3±21.5	102.7±20.1	110.4±15.4
T2	123.2±13.0	116.4±10.7	109.5±11.6	101.6±9.8	96.2±11.1	104.3±13.6
T3	131.3±21.4	113.9±11.3	103.0±11.9	99.7±11.2	94.7±16.5	95.3±18.4
T4	120.6±17.7	114.4±21.6	99.9±20.2	90.6±17.9	90.1±19.6	88.3±23.0
Probability	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05

Note: T1: Bathing once at 12:00 hours, T2: Bathing twice (12:00 and 15:00 hours), T3: Bathing thrice (09:00, 12:00 and 15:00 hours) and T4: Control (no bathing)

The magnitude of the effect on milk production attributable to heat stress is often positively correlated with the productivity of the animals. In this scenario, the productivity of Jersey crossbreds has less than 10 kg per day average production meaning these animals have less tendency to respond to the impact of heat stress (Moran, 2005; Tapki and Sahin, 2006). This could largely be due to elevated metabolic heat production relating to high feed intake in high producing cows. For example, Kadzere *et al* (2002) observed a considerable decline in milk yield along elevated rectal temperature of above 39^{0}C. Likewise, higher frequency of eating, drinking and standing, and a lower frequency of ruminating, locomotion and resting were found associated with hot climate amongst high yielder as compared to low producing cows (Tapki and Sahin, 2006).

Reduction in milk production is one of the major economic impacts of thermal stress in dairy cattle. Decreased milk yield due to thermal stress is more prominent in Holstein than in Jersey cattle (Sharma *et al.,* 1983). Decreased synthesis of hepatic glucose and lower non-esterified fatty acid (NEFA) level in blood during thermal stress (Baumgard *et al.,* 2007; Rhoads *et al.,* 2009, Wheelock *et al.,* 2010) causes reduced glucose supply to the mammary glands resulting low lactose synthesis which in turn ensues low milk yield (Nardone *et al.,* 2010). Reduction in milk yield is further intensified by decrease in feed consumption by animals to compensate high environmental temperature (Blackshaw and Blackshaw, 1994; Nardone *et al.,* 2010). Reduced milk production due to thermal stress is attributable only partly to decrease in feed intake. However, only 35% of the reduction in milk production is due to decreased feed intake while remaining 65% is attributable to direct effect of thermal stress (Rhoads *et al.,* 2009). Other factors resulting in reduced milk production during thermal stress are decreased nutrient absorption, effect in rumen

function, hormonal status and increased maintenance requirement resulting reduced net energy supply for production (Bernabucci *et al.*, 2010; Wheelock *et al.*, 2010).
Heat stress can cause a decline in milk production since the feed intake might decrease. When comparing cows with and without access to shade, the milk yield has been shown to be higher for shaded cows. However, the milk composition does not differ between shaded and unshaded cows. Daily milk yield also shows less variability when the cows have access to shade (Kendall *et al.*, 2006). Comparing *B. taurus* cattle, Sharma *et al.* (1983) reported that Jerseys were more resistant to heat stress effects on milk production than Holsteins. In the milk production performance, another researcher Aii *et al.* (1998) reported an increase in milk production of 0.66-1.90 kg/ day for cows producing 20-25 kg/day using the combination of mist and fan.

Milk quality parameters
Fat, Solid-not-Fat (SNF), Protein and Lactose percentage
The milk fat of experimental animals was recorded on a fortnightly interval and average and standard deviations of which are presented in table 3. The milk fat data were found statistically non-significant between the different treatment groups indicating that there could be no effect in terms of milk fat percentage of bathing frequency to the lactating crossbred Jersey cattle during the summer period.

Table 3: Effect of bathing frequency on milk fat % on different days of the experiment

Treatments	0 days	15 days	30 days	45 days	60 days	75 days	90 days
T1	4.4±0.9	4.0±0.7	4.6±0.6	4.8±0.6	4.3±0.7	5.3±0.8	5.0±1.0
T2	4.9±0.5	4.9±0.5	4.7±0.5	4.9±0.5	5.3±0.5	5.2±0.4	5.5±0.6
T3	3.6±0.3	4.8±0. 6	4.6±0.3	5.4±0.4	5.6±0.8	5.5±0.3	5.5±0.3
T4	3.5±0.2	4.9±0.6	4.6±0.6	4.8±0.5	5.0±0.4	5.2±0.6	5.0±0.6
Probability	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05

Note: T1: Bathing once at 12:00 hours, T2: Bathing twice (12:00 and 15:00 hours), T3: Bathing thrice (09:00, 12:00 and 15:00 hours) and T4: Control (no bathing)

Similarly, the milk SNF of the experimental animals was recorded in fortnightly interval of the different treatments in summer condition is presented in table 4. The results of SNF were found statistically non-significant between the different treatment groups. During the research period, implying the normal water bathing effect were not seen in the experimental animals of milk SNF in different treatment groups.

Table 4: Effect of bathing frequency on SNF % in different treatment groups

Treatment	0 days	15 days	30 days	45 days	60 days	75 days	90 days
T_1	9.9±0.1	9.7±0.2	9.8±0.3	9.9±0.2	9.6±0.6	9.8±0.5	9.8±0.7
T_2	10.0±0.2	10.0±0.2	10.1±0.2	10.0±0.2	10.1±0.2	10.3±0.2	10.6±0.2
T_3	9.8±0.2	9.7±0.2	9.6±0.3	10.0±0.2	9. 9±0.3	10.1±0.2	10.2±0.2
T_4	9.6±0.4	9.6±0.3	9.7±0.3	9.8±0.4	9.7±0.3	9. 8±0.3	10.0±0.3
Probability	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05

Note: T1: Bathing once at 12:00 hours, T2: Bathing twice (12:00 and 15:00 hours), T3: Bathing thrice (09:00, 12:00 and 15:00 hours) and T4: Control (no bathing)

Likewise, the milk protein (casein) of the experimental animals across fortnightly interval during the research period of the different treatment groups of normal water bathing in summer condition were presented in table 5. The results of milk protein analysis also did not reveal any significance statistically. This means, this research shows that in the Chitwan condition heat stress does not have significant importance in terms of milk quality parameters.

Table 5: Effect of frequency of bathing on milk protein percentage during summer

Treatment	0 days	15 days	30 days	45 days	60 days	75 days	90 days
T_1	3.9±0.1	3.8±0.1	3.9±0.2	3.9±0.1	3.8±0.2	4.0±0.2	3.9±0.3
T_2	4.0±0.1	4.0±0.1	4.0±0.1	4.0±0.1	4.0±0.2	4.1±0.1	4.2±0.1
T_3	3.8±0.0	3.9±0.1	3.8±0.1	4.0±0.1	4.0±0.1	4.1±0.1	4.1±0.1
T_4	3.7±0.1	3.8±0.2	3.8±0.2	3.9±0.2	3.9±0.1	4.0±0.2	4.0±0.1
Probability	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05

Note: T1: Bathing once at 12:00 hours, T2: Bathing twice (12:00 and 15:00 hours), T3: Bathing thrice (09:00, 12:00 and 15:00 hours) and T4: Control (no bathing)

The milk lactose of the experimental animals was recorded in fortnightly interval of the different treatment of normal water bathing effect in summer condition was presented in table 6. The result of milk lactose of the experimental animal between different treatments groups were fund statistics non-significant. During the summer condition normal water bathing effect on milk lactose were not found in different treatment groups of the experimental animals.

Table 6: Effect of bathing frequency on lactose level in different treatment groups

Treatment	0 days	15 days	30 days	45 days	60 days	75 days	90 days
T_1	5.9±0.2	5.7±0.2	5.8±0.2	5.9±0.2	5.7±0.3	5.9±0.3	5.9±0.4
T_2	5.9±0.2	6.0±0.1	6.0±0.2	6.0±0.2	6.1±0.2	6.2±0.2	6.4±0.2
T_3	5.7±0.1	5.8±0.2	5.7±0.2	6.0±0.1	6.0±0.2	6.1±0.1	6.1±0.2
T_4	5.7±0.2	5.7±0.3	5.8±0.2	5.9±0.3	5.8±0.2	5.9±0.2	6.0±0.2
Probability	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05

Note: T1: Bathing once at 12:00 hours, T2: Bathing twice (12:00 and 15:00 hours), T3: Bathing thrice (09:00, 12:00 and 15:00 hours) and T4: Control (no bathing)

Knapp and Grummer (1991) reported that response of cows to heat stress during summer season showed significant lower ($P<0.05$) in milk components with the lowest values during July. In contrary, however, the higher components were detected during winter season with the highest values during January. Heat stress significantly ($P<0.05$) reduced milk fat, protein, lactose, SNF, TS and ash contents in summer season than in summer season. This study did not scope the seasonality of these parameters, such comparisons could not be made. Nateghi *et al.* (2014), along the line, reported that the protein content of summer and winter milks statistically did not show any significant difference ($p>0.05$), however, the amount of protein contained in summer milk was higher than winter milk as its amounts in summer and winter milks were 3.71% and 3.01%, respectively.

Knapp and Grummer (1991) also indicated that a decrease in milk quality parameters are usually linked with increased maximum daily temperatures. Bouraoui et al. (2002) found that milk fat and milk protein were lower for the summer season. Ozrenk and Inci (2008) also supported the usual claim in that milk fat, protein and total solids percentages in cow milk are the highest during the winter and the lowest during the summer.

CONCLUSION

This study kept track of the changes in milk yield and quality parameters like milk fat, SNF, lactose and protein percentages in crossbred Jersey cattle in Chitwan condition. However, the visible and significant difference in terms of the tested parameters could not be evidenced as part of this experiment. The results obtained from the study did not, however, confer to the recommendation and hypothesis that extremities of climate are expressed in terms of production and economic attributes. This could perhaps be due to the reason that either the animals have already been more or less suited to local harshness of summer or the temperature humidity index could perhaps be the right parameter to get more impressive results as part of the study (Granter, 2011). On the other hand, the thermoneutral zone of different breeds vary and a more detailed study scoping the breed effect is also deemed essential.

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COMPETING INTEREST
The authors have declared that there exists no competing interest relating to this publication.

AUTHOR'S CONTRIBUTION
This publication is the collaborative effort of all the authors. Author TPP has designed the study, prepared the protocol and the first manuscript. Authors BRA and DBA have worked on finalizing the protocol and laboratory analysis. Author BSS processed and analyzed the data. All authors have reviewed and provided input to improve the impression of the manuscript.

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