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EFFECT OF DIFFERENT HOUSING MANAGEMENT STRATEGIES ON PRODUCTION AND BEHAVIORAL RESPONSE OF BUFFALOES DURING DRY HOT SUMMER

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ABSTRACT

The current study was conducted with an aim to evaluate the effect of housing strategies on the production and behavioral responses of Nili-Ravi buffaloes during dry hot summer (May and June). The study was conducted at Buffalo Research Institute (BRI), Livestock Experiment Station (LES), Bhunike, Distt. Kasur, Punjab. Nili-Ravi buffaloes (n=20) with similar milk production and stage of lactation were selected from the herds maintained at LES, Pattoki. Buffaloes were divided into four different groups with 5 buffaloes in each group. Group A was kept under roof shade only (control); B was given anti-stress supplement (10gm, dry yeast powder; *Saccharomyces cerevisiae*); C under fans and group D buffaloes under fans with showers, provided with roof shades. Correspond to the temperature humidity index (THI) for May (85.6) and June (87.6), the daily milk production (MP; liter) was noticed significantly ($P \leq 0.01$) high in group D (7.33±0.10) as compared to animals in group A (6.39±0.13), B (6.52±0.09) and C (6.95±0.11). Similarly, dry matter intake (Kg; weekly) was high for group D (15.4±0.16; $P \leq 0.05$). However, cost per liter of milk production was lower for group D buffaloes. Group D buffalo's performance was concluded best in terms of cost per liter of milk production.

Key words: Buffalo, Milk production, Heat stress.

INTRODUCTION

The two best buffalo breeds in Pakistan are the Nili-Ravi and Kundi primarily inhabited in the irrigated areas and alongside rivers with the potential of providing more than 5000 liters of milk production per lactation (Bilal *et al.,* 2006). Various factors are affecting buffalo productivity. Among them, heat stress is a challenging issue for the dairy farmers of Pakistan. Geographical location of Pakistan is in sub-tropic as it is situated 23.6 degree above the line of equator between tropic of Cancer and tropic of Capricorn. Therefore, summer season prevails for long duration with high ambient temperature and relative humidity. Environmental temperature may rise up to 45°C in hot dry conditions (FAO, 2006) and relative humidity above 90% in hot humid conditions which is far above the comfort zone for high producing lactating animals.

The climatic conditions of Pakistan divided into five different prevailing seasons whereas, May and June is generally regarded as dry hot period due to high ambient temperature and moderate to low humidity (Naz and Ahmad, 2006). Data obtained from Pakistan meteorological department (Lahore) indicated the maximum temperature humidity index (THI) level of 88 and 91 due to high air temperature (40.2°C and 42.5°C) and humidity (37.8% and 40%) during May and June (2012), respectively, that are indicating very high environmental temperature and low humidity that together made hot dry environment and might be responsible for heat stress on lactating animals pushing them beyond the comfort or thermo-neutral zone.

Exposure of lactating animals under hot climatic conditions in tropical and subtropical areas is considered as major constraint on animal productivity as well as depression in the feed intake (Marai *et al*., 2007). According to the findings of Aggarwal and Singh (2010), the productive parameters like milk yield and dry matter (DM) intake were found variable under various housing strategies in heat stressed Murrah buffaloes at temperature humidity index (THI) of 80.3 during hot dry climate. No comprehensive heat stress study was available on Nili-Ravi buffaloes under various housing strategies; therefore, current study was conducted with an objective to evaluate the production and behavioral performance of lactating Nili-Ravi buffaloes during hot-dry summer accompanied by high environmental temperature and low humidity.

MATERIALS AND METHODS

Experimental Site: The research was conducted at the Buffalo Research Institute (BRI), Livestock Experiment Station (LES), Pattoki, Distt. Kasur, Punjab. The experimental station is located in central irrigated area of Punjab (31° North, 73° East).

Experimental treatments: Mature lactating multiparous (3rd, 4th, 5th and 6th parity) Nili-Ravi buffaloes (n=20) with similar level of milk production and stage of lactation were selected from the herd maintained at LES, Pattoki and were raised during months of May and June (hot-dry, mid-summer). The Nili-Ravi buffaloes were randomly assigned to 4 different groups. Group A (control) was kept under roof shade (height: 11 feet) only; B given anti-stress product(10gm, dry yeast powder; *Saccharomyces cerevisiae*); C under fans (size, 48"; speed, 360RPM and duration, 12 hours in day time on daily basis) and group D buffaloes were kept under fans (size, 48"; speed, 360RPM and duration, 12 hours in day time on daily basis) with showers (for 30 min after every 1.5 hour, from 8am to 8pm). Milk production was similar for all treatment groups. Maize Silage was offered *ad-libitum* to meet the maintenance requirements at 11.00 AM daily and was accessible till next morning milking whereas, concentrate was offered 1 kg for every 2 liters of milk produced (SMEDA, 2008; Table-1). First 10 days were taken as adjustment period followed by 50 days for data recording and sample collection.

Meteorological parameters

Environmental temperature (°C) and relative humidity (%): Ambient environmental temperature (°C) and relative humidity (%) was recorded during peak hours of day (12:00pm to 2:00pm) using hygrometer (Thermo-Hygro; TH-208 B). Average temperature was noted as 41.5°C and 41.3°C and average humidity as 22.3% and 30.3% for the months of May and June, respectively (Fig.1).

Wind velocity (WV; km/hour): Wind velocity (km/hour) was determined during peak hours of day (12:00pm to 2:00pm) with the help of digital anemometer (Intel Smart Sensor; AR-816). Average value of wind speed was noticed as 8.87 Km/h and 9.63 Km/h for the months of May and June (Fig.1).

Temperature Humidity index (THI): Temperature humidity index was noted by collecting data on air temperature and relative humidity, which was then calculated using following formula as described by Mader *et al*. (2006).

$$THI = (0.8 \times Tdb) + [(RH/100) \times (Tdb - 14.4)] + 46.4$$

Whereas;

THI: Temperature humidity index; RH: Relative humidity; Tdb: Dry bulb temperature

Average temperature-humidity index value was noted as 85.6 and 87.6 (Fig.1) in relation to environmental temperature and humidity during May and June, respectively.

Production parameters

Dry matter intake (DMI; kg): Buffaloes in each treatment were fed on maize silage (*ad-libitum*) and concentrate (1 kg for 2 liters of milk production) in morning. The orts were collected next morning for estimation of daily feed intake and dry matter intake which were calculated after drying the samples in hot air oven on weekly basis.

Water intake (liter): Water intake (liter) was measured by measuring the initial and final volume of water in the water trough and subsequently subtracted final value from initial value after 24 hours. The reading was noted regularly on weekly basis.

Behavioral parameters: Feeding time was calculated during 8am to 7pm (fortnightly basis) by observing how much time is spent on manger by buffalo for feeding only and drinking time was calculated during 8am to 7pm (fortnightly basis) by observing water intake by buffalo while standing on water trough with her mouth inside water. Feeding and drinking frequency were noted between 8am to 7pm (fortnightly basis) by observing how many times buffaloes moved to manger and water trough for feed intake and water intake, respectively.

Milk production: Milk production (liter) was recorded daily in the evening 6:00PM and morning 6:00AM following the practice of hand milking.

Milk composition: Milk samples were collected in plastic vial from each animal, stored at 4^0C and analyzed for milk composition i.e. total solids (TS%), solids-not-fat (SNF%) and milk fat% by the method described by AOAC (1999). The samples were analyzed on fortnightly basis in laboratory in the "Department of Dairy Technology", Ravi campus, UVAS.

Body condition scoring (BCS): A panel of four scientific personnel examined the body characteristics of lactating buffaloes for determination of body condition score before the start of trial and subsequently at the end of trial.

Economics of milk production: The production cost per liter of milk was calculated for each group at the end of trial. The cost per liter of milk was calculated by considering feed (silage and concentrate), anti-stress supplement, electricity and labor cost. These input costs were divided by the milk production value.

Statistical analysis: The recorded data were subjected to statistical analysis by using analysis of variance technique (ANOVA) under completely randomized design (CRD). The difference of means among treatment groups were determined by using Duncan Multiple Range Test (DMRT; Steel *et al.,* 1997) for the interpretation of results and plausible conclusions with the help of statistical software (Statistical packages for social sciences; SPSS).

RESULTS AND DISCUSSION

Dry matter intake (DMI; kg): Non-significant (P>0.05) differences were observed between group B (14.33±0.05) and C (14.6±0.10), whereas significant (P≤0.01) variation was observed between control group A (13.89±0.1) with group D (15.4±0.16; Table-3). Higher (P≤0.01) dry matter intake (DMI) level was noticed in group D buffaloes as compared to group A and B buffaloes.

The findings of our study are similar with the results of Aggarwal and Upadhyay (2013) who reported immediate decrease in DMI (5kg/day) in cows in response to high environmental temperature. Similarly, Jonsson *et al*. (1997) suggested that the reduction in dry matter intake was observed when dairy animals were exposed to heat stressed conditions. Similarly, Richards *et al*. (1995) reported that dry matter intake is altered in dairy animals as a result of heat stress conditions. Scott *et al*. (1983) alsofound a negative relationship between high environmental temperature and dry matter intake (DMI).

Water intake (WI; liter): The mean water intake of Nili-Ravi buffaloes was found to be 55.5±2.1, 57.6±0.95, 46.8±1.5 and 44.6±1.08 for the treatment groups A, B, C and D (Table-3). Non-significant difference (P>0.05) were observed between A and B group. Whereas, significant difference (P≤0.01) of control group A with the group C andD buffaloes.

The results of our experiment are in line with the findings of El-Koja *et al*. (1980) concluded that high temperature resulted in an increase in water intake (96.6 and 55.9 L/day). However, findings of Marai and Haeeb (2010) are similar with our results as they reported that in Friesian cows, the free intake was noted as 19.05 L/day under mild climate (16°C and 62% RH) and 31.16 L/day under hot climate (39°C and 62% RH, for 7 h daily over 11 days), respectively. The variation of water intake might be due to physiological state, age and breed difference.

Behavioral phenomenon

Feeding time: The mean feeding time (minutes) of Nili-Ravi buffaloes was found as 175±3.5, 195±3.5, 205±4.5 and 230.5±4.5 for the treatment groups A, B, C and D (Table-3). The feeding time was noted higher (P≤0.05) in group D and lowest (P≤0.05) in control group A. The results suggested a significant (P≤0.05) variation for control group A with group D. Non-significant (P>0.05) variations were observed between group B and group C.

The outcomes of our study are related to the findings of Hahn (1999) and Ominski *et al*. (2002) who reported that high temperature during summer may have negative impact on animal intake.

Drinking time: The mean drinking time (minutes) was observed higher in group A (9.12±0.42) followed by control group B (9.12±0.42), group C (7.62±0.23) and then group D (7.12±0.31; Table-3). Non-significant (P>0.05) differences were observed between group A and B. Group D buffaloes responded with lower (P≤0.05) drinking time as compared to group A and B. Similar, to our results, Marielena and Liang (2004) reported similar results and stated that high temperature during summer may have negative impact on animal intake and cows spent more time for drinking in hot climate (13.1 min/day) than cool environment (12.4 min/day).

Feeding frequency: Buffaloes were observed for feeding frequency and values were noted as 4.00±0.40, 4.25±0.25, 4.50±0.28 and 5.25±0.25 for treatment group A, B, C and D, respectively. Whereas, non-significant (P≤0.05) differences were noted between group A and B and similarly, between C and D. However, group C and D were found to have more feeding frequency (P≤0.01) than control group A. The findings of our study are similar to the results of Tapki and Sahin (2006) who reported that dairy animals in hot weather may show less frequency of feed intake.

Drinking frequency: Drinking frequency among buffaloes was noted and values were found as 4.00±0.25, 4.75±0.28, 5.50±0.25 and 5.25±0.40 for treatment groups A, B, C and D, respectively. Variations among group A and B as well as C and D were non-significant (P≤0.05). Lowest drinking frequency was noted for group D buffaloes (P≤0.01) than other treatment groups. The results of our study are close in line to the findings of Tapki and Sahin (2006) who reported that high producing dairy animals in hot weather may show more frequent visits to water troughcompared to low producing Holstein cows that showed less frequent visit. The difference might be due to provision of showers and fans in group D which made their micro climate cool as compare to hot environment of treatment groups A and B.

Milk production (MP; liter): Daily milk production (liter) was recorded and values were found as 6.39±0.13, 6.52±0.09, 6.95±0.11 and 7.33±0.10 for the treatment groups A, B, C and D (Table-2). Control group A and B were found to have non-significant (P>0.05) differences. Group C and D buffaloes showed higher (P≤0.001) milk production and group A and B buffaloes indicated the lower level of MP.

Our results are in-line with the findings of Armstrong (1994), Aggarwal (2004) and Aggarwal and Singh (2008) as the reported that during hot dry environment milk yield is increased in response to water cooling. The results coincide with the outcomes of Collier *et al*. (2006) who reported that Increase yield of milk about 0.8kg/head/day with reduction in the body temperature of about 1.95°C was noticed by using sprinklers and fans only, installed in holding pen area. Similarly, Igono *et al*. (1987) reported that milk production can be increased by

2kg/day among lactating cows treated with spray and ducted air system for 20 min than shaded controls. That is also helpful in maintaining of body temperature near to the normal (below 39°C). Since, dry matter intake (DMI) value was least in treatment groups A and B, therefore it might be interpreted that lower milk production in these treatment groups could be the consequence of less intake of nutritive components. Moreover, buffaloes might be spending lot energy in dissipating heat load from body through evaporation thereby less energy available for production purpose. On other side, treatment groups C and D buffaloes took an advantage of cooling measures and intake was more, consequently more energy and nutritive components might be available for milk production. Similarly, water intake in group C and D were might be enough to comply the body needs for producing milk as compare to group A and B where water intake value was high that might be used to combat the heat stress conditions during this hot dry season. Andrew and Devender (1999) reported the similar finding and said that during heat stress conditions with temperature humidity index value more than 80, the water intake my increase 50 percent more as compared to cooled cows to. Also reported the related results that with increase in environmental temperature the dry matter intake and milk production became low, but water intake was getting more might be in order to struggle against dehydration, thirst and heat load.

Milk composition: Milk was analyzed for its various components including fat%, SNF% and TS %. The mean values of fat% were found as 6.55±0.10, 6.73±0.07, 6.84±0.07 and 7.12±0.06 for groups A, B, C and D(Table-2). Non-significant (P>0.05) variation were found between A and B, similarly B and Cfor Solids not fat (SNF) %. The highest value of SNF (9.90±0.04) was found for group D buffaloes and lowest in group A (9.44±0.12; P≤0.05). Correspond to the values of Fat and SNF %, thetotal solids (%) were found as 16.10±0.09, 16.35±0.07, 16.67±0.11 and 17.03±0.10for group A, B, C and D, respectively. Non-significant (P>0.05) variation were noticed betweengroup A, B and between group C and D.

Our results are in accordance with the findings of McDowell *et al*. (1976) who reported that milk constituents are greatly affected by hyperthermia in lactating Holstein cows that were transferred from an air temperature of 18°C to 30°C, milk fat, solids-not-fat and milk protein percentages decreased with 39.7%, 18.9% and 16.9%, respectively. Aggarwal and Singh (2008) reported that in a comparative study, one group of buffaloes was kept under water showers and other group of buffaloes was kept in a wallowing pond. The results indicated that in wallowing group of buffaloes, the fat, protein and lactose content of milk was significantly (P≤0.05) improved as compared to showers group.

Body condition scoring (BCS): At the start of research trail, the body condition score (BCS) for each treatment group was 3.1±0.1. At the end of research trial, lactating buffaloes were examined for any change in their body mass cover and BCS values were 3.05±0.05, 3.10±0.06, 3.20±0.09 and 3.40±0.06 for group A, D, B and C. However, these variations were found as statistically non-significant (P>0.05) for group C with group D but significant (P≤0.05) for group D with control group A and B.

Similar to our findings, Lacetera *et al*. (1994) reported a body condition score of 0.0 vs. +0.4 points in female Holstein-Friesian calves exposed to hot environment as compared to the calves kept under thermo-neutral conditions. Body condition score for treatment group A and B is less that might be due to stress under hot environment and decrease dry matter intake. Animal body might be spending more energy in reducing heat load from body.

Milk production economics: Milk production economics was compared among the buffaloes with different housing strategies using prevailing variable costs as indicated in Table-4. Daily cost of milk production was higher in treatment group B, C and D as compare to control group A. Therefore, gross margin was high for group D buffaloes followed by group C.

Table-1. Ingredients and chemical composition of concentrate ration fed to lactating Nili-Ravi buffaloes.

Ingredients	Inclusion level (%)
Maize	8
Cotton Seed cake	22
Rape seed cake	3
Wheat bran	32
Maize gluten	20
Molasses	14
Mineral mixtures	1
Crude Protein (CP) %	18.0
TDN	76.0
ME	2.6 M.cal/Kg

Daily production cost was noted high for group C and group D buffaloes during hot dry season (May-June) as a result of electricity and equipment expenditure in addition to feed and labor cost. But overall cost per liter of milk was low due to high profit margin for group D buffaloes. Our findings are in-line with Aggarwal and Upadhyay (2013) who reported that thermal stress imposes significant economic burden that is a serious threat to livestock farming. Also, our findings are in-line with Dhuyvetter (2000) who stated that due to variation in milk prices, feed cost and feed-to-milk conversion, the economics return to the cooling cows may also vary however, if the extreme ranges consider, the return to cooling were positive. This might be due to fact that buffalo is adapted to sub-tropics and resistant to minor rise in environmental temperature. Higher costs associated with feed and cooling expenses were noticed but the additional costs for groups C and D were offset by higher milk production, thus lowering costs/ liter of milk production making high margins for buffaloes under fans with and especially for group D buffaloes under fans along showers. Additional charges of cooling measures (fans with or without showers) offset the marginal costs effectively so as to execute these strategies. On other side, added cost of anti-stress supplement increased cost per liter of production. Milk production was not enough to increase the marginal revenue.

Table-2. Milk production (daily) and milk composition (fortnightly) of Nili-Ravi buffaloes during hot dry summer.

Groups	Milk Production (liter)	Milk Composition		
		Fat %	SNF%	TS%
A (Control)	6.39±0.13^{c}	6.55±0.10^{c}	9.44±0.12^{c}	16.10±0.09^{b}
B	6.52±0.09^{c}	6.73±0.07^{bc}	9.64±0.04^{bc}	16.35±0.07^{b}
C	6.95±0.11^{b}	6.84±0.07^{b}	9.76±0.07^{ab}	16.67±0.11^{a}
D	7.33±0.10^{a}	7.12±0.06^{a}	9.90±0.04^{a}	17.03±0.10^{a}

A: Roof shade B: anti-stress product C: Fans D: Shower and fans
Means having different superscript in column are significantly different (P≤0.05)

Table-3. Dry matter intake (DMI; daily), water intake (liter; daily), feeding and water intake time (fortnightly) in Nili-Ravi buffaloes during hot dry summer.

Groups	Dry Matter Intake (Kg)	Water Intake (WI, Liter)	Feeding Time (min.)	WI Time (min.)
A (Control)	13.89±0.17^{c}	55.5±2.1^{a}	175±3.5^{c}	9.12±0.42^{a}
B	14.33±0.05^{b}	57.6±0.95^{a}	195±3.5^{b}	9.12±0.42^{a}
C	14.60±0.10^{b}	46.8±1.5^{b}	205±4.5^{b}	7.62±0.23^{b}
D	15.40±0.16^{a}	44.6±1.08^{b}	230.5±4.5^{a}	7.12±0.31^{b}

A: Roof shade B: anti-stress product C: Fans D: Shower and fans
Means having different superscript in column are significantly different (P≤0.05)

Table-4. Milk production economics (Pakistan rupee; PKR) in lactating Nili-Ravi buffaloes.

Particulars	**Control**	**Anti-stress**	**Fans**	**Showers +Fans**
Total Silage Consumed (Kg's)	8323	8827	8925	9562
Silage/day/Animal (**X**; pkr)	107.9	114.4	115.7	124.0
Concentrate/d/Anim (**Y**; pkr)	93.7	93.7	93.7	93.7
Yea-Sacc/day/animal (**Z**; pkr)	0	9.7	0	0
Feed Cost /day/animal **(W= X+Y+Z)**	201.6	217.8	209.4	217.7
Electricity cost/day/animal **(E)**	0	0	1.4	3.3
Labor Cost/day/animal **(L)**	12.5	12.5	12.5	12.5
Total production Cost/d/Anim. **(TPC=W+E+L)**	214.1	230.3	223.3	233.5
Milk Production /day/animal (**MP**; liter)	6.39	6.53	6.96	7.34
Cost per liter of milk **(TPC/MP)**	**33.5**	**35.2**	**32.1**	**31.8**
Daily Milk Sales @ 60/-per liter	383.6	391.5	417.3	440.4
Gross Margin (PKR) = Daily milk sales – TPC	**169.5**	**161.5**	**194.0**	**206.9**

Silage price/kg= 3.5/- rupee; Concentrate price/kg=23/-rupee; Yea-Sacc (25Kg) = 23750/-rupee
Electricity cost/month= two fans: 192/- rupee & 1 water pump: 264/- rupee;
Labor cost/month= 7500/- rupee

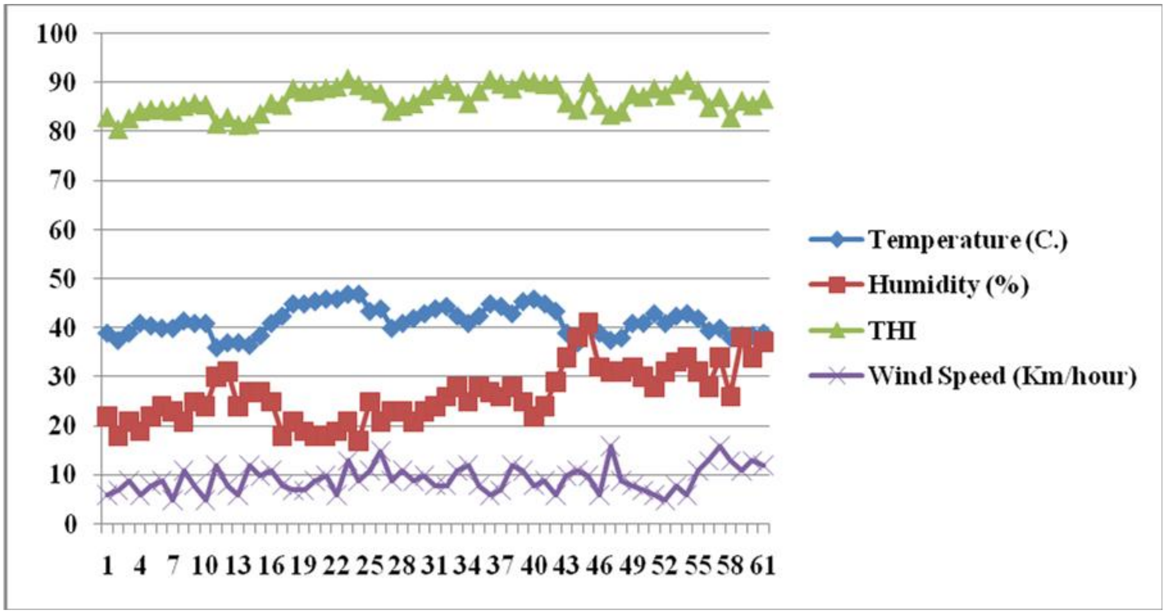

Fig. 1. Meteorological Indices for hot dry season (May, June)

Conclusion: It may be concluded that fans with showers are best strategy to reduce heat stress followed by strategy on using only fans during hot dry summer.

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