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RESEARCH ARTICLE

Influence of calf-mother interaction on performance and behaviour of Murrah buffalo calves during heat stress

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Abstract: The primary objective of the research was to study how calf-mother contact and heat stress ameliorative measures would impact the behavior and growth of Murrah buffalo calves. The study was conducted from April to mid-September. A total of 21 calf-mother Murrah buffalo pairs were selected at the time of birth and categorized into three groups (n=7 pairs). In the first group (T0), the calves and mothers were separated at birth, but they were allowed limited interaction twice-daily for suckling during milking times. In the second group (T1), the calves had continuous unrestricted contact with their mothers and were free to suckle colostrum for up to 5 days. Afterward, the calf-mother pairs were housed in adjacent enclosures separated by a fenceline. The third group (T2) received the same provisions as the second group (T1), but in addition, the calf-mother pairs were provided with fans and foggers to alleviate heat stress. Statistical analysis involved comparing means using one-way ANOVA and univariate general linear models (GLM) both within and between the groups. Results showed that among the experimental calves, those in group T2 exhibited significantly higher ($p<0.05$) average daily gain (ADG) compared to those in groups T1 and T0 at weekly interval. Calves in group T2 spent significantly ($p<0.05$) more time resting, eating, and engaging in rumination compared to calves in groups T1 and T0. Both T2 and T1 calves demonstrated a significantly ($p<0.05$) lower frequency of abnormal behaviors than the T0 calves. The findings clearly demonstrates that provision of fenceline mother-calf contact along with fan-fogger system in the shed reduces the stress and improves the growth, behaviour and welfare of calves than restricted contact calves.

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Introduction

The emotional connection between a mother and her young can be understood as a special, affectionate attachment that lasts a long time and survives temporary separations (Newberry and Swanson, 2008). This bond is marked by behaviors like grooming, providing nourishment, warmth, and protection, resting in close contact, and coordinating activities together. Staying close fulfills a social comforting role, offering a soothing effect to both mothers and their young. The calming and satisfying aspect of physical touch, sharing food, and grooming among bonded individuals is evident in the reduction of heart rate and the release of natural pain-relieving chemicals (Feh and de Mazieres, 1993). The process of bonding begins as progesterone levels decrease and estrogen levels rise, leading to an increase in oxytocin hormone. This bonding is fully established within five minutes after birth. Comparatively, when compared to complete separation, allowing contact between a mother and her offspring through a barrier reduces the behavioral reaction to weaning (Price et al. 2003). However, in organized and commercial dairy farming systems, this social bond is broken when calves are separated from their mothers shortly after birth. This results in lowered immunity, reduced productivity, and an increase in abnormal behaviors displayed by both mothers and their young (Kumar et al. 2017). Buffaloes possess a heightened sensitivity to heat stress due to their dark body color, fewer hairs, and a lower density of sweat glands. Their thicker skin reduces the potential for cutaneous evaporation, making them less capable of dissipating excess metabolic heat, rendering them susceptible to heat stress (Marai and Haeeb, 2010). Significant environmental factors impacting buffaloes in India encompass air temperature, relative humidity (RH), solar radiation, and the temperature humidity index (THI) (Chaudhary et al. 2015). All these environmental elements contribute to heat stress in animals, when the combinations of environmental variables exceed the animal's thermoneutral zone (TNZ) (Buffington et al. 1981). Predictions suggest that global temperatures could rise by 1.8-4°C by the year 2100 (Field et al. 2015). The Intergovernmental Panel on Climate Change has also highlighted the heightened vulnerability of developing countries like India to extreme climatic events due to their reliance on climate-sensitive sectors like agriculture and its allied fields. Multiple studies indicate that abrupt temperature changes (increases in maximum temperatures) during summer are likely to exacerbate stress in buffaloes, detrimentally impacting their productive capabilities, resulting in substantial losses (Upadhyay et al. 2007).

Several techniques have been devised to mitigate heat stress in buffaloes, aiming to uphold their production performance. These methods primarily focus on enhancing the dissipation of heat and lowering skin temperature, ultimately ensuring the well-being of the buffaloes. Providing shade to the animals alone can decrease over 30% of the total emitted heat. Within sheltered environments, strategies such as utilizing air movement (fans), wetting the animals, facilitating air cooling through evaporation, and using shade to minimize direct solar radiation are employed to augment heat dissipation, proving effective in heat loss. Approaches such as employing ceiling fans, spray cooling, misters, foggers, and combinations thereof, such as sprinkler and fan cooling systems, are extensively adopted to alleviate heat stress in buffaloes (Yadav et al. 2016; Kumar et al. 2018). Wallowing, a natural behavior of buffaloes, also serves as a method to counteract heat stress. Among these methods, time-controlled evaporative cooling has demonstrated favorable outcomes in reducing the Temperature-Humidity Index (THI), thereby safeguarding the production and reproductive functions of buffaloes (Sinha et al. 2017; Ahmad et al. 2017).

Considering the effects of fenceline calf contact and heat stress ameliorative measures the present study was undertaken to investigate its effect on growth and behaviour of the calves. The aim of the study was to alleviate stress of buffalo calves that they bear during summer season which usually leads to loss of farmers.

Materials and Methods

Location of experiment and Climatic condition

The study was carried out at the Livestock Research Centre (LRC), ICAR-NDRI, Karnal. This center is positioned at coordinates 290 42' 20' N Latitude and 760 58' 52.5' E Longitude, at an elevation of 247 meters above sea level. During the summer, the highest recorded temperatures range from 42 to 46 °C, while in winter, they range from 2 to 5 °C, with a daily fluctuation of 16–22°C. The typical annual rainfall in this area amounts to approximately 650 mm.

Experimental animals

The research was undertaken during the summer months spanning from April to mid-September. For this study, a total of 21 pregnant Murrah buffaloes in advanced stages of pregnancy were chosen from the institute's buffalo herd. These buffaloes were relocated to the maternity section 15 days before their expected calving date. Once calving was successful, the pairs of mothers and their calves were split into three groups, each having 7 pairs. The groups were divided according to the parity levels (3.43 ± 0.43). In the first group (T0), the buffalo mothers were allowed to nurse their calves with colostrum and then milked twice daily. After milking, they were separated from their calves and kept in a shelter without any additional measures to protect them from heat stress. In the second group (T1), the buffalo mothers were in direct contact for first five days and were allowed free choice colostrum suckling and afterwards were housed in proximity to their calves through a fence line. They were permitted to nurse their calves twice a day, following the morning and evening milking sessions, similar to the first group. These buffaloes were also housed in a shelter without specific measures to mitigate heat stress. In the third group (T2), all conditions were similar to T1 group but these buffaloes were provided with time controlled fogging and fanning system to protect them from the effects of heat stress.

Housing and feeding of experimental animals

Housing

About 15 days prior to the expected calving date, pregnant animals in advanced stages of pregnancy were moved to maternity pens specifically designed for calving. These pens consisted of both open and covered areas placed next to each other. Each pen had a total floor space of 12 m^2, with the floor being made of concrete. To prevent injuries, rubber mattresses were placed on the floor. After 5 days from the time of calving, the buffaloes were transferred to experimental shed. These sheds also had adjacent open and covered sections. In the experimental shelter used by the groups FCC and FCC-HSP, a barrier made of galvanized iron pipes (1 inch in diameter) was set up along the entire length of the shelter, including both the covered and open areas. This barrier was at a height of 5 feet from the ground and was equipped with wire mesh (1x1 centimeter) to allow for visual, auditory, olfactory, and limited tactile interaction. In the FCC-HSP group's shelter, additionally foggers and fans were installed in covered area. The foggers and fans were automated and operated on a time-based schedule. Cross foggers with four outlets were set at a 90° angle. Positioned at a height of 8 feet within the covered space, these foggers emitted fine droplets (85 Micron) @ 22 liters per hour. Two wall-mounted fans (36 inches in diameter) were placed on one side of the shelter, spaced 6 meters apart and blowing air at a rate of 10000-11000 cubic feet per minute (cfm) with a maximum throw distance of 9 meters. Cross foggers were dispersing fog in intervals of 45 seconds, followed by fanning in every 5 minutes from 11:00 AM and 4:00 PM.

Feeding

The calf's diet was adjusted in line with the ICAR-2013 standard guidelines for the nutrition of growing buffalo calves. Calves were offered buffalo milk twice daily amounting to 10% of their body weight, until they reached 3 to 4 months of age. Starting from their second week of life, they were provided with chopped maize green fodder without any restrictions, along with clean water and a salt lick block. The calves were given calf starter from second week onwards @ of 1% of their body weight, and they had unrestricted access to chopped green fodders. The calf starter consisted of maize (33%), wheat bran (21%), gram (10%), groundnut cake (33%), mineral mixture (2%), and common salt (1%). This included a formulation comprising 21% digestible crude protein, energy content of 2632 kcal/g, and 70% of total digestible nutrients.

Recording of climatic variables and temperature humidity index (THI)

To analyze the Temperature Humidity Index (THI) of every shed, a Zeal (made in UK) dry-wet bulb thermometer was employed to measure the dry and wet bulb temperatures. This measurement was done daily between 2:30 PM and 3:00 PM throughout the experimental duration. The THI was computed using the NRC (1971) formula.

$$THI = 0.72\ (Tdb + Twb) + 40.6$$

Where, Tdb = dry bulb temperature (ºC)

Twb = wet bulb temperature (ºC)

Statistical analysis

Comparisons of calf body weight, ADG, and various behaviors were conducted using IBM SPSS version 28.0.1.1 software, employing a one-way analysis of variance (ANOVA) and univariate general linear models (GLM). The model incorporated treatment and time as fixed factors, along with their interaction. Differences were considered statistically significant when p < .05. Results are presented as LS means ± SE.

Results and Discussion

Environmental parameters

Data on fortnightly average maximum temperature is presented in the table 1. The heat stress ameliorative measuring provided by time controlled fogging coupled with fanning were able to reduce the maximum temperature inside the shed housing T2 buffaloes to the extent of 3.51 ºC (the reduction in overall mean between T0 and T2 sheds). Data on fortnightly average afternoon dry bulb (Db) and wet bulb (Wb) temperature are presented in the table 2. Fortnight average THI data is presented in the table 3. The overall difference in THI between the T1 and T2 shed was 3.34. The environmental variables like maximum temperature and THI are the best indicators of environmental heat stress on animals (Armstrong 1994).

Body weight and average daily gain (ADG) of calves

The average body weight of calves at birth among the three treatment groups had no significant differences (Table 4). The significant (p<0.05) difference in calves' body weight was seen from 3rd week onwards and continued till the 12th week of study. At third week the body weight of T2 calves was higher (p<0.05) than T0 calves. At the end of 12 weeks of age the average body weight was significantly (p<0.05) different among the three treatment groups, with T2 calves having higher average body weight followed by T1 and T0 calves. The data on average ADG recorded at weekly intervals in calves is presented in the table 5. The ADG was higher (p<0.05) in T2 and T1 group as compared to T0 group right from first week onwards till fourth week. After fourth week no significant difference was seen in ADG between the groups till the tenth week. The significant (p<0.05) differences in ADG among the three groups of calves were again seen in 11th

Table 1: Fortnightly mean maximum and minimum temperature (ºC) inside the sheds

Fortnight	Maximum temperature (°C)		
	T0 shed	T1 shed	T2 shed
1	36.14^a±0.63	36.15^a±0.61	32.83^b±0.46
2	36.24^a±1.08	36.26^a±1.95	33.04^b±0.93
3	36.60^a±0.70	36.67^a±0.75	32.1^b±0.72
4	35.69^a±0.99	35.62^a±0.91	31.76^b±0.81
5	36.47^a±0.82	36.37^a±0.80	32.37^b±0.73
6	36.40^a±0.64	36.48^a±0.60	32.1^b±0.64
7	36.57^a±1.06	36.55^a±1.06	32.07^b±1.06
8	31.92^a±0.71	31.90^a±0.72	28.17^b±0.56
9	33.17^a±0.37	33.13^a±0.31	30.37^b±0.37
10	32.88^a±0.66	32.87^a±0.60	30.08^b±0.69
11	30.81^a±0.49	30.82^a±0.48	29.31^b±0.42
Overall mean	34.81^a±0.26	34.78^a±0.23	34.81^a±0.26

Data are presented as LS means ± SE. a, b indicate differences between the mean values of different groups.
Differences at all points for each parameter were considered at P < 0.05.

and 12th week of study. The overall average ADG was significantly higher (p<0.05) in T2 (0.560±0.02 kg) group as compared to T1 (0.506±0.02 kg) and T0 (0.473±0.01 kg) groups.

The overall higher average body weight of calves in T1 and T2 group compared to T0 group might be due to direct contact with mother during first five days after birth and free choice colostrum sucking and thereafter fenceline contact with mothers after 5 days which might have helped them achieve greater body weight due to lesser stress. Similar findings were reported by Hassan et al. (2019) and Chaudhary et al. (2022). While the higher body weight achieved in T2 group compared to T1 group might be due to cumulative effect of fenceline calf contact and heat stress amelioration provided the shed of T2 group. The initial higher ADG during first 4 weeks after birth may be due to consequence of free choice colostrum suckling during first five days after birth in T1 and T2 group of calves. The superiority of the fenceline group calves on ADG in the current study may be attributable to free choice colostrum suckling during the first five days after birth along with a lower level of stress caused by the social stimulation offered by mother contact to the calves through the provision of fenceline contact. Our findings are consistent with those of Hassan et al. (2019), Chaudhary et al. (2022) for buffalo calves and Price et al. (2003) and Kisac et al. (2011) for cattle calves, who found that fenceline mother-reared calves saw greater

Table 2: Fortnightly mean afternoon dry bulb (Db) and wet bulb (Wb) temperature (ºC) inside experimental sheds

Fortnight	Db temperature (°C)			Wb temperature (°C)		
	T0 shed	T1 shed	T2 shed	T0 shed	T1 shed	T2 shed
1	35.71^{b}±0.61	35.513^{b}±0.6	32.91^{a}±0.61	20.92^{b}±0.47	20.72^{b}±0.54	18.12^{a}±0.47
2	35.12^{b}±1.15	34.92^{b}±1.17	32.32^{a}±1.15	21.36^{b}±0.43	21.16^{b}±0.50	18.56^{a}±0.43
3	34.53^{b}±1.14	34.73^{b}±1.16	30.13^{a}±1.14	24.13^{b}±0.36	23.93^{b}±0.43	20.93^{a}±0.36
4	34.85^{b}±1.12	35.05^{b}±1.14	30.45^{a}±1.12	25.06^{b}±0.41	24.86^{b}±0.48	21.86^{a}±0.41
5	35.67^{b}±0.85	35.47^{b}±0.87	31.87^{a}±0.85	26.47^{b}±0.35	26.67^{b}±0.42	23.27^{a}±0.35
6	34.43^{b}±1.06	34.23^{b}±1.08	31.53^{a}±1.06	26.24^{b}±0.22	26.44^{b}±0.29	24.94^{a}±0.22
7	34.47±1.36	34.27±1.38	32.17±1.36	27.60^{b}±0.44	27.20^{b}±0.51	26.10^{a}±0.44
8	30.53^{b}±0.66	30.33^{b}±0.68	28.43^{a}±0.66	28.21^{b}±0.29	27.81^{b}±0.36	26.91^{a}±0.29
9	31.70^{b}±0.49	31.90^{b}±0.51	30.20^{a}±0.49	28.17^{b}±0.24	28.37^{b}±0.31	27.77^{a}±0.24
10	31.73^{b}±0.71	31.93^{b}±0.73	29.83^{a}±0.71	28.33^{b}±0.25	28.53^{b}±0.32	27.23^{a}±025
11	30.20^{b}±0.50	30.00^{b}±0.52	27.80^{a}±0.5	27.69^{b}±0.31	27.49^{b}±0.38	25.29^{a}±0.31
Overall mean	33.52^{b}±0.28	33.46^{b}±0.30	30.67^{a}±0.30	25.86^{b}±0.20	25.77^{b}±0.27	23.75^{a}±0.27

Data are presented as LS means ± SE. a, b indicate differences between the mean values of different groups. Differences at all points for each parameter were considered at P < 0.05.

*Db = Dry Bulb ; Wb = Wet bulb

Table 3: Fortnightly mean THI inside different experimental sheds

Fortnight	THI (Afternoon)			Difference between THI in T1 and T2 sheds
	T0 shed	T1 shed	T2 shed	
1	81.37^{bWXY}±0.63	81.15^{bWXY}±0.68	77.27^{aYZ}±0.63	-3.88
2	81.27^{bWX}±1.10	81.05^{bWXY}±1.15	77.16^{aYZ}±1.10	-3.89
3	82.83^{bXYZ}±1.04	82.90^{bYZ}±1.09	78.30^{aZ}±1.04	-4.60
4	83.74^{bXYZ}±1.00	83.81^{bYZ}±1.05	79.20^{aZ}±0.99	-4.61
5	85.34^{bZ}±0.77	85.34^{bZ}±0.82	80.37^{aZ}±0.77	-4.97
6	84.28^{bXYZ}±0.90	84.28^{bYZ}±0.95	81.26^{aZ}±0.9	-3.02
7	85.29^{bYZ}±1.26	84.93^{bYZ}±1.31	82.55^{aZ}±1.26	-2.38
8	82.89^{bXYZ}±0.65	82.53^{bYZ}±0.70	80.44^{aZ}±0.65	-2.09
9	83.71^{bXYZ}±0.47	84.00^{bXYZ}±0.52	82.34^{aZ}±0.47	-1.66
10	83.84^{bXYZ}±0.68	84.13^{bYZ}±0.73	81.68^{aZ}±0.68	-2.45
11	82.29^{bWXYZ}±0.52	82.07^{bXYZ}±0.57	78.83^{aZ}±0.52	-3.24
Overall mean	83.35^{b}±0.26	83.29^{b}±0.31	79.95^{a}±0.29	-3.34

Data are presented as LS means ± SE. a, b indicate differences between the mean values of different groups. Where, W, X, Y, Z indicate differences in the same group at different time intervals. Differences at all points for each parameter were considered at P < 0.05.

*THI= Temperature humidity index

average daily gains than the calves that had restricted contact with their mothers. While the higher ADG in T2 group confirms that summer protective measures help in better growth of the calves when deployed in conjunction with fenceline contact. Similar results of higher ADG under summer ameliorative measures were reported by Kamal et al. (2014) in cattle and Barman et al. (2017) in buffalo calves.

Resting behaviour of calves

The mean time spent resting was significantly ($p<0.05$) different among the three groups, with T2 having longest resting time followed by T1 and T0 calves throughout the experimental period (Table 6). The mean time spent on resting showed declining trend from first of age till 12th week of age in all the three groups of calves. The fenceline contact calves (T1 and T2) rested for a longer period of time than calves that had just restricted contact. These findings are consistent with those of Price et al. (2003) and Haley et al. (2006), who found that when mother and calf were in close proximity they rested more. The findings of Jensen (2004), Calvo-Lorenzo et al. (2016) and Chaudhary et al. (2022), who reported that calves spend 16–19 hours per day lying down between the ages of 21 and 70 days, also support for the findings of the current study. Higher resting time in T2 group compared to T1 and T0 group may be due to cumulative effect of fenceline mother contact and heat stress ameliorative measures provided in T2 shed. Higher resting time reported in T2 group calves in our study is in agreement with the finding of Chikkagoudara et al. (2022).

Table 4: Body weight (kg) of different treatment groups of calves recorded at weekly intervals

Week after birth	Body weight (kg)		
	T0	T1	T2
At birth	29.00±0.93	28.90±0.77	28.44±0.94
1	32.75±0.72	34.33±0.68	34.01±1.05
2	36.63±0.57	39.45±0.98	39.89±1.38
3	39.93^{a}±0.83	44.53^{ab}±1.28	45.14^{b}±1.78
4	43.47^{a}±0.85	48.89^{ab}±1.41	50.00^{b}±2.22
5	47.13^{a}±0.78	52.33^{b}±1.30	52.97^{b}±2.02
6	50.18^{a}±0.77	54.84^{b}±1.13	55.54^{b}±1.88
7	53.40^{a}±0.87	57.30^{b}±0.96	58.74^{b}±1.56
8	56.15^{a}±0.80	59.64^{b}±0.98	61.76^{b}±1.32
9	59.52^{a}±0.81	62.06^{ab}±0.90	64.91^{b}±1.19
10	62.35^{a}±0.82	64.89^{a}±0.81	68.07^{b}±1.11
11	65.75^{a}±0.78	68.24^{a}±0.80	71.64^{b}±1.03
12	68.73^{a}±0.72	71.43^{b}±0.72	75.46^{c}±0.89

Data are presented as LS means ± SE. a, b and c indicates differences between the mean values of different groups. Differences at all points for each parameter were considered at $P < 0.05$.

Table 5: Average daily gain (kg/d) of different groups of calves recorded at weekly intervals

Week after birth	Average daily gain (kg/day)		
	T0	T1	T2
1	0.536^{a}±0.06	0.776^{b}±0.03	0.796^{b}±0.05
2	0.555^{a}±0.05	0.732^{ab}±0.06	0.839^{b}±0.06
3	0.471^{a}±0.07	0.726^{b}±0.05	0.751^{b}±0.06
4	0.505^{a}±0.03	0.622^{b}±0.04	0.694^{b}±0.07
5	0.524±0.03	0.492±0.04	0.424±0.04
6	0.436±0.03	0.359±0.05	0.367±0.04
7	0.460±0.02	0.351±0.04	0.457±0.06
8	0.393±0.03	0.335±0.04	0.431±0.05
9	0.481±0.05	0.345±0.04	0.451±0.05
10	0.405±0.03	0.404±0.03	0.451±0.03
11	0.486^{a}±0.02	0.480^{b}±0.04	0.510^{b}±0.03
12	0.426^{a}±0.02	0.455^{a}±0.02	0.545^{b}±0.03
Overall	0.473^{a}±0.01	0.506^{a}±0.02	0.560^{b}±0.02

Data are presented as LS means ± SE. a, b indicate differences between the mean values of different groups. Differences at all points for each parameter were considered at $P < 0.05$.

Standing behaviour of calves

The data on average daily time spent on standing by the calves is presented in the table 7. The time spent on standing by calves on day 6, 10, 15, 75 and 120 was significantly ($p<0.05$) lowest in T2 followed by T1 and T0 group calves. While on rest of the recorded days, the time spent on standing was significantly ($p<0.05$) shorter in T2 and T1 calves than T0 calves. The overall mean time spent on standing among the three groups of calves was significantly ($p<0.05$) lower in T2 group of calves followed by T1 and T0 group of calves. The mean time spent on standing showed rising trend from first week of age till 12th week of age in all the three groups of calves.

The lower standing time in T2 and T1 group might be due to their mothers' continued olfactory, auditory, and visual contact with the calves. This suggested that fenceline interaction helped the calves cope with their new environment and minimize the separation anxiety. Fenceline housed calves (T1 and T2) spent less time standing than calves that were allowed restricted contact (T0). Our findings are consistent with the findings of Loberg et al. (2008), Enriquez et al. (2010) and Chaudhary et al. (2022). The lowest standing time recorded in T2 group calves then T1 calves might be due to synergestic effect of fenceline mother contact and heat stress amelioration provide in the shed. These findings are in agreement with Chikkagoudara et al. (2022).

Table 6: Average time spent on resting (min/d) by the calves during summer season

Day after birth	Resting time (min/day)		
	T0	T1	T2
6	1066.20^a±4.20	1190.20^b±6.51	1244.70^c±3.89
10	1054.40^a±4.02	1159.24^b±5.21	1220.14^c±5.26
15	1031.42^a±4.11	1101.45^b±3.52	1161.00^c±5.82
30	993.39^a±5.94	1057.13^b±2.14	1095.87^c±4.07
45	984.61^a±7.38	1020.07^b±4.63	973.69^c±5.98
60	938.50^a±7.48	971.52^b±3.26	958.31^c±5.56
75	903.85^a±4.72	929.75^b±5.21	961.69^c±4.36
90	849.93^a±4.62	932.21^b±6.88	939.59^c±4.99
120	831.74^a±4.60	876.25^b±5.11	899.66^c±3.61
Overall	961.56^a±11.26 (16.30 hrs)	1026.42^b±14.18 (17.11 hrs)	1050.52^c±17.08 (17.51 hrs)

Data are presented as LS means ± SEM. a, b, c indicate differences between the mean values of different groups. Differences at all points for each parameter were considered at $p < 0.05$.

Table 7: Average time spent on standing (min/d) by the calves

Day after birth	Standing time (min/day)		
	T0	T1	T2
6	373.80^c±4.20	249.81^b±6.51	195.30^a±3.89
10	385.60^c±4.02	280.76^b±5.21	219.86^a±5.26
15	408.58^c±4.11	338.55^b±3.52	279.00^a±5.82
30	446.61^c±5.94	382.87^b±2.14	344.13^a±4.07
45	455.39^b±7.38	419.93^a±4.63	466.32^a±5.98
60	501.50^b±7.48	468.48^a±3.26	481.69^a±5.56
75	536.15^c±4.72	510.25^b±5.21	478.31^a±4.36
90	590.07^b±4.62	507.79^a±6.88	500.41^a±4.99
120	608.26^c±4.60	563.76^b±5.11	540.34^a±3.61
Overall	478.44^c±11.26 (7.97 hrs)	413.58^b±14.18 (6.90 hrs)	389.48^a±17.08 (6.50 hrs)

Data are presented as LS means ± SEM. a, b, c indicate differences between the mean values of different groups. Differences at all points for each parameter were considered at $P < 0.05$.

Eating behaviour of calves

The average daily time spent eating by the calves is presented in the table 8. The significant ($p<0.05$) difference in eating time among the three groups of calves were seen on day 30 and 120, with T2 calves having highest eating time followed by T1 and T0 group of claves. On the remaining recorded days T2 and T1 groups of calves had significantly ($p<0.05$) higher eating time than T0 group of calves. When compared to the T0 calves, the T1 and T2 calves began nibbling the meal significantly ($p<0.05$) sooner. The mean time spent on eating showed an increasing trend from first week of age till 12th week of age in all the three groups of calves.

It was seen that fenceline calves (T1 and T2) spent more time eating than restricted contact calves (T0). This might be due to the free choice suckling in T2 and T1 group calves during the first five days after birth. It has already been reported that

Fig 1: Cross-sucking behaviour in T0 group of calves

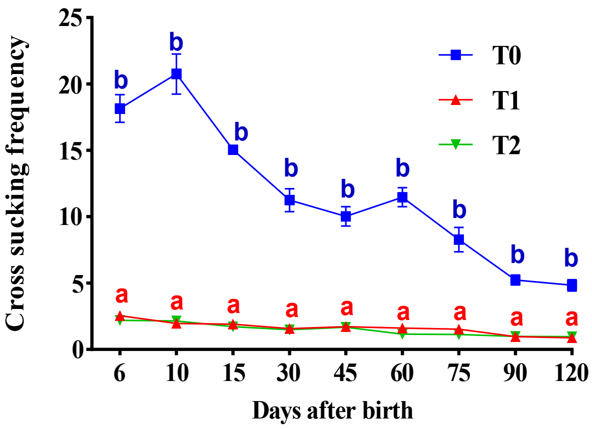

Fig 2: Mean frequency of cross-sucking by the calves

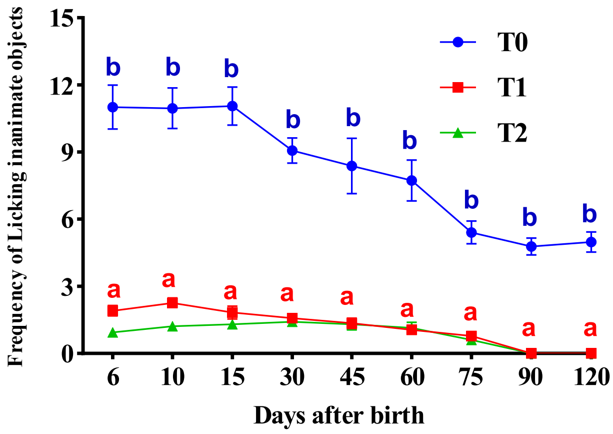

Fig 3: Mean frequency of licking inanimate objects by the calves

Table 8: Average time spent on eating (min/day) by the calves during summer season

Day after birth	Eating time (min/day)		
	T0	T1	T2
30	1.10^{a}±0.16	14.42^{b}±1.01	19.46^{c}±1.06
45	15.85^{a}±0.93	48.18^{b}±0.86	50.01^{b}±1.47
60	28.65^{a}±1.01	68.80^{b}±1.28	75.37^{b}±3.51
75	70.99^{a}±2.18	108.92^{b}±4.30	113.80^{b}±2.57
90	122.62^{a}±2.94	188.68^{b}±2.22	188.49^{b}±3.12
120	196.96^{a}±3.02	216.09^{b}±3.11	231.48^{c}±3.17

Data are presented as LS means ± SEM. a, b, c indicate differences between the mean values of different groups. Differences at all points for each parameter were considered at $P < 0.05$.

consuming more colostrum has significant impacts on GIT development and alters GI hormones and digestive enzymes (Parashar, 2021). Additionally, this might be due to transition from free-choice colostrum suckling to limited suckling and larger body weight, which led to earlier solid feed nibbling and longer feeding times in fenceline group calves (T1 and T2). These results are in accordance with those reported by Price et al. (2003), Haley (2006), Loberg et al. (2008) and Parashar (2021) who found that calves that had fenceline contact with their mothers ate for longer periods of time than calves those did not. Due to restricted suckling and restricted contact with mothers soon after birth might have lead to reduced eating time in restricted contact calves (T0). The highest eating time in T2 group might be due to the both free choice suckling followed by fenceline calf contact and the heat stress ameliorative measures provided in the T2 shed. The findings of higher eating time due heat stress amelioration are in agreement with that of Chikkagoudara et al. (2022).

Rumination behaviour of calves

The time spent by calves ruminating is presented in the table 9. The significant ($p<0.05$) difference in rumination time among the three groups of calves were seen on day 30 and 120, with T2 group calves having highest rumination time followed by T1 and T0 group of claves. On the remaining recorded days T2 and T1 groups of calves had significantly ($p<0.05$) higher rumination time than the T0 group of calves. The mean time spent on rumination showed an increasing trend from recorded day till 12th week of age in all the three groups of calves.

In the current study, newborn calves did not engage in rumination until 15 to 20 days after birth. Higher feed intake and feeding duration may have contributed longer rumination times in fenceline calves (T1 and T2) from day 30 to 120 in our study. Similar findings were reported by Enriquez et al. (2010) and Chaudhary et al. (2022), who noted that fenceline-housed calves spent more time ruminating than the calves that were separated. Highest rumination time was seen in T2 in which heat stress amelioration was provided. The findings are in lines with those of Chikkagoudara et al. (2022) who reported similar findings; higher ruminating time in heat stress ameliorated group calves.

Abnormal behaviour

Cross sucking frequency in calves

The overall average and average frequency on all recorded days of cross suckling was significantly ($p<0.05$) higher in T0 group of calves than the T1 and T2 groups of calves (fig 2). More instances of cross suckling were observed in T0 group (Fig 1). There was declining trend in cross suckling frequency with the age in all the three groups (fig. 1). The frequency of overall mean ± SE of cross suckling were 11.67±0.75, 1.63±0.09 and 1.49±0.08 in T0, T1 and T2 group of calves respectively.

Fig 4: Calves licking inanimate objects

Table 9: Average time spent on rumination (min/day) by the calves during summer season

Day after birth	Rumination time (min/day)		
	T0	T1	T2
30	2.41^a±0.23	20.43^b±1.17	25.83^c±1.53
45	25.79^a±1.17	54.42^b±1.81	59.42^b±2.25
60	33.54^a±2.17	79.43^b±1.11	89.55^c±1.54
75	81.83^a±2.03	145.17^b±2.20	150.40^b±1.65
90	167.22^a±2.27	227.84^b±2.91	232.25^b±2.04
120	214.57^a±3.28	258.14^b±1.11	268.38^b±5.99

Data are presented as LS means ± SEM. a, b, c indicate differences between the mean values of different groups. Differences at all points for each parameter were considered at $P < 0.05$.

The calves in T2 and T1 group exhibited negligible cross-sucking behaviour, which may be due to the fact that the calves in T2 and T1 group had complete mother contact for first five days followed by fenceline contact after five day. The calves in these groups (T1 and T2) were having more visual, tactile and auditory contact with their mothers. This may have provided an opportunity to calves to concentrate more of its attention upon its mother and dietary habits, which may have resulted in negligible oral abnormal behaviour. The lower levels of behavioral discomfort shown in these calves may be another reason why there is less cross-sucking in T2 and T1 group of calves. Our findings are in agreement with the findings of Stookey et al. (1997), Price et al. (2003), Johnsen et al. (2015), Pérez-Torres et al. (2016), Chaudhary et al. (2022) and Ingle (2022) who used fenceline weaning in calves which supports our findings of fenceline contact between mother and young causes less behavioral distress than the sudden separation of calves from their mothers after birth.

Although restricted contact calves were given access to natural suckling and mother touch, even then they showed higher cross-sucking behaviour throughout the study, which might have been caused by their mothers' limited contact periods. The restricted contact calves (T0) in our study had shorter periods of contact, which increased their desire for natural suckling and increased the amount of non-nutritive suckling. The findings of the current study are in consistent with Enriquez et al. (2010) who reported that calves responded more behaviorally to temporary separation and came to the conclusion that these limited contacts cause significantly more psychological stress than the contact between mother and calves along the fence.

Frequency of licking inanimate objects in calves

The data on the average frequency of licking inanimate objects is presented in the fig 3. The overall average and average frequency on all recorded days of licking inanimate objects was significantly ($P<0.05$) higher in T0 group of compared to T1 and T2 groups of calves. There was declining trend in frequency licking inanimate objects with the age in all the three groups (Fig. 3). The frequency of overall mean ± SE of licking inanimate objects were 8.15±0.42, 1.20±0.12 and 0.88±0.09 in T0, T1 and T2 group of calves respectively.

Direct mother contact and free will colostrum suckling during early life followed by fene-line contact in T1 and T2 group may have reduced the frequency of licking inanimate objects. The maternal contact and free choice colostrum suckling allows calves spent the majority of their time sleeping and resting because their nutritional social needs had been met. Dam's presence might have calmed the calves, resulting in less licking of the items in the calf pen. Similar finding was reported by Krohn et al. (1999) and Veissier et al. (2013), who found that calves who stay with their mother during the first four days of life exhibit less non-nutritive oral behaviour following weaning. Our findings are also consistent with those of Haley et al. (2006) and Jung & Lidfors (2001), who reported that extending the length of milk consumption has been indicated to minimize non-nutritive licking and sucking in mother-fed calves. When newborn calves suckle the udder, it was observed that young one's to focus their actions more on milk or solid food consumption or on the mother. Natural suckling and fenceline interaction with the calves appear to benefit the claves by reducing non-nutritive oral behaviour. Similar findings of lower frequency of licking inanimate objects by the calves in fenceline mother contact have been reported by Choudhary et al. (2022) in buffalo calves and Ingle (2022) in Sahiwal calves.

Conclusion

Behaviour plays a critical role in evaluating the animal's comfort level, which in turn affects its production. The extended mother-calf contact and reduced stress levels associated with fenceline contact played a crucial role in promoting better growth and reducing abnormal behaviors. Notably, the lowest occurrence of cross-sucking and licking inanimate objects in fenceline groups indicates that these calves experienced less behavioral distress and displayed more natural behaviors. The findings of this research underscore the importance of early and continuous mother-calf contact, as well as the positive effects of heat stress amelioration, in promoting the growth, comfort, and behavioral well-being of calves. These insights can inform management practices aimed at optimizing calf rearing conditions for improved animal welfare and productivity.

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