



Effect of flooring system on maintenance behaviours of cows

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ABSTRACT

To evaluate the effect of floor on maintenance behaviours of cow in loose housing system, four groups, viz. T0 (concrete in covered and brick-paved in open area), T1 (concrete in covered and sand bed in open), T2 (rubber mat in covered and sand bed in open) and T3 (rubber mat in covered and brick-paved in open) were studied. Feeding was the major activity (39–44%) of day, with significant difference between groups. In covered area, lying and standing rumination, while in open area idling, were significantly different between groups during day. During night lying-rumination was major activity (62–69%). Night idling, standing-rumination, lying and lying-rumination behaviour, were significantly different between groups. Overall most of the time in each group was devoted to lying-rumination (45–53%) and feeding (18–21%). Area wise, open area was more occupied and posture wise sitting posture dominated in all the groups. Overall feeding, idling and standing-rumination in open, lying-rumination (in open or covered area), sleeping, total standing time and total sitting time were significantly different between groups. Feeding time showed positive trend in rubber matted floor (T2, T3). More lying-rumination and sleeping time was seen in rubber matted covered area. Sand bedding in open area reduced the standing and standing-rumination activity, while promoting the sitting/lying time. Rubber matting in covered area and sand bedding in open area, was found favourable for maintenance behaviour of dairy cows.

Keywords: Behaviour, Floor, Lying, Rubber mat, Sand bed, Welfare

Indian dairy sector is continuously growing owing to increase in urbanization and income level, domestic milk demand is expected to be doubled than present till 2050 (Anonymous 2019). Dairying in India, is shifting from mere livelihood option to intensive system. Walking and lying comfort of animal is directly related with the floor in intensive systems (Sonck *et al.* 1999). Concrete or brick are commonly used floor in dairy housing. However, these floor may offer several disadvantages in term of walking and standing (Phillips and Morris 2000) given their lower (0.35) coefficient of friction (Rushen and de Passille 2006) and discomfort due to more standing time (Chapinal *et al.* 2009). Further, housing animals in hard floor surfaces for long may predispose them to several health and welfare related issues such as lameness (Espejo *et al.* 2006). Prevalence of lameness in Indian dairy animal has already been reported (Randhawa 2006, Sood and Nanda 2013). To decrease the incidence of floor related issues provision of alternative floor, viz. rubber mat, sand bed, etc. are being considered now-a-days. However, scientific studies exploring their effect on animal behaviour under Indian

conditions are rare. Keeping in mind the above mentioned facts, the present study was undertaken to evaluate the effect of floor surface on behavioural profile of crossbred cows under loose housing system.

MATERIALS AND METHODS

The present study was conducted at ICAR-Indian Veterinary Research Institute (IVRI), Bareilly, Uttar Pradesh, India. The institute farm is located at an altitude of 169.2 m above the mean sea level, at latitude of 28°22' north and longitude of 79°24' east. Climate in this region is humid-subtropical with high variation between summer and winter temperatures. Summer extend from early April to October, with the monsoon season in between. Winter starts in October and peaks in January. Extreme temperatures range from 4°C to 44°C. The annual mean temperature is 25°C, monthly mean temperatures range from 14°C to 33°C. The average annual rainfall is approximately 1714 mm.

Crossbred (HF/Jersey/BS × Harijana, named as *Vrindavani*) cows (n=24), from first to third parity and in early lactation (below 45 days in milk) were selected and randomly assigned into four groups (6 in each group). Experimental animals were kept in loose housing system with covered (roofed) area over feeding platform and an open resting area. Roof was made up of corrugated cement sheets having East-West orientation of long axis. Water

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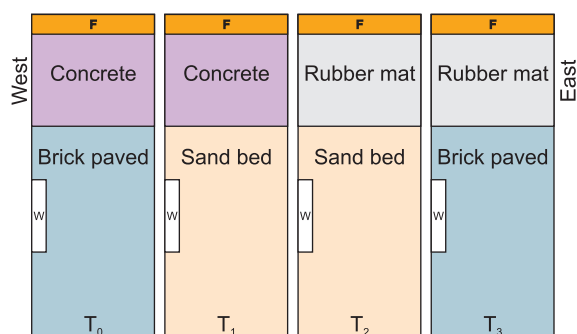


Fig. 1. Schematic diagram of experimental shed with different floor (F, feeding manger; W, water trough).

troughs were provided in open area. Animals were milked in the milking parlour located at the distance of approx. 200 m from experimental shed. Concentrate ration was given as per milk yield at the time of milking. Green fodder (maize/berseem/oat) was provided *ad lib.* and dry fodder/ wheat straw was also made available all the time.

Four different floor combination in covered and open area of house were, viz. T0 (covered area- concrete floor, open area- brick paved floor), T1 (covered area- concrete floor, open area- sand bed floor), T2 (covered area- rubber mat floor, open area- sand bed floor), T3 (covered area- rubber mat floor, open area – brick paved floor) (Fig. 1). Cows were housed in different groups for 6 months (June–November). Rubber mats (20 mm thick) made up of virgin rubber with channeled surface, were laid over the existing concrete floor in two groups (T2 and T3). Sand bed (avg. 80 mm thick) was prepared using fine river sand over the existing brick paved floor of open area in T1 and T2. Further, new sand was added as and when required to maintain proper depth. Floor space was provided as per BIS (Bureau of Indian Standards) norms, i.e. more than 3.5 m² in covered area and 7 m² in open area for each cow.

Behavioural activities of cows were recorded using CCTV camera at 3rd month, 4th month, 5th month and 6th month after housing for consecutively three days at each occasion. Each day recording was done for 18 h. After recording, each video film was observed by single observer and various behavioural activities were categorized. In each recording, animal was observed for posture (standing or lying), location (open area or covered area) and activity (feeding, ruminating, drinking, idling or doing nothing, elimination). Then different behaviours were quantified using 5 min instantaneous scan sampling method (Pullin *et al.* 2017). For this, 3 core animals from each group were randomly selected and observed. In this way, each group had 9 observations (3 animal × 3 days) each month.

Ethical approval: This study was approved by the institutional animal ethics committee (IAEC) and complies with animal ethics policy.

The information collected by data sheet was pooled and analyzed as per standard statistical procedure (Snedecor and Cochran 1994). Repeated measure ANOVA and multiple comparisons were used for continuous variables. Tukey test was used for the multiple comparisons.

RESULTS AND DISCUSSION

Feeding behaviour: Feeding time in day differed significantly ($P < 0.05$) between treatments (Table 1). Feeding was the major activity representing 39–44% of day time. Highest feeding time was observed in T3 (rubber mat) group and lowest feeding time was found in T1 (concrete) group. Improvement in feeding time (avg. 18.2 min) was noticed in T3 in comparison to T1, due to rubber matted covered area. However, in T2, feeding time was similar to non-rubber mat groups (T0 and T1). This might be because feeding is compulsory activity and irrespective of floor at feeding platform, cow spent minimum required time at

Table 1. Behaviours of cow (mean±SE min) in standing posture under different flooring system

	Behaviour	Time	Area	T0	T1	T2	T3
Standing posture	Feeding	Day	Covered	150.90±5.41 ^{ab}	139.09±3.19 ^b	146.67±4.95 ^{ab}	157.29±3.88 ^a
		Night	Covered	54.09±5.31	60.06±5.53	64.51±5.56	71.66±3.31
		Daily (overall)	Covered	205.00±6.79 ^b	199.16±6.63 ^b	211.18±6.21 ^{ab}	228.95±5.60 ^a
	Idling	Day	Open	35.27±3.32 ^a	17.08±2.16 ^b	19.58±1.17 ^b	23.89±3.53 ^b
			Covered	74.37±8.22	82.01±12.42	52.36±8.73	76.59±10.97
		Night	Open	77.43±8.28 ^a	48.61±6.78 ^b	55.69±7.41 ^{ab}	62.29±5.05 ^{ab}
			Covered	10.48±2.14 ^b	9.86±1.60 ^b	13.05±2.45 ^b	27.50±6.68 ^a
		Daily (Overall)	Open	112.70±7.46 ^a	65.69±5.49 ^b	75.28±7.31 ^b	86.18±4.13 ^b
			Covered	84.86±8.95	91.87±13.83	65.41±10.81	104.09±15.50
	Standing–Rumination	Day	Open	3.61±1.02	3.81±1.08	2.29±0.69	1.73±0.67
			Covered	3.95±1.28 ^b	12.15±2.56 ^a	1.87±0.90 ^b	4.51±1.23 ^b
		Night	Open	56.94±7.99 ^a	41.04±6.41 ^{ab}	25.62±5.05 ^b	50.20±10.19 ^{ab}
			Covered	9.58±3.28 ^{ab}	0.20±0.11 ^b	7.70±2.34 ^{ab}	15.83±3.70 ^a
		Daily (Overall)	Open	60.56±7.51 ^a	44.86±6.30 ^{ab}	27.91±4.80 ^b	51.94±10.07 ^{ab}
			Covered	13.54±3.20	12.36±2.53	9.58±2.34	20.34±3.99
	Total standing time*			271.67±23.11 ^a	214.79±22.17 ^{ab}	178.19±20.66 ^b	262.57±24.81 ^a

Means bearing different superscripts (a, b, c) differ significantly ($P < 0.05$) row wise. *Day hours, 7:30–11:30; 13:30–15:30 hrs; *Night hours, 17:30–5:30 hr; +, total standing time does not include feeding time.

feeding. It is in agreement with the findings of Stefanowska *et al.* (2001), who suggested that cattle maintain eating times even when conditions at the feed bunk are less than optimal.

Feeding time in night did not differ significantly between treatments. In comparison to day, during night the feeding time was almost half in all the groups. It indicated that feeding is preferred activity of day hours. This is in agreement to previous findings (Gibb *et al.* 1998, DeVries *et al.* 2003, John *et al.* 2017).

Overall (day + night) feeding was second most important activity after lying-rumination, irrespective of floors. Cows spent 18–21% of overall time in feeding. This is in consistent with earlier findings (Blowey 1994, Fregonesi *et al.* 2004). Overall feeding time differed significantly ($P < 0.05$) between treatments. In feeding platform, rubber mat was found to promote overall feeding time. Increased feeding time might be indicative of relief while standing in rubber mat than hard concrete floor at feeding area. Similarly, several studies revealed that providing rubber flooring in the feeding area significantly increased the time spent standing in the feed area (Fregonesi *et al.* 2004, Tucker *et al.* 2006).

Idling behaviour: Day idling time (in open area) differed significantly ($P < 0.05$) between treatments. Idling was second major activity during day (20–31% of day time). It was more in covered than open area in all groups, which obviously represent shade seeking behaviour. Brick floor (T0) resulted in more day idling time in open area, as compared with alternative floor (sand bed).

Night idling time differed significantly ($P < 0.05$) between treatments for open and covered area. Idling ranged from 8–13% of night time in different groups. Unlike day, preferred area for idling during night was open area, irrespective of groups. Night idling in open area was more in T0 and T3 group, while in covered area it was more in T3 group. Higher idling time in harder (brick) floor suggest that animal were forced to stand idle more time instead of lying, in these surfaces. While comfort offered by sand bed in open area reduced idling time during night. Comparison between T3 and T0 group indicated that rubber mats are more suitable for standing than brick.

Daily (overall) idling time differed significantly ($P < 0.05$) between treatments only in open area. It was highest in T0 group and lowest in T1 group. Increased time spent standing idle has been suggested as indicator of poor cow comfort (Feddes *et al.* 1995). It has also been reported previously that concrete floor result in more idling behaviour (Haley *et al.* 2000). In our study, providing sand bed in resting area was found helpful in reducing idling time. Daily more idling in open area was observed in conventional flooring (concrete with brick-paved in open) provided in India for cow housing than in sand floors. While rubber matted covered area was no different than concrete with respect to total idling time.

Rumination in standing posture: Irrespective of groups, small fraction of day time (max. 12 min) was devoted to standing-rumination activity. It differed significantly

($P < 0.05$) between treatments in covered area and was highest in T1 group.

Night standing-rumination differed significantly ($P < 0.05$) between treatments for open and covered area, and was more in brick floor (T0 and T3) than sand bed floor (T1 and T2). In covered area, T3 group spent more time in standing-rumination during night. In general irrespective of floor, during night standing-rumination was mostly in open area as similar to idling time. Provision of sand bed in open area reduced the time spent in standing-rumination. It is evident from the results that rumination in standing position shows diurnal variation and it is mostly performed during night time.

Overall total standing-rumination time differed significantly ($P < 0.05$) between treatments for open area and it was higher in brick floor (T0 and T3). In general, time devoted in standing-rumination was lower compared to lying rumination. It is in agreement with previous study (Phillips and Leaver 1986). Standing-rumination activity was performed mostly in the open area and sand bedding resulted in reducing this behaviour. Cow naturally prefers to ruminate in lying, than in standing position (Cooper *et al.* 2007). However, decreased motivation for lying-rumination given hardness of floor, resulted in rumination while standing. Moreover, standing-rumination was replaced in sand bedded floor with more lying rumination.

Total standing time: Overall time spent in standing posture differed significantly ($P < 0.05$) between treatments. Sand bedded open area promoted the natural behaviour of lying by offering more comfortable surface to lie down, therefore standing time was lower. While on other (brick, concrete or rubber mat) surfaces higher standing time indicated the inferiority of these surfaces as far as lying behaviour is considered. Reduced lying or more standing is generally interpreted as an indication of poor welfare (Fisher *et al.* 2003) and poor cow comfort (Miller and Wood-Gush 1991, Krohn *et al.* 1992). Gomez and Cook (2010) reported that cows on deep-bedded sand stalls spent significantly less time standing compared to cows housed on mattress. Additionally, cows on deep-bedded sand stalls spent significantly more time lying down than cows housed on mattress farms. The potential benefits of the additional cushioning and improved footing provided by rubber floors are likely neutralized by additional standing time and claw overgrowth (Bicalho and Oikonomou 2013). However, it has been reported that cushioning properties of rubber flooring are not as good as that of straw (Boyle *et al.* 2005). All these findings are in support of our study.

Lying (without rumination): Day lying time in open or covered area did not differ significantly between treatments (Table 2). However, night lying time in open or covered differed significantly ($P < 0.05$) between treatments. But it was negligible activity (< 5 min. in any group) in covered area during night time. Overall lying (without rumination) time differed significantly ($P < 0.05$) between treatment only for open area. It was higher in T2 group. Cow did not spend much time in lying alone without rumination, it suggest

Table 2. Behaviour of cow (mean±SE minutes) in sitting posture under different flooring system

	Behaviour	Time	Area	T0	T1	T2	T3
Sitting posture	Lying	Day	Open	13.12±2.96	11.04±2.22	18.47±1.84	10.41±3.22
			Covered	27.84±3.75	16.31±3.09	28.54±5.00	20.20±3.57
		Night	Open	17.50±3.70 ^b	12.56±1.44 ^{bc}	29.65±4.92 ^a	1.87±0.69 ^c
	Covered		4.58±2.01 ^a	0.76±0.45 ^{ab}	0.83±0.46 ^{ab}	0.62±0.36 ^b	
	Daily (Overall)	Open	30.62±3.69 ^b	23.61±2.49 ^{bc}	48.12±5.65 ^a	12.29±3.12 ^c	
		Covered	32.43±5.56	17.08±3.22	29.37±5.06	20.83±3.69	
	Lying-Rumination	Day	Open	37.15±9.42	67.56±12.54	68.81±13.29	38.68±8.42
			Covered	9.30±2.67 ^b	7.98±3.48 ^b	15.90±4.2 ^{ab}	24.51±2.97 ^a
		Night	Open	394.23±27.72 ^b	496.67±10.26 ^a	467.01±14.70 ^{ab}	291.18±33.30 ^c
	Covered		50.06±18.00 ^b	0.41±0.23 ^b	14.23±5.78 ^b	167.01±25.88 ^a	
	Daily (Overall)	Open	431.38±33.87 ^{bc}	564.23±19.16 ^a	535.83±25.53 ^{ab}	329.86±39.85 ^c	
		Covered	59.37±18.44 ^b	8.40±3.46 ^b	30.13±6.40 ^b	191.52±25.98 ^a	
	Sleeping	Day	Open	0.69±0.32 ^b	2.91±0.67 ^{ab}	3.26±0.94 ^a	1.52±0.50 ^{ab}
			Covered	3.75±0.89 ^a	0.00±0.00 ^c	2.22±0.76 ^{ab}	0.62±0.25 ^{bc}
		Night	Open	40.97±3.57 ^a	49.79±3.78 ^a	40.34±3.34 ^a	20.83±2.39 ^b
			Covered	4.09±1.67 ^b	0.00±0.00 ^b	1.31±0.52 ^b	10.97±2.29 ^a
		Daily (Overall)	Open	41.67±3.58 ^a	52.70±4.25 ^a	43.61±3.87 ^a	22.36±2.42 ^b
			Covered	7.84±1.72 ^{ab}	0.00±0.00 ^c	3.54±0.82 ^{bc}	11.59±2.27 ^a
	Total sitting time				603.33±20.65 ^{bc}	666.04±21.42 ^{ab}	690.63±17.43 ^a

Means bearing different superscripts (a, b, c) differ significantly ($P<0.05$) row wise. *Day hours, 7:30–11:30; 13:30–15:30 hrs; *Night hours, 17:30–5:30 h; +total standing time does not include feeding time.

that cow preferably ruminate while lying down.

Lying–Rumination behaviour: Day lying-rumination time in covered area differed significantly ($P<0.05$) between treatments. Comparatively more lying-rumination in day was observed in groups with rubber matted covered area (T2 and T3). More cushioning offered by rubber mat than concrete might promote the lying-rumination in covered area. However, for lying-rumination in day, open area was preferred in all the groups, in contrary to other day behaviours, where covered area was preferred.

Night lying-rumination time differed significantly ($P<0.05$) between treatments for both open and covered area. Comparatively more lying-rumination in night was observed in groups with sand bedded open area (T1 and T2). While in covered area higher lying-rumination was recorded in T3 group. In general, irrespective of floor, lying-rumination was found as major activity (62–69% of time) of night and it was performed preferably in open area. Night lying-rumination time was favourably modified in sand bed floor, irrespective of floor (rubber mat/concrete) in covered area. However, rubber matted covered area promoted lying rumination time only in group without sand bed in open (T3). Moreover, the lying time during night hours remained higher in sand groups (T1 and T2) than with brick paved groups (T0 and T3).

Overall lying-rumination time differed significantly ($P<0.05$) between treatments for both open and covered area and trend between the groups was similar to that of night lying-rumination time. It was higher in T1 and T2 groups for open area and T3 for covered area. Floor surface was found to strongly affect this behaviour. Overall lying rumination activity was improved in sand bedded groups.

In general, lying-rumination was principal daily activity (45–53% of time daily) mostly performed in open area irrespective of floor. In previous studies also, it was concluded that lying behaviour is high priority behaviour in dairy cows (Munksgaard *et al.* 2005, Cooper *et al.* 2007). Further, rumination in cows is preferred in lying down position, occurring in about 80% of resting bouts (Cooper *et al.* 2007, Schirmann *et al.* 2012). Floor surface was found to affect lying-rumination behavior. Sand bedded open area (T1 and T2) encouraged lying-rumination behavior in comparison to brick. Rubber matted covered area, improved lying-rumination only in absence of sand bedded open area. This might indicate that sand bed was more comfortable for lying than rubber mat, concrete or brick. Lying time has been suggested as a measurable and usable indicator of animal welfare (Fregonesi and Leaver 2002). Madke *et al.* 2010 also reported that sand bedding in hot season proved most comfortable floor to crossbred cows in northern India and lying rumination time was higher in sand bedding than mat or concrete group. Cows housed in sand-bedded free stalls had a significantly greater proportion of long lying bouts (>60 min) than did cows in mattress bedded free stalls (Cook *et al.* 2004). Cows also have longer lying times on rubber mats than on concrete (Rushen *et al.* 1998, Chaplin *et al.* 2000). These studies are in agreement with our findings.

Sleeping behaviour: Overall sleeping time differed significantly ($P<0.05$) between treatments in open and covered area. Highest sleeping time in open area was observed in T1, while lowest in T3 group. Cows in T3 group spent highest time in sleeping daily in covered area. Sleeping was generally observed in open area of shed as

similar to lying-rumination activity. Sleeping in open area was almost similar between groups except T3, in which it was lower. It has been reported previously that dairy cows sleep for about 4 h/d, in short 3 to 5 min bouts throughout the day (Ternman *et al.* 2012). However, in our study, sleeping time was found below 1 h/d irrespective of groups which may be due to climatic variation.

Total sitting time: Overall time spent in sitting posture differed significantly ($P < 0.05$) between treatments. It was highest in T1 followed by T2 group. In agreement to our findings, total sitting time in dairy cattle has been reported as 8 to 16 h per day in earlier studies (Webster 1994, Dechamps *et al.* 1989, Haley *et al.* 2000, 2001). Therefore, the quality of the lying surface becomes utmost important for the animals. Our findings suggest that sand bedded open area can increase the sitting time. In previous report, increased resting time in deep-bedded sand stalls was suggested as important evidence of superiority of this housing system regarding cow comfort standards (Bicalho and Oikonomou 2013). It has been concluded in previous reports that softness of flooring in cow shed substantially increases the time spent lying down (Wechsler *et al.* 2000, Haley *et al.* 2001, Drissler *et al.* 2005, Rushen *et al.* 2007). In a recent study, Sahu *et al.* (2019) also found similar results with respect to sand bed floor as found in our study.

In this study, floor surface was found to affect lying, feeding and rumination behaviour of cows in loose housing system. Covered area of loose house was mainly used for feeding, idling and standing rumination activity in day time. Further animal spent most of the day time under the shade while during night animal remained mostly in open area irrespective of floor. Rubber matted covered area was found to improve the feeding and resting time and reduce the idling time. In our study cow spent most of the daily time at open area of house, therefore floor at this area should meet the lying comfort of the animal. During day and night both, lying rumination was mainly performed in open area. Sand bedded open area was found to increase the lying and rumination time and reduce standing rumination time. Sand bed was preferred for sleeping during night. This indicated that sand bed was more comfortable for lying than rubber mat, concrete or brick. In conclusion, modifying loose housing system with rubber mat in place of concrete in covered area and sand bed in place of brick floor in open area was found superior to provide more comfort for dairy cows.

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