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Evaluation of productive and reproductive performance of crossbred dairy cattle reared under conventional tie barn and loose housing system during summer season#

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Abstract

The productive and reproductive performance of crossbred dairy cows kept at conventional tie barn and loose housing system were evaluated. The study was conducted in ULF & FRDS, Mannuthy. Twenty crossbred dairy cows in early lactation were selected and randomly divided into two groups. Group one consists of animals housed under loose housing system (T1) and group two consists of animals housed under conventional barn system (T2). Daily milk yield and meteorological data of ambient temperature and relative humidity of both housing systems were recorded. Reproductive parameters like onset of oestrus, intensity and duration of oestrus, service period and number of services per conception were recorded.The mean ambient temperature (ºC), relative humidity (%) and Temperature Humidity Index of loose house and tie-barns were 29.89±0.15 and 30.43±0.98, 66.95±3.27 and 78.07±3.31, 80.68±0.71 and 83.30±0.66 respectively and were significantly different between the two housing systems.The mean values of milk yield (kg) were 14.710±1.105 and 14.780±1.105 in T1 and T2 at the beginning of the study and were statistically similar. During the third month there was significant reduction in milk yield(kg) of T2 while the milk yield of T1 remained consistent. The milk yield (Kg) dropped significantly for both T1 and T2 during fourth month of lactation and was 12.160±0.801 and 9.980±0.801 respectively. The mean service period(days) was 121.20±35.808 for T1 and 157.00±72.414 for T2 and median values of duration of oestrus(h) were 24.00(78) and 12.00(36) and both differed significantly.Both of them differed significantly between the treatment groups. Onset of oestrus, intensity of oestrus and number of services per conception were similar for cows housed in both housing systems. The mean daily milk yield and reproductive parameters like service period and duration of oestrous of crossbred cattle were better in loose housing system. This study shows that loose housing system could be recommended for housing dairy cattle during summer.

Keywords*: Housing system, summer season, milk production, reproduction, THI*

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Housing systems for dairy cattle have been primarily considered for animal safety, economic benefits and labour efficiency. They can unintentionally impact the social and individual behaviour of dairy cattle, either negatively or positively (Pollock and Hurnick, 1979). In terms of movement, cows are kept in either tie-stall barns (restrained in stanchions) or loose-housing barns (where they have freedom to move within a group pen) (Sawa and Bogucki, 2011). The evolution of various housing systems over the past few decades has mainly been influenced by technical innovations which addressed to the changes in cow needs, farmer expectations, and the societal and environmental impacts. These needs and expectations lead to a diverse range of dairy housing systems. While tie-stalls (TS) are still in use, cubicle housing systems (CB), commonly known as freestall barns, have become widely adopted since the 1970s (Bewley *et al*., 2017). Both systems have pros and cons, which can impact milk quantity and quality in various ways. In reviewing studies comparing tethered and loose housing systems on cows' milk production, health, fertility, and behaviour, Zdziarski *et al*. (2002) concluded that neither system was clearly better, though the loose housing system offered some advantages. Housing systems have an impact on cow fertility (Sawa and Bogucki, 2011), health (Schnier *et al*., 2002), and production (Anderson, 1997). Harman *et al*. (1996) opined that the time from calving to conception is often regarded as the best single measure of cow fertility. Research has indicated that high temperature conditions can lead to significant rise in body temperature and respiratory rate (Collier *et al*., 2006) as well as a considerable decline in feed intake (West *et al*., 2003), milk production (Lambertz *et al*., 2014) and reproductive performance (Lozano *et al*., 2005). The temperature-humidity index (THI) is widely used as an important environmental tool to assess heat stress in dairy production (Ammer *et al*., 2018). Cows can manage a certain range of THI without compromising their productivity. However, when THI surpasses a specific threshold, cows lose their ability to regulate thermal balance, leading to heat stress. This negatively impacts milk production, reproductive performance and overall welfare (Becker *et al*., 2020) resulting in substantial economic losses (Gunn *et al*., 2019). The present study investigates the productive and reproductive performance of crossbred cattle reared under conventional tie barn and loose housing system and the influence of summer season on the productive performance of the crossbred cattle.

Materials and methods

The research was conducted to assess the welfare of crossbred dairy cows reared under conventional tie barns and loose housing system. The study was conducted at University Livestock Farm and Fodder Research and Development Scheme (ULF & FRDS), Mannuthy. The study period was during summer season from February 2024 to May 2024 (Sasidharan, 2023). The animals were randomly allotted into two groups of ten animals each. First treatment (T1) consists of animals reared under loose housing system with covered space of 3.5m^2 and open space of 7m^2. Second treatment (T2) includes animals reared under conventional tie barn having 4 standing space with asbestos roof and fed as per management practices prevailing in the farm. Ambient temperature and relative humidity were measured using an electronic logger (HOBO Pro V2, Onset Computer Corporation, USA) both inside and outside the shed and THI was calculated. Daily milk production was recorded and peak yield was noted. The intensity of oestrous was studied as described by Azeez (2014) based on behavioural changes like restlessness, mounting, chin resting and rubbing. Physiological changes during heat like vulval oedema, urination and genital discharge were evaluated by visual appraisal. Gynaecological observations such as fern pattern, cervical relaxation and uterine tonicity were assessed. Intensity of oestrus was scored as intense, intermediate, and weak. Postpartum reproductive parameters such as onset of oestrus, duration of oestrus, service period, calving to first service and number of services per conception were recorded during the experimental period. The data obtained on various parameters were statistically analysed as per the method of Snedecor and Cochran (1994) using

Fig.1. Loose housing system -Animals were housed in open paddock with 7m^2 per animal and covered area of 3.5m^2 per animal

Fig. 2. Conventional tie barn system- Animals reared in conventional tie barn having asbestos roof and with a covered area instead of standing space of 4 m^2 per animal (T2)

Table.1. Mean values of ambient temperature (°C), relative humidity (%) and THI in crossbred cattle

Parameter	Ambient temperature (Mean ±SE) (˚C)		t value	p value
	T1(Loose house)	T2 (Tie barn)		
Max. Temperature	37.05±0.87	34.67±0.93	1.865	0.081 ns
Min. Temperature	24.54[a]±0.51	27.1[b]±0.40	-3.920	0.001**
Avg. Amb. Temperature	29.89[a]±0.15	30.43[b]±0.98	-0.860	0.003**
Max. relative humidity	85.9±2.90	95.44±3.50	-2.097	0.052 ns
Min. relative humidity	48±4.37	54.57±6.30	-0.857	0.404 ns
Average relative humidity	66.95[a]±3.27	78.07[b]±3.31	-2.385	0.03*
THI	80.68[a]±0.71	83.30[b]±0.66	7.232	<0.01**

*Means with different superscripts (a,b) differ significantly along row (*p<0.05) (**p<0.01), ns- non-significant*

repeated measures of analysis of variance (ANOVA) and linear regression analysis. The data were analysed using computerized software programme SPSS V. 24.0.

Results and discussion

There were significant differences in both average ambient temperature(°C) and minimum ambient temperature(°C) between the two treatment groups (Table 1) and the values were 29.89±0.15 and 30.43±0.98, 24.54±0.51and 27.1±0.40 respectively in T1 and T2, in which T2 had higher ambient temperature and minimum ambient temperature. There was no significant difference in maximum ambient temperature. This was consistent with the findings of Biasato *et al*. (2019) who observed higher ambient temperatures in tie-stall barns when compared to freestall barns. Also, there was significant difference between relative humidity in both treatment groups. The mean values of average relative humidity (%) were 66.95±3.27 and 78.07±3.31 respectively in T1 and T2. T2 recorded higher significant value as depicted in Table 1. The mean values of maximum and minimum relative humidity (%) were similar. This is parallel to the findings of Vtoryi *et al*. (2018) wherein higher relative humidity was found inside tiebarns. During summer, as ambient temperatures and relative humidity rise within barns, dairy cows' ability to release heat become compromised. The combination of environmental conditions and the metabolic heat produced by the cows can lead to an accumulation of heat, resulting in heat stress. This condition has serious negative effects on the cows' health, well-being, and performance (West *et al*., 2003). The temperature-humidity index (THI), a bioclimatic measure that combines ambient temperature (AT) and relative humidity (RH), is commonly used to gauge the level of heat stress in dairy cows (Ouellet *et al*., 2019). The values of THI were also significantly different between treatment groups. The mean values of THI were 80.68±0.71and 83.30±0.66 respectively in both treatment groups (Table 1) showing significant difference between the groups. Similar findings were given by (Cartwright *et al*., 2022) who stated that there was no uniform distribution of airflow in tie stall barns compared to free stall barns. So, it was difficult to control the increased temperature and humidity formed inside the tie stall barns. Pennington and Deven (2010) reported the ranges of THI in dairy cows as mild stress (THI 72), moderate stress (THI 80 to 89) and severe stress (THI 90 to 99). In both the housing systems the mean values of THI were ≥ 80 indicating the animals were under moderate heat stress.

There was no significant difference in the daily milk yield between the treatment groups (Table 2). The milk yield was similar in T1 and T2 in the beginning of the study. While the animals entered mid lactation the milk production was significantly reduced in both the treatment groups. During the third month of early lactation period there was significant reduction in milk yield in T2 while the milk yield in T1 remained consistent throughout the early lactation period. In both the treatment groups there was a significant reduction in the milk yield during the

Table. 2. Mean values of daily milk yield (Kg) in crossbred dairy cattle

Months	Daily milk yield (Mean±SE) (Kg)		F Value	p Value
	T1 (Loose house)	T2 (Tie barn)		
Month 1	14.710[a]± 1.106	14.780[a]± 1.106	0.002	0.965
Month 2	14.770[a]± 0.922	13.530[a]± 0.922	0.904	0.354
Month 3	13.736[a]± 0.850	11.550[b]± 0.850	3.303	0.086
Month 4	12.160[b]± 0.801	9.980[c]± 0.801	3.706	0.07
F Value	6.529	15.889		
p Value	*0.004	*0.01		

Means with different superscripts (a,b) differ significantly along column (p<0.05)

Table.3. Correlation coefficient between milk yield (Kg) of treatments with THI

Treatment 1	Treatment 2
-0.914**	-0.745*

*** Significant at 1% level, *Significant at 5% level*

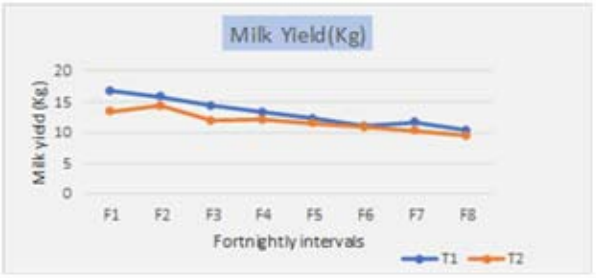

Fig.3. Milk yield in different fortnightly intervals

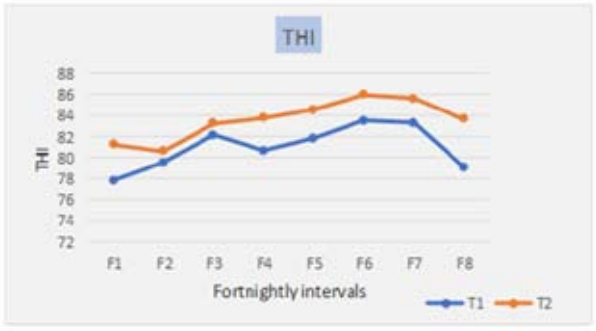

Fig. 4. THI value in various fortnights between treatment groups

mid lactation. The persistency of milk yield in T1 group indicated better welfare of cows in loose housing.

The higher THI in tie barn would have negatively squed the milk yield in T2 as opined by West *et al*. (2003). Bouraoui *et al.* (2002) showed that there was 21 percent decrease in milk yield when the THI rises from 68 to 72 percent. Tancin *et al.* (2004) had similar findings that milk production decreased when animals were kept at tie stall systems. While contrasting finding were given by Sawa and Bogucki (2011).

Correlation study showed that THI is negatively correlated with milk yield and is highly significant in T1 as shown in Table 3. The milk production of animals in loose houses was not affected as that of animals in tie barns since THI was comparatively less in loose houses. Harithalekshmi and Ajithkumar (2021) documented that premonsoon (March -May) was the season of heat stress in central zone of Kerala and found that THI was highly negatively correlated with milk yield.

Fig 3. represents the fortnightly milk yield obtained from both treatments and Fig 4. represents the THI values of corresponding fortnights. By comparing both the milk yield in T1 is higher than T2 and the corresponding THI value of T1 is lesser than T2.

The median values of duration of oestrus (h) were 24.00(78) and 12.00(36) respectively in both treatment groups (Table 4) and were significantly different. Normal duration of oestrus in Holstein cows are (20.3±10.4h) (Lyimo *et al*., 2000). The values were in normal range for animals under both housing systems. Sood and Nanda (2006) reported (8.5–13h) shorter duration of oestrus. As the physical activities of animals in tie barns were less their behavioural expression of heat like mounting was also not pronounced. Further, Smid *et al*. (2024) showed that outdoor cows exhibited a longer duration of oestrus compared to indoor cows.

Regarding the intensity of oestrus (Table 4) no significant difference was noticed between treatment groups. The oestrus signs such as mounting behaviour (Fig.5), sniffing at the back region (Fig.6), chin resting (Fig.7) and typical fern pattern (Fig. 8) are depicted. Regarding the number of services per conception (Table 4) the present study shows no significant difference between treatment groups, as reported by Leso *et al*. (2019). Contrasting findings were given by Kowalski *et al.* (2003) who found that in a loose barn, the first service conception rate was seven per cent higher compared to a

Table 4. Median values of duration of oestrus (h), intensity of oestrus and number of services per conception in crossbred cattle

Parameter	Median (IQR)		p value
	T1(Loose house) n=10	T2(Tie barn) n=10	
Duration of oestrus (h)	24.00^{a}(78)	12.00^{b}(36)	*0.030
Intensity of oestrus	7.00(4)^{ns}	6.50(1)^{ns}	0.134
Number of services per conception	2.00(1.75)^{ns}	2.00(1.75)^{ns}	0.406

Means with different superscripts (a,b) differ significantly along row (p<0.05); ns- non-significant

Table 5. Mean Values of onset of oestrus (days) and service period (days) crossbred cattle

Parameter	(Mean ± SE) (Days)		F value	p value
	T1(Loose house) n=10	T2 (Tie barn) n=10		
Onset of oestrus (Days open)	38.33±5.317	39.67±4.077	1.737	0.897^{ns}
Service Period (days)	121.20^{a}±35.808	157.00^{b}±72.414	-1.401	*0.038

Means with different superscripts (a,b) differ significantly along row (p<0.05); ns- non-significant

Fig. 5. Mounting behaviour

Fig.6. Sniffing at the back region

Fig. 7. Chin resting

Fig. 8. Typical Fern pattern- An arborescent Crystalline pattern resembling a typical fern Frond can be observed

tethered barn. Schefers *et al*. (2010) stated that intensity of oestrus was influenced by various environmental and management factors.

There was no significant difference between treatment groups regarding onset of oestrus after parturition (Table. 5). Similar findings were given by Pollock and Hurnik (1979). The mean service period was 121.20±35.808 for T1 and 157.00±72.414 for T2 and they differed significantly (Table. 5). Earlier research has shown that the service period for crossbred cattle ranged from 121.60 ± 16.74 days (Kumar et al., 2015) to 122.00 ± 24.31 days (Hussain et al., 2012) Service period was in normal range for animals in T1. Similar findings were given by Perisic *et al*. (2024) and reported that in tethered system service period was 171 days, the animals under loose housing systems had a service period of 127 days. This indicates better fertility rate in animals under loose housing system than tie stall system. Majewska (2006) found that the percentage of cows culled for infertility was lower in the loose housing system (41.2%) compared to the tethered system (56.7%).

Conclusion

The study elucidated loose housing system over conventional tie barn system in terms of both productive and reproductive performance. Early lactation milk yield was persistent in cattle housed under loose housing system. THI was relatively higher in tie barn which had adversely affected the milk yield there. Regarding the reproductive performance, animals in loose housing system had reduced service period, which is best indicator of fertility rate. Since heat stress was comparatively less in loose housing system, the welfare of the animals was better there. So that they performed efficient in terms of productive and reproductive performances. Considering the above facts loose housing system could be recommended for improving the production and reproduction efficiency of crossbred dairy cattle.

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Conflict of interest

The authors have no conflicts of interest to declare.

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