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Assessments of welfare of Marathwadi buffalo calves under different housing systems

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Abstract
The study was conducted at the Livestock Farm Complex, College of Veterinary and Animal Sciences, Udgir, Maharashtra, to evaluate the effect of different housing systems on the welfare of Marathwadi buffalo calves. Sixteen three month old calves were randomly divided into two groups of eight each: barn housing (T_1) and loose housing (T_2), and were observed for 15 weeks. Parameters including body weight, feed and water intake, physiological responses, behavioral patterns, and blood profiles were recorded. Average weekly weight gain, feed intake, and water intake were slightly higher in T_2, with water intake showing a significant difference ($p<0.05$). Heart rate and pulse rate were significantly lower in T_2, indicating reduced stress, while rectal temperature showed no significant difference. Calves in T_2 exhibited longer rumination time, higher social interaction, and lower serum cortisol levels ($p<0.05$), suggesting improved welfare compared to T_1. No significant differences were noted for hemoglobin and packed cell volume. Overall, the study concluded that the loose housing system provided better behavioral expression, physiological comfort, and lower stress indicators, making it a more favorable housing system for Marathwadi buffalo calves.

Keywords: Behavior & health monitoring, cortisol, hematology, marathwadi buffalo calves, welfare

Introduction
Livestock plays a vital role in Indian agriculture, engaging nearly 70% of the population, most of whom are small to medium-scale farmers. Buffalo farming is especially significant, contributing over 50 million tons of milk and 1.43 million tons of meat annually (ICAR), and supporting the livelihood of marginal farmers and landless laborers. According to the 20th Livestock Census, the total bovine population in India is 302.34 million, with 109.85 million buffaloes, known for high-quality milk and adaptability to low-quality feed and harsh climates. India has emerged as the world's largest milk producer, growing from 17 million tons in 1950-51 to 230 million tons in 2022-23 (Agrawal and Raju, 2021) [2], improving per capita availability from 130 g/day to 460 g/day (Chattacharjee and Patel, 2016) [6]. The buffalo sector accounts for 66.3% of global buffalo milk production (ICAR-CCARI, 2019) [12], highlighting its economic and nutritional importance. The calf stage is critical for lifelong productivity, with welfare conditions impacting growth, immunity, and future yield. Proper housing plays a major role in calf health, comfort, and behavior, influencing parameters such as feed and water intake, growth rate, and stress indicators like serum cortisol. Despite its importance, research on buffalo calf welfare, particularly comparing housing systems in India, remains scarce. Most farmers rely on traditional tie-barn systems without standardized planning, which may negatively affect animal welfare (Sastry and Thomas, 2005) [19]. The Marathwadi buffalo, an indigenous breed well-suited to the region, thrives on low external inputs (Bande *et al.*, 2018) [4] and is widely reared by smallholders in Maharashtra.

Materials and Methods
The present study was conducted to assess the growth, feed and water intake, hematological parameters, serum cortisol, environmental parameter, physiological responses, behavior, and

welfare of Marathwadi buffalo calves under two different housing systems: Barn Housing (T_1) and Loose Housing (T_2). A total of 16 buffalo calves (all older than three months) were randomly divided into two groups of 8 animals each. The barn housing system (T_1) had a concrete floor, whereas the loose housing system (T_2) had an earthen (Katcha) floor, providing different flooring conditions to study their effects on calf health and performance. The experiment was carried out over a period of 105 days (15 weeks) at the Calf Unit, Livestock Farm Complex (LFC), College of Veterinary and Animal Sciences, Udgir, Maharashtra, India.

Results and Discussion

Weekly body weight and weight gain

Studies have reported varying effects of housing systems on the growth performance of buffalo calves, particularly in terms of body weight and weekly weight gain (Table 1). In the present study, the average initial body weight of calves in barn housing was 75.49±1.70 kg, increasing to a final weight of 82.02±1.16 kg, while those in loose housing started at 74.66±1.60 kg and reached 81.48±1.22 kg. Similarly, the average weekly weight gain increased from 0.83±0.05 kg/week to 0.95±0.01 kg/week in barn housing and from 0.76±0.03 kg/week to 1.01±0.02 kg/week in loose housing, with no statistically significant variation between the groups. These findings suggest that both housing systems provide comparable conditions for supporting calf growth when nutrition and management are standardized. This is in agreement with Patil and Bhokre (2016) [16], Mane and Kharwadkar (2018) [15], and Kadam (2019) [13] who also reported non-significant differences in body weight and weight gain between housing types, though loose housing tended to show slightly better performance. In contrast, Sanap *et al.* (2018) [18] reported significant improvements in growth under certain housing modifications, indicating that structural or environmental differences may impact growth outcomes in specific contexts.

Table 1: Growth performance under barn and loose housing

Category	Parameter	Barn housing (Mean ± SE)		Loose housing (Mean ± SE)		Stats
		Initial	Final	Initial	Final	
Growth parameter	Weekly body weight (kg)	75.49±1.70	82.02±1.16	74.66±1.60	81.48±1.22	NS
	Weekly body weight gain (kg)	0.83±0.05	0.95±0.01	0.76±0.03	1.01±0.02	NS

Feed Intake

Feed intake is a vital parameter in assessing growth and welfare in calves, and in the present study (Table 2), Marathwadi buffalo calves housed under loose housing consistently showed slightly higher intake across daily, weekly and cumulative measures compared to barn housing, although the differences were statistically non-significant. The initial daily feed intake was 9.66±0.74 kg/day in barn housing and 9.78±0.67 kg/day in loose housing, which increased to 10.61±0.23 kg/day and 11.22±0.24 kg/day, respectively, by the end of the study.

Similarly, the initial weekly feed intake was 67.62±1.96 kg for barn-housed calves and 68.46±1.77 kg for loose-housed calves, rising to 74.34±0.74 kg and 78.60±0.67 kg, respectively, at the final stage. The trend extended to cumulative feed intake, where barn-housed calves increased from 540.96±0.74 kg initially to 594.76±12.79 kg finally, while loose-housed calves rose from 547.68±0.67 kg to 628.84±13.31 kg. Although all differences were non-significant, the consistently higher intake observed in loose housing may be attributed to improved comfort, reduced stress, and easier access to feed, supporting better feeding behavior. These findings are in agreement with Patil and Bhokre (2016) [16] and Sudam (2021) [21], who also noted higher feed intake in loose-housed calves. However, studies such as Yacob *et al.* (2005) [23] reported no significant variations, indicating that housing type alone may not significantly affect feed consumption unless combined with factors like feed quality, management, and environmental modifications.

Table 2: Effect of housing system on feed intake

Category	Parameter	Barn housing (Mean ± SE)		Loose housing (Mean ± SE)		Stats
		Initial	Final	Initial	Final	
Feed Intake	Daily feed intake (kg/day)	9.66±0.74	10.61±0.23	9.78±0.67	11.22±0.24	NS
	Weekly feed intake (kg/week)	67.62±1.96	74.34±0.74	68.46±1.77	78.60±0.67	NS
	Cumulative feed intake (kg/week)	540.96±0.74	594.76±12.79	547.68±0.67	628.84±13.31	NS

Water Intake

Studies evaluating water intake across different housing systems have generally shown higher consumption in more open environments (Table 3). In the present study, Marathwadi buffalo calves under loose housing consumed significantly more water than those in barn housing. The initial daily water intake was 8.15±0.42 L/day in barn housing and 8.53±0.26 L/day in loose housing, which increased to 9.63±0.35 L/day and 10.20±0.28 L/day, respectively, at the final stage. Similarly, the initial weekly water intake was 57.05±3.00 L/week for barn-housed calves and 59.71±1.86 L/week for loose-housed calves, rising to 67.46±2.45 L/week and 71.45±2.00 L/week, respectively, at the final stage. The cumulative intake also followed this trend, with barn-housed calves increasing from 456.40±3.00 L initially to 539.69±19.65 L finally, while loose-housed calves rose from 477.68±1.86 L initially to 571.64±16.01 L finally. These differences were statistically significant ($p<0.05$), indicating that housing type does influence water consumption. This finding aligns with previous studies by Choure (2010) [7], Mane and Kharwadkar (2018) [15], and Patil and Bhokre (2016) [16], which reported greater water intake in loose housing systems due to factors such as increased movement, higher exposure to ambient temperature, and behavioral freedom. Conversely, Gautam (2012) [10] observed no significant differences, suggesting that environmental design and climatic conditions may modulate the effect. Overall, the present study confirms that loose housing promotes greater hydration, potentially contributing to improved physiological regulation and comfort in buffalo calves.

Table 3: Effect of housing system on water intake

Category	Parameter	Barn housing (Mean ± SE)		Loose housing (Mean ± SE)		Stats
		Initial	Final	Initial	Final	
Water Intake	Daily water intake (L/day)	8.15±0.42	9.63±0.35	8.53±0.26	10.20±0.28	*
	Weekly water intake (L/week)	57.05±3.00	67.46±2.45	59.71±1.86	71.45±2.00	*
	Cumulative water intake (L/week)	456.40±3.00	539.69±19.65	477.68±1.86	571.64±16.01	*

Physiological Parameter

Physiological parameters such as rectal temperature, heart rate, and pulse rate serve as reliable indicators of stress and environmental adaptability in livestock (Table 4). In the current study, Marathwadi buffalo calves housed in barn systems recorded a rectal temperature of 38.55±0.04 °C, while those in loose housing averaged 38.35±0.04°C, showing no significant difference. This suggests that both housing systems were equally effective in maintaining normal body temperatures. These findings are consistent with earlier reports by Patil and Bhokre (2016) [16] and Bhatta *et al.* (2005) [5], who observed stable rectal temperatures across housing types. However, heart rate and pulse rate differed significantly (p<0.05), with barn-housed calves showing higher values (71.03±0.81 bpm and 65.52±0.82 bpm, respectively) compared to those in loose housing (65.63±0.83 bpm and 60.62±0.76 bpm). These differences suggest elevated physiological stress in confined housing. The results align with studies by Kumari *et al.* (2017) [14] and Gaikwad (2018) [9], which reported lower heart rates in loose housing due to reduced stress. Similarly, Wagh (2009) [22] and Patil and Bhokre (2016) [16] noted higher pulse rates in more restrictive housing setups. Overall, while thermal regulation was unaffected, the significantly lower heart and pulse rates in loose housing indicate better welfare and lower stress levels in calves housed under more open, flexible conditions.

Table 4: Effect of housing system on physiological parameters

Category	Parameter	Barn housing (Mean ± SE)		Loose housing (Mean ± SE)		Stats
		Initial	Final	Initial	Final	
Physiological parameter	Rectal temperature Co	38.41±0.13	38.35±0.04	38.60±0.10	38.55±0.04	NS
	Heart rate (beats/min)	74.63±0.64	71.03±0.81	71.61±0.59	65.63±0.83	*
	Pulse rate (beats/min)	74.13±0.50	70.47±0.65	71.36±0.54	65.52±0.82	*

Behavioural observation

Behavioral observations revealed significant differences between barn and loose housing systems in Marathwadi buffalo calves (Table 5). Calves in loose housing spent more time ruminating, with an average of 407.38±2.58 min/day compared to 382.28±3.45 min/day in barn housing (p<0.05), indicating better digestive comfort and reduced stress. These findings support earlier studies by Wagh (2009) [22] and Kadam (2019) [13], which highlighted increased rumination in open housing systems. In contrast, self-licking/grooming behaviors were significantly more frequent in barn-housed calves (74.03±2.40 acts/day) than those in loose housing (57.94±2.06 acts/day). Suggesting that restricted environments may promote repetitive or stress-induced behaviors. Similar conclusions were drawn by Gautam (2012) [10], linking increased self-grooming to reduced space and behavioral restriction. Within the loose housing group, calves spent an average of 629.8±4.12 min/day under shade and 810.19±4.13 min/day in open areas, indicating a preference for open spaces for exploration and social activity, while still actively seeking shade for thermal comfort. These trends underscore the importance of providing both covered and open spaces in calf housing systems. Additionally, calves in loose housing exhibited more social behavior (23.24±0.87 acts/day) than those in barn housing (19.50±0.23 acts/day), showing that increased space and freedom of movement enhance opportunities for interaction, play, and natural behavior expression. Overall, these findings suggest that loose housing environments are more conducive to promoting natural, healthy behaviors in buffalo calves, contributing positively to their overall welfare and psychological well-being

Table 5: Behavioral indicators of welfare in different housing system

Category	Parameter	Barn housing (Mean ± SE)		Loose housing (Mean ± SE)		Stats
		Initial	Final	Initial	Final	
Behavior observation	Resting duration (min/day)	623.75±4.19	624.00±2.16	597.12±3.69	601.52±1.45	*
	Rumination (min/day)	379.25±6.83	396.17±12.24	424.87±10.51	417.45±13.87	*
	Self-licking/Grooming (min/day)	66.75±8.75	74.03±2.40	48.37±5.49	57.94±2.06	*
	Social behavior (No of acts/day)	17.12±1.17	19.50±0.23	19.97±0.59	23.24±0.87	*
	Time in shaded area (min/day)	...	…	642.25±18.98	629.80±4.12	*
	Time in open area (min/day)	...	…	797.75±18.98	810.19±4.13	*

Biochemical Parameter

Stress is a key indicator of animal welfare, as prolonged stress can impair growth, immunity, and overall health in calves (Table 6). Serum cortisol is a reliable biomarker used to assess stress levels. In this study, the initial serum cortisol level was 0.52±0.08 ng/ml in barn housing and 0.44±0.06 ng/ml in loose housing, which changed to 0.49±0.13 ng/ml and 0.42±0.07 ng/ml, respectively at the final stage. Calves housed in barn systems showed higher cortisol levels compared to those in loose housing, with the difference being statistically significant (p<0.05). These findings suggest that loose housing provides a more comfortable and less stressful environment. This is supported by Cucuzza *et al.* (2014) [8] and Sudam (2021) [21], who reported lower cortisol levels in loose-housed animals due to better space allowance and reduced confinement. However, Habeeb *et al.* (2012) [11] noted that stress may still occur in loose systems under extreme heat without adequate shading, emphasizing the importance of well-managed housing conditions.

Table 6: Effect of housing system on serum cortisol levels

Category	Parameter	Barn housing (Mean ± SE)		Loose housing (Mean ± SE)		Stats
		Initial	Final	Initial	Final	
Biochemical	Serum cortisol (ng/ml)	0.52±0.08	0.49±0.13	0.44±0.06	0.42±0.07	*

Hematological parameter

The hematological parameters of Marathwadi buffalo calves revealed no statistically significant differences between barn and loose housing systems (Table 7), indicating that both environments effectively supported stable blood profiles. The average hemoglobin (Hb) concentration was 10.48±0.15 g/dL in barn housing and 10.78±0.22 g/dL in loose housing, suggesting slightly higher oxygen-carrying capacity in the latter, though the difference was not significant. This finding aligns with Patil and Bhokre (2016) [16] and Kadam (2019) [13], while Sudam (2021) [21] reported similar trends of elevated Hb in loose systems. Similarly, packed cell volume (PCV) averaged 32.83±0.34% in barn-housed calves and 33.65±0.50% in loose housing, indicating stable circulatory function across systems. These outcomes support earlier work by Patil and Bhokre (2016) [16], though Sanap *et al.* (2014) [18] observed housing-induced variations under different environmental conditions. White blood cell (WBC) counts were also comparable, recorded at 9.93 × 10^3/cm in barn housing and 10.12 × 10^3/cm in loose housing, showing no significant change in immune response. While Radkowska and Herbut (2014) [17] noted higher WBCs with greater environmental exposure, controlled management in the current study likely minimized such effects. Red blood cell (RBC) counts remained stable as well, averaging 6.65 × 10^6/cm in barn housing and 6.80 × 10^6/cm in loose housing, in agreement with the findings of Patil and Bhokre (2016) [16] and Ahmad *et al.* (2017) [3]. Overall, the data suggest that both housing systems maintained a healthy physiological and hematological profile with loose housing showing marginal, though non-significant, improvements in certain parameters.

Table 7: Effect of housing system on hematological parameters

Category	Parameter	Barn housing (Mean ± SE)		Loose housing (Mean ± SE)		Stats
		Initial	Final	Initial	Final	
Hematological	Hemoglobin (g%)	10.43±0.41	10.48±0.15	10.56±0.37	10.78±0.22	NS
	Packed cell volume (%)	33.32±1.44	32.83±0.34	33.23±0.48	33.65±0.50	NS
	WBC (cm)	10.15±0.51	9.93±0.13	9.65±0.60	10.12±0.16	NS
	RBC (cm)	6.72±0.25	6.65±0.14	6.91±0.16	6.80±0.22	NS

Environmental parameter

The weekly average environmental parameters of barn and loose housing systems were recorded during morning, afternoon, and evening hours (Table 8). Average temperatures (°C) were 23.58±0.42 and 23.59±0.39 in the morning, 27.58±0.25 and 27.60±0.26 in the afternoon, and 23.28±0.38 and 23.29±0.39 in the evening for barn and loose housing, respectively, with a significant difference (p<0.05) in the afternoon. Relative humidity (%) was similar between housing systems across all times of day, showing no significant difference. The THI values were 69.95±0.58 and 69.96±0.54 in the morning, 70.52±0.44 and 75.60±0.46 in the afternoon, and 70.85±0.56 and 70.86±0.56 in the evening, with a significant difference (p<0.05) observed during the afternoon. Overall, the environmental conditions of both housing systems were comparable, except for slightly higher temperature and THI in loose housing during the afternoon, suggesting a marginally warmer microclimate under loose housing at peak daytime hours.

Table 8: Average temperature, relative humidity, and Temperature-Humidity Index (THI) in different housing systems

Parameter	Time of Day	Barn Housing (Mean ± SE)	Loose Housing (Mean ± SE)	Stats
Temperature (°C)	Morning	23.58±0.42	23.59±0.39	NS
	Afternoon	27.58±0.25	27.60±0.26	*
	Evening	23.28±0.38	23.29±0.39	NS
Relative Humidity (%)	Morning	50.87±0.79	50.83±0.81	NS
	Afternoon	53.79±0.90	53.82±0.92	*
	Evening	65.37±0.62	65.42±0.63	NS
THI	Morning	69.95±0.58	69.96±0.54	NS
	Afternoon	70.52±0.44	75.60±0.46	*
	Evening	70.85±0.56	70.86±0.56	NS

Health parameters

Category	Parameter	Observations-Barn Housing	Observations-Loose Housing
Parasitic Screening	Weekly screening & deworming	Subclinical infestations detected occasionally; timely deworming effective. No significant complications.	Same as barn housing; infestations remained subclinical and controlled with treatment.
Skin Health	Skin condition	Mild dryness, occasional scratches, slight tick infestation. Slightly higher dermatitis incidence due to hard flooring.	Generally smooth coat, fewer skin-related issues, better natural grooming.
Disease Incidences	Illness occurrence	Two calves had mild anorexia episodes, recovered quickly. Mild fever in one calf. No severe/chronic disease.	One calf had brief diarrhoea episode managed through dietary adjustments. One calf had mild fever. No severe disease.

The body condition score (BCS) of buffalo calves ranged from 2.5 to 3.5 in barn housing and 2.5 to 4.0 in loose housing, indicating that both systems maintained adequate nutritional status. Most calves in barn housing showed moderate to good body condition, whereas loose housing calves exhibited slightly higher overall BCS, with one calf reaching a score of 4.0 (fat condition). This slight improvement in loose housing may be attributed to increased access to forage and natural movement, which supported better metabolic balance. Importantly, no calves had a BCS below 2.5 in either system, confirming proper nutritional management and the suitability of both housing systems for calf growth and welfare.

Conclusion

The present study comprehensively evaluated growth performance, behavioral patterns, physiological and hematological responses, and general health of Marathwadi buffalo calves under barn and loose housing systems. Although both housing systems supported similar growth, feed and water intake, and overall health, loose housing provided distinct welfare advantages. Calves housed in loose systems exhibited longer rumination duration, higher social interaction, cleaner skin, and slightly better body condition. Heart rate and serum cortisol levels were lower in loose housing, indicating reduced stress, while other physiological and hematological parameters remained within normal ranges. The ability to express natural behaviors, combined with improved comfort and lower stress, suggests that loose housing can enhance calf welfare, reduce veterinary costs, and minimize economic losses without compromising performance.

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Conflict of Interest

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