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Growth Response to a Scientific Feeding Intervention in Fattening Male Murrah Buffalo Crossbreds under Field Conditions in Kerala, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Buffaloes rearing play a vital role in India's rural economy, contributing significantly to milk and meat production. While buffalo milk has received considerable policy and research attention, the rising demand for buffalo meat, particularly from male buffaloes necessitates focus on growth optimisation. In Kerala, where smallholder systems dominate, buffalo meat production remains limited and often constrained by inadequate and imbalanced feeding practices, leading to poor growth and economic returns. This study assessed the impact of a scientifically formulated feeding intervention on the growth performance of Murrah crossbred male buffaloes raised for meat in Thrissur, Kerala. A total of 28 animals were enrolled, of which 24 were retained for analysis after

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excluding extreme outliers. Over a 60-day period, buffaloes were maintained under uniform management conditions with a total mixed ration (TMR) containing 18% crude protein. Body weight was estimated using Shaeffer's formula, and average daily gain (ADG) was calculated. A paired t-test was conducted to assess statistical significance. The initial mean body weight was 181.92 ± 9.81 kg, increasing to 202.28 ± 8.32 kg post-intervention ($p = 0.0068$). The average gain was 20.36 ± 6.85 kg, with an ADG of 0.34 kg/day. Approximately 87.5% of the buffaloes demonstrated positive weight gain, indicating the effectiveness of the feeding strategy. The results confirmed that short-term, scientific nutritional interventions can significantly enhance weight gain in male buffaloes under field conditions. Wider adoption of standard feeding protocols, combined with farmer education and extension support, could improve meat productivity and profitability in smallholder systems.

Keywords: Nutritional intervention; average daily gain; growth; buffalo; field conditions.

1. INTRODUCTION

Buffaloe rearing constitute a vital component of India's livestock-based rural economy, significantly contributing to both milk and meat production. India remains one of the world's largest producers and exporters of carabeef (Bhogal & Beillard, 2023). According to Bhogal and Beillard (2024), carabeef production in market year 2024 is projected at 4.61 million metric tons (carcass-weight-equivalent), up from 4.47 million metric tons in 2023. In 2023–24, buffalo meat accounted for more than 82% of India's total animal product exports (Jadhav, 2024).

Although Kerala is not a major buffalo-producing state, there is growing interest in buffalo meat production, particularly in smallholder livestock farmers. However, buffalo meat production in the state remains relatively limited, with output declining from approximately 117,420 tonnes in 2021–22 to 102,130 tonnes in 2022–23 (DAHD, 2023). Traditional rearing systems commonly practised in Kerala often involve nutritionally imbalanced or inadequate feeding regimens, resulting in poor nutrient intake and suboptimal growth performance (Sivagnanam & Pulikkamath 2019). These deficiencies manifest as reduced average daily gain (ADG), delayed maturity, and inefficient feed conversion, ultimately diminishing profitability and long-term sustainability Nissanka *et al.* .2010). Improving ADG is therefore critical to enhancing economic returns, particularly within smallholder meat production systems.

Nutrient requirement was based on age and physiological status and locally available feed resources, offer significant potential to enhance weight gain, feed conversion efficiency, and overall economic viability in buffalo meat production. However, their adoption at the field level remains limited, primarily due to low awareness, financial constraints, and inadequate access to advisory services (Wakweya, 2023). In the context of Kerala, where buffalo farming is predominantly smallholder-based, fodder resources are scarce, and traditional practices prevail, these constraints are particularly pronounced (Sivagnanam & Pulikkamath, 2019). Consequently, undernutrition, poor growth rates, and diminished profitability are common, highlighting the urgent need for scalable and farmer-centric nutritional interventions. While numerous studies have evaluated growth performance under controlled experimental conditions, there is a paucity of field-based evidence from smallholder production systems. This study addressed that gap by assessing the impact of a scientifically designed feeding intervention on the growth performance of Murrah crossbred male buffaloes reared for meat in Kerala. Specifically, it quantified weight changes over 60 days, calculated average daily gain (ADG), and statistically compared pre- and post-intervention weights to evaluate the practical effectiveness of the feeding strategy in real-world farming conditions.

2. MATERIALS AND METHODS

The study was conducted at a male buffalo fattening unit in the Thrissur district of Kerala state, involving 28 crossbred male Murrah buffaloes, approximately 1.5 years of age. Except for the feeding regimen, all other management conditions were maintained uniformly throughout the study period, which coincided with Kerala's late winter season. Preliminary observations indicated that the Murrah crossbred male buffaloes exhibited suboptimal weight gain and incurred higher feed

costs under traditional management practices Therefore, a scientific management intervention was undertaken to address the issues of suboptimal growth and high feed cost on evaluation of the general farm management provided to the male buffaloes. Hence it was decided to introduce a feeding plan (Table 2) consisting of TMR. The TMR pellets had balanced nutritional composition (Table 1) as that of grade lll cattle feed as per BIS standard (BIS. 2009). This feed was much cheaper than the earlier feed that was provided to the buffaloes by the farmer. The mineral mixture was also replaced by a cheaper alternative. Body weight estimations were performed using morphometric measurements. Live body weight was calculated using Shaeffer's formula for buffaloes: $W = (L \times G^2) / 660$, where *W* is the estimated live body weight in kilograms, *L* is the body length (from the point of the shoulder to the pin bone) in inches, and *G* is the chest girth in inches. Baseline body weights (day 0) were recorded before the feeding intervention, and post-intervention weights were measured on day 60 because the experiment was carried out for a period of 60 days. Average daily gain (ADG) was calculated using the formula: ADG = (Final Weight − Initial Weight) / Number of Days.

Statistical analysis: To enhance the robustness of the statistical analysis, data points indicating weight gains exceeding 100 kg over 60 days were excluded as outliers. This refinement yielded a final dataset comprising 24 animals. hence, Descriptive statistics, including means for initial and final body weights, were computed. A paired *t*-test was conducted to evaluate the significance of weight change pre- and post-intervention.

Table 1. TMR Pellet nutritional composition Gr**ade lll as per BIS standard**

Nutrient	Specification
Moisture	11% max
Crude Protein (CP)	18% min
Crude Fat	2.0% min
Crude Fiber	15% min
Acid Insoluble Ash (AIA)	5% max
Total Digestible Nutrients (TDN)	70% min

Table 2. Feeding schedule adopted (for a 150 kg Buffalo)

Feed given initially			Feeding given during study period		
Item	**Quantity fed per day (Kg)**	**Rate/kg (Rs.)**	**Item**	**Quantity fed per day (Kg)**	**Rate/kg (Rs.)**
Commercial feed	1.00	27.00	TMR pellets	1.5	25.00
Tamarind Seed (boiled)	0.175	33.80	Mineral Mixture	0.025	110.00
Wheat Bran	0.25	25.80			
Rice Bran	0.25	19.40			
Mineral Mixture	0.025	168.00			
Cost of feed (Rs.) per day	48.42		37.75		
Savings (Rs.)			10.67		
Savings (%)			22.04		

3. RESULTS AND DISCUSSION

Table 3 presents individual-level data on initial and final body weights, weight gain, and average daily gain (ADG). The mean initial body weight was 181.92 ± 9.81 kg (Mean ± SE), which increased to 202.28 ± 8.32 kg post-intervention, resulting in an average weight gain of 20.36 ± 6.85 kg. The corresponding ADG was calculated at 0.34 kg/day.

Table 3. Body Weight and Average Daily Gain (ADG) of buffaloes before and after feeding intervention

S. No.	Initial Weight (kg)	Final Weight (kg)	Weight Gain (kg)	ADG (kg/day)
1.	191.99	185.56	-6.43	-0.107
2.	250.44	266.86	16.42	0.274
3.	238.79	262.46	23.67	0.394
4.	238.79	250.44	11.65	0.194
5.	153.22	190.06	36.84	0.614
6.	236.79	262.46	25.67	0.428
7.	236.79	234.55	-2.24	-0.037
8.	152.79	240.0	87.21	1.453
9.	171.05	196.91	25.86	0.431
10.	123.07	185.31	62.24	1.037
11.	147.49	153.22	5.73	0.096
12.	187.06	236.79	49.73	0.829
13.	98.52	155.66	57.14	0.952
14.	153.22	148.0	-5.22	-0.087
15.	113.64	161.73	48.09	0.802
16.	281.67	244.0	-37.67	-0.628
17.	110.45	153.7	43.25	0.721
18.	175.81	149.15	-26.66	-0.444
19.	187.06	236.79	49.73	0.829
20.	211.68	176.73	-34.95	-0.582
21.	152.67	204.32	51.65	0.861
22.	180.56	201.83	21.27	0.354
23.	180.56	201.83	21.27	0.354
24.	191.99	156.43	-35.56	-0.593

Table 4. Effect of Experimental Treatment on Body Weight and Average Daily Gain (Paired t-test analysis)

Parameter	Value
Average Initial Weight (Mean ± SE)	181.92 ± 9.81 kg
Average Final Weight (Mean ± SE)	202.28 ± 8.32 kg
Average Weight Gain (Mean ± SE)	20.36 ± 6.85 kg
Average Daily Gain (ADG)	0.34 kg/day
Paired t-test Statistic	2.974
p-value	0.0068

Statistical analysis using a paired *t*-test revealed a significant increase in body weight following the feeding intervention (t = 2.974, p = 0.0068), indicating that the standardized feeding plan had a positive impact on growth performance (Table 4). Notably, this improvement remained statistically significant ($p < 0.01$) even after the exclusion of outlier data, enhancing the robustness and biological credibility of the findings. The observed ADG of 0.34 kg/day aligned well with expected values for Murrah crossbred buffaloes managed under semi-intensive systems, reinforcing the practical relevance and feasibility of the feeding strategy.

Numerous studies have underscored the benefits of science-based feeding strategies in improving buffalo growth and production efficiency. For instance, Azmi *et al*. (2021) demonstrated that supplementation and improved management practices, such as early weaning and quality feeding, significantly enhanced growth and metabolic development in buffalo calves. Similarly, Murrah crossbred buffaloes have consistently outperformed Swamp and Bhadawari buffaloes in terms of weight gain and feed conversion efficiency, yielding higher profitability and nutrient utilisation under improved nutritional planes (Das *et al*., 2009).

Despite the clear advantages of standardised feeding protocols, their adoption at the field level remains limited in smallholder buffalo meat

production systems. Constraints include inadequate farmer awareness, poor access to quality feed, insufficient advisory services, and economic barriers that discourage investment in scientifically balanced nutrition. For instance, in the present study, the baseline feeding practice employed by the farmer was not based on scientific recommendations. Additionally, a lack of knowledge regarding formulated rations such as TMR as evident, as no farmers in the study area were familiar with the concept. Previous research by Tipu *et al*. (2021) showed that a TMR containing 12% crude protein (CP) yielded the highest daily weight gain (0.93 kg) and feed efficiency (7.90 kg/kg gain) in Nili Ravi buffalo calves. In contrast, the present study employed a TMR with 18% CP, yet baseline knowledge of such feeds was lacking among farmers. This gap highlights the need for localised demonstration models and targeted extension services. Furthermore, inconsistent feed supply chains, limited veterinary infrastructure, and the absence of performance monitoring mechanisms continue to impede effective implementation. The benefits of improved housing and feeding strategies have also been validated in previous works. For instance, Kumar et al. (2018) reported that Murrah buffalo calves reared in loose housing systems with ICAR- feeding standard exhibited higher ADG and better cost-efficiency in hot-humid climates than those housed in conventional barns. Likewise, Jha et al. (2021) demonstrated that feeding male buffalo calves with formulated rations led to a substantial improvement in ADG (803 g/day) and economic returns (₹20,230), while in this study, total feed cost was reduced by 22.04% compared to traditional practices. These findings align with the present study, which observed a statistically significant improvement in body weight and an ADG of 0.34 kg/day following the implementation of a standardised feeding intervention. Although the observed ADG in this study may appear modest compared to some controlled experimental settings, it remains biologically plausible and well within the expected range for Murrah crossbred buffaloes under semi-intensive systems. For context, Naveena and Kiran (2014) reported that buffaloes gain approximately 0.85 kg/day during their first year, which declined to 0.66 kg/day by the second year. Similarly, Mahmoudzadeh (2007) found that the ADG in buffalo male calves ranged between 503 and 951 g/day, depending on the diet. Under controlled conditions in Kerala, Pramod et al. (2018) reported an ADG of 0.595 kg/day in young Murrah bulls, indicating the performance ceiling under ideal management. The exclusion of outlier data points (those showing over 100 kg weight gain in 60 days) was methodologically justified to ensure biological plausibility and statistical robustness. Such anomalies likely resulted from measurement errors or mis recorded data, given that they far exceed realistic expectations for the breed over a two-month period. Overall, this study reinforces the value of science-based, standardised feeding regimens in enhancing production efficiency in meat-purpose buffaloes, especially within smallholder systems. The significant improvements in growth performance observed over a short intervention period highlight the potential for wider field-level adoption of such practices. Additionally, the study underscores the importance of performance monitoring and data-driven adjustments to feeding strategies. Future research should explore extended intervention periods and assess feed conversion ratios, carcass quality, and cost-benefit metrics to provide a more comprehensive understanding of the long-term economic and production impacts of standardised feeding in buffalo farming.

4. CONCLUSION

This study highlighted the tangible benefits of implementing a scientific feeding plan in smallholder male buffalo rearing system in Kerala. The improvement in average daily gain (ADG) and overall body weight over a 60-day period affirmed the potential of adopting evidence-based nutritional strategies, even in resource-limited field settings. Despite the modest intervention duration and sample size, the results reinforced the premise that targeted nutritional improvements can yield measurable growth performance gains in Murrah crossbred buffaloes. Crucially, the study also exposed systemic barriers, such as limited farmer awareness, lack of exposure to total mixed rations (TMR), and infrastructural gaps, that inhibit the widespread adoption of best feeding practices. Addressing these bottlenecks through field-level demonstrations, localised advisory support, and policy-driven extension services could bridge the science-practice divide. Moving forward, integrated research focusing on feed conversion efficiency, carcass quality, and return-on-investment metrics will be essential to scale up such interventions and ensure sustainable

profitability for smallholder buffalo meat producers in India.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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