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RESEARCH ARTICLE

The Effect of Early Weaning on Performance, Health Parameters, and Carcass Traits of Bonsmara Bull Calves Under Feedlot Conditions

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Abstract: A feedlot is an intensive farming system used for finishing livestock. This study analyzed the performance, health, and carcass traits of Early-Weaned Calves (EWC) and Traditionally-Weaned Calves (TWC). A total of 285 Bonsmara bull calves were grouped into two weaning strategies, with 136 EWC (255±27.30 kg) and 149 TWC (308±24.60 kg). Backgrounding was followed by a finishing phase, with a grower-adaptation and finisher ration provided *ad libitum* at 3% body weight. Performance traits evaluated included Initial Body Weight (IBW), End Body Weight (EBW), Dry Matter Intake (DMI), Average Daily Gain (ADG), and Feed Conversion Ratio (FCR), while health parameters focused on morbidity, mortality, and case fatality rates. Carcass traits, including Hot Carcass Weight (HCW), Cold Carcass Weight (CCW), Dressing Percentage (DP), Chilling Loss (CL), Carcass Grades (CG), Carcass Conformation (CC), and Marbling Score (MS), were assessed. The IBW and EBW of EWC were lower ($P<0.001$) by 54 kg and 69 kg, respectively, compared to TWC. Weaning treatment significantly ($P<0.05$) affected the overall ADG and FCR without impacting DMI ($P>0.05$). The TWC had 7.23% greater ADG and 5.08% lower FCR than EWC. The TWC exhibited higher total morbidity, mortality, and case fatality rates by 0.83%, 0.67%, and 10% than EWC, respectively. Although TWC had heavier carcasses than EWC ($P<0.05$; 328.41 vs. 285.89), no significant differences ($P>0.05$) were noted in other carcass traits. Weaning treatment influenced BW, carcass weights, ADG, and FCR without impacting DMI and carcass traits assessed in this study.

Keywords: Weaning Treatment, Intensive Beef Production, Production Parameters, Morbidity and Mortality, Slaughtering

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Introduction

In southern Africa, production systems are heavily impacted by environmental and economic factors, leading to transitions from extensive pasture-based systems to more intensive, concentrate-based finishing systems before market [1]. South Africa's beef production exhibits a dual structure, comprising a well-established, commercialized formal sector alongside a

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developing, informal sector [2]. Feedlots acquire young, weaned calves from grazing systems, while beef cattle farmers tend to focus on increasing their herds through a larger number of cows and calves raised on pasture or natural grazing [3]. The weaned calves, typically weighing between 160 and 190 kg, are primarily kept in a backgrounding phase to prepare them for the finishing phase [4]. According to [5], about 70% of weaned calves are sold to feedlots to be fattened to reach the slaughter weights of 400 to 450 kg, which yields carcasses weighing about 220 to 250 kg.

A feedlot is defined as a confined area with water and feeding facilities where livestock are completely hand-fed or mechanically fed to consistently produce fresh quality meat. The animals produced are well-fleshed, lean, and exhibit good conformation [6]. Implementing Early Weaning (EW) practices has demonstrated benefits such as enhanced feed efficiency, improved marbling, and better carcass quality at slaughter [7, 8]. The EW steers placed on an accelerated finishing program in the feedlot can reach market weight at less than a year of age, allowing calves born in spring to be sold the following year when cattle prices are typically high [7]. Because EW steers are usually given a high-grain diet for an extended period, they produce high-quality carcasses [7].

The early weaning practice may result in lower calf value at weaning compared to calves weaned conventionally [9, 10]. This practice is normally implemented to reduce the nutrient requirements of the cows when the quality of pasture declines [11]. The health of early weaned calves is of critical concern since many beef producers expressed their dissatisfaction, and it is widely acknowledged that these calves tend to underperform relative to those weaned conventionally [7]. They began finishing on a high energy ration, younger, and progressed to slaughter at lower live weights than their conventionally weaned calves. The authors noted that there is sparse information available in South Africa regarding the outcomes of early weaning or light-weight beef calves in feedlot environments. Consequently, it is essential to evaluate the impact on animals managed concurrently, entering and completing the feedlot phase simultaneously, and fed comparable diets following the weaning stage.

It was hypothesized that 1) Even though TWC will show better health parameters in a backgrounding program, high respiratory morbidities and mortalities can be expected in the early stage of the finishing phase, and that 2) There will be no significant difference in the finishing phase on the performance traits, and EWC will have better carcass traits than the TWC group. This study aimed to assess various performance traits, including dry matter intake, average daily gain, and feed conversion ratio, as well as health parameters such as morbidity, mortality, and case fatality rates between the EWC and TWC groups. Additionally, it also evaluated carcass traits, including hot and carcass weights, dressing percentage, chilling loss, quality grading, carcass conformation, and marbling score under feedlot conditions.

Materials and Methods

Ethical Approval

Veterinary surgeons at Sparta Feedlot played a central role in upholding all ethical and animal welfare standards throughout the trial. Their responsibilities included designing and overseeing preventive health, vaccination, and biosecurity programs; continuously monitoring animal health and welfare; promptly diagnosing and treating disease or injury; and supervising all veterinary interventions in accordance with South African regulatory requirements. Comprehensive health records were maintained through the feedlot's electronic identification and traceability systems, ensuring compliance with treatment protocols and withdrawal periods for food safety. Veterinarians also worked closely with feedlot management and nutritionists to minimize health risks associated with feeding and management practices. Collectively, these measures ensured that the study was conducted under strict veterinary supervision, with due regard for animal welfare, ethical research conduct, and industry best practice.

Description of the Study Area

Finishing Phase

The trial for the finishing phase was carried out at Sparta Baby Beef feedlot, located 15 kilometres North of Marquard at coordinates -28.5811831 S; 27.4862413 E and elevation of 1492 meters above sea level, receiving annual rainfall of 357mm. The average summer temperature ranges from 16.2 to 28.50°C, while winter temperatures vary from 4 to 17°C [12]. This area is situated in the eastern Free State, within the Thabo Mofutsanyane District, under the Setsoto local municipality. With a stocking rate of around 120,000 cattle per season, this feedlot is among the largest in South Africa. To mitigate the dust in the feedlot environment, all pens were watered daily, particularly during the dry season [13].

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Abattoir

The animals were transported to Sparta Foods abattoir in Welkom at coordinates -27.991077 S; 26.768838 E, located in the Lejweleputswa District under the Matjhabeng municipality. This area is situated at an elevation of 1339.70 m, with annual high temperatures reaching 26.20°C and low temperatures at 13.30°C [14], along with an annual rainfall of 577 mm [15].

Animal Management and Treatments

Feedlot Processing

The same receiving protocols [16, 17] and processing protocols [18] used in the backgrounding program were applied in the finishing program. All animals in the study received a subcutaneous injection of 2ml per head of Bovishield Gold One Shot (Zoetis, South Africa) to protect against bovine respiratory syncytial virus (Mannheimia/ Pasteurella) haemolytica, infectious bovine rhinotracheitis (bovine herpes virus-1), bovine viral diarrhea (bovine viral diarrhea virus), parainfluenza-3 (bovine parainfluenza-3 virus) and a 5ml per head of 7-way clostridial vaccine (Multiclos; MSD, Animal Health, South Africa). During the processing, calves were also vaccinated against botulism and anthrax (Botulax Intervet SA, Edenvale, South Africa), lumpy skin disease (Lumpyvax: MSD, Animal Health, Intervet - South Africa). For external parasite control, Atilla (Comvet Animal Health – Johannesburg, South Africa) was used. Animals were implanted with a growth enhancer containing 200 mg of trenbolone acetate and 20 mg of ß-oestradiol (Revalor® H; MSD, Animal Health, Intervet - South Africa) behind the left ear. Calves with a rectal temperature exceeding 37.40°C were marked with paint on their abdominal side and treated for respiratory diseases with macrolides (Draxxin-tulathromycin, Zoetis, South Africa) at a 1 ml per 40 kg dose being administered subcutaneously. This was based on the early detection ranch treatment protocol recommended by the veterinary consultant. Additionally, animals were tagged with a purple plain tag, a colored identification tag, and a high-frequency electronic tag.

Experimental Animals and Sample Sizes

A total of two hundred and eighty-five (285) Bonsmara bull calves were transported 60 km from the Alma Sparta backgrounding farm in Clocolan to the Sparta Baby Beef feedlot in Marquard for the finishing phase. Shipping entailed loading calves separately into three double-axle trucks according to each group, which is in line with that of [19]. The finishing phase trial was conducted from late-November 2023 to late-March 2024, and each group was allocated to pens for a period of 123 days. Post backgrounding program, the Initial Body Weight (IBW) of the EWC (n = 136) group was 255±27.30 kg while the IBW of the TWC group (n = 150) was 308±23.60 kg (SEM = 3.31).

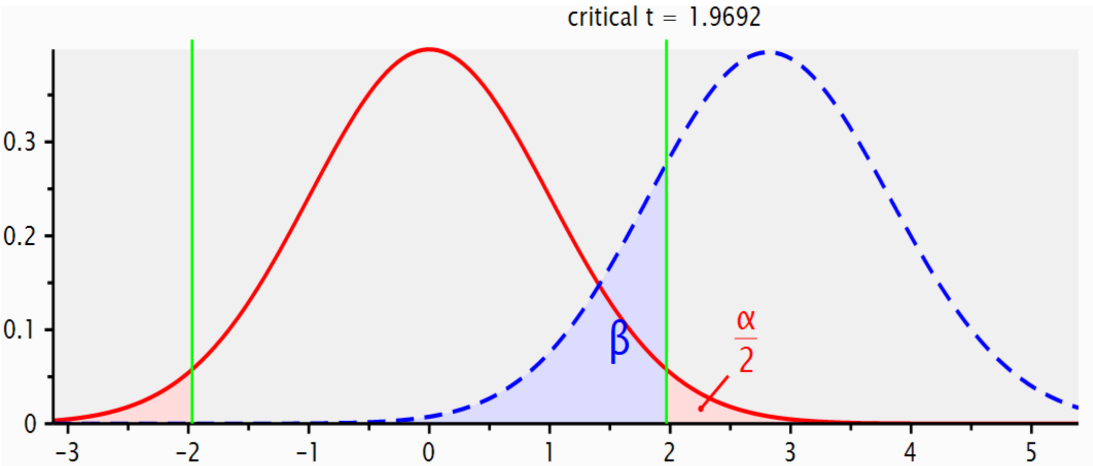

Fig. 1: G*power analysis for statistical power, critical t-value, and sample size

A previous study evaluating Dry Matter Intake (DMI) of different distillers' grains in early-weaned beef calves was used to estimate the expected effect size [20]. An a priori power analysis was conducted using G*Power software (GPowerWin 3.1.9.7), assuming an effect size of 0.35, a significance level (α) of 0.05, and a desired statistical power of 0.80. The analysis indicated that a minimum of 130 steers per treatment group was required to detect a biologically meaningful difference, corresponding to a critical t-value of 1.97. This resulted in a required total sample size of 260 calves. To account for potential losses due to morbidity, mortality, or removal of animals during the finishing phase, additional calves were included, resulting in a final study population of 285 calves. This sample size is consistent with comparable studies in the literature, such as those of [17] and [20], who used sample sizes of 239 and 250 calves, respectively.

Feed Management

Both groups were fed grower ration (Table 1) ad libitum for a period of seven (7) days and spent the remaining days on finisher ration (Table 2) ad libitum. The grower ration diet contained 42:58 forage to concentrate, 11.83% Crude Protein (CP), and 1.27 Mcal per kg NE_m. At the same time, finisher ration contained 23:77 forage to concentrate, 10.65% CP, and 0.96 Mcal per kg NE_m. The diet was formulated based on [21-24] to achieve 1.44 Mcal NE_m per kg, 13% CP, and minimum recommended levels of minerals and vitamins. The expected average daily feed intake was 12 kg with an average daily gain target of 1 kg per calf. The mixing of diets and loading procedures is in line with that outlined by [25]. The feed bunk management was based on the slick-bunk management system [25, 26]. Feed quantities were adjusted each morning before feeding based on the feed bunk scores [27]. The floor space ranged from 9 m^2 per small animal to 14 m^2 per larger animal, while the feed trough spacing was 220 mm per animal at ad libitum feeding. Clean water was supplied continually through cement water troughs with run-through flow.

Table 1: The composition and nutritive value of the grower ration fed in the finishing phase

Ingredients	Grams/head/day	Percentages (%)
Hominy chop	2200	33.85
Sunflower oilcake	500	7.69
Corn silage	2700	41.54
Bran	450	6.92
Molasses	190	2.92
Mineral Premix	*460*	7.08
Total Mixed Ration	*6500*	100
Mineral Premix content		
Premix chop	85.25	18.53
Salt	180	39.13
Lime	120	26.09
Urea	70	15.22
SM44 – Compound	1.85	0.40
Grower Premix	3	0.65
Total Mineral Premix Content	460	100

Moisture = 21.53%; Crude Protein = 11.83%; ADF = 4.56%; NDF = 18.37%; ADL = 1.05. The Energy content expressed in Mcal/kg: TDN = 48.40 DM%; ME 7.28 Mcal/kg; NE_M = 1.18 Mcal/kg; NE_g = 0.80 Mcal/kg. Protein = 9.38%; Fat = 3.39%; Fibre = 6.37%; Ash = 3.61%; Calcium = 0.74%; Phosphorus = 0.32%

Health Management

Throughout the finishing period, groups were checked daily and treated for various diseases by experienced personnel, especially in the first to fourth week after arrival [19]. Any calf that was determined to be critically ill was separated and examined further by pen riders [19]. Various antibiotics were used throughout the finishing phase, including: Amphenicol (Nuflor – florfenicol, MSD, Animal Health, South Africa) at 4 ml per 45 kg, Beta-lactam (Excenel – ceftiofur, Zoetis, South Africa) at 1 ml per 50 kg, Beta-lactam (Excede – ceftiofur, Zoetis, South Africa) at 1ml per 30 kg, Sulphonamide (Reverin LA – tetracycline and (Cevamac 1% Injectable solution, Ceva, Animal Health, South Africa), at 1 ml per 50 kg for internal parasites and some of the external parasites.

Re-Implant and Marketing

On day 58, calves were weighed and re-implanted with a growth implant containing 200 mg of trenbolone acetate and 20 mg of oestradiol -17 ß (Revalor-H; Intervet SA) [28]. On the 26th day after re-implanting, both groups were introduced to a supplemented ration of Zilmax, which was the last phase before marketing, and this ration included Zilpaterol Hydrochloride (ZH) (see Table 2) [29]. The market readiness was checked by visual appraisal, while medicine withdrawal dates were checked in the Microsoft Dynamics Navision (NAV software) system before they were loaded on the truck. At the end of the feeding period, the TWC group was loaded onto the trucks first and the EWC group after.

Table 2: The composition and nutritive value of the finisher ration fed in the finishing phase

Ingredients	Grams/head/day	Percentages (%)
Milled Maize	3235	26.96
Hominy Chop	4936	41.13
Sunflower oilcake	228	1.90
Corn silage	2504	20.87
Bran	204	1.70
Molasses	243	2.03
Wheat straw	240	2.00
Mineral Premix	*410*	3.42
Total	*12 000*	100
Mineral Premix content		
Premix	4	0.98
Salt	92	33.17
Lime	169	41.22
Urea	92	22.44
Availa zn	3	0.73
Monensin	2	0.49
SM44 – Compound	1.85	0.45
Zilmax*	0.085	0.42
Total Mineral Premix content	410	3.42

Moisture = 24.66%; Crude Protein = 10.65%; ADF = 7.57%; NDF = 18.19%; ADL = 2.85%; Starch = 29.86%; Fat = 4.09%; The Energy content expressed in Mcal/kg: TDN = 80 DM%; ME 1.41 Mcal/kg; NE_M = 0.96 Mcal/kg; NEg = 0.66 Mcal/kg. Mineral Premix is a total of portion supplement*; Zilmax ration*: Zilpaterol hydrochloride supplemented ration transitioned on the last 40 days before marketing

Collection of Performance Traits

The calf body weight was measured individually with a Silencer hydraulic chute with scale calibrated at 280 kg of certified weights before use [25] during days 0, 58th, and 123rd. Diets were loaded on the Ital-feeder wagon (that can load up to 8t feed) mounted with a scale during daily feeding operations. The feed delivery was based on the quantity of residual feed from the previous day's offering to allow monitoring of daily consumption [16, 30]. The Average Daily Feed Intake (ADFI) was recorded daily throughout the finishing phase. Based on the system data, Dry Matter Intake (DMI) was calculated by adjusting as-fed intake to diet Dry Matter (DM) content [25]. The DM analysis of the concentrate ingredients was conducted each time a new batch of concentrate was prepared. The Average Daily Gain (ADG) was calculated by subtracting IBW from EBW and dividing by the number of days during each interval in the finishing program. The Feed Conversion Ratio (FCR) during the finishing period was calculated by dividing ADG by DMI (DMI/ADG) (see Table 3) [31-33].

Collection of Health Data

The morbidity, mortality, and the Case Fatality Rate (CFR) were recorded and determined during the finishing phase (see Table 3). The number of processing morbidities, and mortalities in the finishing phase was recorded daily along with their identification tags, diagnoses, and quantity of medication used. Table 4 presents how the morbidity, mortality, and case fatality rates were determined. The diagnosis was based on the visual detection of clinical signs such as nasal discharges, dry or wet muzzle, depression, fever, and poor condition of the calf [34, 35]. The incidence of digestive disorders such as bloat and acidosis (acute and chronic incidence) in the feedlot was also monitored [36]. The following formulas in Table 3 were used to determine the production traits and health parameters in the finishing phase.

Table 3: Presentation of formulas for determining the production traits and health parameters

Parameters	Formula
Production traits	
Average IBW	Total IBW/ number of animals in the group (*n*)
Average EBW	Total EBW / number of animals in the group (*n*)
ADG	(EBW – IBW) / Total number of days in program
ADFI (AS IS)	Total fed/ quantity of animals in group
DMI	ADFI - Moisture%
FCR	DMI / ADG
Health parameters	
Processing Morbidity %	Quantity treated/ Quantity in group x 100
Respiratory morbidity %	Quantity treated for respiratory infections/Quantity in group x 100
Tick-borne diseases %	Quantity treated/ Quantity in group x 100
Feedlot relapse %	Quantity relapsed/ Total treatments x 100
Overall morbidity %	Total treatments/ Quantity in group x 100
Mortality %	Quantity of deaths/ Quantity in group x 100
Case fatality rate %	Quantity of death/ Quantity of treatments x 100
Carcass traits	
CCW	HCW – 3%
CL	(HCW – CCW) / HCW x 100
DP	HCW/ EBW x 100

Slaughtering and Carcass Evaluation

On day 124 in the finishing phase, all steers were checked for withdrawal of medication before being shipped to the abattoir. The animals were harvested within 1 day at the slaughterhouse, which is located 110 km from the feedlot facilities. These animals were weighed individually before slaughtering and after exsanguination in order to obtain pre-slaughter Body Weight (BW) and Hot Carcass Weight (HCW), respectively. Animals were stunned using a captive bolt and then bled from the jugular vein according to the commercial abattoir practices. Fig. 2 shows the slaughtering procedure. The head, tail, lower legs, hide, and all internal organs were removed before splitting the carcass into two halves along the spinal column [37]. The animal identification, packer sequence, carcass class, and Hot Carcass Weight (HCW) were recorded before the carcass was dissected into right and left portions (see Fig. 3; [20]. The Dressing Percentage (DP) was calculated by dividing HCW by EBW times 100, while Cold Carcass Weight (CCW) was determined at 3% of the HCW [38, 39]. Fig. 3 presents hanged carcasses in a chilling room. The Chilling Loss (CL) percentage was calculated by deducting CCW from HCW, dividing by HCW times 100 (see Table 4).

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Fig. 2: Slaughtering procedures from stunning to hide removal: (A) Stunning and hanging of animal, (B) Cutting the throat, (C) Removal of head, (D) Hide removal and opening of animal

Table 4: South African Carcass Classification System Source: [49]

Trait	**Beef/Sheep/Mutton**						
Age	A		AB	B		C	
Permanent incisors (#)	0		1-2	3-6		>6	
Roller mark	AAA		ABAB	BBB		CCC	
Colour	Purple		Green	Brown		Red	
Tenderness	Most tender		Tender	Less tender		Least tender	
Fat grade	0	1	2	3	4	5	6
Beef (fat thickness mm)	0	<1	>1<3	>3<5	>5<7	>7<10	>10
Sheep (fat thickness mm)	0	<1	>1<4	>4<7	>7<9	>9<11	>11
Conformation				Class			
Very flat				1			
Flat				2			
Medium				3			
Round				4			
Very round				5			
Damage				Class			
Slight				1			
Moderate				2			
Severe				3			

Source: [49]

After 48 h chilling at 4°C, the Ribeye Area (REA) was exposed by cutting between the 6th and 7th rib (Fig. 3) [40]. The Marbling Scores (MS) were evaluated based on the score cards methodology [41] as described by [42] and [43]. Because the marbling scores were not provided on close-out sheets, through observation, it was concluded that MS were rated 10 (21%) on the MS cards. The slaughter age and weight are positively correlated to Intra-Muscular Fat (IMF) [44-48]. The AUS-MEAT marbling score ranged from 0 (0%) to 9 (21%) (Fig. 4). The Carcass Conformation (CC) was visually observed and scored which ranges from 1 (very flat) to 5 (very round) and the quality grade (A, AB, B, C) were determined by using South African carcass classification system (see Table 4) [49].

Statistical Analysis

Data was recorded, and the initial calculations were done using Microsoft Excel, while the observations with the missing weights or biologically impossible weights were removed from the database. The data collected for animal performance throughout the finishing phase were analyzed using the Statistical Analysis Software [51] version 9.4 (SAS Institute Inc., Cary, NC). All the collected data were tested for normality using Shapiro–Wilk's test before analysis. The Student T-test was used for analysis of variance between two weaning strategies in performance traits, health parameters, and carcass traits. The significance levels were observed at P<0.05.

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Fig. 3: Carcasses in a chilling room are being cut between the 6th and 7th ribs

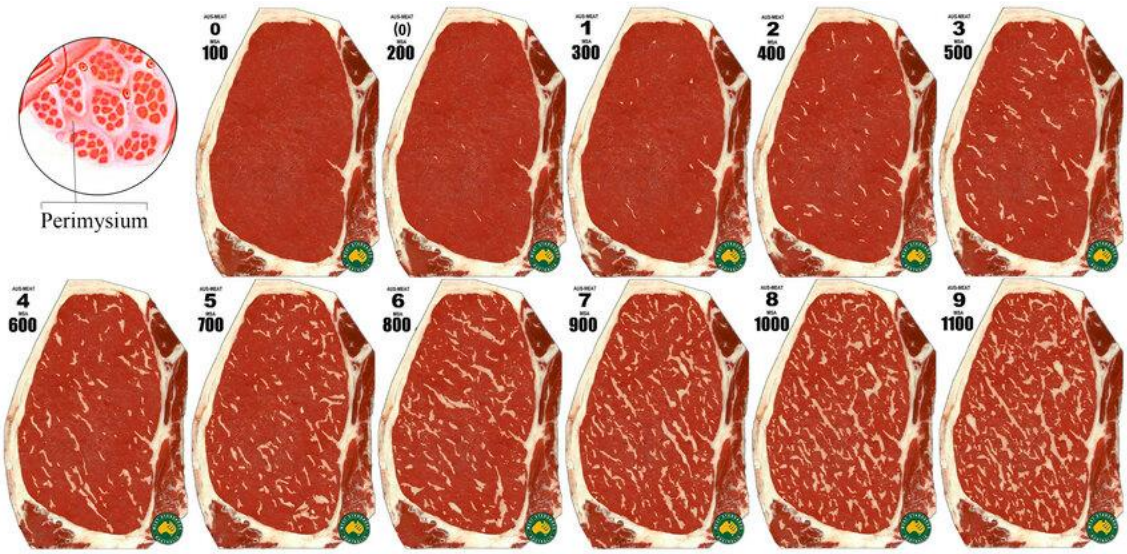

Fig. 4: The AUS-MEAT marbling score standards are being measured from 0 (least) to 9 (most) (Adapted from [41], [50]

For health data, such as morbidity, mortality, and case fatality rates in treatment groups, were presented as a percentage and were calculated by adding the total number of treatments per group divided by the total number of animals per group times 100 in the finishing phase [52-55].

Results

EWC or lighter calves benefit the cow-calf producers by reducing the nutritional requirements of the cows and restoring the body condition of the cows for the next breeding season. What benefits are there for feedlot operators in finishing EWC? Table 5 presents the number of measurements analyzed, raw means, and standard deviations for production efficiency. Table 6 presents morbidities, mortalities, and case fatality rates, while Table 7 presents the carcass traits of the two groups.

Performance Parameters

Initial and End Body Weights

There was a significant difference ($P<0.05$) in the Initial Body Weight (IBW), Re-Implant Body Weight (RIBW), and the Final Body Weight (FBW) between the groups. The EWC group was 54 kg (SEM = 3.31), 52 kg (SEM = 4.84), and 69 kg (SEM = 6.04) lighter than TWC on IBW, RIBW, and FBW, respectively (Table 5). From the IBW to RIBW and from RIBW to FBW, EWC increased by 42.95% and 25.89%, respectively, while TWC increased by 35.11% and 26.56%. During the first 58 days of the finishing phase, EWC grew faster than TWC by 7.84%, while growth of the last 65 days in the feedlot slightly differed by 0.67% (EWC = 25.89% and TWC = 26.56%). In terms of the overall feedlot BW, EWC increased by 80.71%, and their growth was 9.61% higher than that of TWC (79.95 vs. 70.99).

Performance Traits

In Table 5, during the first 58 days, there were no significant differences (P>0.05) in the DMI (P = 0.36; SEM = 0.34), ADG (P = 0.69; SEM = 0.05), and the FCR (P = 0.23; SEM = 0.18). During the last 65 days, there was no significant difference observed in DMI (P = 0.45; SEM = 0.16), but ADG and FCR differed significantly (P < 0.05; SEM = 0.06 and SEM = 0.14, respectively) between the two groups. Though statistically there were no significant differences observed during the first 58 days, there was a slight difference in the DMI, ADG, and the FCR between the groups. The DMI and FCR in the EWC group were 3.29% and 4.40%, respectively, lower than those of the TWC group, and surprisingly, the EWC had 1.07% greater ADG than the TWC group. During the last 65 days, the DMI and ADG of the TWC group were higher by 1.23% and 17.24%, respectively, with 15.89% lower FCR than that of EWC. The overall DMI and ADG for TWC were 2.29% (SEM = 0.18) and 7.23% (SEM = 0.04) higher, with 5.08% (SEM = 0.10) lower FCR in the EWC group. From Table 5, the ADG of EWC and TWC decreased by 0.44 kg (30.34%) and 0.17 kg (10%), respectively, from Re-implant ADG to Market ADG. At the same time, the DMI has increased by 0.31 kg and 0.12 kg for EWC and TWC, respectively.

Table 5: The Least Square Means (LSM), Standard Deviations (SD±), and the *P*-values of the production traits in the finishing phase

Performance traits	EWC	TWC	SEM[c]	Cohen's d[d]	P values
Initial BW (kg)	254.86[a] ±27.28	308.47[b] ±24.56	3.31	-0.27	<0.001
*Re-implant BW (kg)	364.32[a] ±41.22	416.76[b] ±33.79	4.82	-1.40	<0.001
*Re-implant ADG (kg)	1.89[a] ±0.38	1.87[a] ± 0.42	0.05	0.05	P = 0.69
*Re-implant DMI (kg)	9.43[a] ±0.98	9.74[a] ± 2.41	0.34	-0.17	P = 0.36
*Re-implant FCR (kg)	5.00[a] ±0.52	5.22[a] ±1.29	0.18	-0.22	P = 0.23
**Market ADG (kg)	1.45[a] ±0.45	1.70[b]±0.44	0.06	-0.56	<0.001
**Market DMI (kg)	9.74[a] ±0.96	9.86[a] ±0.92	0.16	-0.13	P = 0.45
**Market FCR (kg)	6.71[a] ±0.66	5.79[b] ±0.54	0.14	1.52	<0.001
Market BW (kg)	458.63[a] ±52.02	527.45[b] ±41.95	6.04	-1.46	<0.001
BW gain (59 to 123 days) (kg)	94	111			
***Feedlot ADG (kg)	1.66[a] ±0.30	1.78[b] ±0.30	0.04	-0.41	<0.001
***Feedlot DMI (kg)	9.59[a] ±0.98	9.81[a] ±1.77	0.18	-0.18	P = 0.25
***Feedlot FCR (kg)	5.79[a] ±0.59	5.51[b]±1.00	0.10	0.34	<0.001

a, b Within a row, means with different superscript letters differ significantly, P<0.05; cSEM is a standard error of the mean; dCohen's d Trivial = 0.00 – 0.19; Small = 0.20; Medium = 0.50 and Large = 0.80; *Re-implant – from 1 to 58th day; **Market - from implanting to market (from 59 to 123rd day); ***Overall - from 1 to 123rd day in feedlot

Health Parameters

Table 6 presents the quantity and percentages of animal health parameters in the finishing phase. There were no processing morbidities observed or detected during feedlot processing, nor were there any morbidities related to the digestive system during the feedlot operation. During the first 20 days in the feedlot, there were six (6) treatments administered in each trial group (Fig. 5). Fig. 5 also indicates that the EWC group received the last treatment on the 37th day, while the new treatments from the TWC group emerged even after the 47th to 87th day. All the treatments from TWC were administered to newly treated calves, while only 37.5% of EWC were newly treated calves, and the rest were re-treated calves from the backgrounding program. This resulted in a 62.5% feedlot relapse rate in the EWC group (see Table 6). The total respiratory treatments for EWC and TWC were 5.15% and 5.37%, while tick-borne disease morbidity was 0.73% and 1.34%, respectively. However, no digestive-related treatments were observed in this study. The overall morbidity percentage for EWC and TWC was 5.88% and 6.71%, respectively. The morbidity for TWC was 0.83% higher than that of EWC. During the 49th day in the feedlot, one calf died untreated due to acute ruminal acidosis in the TWC group, which resulted in a mortality rate of 0.67% and a case fatality of 10%.

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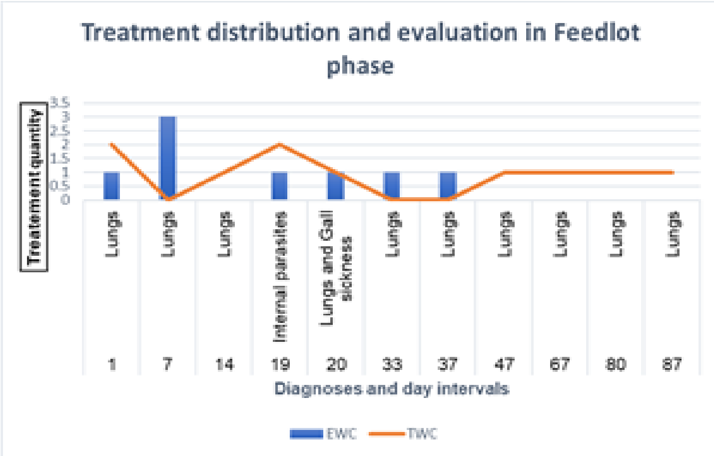

Fig. 5: Treatment distribution and evaluation in the feedlot Treatment not treatment on the y axis

Table 6: The quantity and percentages (%) of animal health parameters in the finishing phase

Health parameters	EWC (%)	TWC (%)
Processing treatments[1]	0	0
Respiratory morbidity[2]	$\left(\frac{7}{136} x\ 100\right)$ = 5.15	$\left(\frac{8}{149} x\ 100\right)$ = 5.37
Tick-borne treatments[3]	$\left(\frac{1}{136} x\ 100\right)$ = 0.73	$\left(\frac{2}{149} x\ 100\right)$ = 1.34
Feedlot relapse[4]	$\left(\frac{5}{8} x\ 100\right)$ = 62.5	0
Overall Morbidities[5]	$\left(\frac{8}{136}\ x\ 100\right)$ = 5.88	$\left(\frac{10}{149}\ x\ 100\right)$ = 6.71
Digestive mortality[6]	0	$\left(\frac{1}{149} x\ 100\right)$ = 0.67
Case fatality rate (%)[7]	0	$\left(\boldsymbol{\frac{1}{10}\ x\ 100}\right)$ = 10

1- Processing treatments respiratory related due to high rectal temperature (>37.40°C)

2- Respiratory-related treatments during the finishing program

3- Tick-borne treatment during finishing program

4- Feedlot retreated calves from backgrounding and feedlot

5- Total morbidities in finishing the program

6- Digestive deaths without treatment

7- Case fatality (amount of deaths/number of treatments times 100) norm < 10% (According to Sparta Veterinary Consultant, [56], personal communication)

Carcass Traits

Most of the carcasses in this study were classified as A2, with a few classified as A3 in both treatment groups. The EWC group included five animals classified as A3, while the TWC group included four animals classified as A3. The TWC group had heavier carcasses (HWC and CCW) when compared to the EWC group ($P < 0.001$; SEM = 4.32 and SEM = 4.19, respectively), but no difference was found on DP, CL, CG, CC, and MS. The results of this study indicated that the carcasses of TWC were 14.87% higher than those of EWC.

Study Limitations

High-frequency tags contain important data such as calf origin, vaccination and treatment data, the initial and latest body weight, and ADG. Some tags are missing and need to be replaced with new tags, which, if there is a discrepancy, can affect the quality of the data and the required quantity of animals per group. Other carcass traits, such as average fat thickness (1 – 6), measurement of Ribeye Area (REA), estimated lean meat yield, internal fat (KPH) %, and yield grade, were not properly recorded as anticipated due to the abattoir system, which may affect the quality of data for the study. The sample size was supposed to be 150 animals per group, but due to a lack of lighter Bonsmara calves, only 136 calves were available and came from the same sources.

Table 7: The carcass traits during slaughtering

Carcass traits	EWC	TWC	[c]SEM	[d]Cohen's d	P *values*
HCW (kg)	285.89[a] ±36.58	328.41[b] ±30.85	4.32	-1.26	<0.001
CCW (kg)	277.31[a] ±35.48	318.56[b] ±29.92	4.19	-1.26	<0.001
CL %	3.00[a] ±1.10	3.00[a] ±0.93	0.13	-1.26	P = 1
Dressing %	62.48[a] ±5.83	62.31[a] ±3.98	0.64	0.03	P = 0.79
Carcass class	1.00[a] ±1.00	1.00[a] ±1.00	0.00	0.00	P = 1
Carcass conformation	5.00[a] ±0.00	5.00[a] ±0.00	0.00	0.00	P = 1
Marbling score	10.00[a] ±0.00	10.00[a] ±0.00	0.00	0.00	P = 1

a, b Within a row, means with different superscript letters differ, P < 0.05; cSEM is a standard error of the mean; dCohen's d Trivial = 0.00 – 0.19; Small = 0.20; Medium = 0.50 and Large = 0.80; Hot Carcass Weight (HCW); Cold Carcass Weight (CCW); Chilling Loss (CL)

Discussion

Body Weights

The results of this study indicated that the EWC group was lighter throughout the finishing phase, which might be an indication that EWC needs extra days in order to finish at heavier weights. These results are similar to those reported by [28], who found that yearling-fed steers were heavier than calf-fed steers from feedlot entry to slaughtering. Should beef producers provide EWC with extra days in the backgrounding program or in the finishing phase?

Performance Traits

In Table 5, the weaning treatment significantly (P < 0.05) affected the overall ADG and FCR, with no significant effect on the overall DMI (P = 0.25). Even though there was no statistical difference observed in the DMI, the TWC group had 2.29% greater DMI than the EWC group.

Similarly, [28] found that yearling steers had greater DMI (1.36 kg per animal; P < 0.001) and ADG (0.13 kg; P = 0.003). Interestingly, the EWC group had lower DMI and FCR, but with greater ADG than TWC during the first 58 days in the feedlot. However, this might be an indication that EWC adapted quickly to the finishing environment and that they have better efficiency than their counterparts. Furthermore, this may be recognized as compensatory growth in the EWC group.

Even though statistically there was no significant difference in DMI, the DMI of the TWC group has been slightly greater from the beginning to the end of the finishing phase. These results are in line with those of [57], who found that early weaned steers had the greatest feed efficiency with the lowest daily DMI intake. Contrastingly, [58] found that the DMI of TW steers decreased (P < 0.05) and increased feed efficiency trend (P < 0.07) from the initiation to re-implantation. However, the TWC group claimed greater ADG and DMI with lower FCR on the last 65 days on finishing, which is an indication of good recovery from the adaptation stress. These results are in line with [59], who found that even though EWC may influence FE in the initial stages, such differences cannot persist in the finishing phase. It was also hypothesized that there wouldn't be a significant difference in the performance traits in the finishing phase.

However, the lack of statistical significance (P < 0.05) on the DMI, ADG, and FCR between the groups during the first 58 days is an indication of EWC's potential to achieve similar production levels as compared to their TWC group counterparts. [59-61] supported the results of this study that the EWC that were placed in the finishing phase at the same age as their contemporaries subjected to conventional weaning possess no differences in feed efficiency or conversions. It must also be clearly stated that the overall growth of the EWC group was 8.96% greater than that of the TWC group, and this might be an indication of their ability to utilize feed more efficiently than their counterparts. The results are also supported by [7]. Contrastingly, [62] and [63] documented improved feed efficiency of TW steers. The study also revealed that there was a corresponding increase in BW, DMI, and FCR with a decrease in ADG from Re-implant to marketing. According to [64], this might be a function of increased BW, and age-to-BW ratio, and/or an increase in rumen volume-to-BW ratio of yearlings [28].

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Health Parameters

Morbidity, Mortality, and Case Fatality Rate

A 0% processing treatment from the two groups in feedlot processing is an indication of healthier calves from the backgrounding program. According to [65], one of the vital roles of backgrounding programs is to improve the health condition of the calves, thereby supplying feedlots with healthier calves.

The EWC group had the highest percentage of relapsed treatment, with a lower percentage of new treatments, while TWC had the highest percentage of new treatments in the finishing phase. The high relapse percentage shown in the EWC group may be an indication of persistent infection or ineffectiveness of antibiotic treatments, while a lower percentage of new pulls indicates that they adapted well in the finishing environment. This lower percentage of pulls is related to the greater ADG observed in EWC during the first 58 days in the feedlot phase. During these 58 days, the BW of the EWC and TWC groups increased by 43% and 35%, respectively. These results are similar to those reported by [66] and [67], who found that increased body weight at placement was associated with lower rates of morbidity and mortality.

[68] found that based on the arrival weight, most of the deaths were associated with bovine respiratory disease, and the mortality rate increased by 20 – 35% for each 100 kg weight decrease in the initial BW of cattle. A high percentage of new treatments in the TWC group is an indication of distress and failure to adapt quickly in the feedlot environment, reintroduction to a stressful environment in already adapted animals. The results align with our hypothesis that even though traditionally weaned calves will show better health parameters in backgrounding, high morbidities and mortalities can be expected in the early stage of the finishing phase, in which Bovine Respiratory Disease (BRD) will be the major cause. In Table 6. The morbidity percentages of 5.88 and 6.71 in the EWC and TWC groups, respectively, and 0.67% mortality in the TWC group, are in line with those of [53], who found 7.05% and 0.64% of morbidity and mortality, respectively.

Another indication of failure adaptation by TWC is one calf that died due to acute ruminal acidosis. According to [36, 69-71], a sudden change in the diet on an intake of a high percentage of carbohydrates, which are easily fermentable by ruminants, initiates the transition of gram-positive to gram-negative bacteria in the rumen, which may lead to acute and chronic acidosis.

The case fatality rate of 10% in the TWC group indicates a good ratio of deaths to treatments. [72] reported a 91% reduction in the overall incidence of respiratory morbidity for EW steers when contrasted against the average of Conventionally Weaned (CW) steers that were either creep-fed or remained unsupplemented before weaning and underwent similar vaccination strategies. These authors also reported a small incidence of digestive morbidity (7%) that did not differ between calves weaned at 90 or 215 days of age. However, the lower incidence of morbidity exhibited by the EWC group may be a function of increased dry matter intake upon arrival at the feedlot, an enhanced immune system, or the combination of the two [73].

From Figure 5, it is evident that most of the treatments appeared during the first 37 days after feedlot arrival. [74] reported that cattle treated within the first 20 days after arrival were more likely to have treatment failures than cattle treated in the first 40 days. The study only evaluated cattle treated up to day 60 and did not specifically evaluate the timing of fatal disease onset. The new treatments observed at a later stage of finishing in this study by heavier calves (Fig. 5) are associated with Acute Interstitial Pneumonia (AIP). According to [18, 75], heavier calves had an increased risk of AIP. However, both AIP and BRD can be misdiagnosed by one another since they have similar clinical symptoms [76, 77].

Carcass Traits

The EWC group finished at a lighter BW than the TWC group, which consequently resulted in lighter carcasses (HCW and CCW) than the TWC group. These results are similar to those of [78] and [59], who found that calves weaned early at 100 to 150 days had lighter carcasses than those weaned conventionally at 200 to 240 days of age, even when slaughtered under similar fat thickness criteria. The results of our study are in contrast with those of [7, 60, 72], who found no differences in hot carcass weight between early-weaned and conventionally weaned calves. However, it is important to highlight that in those studies, EWC (between 70 and 152 days) were fed to high-concentrate supplementation regimes, while in some studies, calves were placed immediately into the finishing phase right after weaning. Therefore, the longer feeding duration with high-concentrate diets before slaughter could have been a determining factor for EWC to achieve similar carcasses to their counterparts.

The DP observed in this study from both groups was 62% and these observations are above norms suggested by [79], Department of Agriculture and Rural [80] that DP of animals which are lean can be up to 60%, and DP found by [38] of 60.08% and 61.61% when they compared ideal weight animals (≥200 kg) and sub-ideal weight (<200 kg), respectively. Most South African feedlots target the production of A2 and A3 carcasses from weaner calves, based on carcass maturity as determined by dentition (0–2 teeth) [81]. In South Africa, only a small proportion (approximately 5–10%) of the carcass classification system is effectively utilised, with the majority of carcasses falling into the A2, A3, AB2, and AB3 classes, while relatively few are classified into other categories [82].

Our study results indicated that carcass weights or weaning weights did not influence the carcass traits such as CL, DP, CG, CC, and MS. Similarly, [83] found that all carcass traits measured in their study were similar, which may be subject to similar growth performance in backgrounding and finishing phases. [84, 85], and [86] observed no Yield Grade (YG) differences between the weaning treatment groups.

[60, 87, 88] supported these results that the differences in Intra-Muscular Fat Deposition (IMF) were eliminated when EW was combined with an extended post-weaning grazing or growing period. [28] submitted that the modest differences in DOF and final BW among the two production systems resulted in no differences in marbling scores. These results were supported by [9, 62, 63, 85, 89, 90, 91], found an increased IMF and MS when EW calves are fed a high-concentrate diet beginning immediately after weaning and continuing through harvest.

Even though the results of the current study did not support the hypothesis that the EWC group will possess better carcass traits than the TWC group, our study results didn't include the Ribeye area (REA), Kidney, Pelvic, And Heart (KPH), and pH of the carcasses, which might have been in favor of the EWC group. Furthermore, the REA was exposed by cutting between the 6th and 7th rib rather than the 12th and 13th rib. So, future research in South Africa needs to be conducted to determine whether early weaning does influence the carcass quality, such as REA, KPH, and pH.

Conclusion and Recommendations

This research trial aimed at determining the effect of early weaning of Bonsmara bull calves on their performance traits, health parameters, and carcass traits. Based on the quantitative analysis, it can be concluded that the EWC group was lighter throughout the finishing phase, resulting in lighter carcasses than the TWC group. However, the weaning treatment influences the BW, ADG, FCR, CW without impacting the DMI, and the carcass traits such as DP, CL, CC, CG, and MS. The EWC group adapted more rapidly in the finishing phase than TWC due to a lower percentage of new treatment and slightly greater ADG during the first 58 days. Based on these conclusions, the farmers should consider finishing TWC due to their heavier BW, which results in heavier carcasses and better performance than EWC calves. The conclusion that the EWC group resulted in a lighter carcass harvest than the TWC implies that more days on feed are required to increase carcass weight during harvest. In order to better understand the implications of these results, future studies could address the effect of finishing length or period of early weaning on the performance and carcass traits under feedlot conditions. More emphasis should be placed on precision feeding, carcass traits such as rib eye area (REA – with standard method of recording marbling scores), Kidney, Pelvic, And Heart (KPH), pH, as there might be a benefit of early weaning thereof.

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Novelty Statement

The findings of the present study demonstrate that weaning strategy influences body weight, and consequently carcass harvest weight, as well as average daily gain and feed conversion ratio, without affecting dry matter intake or other carcass characteristics (carcass length, dressing percentage, carcass conformation, carcass grade, and marbling score). These findings are directly applicable to South African feedlot systems, which predominantly utilize Bonsmara cattle and other locally adapted beef breeds and commonly employ both early and conventional weaning practices. The absence of treatment effects on intake and carcass quality parameters suggests that alternative weaning strategies can be implemented within South African feedlots without compromising carcass classification outcomes, while still influencing growth efficiency and production performance.

Author's Contributions

Kgotso Patrick Matli: Executed all the research trials and contributed to the writing of the manuscript.
Thobela Louis Tyasi: Coordinated the data-analysis and contributed to the writing of the manuscript.
Pieter Fourie: Designed the research plan and organized the study and contributed to the writing of the manuscript.

Ethics

This article is original and has never been published before.

Conflict of Interest

The authors have declared no conflict of interest.

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