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Growth Performance and Hematology of Khao Lamphun Calves with the Implementation of Creep Feeding

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ABSTRACT

The study aimed to evaluate the effect of creep feeding on growth performance and the hematological and biochemical profiles of Khao Lamphun calves. Twenty Khao Lamphun cow-calf pairs were randomly allotted into two treatments: T1, no supplementation of creeping feed (n=10), and T2, with concentrates as creep-feeding (n=10). Production or growth performance was evaluated based on body weight gain (BWG), heart girth (HG), hip height (HH), and body length (BL) throughout the experimentation. By day 120, the final live weight of the creep-fed calves was greater than the non-creep-fed calves, p<0.01). The creep-fed calves also showed a higher average BWG than the non-creep-fed calves. The final body conformation indices, i.e., HG, HH, and BL of the creep-fed calves, were higher than the non-creep-fed p<0.05). The hematological profiles showed no difference in the plasma glucose levels between the two groups. The cholesterol level of the creep-fed calves was higher than the non-creep-fed calves (p<0.05). Similarly, no differences were found in calf's serum biochemical and differential leukocyte profiles between treatment groups. In conclusion, the implementation of creep feeding can lead to improved growth performance and health parameters of Khao Lamphun calves. Therefore, it is recommended as a routine practice to enhance the productivity of Khao Lamphun calves in Thailand and, presumably, in other cattle farms.

***Keywords:** body conformation; creep feeding; growth performance; haematology; Khao Lamphun cattle*

INTRODUCTION

Thailand is situated in a tropical climate zone, which affects the efficacy of livestock production, particularly during the hot season (Sae-tiao *et al*., 2019). The tropical climate in Thailand impacts animal productivity (Thornton *et al*., 2022) and reproductive performances, including young calves and adult cattle (Oke *et al*., 2021), as well as their utilization of nutrients from forage plants (Moyo & Nsahlai, 2021). Thailand's native cattle *Bos indicus (Zebu)*, i.e., Khao Lamphun cattle, exhibit a phenotypic trait such as a prominent dorsal hump, which is a unique and elegant body conformation that dessert to be well-conserved. However, the prevalence of sophisticated farming technologies and automation has reduced the need for Khao Lamphun cattle in conventional agricultural practices. Consequently, the significance of these cattle in the agricultural landscape has diminished. Additionally, Khao Lamphun beef is of high quality, rich in protein, and low in fat, making it suitable for health-conscious consumers (Bunmee *et al*., 2018).

To address the increasing need for higher cattle productivity, farmers are continuously researching solutions to improve the efficiency and performance of such valuable species. The goal is to optimize production processes, increase yields, and maintain sustainable feeding practices. For cattle production systems, early postnatal nutritional control is crucial. It has been shown that modifying nutritional intake during this period of time can have long-term impacts on the physiology and growth of beef cattle (Harvey *et al*., 2021). It has been known that creep feeding is one quick way to provide supplementary solid feed to pre-weaning calves (Nepomuceno *et al*., 2017). It helps to increase body weight or immunological indices, as well as to improve the weaning weight of the calves and pregnancy rates of cows (Santa Cruz *et al*., 2022). The lack of creep feeding can have multiple detrimental impacts on the growth and overall well-being of juvenile animals (Pluske *et al*., 2018). It also can offer supplementary nutrients that may not be adequately provided by the mother's milk alone, particularly during their crucial growth stages (Blavi *et al*., 2021).

Creep-feeding is also a strategy to mitigate these climate-induced challenges, and hence, it is a crucial practice to provide supplemental nutrients to nursing beef calves, either through concentrates or high-quality forages. This supplementation is particularly essential during the early growth stages because the milk produced by lactating beef cows generally supplies only about half of the nutrients required for optimal calf growth, reaching 3 to 4 months of age. Without additional nutrient support, calves may not reach their full growth potential, enabling creep-feeding a critical component to ensure sufficient nutrient supplement during the suckling phase (Lardy & Maddock, 2007). Moreover, creep-feeding also allows calves to have an increased ADG, final weaning weights, and viability (Santa Cruz *et al*., 2022). Creep-feeding has also been reported to positively increase weaning weight, accompanied by the alteration of intestinal health in young pigs (Boston *et al*., 2022).

As mentioned above, creep-feeding provides supplemental feed to nursing calves, allowing them to consume additional and adequate nutrients beyond what is available through maternal milk and forages. Therefore, the objective of this study was to evaluate the effects of creep-feeding on growth performance as well as the hematological and biochemical profiles of Khao Lamphun calves.

MATERIALS AND METHODS

Experimental Animals and Treatments

The study was conducted strictly stipulated based on the standard of animal use for scientific research, supervised by the Animal Conduct Control Committee for Scientific Work, Phayao University (certificate UP-AE61-01-01-002). In total, 20 postpartum Khao Lamphun cow and calf pairs from the Phayao Livestock Research and Breeding Center, Phayao Province, were used in this study in 2019. All animals were randomly divided into two treatment groups as follows. In the control group (T1), no creeping feed was provided to the calves (n=10) of the postpartum cows. In the treatment group (T2), the calves were given with creeping feed (n=10).

Feeding Management

Cows were fed with roughage Ruzi grass (*Brachiaria ruziziensis*) supplemented with concentrates of 1% (by body weight). Calves were approximately 60 days of age at the initiation of the study. In the creep-feeding group (T2), their ration contained 18.43% of crude protein (CP), as shown in Table 1. During the experiment, calves consumed creeping feed about 50 g/head/day from days 0 to 30. From day 30 to 60, their intake increased to 100 g/head/day; by days 120 to 150, they can consume 200 g/head/day. The calves were allowed to enter the creep feed through *ad libitum*.

Study Area

The study was performed at the Phayao Research and Breeding Center, located at the latitude of 19° north and longitude at 99° east. The terrain sits moderately above sea level of 440 m, and the climatic characteristics are an average tropical savannah temperature of 25 °C with an average relative humidity of 73%.

Body Weight and Conformation Measurements

The present study collected all data at the Phayao Animal Research and Breeding Center, Muang Phayao District, Phayao Province. Thailand's native cattle exhibit typical traits of *Bos indicus (Zebu)* were used. In the control group (T1), no creeping feed was provided to female calves (n=5) and male calves (n=5). In the treatment group (T2), male calves (n=5) and female calves (n=5) were all given creeping feed. Calves' body weights (BW) were recorded on the first day of the experiment and every month using a digital scale for the calculation of their average daily gain (ADG) (Iqbal *et al*., 2019). Withers height (WH) was assessed from the base of the forefoot to the highest point of the withers using a measuring stick. The circumference of heart girth (HG) was measured by wrapping a tape around the chest region right behind the elbow. The hip height (HH) was measured from the base of the hindfoot to the hook bone. The body length (BL) was determined as the distance from the point of the shoulder to the point of the rump (Khan *et al*., 2011; Pezhveh *et al*., 2014).

Hematological and Biochemical Analyses

Weekly blood samples were collected from the jugular vein using EDTA-coated and non-EDTA vacutainers to obtain plasma and serum, respectively,

Table 1. Compositions and proximate analyses of creep-feeding ration for Khao Lamphun calves at 60-180 days of age

Ingredients	Creep feed, %
Cassava chips	22
Ground corn	25
Rice bran	10
Full-fat soybean	6
Soybean meal	30
Molasses	4
Premix	0.5
DCP 18	1
Dolomite	1.5
Total	100
Calculated chemical composition (% dry matter basis)	
Dry matter	88.68
Crude protein	18.43
Ether extract	3.94
Nitrogen-free extract	56.02
Crude fiber	3.66
Neutral detergent fiber	12.91
Acid detergent fiber	5.93
Calcium to Phosphorus ratio (Ca : P)	1.59

four hours after the morning feeding. Plasma and serum samples were then divided into aliquots and stored at −20 °C until use, with a maximum storage duration of 7 days.

For hematological and biochemical analyses, blood samples (approximately 10 mL) were collected from the jugular vein of calves into serum tubes containing sodium heparin on the last day of each month before the morning feeding. Hematological investigations were carried out using an automated analyzer, Sysmex XN-550, AL Random Access Hematology Machine (SYSMEX CORPORATION, Japan) (Shah *et al*., 2021). Glucose and total cholesterol concentrations of blood plasma were determined using applicable kits (Jiuqiang Biological Technology Co., Ltd, Beijing, China) and an automated analyzer (HITACHI 7020 Automated Biochemical Analyzer; HITACHI, Tokyo, Japan) (Kim *et al*., 2018).

Experimental Designs and Statistical Analyses

The study utilized an independent samples t-test to determine the differences between two experimental groups, i.e., the treatment group (creep-feeding) and the control group. A total of 20 calves were randomly assigned to each group (10 calves per group). Data were analyzed using R software (version 4.3.2). The t-test was employed to detect whether any differences in growth performance (ADG), body conformation (HG, HH, BL), and blood parameters were significant at the level of $p<0.05$ between the treatment and control groups.

RESULTS

Growth Performance

Our results showed that calf's ADG on the last day of the creep-feeding group was significantly higher ($p<0.05$) than that of the control group. As shown in Table 2, the final body weight of the creep-feeding group was also higher than that of the control group ($p<0.05$). Their body conformation parameters, such as HG, HH, and BL in the creep-feeding group, were significantly higher than in the control group ($p<0.05$; Table 3).

Concentrations of Plasma Metabolites

There was no significant difference between the control and creep feeding groups in terms of the average glucose levels throughout the experimental period from days 30 to 120 (Figure 1A). In contrast, the average cholesterol level from days 30 to 120 revealed a significant difference, with the creep feeding group exhibiting a higher level than the control group, indicated by $p<0.01$, as shown in Figure 1B.

Hematological Profile of Calves

After receiving creeping feed for 30 to 120 days, the calves' hematological parameters, including red cell concentrations Figure 2A, hematocrit (Figure 2B), hemoglobin concentration (Figure 2C), mean corpuscular hemoglobin concentration (Figure 2D), and platelet numbers (Figure 2E), were not significantly different when compared to the control group. The mean corpuscular volume in the group received creep-feeding was higher than that in the control group ($p<0.05$), as shown in Figure 2F. Similarly, the mean corpuscular hemoglobin concentration in the calves with creep-feeding was higher than that in the control group ($p<0.05$), as shown in Figure 2G.

Differential Leukocyte Counts of calves

The percentage of white blood cells (Figure 3A), lymphocytes (Figure 3B), eosinophils (Figure 3C), and basophils (Figure 3D) of calves in the creep feeding group had no significant differences compared to those in the control group. However, the percentage of neutrophils (Figure 3E) and monocytes (Figure 3F) in the control group was higher than in the creep-feeding group.

Table 2. Growth performance of Khao Lamphun calves with or without creep-feeding at the initial (day 0) and day 120 after treatment

Variables	Treatments		SEM	p-value
	Non-creep feeding	Creep-feeding		
Initial live weight (day 0)				
Female (n=10)	51.60±2.70	52.00±7.48	1.67	0.91
Male (n=10)	47.20±3.11	48.00±5.33	1.30	0.78
Average	49.40±3.59	50.00±6.48	1.14	0.80
Final live weight (day 120)				
Female	91.57±9.81^{a}	104.71±8.36^{b}	2.42	< 0.01
Male	87.63±10.74^{a}	101.24±13.91^{b}	2.01	< 0.01
Average	89.16±10.43^{a}	101.91±12.99^{b}	1.57	< 0.01
Average daily gain				
Female	0.36±0.04^{a}	0.43±0.04^{b}	0.01	< 0.01
Male	0.34±0.05^{a}	0.41±0.06^{b}	0.01	< 0.01
Average	0.35±0.05^{a}	0.41±0.06^{b}	0.01	< 0.01
Creep feed efficiency				
Female	-	1.90±0.33	-	-
Male	-	1.80±0.23	-	-
Average	-	1.86±0.23	-	-

Note: ^{a,b}Different superscripts in the same row differ significantly at $p<0.01$. SEM= standard error of the mean.

Table 3. Body conformation of Khao Lamphun calves with or without creep-feeding at the initial (day 0) and day 120 after treatment

Variables	Treatments		SEM	p-value
	Non-creep feeding	Creep feeding		
Initial body conformation (day 0)				
Heart girth (HG, cm)				
Female	59.71±2.23	60.14±2.67	10.50	0.72
Male	61.95±1.64	61.06±1.38	0.21	0.05
Average	62.08±2.16	60.88±1.70	0.22	0.67
Hip height; HH (cm)				
Female	63.00±2.07	63.57±2.69	0.49	0.63
Male	63.22±3.92	62.48±2.51	0.45	0.44
Average	63.13±3.29	62.69±2.55	0.34	0.52
Body length; BL (cm)				
Female	55.78±1.92	57.28±3.35	0.54	0.30
Male	55.27±1.66	55.89±1.47	0.22	0.17
Average	55.47±1.76	56.16±1.99	0.22	0.12
Final body conformation (day 120)				
Heart girth (HG, cm)				
Female	104.71±4.68^{c}	111.57±4.92^{d}	1.24	0.01
Male	104.59±9.06^{c}	110.03±7.24^{d}	1.19	0.02
Average	104.63±7.58^{a}	110.33±6.82^{b}	0.90	< 0.01
Hip height (HH, cm)				
Female	97.57±5.41^{c}	102.00±3.69^{d}	1.49	0.04
Male	99.68±6.15	101.86±5.20	0.80	0.18
Average	98.86±5.89^{c}	101.88±4.90^{d}	0.65	0.02
Body length (BL, cm)				
Female	90.00±5.23^{c}	94.85±4.22^{d}	1.67	0.03
Male	89.40±6.17	92.55±7.39	0.99	0.10
Average	89.63±5.75^{c}	93.00±6.90^{d}	0.77	0.02

Note: ^{a,b}Different superscripts in the same row differ significantly at $p<0.01$; ^{c,d}Different superscripts in the same row differ significantly at $p<0.05$.

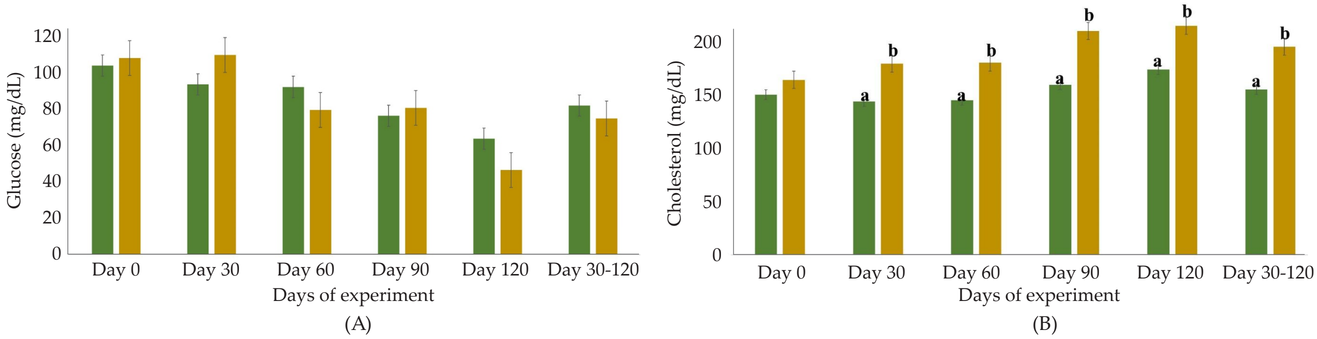

Figure 1. Serum biochemical indices of non-creep feeding (■) and creep-feeding (■) groups in Khao Lamphun calves during days 0-120 after treatment. Blood glucose (A) and cholesterol (B). Different alphabetic letters indicate significant differences ($p<0.05$).

DISCUSSION

This study found a positive impact of creep feeding on the growth performance of Khao Lamphun calves, particularly in the improvement of ADG and immunological parameters. It has a similar trend to previous studies in that creep-feeding improves preweaning weight gain of the calf raising in tropical pastures (Carvalho *et al.*, 2019). Few studies show the native growth performance of calves fed with creeping feed. This suggests that the substitution effect could be related to the amount of nutrients consumed in each calf. After birth, the calf needs a lot of energy and protein to support body growth. However, cow milk can be limited and may not meet the needs of growing calves. Therefore, creep-feeding provides essential energy, protein, vitamins, and minerals for growth (Carvalho *et al.*, 2019). As mentioned above, creep feeding is a valuable management strategy in calf production, especially in the systems prioritized early growth (Catussi *et al.*, 2024), and is economically viable (Santa Cruz *et al.*, 2022). It is reported that Nellore heifers fed with creeping feed supplement during the preweaning phase have shown improved growth (ADG), body weight, and body adiposity compared to the calf in the control group (da Paixão *et al.*, 2023).

In this study, calves in the creep-fed group exhibited superior growth performance primarily due to their increased nutrient intake (Reed *et al.*, 2006). The diet provided to the creep-supplemented group contained 18.43% crude protein (CP) and sufficient metabolizable energy (ME) as in the recommended

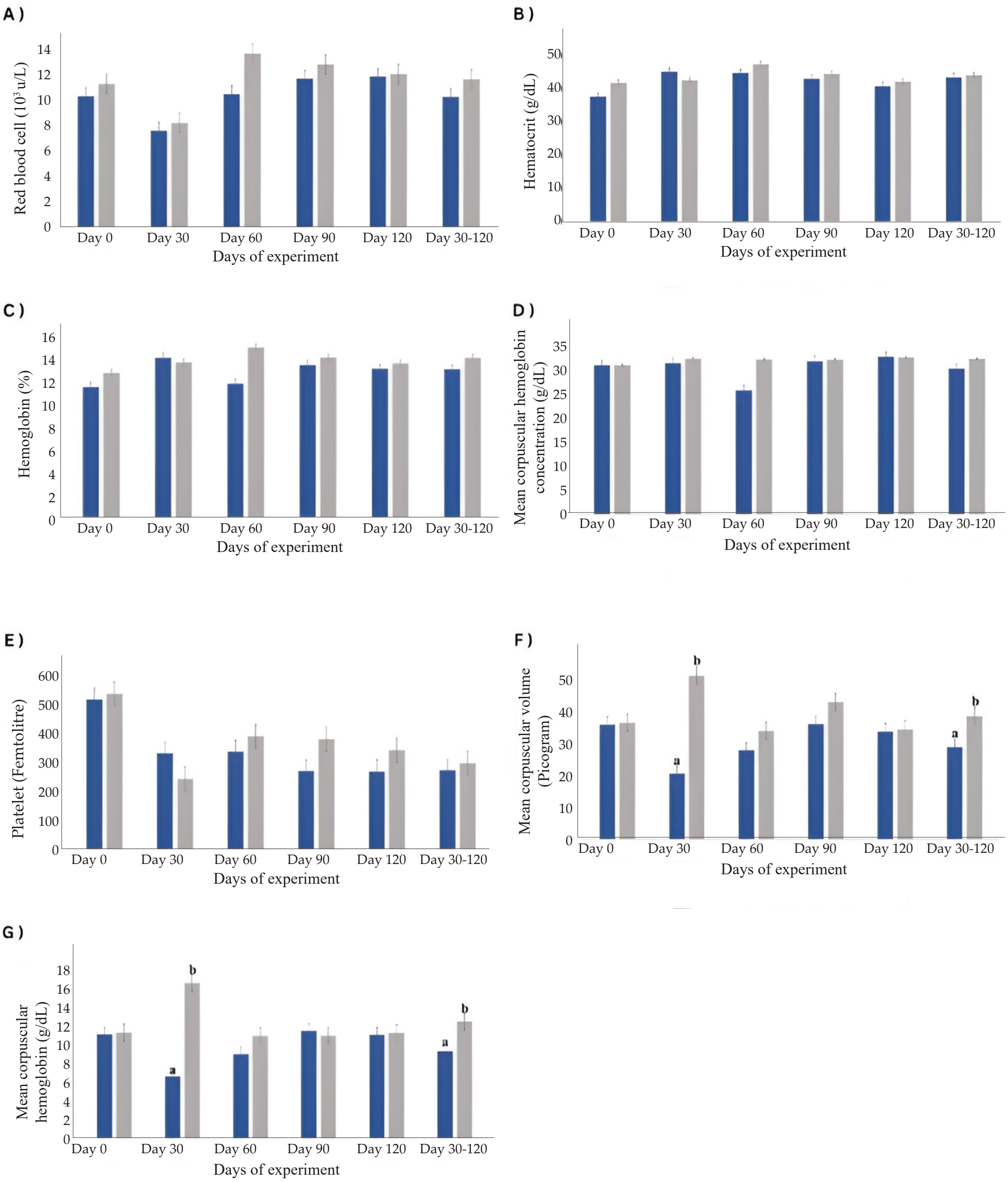

Figure 2. Hematological indices of non-creep feeding (■) and creep-feeding (■) groups in Khao Lamphun calves during days 0-120 after treatment; red blood cell (A), hematocrit (B), hemoglobin (C), mean corpuscular hemoglobin concentration (D), platelet (E), mean corpuscular volume (F) and mean corpuscular hemoglobin (G). Different alphabetic letters indicate significant differences (p<0.05).

Nutrient Requirements of Beef Cattle for Thailand. As a result, the creep-fed calves achieved an ADG of 0.41 kg/day, significantly outperforming the control group, which only had an ADG of 0.35 kg/day. Such an outcome highlights the efficiency of creep-feeding in meeting the nutritional needs of growing calves and enhancing their overall performance, including body adiposity (da Paixão *et al*., 2023).

In this study, there were no differences in plasma glucose levels between groups. However, at certain time points, the treatment group supplemented with creeping feed had higher glucose levels than those without creep-feeding. This finding is consistent with previous studies, where increased plasma IGF-I and glucose concentrations were observed in the creep-fed animals (Reis *et al*., 2015), which is crucial for the health and growth of calves (Carvalho *et al*., 2019). It is well-known that glucose fuels the central nervous system that regulates growth-related hormonal secretions (Muroya *et al*., 2022). It can directly affect insulin-like growth factor-I (IGF-1) secretion and, in turn, regulate growth in calves (Lucy, 2008). It also

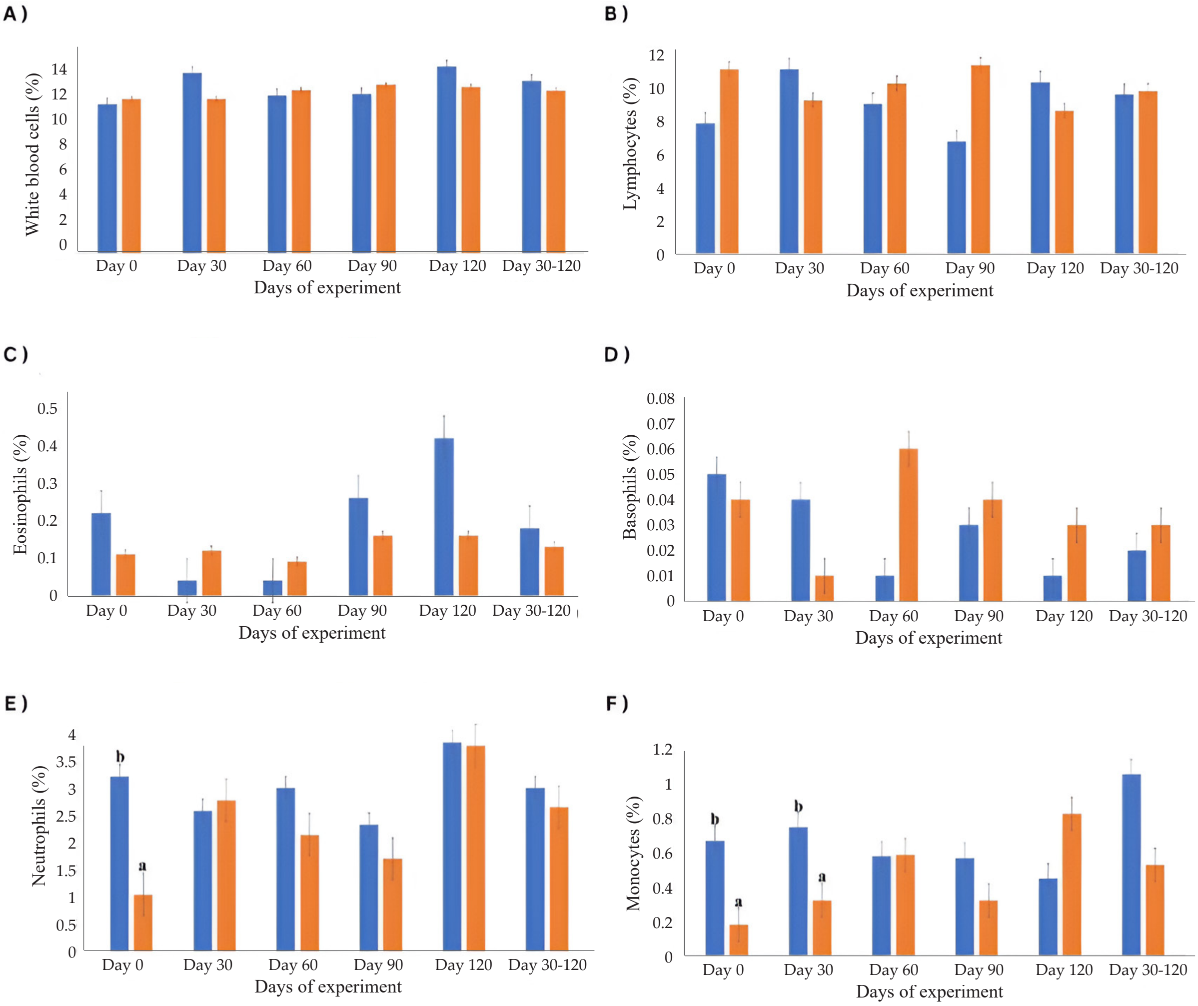

Figure 3. Hematological indices of non-creep feeding (■) and creep-feeding (■) groups in Khao Lamphun calves during days 0-120 after treatment; white blood cells (A), lymphocytes (B), eosinophils (C), basophils (D), neutrophils (E), and monocytes (F). Different alphabetic letters indicate significant differences (p<0.05).

plays a critical role in muscle protein synthesis, which contributes to increased growth rates and improved muscle development, as well as metabolic regulation of the electron transduction between the cytosol and mitochondria (Catussi *et al*., 2024).

The supplementation of creeping-feed was also found to be associated with the elevation of cholesterol levels compared to the group without creep-feeding, which is consistent with the findings reported in a previous study in piglets (Byrgesen *et al*., 2021). Apparently, cholesterol is a key component of cell membranes that play an important role in normal cell functions; erratic lipid distribution or metabolisms can have serious consequences on cells and the animal body (Paukner *et al.*, 2022). Moreover, cholesterol is mostly acquired through dietary sources, and cholesterol metabolisms are important in maintaining the normal functions of immune cells (Cardoso & Perucha, 2021). Previous studies have revealed that cholesterol can alter signaling pathways critical for normal development by interfering with cholesterol transportation within cells, and it also serves as the second messenger between patched I and smoothened (SMO) in the hedgehog signaling pathway during development (Griffiths & Wang, 2021).

In the present study, hematological parameters, including red blood cell counts, hematocrits, hemoglobin concentrations, mean corpuscular hemoglobin concentrations, and platelet counts, showed no differences between the treatment and control groups (p>0.05). In other words, our results demonstrated that hematological indices in creep-fed calves were similar to those observed in the control group, which is consistent with a previous report (Nwachukwu *et al*., 2015). Although the red cell count in the creep-fed calves did not differ from that in the control group, its mean value was still slightly higher in the creep-fed group. However, mean corpuscular volume (MCV) represents the average size of red blood cells, and mean corpuscular hemoglobin concentration (MCHC) measures the average hemoglobin concentration within the red blood cells. Given that hemoglobin is the protein responsible for carrying oxygen, a sufficient level of blood hemoglobin concentration is vital for maintaining optimal oxygen delivery to body tissues; adequate oxygen delivery to tissues and muscles is considered essential for metabolic processes that drive growth, including protein synthesis and energy production (Singh *et al*., 2024).

The present study showed that the supplementation of creeping feed did not affect the levels of neutrophils, lymphocytes, monocytes, or eosinophils when compared to the control group without creep-feeding, aligning with the findings from other studies. The current results imply that the creep feeding regimen applied in this study generally exerts beneficial impacts on the animals and that the health condition of the experimental animals was well-maintained throughout the study period. It is suggested that the creeping rations used in the present study have no discernible negative influence on the animals and that the experimental animals were all maintained healthily throughout the entire study period (Nwachukwu *et al*., 2015). In addition, this study showed that monocytes and neutrophils were reduced in the creep-feeding group, which may influence weaning impacts on the tract health of young calves (Boston *et al*., 2022). Physiologically, creep-feeding can also enhance the generation and functionality of the immune cells, including neutrophils, monocytes, and lymphocytes, which are essential for a robust immunological response to the infection and/or any environmental insults to the animals (Middelkoop *et al*., 2020). Overall, these findings support the idea that creep feeding can be a sustainable practice for improving the productivity of native cattle breeds like Khao Lamphun in Thailand.

CONCLUSION

The findings of the present study indicate that creep feeding enhances the growth performance and hematological and biochemical profiles of Khao Lamphun calves by days 30-60 and day 120 after experimental treatment. Our results suggest that farmers could adopt this strategy to improve calf's health and productivity in adulthood, and ultimately to benefit more sustainable cattle farming practices in the future.

CONFLICT OF INTEREST

We certify that there is no conflict of interest with any financial, personal, or other relationships with other people or organizations related to the material discussed in the manuscript.

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