

Optimizing Hand-Rearing Protocol through Nutritional Strategies to Improve Survival of Punjab Urial (*Ovis vignei punjabiensis*) Lambs

Muhammad Rizwan Khan¹, Muhammad Zaman Zahid¹, Warda Gill¹, Junaid Nadeem¹, Muhammad Azhar^{1*}, Huma Kalsoom², Amna Fayyaz¹, Muhammad Mujahid Khalid¹, Muhammad Abdur Rahman¹, Ammara Aslam¹, Ali Haider¹, Aftab Ahmed¹, Kiran Saleem¹, Mubarik Mahmood² and Abdur Rahman²

1. Punjab Wildlife and Parks Department, Lahore, Pakistan

2. University of Veterinary and Animal Science, Lahore, Pakistan

*Correspondence: azhar.vet11@gmail.com

SUMMARY

The purpose of this study was to establish and implement a successful hand-rearing protocol for Punjab urial (*Ovis vignei punjabiensis*) lambs. This study involved three nutritional protocols applied to three groups of urial lambs, comprising three lambs in each group. In the first protocol, lambs were fed sheep milk, diluted tetra milk pack, fresh lucerne, and parched gram at different age levels. In the second protocol, milk was started at 25% of body weight, which was then gradually reduced until weaning at 13 weeks of age. Lucerne hay was also introduced on the 5th day of age. The third protocol involved feeding tetra-packed milk from the 7th day of age at 30% of body weight, which was gradually reduced to 3% until weaning at 13 weeks of age. Lucerne hay-based pelleted total mixed ration was also fed at 1.8% of body weight, which increased to 4% of body weight until weaning. Weekly weight gain, average daily gain, daily feed intake, and weekly feed conversion ratio of animals were recorded. Prophylactic treatment for helminths and health issues such as diarrhea and lameness was effectively managed. Unfortunately, animals died at one month of age due to diarrhea and digestive issues in the first protocol. However, all animals survived, albeit with poor growth performance, in the second protocol. In the third protocol, all animals survived with better growth performance. This study proved the role of balanced nutrition, regular growth monitoring, and early veterinary intervention in the survival of zoo animals.

Keywords: Urial, Hand-rearing, Wildlife, Conservation

Citation: Khan, M. R., M. Z. Zahid, W. Gill, J. Nadeem, M. Azhar, H. Kalsoom, A. Fayyaz, M. M. Khalid, M. A. Rahman, A. H. Ammara Aslam, A. Ahmed, K. Saleem, M. Mahmood, and A. Rahman. 2026. Optimizing Hand-Rearing Protocol through Nutritional Strategies to Improve Survival of Punjab Urial (*Ovis vignei punjabiensis*) Lambs. Journal of Wildlife and Ecology. 10: 74-84.

Received: 20 March, 2026

Revised: 18 May, 2026

Accepted: 25 May, 2026

Published: 30 June, 2026

INTRODUCTION

The Punjab urial (*Ovis vignei punjabiensis*), a subspecies of the urial wild sheep, is an endemic ungulate found primarily in the arid and hilly terrains of the Punjab province in Pakistan (Khattak et al., 2021). Belonging to the Bovidae family, it is distinguished by its reddish-brown coat, white underparts, and prominent spiral horns, particularly pronounced in males. According to the International Union for Conservation of Nature (IUCN), the Punjab urial species is declared vulnerable,

citing habitat fragmentation, illegal hunting, overgrazing by domestic livestock, and human encroachment as major threats to its survival (Awan, 2001).

In response to these challenges, zoos and safaris play a key role in protecting vulnerable animals. Long-term conservation success requires scientifically proven solutions. Among these solutions, the survival of newborn animals is important. For their survival, the feeding of balanced nutrition (Fimbres et al., 2002; Santra et al., 2002), the use of prophylactic treatment, disease prevention (Awan, 2001), and growth optimization (Chishti et al., 2022; Dutta et al., 2025) are primary factors that must be managed well for the positive reinforcement and welfare of animals.

Despite the critical importance of hand-rearing for the conservation of Punjab urial, there is a significant absence of scientifically validated, species-specific protocols addressing nutritional requirements, feeding strategies, and weaning management for Punjab urial lambs. Existing feeding practices in zoological institutions of Pakistan lacks nutritional protocols for hand rearing of Punjab urial. This knowledge gap contributes to high neonatal mortality rates and suboptimal growth performance in captive-bred Punjab urial lambs, undermining conservation efforts. We hypothesized that a structured hand-rearing protocol incorporating species-appropriate milk feeding schedules, early introduction of pelleted total mixed ration, and systematic nutritional management would significantly improve survival rates and growth performance of Punjab urial lambs. Specifically, we predicted that gradual reduction of milk intake coupled with early provision of high-quality pelleted TMR (Total Mix Ration) would facilitate smooth weaning transition and enhance overall lamb health and growth performance.

MATERIALS AND METHODS

STUDY LOCATION AND ANIMALS

This study was conducted at Safari Zoo, Punjab Wildlife and Parks Department, Lahore, Pakistan, from April 2023 to September 2023. Nine Punjab urial (*Ovis vignei punjabiensis*) lambs were included in the study. The lambs were divided into three groups (Group 1, Group 2, and Group 3), with three lambs in each group. All lambs were hand-reared from birth due to maternal rejection or inadequate maternal care.

Housing and Environmental Management

Lambs were reared with 15ft wide, 25ft long and 8ft high enclosure having 15ft open and 10ft covered areas. The house was well ventilated with temperature ranging from 28°C to 34°C during the study period. Lambs had ad libitum access to clean drinking water throughout the study.

Health Management

All lambs received prophylactic treatment for common health issues. Fecal samples were examined on weekly basis. Deworming was performed at one month of age with Albendazole (10 mg/kg body weight, oral). Peripheral blood

smear was examined at one month of age, and two lambs were positive for blood parasite. Hence, anti-protozoal medication was given which included Diminazine Aceturate @ 3mg/kg once and Oxytetracycline @ 10mg/kg for 3 days. Vitamin supplementation (vitamins A, D3, and E) was also provided fortnightly via intramuscular injection for the first month. Any signs of illness including diarrhea, immediately addressed with appropriate veterinary intervention.

DATA COLLECTION

Individual body weights were recorded weekly using a digital scale (precision ± 10 g). Weekly weight gain (kg) was calculated as the difference between consecutive weekly weights. Average daily gain (ADG, g/day) was calculated by dividing weekly weight gain by 7. Daily feed intake (DFI) was recorded by weighing feed offered and refused for each lamb. Weekly feed conversion ratio (FCR) was calculated as the ratio of total feed consumed (kg) to total weight gain (kg) for each week (Figure 1). The details of the three nutritional protocols used in the study are given in Table 1, while the nutrient compositions of milk, pelleted TMR, and the list of ingredients of PTMR used for urial lambs are provided in Table 2.



Figure 1: Feeding behavior of Punjab Urial (*Ovis vignei punjabiensis*) Lambs.

STATISTICAL ANALYSIS

Data on body weight, weekly weight gain, average daily gain, daily feed intake, and feed conversion ratio were analyzed using descriptive statistics (mean $\pm$ standard error). Due to the small sample size within each group ($n=3$ per group), comparisons between protocols were performed using independent samples t-tests for normally distributed data. Although the sample size was limited, t-tests were employed as an exploratory analytical approach to identify potential trends and differences between protocols, with the understanding that results should be interpreted cautiously and validated in larger studies. Statistical significance was set at $P < 0.05$. All statistical analyses were performed using SPSS software (version 25.0).

ETHICAL APPROVAL

All procedures involving animals were conducted in accordance with the ethical guidelines of the Punjab Wildlife and Parks Department. The study adhered to

principles of animal welfare, minimizing stress and ensuring appropriate veterinary care throughout the experimental period.

Table 1: Description of different protocols used to rear Punjab Urrial lambs

Parameter	Protocol 1	Protocol 2	Protocol 3
Duration of study	1-4 th weeks of age	1-13 th weeks of age	1-13 th weeks of age
Number of lambs	3	3	3
Milk source	Domestic sheep milk	Diluted tetra milk pack	Concentrated Tetra milk pack
Milk feeding (% body weight)	15	25	30
Frequency of milk feeding (gradually decreasing)	3-0	6-0	6-0
Weaning age	Died at one month of age	13 th weeks	13 th weeks
Weaning strategy	Died at one month of age	Gradually increased solid feed while decreasing milk quantity as percentage of body weight (25% to 0 % until weaning)	Gradually increased solid feed while decreasing milk quantity as percentage of body weight (25% to 0 % until weaning)
Age at solid feeding	5 th days of age	5 th days of age	15 th days of age
Solid feeding strategy	Ad libitum fresh lucerne was provided at 5 th day of age which gradually increased. Alongside, parched gram was introduced at 15 th days of age at 50g per animal.	Ad libitum fresh lucerne was provided at 5 th day of age which gradually increased.	Lucerne hay based Pelleted TMR was introduced at 15 th day of age (started 100g per animal to 4pc of body weight until weaning.
Forage to concentrate ratio	80:20	100:0	10:90
Prophylaxis/treatment	Diarrhea treatment and deworming prophylaxis	Diarrhea treatment and deworming prophylaxis	Structured prophylaxis plan; diarrhea treatment recorded
Growth performance data	Recorded — feed intake, weekly gain, and FCR but data was not statistically analyzed because of limited data set.	Recorded — feed intake, weekly gain, and FCR	Recorded — feed intake, weekly gain, and FCR

Table 2: Nutrient composition of Milk and pelleted TMR along with the list of Ingredient of PTMR used for Urial Lambs.

Milk Composition/100ml (on dry matter basis)	
Protein (g)	2.7
Milk Fat (g)	3.5
Energy (kcal/100ml)	63
Carbohydrates	5.1
Ca (mg/100ml)	100
Na (g)	0.07
Vitamin A (IU/100ml)	177.6
Vitamin D (IU/100ml)	34
Nutrient composition of Pelleted Total Mix Ration (starter phase) used in protocol 3 (%) on dry matter basis	
Dry matter	93
Crude protein	20.5
Ether extract	4.53
Metabolizable Energy (kcal/kg)	2900
Ash	13
Neutral detergent fiber (NDF)	22.7
Acid detergent fiber (ADF)	12.4
Ingredients of Pelleted Total Mix Ration (PTMR) for starter phase used in protocol 3 (%inclusion in total diet on as fed basis)	
Ingredient	% in total feed (as fed basis)
Maize grain	30
Wheat grain	10
Soyabean meal	14
Canola meal	11.5
Wheat bran	12
Lucerne Hay	15
Molasses	5
Vito-mineral mixture	1
Salt	0.5

RESULTS

SURVIVAL AND HEALTH OUTCOMES

Survival outcomes differed markedly among the three protocols. In Protocol 1 (Group 1), all three lambs died within the first month of age. Mortality was attributed to severe diarrhea and digestive disturbances, likely resulting from abrupt dietary changes and inadequate nutritional balance. In Protocol 2 (Group 2), all three lambs survived to weaning; however, growth performance was poor, and lambs exhibited signs of nutritional stress including reduced activity and poor body condition. In Protocol 3 (Group 3), all three lambs survived with superior growth performance and overall health status compared to the other groups. Health issues encountered included diarrhea addressed through veterinary care.

Prophylactic deworming and vitamin supplementation were well-tolerated across all groups.

GROWTH PERFORMANCE

Table 3 presents the weekly body weight progression of lambs across the three protocols. Lambs in Protocol 3 consistently exhibited higher body weights from week 2 onwards compared to Protocol 2. Protocol 1 data are limited due to early mortality. Weekly weight gain and average daily gain are presented in Table 3. Protocol 3 lambs demonstrated significantly higher weekly weight gains and average daily gains compared to Protocol 2 throughout the study period. Daily feed intake and weekly feed conversion ratio are presented in Table 3. Protocol 3 lambs exhibited higher daily feed intake and more favorable (lower) feed conversion ratios compared to Protocol 2, indicating superior feed utilization efficiency. Overall, the results demonstrated that Protocol 3 consistently outperformed Protocols 1 and 2 in terms of growth performance and feed efficiency, while Protocol 1 showed the least favorable outcomes during the early experimental phase. Moreover, a comparison of feed intake, weekly weight gain, and feed conversion ratio among the three feeding protocols is presented in Figures 2 to 4.

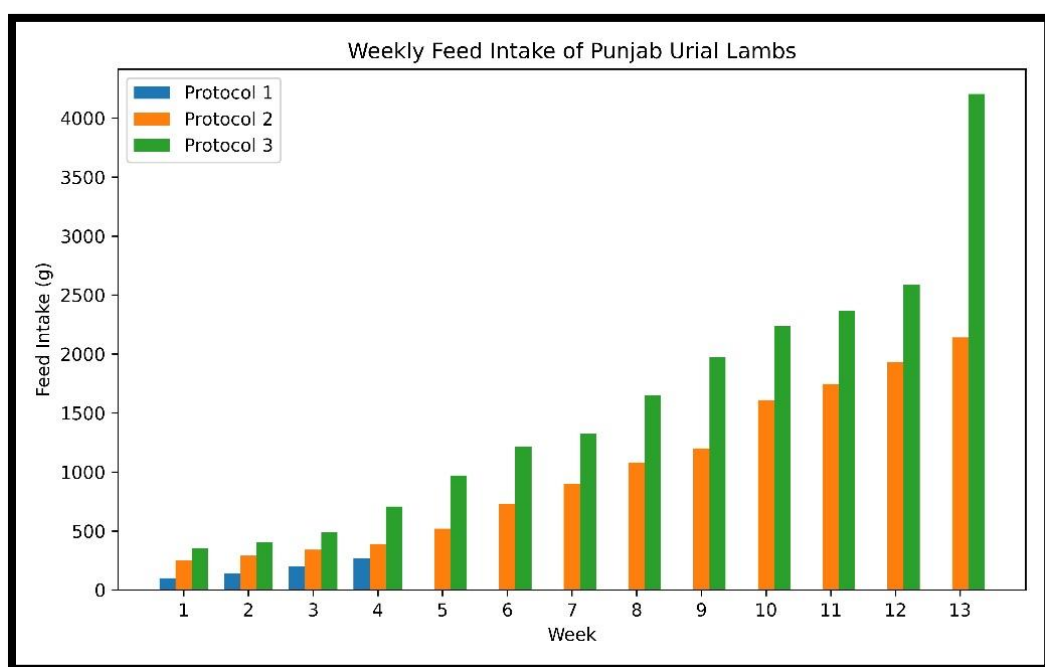


Figure 2: Comparative analysis of three feeding protocols in terms of feed intake

DISCUSSION

In the present study, feed intake showed higher values when pelleted total mixed ratio was fed to Punjab urial lambs. This is consistent with Retnani et al. (2022), who reported increased dry matter intake when pelleted feed was fed to small ruminants, including sheep lambs. Similarly, Greenhalgh and Reid (1973) also

reported higher feed intake when concentrate pelleted feed was fed to sheep. Moreover, about a 14% increase in feed intake was observed in growing lambs when pelleted feed along with lucerne hay was fed to growing lambs (Alshamiry et al., 2023). These evidences support and verify the present research in which feed intake increases when concentrated pelleted feed along with lucerne hay is given to young lambs.

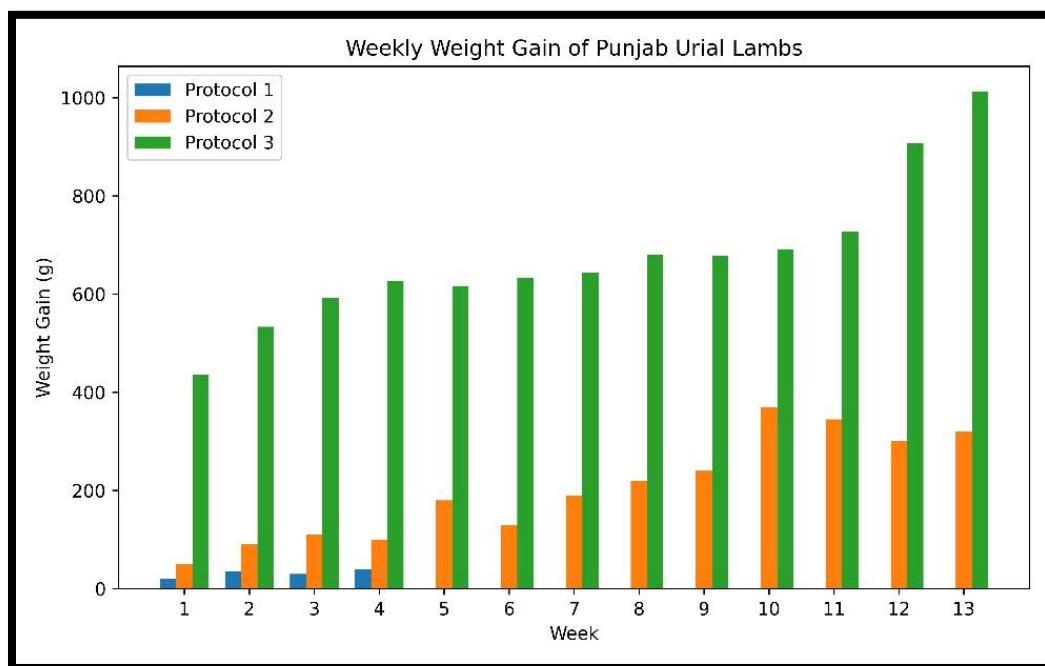


Figure 3: Comparative analysis of three feeding protocols in terms of weight gain.

In the current study, weight gain showed higher values when lucerne hay-based pelleted total mix ration was fed to Punjab Urial lambs. This is in accordance with Alshamiry et al. (2023), who reported an increase in weight gain when pelleted concentrate feed was fed along with lucerne hay. Similarly, Das (2010) reported maximum ADG in lambs when supplemented with a concentrate mixture at 1.5% of body weight. Additionally, the inclusion of concentrate in the diet enhanced body weight gain, daily DM intake, DM, and ADF digestibility in lambs and kids (Chaturvedi et al., 2000; Das and Ghosh, 2007; Jatta et al., 2022). Likewise, Fimbres et al. (2002) reiterated that an increase in live weight gain is associated with higher concentrate feeding levels and thus greater dry matter intake. Another study found that increased concentrate levels in the feed positively impacted body weight, growth rate, and the neonatal behavior of lambs up to weaning (Omar et al., 2019).

The feed conversion ratio in the present study showed better feed efficiency in all groups when pelleted feed was used. This is consistent with Raju et al. (2021), who explained better FCR when pelleted feed is used compared to mash form. Pelleted feed improves the Feed Conversion Ratio (FCR) in small ruminants like sheep primarily by enhancing feed intake, reducing feed wastage, and improving nutrient utilization efficiency. Moreover, lambs fed a high-protein

pelleted concentrate showed significantly higher average daily gain (ADG) and improved FCR than those fed un-pelleted feeds (Retnani et al., 2022). Furthermore, Raju et al. (2021) reported that pelleted complete feeds allowed better rumen fermentation synchronization, contributing to improved FCR in lambs.

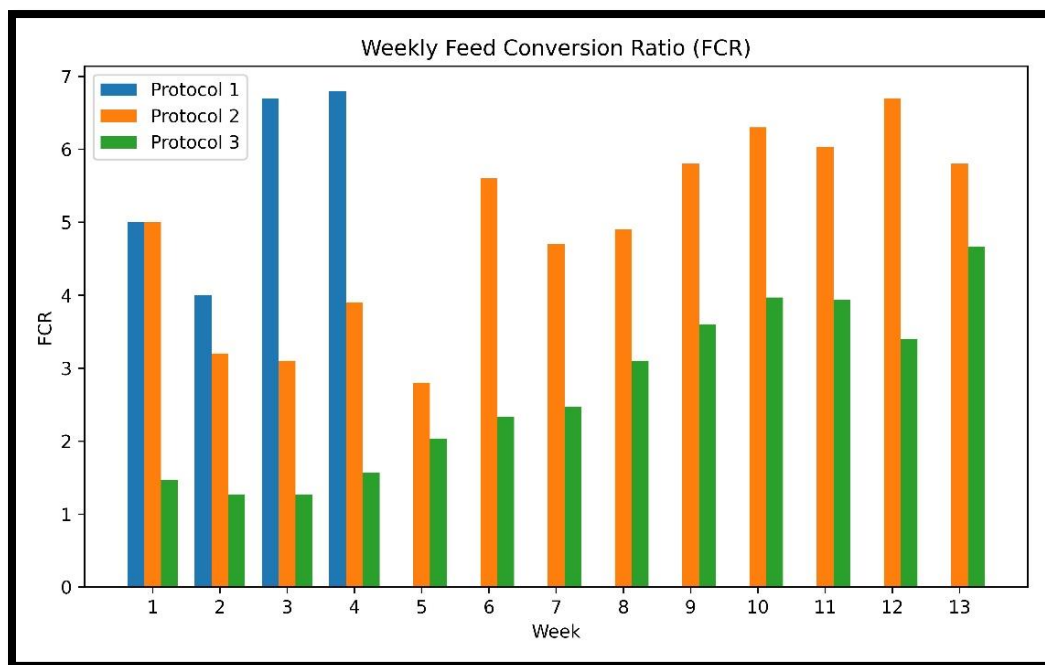


Figure 4: Comparative analysis of three feeding protocols in terms of feed conversion ratio (FCR)

Concentrate to roughage ratio is an important factor to be considered for improving feed efficiency. In the present study, a forage to concentrate ratio of 20:80 was used, which showed better results for feed intake, weight gain, and FCR. Feeding a higher concentrate to roughage ratio (80%C: 20%R) and (70%C: 30%R) improved body weight and vigor of newborn lambs (Omar et al., 2019). Lambs fed hay supplemented with concentrate at 20% had a better feed conversion ratio compared to other treatments (Jatta et al., 2022).

Furthermore, Carvalho et al. (2007) observed that a greater quantity of roughage and less concentrate feed in the diets lowers the live weight gain of the lambs. Moreover, McClure et al. (2000) reported that lambs on forage diets had greater intestinal weight and gut fill than lambs on concentrate diets. Congruently, Jabbar and Anjum (2008) expounded a better growth rate at a forage to concentrate ratio of 25:75 in Lohi sheep. Furthermore, Papi et al. (2011) justified that increasing levels of concentrate in the total diet improved dry matter intake, average daily gain, and carcass weight. All these studies align with the present study, thereby validating the rearing protocol for Punjab Urial lambs.

CONCLUSIONS

This study demonstrates that a structured hand-rearing protocol incorporating gradual milk reduction (30% to 3% of body weight over 10 weeks) and early introduction of pelleted total mixed ration can support successful survival and growth of Punjab urial lambs in captivity. While Protocol 3 showed promising results with 100% survival and superior growth performance compared to alternative approaches, these findings should be interpreted cautiously given the limited sample size and lack of experimental replication. The results suggest that appropriate nutritional management, systematic growth monitoring, and timely veterinary intervention are important factors in hand-rearing endangered wild ungulates.

RECOMMENDATIONS

1. Adopt Wildlife conservation approaches by using scientifically proven nutritional practices, regular growth monitoring, and proactive veterinary care for welfare of zoo animals
2. Moreover, this protocol provides a replicable framework for other wild ruminants at other wildlife rehabilitation and conservation programs to strengthen the sustainable rearing of endangered ruminants in Pakistan and comparable ecological regions. However, future research on large population will be required for the suitability of this protocol under different environmental and field conditions.
3. Conduct future research to validate this protocol under controlled experimental conditions with larger sample sizes and concurrent treatment groups to strengthen statistical inference and generalizability.
4. Investigate long-term outcomes including post-weaning growth, reproductive performance, disease resistance, and survival to adulthood in hand-reared Punjab urial.
5. Evaluate the protocol's effectiveness across different seasons and environmental conditions, and assess its applicability to field-based or semi-captive conservation settings.
6. Develop species-specific milk replacer formulations based on detailed analysis of Punjab urial milk composition to optimize nutritional adequacy during the milk-feeding phase.
7. Establish collaborative multi-institutional studies to build a larger dataset and refine evidence-based guidelines for Punjab urial neonatal management in ex-situ conservation programs.

These recommendations aim to improve neonatal survival and growth outcomes in captive Punjab urial populations, supporting broader conservation objectives for this endangered subspecies.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the support of the Punjab Wildlife and Parks Department particularly the management of study sites and academic partners for rendering their resources to accomplish this study.

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Table 3: weekly feed intake, weekly weight gain, and weekly FCR of Punjab Urial Lambs reared in all protocols

Week	Feed Intake (g)			Weight Gain (g)			FCR		
	Protocol 1 (Mean±SD)	Protocol 2 (Mean±SD)	Protocol 3 (Mean±SD)	Protocol 2 (Mean±SD)	Protocol 2 (Mean±SD)	Protocol 3 (Mean±SD)	Protocol 2 (Mean±SD)	Protocol 2 (Mean±SD)	Protocol 3 (Mean±SD)
1	100±20.3	250±40.2	351.3±41.6	20±4.3	50±10.2	435.0±107.6	5.0±0.12	5.0±0.21	1.467±0.404
2	140±15.2	290±39.6	405.0±44.4	35±3.8	90±21.3	533.3±51.3	4.0±0.04	3.2±0.06	1.267±0.15
3	200±28.7	340±50.1	487.0±38.9	30±4.1	110±25.1	591.7±23.6	6.7±0.08	3.1±0.12	1.267±0.05
4	270±35.2	390±41.3	706.0±27.8	40±7.4	100±20.2	626.7±29.3	6.8±0.14	3.9±0.052	1.567±0.05
5	-	520±45.4	970.0±34.0	-	180±38.5	616.7±70.9	-	2.8±0.03	2.033±0.23
6	-	730±50.3	1212±43.9	-	130±40.1	633.3±74.9	-	5.6±0.18	2.333±0.31
7	-	900±45.3	1323±45.0	-	190±31.2	643.3±90.7	-	4.7±0.41	2.467±0.37
8	-	1080±44.8	1650±40.2	-	220±40.2	680±100	-	4.9±0.08	3.10±0.45
9	-	1200±55.2	1970.7±49.6	-	240±38.4	678.3±148.7	-	5.8±0.13	3.60±0.69
10	-	1610±39.4	2235.3±40.8	-	370±32.6	691.7±161.6	-	6.3±0.22	3.967±0.90
11	-	1745±41.3	2366±33.4	-	345±28.9	726.7±151.8	-	6.03±0.11	3.933±0.80
12	-	1930±52.5	2586.3±37.1	-	300±45.7	906.7±171.6	-	6.7±0.04	3.40±0.60
13	-	2140±61.4	4204.7±44.5	-	320±27.4	1013.3±164.4	-	5.8±0.20	4.667±0.68

Competing interests: There is no conflict of interest among the authors of study.

Funding: The current study was self-funded and no funding agency or organization was involved.

Authors' contributions: MRK, MZZ, and MA conceived and designed the study. MZZ, WG, and MA managed animal feeding trials and data collection at study sites. MZZ, AF, KS, and HK performed data analysis and interpretation. MZZ, MA, and AR contributed to the formulation of the Pelleted Total Mixed Ration. MA, AA, and AH monitored health parameters. MZZ, MMK, and MA drafted the manuscript. JN provided necessary departmental resources, while all authors participated in reviewing and editing the final version. All authors read and approved the final manuscript.

