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Research Article

Effect of feeding different levels of duckweed on the growth of Nepalese Boer-cross goat

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ABSTRACT

The experiment was conducted to determine the feed intake and body weight (BW) change of Boer cross buck supplemented with a commercial concentrate mass and combinations of commercial concentrate (CF) with duckweed (*Lemna minor*) at varying inclusion levels at Goat Research Farm of the Directorate of Agricultural Research (DoAR), Khajura, Banke District, under Nepal Agricultural Research Council (NARC) Nepal for 90 days (2024/25). In the experiment sixteen healthy bucks 6-7 months old with an average initial body weight 14.43 kg were randomly allocated to four dietary treatments:100% CF+ 0% duckweed (T_0), 90 % CF + 10% duckweed (T_1), 80% CF + 20% duckweed (T_2), and 70% CF + 30 % duckweed (T_3), with *ad libitum* Napier grass provided across all groups. The results reveled that, significant ($p<0.05$) difference was observed in a total dry matter intake (DM, g/d) and found highest in control group T_1 and lowest in treatment T_2, i.e., substitution with increasing rate of duckweed reduce the total dry mater intake. However, the difference was non-significant with treatment T_2 and T_3. Total body weight gain, average daily body weight gain and final body weight was observed significantly ($p<0.05$) highest in treatment T_2 and lowest in T_1, whereas the difference was non -significant ($p>0.05$) between treatment T_2 and T_3. Similarly, feed conversion ratio (FCR) was observed lowest in T_2 treatment compared to T_1 and the difference was non-significant with treatment T_2 and T_3. From the results it indicated that, duckweed is a good source of protein and it can utilize up to 20% as substitution of concentrate ration during growing period of goat without compromising their growth performance.

Introduction

Goat production is a vital component of livestock agriculture globally and plays a particularly significant role in the livelihoods of rural communities in developing countries (Ketema, 2007; Thornton et al., 2009). In Nepal, goat rearing has long been an integral economic activity for smallholder farmers operating under mixed crop-livestock systems. While goats have traditionally been raised for subsistence, the increasing demand for goat meat regarded as a high-quality animal protein has led to a shift from subsistence to semi-commercial and commercial production systems. The sustainability and profitability of commercial goat farming depend largely on effective nutritional and forage management strategies. Seasonal shortages and high costs of conventional feedstuffs present substantial constraints for goat producers in Nepal (Upreti and Shrestha, 2006). Although goats are known for their adaptability to diverse environmental conditions and their ability to utilize low-quality forages (Abedo et al., 2013), optimal growth and productivity still require well-balanced diets. Supplementation of low-quality roughages with commercial concentrates can improve intake and nutrient utilization; however, the cost and inconsistent availability of commercial feeds have prompted the search for alternative feed resources.

Duckweed (*Lemna minor*), a rapidly growing aquatic plant, has recently gained attention as a potential alternative protein and nutrient source for livestock. Duckweed is rich in protein, minerals, and essential amino acids, making it a promising supplement to traditional rations, especially in regions where conventional feed resources are limited or expensive. Incorporating duckweed into goat diets may reduce reliance on commercial concentrates, lower feed costs, and enhance the sustainability of goat production

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systems. Despite its nutritional potential, limited research has been conducted on the use of duckweed as a feed supplement for goats, particularly in Nepal. Knowledge gaps remain regarding the optimal inclusion levels of duckweed in goat diets and its effects on intake, growth performance.

Therefore, the objective of this study was to evaluate the effect of incorporating duckweed (*Lemna minor*) at varying levels, mixed with commercial concentrate, on the growth performance of Boer cross goats.

Materials and Methods

Experimental Site and Animals

This study was carried out at the Goat Farm of the Directorate of Agricultural Research (DoAR), Khajura, Banke District, under the Nepal Agricultural Research Council (NARC), Nepal (28°06'N, 81°37'E) over a period of three months. Sixteen healthy, growing Boer crossbred bucks aged 6–8 months, with an initial mean body weight of 14.43 ± 1.59 kg (mean ± SEM), were selected for the experiment. The animals were randomly assigned into four groups (n = 4 per group) based on body weight following a completely randomized design (CRD). All goats were dewormed prior to the onset of the trial and housed in well-ventilated, wooden-floored pens equipped with individual feeding and watering facilities.

Experimental Diets and Feeding Management

Prior to data collection, all goats underwent a one-week adaptation period during which they received duckweed and a commercial concentrate mixture at 1.0% (NRC, 2007) of body weight, along with Napier grass (*Pennisetum purpureum*) provided *ad libitum*. The experimental feeding phase lasted for 90 days. Animals received their respective diets in two equal portions at 09:00 and 17:00 hours daily. Feed intake was recorded by weighing the rations offered and refusals. Body weights were measured at the start of the experiment and at 15-day intervals thereafter, always in the morning before feeding and watering.

Table 1: Experimental diet of the animals

Treatments	Experiment Diet	Reference
T_0	Commercial Feeds **+** Napier grass + 0% duckweeds (*Lemna minor***)**	
T_1	90% Commercial Feeds **+** Napier grass + 10% duckweeds (*Lemna minor***)**	FAO (2001)
T_2	80% Commercial Feeds **+** Napier grass + 20%duckweeds (*Lemna minor*)	
T_3	70% Commercial Feeds+Napier grass+30% duckweeds (*lemna minor*)	

Chemical Analysis of Feed Ingredients

Samples of harvested duckweed were sent to the National Animal Nutrition Research Center, Khumaltar, under (NARC) for chemical analysis. Representative samples were analyzed for fresh dry matter (FDM), dry matter (DM), crude protein (CP), total ash (TA), organic matter (OM), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), hemicellulose (HC), cellulose (C), calcium (Ca), and phosphorus (P) following AOAC (1990) methods. The chemical composition of duckweed is presented in Table 2.

Table 2: Chemical Composition of Duckweed (Percentage on DM basis)

Ingredient	FDM	CP	EE	T_ Ash	CF	NDF	ADF	ADL
Duckweed (*Lemna minor*)	5.22	14.04	2.36	29.10	30.78	66.12	31.72	2.30

FDM = Fresh Dry Matter, CP = Crude Protein, EE = Ether Extract, T_ash = Total Ash, CF = Crude Fiber, NDF = Neutral Detergent Fiber, ADF = Acid Detergent Fiber, ADL = Acid Detergent Lignin, HC = Hemicellulose, C = Cellulose, Ca = Calcium, P = Phosphorus.

Data Collection and Statistical Analysis

Data were collected on daily dry matter intake (DMI), daily body weight gain (BWG), final body weight, and feed conversion ratio (FCR) during 2024/25. All statistical analyses were performed using Minitab 17.1.0 software. One-way analysis of variance (ANOVA) was used to assess the effects of the dietary treatments, followed by Tukey's post-hoc test for multiple comparisons. Results were considered statistically significant at $p < 0.05$.

Results and Discussion

Effect of Dietary Treatment on Growth Performance

The effects of supplementing duckweed (*Lemna minor*) at varying levels mixed with commercial concentrate on the growth performance of Boer cross goats are presented in Table 3. There were no significant differences among treatments in initial body weight (IBW), confirming uniformity at the onset of the experiment ($p = 0.959$). However, significant differences were observed for final body weight (FBW), total body weight gain (TBW), and daily body weight gain (DBW)

across treatments ($p < 0.05$). Goats in the T_2 group (80% CF+ 20% duckweed) achieved the highest FBW (21.38 kg), which was significantly greater than the control group (T_o: 18.25 kg) and other treatment groups. Similarly, T_2 recorded the highest TBW (5.00 kg) and DBW (55.56 g/day), both significantly higher than T_o (TBW: 3.83 kg; DBW: 42.50 g/day). The T_1 and T_3 groups (10% and 30% duckweed inclusion, respectively) showed intermediate values that were not significantly different from either the control or T_2.

Table 3. Effects of different levels of duckweed mixed with concentrate on growth performance of Boer cross buck

Parameters	T_0	T_1	T_2	T_3	P-value	LSD (5%)	CV (%)
IBW (kg)	14.43 ±1.59	14.63±0.75	14.50 ± 0.65	15.00±1.14	0.959	2.49	11.04
FBW (kg)	$18.25±0.48^{b}$	$18.88±0.83^{ab}$	$21.38±0.52^{a}$	$19.25±0.85^{ab}$	0.038*	2.13	7.1
TBW (kg)	$3.83 ± 0.18^{b}$	$4.25±0.14^{ab}$	$5.00 ± 0.20^{a}$	$4.25±0.32^{ab}$	0.020*	0.68	10.26
DBW (g/day)	$42.50±1.94^{b}$	$47.22±1.60^{ab}$	$55.56±2.27^{a}$	$47.22±3.59^{ab}$	0.020*	7.6	10.15

Different superscripts within a row indicate significant differences ($p < 0.05$). IBW = Initial Body Weight; FBW = Final Body Weight; TBW = Total Body Weight Gain; DBW = Daily Body Weight Gain. T_o=100% Commercial Feed; T_1=90% Commercial Feed + 10% duckweed; T_2=80% Commercial Feed + 20% duckweed; T_3=70% Commercial Feed + 30% duckweed. All experimental goats were supplied with ad libitum Napier grass as the basal roughage source throughout the experimental period.

This result demonstrates that partially replacing commercial concentrate with 20% duckweed significantly improves growth performance in Boer cross goats. This aligns with previous research emphasizing duckweed's high protein content and nutrient-rich profile (Leng et al., 1995; Appenroth et al., 2017). Duckweed species, including *Lemna minor* and *Lemna gibba*, contain crude protein levels ranging from 15% to 45%, which can enhance fermentation characteristics and animal growth without adversely affecting digestibility. Optimizing rumen fermentation is essential for ruminant productivity, with microbial activity dependent on the availability of nitrogen in the form of ammonia and energy sources (Yusran & Teleni, 2000; Rostini et al., 2014). The inclusion of protein-rich duckweed likely improves ammonia availability, supporting microbial growth and fermentation efficiency.

Effect of Dietary Treatment on Dry Matter Intake

Table 4 presents the effects of dietary treatments on dry matter intake (DMI) from concentrate plus duckweed, Napier grass, and total daily intake in Boer cross goats. The control group (T_o) exhibited the highest dry matter intake on concentrate and duckweed (216.91 g/day), Napier grass (616.24 g/day), and total DMI (833.15 g/day), all significantly greater than the other treatment groups ($p < 0.05$). The lowest DMI values were observed in T_1 and T_2, while T_3 showed intermediate intake levels.

Table 4. Effects of different levels of duckweed mixed with concentrate on dry matter intake in Boer cross buck

Parameters	T_0	T_1	T_2	T_3	P-value	LSD value	C.V. (%)
Concentrate and Duck Weed DM Intake (g/d)	$216.91^{a}±2.63$	$195.34^{c}±1.07$	$198.85^{c}±0.83$	$208.69^{b}±1.82$	0.000*	5.34	1.69
Napier DM Intake (g/d)	$616.24^{a}±2.04$	$587.36^{c}±0.57$	$590.75^{c}±2.54$	$601.16^{b}±0.60$	0.000*	5.19	0.56
Total DM Intake (g/d)	$833.15^{a}±4.63$	$782.70^{c}±1.47$	$789.60^{c}±2.26$	$809.85^{b}±1.76$	0.000*	8.69	0.7
FCR	21.94^{a}	19.39^{ab}	15.87^{c}	18.48^{bc}	0.011*	3.24	11.11

Different superscripts within a row indicate significant differences ($p < 0.05$). DMI = Dry Matter Intake, FCR= Feed Conversion Ratio. T_o = 100% Commercial Feed; T_1 = 90% Commercial Feed + 10% duckweed; T_2 = 80% Commercial Feed + 20% duckweed; T_3 = 70% Commercial Feed + 30% duckweed. All experimental goats were supplied with *ad libitum* Napier grass as the basal roughage source throughout the experimental period.

These results also indicate that increasing levels of duckweed in the diet led to a reduction in overall dry matter intake. A reduction in dry matter intake with higher duckweed inclusion indicates that goats can satisfy nutrient requirements with less feed due to duckweed's high nutrient density (Leng et al., 1995). Feed intake is influenced by genetic, environmental, and management factors, while protein requirements for maintenance depend on ration composition and animal condition (Sunarso, 2012). Nutrient digestibility is a key indicator of feed quality and livestock performance (Despal & Permana, 2008). Previous studies report dry matter digestibility in goats of 64.6–68.5% on grass-based diets and up to 77% with fermented feeds (Wirawan et al., 2012; Rostini et al., 2014), while protein digestibility ranges from 65% to

68%. The current study supports these findings, showing that duckweed inclusion up to 45% can provide a balanced protein and energy supply. Additionally, bioactive compounds in duckweed may further enhance rumen fermentation and nutrient utilization, improving feed conversion efficiency and overall animal health (Appenroth et al., 2017; Chaji et al., 2025). This results also supported by Huque et al. (1996), cattle can be fed duckweed as part of a concentrate mixture without experiencing any adverse effects.

Conclusion

Duckweed (*Lemna minor*) can be recommended as an economical, locally available, and sustainable alternative protein source, with approximately 20% inclusion in concentrate mixtures identified as the optimal level for improving growth performance and feed efficiency in Boer cross goats under stall-fed conditions. Adoption of duckweed-based feeding strategies may contribute to lowering feeding costs and promoting sustainable small ruminant production systems in developing countries.

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