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Management Practices and Consumption Patterns of Small Ruminants in the Fiji Islands

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Abstract

Despite their importance to Fiji's food security due to their adaptability and ease of production, the production practices of sheep and goats in Fiji are not well understood. This study characterized small ruminant production systems and determined the meat consumption patterns in Fiji Islands. Data were collected from 270 sheep and goat producers in Fiji's two main islands, Viti Levu and Vanua Levu, using a structured questionnaire that captured socio-demographic information, the importance of small ruminants to farmers, challenges faced, management practices, and household meat consumption patterns. Associations between geographical location and production practices were determined using the chi-squared option of PROC FREQ and logistic regression. Over 95% of the farmers in both islands used paddocking as their primary management strategy. Hindu farmers were four times more likely to use paddocks for raising sheep and goats than Muslim farmers ($p < 0.05$). More than 65% of the farmers reported scabby mouth and foot rot as primary diseases in Vanua Levu, compared to less than 30% in Viti Levu. In Vanua Levu, the preferred age for slaughtering sheep and goats was less than one year, whereas in Viti Levu, it was one and a half years ($p < 0.05$). Most farmers discarded offal and other byproducts, such as skin and blood. Management practices and meat consumption patterns were similar in Viti Levu and Vanua Levu; however, the age of slaughter for small ruminants differed.

Keywords: goats; production systems; meat consumption; sheep; Viti Levu; Vanua Levu

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1. Introduction

Sheep and goats play a central role in food security through the provision of meat and other by-products, such as milk and hides, in many developing regions. In Fiji, sheep and goats are the second most prominent class of livestock after chickens, with an estimated population of approximately 260,000 goats and just below 20,000 sheep [1]. Their adaptability to various environmental conditions makes them suitable for regions like Fiji, with limited resources and vulnerable to climate extremes such as droughts and floods. The small ruminants also require less space and investment as compared to large ruminants such as cattle. Furthermore, in Fiji, the consumption of sheep and goats is significant due to their cultural and religious acceptance across various faiths, unlike cattle, which are restricted to some religious practices [2]. As a result, the small ruminants are integral to traditional agriculture in Fiji where they are key to subsistence farming and economic resilience.

Despite the importance of small ruminants in Fiji, their breeds and production practices remain inadequately documented. Generally, there is a broader research gap in livestock production across the Pacific Islands, where research and development projects have historically focused on climate change disaster risk management and ocean ecosystems due to the region's high vulnerability to climate-related disasters and dependence on coastal ecosystems [3,4]. As a result, the lack of adequate research and organized intervention programs in the livestock sector of the Pacific Islands, including Fiji, has impeded evidence-based improvements in livestock productivity, such as sheep and goats. This has contributed to low food security levels in the Pacific Islands, exemplified by Fiji, where Webster et al. [5] reported that approximately three-quarters of households in Fiji's central division experienced food insecurity indicators, such as running out of food and skipping meals involuntarily, in 2022. After acknowledging this gap, Fiji's government, along with partner organizations such as the Australian Centre for International Agricultural Research (ACIAR) and the Pacific Community (SPC), has initiated policies and projects aimed at strengthening the livestock sector, particularly for sheep and goats. This includes the ACIAR's small ruminant project and the Fiji livestock sector strategy, which involves investment and capacity building in sheep and goat production [1,6]. Despite these efforts, a significant data gap remains regarding small ruminant production in Fiji and the Pacific Islands as a whole. While the ACIAR small ruminant project documented productivity parameters, such as live weights, reproductive performance, and mortality rates, it did not cover production practices, including grazing practices and consumption patterns [1].

Fiji is home to several sheep and goat breeds, including the Fiji Fantastic sheep, a local breed well-adapted to the environment. Introduced sheep breeds like the Dorper, as well as goat breeds such as the Boer and Anglo-Nubian, are also present; however, most of these breeds have struggled to adapt to local production systems and environmental conditions [1]. Reports show that most small ruminants are non-descriptive breeds due to uncontrolled mating [7]. Comprehensive studies on the distribution, performance, and management of these breeds by Fijian farmers are limited. This lack of detailed information hampers the development of targeted improvement programs for small ruminants, which in turn affects both productivity and sustainability. Balehegn et al. [8] and Hidano et al. [9] note that, due to the absence of prior studies, the adoption of intervention strategies to improve livestock productivity is often low among smallholder farmers because the suggested interventions do not align with current practices and sociocultural factors of the beneficiaries. Previous smallholder livestock development programs in the Pacific Islands were deemed unsuccessful due to misalignment with existing practices [10,11]. A detailed characterization of the current management practices of small ruminant producers in Fiji can, therefore, provide a sound foundation for designing intervention programs that match the farmers' socioeconomic and cultural backgrounds, thus enhancing adoption and, consequently, improving productivity.

In addition to management practices, it is also essential to comprehend the small ruminant meat consumption patterns in Fiji. Small ruminants often hold cultural significance, playing crucial roles in traditional ceremonies, feasts, and social gatherings, which in turn influence sustainable management and marketing strategies [1]. Rae [12] and Alexander et al. [13] reported that changes in meat consumption patterns can influence pricing, which in turn affects farmers' decisions on production levels, breeds, and management practices, ultimately impacting overall productivity. Although little, if any, data has been reported on Fiji, social and cultural factors, such as religion and household size, have been reported to influence meat consumption patterns in regions like Asia and Africa [14,15]. Examining consumption patterns of goat and sheep meat in Fiji is necessary if the industry's productivity and sustainability are to be promoted by aligning production with consumer

preferences. Against this background, the objectives of the study were to characterize small ruminant management systems and to determine the patterns of small ruminant meat consumption in Fiji. A good understanding of current management practices of small ruminants by resource-limited communities is key to designing tailor-made intervention programs to improve food security and household income in Fiji. Identifying consumer preferences for goat and sheep meat, such as favored breeds, age groups, and/or specific cuts, can help guide production practices to meet specific consumer demands.

The rest of this paper is organized as follows: Section 2 covers the study site, respondent sampling, data collection, and analysis. Section 3 presents the study's findings. A discussion of these findings is presented in Section 4, followed by the conclusions in Section 5.

2. Materials and Methods

2.1. Study Site

The study was conducted in the Western Division provinces of Ba and Ra on the island of Viti Levu, and in the Northern Division provinces of Macuata and Bua on the island of Vanua Levu (Figure 1). Viti Levu is one of the largest islands in Fiji, situated at 17°48′ S, 178°0′ E. The island has eight provinces. The second-largest island in Fiji, Vanua Levu, lies 64 km north of Viti Levu and is situated at 16°35′ S and 179°11′ E. There are three provinces on the island. Viti Levu and Vanua Levu were chosen because that is where most of Fiji's sheep and goat farmers are located [1].

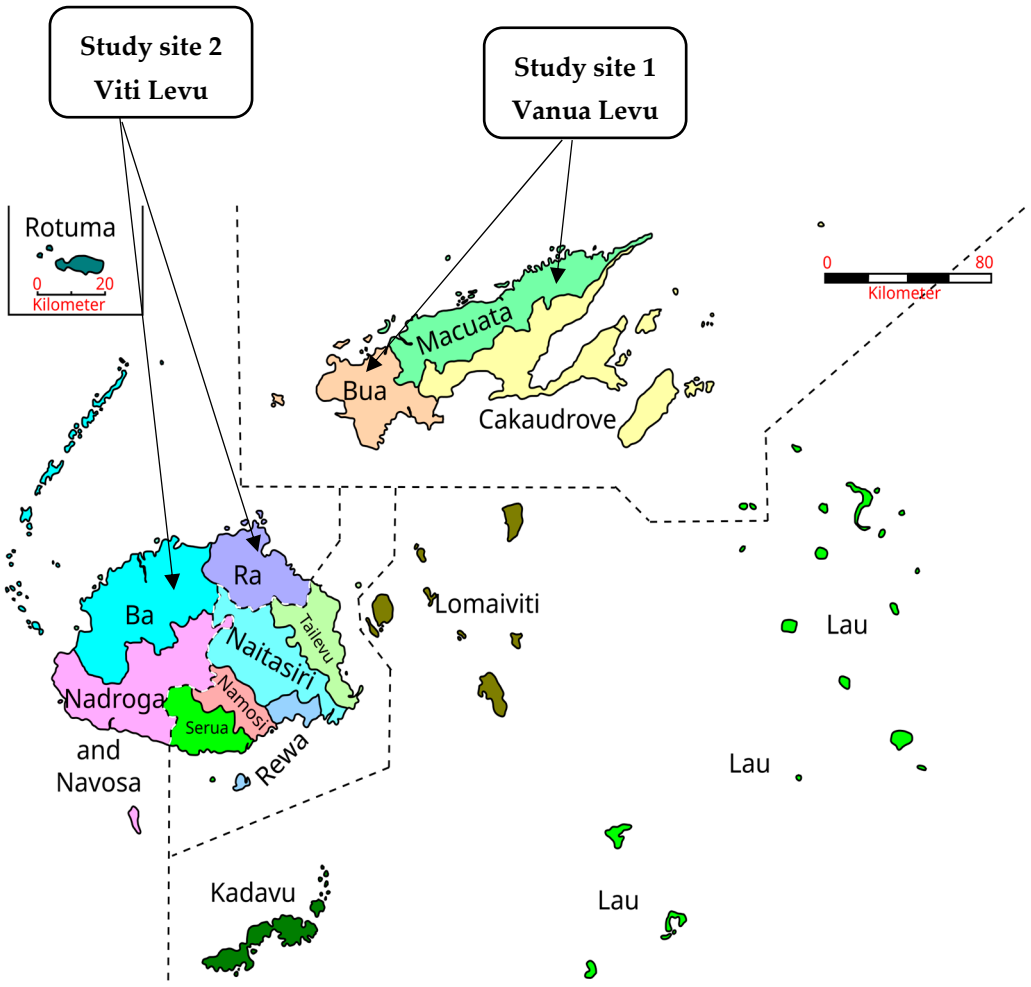

Figure 1. Map of Fiji Islands showing the study sites.

The northern part of Vanua Levu is characterized by coastal vegetation, wetlands, forests, and grasslands [16]. The open grasslands, low-lying wetlands, and steep slopes serve as natural grazing areas for sheep and goats [1]. Farmers cultivate rice in some wetlands, while in drier areas they grow sugarcane, cassava, and taro for their sustenance [17]. During the dry season, when livestock feed is limited, farmers depend on the residues of these crops to feed their sheep and goats [1]. Conversely, the western part of Viti Levu is mainly characterized by dry open grasslands that are suitable for grazing small ruminants [1,16]. Besides livestock production, sugarcane cultivation is common, along with the growth of cassava and taro [17]. Similarly to Vanua Levu, residues from these crops are used as supplementary feed for sheep and goats [1]. The rainfall in these two regions fluctuates depending on the occurrence of tropical cyclones. Most rain falls in January and February, creating lush green pastures for grazing livestock, whereas June to September experiences low rainfall, leading to critical shortages of forage. Temperatures are high from January to April (27–28 °C) and September to December (27–29 °C) [18].

2.2. Questionnaire Design

A structured socio-demographic questionnaire was developed based on previous studies in Pacific Island Countries, such as Cowley et al. [1] and Georgeou et al. [19]. Face validity was assessed by comparing the questions with theoretical constructs and expectations derived from literature and expert review by two extension officers from Fiji's Ministry of Agriculture. Pilot testing was carried out with 10 sheep and goat farmers at each of the two study sites, selected randomly as described in Section 2.3. Feedback from the pilot led to minor revisions of the questions. The final questionnaire consisted of closed-ended multiple choice questions, some of which included 'other (specify)' options to capture unlisted responses. A few of the questions were open-ended. The questions were categorized into three sections. The first section collected socio-demographic data, including the farmers' gender, age, education level, and farm location. The second section gathered information on the importance of small ruminants to farmers, including their production systems, flock sizes, feed availability, and challenges faced by small ruminant farmers. The third section covered household meat consumption patterns, including preferred types of meat, preferred parts of the carcass, frequency of meat consumption, and marketing strategies for small ruminants. The questionnaire was originally written in English and then translated into local Hindi and iTaukei languages with the help of linguistics experts from Fiji National University's College of Humanities and Education. To ensure accuracy, it was back-translated into English by different experts within the same university.

2.3. Sampling Procedure and Data Collection

A stratified random sampling method was used to select farmers for the survey, with the four provinces serving as strata. Farmers rearing sheep, goats, or both were considered. Using a database of farmers who keep sheep and goats from Fiji Ministry of Agriculture records as the sampling frame, participants were randomly selected with the random function in Microsoft Excel. Farmers were interviewed at their homesteads using a pre-tested, structured questionnaire. Only farmers aged 18 years or older were included in the interviews. Respondents aged 35 years and below were classified as young, while those aged 35 and above were classified as older. A total of 270 questionnaires were administered: 130 in Vanua Levu (65 in Ba and 65 in Ra) and 70 in Viti Levu (35 in Macuata and 35 in Bua). The sample sizes for Ba, Ra, Macuata, and Bua were determined based on the total number of farmers in the Fiji Ministry of Agriculture database, using Cochran's [20] formula as suggested by FAO [21]. The number of farmers selected in each

of the four provinces was proportional to the estimated total population, based on the Fiji Ministry of Agriculture's database. The survey was conducted by enumerators fluent in Hindi and iTaukei. To minimize response bias, ambiguous or leading questions were identified during questionnaire pretesting, and survey enumerators were trained to avoid influencing responses. Respondents were assured of confidentiality and explicitly informed that there were no right or wrong answers to eliminate social desirability bias.

2.4. Statistical Analysis

The data were analyzed using the Statistical Analysis System (SAS) v9.4. Chi-square tests were conducted to determine the association between respondents' geographical location and demographic characteristics (gender, age, level of education, religion, occupation, and land size), the prevalence of diseases (Scabby mouth and foot rot) in their flocks, and flock management practices (grazing management systems, feeding practices, and disease management). The PROC FREQ was used to determine the proportions of variables for socio-demographic data, management, and systems in Vanua Levu and Viti Levu. Mean rank scores for challenges faced by farmers, sources of small ruminants for slaughter, age of slaughter for small ruminants, preferred meat cuts, and choice of meat cuts were analyzed using the general linear models with the following model:

$$Y_{ijk} = \mu + \alpha_i + e_{ijk}$$

where

Y = Rank score for (importance of keeping ruminants, sources of slaughter animals, age at slaughter, preferred carcass cuts, and reasons for preferring specific cuts)

μ = population mean.

α_i = effect of the ith location (I = Vanua Levu and Viti Levu)

e_{ij} = residual error $\sim$ N (0; Iσ^2).

Mean separation was performed using the LSMEANS using the PDIFF option at 5% significance level.

The probability of farmers using different small ruminant grazing and feeding practices was analyzed using ordinal logistic regression (PROC LOGISTIC). The logit model included the following predictors: location (Vanua Levu and Viti Levu), religion, age, education, household size, and the farmer's occupation. When computed for each predictor (β_1, …, βt), the odds ratios were interpreted as the proportion of farmers who used a specific grazing practice from the total number of farmers interviewed. The following logit model was used:

$$\text{In}\left[\frac{P}{1-P}\right] = \beta_0 + \beta_{1\times1} + \beta_{2\times2}, \ldots, + \beta_{t\times t} + \varepsilon$$

where

P = probability of farmers using paddocks or free grazing;

In $\left[\frac{P}{1-P}\right]$ = odds ratio (the odds of a farmer using free grazing or paddocks);

β_0 = intercept;

$\beta_{1\times1}$, …, $\beta_{t\times t}$ = regression coefficients of predictors.

ε = random residual error.

3. Results

3.1. Demographic Characteristics

Table 1 summarizes the socio-demographic characteristics of small ruminant farmers in Vanua Levu and Viti Levu. There was no association between the respondents' geographic

location and their demographic characteristics ($p > 0.01$). In both Vanua Levu and Viti Levu, more than 99% of the sheep and goat farmers were male. More than 90% of the farmers in both regions were over 30 years old and had formal education. Most of the small ruminant farmers in both Vanua Levu and Viti Levu were Hindus. More than half of the farmers reported having land of more than 20 acres, with a higher proportion in Viti Levu than in Vanua Levu.

Table 1. Socio-demographic characteristics of small ruminant farmers in Vanua Levu and Viti Levu.

		Frequency (%)		Chi-Square Test
Parameter	**Sub-Components**	**Vanua Levu**	**Viti Levu**	
Gender				ns
	Male	99.45	100	
	Female	0.55	0	
Age				ns
	<30 years	3.9	1.4	
	>30 years	96.1	98.6	
Education				ns
	Formal Education	100	90	
	No formal Education	0	10	
Religion				ns
	Hindus	94.54	88.57	
	Islam	4.92	2.86	
	Christians	0.55	8.57	
Occupation				ns
	Unemployed	90.16	84.29	
	Employed	9.84	15.71	
Land size				ns
	<10 acres	15.5	8.6	
	10–19 acres	24.8	20	
	>20 acres	59.7	71.4	

[ns] $p > 0.05$. Summary: Demographic characteristics of respondents did not differ by geographical location. Most of the respondents were unemployed Hindu males over 30 years old.

3.2. Purposes for Keeping Small Ruminants and Challenges Faced

The mean rank scores for keeping small ruminants are shown in Table 2. In both Vanua Levu and Viti Levu, income was ranked as the most important purpose of keeping sheep and goats ($p > 0.05$). Although the mean rank scores differed ($p < 0.05$), the overall ranking of meat production as a purpose of keeping sheep and goats was second in both Vanua Levu and Viti Levu. Hobby was ranked third as a purpose for keeping sheep and goats, whilst ceremonies ranked lowest in both areas ($p > 0.05$). Although there were differences in mean rank scores for predation, diseases, and cyclones ($p < 0.05$), the overall ranking of challenges faced by sheep and goat producers was the same in both study areas. Diseases were the biggest challenge, followed by cyclones, then predation. Theft was ranked lowest as a challenge to small ruminant production.

Table 2. Mean rank scores (ranks *) for the purpose of keeping small ruminants in Fiji's Vanua Levu and Viti Levu islands.

	Vanua Levu	Viti Levu
Purpose for keeping small ruminants		
Meat	2.05 ± 0.02 (2) [a]	2.36 ± 0.05 (2) [b]
Hobby	2.85 ± 0.19 (3) [a]	2.86 ± 0.03 (3) [a]
Main income	1.01 ± 0.004 (1) [a]	1.00 ± 0.01 (1) [a]
Ceremonies	3.98 ± 0.017 (4) [a]	3.97 ± 0.03 (4) [a]
Challenges faced		
Theft	3.69 ± 0.076 (4) [a]	3.04 ± 0.12 (4) [b]
Predation	2.82 ± 0.04 (3) [a]	2.62 ± 0.06 (3) [b]
Diseases	1.38 ± 0.072 (1) [a]	1.96 ± 0.12 (1) [b]
Cyclones	2.12 ± 0.03 (2) [a]	2.37 ± 0.3 (2) [b]

[a,b] Means in the same row with the same superscripts are the same ($p < 0.05$); * The lower the rank value, the more important the purpose of keeping small ruminants and the challenges faced. Summary: The primary purpose of keeping small ruminants in Fiji is income generation, followed by slaughter for consumption. Diseases were heightened as the main challenge for small ruminant production in Fiji, followed by cyclones.

Scabby mouth and foot rot were highlighted as common diseases among small ruminant flocks in Fiji. Figure 2 shows the perceived prevalence of the two diseases in Viti Levu and Vanua Levu. The perceived prevalence of the diseases differed with geographical location ($X^2 = 7.08$; $p < 0.01$). More than 65% of the farmers in Vanua Levu reported having scabby mouth and foot rot cases in their flocks, whilst less than 35% reported the same for Viti Levu ($p < 0.05$). More farmers reported scabby mouth amongst their sheep and goats in Vanua Levu, whilst the opposite was true in Viti Levu ($p < 0.05$).

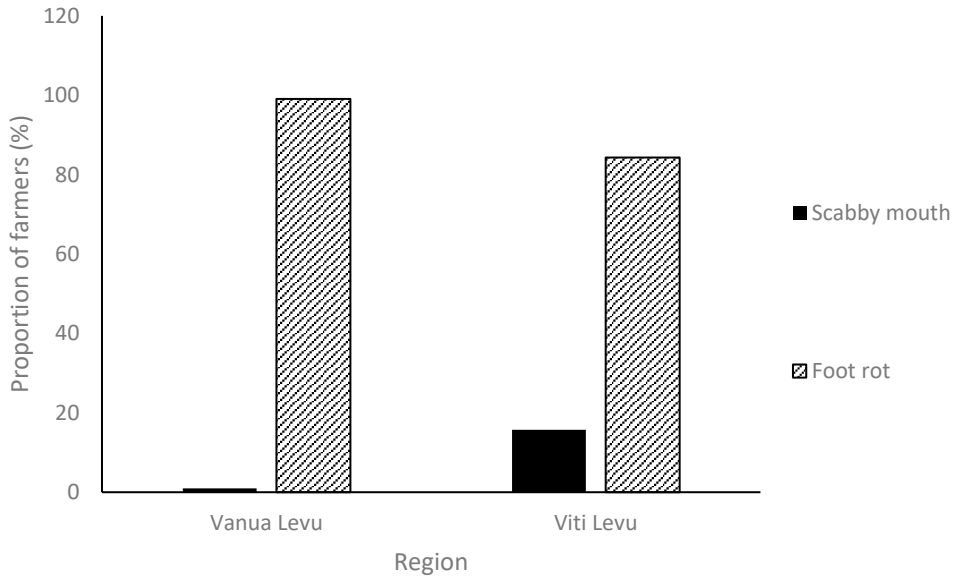

Figure 2. Proportion of farmers reporting scabby mouth and foot rot in their sheep and goat flocks in Fiji's Viti Levu and Vanua Levu islands.

3.3. Small Ruminant Management Practices

Grazing management for small ruminant production varied by geographic location ($X^2 = 20.57$; $p < 0.01$). Figure 3 shows the percentage of farmers using different grazing systems for their small ruminant herds in Vanua Levu and Viti Levu. The most common system in both areas was paddocking, with over 70% of farmers grazing their sheep and goats in paddocks. About a quarter of small ruminant producers in Viti Levu and 6% in

Vanua Levu practiced free grazing. Tethering was the least used system among Viti Levu sheep and goat farmers, accounting for only 4%. Farmers in Vanua Levu reported that they do not tether their sheep and goats. Odds ratios for respondents using various free-grazing and paddock systems are shown in Table 3. Hindu farmers were four times more likely to use paddocks for raising sheep and goats than Muslim farmers ($p < 0.05$). Conversely, Muslim farmers were three times more likely to practice free grazing than Hindu farmers ($p < 0.05$).

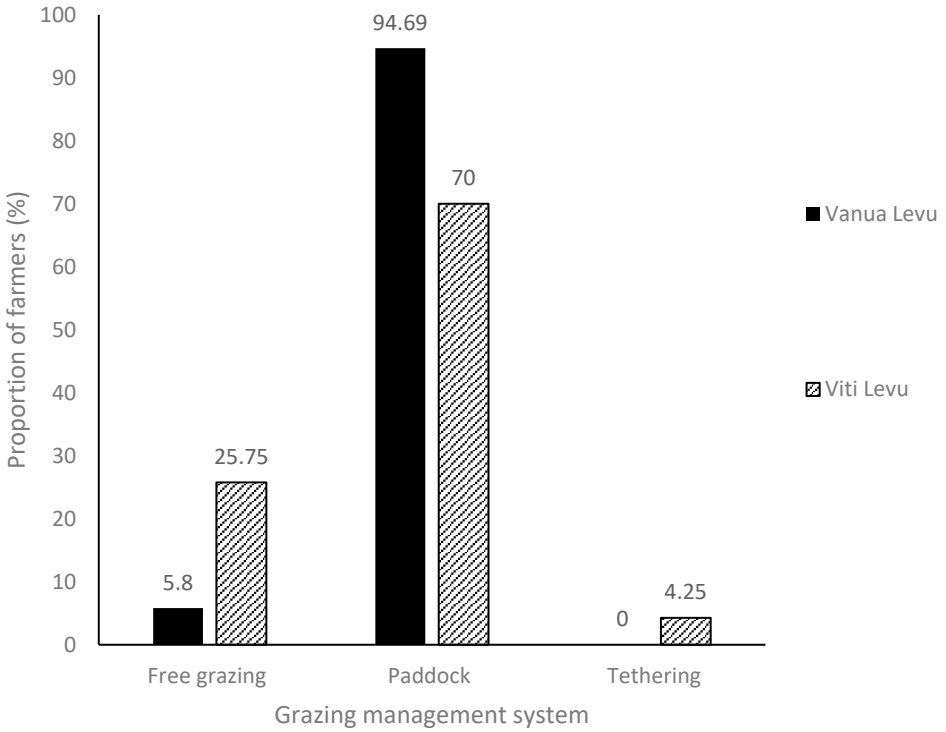

Figure 3. Proportion of farmers using different grazing systems for their sheep and goat flocks in Fiji's Viti Levu and Vanua Levu islands.

Table 3. Odds ratio estimates, lower and upper confidence intervals of Small ruminant producers in Vanua Levu and Viti Levu using different grazing practices.

Predictors	Paddock			Free Grazing		
	Odds	LCI	UCI	Odds	LCI	UCI
Location (Vanua Levu vs. Viti Levu)						
Religion (Hindus vs. Muslims)	3.61 *	1.78	7.48	0.351 *	0.169	0.731
Age (Young vs. old)	1.42 ^{NS}	0.452	4.447	1.059 ^{NS}	0.368	3.046
Education (not educated vs. educated)	2.543 ^{NS}	0.729	8.873	0.397 ^{NS}	0.114	1.382
Size (small vs. large)	0.571 ^{NS}	0.273	1.194	2.055 ^{NS}	0.964	4.382
Occupation (not working vs. working)	0.142 ^{NS}	0.018	1.133	6.816 ^{NS}	0.848	54.769

LCI—lower confidence level: UCI—upper confidence level. Higher odds ratio estimates indicate a greater difference in the likelihood of farmers using paddocking and free-grazing systems. * $p < 0.05$; ^{NS} $p > 0.05$. Summary: Hindu farmers were more likely to use paddocking for grazing their small ruminants, while Muslim farmers were more inclined to use free grazing.

Feeding practices for small ruminant producers varied by geographical location ($X^2 = 25.43$, $p < 0.01$). The proportion of farmers using supplementary feeding for small ruminants in Vanua Levu and Viti Levu is shown in Figure 4a. More than three quarters of the farmers in Viti Levu and Vanua Levu do not supplement their small ruminants. In Viti Levu, about 15% of small ruminant farmers provided supplementary feed, compared with

less than 1% in Vanua Levu. Disease treatment practices by small ruminant producers were the same in both locations ($X^2 = 2.60$, $p > 0.05$). Figure 4b shows the proportion of farmers using conventional and traditional medicine for treating small ruminants in Vanua Levu and Viti Levu. Almost all the farmers said they use conventional medicine to treat their animals. Less than 10% reported using traditional medicine.

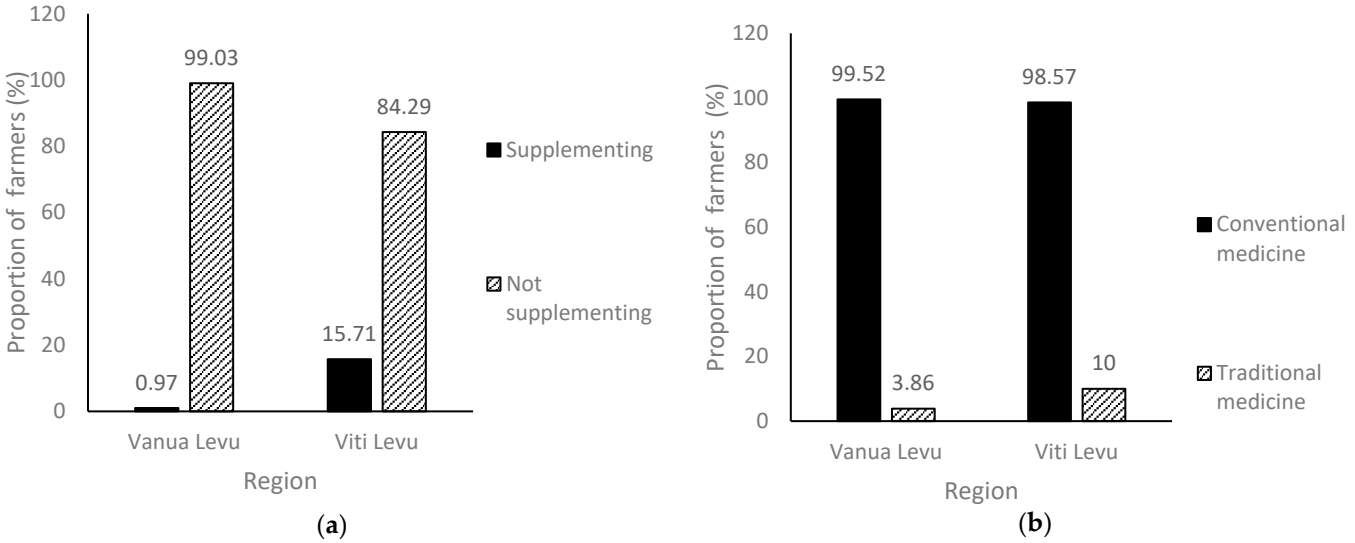

Figure 4. Proportion of farmers (**a**) providing supplementary feed and (**b**) using traditional medicine for their sheep and goat flocks in Fiji's Viti Levu and Vanua Levu islands.

3.4. Slaughter and Consumption Patterns

The mean rank scores for sources of small ruminants for slaughtering by farmers in Vanua Levu and Viti Levu are shown in Table 4. Ranking of sources for small ruminants for slaughter differed by region ($p < 0.05$). In both areas, most of the sheep and goats that were slaughtered came from farmers' flocks ($p > 0.05$). Farmers in Viti Levu ranked purchasing from neighbors second as a source of sheep and goats for slaughter, followed by other villagers, whereas the opposite was true in Vanua Levu ($p < 0.05$). Gift offerings were ranked least as a source of sheep and goats for slaughter in both areas ($p > 0.05$). The average age at slaughter of goats and sheep varied by geographical location (Table 4; $p < 0.05$). In Vanua Levu, the most preferred age for the slaughter of sheep and goats was less than one year, followed by a year and a half, whereas the opposite was true in Viti Levu ($p < 0.05$). Farmers in both areas least preferred slaughtering goats older than 2 years ($p > 0.05$).

The mean rank scores of the most preferred meat cuts for small ruminants in Vanua Levu and Viti Levu are shown in Table 5. The ranking of preferred meat cuts did not differ by geographical location ($p > 0.05$). The shank was the most preferred meat cut, followed by brisket, shoulder, neck, ribs, loin, and offal, in that order. Although they had different mean rankings ($p < 0.05$), overall rankings of taste, fat content, habit, and affordability as reasons for preferring specific meat cuts were the same across the two areas (Table 5). Farmers indicated that their preference for a particular cut of sheep or goat meat was mainly because it had become a habit, with taste coming second. Fat content was ranked least as a reason farmers preferred a particular cut from sheep and goat carcasses.

Table 4. Mean rank scores (ranks *) of sources of small ruminants for slaughtering and age at slaughter by farmers in Vanua Levu and Viti Levu Islands.

	Vanua Levu	**Viti Levu**
Source of small ruminant		
Own flock	1.00 ± 0.006 [a] (1)	1.05 ± 0.008 [a] (1)
Buy from neighbors	2.60 ± 0.038 [a] (3)	2.10 ± 0.052 [b] (2)
Buy from other villagers	2.39 ± 0.038 [a] (2)	2.90 ± 0.052 [b] (3)
Gift	3.99 ± 0.006 [a] (4)	4.00 ± 0.008 [a] (4)
Age at slaughter		
Less than a year	1.77 ± 0.0324 [a] (1)	1.92 ± 0.0442 [b] (2)
A year and a half	1.22 ± 0.032 [a] (2)	1.07 ± 0.044 [b] (1)
Older than 2 years	2.99 ± 0.006 [a] (3)	2.90 ± 0.052 [a] (3)

[a,b] Means in the same row with the same superscripts are the same ($p < 0.05$); * The lower the rank value, the more common the source of animal and age of slaughter. Summary: The main source of goats slaughtered in Fiji was farmers' own flocks. Farmers in Vanua Levu preferred slaughtering their sheep and goats before they turned one year old, while on Viti Levu, they favored slaughtering them at around a year and a half old.

Table 5. Mean rank score (rank *) of most preferred meat cuts and reasons for preference of small ruminants in Fiji's Vanua Levu and Viti Levu Islands.

	Vanua Levu	**Viti Levu**
Preferred meat cuts		
Ribs	4.73 ± 0.073 (5)	4.70 ± 0.0998 (5)
Shoulder	3.10 ± 0.028 (3)	3.10 ± 0.0382 (3)
Neck	4.10 ± 0.044 (4)	4.20 ± 0.061 (4)
Shank	1.16 ± 0.046 (1)	1.20 ± 0.064 (1)
Loin	6.05 ± 0.022 (6)	6.10 ± 0.030 (6)
Brisket	1.91 ± 0.053 (2)	1.90 ± 0.073 (2)
Offal	6.56 ± 0.104 (7)	6.80 ± 0.142 (7)
Reasons for preference		
Tender and juicy	3.00± 0.009 [a] (3)	3.00 ± 0.011 [a] (3)
Taste	2.00 ± 0.118 [a] (2)	2.42 ± 0.169 [b] (2)
Fat content	5.00 ± 0.037 [a] (5)	4.68 ± 0.051 [b] (5)
Habituated	1.00± 0.039 [a] (1)	1.31± 0.051 [b] (1)
Affordability	3.99± 0.020 [a] (4)	3.82 ± 0.028 [b] (4)

[a,b] Means in the same row with the same superscripts are the same ($p < 0.05$); * The lower the rank value, the more preferred the meat cut and the important the reason for preference of a meat cut. Summary: The shank was the most preferred part of sheep and goat carcasses in both Vanua Levu and Viti Levu, followed by the brisket. Preferences for these parts were mainly due to habit and taste.

4. Discussion

Sheep and goats, commonly referred to as small ruminants, play a key role in the food and nutrition security of many developing countries due to their ease of production. Despite their importance, small ruminant production systems and consumption patterns in Pacific Island Countries, Fiji included, are not well characterized. The existing literature on management practices and marketing of small ruminant production in the Pacific Islands is often limited to case studies, technical reports, and government reports, with very few, if any, peer-reviewed scientific articles available. The current study, therefore, contributes new empirical data on small ruminant production practices and consumption patterns in a Pacific island country. This empirical gap justifies drawing comparisons from extensively studied small ruminant production systems in Asia and Africa, which have smallholder production systems similar to those in the Pacific Islands. Although no directly comparable studies on small ruminant production in Fiji were found, the finding that old males dominated the small ruminant farming in Fiji's two main islands was expected. Fiji

is dominated by Hindu, Islamic, and iTaukei cultures, in which males are always regarded as the heads of households [22]. As a result, males take full responsibility for most of the farming activities [22]. Aldosari [23] and Adeyemo and Silas [24] reported that in many developing regions, cultural bias is a key factor that deprives women and youth of livestock ownership. Given that women's and youths' ownership of livestock has been reported to be strongly associated with improved food security and household income [25], efforts should be made to increase their ownership of small ruminants in Fiji.

Given Fiji's diverse religious backgrounds, with the indigenous iTaukei, who are mostly Christians, dominant [26], the finding that most small ruminant owners were Hindus was unexpected. No scientific literature on the association between religion and small ruminant ownership was found; however, the unexpected finding could be attributed to the effect of culture on agricultural practices, as reported by Wang et al. [27] and Thomas et al. [22]. Intervention programs should encourage small ruminant production across all cultural groups in Fiji. It was evident that land size is not a limiting factor for small ruminant production in Fiji, as most farmers own more than 20 acres. Due to their low maintenance requirements, sheep and goats require less land compared to cattle. The current study, however, did not include data on respondents' land rights. Although their research was not specifically on small ruminant production, Kumar and Bhati [28] reported that uncertainty due to limited land rights has adverse effects on agricultural productivity in Fiji. Future studies on the impact of land rights on small ruminant production in Fiji are necessary.

The finding that sheep and goats are primarily kept for income generation aligns with Cowley et al. [1], who emphasized their importance for income generation in Fiji. Previous studies in other developing regions, such as Asia and Africa, have reported that almost 3 quarters of the off-take of goats and sheep is sold as live animals [29,30]. Goats and sheep have been widely reported as better sources of income for resource-poor households than other livestock species because they have stable market value, high demand, tolerance across different cultures, and low investment requirements [31]. The high ranking of meat production as a purpose for keeping small ruminants is consistent with studies by Peacock [32], who reported that although they are mainly raised for sale, households in developing regions often slaughter their goats for consumption. APAARI [33] and Cobbold et al. [34] reported that, although there are formal abattoirs, home slaughter of sheep and goats in Pacific Islands such as Fiji and Papua New Guinea is a common practice. Since Fiji is a country where small ruminants are essential in religious festivities [1], the low ranking of ceremonies as reasons for keeping goats was unexpected. The unexpected result may be due to ceremonies occurring occasionally. Cowley et al. [1] reported event-driven spikes in goat and sheep prices and sales during ceremonies such as Eid al-Adha and the festive season. Such episodic demand spikes for sheep and goats have also been reported in Asia [35].

Diseases are the primary challenge faced by small ruminant producers in both Vanua Levu and Viti Levu. To our knowledge, there are no publications in the Pacific Islands that rank diseases among other challenges to sheep and goat production. However, similar sheep and goat production systems in regions with comparable climatic conditions, production practices, and limited veterinary services consistently identify diseases as the main obstacle for smallholder farmers [36,37]. The high prevalence of sheep and goat diseases in Fiji can thus be attributed to climatic conditions and the lack of adequate veterinary infrastructure, surveillance, and diagnostic programs. Small ruminant production in Fiji is dominant on the western side of Viti Levu and the northern part of Vanua Levu, both of which experience hot, humid climates [1,38]. These conditions facilitate the transmission of infectious diseases in livestock [39]. Consistent with our findings, Brioudes et al. [40] and

Naden [41] reported that diseases are among the key causes of livestock mortality in Pacific Island countries. According to Tukana et al. [42], with a focus on cattle disease control, there is a high rate of disease prevalence among Fijian small ruminant herds due to a lack of effective disease surveillance and control programs.

The finding that very few farmers in Fiji use traditional medicine to treat their sheep and goats agrees with Bakare et al. [43], who reported that, despite limited veterinary services, very few farmers in the Pacific Islands utilize herbal medicine for their livestock. Although most farmers rely on conventional medicines to treat their animals, the high prevalence of scabby mouth and foot rot in Vanua Levu may indicate the ineffectiveness of their treatment and control programs. Fiji's population and agricultural sector are concentrated in Viti Levu [44], which is also home to the country's main urban centers. The high occurrence of small ruminant diseases in Vanua Levu, compared to the low prevalence in Viti Levu, could suggest geographic barriers to animal health services in the more remote, less populated islands. Similarly, rural-urban comparisons in Asia have shown that disease prevalence in small ruminant flocks is higher in rural areas than in peri-urban areas [45,46]. To boost productivity in Fiji, it is necessary to strengthen disease monitoring, surveillance, and control for small ruminants, especially on remote islands such as Vanua Levu. Farmers in regions with limited veterinary services should be encouraged to use traditional medicine. Bakare et al. [43] claim that traditional livestock management practices that include medicinal herbs are highly important socioeconomically for resource-limited farmers and pastoral populations. As expected, cyclones were reported as the second most significant challenge to small ruminant production in Fiji. Unlike cattle, sheep and goats cannot withstand cyclones. There is a need to implement initiatives to reduce the loss of sheep and goats to cyclones in both Viti Levu and Vanua Levu.

The widespread use of the paddocking system for grazing sheep and goats is likely the reason feed shortage was not highlighted as a challenge to small ruminant production in Fiji. Free grazing, a common practice among sheep and goat producers in many developing regions [47], has been reported as one of the main causes of feed shortages [48]. Paddocking allows controlled grazing, thereby promoting the regrowth of sufficient grass and reducing the negative impact of overgrazing on grazing land. The use of paddocks could also explain why very few farmers in Viti Levu tether their goats. Tethering is a feeding practice commonly used by farmers without paddocks to control their sheep and goats' access to cultivated crops [49]. The finding that Hindus were more likely to use paddocks whilst Muslims are more likely to use free grazing might be aligned with differences in religious practices and beliefs. For example, Humane Islamic teachings on animal welfare emphasize allowing animals to roam freely when grazing [50]. Any intervention programs aimed at enhancing sustainable sheep and goat grazing practices should therefore adopt a holistic approach that incorporates religious beliefs alongside environmental, economic, and other social factors.

More than three quarters of farmers in both Vanua and Viti Levu reported that they do not supplement their small ruminants. This aligns with findings from smallholder systems in other developing regions, such as Asia and Africa, where most sheep and goat producers do not provide supplementary feed [51,52]. The widespread use of paddocking, combined with a lack of supplementary feeds, may explain why most farmers do not supplement their sheep and goats. However, paddocking alone, without supplementation during dry periods, is not sufficient to maximize small ruminant productivity. A few farmers in Pacific Island countries supplement their small ruminants with conventional feeds and other expensive commercial products, such as copra meal, which is costly [53]. Exploring the use of inexpensive, non-conventional feed sources, such as food industry by-products and

agricultural wastes, as supplements for small ruminants is recommended. Additionally, training small ruminant producers on hay and silage making is essential.

Expectedly, farmers in this study preferred slaughtering goats at the age of 1 to 1.5 years. Comparative data from Asia and Africa show that sheep and goats are usually slaughtered at 1 to 2 years under communal systems [54]. The finding that most of the small ruminants slaughtered for consumption were from the respondents' own flocks resonates with Gwaze et al. [55] and Zewdie et al. [56], who reported that goat producers in developing regions typically raise and slaughter their own goats to reduce household expenditure. In agreement with the findings of this study, Kumar and Bhati [28] also noted that many sheep and goat producers in Fiji prefer selling their animals to the main market, where they fetch better prices than to community members who usually use personal connections to over-negotiate prices. Communal households, therefore, face market limitations and end up slaughtering their own sheep and goats when the need arises. Local selling and purchasing of small ruminants should be encouraged to increase market access and diversification. The finding that farmers in Viti Levu preferred purchasing sheep and goats from neighbors more than those in Vanua Levu could indicate differences in the market structures of the two areas. Due to higher demand than in Vanua Levu, sheep and goats in Viti Levu are more expensive [1]. It is possible that Viti Levu households prefer to buy from their neighbors in search of better prices. Creating small ruminant market linkages between Fiji's Viti Levu and Vanua Levu can help level up the market structure.

The finding that Vanua Levu farmers slaughtered goats at a younger age than those in Viti Levu was expected. Casey and Webb [57] reported that, due to resource constraints and the need for both food and income, goats in remote areas are often slaughtered at a young age. In contrast, farmers near business hubs like those in Viti Levu usually have the resources, market needs, and knowledge to enhance longer rearing periods resulting in better slaughter weights, meat quality, and profitability [58]. Fijian sheep and goat producers based in Vanua Levu should be given support that enables them to rear their small ruminants for longer periods to optimize meat yield and profitability.

Management practices for ruminants significantly affect meat quality, consumption patterns, and, consequently, the market and sustainability of production systems [59]. In contrast to findings herein that the shank is the most preferred cut on sheep and goat carcasses, it differs from some Asian and African studies by Wilson [60] and Prasad and Kirton [61], which showed that, after slaughtering sheep and goats, the brisket is usually the first cut to be cooked. Given that farmers in this study indicated their preference for carcass cuts is primarily based on habit and taste, which are closely linked, the differences in findings between the current study and studies in Africa and Asia can be attributed to cultural backgrounds. It is therefore important to understand market needs within each country, cultural group, or region before developing production goals for sheep and goats. It would be interesting to conduct similar studies in other Pacific Island countries and compare the findings with those herein.

While the study provides valuable baseline data on sheep and goat production systems in Fiji, some limitations should be acknowledged. The survey was cross-sectional and did not account for seasonal variations in small ruminant production practices in Fiji. Considering that Fiji is characterized by distinct climatic seasons [38], which influence factors such as disease and parasite prevalence, pasture availability, pasture quality, and market access [43], it is expected that production practices and consumption patterns vary across seasons. Longitudinal studies on small ruminant production in regions with similar climatic conditions have demonstrated this variation [62]. Future studies in Fiji should, therefore, examine the effects of seasonality on sheep and goat production practices and consumption patterns. The land tenure aspect, a key challenge to farming in Fiji [26], was

also not explored in detail, along with women's and youth's roles, because very few women and youths participated in the study. Women and youth play very important roles in household food security and income generation, especially in developing regions [23]. Therefore, future research should stratify participant selection based on gender and age to better understand gender and age dynamics in small ruminant production and consumption. It is also likely that some farmers did not have sufficient understanding of certain challenges, such as internal parasites and some diseases, and thus underestimated their true impact. Future studies should combine farmer perceptions with observational studies to ensure accurate characterization of the production systems.

5. Conclusions

This study addresses a significant gap in management practices and constraints in sheep and goat production in Fiji, expanding the limited existing research in the Pacific Islands. Diseases such as scabby mouth and foot rot are the most pressing challenges to small ruminant production in Vanua Levu and Viti Levu, highlighting the necessity of improving access to veterinary services to enhance animal welfare and productivity. These diseases are more common in Vanua Levu than in Viti Levu, emphasizing the need to address spatial disparities in veterinary intervention programs. While there are some differences, most sheep and goat production practices and consumption patterns are similar between Fiji's two main small-ruminant-producing islands. Most farmers in both Viti Levu and Vanua Levu utilize paddocking to graze their sheep and goats, with free grazing being more common in Viti Levu, followed by paddocking. A small number of sheep and goat farmers in Viti Levu practice tethering, which raises significant animal welfare concerns. Encouraging farmers who currently use free grazing or tethering to adopt paddocks could improve both productivity and animal welfare. These grazing practices also reflect cultural influences, with Hindus more likely to use paddocks and Muslims favoring free grazing. Therefore, any intervention programs should be culturally sensitive, incorporate indigenous knowledge, and promote effective and sustainable grazing strategies. In households on both of Fiji's main islands, the shank is the most preferred primary cut from sheep and goat carcasses, a taste preference developed over time. Differences in production and consumption are likely due to Vanua Levu receiving fewer agricultural extension and veterinary services than Viti Levu, owing to its remote location. Intervention programs should consider the diversity among producers regarding religion and culture. Decentralizing services such as veterinary care, extension, and market access could be a key strategy to enhance small ruminant production throughout Fiji. This study provides valuable insights into small ruminant management practices and consumption patterns on Fiji's two main islands. However, the data did not account for seasonal variations in management and consumption. Future research should include longitudinal surveys covering both dry and wet seasons to understand the dynamics of these practices better.

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