biology and life sciences forum

Proceeding Paper

Exploring the Economic Viability of Integrating *Jamnapari* Goat into Underutilized Pastures under Coconut Cultivations in Coconut Research Institute, Sri Lanka †

Tharindu D. Nuwarapaksha [1], Udaya N. Rajapaksha [2], Jayampathi Ekanayake [2], Senal A. Weerasooriya [3] and Anjana J. Atapattu [1,*]

1 Agronomy Division, Coconut Research Institute of Sri Lanka, Lunuwila 61150, Sri Lanka; tdnp.nuwarapaksha95@gmail.com
2 Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Peradeniya 20400, Sri Lanka; unatharanga@gmail.com (U.N.R.); jayampathiekn@gmail.com (J.E.)
3 Department of Agricultural Economics and Business Management, Faculty of Agriculture, University of Peradeniya, Peradeniya 20400, Sri Lanka; senalw@agri.pdn.ac.lk
* Correspondence: aaajatapattu@gmail.com; Tel.: +94-077-3782936
† Presented at the 3rd International Electronic Conference on Agronomy, 15–30 October 2023; Available online: https://iecag2023.sciforum.net/.

Abstract: The aim of this study was to evaluate the economic feasibility of integrating *Jamnapari* goats into underutilized pasture lands under coconut cultivations managed by the Coconut Research Institute of Sri Lanka. Naturally grown and improved pasture samples were collected from coconut estates in the intermediate zone of Sri Lanka. Samples were taken randomly using a quadrant, and analyzed for dry matter (DM) yield (kg/ha), crude protein (CP), and crude fiber (CF) contents. An economic feasibility analysis was carried out based on average DM yields and respective carrying capacities of pastures and related production and economics data. The mean DM yield of natural and improved pastures ranged from 2141 ± 193 kg/ha to 3314 ± 212 kg/ha and 4231 ± 407 kg/ha to 9152 ± 531 kg/ha, respectively. Accordingly, CP and CF of natural and improved pastures ranged from 6.3 ± 0.2% to 18.5 ± 0.2% and 30.0 ± 0.4% to 33 ± 0.3%, respectively. Estimated *Jamnapari* goat carrying capacities for natural and improved pastures were 8 heads/ha and 24 heads/ha, respectively, including does, kids, and a buck. At a 15% discount rate for 10 years, the net present value (NPV) for the coconut monoculture system was approximately 0.45 million rupees, and for integrated systems with natural and improved pastures, it was 1.4 and 4.7 million rupees, respectively. This study concluded that, when goats are integrated with improved and natural pastures rather than maintaining a monoculture, the economic feasibility and profitability will be higher.

Keywords: coconut; natural pastures; improved pastures; dry matter yield; carrying capacity

check for updates

Citation: Nuwarapaksha, T.D.; Rajapaksha, U.N.; Ekanayake, J.; Weerasooriya, S.A.; Atapattu, A.J. Exploring the Economic Viability of Integrating *Jamnapari* Goat into Underutilized Pastures under Coconut Cultivations in Coconut Research Institute, Sri Lanka. *Biol. Life Sci. Forum* **2023**, *27*, 27. https://doi.org/10.3390/IECAG2023-14990

Academic Editor: Daniel Real

Published: 13 October 2023

1. Introduction

Coconut (*Cocos nucifera* L.) cultivated land in Sri Lanka spans approximately 505,000, making the coconut the most widely cultivated plantation crop of the island nation [1]. Due to the morphological characteristics of the coconut tree, the land use efficiency can be low when coconut is grown as a monoculture. Prior studies indicated that the coconut monoculture system and its growth patterns effectively made use of merely 25% of the total land area. Moreover, approximately 30% of the canopy space was put to use, with solar radiation absorption reaching around 44% [2]. Meanwhile, livestock integration is becoming popular among coconut cultivators, as it can benefit resource exchange, especially in areas where arable land is limited for intercropping. Rising costs of inorganic fertilizer and weeding have increased the cost of production of coconut, with the highest proportion of expenditure being for manuring and weeding [3]. Integration of livestock is beneficial to the productivity of coconut lands while reducing the cost of production, especially for manuring and weeding, and increasing nutrient recycling and soil fertility [4]. To continue the high soil fertility of coconut lands, the organic matter content and other factors need to be improved [5]. Naturally grown pastures under coconut trees contain indigenous grasses, herbs, and legumes, and can be a good pasture source for integrated animals. Therefore, introducing smaller ruminants such as goats and sheep into coconut lands can be a potential further increment of productivity of coconut lands [6]. Integrating smaller ruminants into the natural vegetation available in underutilized pastures in coconut lands will bring additional food sources and income to the country using the existing resources. If improved pasture, fodder, and creeping legumes are cultivated under the coconut, the carrying capacity of animals can be multiplied depending on the inputs. However, there can be many economic factors affecting the integration process. Therefore, before this activity, assessing the economic feasibility of the integration to determine whether the process is economically viable to proceed is essential [7]. If this activity is feasible enough, other coconut lands with underutilized pastures can also be considered for small ruminant integration. Therefore, this study aimed to assess the economic feasibility of goat integration into the underutilized pastures in coconut lands, and to identify the level of goat carrying capacity under natural and improved pasture categories in coconut lands.

2. Materials and Methods

2.1. Location and Sample Collection

This experiment was carried out in the Agronomy Division, Coconut Research Institute, Lunuwila (7°20′37″ N, 79°51′42″ E), which is located in the intermediate zone of Sri Lanka. Pasture samples were collected from natural (uncultivated) and improved (cultivated) pastures from Bandirippuwa and Makandura estates, respectively. Coconut lands in the Bandirippuwa estate contained uncultivated or natural pastures for a long period. The Makandura estate contained separately cultivated fields of improved pasture varieties of *Brachiaria brizantha*, *Brachiaria ruziziensis*, and *Brachiaria milliformis*. Natural pastures were further categorized according to identified fields with high grass composition (high_grass), high legume composition (high_legume), low grass composition (low_grass), and grass-legume balanced composition (grass_legume mixed). Quadrant-cut samples (1 m^2) were collected randomly from each identified field under coconut to estimated dry matter (DM) availability.

2.2. Determination of DM Yield

Each quadrant-cut sample was dried at 60 °C to a constant weight. The following equation was used to calculate the percentage of field DM yield (kg/ha).

$$\text{Dry matter (kg/ha)} = \frac{(\text{Dry quadrant} - \text{cut sample weight (kg)}}{\text{Area of the quadrant}(1\ m^2)} \times 10{,}000$$

2.3. Proximate Composition of Pasture Samples

The dried sample used for DM content estimation was ground and sieved and used to determine laboratory DM content, crude protein (CP), and crude fiber (CF) percentages. CP content was determined using the Kjeldahl distillation unit (Kjeltec™ 8100, Hilleroed, Denmark), and CF content was determined using a fiber-determining apparatus (Fibertec™ 8000, Hilleroed, Denmark).

2.4. Estimation of Carrying Capacity of Jamnapari Goats

The mean DM yields were used to determine DM availability for the integration of goats. The area reserved for manure circles per hectare was reduced from the calculated DM yield (1607.4 m^2). As all of the DM would not be utilized, 80% and 90% utilization of the natural and improved pastures, respectively, were considered. The remaining DM availability was divided from the average DM. The average DM intake of goats (3% of body weight) was used to estimate the carrying capacity of goats. The average weight of a doe through the productive period, the average weight of a kid before selling, and the average weight of a stud buck through the productive life were calculated to determine the average DM intake of the herd with does, kids, and a buck. The first batch of does and bucks were assumed to be bought at the breeding age of 11 months, and then replaced with the kids born when they reach sexual maturity, and were serviced at 11 months.

$$\text{Carrying Capacity} = \frac{\text{Available DM (kg/ha)} \times \text{Utilization (\%)}}{\text{DM intake of the herd (1 doe} + \text{2 kids} + \text{1 buck) per year}}$$

2.5. Cost–Benefit Analysis

According to the data collected and calculations performed, a cost–benefit analysis was performed, and net present value (NPV) and benefit–cost ratio (BCR) were calculated to assess the costs, benefits, and net cash flow of coconut monoculture, mono goat farming, and integration (Bt = value of benefits in the tth year, Ct = value of costs in the tth year, r = discount rate (15%), t = time period/year).

$$\text{NPV} = \sum_{t=1}^{n} \frac{\text{Bt}}{(1+r)^{t}} - \sum_{t=1}^{n} \frac{\text{Ct}}{(1+r)^{t}} \quad \text{BCR} = \frac{\sum_{t=1}^{n} Bt/(1+r)^{t}}{\sum_{t=1}^{n} Ct/(1+r)^{t}}$$

3. Results and Discussion

3.1. DM Yield of Pastures

DM yield ranged between 2141 kg/ha and 9152 kg/ha from all pasture categories (Figure 1). The highest DM yield was observed in *B. brizantha* (9152 kg/ha), and the lowest was in the grass–legume mixed category (2141 kg/ha). However, improved pasture categories indicated significantly different DM yields among natural categories, except for high grass. According to [8], DM mass under farmlands was around 2500 kg/ha in the rainy season, and 2000 kg/ha in the drought season, which is in the range of DM yields of natural pastures observed in this study. DM yields of improved pasture varieties found in a previous study were 9000 kg/ha, 7700 kg/ha, and 7400 kg/ha in *B. brizantha*, *B. milliformis*, and *B. ruziziensis*, respectively [9]. *B. brizantha* shows the highest DM yield, which agrees with the findings of the current study. Although in the current study, the yield of *B. milliformis* was lower than the above findings, according to [10], the DM yield of *Pueraria phaseoloides* is 4.46 t/ha under coconut, which is the prominent legume in the high-legumes category of natural pastures, and resulted in 3.31 t/ha in the current study.

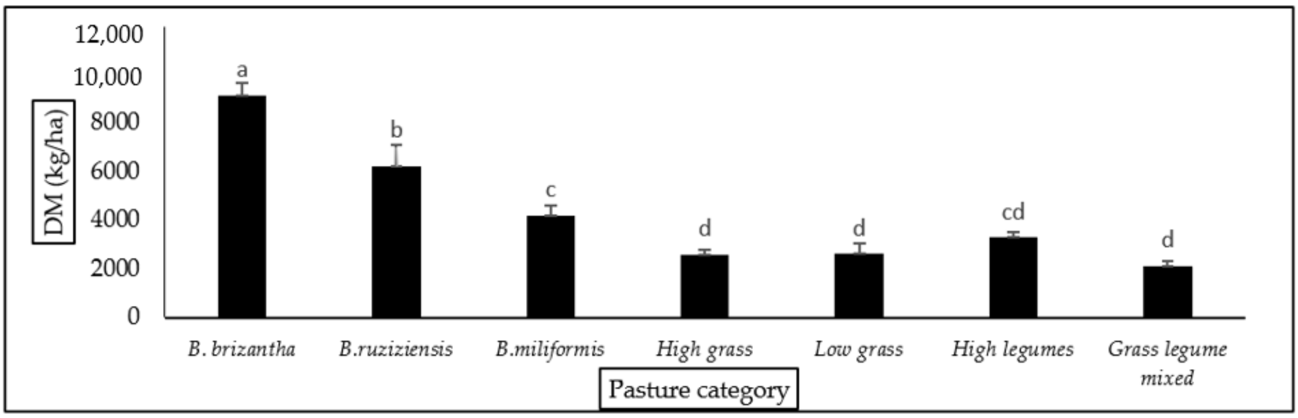

Figure 1. DM yield of improved and natural pasture categories under coconut. (Means that do not share the same letters are significantly different at $p < 0.05$ level).

3.2. CP Content of Pastures Categories

The CP content of natural pastures varied from 9.9% to 18.5%, while it ranged from 6.3% to 7.7% in improved pastures (Figure 2). The CP content of natural pasture categories, low-grass, high-legumes, and grass–legume mixed categories were significantly higher (12.8% to 18.5%) than other improved pasture categories (6.3% to 9.9%). The highest CP percentage was observed in the high-legume category of natural pasture (18.5%), mainly due to the high proportion of legumes in the pasture. All categories were compared with the lowest CP content in *B. brizantha* (6.3%). It has also been found that the role of legumes in a mixed pasture is important for increasing nutritive value, as well as digestibility and aiding in fixing nitrogen and transferring it into grasses in the mixture [11].

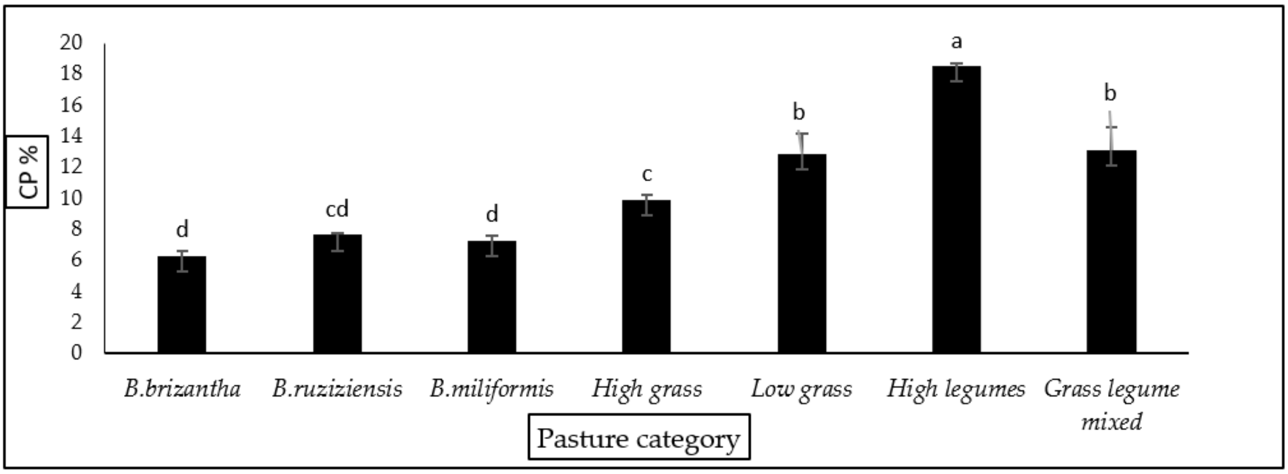

Figure 2. CP content of improved and natural pastures under coconut cultivation. (Means that do not share the same letters are significantly different at $p < 0.05$ level).

3.3. CF Content of Pastures

The CF content of pastures shows less variation among pasture categories. There were fewer significant differences between improved and natural pastures. CF content varied from 30.1% to 33% among pastures (Figure 3). The highest CF percentage was in *B. miliformis* (33%), and the lowest CF content was in the grass–legume mixed category (30.1%). CF content increases when the pasture matures and affects the digestibility of pastures in animals [12]. Therefore, the high CF contents observed in this study could be due to the high maturity levels of pastures. It is likely, therefore, that the digestibility of pastures can be low in animals; however, organized rotational grazing can be used to alleviate this issue.

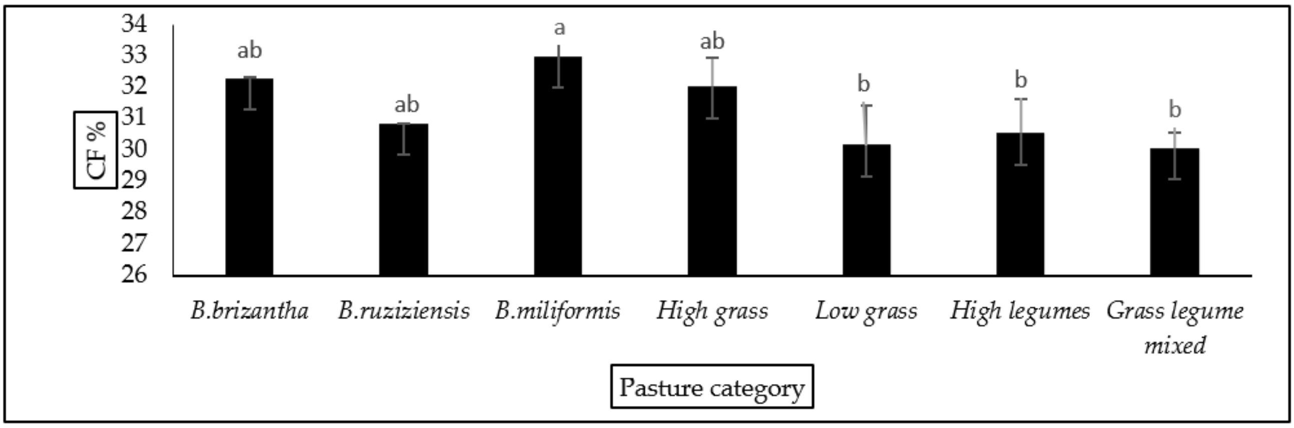

Figure 3. CF content of improved and natural pastures under coconut cultivation. (Means that do not share the same letters are significantly different at $p < 0.05$ level).

3.4. Carrying Capacity of Goats under Natural and Improved Pastures

From the results of the carrying capacity calculation considering 80% and 90% utilization of available natural and improved pastures, it was found that with natural pasture under 1 ha land of coconut, 2 does, 5 kids, and a stud buck would be able to integrate; with improved pasture, it would be 8 does, 16 kids, and a stud buck. Total herd sizes under natural and improved pastures were 8 goats and 24 goats per hectare, respectively.

3.5. Feasibility Tools for Assessing the Profitability of Integration

The results showed that coconut-improved pasture–goat integration has the highest NPV and BCR for 10 years, at a 15% discount rate, while the lowest is for coconut monoculture (Table 1). Therefore, it is feasible and profitable to practice the integration of goats under coconut rather than waste resources under coconut by monoculture system, and increase the profitability and productivity of coconut lands. According to [13], livestock integration substantially improved the income-per-unit-cost from the total system. Additionally, that integrated system represents a key solution for enhancing livestock and coconut production, and safeguarding the environment through prudent and efficient resource use.

Table 1. Variation of NPV and BCR between coconut monoculture and integration of goats into one ha coconut land.

Cropping System	BCR (%)	NPV (Million Rupees)
Coconut monoculture	1.16	0.45
Coconut goat integration (natural pasture)	1.41	1.4
Coconut goat integration (improved pasture)	2.04	4.7

4. Conclusions

The results from this study have shown that the underutilized pastures under coconut lands can be used as potential resources for goat integration with sufficient DM yield and other nutritive components, such as CP and CF. With resource availability, integrating goats into natural and improved pastures is more profitable than coconut monoculture. With improved pastures, the size of the herd increased three-fold more than the natural pastures. The BCR is almost twice as high in coconut-improved pasture–goat integration than coconut monoculture. When comparing the coconut–natural pasture–goat integration system and coconut-improved pasture-goat integration, the NPV showed a three-fold increment in coconut-improved pasture–goat integration. Therefore, it is profitable to practice integrating goats with pastures under coconut, while integrating goats with improved pastures rather than natural pastures.

Author Contributions: Conceptualization, A.J.A., J.E. and S.A.W.; methodology, A.J.A. and U.N.R.; software, T.D.N.; validation, A.J.A., J.E. and S.A.W.; formal analysis, J.E. and S.A.W.; investigation, T.D.N. and U.N.R.; resources, A.J.A. and J.E.; data curation, T.D.N.; writing—original draft preparations, T.D.N. and U.N.R.; writing—review and editing, A.J.A., J.E. and S.A.W.; visualization, T.D.N. and U.N.R.; supervision, A.J.A., J.E. and S.A.W.; project administration, A.J.A. and J.E. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: All data are contained within the article.

Acknowledgments: The authors express their gratitude to the Coconut Research Institute and Faculty of Agriculture, University of Peradeniya, Sri Lanka for supporting this research. We would like to express our appreciation to the technical staff of the Agronomy Division of the Coconut Research

Institute. We extend our gratitude to the editor and three anonymous reviewers for their valuable comments and critical evaluation.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. CBSL Statistics. Central Bank Annual Report Data. Available online: https://www.cbsl.gov.lk/sites/default/files/cbslweb_documents/publications/annual_report/2021/en/Full_Text_Volume_I.pdf (accessed on 13 July 2023).
2. Liyanage, M.D.S.; Martin, M.P.L.D. Soybean-coconut intercropping. *Cocos* **2010**, *5*, 28–31. [CrossRef]
3. Senarathne, S.H.S. Effect of Different Weed Management Strategies on Population Changing Pattern of *Pennisetum polystachion* in Coconut Plantations of Sri Lanka. *CORD* **2019**, *35*, 8. [CrossRef]
4. Samarajeewa, A.D.; Schiere, J.B.; Ibrahim, M.N.M.; Viets, T. Livestock Farming in Coconut Plantations in Sri Lanka: Constraints and Opportunities. *Biol. Agric. Hortic.* **2003**, *21*, 293–308. [CrossRef]
5. Atapattu, A.A.A.J.; Senarathne, S.H.S.; Raveendra, S.A.S.T.; Egodawatte, W.C.P.; Mensah, S. Effect of short term agroforestry systems on soil quality in marginal coconut lands in Sri Lanka. *Agric. Res. J.* **2017**, *54*, 324. [CrossRef]
6. Dissanayaka, D.M.N.S.; Dissanayake, D.K.R.P.L.; Udumann, S.S.; Nuwarapaksha, T.D.; Atapattu, A.J. Agroforestry—A key tool in the climate-smart agriculture context: A review on coconut cultivation in Sri Lanka. *Front. Agron.* **2023**, *5*, 1162750. [CrossRef]
7. Dunning, J.H.; Robson, P. Multinational Corporate Integration and Regional Economic Integration. *J. Common Mark. Stud.* **1987**, *26*, 103–125. [CrossRef]
8. Weerasinghe, W.M.P.B. *Livestock Feeds and Feeding Practices in Sri Lanka*; SAARC Agriculture Centre: Dhaka, Bangladesh, 2019; pp. 181–206.
9. Guenni, O.; Marín, D.; Baruch, Z. Responses to drought of five *Brachiaria* species. I. Biomass production, leaf growth, root distribution, water use and forage quality. *Plant Soil* **2002**, *243*, 229–241. [CrossRef]
10. Liyanage, M.D.S.; Jayasundara, H.P.S.; Fernando, D.N.S.; Fernando, M.T.N. Integration of legume-based pasture and cattle into coconut farming systems in Sri Lanka. *J. Asian Farming Syst. Assoc.* **1993**, *1*, 579–588.
11. Rochon, J.J.; Doyle, C.J.; Greef, J.M.; Hopkins, A.; Molle, G.; Sitzia, M.; Scholefield, D.; Smith, C.J. Grazing legumes in Europe: A review of their status, management, benefits, research needs and future prospects. *Grass Forage Sci.* **2004**, *59*, 197–214. [CrossRef]
12. Blaser, R.E. Symposium on Forage Utilization: Effects of Fertility Levels and Stage of Maturity on Forage Nutritive Value. *J. Anim. Sci.* **1964**, *23*, 246–253. [CrossRef]
13. Seresinhe, T.; Marapana, R.A.U.J.; Kumanayaka, L. Role of local feed resources on the productivity and financial viability of a coconut-cattle integrated system in the southern Sri Lanka. *Anim. Nutr. Feed Technol.* **2012**, *12*, 145–156.