

SHORT

Key determinants of milk production in dairy farms of Jaffna district, Sri Lanka

^aK. Arthika, W.A.D.V. Weerathilake ^{a*}

^aDepartment of Livestock and Avian Sciences, Faculty of Livestock, Fisheries and Nutrition, Wayamba University of Sri Lanka, Makandura, Gonawila (NWP) 60170, Sri Lanka

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*Correspondence: dammika_kandy@yahoo.com

ABSTRACT

Dairy farming has tremendous potential in the economy of the Jaffna district. However, the dairy farms of the district were incompetent to cater to the demands. Therefore, this study investigated the factors determining milk production in dairy farms of the Jaffna district. A total of 150 farms were selected using a stratified and simple random sampling technique. Milk production and socio-economic data were collected using a structured questionnaire covering randomly selected 5 Veterinary Surgeon Divisions. Data were analysed for descriptive statistics followed by multiple linear regression analysis. Results of the descriptive statistical analysis of demographic data showed that 38.6% of farms were under semi-intensive, 37.3% were under intensive management systems and the rest of 24% were under an extensive management system. Further, 65.3% of animals were Jersey crosses, while 22.6% were local breeds and 12% of animals were Sahiwal crosses. About 75% of the farmers were feeding their dairy animals with roadside grasses and only 25% were feeding with quality forages. The average milk production per animal per day was 3.14 L. The best fitted multiple linear regression model predicted that R^2 value of 92.05% daily milk production suggesting that experience of farmers, frequency of drinking water supply, frequency of feeding concentrate, amount of concentrate given (kg d^{-1}), amount of mineral supplement given (g d^{-1}) and types of management system were significantly ($P < 0.05$) affected the daily milk production of Jaffna district. It is suggested that the dissemination of knowledge regarding these key-determinants of milk production is crucial for the improvement of milk production from the Jaffna district.

Keywords: Milk production, key-determinants, Jaffna district, regression

INTRODUCTION

Sri Lanka is an agricultural country endowed with ideal ecological factors. Agriculture is the major determinant behind the sustenance of people and thus contribution to the national gross domestic production (GDP) is about 7% (CBSL, 2020). Livestock, which is one of the important sub-sectors of agriculture, contributes about 1% to the national GDP (DAPH, 2019). Dairy, poultry, swine and micro livestock are the major components of the livestock industry. Among them, dairy is of paramount importance due to its economic potential in the country.

Farming of dairy cattle is practised from prehistoric times in the country and presently it is the major source of income for the rural poor (DAPH, 2019). Dairying is capable of converting low-value agricultural by-products, crop residues and cheap family labour into a valuable market commodity. Milk has the unique property of being the only one specifically prepared in nature as food. Along with raw milk, the consumption of milk products is also popular in the country. When considering the present situation of the dairy industry in the country, still depends on small-scale dairying. According to the DAPH (2019), out of the 424 million litres of milk that was produced locally, the volume of milk entering the formal milk market in 2019 was reduced to 243 million litres while the rest was channelled through informal routes and also consumed domestically. Total milk availability within the country decreased by 9% reaching 1,149 million litres resulting reduction of per capita availability of 58 L in 2018 to 52 L in 2019 (DAPH, 2019).

Although the government is implementing new projects to make the country self-sufficient in dairy, where 61% of milk and dairy requirement is still dependent on imports. The dairy sector of Sri Lanka mainly depends on cattle production systems. Cattle management systems in the country vary according to ecological factors and the aim of the production systems. Main Production systems in the country are classified as an upcountry intensive system, mid-country intensive system, wet and intermediate zone semi-intensive system, intermediate and dry zone extensive system and dry zone intensive system (Abeygunawardena *et al.*, 1997). Among them, the system which is prominent in the Jaffna district, can be categorized as a wet and intermediate zone semi-intensive system with the features of a combination of tethered and/or free grazing with limited feeding of concentrates targeting mostly the household consumption (Abeygunawardena *et al.*, 1997). Animals with high genetic merit are usually managed intensively and the indigenous cattle are usually managed extensively (Ranawana, 2008). According to the DAPH (2019), the contribution of Northern Province to cow milk production in 2019 is 14% and it is in fourth place among the nine provinces of the country. But, the average value of milk production per animal per day from Jaffna district was reported as 2.2 L. It is below the optimum production. There is an urgent need to study the reasons behind this sub-optimal productivity.

In this aspect according to Sheromiha and Kularatne (2016), milk production and productivity of small-scale farms in Sri Lanka is not significantly effective. Covering technical efficiency of cattle farming in Moneragala veterinary region, Thiwyadharsan *et al.* (2013) pointed out that there is a scope of further increasing the milk production by 31% within the study area without increasing the level of inputs or by reducing technical inefficiency among dairy farmers. Increasing the efficiency in production assumes greater significance in attaining potential output at the farm level.

There is comparatively less research on dairy farming in Jaffna district. Therefore, this study aimed to identify the important socio-economic determinants of milk production while researching the prevailing constraints and farmers' perceptions towards dairy farming in Jaffna, Sri Lanka.

MATERIALS AND METHODS

Description of the study area and sample design

Jaffna district was intentionally selected as a study area as there is a necessity to find out the determinants behind the sub-optimal milk production prevailing there. Jaffna district is located in the far north of Sri Lanka in the Northern Province and occupies most of the Jaffna Peninsula. It has an area of 1,025 km². It is divided into four areas geographically: Thenmarachchi, Vadamarachchi, Valikamam and Jaffna Islands. The terrain of the region is almost flat and of low elevation except in the central part of the western sector in the area around Tellippalai where the elevation rises to 10.5 m above sea level. From there it slopes gently towards the south and south-east, while to the north the elevation tends to drop abruptly. The climate of the Jaffna region is considered to be tropical monsoonal with a seasonal rhythm of rainfall. The temperature ranges from 26 to 33 °C. Annual precipitation ranges from 696 to 1125 mm. It is evenly spread over the area. Northeast monsoon rain (from October to January) accounts for more than 90% of the annual rainfall. The Jaffna peninsula is divided into two agro-ecological regions. About 88,000 people were segregated in the district and the majority of them are Sri Lankan Tamils. Natural vegetation of the district consists of non-productive dry zone forest, scrubland and grasslands suitable for livestock production.

This study can be termed as a combination of applied, survey and field research. It was enabled to generalize the findings to a larger population and it has been credited because it allows analysis and relations of variables. Out of 15 Veterinary Surgeon Divisions (VS Divisions) in Jaffna districts, five were selected randomly. Selected VS divisions were Chavakachchaeri, Karaveddy, Kopay, Nallur and Point Pedro. Farms were categorized according to the number of animals as farms with <5 animals, 5 to 20 animals and more than 20 animals. Farmers' contact details were gathered from respective VS divisions. Among available farms, random selection was used to select 10 farms in each category in each selected VS division. About 30 farms from one division and thus sample size of 150 farms were achieved. Primary data for the study were gathered through field questionnaire surveys, interviews and focus group discussions.

The questionnaire consisted of open-ended and closed-ended questions sections related to covering farmers' demographic information, livestock rearing system, management practices, farmers' knowledge, constraints and future perception of dairy farming. The field survey was conducted from April to October 2021.

Further secondary data related to the population distribution of the dairy cattle farmers were collected from the Department of Animal Production and Health (DAPH), Jaffna.

Data description and multiple-regression analysis

Table 1 gives a description of variables for regression model. The dependent variable of the study was measured using the average milk production of litres per animal per day ($L \text{ animal}^{-1} \text{ d}^{-1}$). Subsequently, the following characters were recorded as independent variables: farmers' experience, frequency of water feeding, frequency of concentrate feeding, amount of concentrate ($kg \text{ d}^{-1}$) given, amount of mineral supplement given ($g \text{ d}^{-1}$) and types of management system practiced.

Subsequently, data were subjected to descriptive analysis and confirmatory analysis using Minitab 20 software. The confirmatory statistical analysis was done by using the Multiple Linear Regression model, to predict average milk production ($L \text{ cow}^{-1} \text{ d}^{-1}$) with the quantitative and categorical predictor variables. The form of the multiple linear regression model is as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6$$

Where, β_0 is intercept and β_1 to β_6 are coefficients

Table 1: Description of variables for regression model.

Notation	Variable	Remarks
Y	Average milk production	(L/d/Animal)
X_1	Types of Management system	Extensive /Intensive /Semi intensive
X_2	Experience	Years
X_3	Frequency of water feeding	No of times of water feeding per day
X_4	Frequency of concentrate feeding	No of times of concentrate feeding per day
X_5	Amount of concentrate given	kg/d
X_6	Amount of mineral supplement	g/d

RESULTS AND DISCUSSION

Demographical and socio-economic characteristics

Analysis of descriptive statistics

Table 2 provides a summary of key information related to milk production in Jaffna district.

Table 2: Summary of key information related to milk production in Jaffna district.

Variable	V.S. Division	Mean	SE Mean	St. Dev.
Average milk production (L/d)	Chavakachchaeri	2.983	0.114	0.623
	Karaveddy	3.065	0.180	0.987
	Kopay	2.998	0.176	0.962
	Nallur	3.248	0.119	0.653
	Point Pedro	3.412	0.143	0.784
Average fat percentage	Chavakachchaeri	3.6333	0.0211	0.1155
	Karaveddy	3.7083	0.0309	0.1692
	Kopay	3.5567	0.0266	0.1455
	Nallur	3.5967	0.0222	0.1217
	Point Pedro	3.5733	0.0355	0.1946
Amount of concentrate given (kg/d)	Chavakachchaeri	2.867	0.115	0.629
	Karaveddy	3.150	0.173	0.948
	Kopay	2.967	0.164	0.900
	Nallur	2.983	0.130	0.713
	Point Pedro	3.398	0.181	0.993
Amount of mineral supplement (g/d)	Chavakachchaeri	29.67	1.12	6.15
	Karaveddy	31.67	2.01	11.01
	Kopay	28.77	1.87	10.23
	Nallur	29.83	1.30	7.13
	Point Pedro	34.62	1.56	8.56

Results of the descriptive statistical analysis of demographic data of farmers' gender showed a significant ($P<0.05$) variation as male (82.6%) and female (17.3%). Thus, the major contributors towards the milk production in the Jaffna district were males. As per the impact of the thirty years of civil war in

the northern part of Sri Lanka, most of the widowed ladies started to practice dairy farming to maintain their sustenance. Some of them were beneficiaries of the Wanni Dairy Regeneration Project (WDRP) implemented by the New Zealand government. A study done by Edwards in 2019 pointed out that female farmers have been endowed with empowerment, economic independence and sustainability as a result of extra income earned by increasing dairy production. It contributed to reducing the significant financial vulnerability and deprivation experienced by conflict-affected women. As per the observation still there are females in the Jaffna district who are unemployed and engaged with household works only. Hence, there is a potential to increase the milk production from the Jaffna district if the Government or else Non-Governmental Organizations (NGOs) could provide some support to initiate small scale dairy farms for unemployed females. It will result in the increased participation of female farmers in the milk production of the district.

When considering the ethnicity of the dairy farmers included in the study population all of them are Sri Lankan Tamils. Further, most of the dairy farmers from both males and females were between 45 to 55 y of age. The average age of farmers was 49 y with an average experience of 22 y. These results indicate the lack of participation of the younger generation in livestock practices. There was a turmoil situation in the Northern part of the country from the latter part of the 20th century and thus, most of the younger generation withdrew from studies and started farming practices as their major livelihood. With that, most of them reared dairy animals as a supplement for their income. But, that generation managed to give quality education to their children and most of them engaged in the Government sector. Therefore, nowadays those educated people are very reluctant to practice cultivation and livestock farming. However, to cater to the demand of the increasing population as well as to maintain economic stability, it is advisable to have an income supplement in the form of dairy farming and it can be managed by family members without an additional workforce. It would result in a considerable effect on the total milk production of the district as well.

Descriptive statistical analysis specified that up to 48.6% of the study population had the education up to primary school and only up to 10% have done their higher studies in the form of diploma or bachelor's programme. Through the interviews and discussions with the farmer community, it was observed that the education level has minimal contribution towards the successful running of the farms. It was observed that farmers who have done their education up to the primary level were running the farms successfully with their experiences and were able to fulfil the household requirement. At the same time, they were unaware of the proper feeding, dairy management practices and cutting-edge technologies incorporated into dairy farming. Hence, if the younger generation pays their interest towards the dairy farming practices, they would easily grab the basic concepts behind animal husbandry

and novel technologies. It will create a culmination of improved dairy production from the Jaffna district.

Furthermore, the descriptive analysis of the management systems inferred that 76% of the farmers were practising extensive management systems. Most of the farms with more than 20 dairy animals were under an extensive management system. Free grazing is the salient feature of an extensive system and at the same time, most of the farms were with cattle shed. Average milk production per animal per day was observed low when compared with other management systems. Wijethilaka *et al.* (2018) stated that the merits and demerits of an extensive management system were as follows: extensive farmers are capable to yield higher profit due to low cost for concentrate feeds, low labour, feeding of different forage types and handling a comparatively higher number of animals. Even though extensive farming is profitable, there were limitations for expansion of the extensive farming due to land scarcity, current applicable laws prohibiting straying of animals and usage of public places for free grazing, high probability of spread diseases etc. The same scenario applies to the Jaffna district as well.

However, farmers were not satisfied with an extensive management system and there was a tendency of moving towards an intensive management system with the reduced number of animals. Thus, about 76% of farms were managed as intensive and semi-intensive. The farms maintaining zero-grazing and supplying feed in the form of concentrate and roughages while managing them inside cattle shed were categorized as an intensive management system (Vidanarachchi *et al.*, 2019). Out of 150 farms considered, 86.67% were with cattle shed and the remaining were without cattle shed. Even though there were cattle sheds, those were lack of proper bedding material, sufficient heat stress abatement and proper sanitation and manure disposal. As comfort provided to the cow can affect milk production significantly, proper cattle sheds with all the necessary infrastructures are an important factor to be considered when trying to improve the milk production of a farm. A semi-intensive management system implied a combination of both extensive and intensive systems. Animals were tethered and fed with concentrate and at the same time, they allowed for free grazing as well (Vidanarachchi *et al.*, 2019). Although a higher average milk yield was observed in the intensive management system, the profit margins of the farms were less due to the higher prices of concentrate and supplements. If farmers were provided with concentrates on subsidized prices, it can have a positive impact on increasing the milk production of the district, as well as farmers will be able to get a fruitful profit margin.

Out of the study population, 65.3% of animals were Jersey crosses, while 22.6% were Local breeds and 12% of animals were Sahiwal crosses. Most of the intensive and semi-intensive farming systems reared Jersey crossbreeds. Farms with an extensive management system were more likely to maintain Local as well as Sahiwal crosses due to the compatibility of those breeds to the

climatic condition of the district. Artificial Insemination (AI) was practised mostly in intensive management systems whereas natural service was mostly practised in extensive management systems. Descriptive statistics pointed out that 66.67% of farms were practised AI. But, most of the farmers complained that the success rate of AI was very low. Success rate mainly depends on the timely observation of heat signs and on time inseminations (Mouffok *et al.*, 2019). Farmers were not that much aware of the female reproductive anatomy and related concepts of the oestrus cycle. Some of them were not competent enough to detect heat signs. Another determinant is the distance between VS division offices and the farms. Timely arrivals of AI technicians were lacking. The quality of semen is another paramount determinant of the success of AI (Mouffok *et al.*, 2019). Although semen is available, the quality is always questionable. In the case of the Jaffna district, it is a must to improve the awareness of AI techniques among farmers.

Although high potential Jersey crosses were maintained intensively, suboptimal productivity was observed. Most of the animals were with body condition scores less than 2.5. Feeding practice was one of the major factors behind the body condition score of dairy animals (Sarmini *et al.*, 2017).

About 75.3% of the farmers were feeding their dairy animals with roadside grasses and only 24.6% were feeding with quality forages. Vyas *et al.* (2020) has reported the major bottlenecks of ameliorating dairy productivity of Sri Lanka as follows: inadequacy of good quality feed as well as its quantity feed, sub-standard dairy management practices and ineffectual extension services. According to Zebeli *et al.* (2012), forages are essential constituents of dairy cattle ration and also good quality forage is important in optimizing rumen function thus, improving milk production. Dairy animals in most of the farms were feeding on natural pasture, i.e. Napier grass having low crude protein and digestibility which ends up in suboptimal productivity. Houwers *et al.* (2015) also report the same finding and there are no changes in the feeding practices. Although Jaffna district was under the dry zone of the country, there was no practice of silage feeding. During dry periods of the year silage and hay are of paramount importance to maintain animal health and productivity (Vyas *et al.*, 2020). Further, it is observed a 27% increment in milk production with the introduction of high-protein sorghum silage in a case study in Sri Lanka (Vyas *et al.*, 2020). Hence, dairy farmers of the Jaffna district should be educated about the importance of silage preparations with some initiative support.

Analysis of multiple linear regression

The secondary data analysis, a multiple linear regression model, was fitted to the dependent variable of daily average milk production ($L\ cow^{-1}\ day^{-1}$) to find out the determinants behind milk production in the Jaffna district.

Multiple linear regression model was selected as our study objective was to find out the determinants on dairy milk production. Hence, the average milk

production per animal per day was selected as dependent variable. Most of the feeding related factors and also the management system and experience were tested whether they are having a linear relationship with the milk production.

The result of the multiple linear regression was revealed that there was a significant ($P<0.05$) relation between the average milk production and predictors (Table 3). The fitted model predicts 92.05% (R^2) of the total variation of the average milk production along with management practices at a level of significance. The results revealed that farmers' experience, frequency of water feeding, frequency of concentrate feeding, amount of concentrate given (kg d^{-1}), amount of mineral supplement given (g d^{-1}) and types of management system significantly ($P<0.05$) influenced the average milk production ($\text{L cow}^{-1} \text{d}^{-1}$) of the Jaffna district.

Table 3: Coefficient table for explanatory variables.

Term	Coef	SE Coef	T Value	P Value	VIF
Constant	0.266	0.109	2.43	0.016	
Experience	0.005	0.002	3.13	0.002	1.68
Frequency of water feeding	0.246	0.049	5.06	0.000	3.24
Frequency of Concentrate Feeding	0.146	0.047	3.10	0.002	2.11
Amount of Concentrate given (kg d^{-1})	0.234	0.055	4.25	0.000	5.88
Amount of Mineral Supplement (g/d)	0.022	0.005	4.20	0.000	5.67
Type of Management					
Intensive	0.434	0.080	5.43	0.000	4.04
Semi Intensive	0.252	0.061	4.12	0.000	2.34

The results of the final fitted multiple linear regression models are as follows:

Type of Management

Equation 01

Extensive	Average milk production (L d ⁻¹)	=	0.266 + 0.00520 Experience + 0.2464 Frequency of water feeding + 0.1464 Frequency of Concentrate Feeding + 0.2338 Amount of Concentrate given (kg d ⁻¹) + 0.02175 Amount of Mineral Supplement (g d ⁻¹)
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Equation 02

Intensive	Average milk production (L d ⁻¹)	=	0.699 + 0.00520 Experience + 0.2464 Frequency of water feeding + 0.1464 Frequency of Concentrate Feeding + 0.2338 Amount of Concentrate given (kg d ⁻¹) + 0.02175 Amount of Mineral Supplement (g d ⁻¹)
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Equation 03

Semi-Intensive	Average milk production (L d ⁻¹)	=	0.518 + 0.00520 Experience + 0.2464 Frequency of water feeding + 0.1464 Frequency of Concentrate Feeding + 0.2338 Amount of Concentrate given (kg d ⁻¹) + 0.02175 Amount of Mineral Supplement (g d ⁻¹)
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The results themselves are self-explanatory and accordingly, feeding amount and feeding frequency are having a great impact on milk production (Table 3). But, there was a lack of understanding among the farmers about the concept of using specific nutrients in feed formulation. Vyas *et al.* (2020) also discussed the same constraints in Sri Lanka. Farmers were unaware of the importance of the dry matter and moisture content of feed provided to dairy animals. There is a huge responsibility for policymakers of the dairy industry to focus on the feeding practices and also to educate the farmers in this regard. As discussed earlier, the experience of the farmers is having a positive effect on milk production. They were prone to become experts in management practices with time. Further, the type of management practice is also having an impact on the average milk production. As revealed in the descriptive analysis, the multiple linear regression emphasizes that higher potential animals were maintained intensively and it ends up increasing average milk production. On the other hand, local breeds were maintained extensively and it ends up in low average production.

When considering the constraints faced by farmers, the following were the frequent factors pointed out by them: increased prices of concentrates, lack of timely support from VS divisions, low farm gate prices of milk, poor marketing

network, inadequate quality fodder, insufficient roughages during the dry seasons, unaware about silage preparation mechanisms and inadequate guidance from authorized personnel. Moreover, results suggested there was a necessity to plan comprehensive training sessions targeting farmers to promote better dairy management practices. Beyond training, industry support for monitoring feed quality are needed and at the same time, it is advisable to seek private investment to support the dairy industry. Model summary and analysis variance can be indicated in Table 4 and Table 5, respectively.

CONCLUSIONS

Although steps were taken to improve milk production from Jaffna district, still it is categorized under suboptimal productivity. The findings of this study have concluded that experience of farmers, frequency of water feeding, frequency of concentrate feeding, amount of concentrate given (kg d^{-1}), amount of mineral supplement given (g d^{-1}) and types of management system were significantly influenced the average milk production ($\text{L cow}^{-1} \text{d}^{-1}$) of the Jaffna district. Awareness should be created among the farmers about the factors determining milk production. Rather than the experience and type of management system factors all the other determinants were related to the feeding practices. Therefore, it is suggested proper dissemination of knowledge regarding feed quality and its impact on milk production is needed for the farmers in the Jaffna district.

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SUPPLEMENTARY INFORMATION

Supplementary Table 1: Model Summary

S	R-sq	R-sq (adj)	R-sq (pred)
0.237	92.05%	91.66%	89.90%

Supplementary Table 2: Analysis of Variance table

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	7	92.58	13.23	235.00	0.000
Experience	1	0.55	0.55	9.81	0.002
Frequency of water feeding	1	1.44	1.44	25.59	0.000
Frequency of Concentrate Feeding	1	0.54	0.54	9.60	0.002
Amount of Concentrate given (kg/day)	1	1.02	1.02	18.09	0.000
Amount of Mineral Supplement (g/day)	1	0.99	0.99	17.63	0.000
Type of Management	2	1.66	0.83	14.73	0.000
Error	142	7.99	0.06		
Lack-of-Fit	106	7.06	0.07	2.56	0.001
Pure Error	36	0.94	0.03		
Total	149	100.57			