

Cross-regional assessment of feed efficiency and economic sustainability in local cattle dairy systems of Benin

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Abstract

Knowledge about dairy farming systems' management and profitability is crucial to ensure successful support to local dairy farmers. The objective of this study was to investigate the feed efficiency and profitability among dairy farming systems across climate regions in Benin with target on local dairy cattle breed Borgou, Yakana, Goudali, Goudali x Yakana, Goudali x Borgou. A study conducted on 270 dairy farms to analyze feed efficiency and profitability in different dairy systems: pastoral system (PS); agro-pastoral system (APS) and modern dairy system (MDS). The results highlighted that globally, Goudali breed increased profitability by 5.45%, $p < 0.01$ compared to Borgou breed. The same trend was observed for the crossbred Goudali × Yakana (5.24%) and Goudali × Borgou (4.451%) breeds. Furthermore, Yakana breeds were associated with low profits in both pastoral and agropastoral dairy systems, with even the reduction of profits in the modern dairy system (-1.477%, $p < 0.1$). In terms of breed profitability across climate regions, in Guinean region there was a significant profit ($p < 0.05$) for all breeds, growing by +2.547%; 1.9%; and 1.7% respectively for Goudali, Goudali*Yakana and Goudali*Borgou breeds. Moreover, in Sudano-Guinean region, no significant effect was found, as the breed did not explain the variation in profit. But in Sudanian region, a significant reduction in profit was recorded, especially for Goudali breed (-2.25%). This research provides informations to dairy farmers and policy, guiding them towards the choice of cattle breeds and feed types according to their climate region and dairy system, in order to improve economic profitability.

Key words: cattle breeds; dairy systems; feed; performance; profitability, climate change.

Introduction

In recent years, the dairy sector in West Africa has experienced a rapid increase in demand for milk and dairy products, driven by population growth, rising incomes, urbanization, and changes in dietary preferences (Gbénou et al., 2018). In Benin, national milk production was estimated at 92,475 tonnes in 2021, representing a 2.6% increase from 90,132 tonnes in 2020 (DSA/MAEP, 2022;). Milk and dairy products are widely consumed and contribute substantially to household food security, nutrition, and livelihoods, particularly among Fulani pastoral communities (Ahozonlin et al., 2020). Beyond their nutritional value, dairy production and processing provide important sources of income and contribute to poverty reduction in rural areas (Dossou et al., 2024). Accordingly, the Government of Benin has identified the dairy sector as a priority for agricultural development and food security (DSA/MAEP, 2022).

The cattle population in Benin is predominantly composed of females, with cows, heifers, and calves accounting for approximately 75% of the national herd, reflecting the importance of cattle production for breeding and milk production (Guidimê et al., 2023). Despite its nutritional, economic, and social importance, the dairy sector faces major constraints, particularly low and highly variable milk productivity. Milk yield is influenced by a complex interaction of genetic and non-genetic factors (Gbénou et al., 2020). Genetic factors include breed or genotype, whereas non-genetic factors encompass climatic conditions, seasonality, water and feed availability and quality, lactation stage, herd management, and production system (Djohy et al., 2013, Gbénou et al., 2020, Montcho et al., 2024, Tidjani et al., 2025). These factors may interact differently across agroecological and climatic zones, resulting in substantial variation in animal productivity and production costs.

In 2021, Benin's cattle population was estimated at approximately 2.5 million head and included both indigenous and exotic genetic resources, such as Gir and Girolando cattle (Duteurtre and Corniaux, 2021). Indigenous cattle comprise trypanotolerant taurine breeds, including Somba, Lagunaire/Bobodji, and N'Dama, as well as zebu breeds such as M'Bororo, Goudali, Azawak, and White Fulani. These genetic resources have also contributed to the development of locally adapted crossbred populations, including Borgou cattle (Kassa et al., 2016a). Although indigenous cattle are generally characterized by relatively low milk yields compared with specialized dairy breeds, their adaptation to local environmental conditions, feed resources, disease pressure, and management systems makes them particularly important for sustainable dairy production in Benin.

Several studies have demonstrated significant effects of cattle genotype on milk production (Gbangboche and Alkoiret, 2011; Youssao, 2015). Research conducted in Benin has also examined the productive performance of different local cattle breeds and their responses to environmental and management conditions (Kassa et al., 2016; Gbénou et al., 2020). However, most studies have focused primarily on milk yield, while comparatively little attention has been given to the interaction between cattle genotype, climatic region, feed efficiency, and economic performance. In particular, breed-specific differences in feed efficiency and economic profitability across contrasting dairy production systems remain poorly documented. This knowledge gap is important because higher milk yield does not necessarily translate into greater economic efficiency if it is associated with increased feed requirements and production costs. Evaluating productivity together with feed utilization and economic returns is therefore essential for identifying locally adapted and economically sustainable dairy production strategies.

The objective of this study was to assess feed efficiency and economic profitability across dairy cattle production systems in the main climatic regions of Benin, with particular emphasis on five locally relevant cattle genotypes: Borgou (B), Yakana (Y), Goudali (G), Goudali × Yakana (GY), and Goudali × Borgou (GB). Specifically, the study aimed to characterize differences in productive performance, feed utilization, and economic returns among genotypes and climatic regions, thereby providing evidence for the development of more efficient and economically sustainable dairy production systems in Benin.

Methodology

Study Areas

The present study was conducted in Benin, a West African country, situated between latitudes 6°20'N and 12°30'N and the longitudes 0°45'E and 03°70'E (Figure 1). Data collection was carried out across the three climatic zones of the country: Guinean zone, Sudano-Guinean and Sudanian zones. The Guinean zone is characterized by a bimodal rainfall pattern, with two rainy seasons occurring from April to June and September to November. The average annual precipitation is approximately 1,200 mm. Mean annual temperatures range between 25°C and 29°C, while relative humidity varies from 69% to 97%. Soils in this zone are mainly ferrallitic with occurrences of hydromorphic and vertisol (black cotton) soils in certain localities. The Sudano-Guinean zone experiences a unimodal rainfall pattern, with annual precipitation ranging from 900 mm to 1,110 mm, concentrated between May and October. The mean annual temperature ranges from 25°C to 29°C, relative humidity fluctuates between 31% and 98%. Ferruginous soils are the dominant soil type in this zone. The Sudanian zone also follows a unimodal rainfall regime, with the rainy season spanning from May to October and a dry season from November to April. This zone receives approximately 900 mm of rainfall annually. Temperatures range from 24°C to 31°C, and relative humidity varies widely between 18% and 99% (Figure 1).

Data Collection and analysis

A total of 270 dairy farms located across different climate regions of Benin (Guinean, Sudano-Guinean, and Sudanian) were included in the study. Within each climate region, 90 dairy farms were selected, comprising 30 farms per dairy production system. The production systems studied were the pastoral system (PS), the agro-pastoral system (APS), and the modern dairy system (MS). Farms were selected based on the presence of specific cattle breeds namely: Borgou (B), Yakana (Y), Goudali (G), Goudali x Yakana (GY), Goudali x Borgou (GB). Data collection was conducted using structured farm monitoring sheets, and included the following variables: farm size, number of dairy cows, main factor affecting milk production, total milk produced, production expenses, feed supplementation practices, feed cost, healthcare cost, labor cost, milk sale price. Furthermore, selected dairy farms were longitudinally monitored over a full lactation cycle of 300 days to capture dynamic production and economic variables.

To assess the influence of management practices and lactation period on the farm profitability or yield across the different dairy system and climatic zones, an econometric model was specified as follows (eq. 1):

$$Yield_{is} = \alpha + \beta_n X_{is} + \gamma_{(m-1)} Z_i + \varepsilon_{is} \quad (eq. 1)$$

Where $Yield_{is}$ represents the per capita yield (l) of farm i within dairy farming system s, X_{is} includes variant of farming management practices, Z_i represents farming system invariant, n number of variant variables, m number of farming system considered, and ε_{is} is the error term.

$$Profit_i = \alpha_0 + \alpha_1 cattbreed_i + \alpha_2 Herdinstal_i + \alpha_3 ndairycow_i + \alpha_4 typeoffeed_i + \alpha_5 farm_i + \alpha_6 mainfactor_i + \alpha_7 earlylac_i + \alpha_8 midlac_i + \alpha_9 latelac_i + \alpha_{10} drylac_i + \epsilon_i \quad (1)$$

Where α_i are the parameters to be estimated and ϵ_i is the error term. This equation was estimated separately for each dairy system and for each climate region in order to consider regional and structural heterogeneity, following methodology recommended in farm profitability studies (Diallo et al., 2021).

In order to assess feed efficiency, two indicators have been developed:

Feed profit ratio :

$$Feed \text{ profit ratio} = \frac{Profit}{Feed \text{ Cost}} \quad (2)$$

Feed efficiency ratio :

$$Feed \text{ yield ratio} = \frac{Quantity \text{ produced}}{Feed \text{ cost}}$$

These two reports have enabled a comparative assessment of feed efficiency according to the type of feed used in each system, and provide a database for classifying feeds according to their economic value (FAO, 2020; Taussat et al, 2023). In addition, for each climate region, a comparison of average profits was performed to identify the most profitable dairy system. This region-based analysis can be used to guide policy and technical decisions towards the most efficient system. Additionally, a second equation was estimated for each system, to further analyze the factors which directly influence profit:

$$Profit_i = \beta_0 + \beta_1 tfeedcost_i + \beta_2 thealthcost_i + \beta_3 tlaborcost_i + \epsilon_i \quad (2)$$

Where β_i are the parameters to be estimated and ϵ_i is the error term. This regression allowed us to quantify the respective impact of various expenditure categories (type of feed, health, labor) on the total profitability, following the approaches developed by Chetroiu et al. (2022) and Sigue et al. (2019). All the equations (1) and (2) were estimated using the Ordinary Least Squares (OLS) method. Estimation and validation tests were carried out using Stata 14 software, in accordance with current econometric standards (Wooldridge, 2016).

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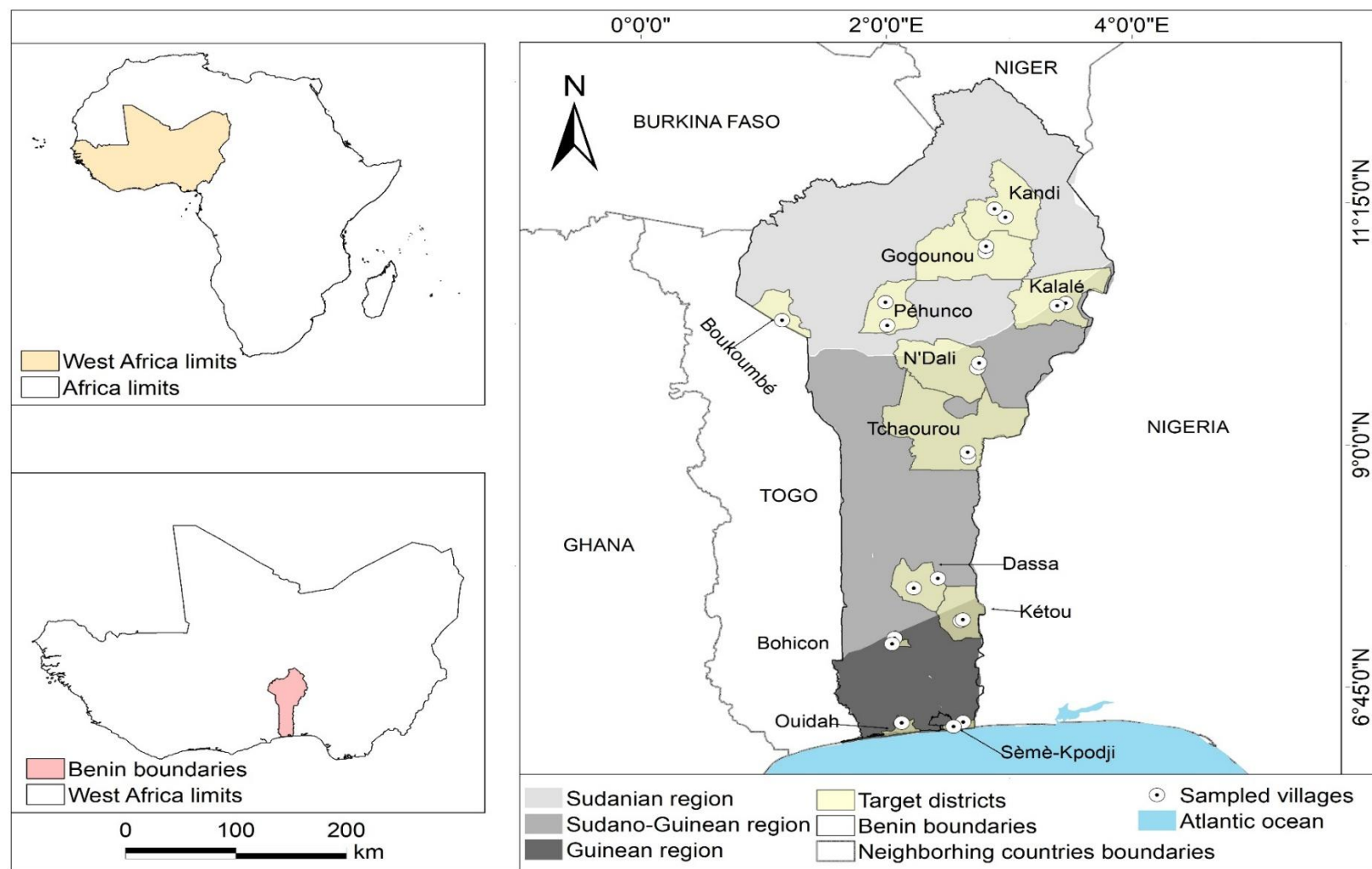


Figure 1: Study Areas

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Results

Determinants of milk production and profit according to dairy systems and climate regions in Benin

Results of econometric estimations of profit determinants are presented in Table 1. Column (1) covers the overall sample, while columns (2) to (4) focus on each specific dairy system. Columns (5) to (7) show results by climate regions. The results presented in column (2) of the table concern agro-pastoral dairy systems. These results indicated that overall, the main determinants of profit in the studied dairy farming systems are cattle breed, feeding practices, farm size and lactation stage. The cattle breed was a significant determinant of the profit. All the cattle breeds considered have more significant positive effect on the profit compared with the Borgou cattle breed, used as a reference. Furthermore the results showed that the Goudali cattle breed, Goudali $\times$ Yakana cattle breed and Goudali $\times$ Borgou cattle breeds generated significantly higher profits than the pure Borgou breed (Table 1). Beyond the breed, the study highlighted that the late lactation stage has a negative impact on profit compared with the other stages. During this lactation stage, milk production declines, while production costs remain constant or even increase. It was observed that the late lactation stage has been characterized by a drop-in milk production, while animal maintenance costs remain constant, leading to a reduction in overall profit. On the other hand, the mid-lactation stage has a significant positive impact on profit. Regardless of the dairy system, the farmers surveyed associate this stage with the period of peak milk yields. We also found that the mode of dairy farm creation and herd installation have also an influence on the profit levels. Dairy farmers who acquired their herd through purchase recorded a significantly higher profit than those whose herd was inherited. Furthermore, our results showed that farms whose creation has been resulting from partnerships between two or more owners recorded a higher average profit than those established by inheritance. Regarding the determinants of milk production and profit across the various climate regions of Benin, the results in column (5) focusing on the Guinean climate region highlighted several factors that significantly influence the dairy farms' profit. These include the number of dairy cows owned by the farm. Farm size was also a key factor influencing profit. Larger farms have the advantage of economies of scale, better access to productive resources (inputs, specialized labor, financing) and can spread their fixed costs more effectively over a higher volume of production, thereby improving profitability. This suggests

Table 1: Estimation of profit determinants according to dairy system in Benin

Profit	Global sample (1)		Dairy System					
			Agro-pastoral dairy systems (2)		Modern dairy system (3)		Pastoral dairy systems (4)	
	Coef.	St.Err.	Coef.	St.Err.	Coef.	St.Err.	Coef.	St.Err.
Dairy Cattle Breeds								
Cattle Breed : ref (Borgou)								
Yakana	1.707***	0.327	0.31	0.201	-1.477*	0.716	0.115	0.227
Goudali	5.448***	1.32	7.228**	2.613	13.368***	3.165	2.547**	0.86
Goudali x Yakana	5.237***	1.244	6.863***	1.703	13.429***	3.069	1.9**	0.803
Goudali x Borgou	4.451***	1.099	6.069***	1.229	13.458***	2.934	1.797**	0.786
Dairy Farm Management Practices								
Number of dairy cows	1.433***	0.18	0.261	0.227	1.039***	0.158		
Crops residues	0.082	0.388	0.099	0.172	0.175	0.101	-2.10***	0.263
Silage	-2.209***	0.822			0.188*	0.095	0	.
Multinutritional blocks	-2.428***	0.745	-0.885*	0.413	0.39***	0.111		
Farm size	0.851***	0.258	13.197***	2.864	0.011	0.713	-3.0***	0.707
Lactation Period								
earlylac	26.123***	6.676	16.193	65.367	85.208	74.496	1.132	3.327
midlac	47.914***	5.424	179.58**	62.538	48.416	47.826	4.982	3.79
latelac	-77.615***	12.001	-284.901*	155.527	-166.608	141.137	-5.318	6.822
drylac	6.378***	1.343	89.688***	27.134	33.364	22.493	0.778	0.591
Mean dependent var	16.291		15.843		17.506		15.526	
R-squared	0.997		1.000		1.000		1.000	
F-test	1174.526		4920.185		30393.222		8728.561	
Akaike crit. (AIC)	274.544		23.982		-28.878		7.533	
SD dependent var	1.242		1.049		0.784		0.823	
Number of obs	90		30		30		30	
Prob > F	0.000		0.000		0.000		0.000	
Bayesian crit. (BIC)	324.541		46.401		-3.656		28.551	

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ **Table 2:** Estimation of profit determinants according to climate region in Benin

Profit	Climate Region					
	Guinean Region (5)		Sudanian Region (6)		Sudano-Guinean Region (7)	
	Coef.	St.Err.	Coef.	St.Err.	Coef.	St.Err.
Dairy Cattle Breeds						
Cattle Breed ref (Borgou)						
Yakana	0.038	0.188	0.073	0.055	-0.214	0.45
Goudali	-1.631	1.125	-2.249***	0.603	1.826	3.09
Goudali x Yakana	-1.174	1.026	-1.828***	0.541	1.781	2.487
Goudali x Borgou	-0.645	0.87	-0.228	0.549	1.255	2.067
Dairy Farm Management Practices						
Number of dairy cows	1.11***	0.157	0.981***	0.068	1.482***	0.323
Crops residues	0.17	0.191	0.032	0.1	-0.925**	0.306
Silage	-0.496	0.333	-2.837***	0.432	0.314	0.515
Multinutritional blocks	-0.188	0.333	-2.672***	0.423	0.157	0.413
Farm size	-0.179	0.318	0.218	0.13	0.345	0.419
Lactation Period						
earlylac	279.699***	77.672	445.406***	37.653	1068.05***	278.877
midlac	132.503***	27.784	145.732***	7.98	273.972***	55.196
latelac	-389.58***	100.137	-577.92***	44.888	-1285.7***	316.818
drylac	-15.777**	5.513	-4.666***	0.797	-53.257**	18.649
Mean dependent var	16.260		15.898		16.716	
R-squared	1.000		1.000		1.000	
F-test	13298.622		56886.715		3062.619	
Akaike crit. (AIC)	-10.645		-53.392		37.327	
SD dependent var	1.201		1.059		1.349	
Number of obs	30		30		30	
Prob > F	0.000		0.000		0.000	
Bayesian crit. (BIC)	15.978		-28.171		62.549	

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

that increasing size or animals' numbers enables fixed costs to be spread more evenly, total milk production to be increased, and the farm's economic efficiency to be improved (Table 1). In addition, in this region, the use of cultivated pasture was less profitable than the use of natural pasture. The results for the Sudanese region (column 6) highlighted a number of profit drivers on dairy farms, some of them conflicting with initial expectations. In contrast to results observed in other regions, the Goudali and Goudali $\times$ Yakana breeds are associated with lower profits than the local Borgou breed. Furthermore, the results from Sudano-Guinean region (column 7) showed several factors that significantly influence the profitability of dairy farms (Table 2). The number of dairy cows on the farm has a positive and significant effect on profit levels. A larger herd size enables fixed costs to be spread over a greater volume of production, increasing total milk production and improving overall economic efficiency.

Feed efficiency and economic profitability of dairy farms according to dairy farming systems and climate regions in Benin

Figure 1 below shows the feed productivity and profitability ratios of the different types of feed used to feed animals across dairy farming systems. Results from analysis clearly showed that multinutritional blocks were associated with higher productivity and profitability ratios than all other feed types used across dairy systems. Analysis of feed efficiency in the modern dairy system, has shown that the use of silage and multi-nutritional blocks as the main source of feed significantly improves profit compared with the exclusive use of natural pasture or grazing areas to feeds animals. Silage, especially, offers better nutritional quality and greater consistency in feed intake. This nutritional stability translates into optimized milk production and, consequently, greater profitability. Furthermore, in pastoral systems, we found that all feeding practices based primarily on concentrated feed and crop residues resulted in lower profits than the use of natural pastures from forest and grazing areas. In these pastoral systems, natural pastures remain a more economically efficient resource. Regarding agro-pastoral dairy systems, the use of agricultural by-products or crop residues has proved to be more efficient than other feed resources.

The results in Table 3 indicated that, in the overall sample, both feed and labor costs had a significant positive impact on profit. An analysis by dairy farming system revealed that, in agro-pastoral systems, feed expenditure was the main determinant of the profit. Meanwhile, in modern dairy systems, both expenditure on feed and health care have a significant influence on the year profit. As for pastoral dairy systems, feed costs remain the most important determinant.

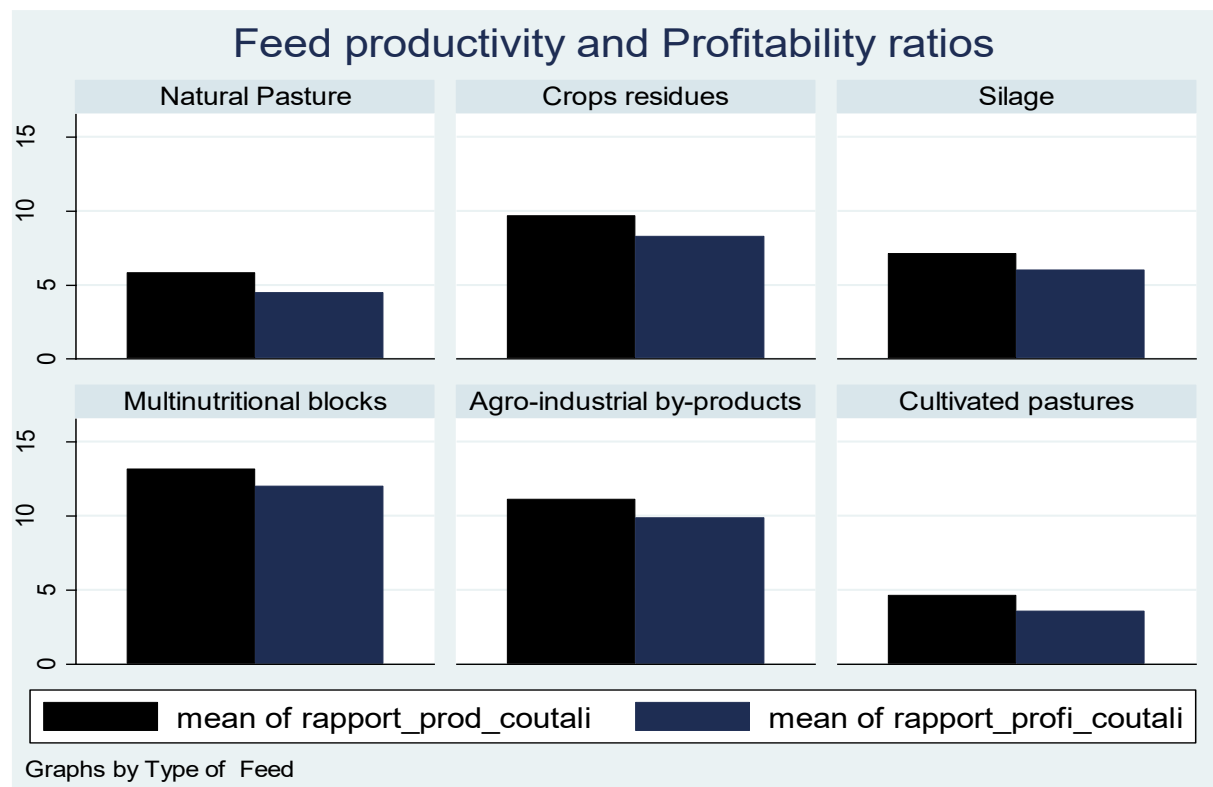


Figure 2: Feed productivity and Profitability ratios

Table 3: Estimation of the types of expense that influence profit for each dairy system across climate region

Profit	Global Sample (1)		Dairy Systems					
			Agro-pastoral dairy systems (2)		Modern dairy system (3)		Pastoral dairy systems (4)	
	Coef.	St.Err.	Coef.	St.Err.	Coef.	St.Err.	Coef.	St.Err.
Total feed cost	0.745***	0.055	1.144***	0.106	0.375**	0.153	0.606***	0.158
Total health cost	-0.088	0.079	0.101	0.401	1.192***	0.324	0.269	0.366
Total labor cost	0.579***	0.067	-0.094	0.46	-0.079	0.267	0.378	0.243
Mean dependent var	16.291		15.843		17.506		15.526	
R-squared	0.999		1.000		0.999		0.998	
F-test	20537.811		20824.826		8371.230		5317.398	
Akaike crit. (AIC)	173.467		24.613		57.854		64.271	
SD dependent var	1.242		1.049		0.784		0.823	
Number of obs	90		30		30		30	
Prob > F	0.000		0.000		0.000		0.000	
Bayesian crit. (BIC)	180.966		28.817		62.058		68.475	
*** $p<0.01$, ** $p<0.05$, * $p<0.1$								

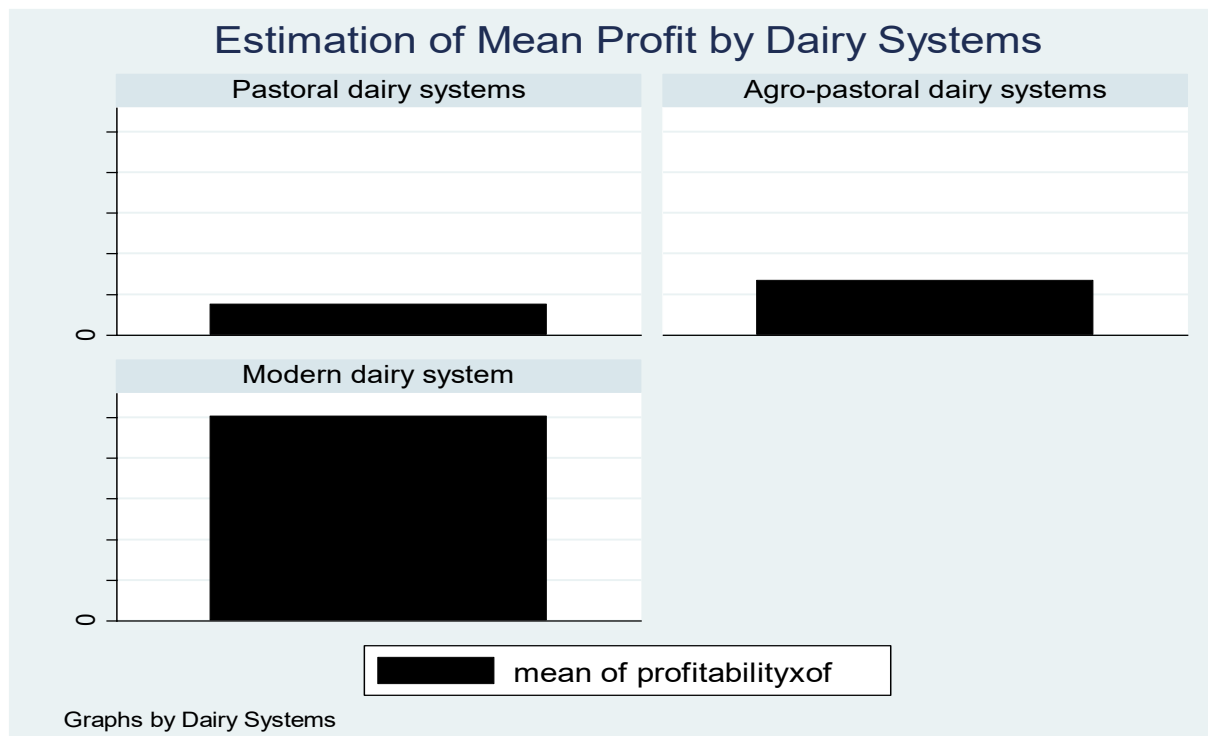
**Figure 3:** Estimation of Mean Profit - Dairy Systems

Figure 3 has shown that the modern dairy systems in our sample are the most profitable, with an average annual net profit of 35,689,627 XOF or around 65,000 US Dollar. They are followed by agro-pastoral dairy systems, which recorded an average annual profit of 13,350,306 XOF or around 24,273 US Dollar. However, pastoral dairy systems appear to be the least profitable, with an average profit of just 7,559,951.9 XOF or around 13,750 USD. This profit hierarchy highlighted the crucial impact of the level of modernization and intensification of farming practices on the economic performance of farms.

Discussion

Generally, our study showed that milk yield and profit have varied depending on the dairy system with pastoral dairy system reporting low profit compared to the other two dairy systems. Pastoral systems were characterized by their seasonal production and low investment in both installation and feed. The low profit recorded in the pastoral dairy system may also be due to the inheritance of the majority of herds from this system. These inherited herds were often challenged by a lack of genetic replacement, traditional management practices and limited access to innovations, all of which reduce their profitability (Ahozonlin et al., 2020; Guidimè et al., 2023). Whereas agro-pastoral dairy farming systems rely on supplements to feed their herds during the dry season. These supplements were mostly sourced from their own farms, and could include cotton seeds and cakes, peanut hulls or other crop residues etc. Meanwhile, the modern dairy system used innovative feeding practices such as forage conservation techniques (silage, hay, straw treated with urea, etc.). It also used industrialized feeds such as multivitamin blocks (Montcho et al., 2018). The owners of these farms did not seem to be ordinary farmers, but investors. Most of the milk produced was sold in the towns (via dairies, supermarket, direct sales or kiosks). The main determinants of milk production identified in this study were cattle breed, herd size, feeding practices, and stage of lactation. Cattle breed is a significant determinant of profit. These results confirm those of Abdoukarim et al. (2013) and Daburon et al. (2017), who highlighted the positive impact of improved cattle breeds on profitability in West Africa. Furthermore, the number of dairy cows owned has a significant positive effect on profit. This relationship is in line with the theory of economies of scale, according to which a larger herd makes it possible to better recover fixed costs and optimize the use of inputs (Guidimè et al., 2023). Similarly, farm size (surface area or total livestock) also improves profit, as reported by Talbi et al. (2015). Farm size was identified by our study as a key factor positively influencing profit. Larger farms benefit from economies of scale, better access to productive resources (inputs, specialized labor, financing) and can spread their fixed costs more effectively over a higher volume of production, thereby improving profitability (Ahozonlin et al., 2020; Talbi et al., 2015). In addition, larger farm size is often associated with greater technological adaptability and more structured management strategies Kassa et al., 2016; Vab et al., 2021). We also found that the mid-lactation period had a significant positive impact on profit. However, the late lactation period is characterized by a decline of milk production, while animal maintenance costs remain constant, resulting in a reduction of the total profit. This trend is confirmed by several studies highlighting the importance of optimal management of lactation periods to maximize the profitability of dairy farms (Kassa et al., 2016; Vall et al., 2021). Furthermore, the extreme variations of milk production as the lactation progresses may be due both to the dry season (November to February), during which forage resources are gradually reduced with the drying up of grazing areas. In terms of total milk yield, the lowest average was recorded in the first lactation. Other studies have shown that the highest level of production, for standard lactations, was recorded in 4th lactation (Houchati et al., 2016) in 2nd lactation (M'hamdi et al., 2021) or in third lactation (Shahin et al., 2017; Talbi and El Madidi, 2015). Regarding the impact of dairy cow feed on profit, our study showed that feed type is a key determinant of profit. Several previous studies have mentioned that the main cause of low livestock productivity in tropical regions is insufficient and poor-quality feed (Montcho et al., 2022). There is also a link between feed and season. As the dry season is characterized by the gradual loss of forage quality and quantity, grasses in tropical regions have a very low feed value that decreases very quickly (Montcho et al., 2025). Ogundeji et al (2021), analyzing the Influence of heat stress on milk production and its financial implications in semi-arid areas of South Africa, found that higher daytime temperatures led to a significant drop of milk production. However, this decline is smaller in more temperate regions.

Conclusion

This study supports dairy farmers in their choice of cattle breeds according to their farm's location and climate region. It also provides data relating to the profitability of breeds according to dairy farming system. Data on feed efficiency and economic profitability depending on the livestock feeding practices have also been provided by this research work. Our findings are an evidence-base for dairy farmers, the scientific community, policies and all stakeholders involved in local milk development in Benin.

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Data Availability Statement: data available in supplementary data

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References

- 1) Abdoukarim, I. Y., Dahouda, M., Attakpa, E. Y., Koutinhoun, G. B., Ahounou, G. S., Toleba, S. S., & Balogoun, B. S. (2013). Diversité des systèmes d'élevages de bovins de race bovine Borgou dans la zone soudanienne du Bénin. *International Journal of Biological and Chemical Sciences*, 7(1), 125-146. <http://dx.doi.org/10.4314/ijbcs.v7i1.11>
- 2) Ahozonlin, M. C., & Dossa, L. H. (2020). Diversity and resilience to socio-ecological changes of smallholder Lagune cattle farming systems of Benin. *Sustainability*, 12(18), 7616. <https://doi.org/10.3390/su12187616>
- 3) Daburon, Annabelle, Véronique Alary, Ahmed Ali, Mohamed El Sorougy, and Jean François Tourrand. "Urban farms under pressure: Cairo's dairy producers, Egypt." *Toward sustainable relations between agriculture and the city* (2017): 73-88. https://doi.org/10.1007/978-3-319-71037-2_5
- 4) Djohy, G., Edja, A.H., Akponikpè, P.I., Olokesus, F., Mahamadou, B. 2013 Thwarting social conflicts regarding water resources access in climate change context: cattle pastoralists' schemes in northern Benin. *Journal of Livestock Science* (ISSN online 2277-6214) 4: 51-59
- 5) Dossou, A. W., Seko Orou, B. M. T., Komagbe, G., Sessou, P., Youssao, A. K. I., Farougou, S., ... & Douny, C. (2024). Nutritional Composition and Chemical Safety of Wagashi Gassirè Cheese Sold in the Southern Benin Markets. *Dairy*, 5(2), 271-286.5. <https://doi.org/10.3390/dairy5020022>
- 6) Duteurtre, G., & Corniaux, C. (2021). Note thématique de réflexion N°1 : Quelles perspectives d'évolutions des contributions des systèmes d'élevage mobiles à l'économie régionale et aux chaînes de valeur de l'élevage en Afrique de l'Ouest. CIRAD, France, 41p.
- 7) Gbangboché, A. B., & Alkoiret, T. I. (2011). Reproduction et production de lait des bovins de race Borgou et N'Dama au Bénin. *Journal of Applied Biosciences*, 46(10), 3185-3194.
- 8) Gbénou, G. X., Soulé, H. A., Akpo, Y., Djénontin, A. J. P., Sidi, H., Babatoundé, S., ... & Mensah, G. A. (2020). Performances laitière et économique des vaches métisses (Gir x Borgou) complémentées avec la drèche de sorgho au pâturage à *Panicum maximum* C1 dans le Nord-Bénin. *Agronomie Africaine*, 32(4), 439-447.
- 9) Guidimé, S. L., Odo, B. P., Djenontin, A. J., Yacoubou, A. M., Worogo, S. H. S., & Idrissou, Y. (2023). Évaluation de la complémentation au Vitanimal sur les performances laitières de vaches Borgou au Bénin. *Revue Marocaine des Sciences Agronomiques et Vétérinaires*, 11(4), 465-473. <https://doi.org/10.5281/zenodo.10448571>
- 10) Houchati, A., Aloulou, R., & M'sadak, Y. (2016). Caractérisations quantitative et qualitative des performances laitières des troupeaux bovins menés en hors sol dans une zone littorale semi-aride (Tunisie). *Revue Marocaine des Sciences Agronomiques et Vétérinaires*, 4(3).
- 11) Kassa, K. S., Ahounou, S., Dayo, G. K., Salifou, C., Issifou, M. T., Dotche, I., ... & Youssao, I. A. K. (2016). Performances de production laitière des races bovines de l'Afrique de l'Ouest. *International Journal of Biological and Chemical Sciences*, 10(5), 2316-2330. <https://doi.org/10.4314/ijbcs.v10i5.29>
- 12) Montcho, M., Babatounde, S., Aboh, A. B., Houndonougbo, F., & Chrysostome, A. M. C. (2018). Perception et adoption des innovations techniques en alimentation des ruminants au Bénin. *Agronomie Africaine*, 30(1), 31-45.
- 13) Montcho, M., Padonou, E. A., Montcho, M., Mutua, M. N., & Sinsin, B. (2022). Perception and adaptation strategies of dairy farmers towards climate variability and change in West Africa. *Climatic Change*, 170(3), 38. <https://doi.org/10.1007/s10584-022-03311-4>
- 14) Montcho, M., Assani, A.S., Bassao, E.N., P.A. Olounladé, A.B. Aboh, B. Sinsin (2024). Seasonal fluctuation of livestock feed resources in dry regions of Benin *Journal of Livestock Science* 15: 300-306 doi. 10.33259/JLivestSci.2024.300-306
- 15) Montcho, M., Assani, A. S., de Dieu Ainamon, J., Aboh, A. B., Olounladé, P. A., & Sinsin, B. (2025). Agroecological mapping of livestock feed resources for sustain productivity and climate resilience in Benin (West Africa). *Discover Sustainability*, 6(1), 33. <https://doi.org/10.1007/s43621-024-00724-2>.
- 16) M'Hamdi, N., Darej, C., Attia, K., Znaidi, I. E. A., Khattab, R., Djelailia, H., ... & Ayadi, M. (2021). Modelling THI effects on milk production and lactation curve parameters of Holstein dairy cows. *Journal of Thermal Biology*, 99, 102917. <https://doi.org/10.1016/j.jtherbio.2021.102917>
- 17) Shahin, A. S. M., Rahman, M. S., Hasan, M. F., Noman, R. F., & Karim, M. R. (2017). dairy farmers' attitude towards use of cattle health card of care-sdvc project. *International Journal of Agricultural Extension*, 4(3), 141-147.

- 18) Talbi, A., & El Madidi, S. (2015). Effects of environmental factors on milk production of Holstein cows in Souss-Massa region of Morocco. *Livestock Research for Rural Development*, 27(6). <https://www.lrrd.org/lrrd27/6/talb27116.html>
- 19) Tidjani, M., Assani A.S., Iwaka, C., Agballa-Belrou, A.R.A., Azalou, M., Worogo, H.S., Alabi, C., Azando, E.V.B., Yabi, Y., Alkoiret I.T. 2025. Perception of the sedentarization of cattle herds by livestock farmers in the Sudanian and Sudano-Guinean zones of northern Benin. *Journal of Livestock Science* 16: 339-349 doi. 10.33259/JLivestSci.2025.339-349
- 20) Vall, E., Sib, O., Vidal, A., & Delma, J. B. (2021). Dairy farming systems driven by the market and low-cost intensification in West Africa: the case of Burkina Faso. *Tropical Animal Health and Production*, 53(2), 288. <https://doi.org/10.1007/s11250-021-02725-z>