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Evaluation of the efficiency of biological and economic indicators in production systems on dairy farms

Evaluación de la eficiencia de indicadores biológicos y económicos en sistemas de producción en fincas lecheras

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ABSTRACT

The efficiency of the livestock system is one of the factors of greatest social and economic interest in rural production areas. The project aimed to assess various biological and economic indicators to identify the most efficient dairy cows in grazing systems with supplementation within the Antioquia-Colombia dairy basin. We used retrospective data from 2009 to 2019 from farms in the municipalities of Entrerríos, San Pedro, and Belmira. The production systems in the northern region of Antioquia share common features typical of many dairy enterprises. They are primarily characterized by their utilization of grazing systems, each employing distinct supplementation regimes.The farms have their own records and official milk control from the cooperatives or associations from which the data was obtained. The productive categories of the evaluated cows were established according to the number of births, and within each subgroup, they were ordered by the total liters per lactation in ascending order. Productive, reproductive, health, and economic variables were recorded. Then cuts were made, thus forming three categories: low, medium, and high production. It was possible to determine the model that showed four groups of variables (breed, milk production per lactation, open days, and silage) with an important correlation of 97% and a greater contribution to the behavior of the cost per liter, obtaining an R2 of 0.91 (P <0.05) and a prediction error of US$ 0.0076 per liter of milk in the evaluated farms. It is concluded that, with few biological and economic predictive indicators, it was possible to identify the most efficient cows in grazing systems.

Keywords: Dairy cow; economic; reproduction; social; sustainability.

RESUMEN

La eficiencia del sistema ganadero es uno de los factores de mayor interés social y económico en zonas de producción rural. El objetivo del proyecto fue evaluar diferentes indicadores biológicos y económicos que permitan identificar las vacas lecheras más eficientes en los sistemas de pastoreo con suplementación de la cuenca lechera de Antioquia-Colombia. Se utilizaron datos retrospectivos de 2009 a 2019 de fincas de los municipios (Entrerríos, San Pedro y Belmira). Estos sistemas de producción presentan características comunes a la mayoría de las empresas lecheras distribuidas en el norte de Antioquia, y se caracterizan principalmente por su utilización de sistemas de pastoreo, cada uno de los cuales emplea distintos regímenes de suplementación. Las fincas cuentan con sus propios registros y control oficial de leche de las cooperativas o asociaciones de donde se obtuvieron los datos. Las categorías productivas de las vacas evaluadas se establecieron de acuerdo con el número de partos y dentro de cada subgrupo se ordenaron por el total de litros por lactancia en orden ascendente. Se registraron variables productivas, reproductivas, sanitarias y económicas. Luego se hicieron cortes, formando así tres categorías: baja, media y alta producción. Se logró determinar el modelo que mostró cuatro grupos de variables (raza, producción de leche por lactación, días abiertos y ensilaje), con una correlación importante del 97% y mayor aporte al comportamiento del costo del litro, obteniendo un R2 de 0.91 ($P<0.05$) y un error de predicción de (US$ 0.0076) por litro de leche en las fincas evaluadas. Se concluye que, con pocos indicadores predictivos biológicos y económicos, fue posible identificar las vacas más eficientes en los sistemas de pastoreo.

Palabras clave: Economía; reproducción; social; sustentabilidad; vaca lechera.

INTRODUCTION

Despite the interesting production of milk in Colombia and its productive, social, and economic importance, it still presents delicate problems of technical-productive and economic indicators such as inefficiency in milk production per hectare on a national average of less than ten liters/day/animal, low animal stocking rate 0.7 animal / ha, the calving interval of more than 440 days, days open more than 150 days, and services per conception of more than three, among others (Colanta, 2019; Tobón, 2022).

Another of the difficulties that affect the dairy sector for the sustainability of the dairy farmer in the country, according to the reports Colanta (2019), is commercialization, noting that for every two liters of milk produced, less than a liter is processed by formal industry. In addition, in the sector, there are high production costs, low productivity compared to the main international players, minimum level of associativity in the links of the chain, high informality in the commercialization and transformation of milk and its derivatives, low level of diversification of products and export destinations and deficient sanitary status in relation to the demands of the markets. In this context, the Colombian dairy industry reveals the need to seek alternatives to strengthen productive efficiency.

However, despite the problem, producers have managed to increase productivity and thus have subpopulations of improved animals that mature earlier and produce more milk with the help of genetic tools and modern biotechnologies, depending on the economy and the market. But the costs of these improvements are charged directly to the improved animals themselves, whose well-being, survival, reproduction, and biodiversity are collaterally affected (Piccardi *et al.*, 2016; Leon-Gomez & Saray-Palacio, 2020).

In recent years, production goals have been globalized, pointing to an increase in the quantity or volume of milk, while characteristics that allow for reducing inputs and production costs have been omitted (Ahlman, 2010; Loaiza-Muñoz, 2020). Therefore, it is of utmost importance to define the best level of production associated with adequate costs and the best dairy cows adapted for grazing systems that, with different supplementation regimes, are managed in the different dairy basins of a region or country (Mayne *et al*., 2000; Mancuso, 2017). In this sense, currently, the production schemes copied in Colombia from developed countries are based on obtaining high production with the supplement of important quantities of quality and expensive food; this is economically viable, while the relation between the sale price of milk and the purchase of these commercial foods is favorable to the producer (Tobón, 2022).

Low reproductive and productive performance translates into economic losses for dairy farmers. For this reason, the improvement of these indicators is essential as an evaluation tool and for checking the livestock herd, contributing to the profitability and sustainability of the farms. Due to the close relationship between these factors, there is a need to estimate the related costs of a non-pregnancy, an abortion, or a discard (De Vries, 2006; Lopes *et al.,* 2009b; Fernández *et al.,* 2020) or an additional day of empty cow (open days) (De Vries *et al.,* 2010), added to the health status derived from various diseases. In this context, without a doubt, the most worrying thing is that most producers do not keep the information or records, or they are incomplete, and consequently, they do not know how much it costs them to produce a liter of milk or if their company is efficient and sustainable (Colanta, 2019; Indrijani *et al.,* 2019).

The system's overall efficiency is one of the factors that have the greatest interest from the productive, social, and economic aspects. The most common modality to evaluate it is through indicators of biological and economic productivity. But when it occurs under conditions of scarce and expensive resources, efficiency should be valued not only through the products but also through the inputs of the system (Alonso *et al.,* 2018; Marini *et al.,* 2021).

The estimation of reproductive and productive variables in dairy farms will allow for assessing the economic and global behavior of the system. Thus, recently, bioeconomic models have been proposed to analyze the efficiency of these indicators; the models obtained will contribute to the diagnosis and correct decision-making (Duque *et al.,* 2018; ACHA-Asociación de Criadores de Holando Argentino, 2021).

To be more precise in making efficient decisions, the use of low-input, technological, and computational tools such as the internet of things, big data, and artificial intelligence is needed to systematize and analyze the efficiency and competitiveness of dairy production systems. Likewise, it is a priority to set up medium- and long-term public policies that promote smart, more resilient, competitive, and sustainable livestock farming (IICA-Instituto Interamericano de Cooperación para la Agricultura, 2019; Colanta, 2019).

In this context, milk production in grazing systems requires a holistic and systemic vision with a more detailed knowledge of the interactions between its elements to understand the mechanisms associated with the technical, the productive, and, of course, the efficient, as well as to interpret its variations and adaptations over time. As mentioned, there are various weaknesses and inefficiencies in grazing milk production systems, which can cause a high economic impact and so the unviability of the company (Carulla & Ortega, 2016; Loor & Saltos, 2021).

For this reason, the aim of this investigation was to study the use of biological and economic indicators in the cows of the dairy basins of Antioquia to find the most efficient animals for grazing systems.

MATERIALS AND METHODS

Data from dairy farms were used between 2009 and 2019 from the basin of the municipalities of (Entrerríos, San Pedro, and Belmira), located north of the department of Antioquia-Colombia, between 6°4” north latitude and 75°25” west longitude. The climate in the area oscillates between 14 and 16°C on average (Alcaldía municipal de Belmira (2021); Alcaldía municipal de Entrerríos (2021); Alcaldía municipal de San Pedro, 2021).

The productive system used presents characteristics common to most of the dairy farms distributed in the north of Antioquia, which is characterized by being a grazing dairy system based on kikuyo grass (*Pennisetum clandestinum*), which contributes more than 50% of the diet. Daily total with different supplementation regimes (corn and sorghum silos, vegetable and vegetable harvest residues, by-products of the food industry, commercial balancing, silage, nutritional blocks, and mineralized salt). These establishments-farms have their own records (good livestock practices) and official milk control from the cooperatives or dairy associations from which the data were obtained.

Records per cow

Productive and economic variables. The genetic origin of your parents Race Holstein, Jersey, Crosses (RACE H, J, C), and date of birth and Condition corporal (CC).

From each lactation. calving dates, number of services performed to get pregnant (SC), total liters of milk in lactation (PDNLACT), liters adjusted to 305 days, and days of calving interval (CI). Total days that the cow is not in gestation or open days (OD), illness (ENF), date, and reason for culling.

Milk. (PDN TOTAL) total production * price of the liter of milk paid to the producer. Expenses: need to purchase some categories. Direct and indirect costs (COSTS) are derived from the milk production activity on each farm and per cow COSTENF (Costs illness). Balance: income (milk) - expenses (direct and indirect costs). Utility, profitability, and the cost-benefit relationship of the production system.

Analysis of the information. The productive categories will be ordered according to the number of calving (NC), and within each subgroup, they will be ordered by the total liters per lactation (TL) of the cows in ascending order. Then cuts were made, obtaining three-thirds of comparable size, thus forming three categories: low, medium, and high production. This method is adapted from the work of Marini & Oyarzabal (2002).

The effect of the production level on the response variables was evaluated at a univariate level with a parametric analysis of variance to a classification criterion, followed by the Tukey multiple comparisons test or with the non-parametric Kruskal-Wally's test, followed by Dunn's multiple comparisons evaluate as proper (Sheskin, 2011).

The multivariate association between productive traits and reproductive traits was evaluated by calculating the canonical correlation between both groups of variables. The existence of potential informative clusters was analyzed with the multivariate technique of principal components using different combinations of productive and reproductive indicators. The discriminating power of these indicators in the differentiation of the low, medium, and high production groups was evaluated using a Canonical discriminant analysis (Carrasco & Hernán, 2016).

RESULTS AND DISCUSSION

In Europe, North America, and other leading countries in the dairy sector, milk production has increased rapidly in the last 30 years; it has even doubled due to the combination of genetic improvement, nutritional supplementation, and technical management, with a marked emphasis ranked in the volume of milk produced (Albertone *et al.,* 2020; USDA-United States Department of Agriculture, 2020; Borowski *et al.,* 2020). The historical need to increase productivity per cow necessarily leads to increased production costs, including labor and land resources. Similarly, higher milk production per hectare continues to be one of the indicators of greatest interest to producers based on their economic survival (Veerkamp *et al.,* 2015; Arboleda, 2020). This behavior is explained by the selection pressure for higher milk production in favor of breeds such as the Holstein.

However, in the current model, it is essential to assess other variables, such as longevity, adaptation, feeding requirements, health, and reproductive characteristics, which are unfavorably correlated with milk production (Dutour & Melucci, 2010; Horvath *et al.,* 2017a). Likewise, other researchers have said that selection only for milk production causes negative effects on udder health (Heringstad *et al.,* 2016) and reproductive behavior (Haile-Mariam *et al.,* 2003; Kadarmideen *et al.,* 2013; Reyes *et al.,* 2020). The municipalities in this study share the philosophy of these countries, and this is the case in the rest of Colombia, where the Holstein breed predominates. It is inferred that their greater presence in the region is largely due to a sociocultural inclination, based on the fact that most producers are people with a very conservative profile, traditionalists who are reluctant to change to use new breeds or crosses, and really value production costs (Colanta, 2019; Tobón, 2022). The evaluation of the cows in the study areas is shown below. Table 1 shows that in the municipalities studied, there was a greater presence of the Holstein breed, on average, with 85% participation, followed by the Jersey breed with 12%, and lastly, the crosses that are usually of different breeds, with a higher degree of predominance between animals Taurus breed and Indicus breed (Holstein x Jersey and Holstein x Cebu), only represented on average 3% of participation. It is considered important to effectively manage genetics and their respective crosses to obtain maximum biological and economic efficiency without neglecting those animals that present the best adaptation in each municipality.

Table 1. Dairy breeds in Entrerríos, San Pedro and Belmera municipalities between 2009 and 2019.

Municipality	Genotype		
	Holstein %	Jersey %	Crosses %
San Pedro (n-cows= 890)	86	11	3
Belmira (n-cows= 699)	83	13	4
Entreríos (n-cows= 773)	85	12	3
Average (n-cows= 787)	85	12	3
Variatión %	3	2	1
Standar deviatión	1.52 ± 0.11	1± 0.02	0.57± 0.06

In Table 2, the reproductive variables SC, BCI, and DO present a better performance in the municipalities of Entrerríos and San Pedro (2, 412 and 142 VS 3, 416 and 146), respectively, compared with the municipality of Belmira, which had lower reproductive performance (4, 465 and 195). In the health aspect, it was found that the pathology with the greatest presence in the municipalities of the study was mastitis, followed by lameness and abortions.

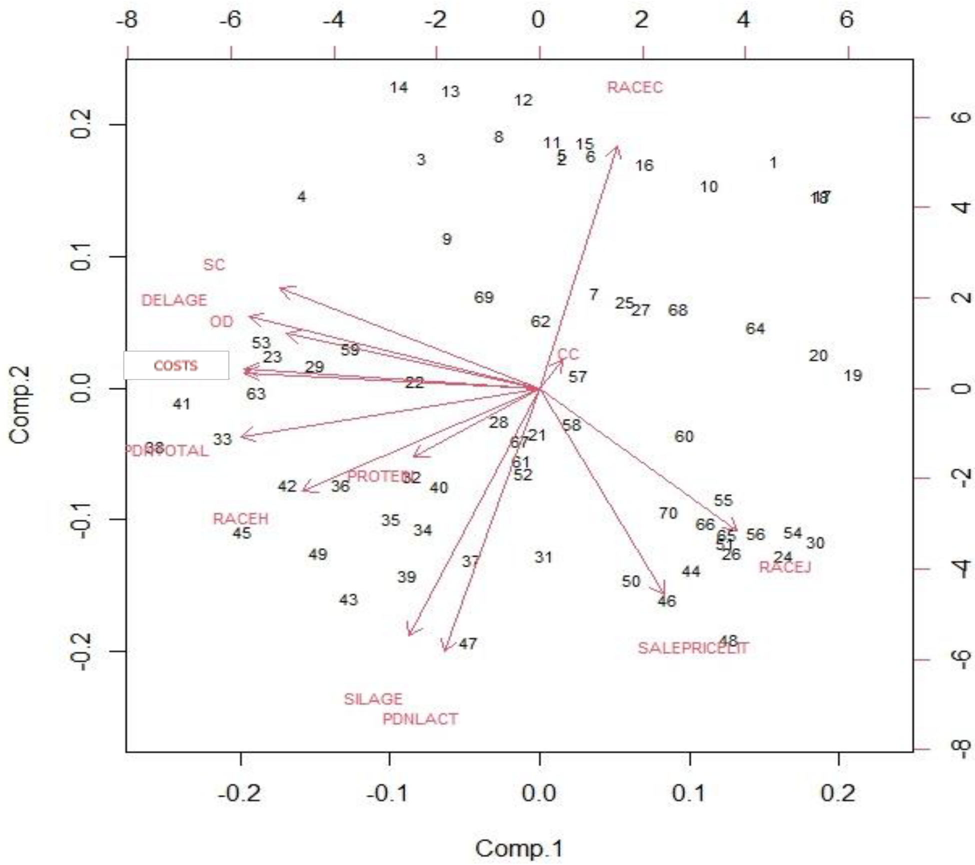
Table 2. Evaluation of reproductive variables.

Variable	SC	BCI	DO	LP305	TL	Disease	Discard %
Municipality San Pedro	3 a (1- 7)	416 a	146 a	5490 a	32940 a	Mastitis, abortions	7
Municipality Belmira	4 a (1- 9)	465 ab	195 ab	4880 b	24400 b	Lame ness, mastitis, abortions	11
Municipality Entrerríos	2 ab (1- 6)	412 a	142 a	5795 a	34770 a	Mastitis, abortions	9
Average	3	431	161	5388	30703		9
Standard Deviation	1	29.51±0.27	29.51±0.27	465.89±407	5535±4000	-	2

Arithmetic averages, SC (services per conception), BCI (birth-conception interval, DO (days open), LP305 (production liters per lactation, TL (total production liters in its useful life), SD = ± Standard deviation, different letters indicate difference significant $p < 0.05$ Services by conception are expressed as median and ranges.

Regarding the variable discard of production cows, it was obtained that the highest percentages were in the municipality of Belmira at 11%, followed by Entrerríos at 9%, and the lowest value was San Pedro at 7%.

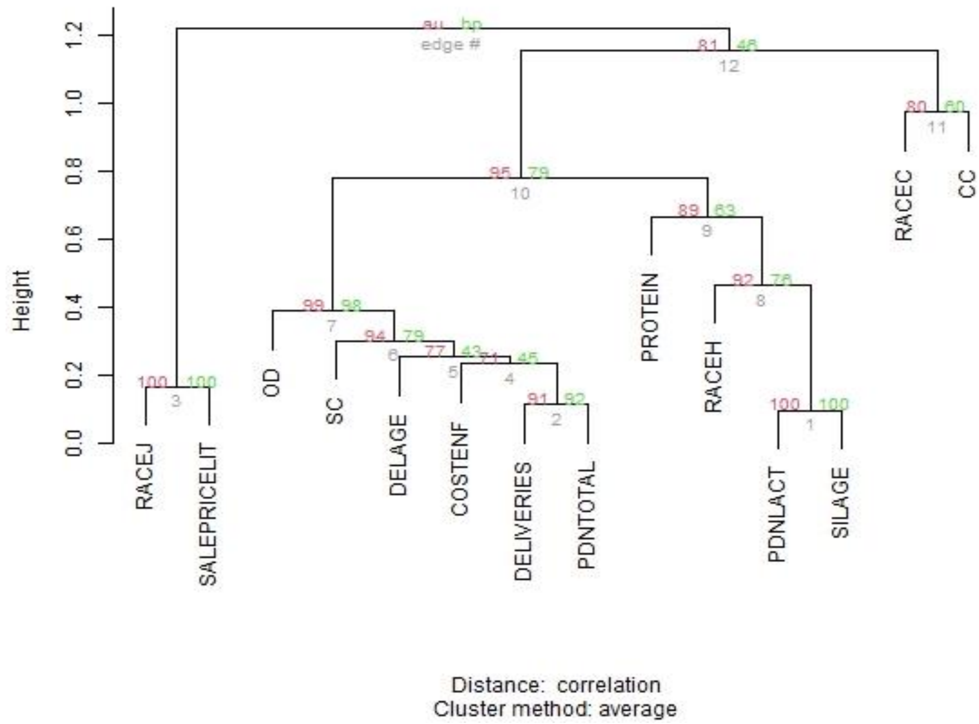
Several studies showed that the Holstein x Jersey cross has better productive performance in grazing systems (Dutour *&* Melucci*,* 2010; Hernández & Ponce de León, 2018), a fact that could be attributed to lower maintenance requirements and the heterotic effect. Similarly, this situation explains the relationships between cow size and conversion efficiency (Veerkamp *et al.,* 2015; Horvath *et al.*, 2017b), bearing in mind the dilution of the direct maintenance cost and the availability of more surplus resources to dedicate them to milk production. Also showing that, with higher production, it is possible that production costs will increase, regardless of the genotype. Therefore, in these grazing systems, the predominance of Holstein cows is observed, which, even being heavier and more voluminous, produce more milk than the other genotypes, differences that disappear in crossbred cows (Holstein and Jersey) with more than one calving (Dono *et al.,* 2013; Villalobos & Ching-Jones, 2019). Even so, it is necessary to continue analyzing information with a greater number of animals, deliveries, or lactations to optimize decisions when choosing the genotypes best adapted to the system and less demanding on external feeding. Other crosses to derive indicators of reproductive efficiency have been used in commercial farms of Rosario-Argentina, where they compared the pure Holstein breed and the crosses (Swedish red & white / Holstein). In this trial, the crosses had a superior reproductive performance expressed for 30 empty days less than pure Holsteins (Mancuso, 2017).



Meaning of acronyms: OD (Open days), SC (Services by conception), COSTS (Costs), CC (Corporal condition), RACEJ (Jersey race), SALEPRICELIT (Sale price litre), PDNLACT (Production by lactation), RACEH (Holstein race), RACEC (Crosses race), PDNTOTAL (Total production).

Figure 1. Relationship between biological and economic variables in the study farms.

According to the principal components analysis (Figure 1), in the comparison between the biological and economic variables, the relationships were: the breed with silage and production by lactation. On the other hand, the sale price of a liter of milk with the breed, services by conception, days open, number of deliveries, silage, and total milk production stand out with greater relevance.



RACEJ (Jersey race), SALEPRICELIT (Sale price litre), OD (Days open), SC (Services by conception), COSTENF (Costs illness), DELIVERIES (Brings), PDNTOTAL (Total production), RACEH (Holstein race), PDNLACT (Production by lactation) RACEC (Crosses race), CC (Corporal condition).

Figure 2. The cluster of correlation between biological and economic variables in the study farms of three municipalities in the north of Antioquia.

The respective clusters that were formed through the dendrogram (Figure 2) between the biological and economic variables evaluated on the studied farms are observed, thus corroborating the analysis of the main components. 97% correlations were obtained between the clusters: breed, lactation production, silage, and open days with the sale price of a liter of milk. Allowing the establishment of the model with the variables of greater weight in this evaluation and, therefore, better explaining the behavior in the response variable: the sale price of a liter of milk.

The evaluation of the economic variables made it possible to establish that the municipalities of San Pedro and Entrerríos obtained a similar performance in production costs and profits in the commercialization of a liter of milk (Table 3). Unlike the municipality of Belmira, the production cost of a liter of milk was lower (US $ 0.22). It is worth mentioning that feeding with silage and commercial feed represented between 55 and 65% of direct costs, although the sale of a liter was lower than in the other two municipalities (1,172 pesos = US $ 0.36). Even so, it achieved better utility (423 pesos per liter), profitability (69.8%), and a better cost-benefit ratio (1.56) ($p < 0.05$). Showing in this way the economic importance of obtaining lower direct and indirect costs associated with milk production.

In contrast, in countries like New Zealand and Australia, dairy farmers rely on pastures as the main source of food for dairy production. Therefore, they have been selecting a cow for milk that has adapted to the contributions of the pasture throughout the year, with moderate individual productions but higher productivity per hectare and lower maintenance costs (FAO-Organización de las Naciones Unidas para la Agricultura y la Alimentación, 2019; Albertone *et al.,* 2020; ADHI-Australian Dairy Herd Improvement Scheme, 2021).

Cattaneo *et al*. (2012) and Aldaz-Álvarez (2020) propose that to improve the efficiency of OD, it is essential to improve the detection of heat in cows, and with this, a benefit of 8% in production costs would be achieved.

Likewise, this project found that the variable services by conception impact costs because they affect the economy and productivity, not only due to the cost of the process but also due to the relationship with OD, the birth rate, and the CI. Similarly, we agree with studies conducted in the United Kingdom, which pointed out the economic impact of this indicator on costs, reporting losses of 9% of the system's utility (Brickell *et al.,* 2009; Brickell & Wathes, 2011).

Table 3. Economic variables were obtained in the production systems of the study, based on a liter of milk in Colombian pesos and dollars in 2019.

Variable Municipality	Direct costs	Indirect costs	Cost per liter	Sale per-liter	Profit	Profitability %	Cost/Benefit
San Pedro	678.75 (75%)	166.25 (25%)	845 a Us $ 0.25	1190= Us $ 0.36 a	345 a Us $ 0.10	345/678.75*100=50.8a	1190/845= 1.40 a
Belmira	605.62 (78%)	143.38 (22%)	749 ab Us $ 0.22	1172= Us $ 0.36 a	423 b Us $ 0.12	423/605.62*100=69.8b	1172/749= 1.56 b
Entrerríos	703.20 (79%)	151.80 (21%)	855 a Us $ 0.26	1220 = Us $ 0.37 ab	365 a Us $ 0.11	365/703.20*100=51.9a	1220/855= 1.42 a

Different letters represent significant differences p (<0.05). In Colombian pesos of the year 2019 (representative market rate $ 1 Us = 3,282.39 pesos). Republic Bank, 2019.

Regarding reproductive variables, one of the most relevant has been the Brings (DELIVERIES) (Figure 2). The literature reports that, for each month of delay in the calving date, the negative impact on income is 8% due to breastfeeding (Giordano *et al.,* 2012; Galvao *et al.,* 2013; Velázquez *et al*., 2021). Other studies in Brazil, according to Lopes *et al.* (2009a), analyzed different zootechnical indices in the composition and evolution of dairy farms over several years and included that CI presented the greatest influence, followed by age at first calving and mortality rate. Similarly, Marini *et al*. (2021), in dairy farms in Argentina, saw that when values are optimized based on the calving interval, this management is reflected in production costs. The results found in this work coincide, considering that the CI in the evaluated municipalities was, on average, 435 days and the OD was 161; these values agree with those presented by Colanta (2019). However, they differ from those reported in these same municipalities by CEDAIT - Centro del Desarrollo Agrobiotecnológico de Inovacion e Integración

Territorial (2021) and other researchers in different latitudes, in which they report CI and OD slightly higher than those obtained in this work. It is considered that the ideal or goal in dairy production of the CI is to have a calf every year (365 days), and this period contains a gestation that is constant at 270 days; it remains a variable on which the producer can intervein in the OD (period comprised between calving and new conception), and it is appropriate not to exceed 90 days (De Luca, 2019; Murray, 2018). In the same way, OD significantly affects the production costs of a liter of milk by directly affecting the productive performance of days in milk or lactation, which in the region is calculated for milk systems at (US $ 9.42 per day) (CEDAIT, 2021).

The model showed four groups of variables (breed, milk production by lactation, open days, and silage), with an important correlation of 97% and with a more significant contribution to the performance of the price of the liter, obtaining an R2 of 0.91 (p <0.05) and a prediction error of $ 25 Col = (Us $ 0.0076) per liter of milk in the farms evaluated.

Below, in Figure 3, the relationship between the main biological and economic variables of the study is indicated.

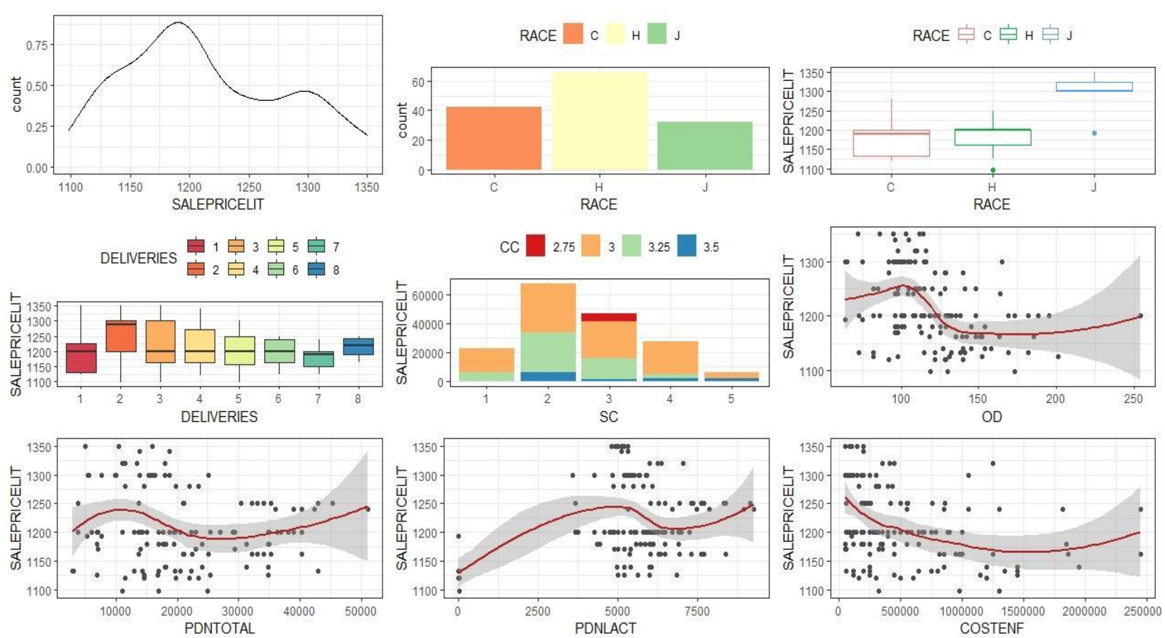


Figure 3. Relationship between biological and economic variables in the study farms.

The study of variables of productive and economic efficiency in dairy farming is essential to being able to impact the productivity of the livestock company (Lopes *et al.,* 2009a; Aprocal - Asociación pro calidad de la leche y sus derivados, 2020; Fernández *et al.,* 2020; CEDAIT, 2021). The use of selection and crossing in dairy systems is an alternative to improve production, health, fertility, and survival while being able to achieve greater productivity benefits because of heterosis. And, of the alternative breeds to the Holstein proposed with this objective, Jersey is referenced as the most widely used, followed by the Swiss Brown, for presenting a better balance in the fat/protein ratio with respect to the other two, being an option industrially and nutritionally appropriate (Comerón *et al.,* 2007; ACHA, 2021). In this research, the variable race obtained results like those proposed by these researchers; it only differs in that instead of the Brown Swiss race, crosses of Holstein x Jersey and Holstein by Cebu were found in the study areas as an alternative.

The literature reports that the decrease in calving represents losses between 5 and 30% of the annual replacement and, therefore, a smaller number of animals available for sale (Murray, 2018; Arboleda, 2020). In this work, the values of the three municipalities analyzed and the discard percentages were lower (Table 2). Along the same lines, Shafer (2006) and Horvath *et al*. (2017b) state that producers recognize that longevity plays a valuable role in profitability. Works by Cappellini (2011), Horn *et al*. (2012), and Marini *et al*. (2021) confirm that higher milk production would not be enough to guarantee higher income if they are not accompanied by other variables such as increased longevity and higher calving rates. Also, Boulton *et al*. (2017) point out that any heifer that dies or is slaughtered before giving birth translates into a financial problem due to the lower number of annual births if that involuntary disbursement is not recovered and must be covered by the income obtained in another area to equalize the loss. The results of this research (Table 2 and Figure 1) coincide with those of these authors and reaffirm what was stated by Rogers *et al*. (1988) and Hailiang *et al*. (2019), who argue that the economic advantage of longevity is based on retaining productive cows for as long as possible, ensuring that less productive cows are replaced as soon as possible to obtain better productive and economic efficiency.

Regarding the productive part, this research found that the variables production by lactation and total milk production were important in the economic prediction of the model (Table 2). This is supported by the main aim of the dairy system, which is the production and commercialization of milk that accounts for more than 90% of the system's income (ICAR-International Committee for Animal Recording, 2021; Montoya-Zuluaga *et al.,* 2017; Colanta, 2019). Similarly, it was confirmed that these variables were directly correlated with the production costs of a liter of milk and explained the model of biological and economic efficiency of the system in 91% ($p < 0.05$). This confirms what has been reported by other studies, where it is mentioned that the economic efficiency of Holstein cows is not only determined by milk production but that other reproductive and productive variables should also be estimated (Le Blanc, 2010; Fernández *et al.,* 2020; Kong *et al.,* 2017; Reyes *et al.,* 2020).

It is important to mention that when the global productive efficiency of a dairy farm is evaluated, multiple options are presented for analyzing variables and their situations, which allow different scenarios to be proposed for the Latin American region, which not only depends on the producer but also that are influenced by world market conditions. However, it is possible to have tools that allow justified cost management to try to give sustainability to the dairy "business".

CONCLUSIONS

With few biological and economic variables, it was significant to determine efficiency with reasonable precision. These variables will be integrated into a web application module, which allows evaluation of the impact of viability and decision-making in dairy farming in grazing systems.

On the other hand, the data obtained in this research suggests advancing proposals with more robust simulation models to select the productive cows that best adapt to their natural environment.

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