UNIVERSIDADE FEDERAL DO PARANÁ

MARIANNA MARINHO MARQUETTI

# ÍNDICES ZOOTÉCNICOS DE REBANHOS EM CONTROLE LEITEIRO OFICIAL EM CASTRO, PARANÁ

CURITIBA

2025

MARIANNA MARINHO MARQUETTI

# ÍNDICES ZOOTÉCNICOS DE REBANHOS EM CONTROLE LEITEIRO OFICIAL EM CASTRO, PARANÁ

Dissertação apresentada ao Programa de Pós-graduação em Zootecnia, Área de Concentração Nutrição e Forragicultura, Setor de Ciências Agrárias, Universidade Federal do Paraná, como requisito parcial para obtenção do título de Mestre em Zootecnia.
Orientador: Prof. Dr. Rodrigo de Almeida

CURITIBA

2025

DADOS INTERNACIONAIS DE CATALOGAÇÃO NA PUBLICAÇÃO (CIP)
UNIVERSIDADE FEDERAL DO PARANÁ
SISTEMA DE BIBLIOTECAS – BIBLIOTECA DE CIÊNCIAS AGRÁRIAS

Marquetti, Marianna Marinho
Índices zootécnicos de rebanhos em controle leiteiro oficial em Castro, Paraná / Marianna Marinho Marquetti. – Curitiba, 2025.
1 recurso online: PDF.

Dissertação (Mestrado) – Universidade Federal do Paraná, Setor de Ciências Agrárias, Programa de Pós-Graduação em Zootecnia.
Orientador: Prof. Dr. Rodrigo de Almeida

1. Bovinos de leite. 2. Bovinos de leite - Produtividade. 3. Leite - Qualidade. I. Almeida, Rodrigo de. II. Universidade Federal do Paraná. Programa de Pós-Graduação em Zootecnia. III. Título.

Bibliotecária: Elizabeth de Almeida Licke da Luz CRB-9/1434

MINISTÉRIO DA EDUCAÇÃO
SETOR DE CIÊNCIAS AGRÁRIAS
UNIVERSIDADE FEDERAL DO PARANÁ
PRÓ-REITORIA DE PÓS-GRADUAÇÃO
PROGRAMA DE PÓS-GRADUAÇÃO ZOOTECNIA -
40001016082P0

**ATA Nº0012025**

# ATA DE SESSÃO PÚBLICA DE DEFESA DE MESTRADO PARA A OBTENÇÃO DO GRAU DE MESTRA EM ZOOTECNIA

No dia vinte e cinco de fevereiro de dois mil e vinte e cinco às 08:30 horas, na sala de reuniões do Departamento de Zootecnia, Setor de Ciências Agrárias da UFPR, foram instaladas as atividades pertinentes ao rito de defesa de dissertação da mestranda **MARIANNA MARINHO MARQUETTI**, intitulada: **Índices Zootécnicos de rebanhos em controle leiteiro oficial em Castro, Paraná**, sob orientação do Prof. Dr. RODRIGO DE ALMEIDA. A Banca Examinadora, designada pelo Colegiado do Programa de Pós-Graduação ZOOTECNIA da Universidade Federal do Paraná, foi constituída pelos seguintes Membros: RODRIGO DE ALMEIDA (UNIVERSIDADE FEDERAL DO PARANÁ), ANDRÉ OSTRENSKY (PONTIFÍCIA UNIVERSIDADE CATÓLICA DO PARANÁ), LAILA TALARICO DIAS (UNIVERSIDADE FEDERAL DO PARANÁ). A presidência iniciou os ritos definidos pelo Colegiado do Programa e, após exarados os pareceres dos membros do comitê examinador e da respectiva contra argumentação, ocorreu a leitura do parecer final da banca examinadora, que decidiu pela APROVAÇÃO. Este resultado deverá ser homologado pelo Colegiado do programa, mediante o atendimento de todas as indicações e correções solicitadas pela banca dentro dos prazos regimentais definidos pelo programa. A outorga de título de mestra está condicionada ao atendimento de todos os requisitos e prazos determinados no regimento do Programa de Pós-Graduação. Nada mais havendo a tratar a presidência deu por encerrada a sessão, da qual eu, RODRIGO DE ALMEIDA, lavrei a presente ata, que vai assinada por mim e pelos demais membros da Comissão Examinadora.

CURITIBA, 25 de Fevereiro de 2025.

Assinatura Eletrônica
27/02/2025 15:20:29.0
RODRIGO DE ALMEIDA
Presidente da Banca Examinadora

Assinatura Eletrônica
27/02/2025 23:00:18.0
ANDRÉ OSTRENSKY
Avaliador Externo (PONTIFÍCIA UNIVERSIDADE CATÓLICA DO PARANÁ)

Assinatura Eletrônica
28/02/2025 15:13:14.0
LAILA TALARICO DIAS
Avaliador Interno (UNIVERSIDADE FEDERAL DO PARANÁ)

MINISTÉRIO DA EDUCAÇÃO
SETOR DE CIÊNCIAS AGRÁRIAS
UNIVERSIDADE FEDERAL DO PARANÁ
PRÓ-REITORIA DE PÓS-GRADUAÇÃO
PROGRAMA DE PÓS-GRADUAÇÃO ZOOTECNIA -
40001016082P0

# TERMO DE APROVAÇÃO

Os membros da Banca Examinadora designada pelo Colegiado do Programa de Pós-Graduação ZOOTECNIA da Universidade Federal do Paraná foram convocados para realizar a arguição da dissertação de Mestrado de **MARIANNA MARINHO MARQUETTI**, intitulada: **Índices Zootécnicos de rebanhos em controle leiteiro oficial em Castro, Paraná**, sob orientação do Prof. Dr. RODRIGO DE ALMEIDA, que após terem inquirido a aluna e realizada a avaliação do trabalho, são de parecer pela sua APROVAÇÃO no rito de defesa.

A outorga do título de mestra está sujeita à homologação pelo colegiado, ao atendimento de todas as indicações e correções solicitadas pela banca e ao pleno atendimento das demandas regimentais do Programa de Pós-Graduação.

CURITIBA, 25 de Fevereiro de 2025.

Assinatura Eletrônica
27/02/2025 15:20:29.0
RODRIGO DE ALMEIDA
Presidente da Banca Examinadora

Assinatura Eletrônica
27/02/2025 23:00:18.0
ANDRÉ OSTRENSKY
Avaliador Externo (PONTIFÍCIA UNIVERSIDADE CATÓLICA DO PARANÁ)

Assinatura Eletrônica
28/02/2025 15:13:14.0
LAILA TALARICO DIAS
Avaliador Interno (UNIVERSIDADE FEDERAL DO PARANÁ)

Aos meus pais, José e Maria, que não mediram esforços para a realização deste sonho.

A minha irmã Rafaela, grande incentivadora e apoio nos momentos difíceis.

Dedico.

## AGRADECIMENTOS

A Deus, por abençoar meus caminhos, me trazer clareza nos momentos difíceis e confiança quando duvidei que era possível.

Aos meus pais, que com toda a sua dedicação e seu amor, acreditaram em mim, me ampararam e me fizeram chegar até aqui.

À minha irmã, que sempre foi uma grande amiga e fonte de inspiração.

Ao meu orientador Rodrigo de Almeida, pela orientação e confiança durante esses anos, mas principalmente pelo exemplo de profissionalismo e caráter.

Aos amigos que estiveram e estão presentes em todos os momentos da minha vida e em especial a Gabriela e ao Luís Gustavo, obrigada por serem exatamente quem vocês são.

Ao garoto que surgiu de repente, bagunçou e coloriu os meus dias, me fazendo muito mais feliz.

Aos colegas do Grupo do Leite da UFPR, pela colaboração e pelas trocas.

À Castrolanda Cooperativa Agroindustrial e a Associação Paranaense de Criadores de Bovinos da Raça Holandesa pelo apoio a este projeto.

Muito obrigada!

**“Eu quero ser tudo que sou capaz de me tornar”**

**Katherine Mansfield**

**RESUMO**

Os objetivos deste estudo foram comparar índices zootécnicos de rebanhos grandes e tradicionais, que realizam Controle Leiteiro Oficial há muitos anos, com aqueles índices calculados em rebanhos pequenos e médios, que iniciaram o Controle Leiteiro Oficial a partir de 2023 e os índices zootécnicos entre rebanhos de distintos grupamentos raciais; Holandês, Jersey e mistos. Relatórios mensais do Controle Leiteiro Oficial (n = 3.029) foram compilados contendo índices zootécnicos de 277 rebanhos, sendo 97 tradicionais e 180 novos, e 170 Holandês (HOL), 74 Jersey (JER) e 35 mistos (MIX), da região de Castro, estado do Paraná, durante um período de 18 meses, de julho de 2023 a dezembro de 2024. Doze índices foram avaliados e comparados entre os rebanhos. A análise estatística foi realizada usando o procedimento MIXED do SAS, que considerou, como fixos, os efeitos de raça, categoria de rebanho (novo ou tradicional) e estação do ano, sendo que, o rebanho foi considerado efeito aleatório. Os novos rebanhos tinham em média 88 vacas, enquanto os rebanhos tradicionais tinham 373 vacas. Como esperado, a produção média diária de leite foi maior para rebanhos tradicionais do que para rebanhos novos (30,76 vs. 20,97 kg/d; $P<0,01$), e também foi maior em rebanhos da raça Holandesa do que em rebanhos da raça Jersey e mistos (29,63, 24,26 e 23,70 kg/d, respectivamente; $P<0,01$). Foi observado menor DEL (dias em leite) para rebanhos tradicionais em relação aos novos (222,95 vs. 240,08 d; $P<0,05$) e houve diferença significativa entre as raças (225,63, 217,44 e 251,48 d, para rebanhos HOL, JER e MIX, respectivamente; $P<0,05$). Tanto rebanhos tradicionais quanto novos, e como os três grupamentos raciais avaliados, apresentaram valores acima do ideal 180 DEL. Os teores de gordura, proteína e sólidos totais do leite não diferiram ($P>0,05$) entre as categorias do rebanho. Entretanto, os componentes do leite apresentaram diferenças entre raças, sendo que para os rebanhos Jersey as porcentagens de gordura, proteína e sólidos totais foram maiores ($P<0,01$) do que os rebanhos Holandeses ou mistos, respectivamente, 4,38, 3,71 e 3,95% para gordura do leite; 3,58, 3.28 e 3.44% para proteína do leite e 13,37, 12,46% e 12,88% para sólidos totais do leite. O teor de lactose e a contagem de células somáticas, indicadores da qualidade microbiológica do leite, apresentaram diferenças entre as categorias de rebanho, nas quais os rebanhos tradicionais apresentaram menor CCS (277.000 vs. 358.000 células/mL; $P<0,05$) e maior porcentagem de lactose (4,57 vs. 4,49%; $P<0,01$). A idade média das vacas também diferiu entre as categorias de rebanho e os grupamentos raciais, onde os novos rebanhos descartaram menos vacas, aumentando a média idade do rebanho (61,1 vs. 50,2 meses; $P<0,01$), e a JER mostrou-se mais longeva que os rebanhos

HOL ou MIX (58,4, 52,2 e 61.9 meses, respectivamente; $P<0{,}01$). Ambos os efeitos de categoria do rebanho e raça predominante do rebanho não afetaram ($P>0{,}05$) as variáveis reprodutivas intervalo entre partos e dias abertos. Conclui-se que, rebanhos leiteiros podem se beneficiar do Controle Leiteiro Oficial realizado mensalmente, melhorando seus índices zootécnicos, aumentando a produtividade e, por consequência, a lucratividade dos produtores.

Palavras-chave: controle leiteiro oficial, índices zootécnicos, vacas leiteiras

# ABSTRACT

The first objective of this study was to compare zootechnical indexes of large and traditional herds, which have been performing Official Dairy Herd Improvement (DHI) for many years, with those indexes observed in small and medium-sized herds, which started Official DHI only in 2023. A second objective was to compare zootechnical indexes between herds of different racial groups: Holstein, Jersey and mixed. Monthly DHI reports (n = 3,029) were compiled containing zootechnical indexes of 277 herds (97 traditional and 180 new; 170 Holstein, 74 Jersey, and 35 mixed herds) from Castro region of Paraná State, Southern Brazil, during an 18-month period, from July, 2023 to December, 2024. Twelve indexes were evaluated and compared among herds. Statistical analysis was performed using the MIXED procedure of SAS, with the fixed effects of genetic group, season and herd category (new or traditional), and herd as a random effect. New herds had an average 88 ± SD total cows in the herd, whereas traditional herds had 373 ± SD cows. As expected, average daily milk production was higher for traditional DHI herds than new herds (30.76 vs 20.97 kg/d; $P<0.01$), and also it was higher in Holstein than Jersey or mixed herds (29.63, 24.26, and 23.70 kg/d, respectively; $P<0.01$). The variable DIM (days in milk) presented significant values between herd's categories (222.95 vs 240.08 d; $P<0.05$) and among herd's predominant genetic group (225.63, 217.44, and 251.48 days; $P<0.05$). Both traditional and new herds, and the three breed groups evaluated, presented values above the ideal 180 days in milk (DIM). The fat, protein and total solids contents of the milk did not differ ($P>0.05$) between the herd categories. However, there were differences between breeds, where the milk from Jersey herds presented higher ($P<0.01$) milk components than from Holstein or mixed herds; 4.38, 3.71 and 3.95% for milk fat; 3.58, 3.28 and 3.44% for milk protein and 13.37, 12.46% and 12.88% for total milk solids. The lactose content and somatic cell count, important indicators of the microbiological quality of milk, showed differences for herd's category, in which it was observed on traditional DHI herds lower SCC (277.4 vs 357.9 cells/mL; $P<0,05$) and higher lactose percentage (4.57 vs 4.49%; $P<0.01$). The average age of cows also differed between herd categories and breed groups, where new herds culled fewer cows, increasing the average herd age (61.1 vs. 50.2 months; $P<0.01$), and JER herds were longer-lived than HOL or MIX herds (58.4, 52.2 and 61.9 months, respectively; $P<0.01$). Both herd category and predominant breed effects did not affect ($P>0.05$) the reproductive variables calving interval and days open. In conclusion, dairy herds can benefit from the Official DHI carried out monthly, improving their zootechnical indexes, increasing their productivity and, consequently, the profitability of producers.

Keywords: dairy herd improvement, zootechnical indexes, dairy cattle

LISTA DE TABELAS

Table 1. Descriptive statistics from traditional DHI herds. ........................................... 23

Table 2. Descriptive statistics from new DHI herds. ..................................................... 23

Tabela 3. Zootechnical indexes from new and traditional DHI herds. ........................... 24

Tabela 4. Zootechnical indexes from Holstein, Jersey, and mixed herds. ...................... 43

## LIST OF ABREVIATIONS

APCBRH – Associação Paranaense de Criadores de Bovinos da Raça Holandesa

DHI – Dairy Herd Improvement

DIM – Days in milk

SCC – Somatic cell count

TBC – Total bacterial count

SUMÁRIO

Capítulo 1 ........ 15
Zootechnical Indexes: A comparative study between traditional and new herds under official milk-recording ........ 15
ABSTRACT ........ 16
INTRODUCTION ........ 18
MATERIALS AND METHODS ........ 20
DHI service ........ 20
Data Set ........ 21
Statistical analysis ........ 22
RESULTS ........ 23
Daily milk production and corrected milk production ........ 25
Days in Milk ........ 25
Milk Fat, Protein and Solids contents ........ 25
Fat+True Protein production ........ 25
Lactose and Somatic Cell Count ........ 26
Average age of the herd ........ 26
Calving interval and days open ........ 26
DISCUSSION ........ 26
CONCLUSION ........ 30
ACKNOWLEDGMENTS ........ 31
REFERENCES ........ 32
Capítulo 2 ........ 37
A comparative study between Holstein, Jersey and mixed herds under official milk-recording ........ 37
ABSTRACT ........ 38
INTRODUCTION ........ 39
MATERIALS AND METHODS ........ 41
Data Set ........ 41
Statistical analysis ........ 42
RESULTS ........ 43
Daily milk production and 180-DIM corrected milk production ........ 43
Days in milk ........ 43
Milk fat, milk protein, and milk solids contents ........ 44
Fat+True Protein production ........ 44
Milk lactose and somatic cell count ........ 44

Average age of the herd ........................................................................................ 45
Calving interval and Days open........................................................................................ 45
DISCUSSION........................................................................................................... 45
CONCLUSIONS ........................................................................................................ 48
ACKNOWLEDGMENTS ............................................................................................... 48
REFERENCES .......................................................................................................... 49

# CAPÍTULO 1

**Zootechnical indexes: A comparative study between traditional and new herds under official milk-recording**

Marianna Marinho Marquetti[a], José Augusto Horst[b], Altair Antonio Valloto[b], Daiana Rosa Oliveira[c], Laila Talarico Dias[a], Rodrigo de Almeida[a*]

[a]Programa de Pós-graduação em Zootecnia, Universidade Federal do Paraná – UFPR, Curitiba, Paraná, Brazil.

[b]Associação Paranaense de Criadores de Bovinos da Raça Holandesa – APCBRH, Curitiba, Paraná, Brazil.

[c]Castrolanda Cooperativa Agroindustrial – Castrolanda, Castro, Paraná, Brazil

*Corresponding author. Current address: Universidade Federal do Paraná, Departamento de Zootecnia, Rua dos Funcionários, 1540, CEP 80035-050, Curitiba, Paraná, Brazil. E-mail address: ralmeida@ufpr.br (Rodrigo de Almeida).

## ABSTRACT

This study aimed to compare the zootechnical indexes in large and traditional herds in the DHI service with those observed in small and medium-sized growing herds, which began official milk recording in July 2023. Monthly DHI reports (n=3,029) were compiled containing information on the zootechnical indexes of 277 herds (97 traditional and 180 new ones), during the 18-month period (July 2023 to December 2024). Twelve zootechnical indexes considered most important were evaluated and compared between herds' category. Statistical analysis was performed using the MIXED procedure of the SAS program. The model included herd category (new or traditional), breed, and season as fixed effects, and herd as a random effect. The study presented an average of 88 animals in new herds and 373 animals in traditional herds. Statistical differences were found between the majority of zootechnical indexes measured. Daily milk yield was higher for traditional DHI herds than for new DHI herds (30.76 vs 20.97 kg/d; $P<0.01$). The DIM presented significant results between traditional and new DHI herds (222.95 vs 240.08 days; $P<0.05$), and both traditional and new herds presented DIM above the target. No differences were found between traditional DHI and new DHI herds for milk fat content (3.97 vs 4.05%; $P=0.14$), milk protein content (3.44 vs 3.43%; $P=0.79$) and milk solids (12.97 vs 12.96%; $P=0.87$), showing that the payment system for milk components benefits both large and traditional DHI herds as well small/medium new DHI herds. The production of fat plus true protein was higher for traditional herds than for new herds (2.18 vs 1.52 kg/d, $P<0.01$). Statistical differences were found between lactose content (4.57 vs 4.47%; $P<0.01$) and in somatic cell count (271.73 vs 346.21 cél/mL; $P<0.01$), with lower SCC and higher percentage of lactose being observed in traditional DHI herds, indicating higher quality of milk in these herds. Average age of the animals presented a difference (51.87 vs 63.11 months; $P<0.01$), indicating that traditional DHI herds culled more cows than new herds. No differences were observed for calving interval (439.61 vs 444.67 days; P=0.46) and days open (157.13 vs 163.55 days; P=0.36). In conclusion, results demonstrated that measuring zootechnical indexes in a monthly basis using DHI help dairy herds to achieve better development and efficiency.

Keywords: zootechnical indexes, dairy herd improvement, dairy cattle

# INTRODUCTION

Ranking as the fifth largest milk producer in the world, Brazil produces more than 36 billion liters annually (Marta, 2023). Dairy farming plays a crucial role in the country, not only because of its wide presence throughout the national territory, but also because of its contribution to the economic and social development of the communities involved. It is estimated that milk production is present in 98% of Brazilian counties, which are predominantly small and medium-sized herds (*Produção de Leite No Brasil | IBGE*, n.d.). On the national scene, the state of Paraná stands out as the second largest milk producer, responsible for 14% of total milk produced in the country.

Despite constant progress, Brazil still has low zootechnical, economic and productive indexes (*Uso de Ferramentas de Gestão Na Atividade Leiteira: Estudo de Caso*, n.d.). Brazilian dairy production is significantly lower than leading countries in the dairy sector, such as the USA, which achieve an average of 11,034 liters of milk cow/year *(Replacement Heifer Prices Hit Monumental Highs, 2024*), while in Brazil this average is only 2,204 liters cow/year.

Although Brazil has modest numbers for most zootechnical indexes, Castro county at Paraná State is the municipality with the largest national milk production, with 426 million liters of milk annually sold (*Produção de Leite No Brasil | IBGE*, 2022), with indexes comparable to those of major milk-producing countries such as the USA and Europe. Being the largest national milk producer, Castro relies on the Castrolanda Cooperative, a large cooperative, which currently has approximately 300 dairy herds under its supervision. In 2021, production reached 435.5 million liters of milk collected by the Cooperative (*Faturamento da Castrolanda atinge valor recorde de R$ 7 bi* |, n.d.). The search for improving the activity is constantly needed, considering that production numbers continue to evolve significantly.

Inadequate management can result in reduced economic return, harming the entire property. Effective planning in dairy activities is crucial to achieve efficiency and development (Silva et al., 2015). Proper management allows small and medium-sized producers to develop and expand their activities (Ferrazza et al., 2018). For traditional and consolidated herds, adequate management brings security and constancy to the activity, and also helps to improve the quality of the milk produced (Ingham et al., 2011).

A simple management and planning approach involves controlling zootechnical indexes, which are fundamental for dairy producers' decision-making (*Economic Selection Index in Small Rural Dairy Farms | Journal of Dairy Research | Cambridge Core*, n.d.). There are hundreds of zootechnical indexes that can help manage a herd, involving all different areas of the dairy activity. Zootechnical indexes are indicators used to evaluate the performance and productivity of dairy herds. They are based on quantitative and qualitative data, collected over time, and provide important information about the productive efficiency and health of animals. This information helps dairy producers monitor and improve herd productivity, identify possible health problems, adjust feeding and implement appropriate management measures (*Anuario Leite 2018 | PDF | Leite | Brasil*, n.d.). With information generated by zootechnical indexes, milk producers can make more informed decisions and optimize production, also ensuring the well-being of the animals.

In the Paraná State, there is an official Dairy Herd Improvement (DHI) service, carried out by the Associação Paranaense de Criadores de Bovinos da Raça Holandesa (APCBRH). The Holstein Breed Association of Paraná State has the most important DHI organization in Brazil, with almost 70% of all Brazilian official milk-recorded cows. The information on zootechnical indexes can be easily obtained by the producers via reports generated through the Association's website.

It is estimated that there are approximately 110,000 dairy herds in Paraná (*Bovinocultura de Leite, n.d*.), and from this estimation, only 400 herds adopt the official DHI service at Paraná State, resulting in only 2.75% of the herds under official milk-recording. This study compiled information from the official DHI reports of 277 herds, which represents almost 100% of the herds from Castro, associated with Cooperative Castrolanda. The unique aspect of this study is to be based on a concrete and fully dataset, because previous studies conducted with the database from APCBRH were always relative to the minority of traditional herds, and consequently, a biased representation.

Zootechnical indexes are very useful and benefit both small/medium-sized growing herds as well as large and consolidated herds. Despite their importance, there is no data (as far as our knowledge goes) on the relevance of measuring these indexes within farms and taking into account the effect of the season of the year, allowing a comparison between herds that have controlled the indexes for a longer time and the ones that just started collecting zootechnical information. Our expectation is also to generate information concerning the benefits of official milk recording, and which are the indexes most improved by the monthly milk recording of dairy herds. Therefore, the aim of this study is to compare the zootechnical indexes of small and medium-sized herds with indexes of larger and more traditional herds associated with Castrolanda Cooperativa Agroindustrial, Campos Gerais County, Paraná State, Southern Brazil.

## MATERIALS AND METHODS

### DHI service

Official DHI is carried out by the Associação Paranaense de Criadores de Bovinos da Raça Holandesa (APCBRH) and generates reports with specific and personalized information about each of the associated herds. APCBRH technicians visit the farms monthly and registered milk production daily (in 2 or 3 milking/day) and collected a milk sample from each animal. Crucial events such as birth date, calving date, insemination date, dry-off date, culling date, among others, are also collected. All this information is stored in a specific program, called Web+Leite, where each registered herd has an individual identification.

Herds that started DHI service only in 2023 were considered “new herds”, but not necessarily the herd was all new on the activity. The herds that have already adopted the DHI service generate reports every month, while the herds that started monitoring in 2023, that is, small and medium herds, carry it out every two months.

**Data Set**

This study had initially 3,095 reports and 318 herds, after an edition process, herds with only 1 or 2 monthly controls were excluded. So, after this edition, the final numbers were 3,029 reports and 277 herds. From the 3,029 reports analyzed, the herds had an average of 199 lactating cows and 55 dry cows. When separated by category, the new herds had an average of 74 lactating animals and 12 dry cows, while the old herds had an average of 305 lactating cows, and 91 dry cows. Monthly reports were divided by herd category; 1,634 reports are from traditional DHI herds (53.95%) and 1,395 from new DHI herds (46.05%). Herds that carried out official DHI between 5 and 45 years were considered traditional. The present study compiled data from the DHI service, from July 2023 to December 2024, from 277 dairy herds associated with Cooperativa Castrolanda. From these 277 herds, 97 are in general larger and consolidated herds and 180 are small and medium-sized herds. From the 3,029 reports, 1,634 came from traditional herds, which already carried out their DHI monthly and, consequently, obtained information on their zootechnical indexes. These traditional herds adopt DHI monthly milk recording for a long time, some of them since 1974. The remaining 1,395 reports came from the new, small and medium-sized herds, which began their monitoring only in mid-2023, with the support of the Programa Mais Leite Saudável, carried out by the Cooperative Castrolanda.

Within the DHI reports, 12 zootechnical indexes were measured: daily milk production, milk production corrected for 180 days in milk, days in milk (DIM), % milk fat, % of milk (total) protein, % lactose, % solids, fat+true protein production, somatic cell score, average age of the animals in the herd, calving interval and days open.

**Statistical analysis**

SAS software version 9.4 (SAS Institute Inc., Cary, NC) was used for data editing and analysis. Breed, season, and category of herds (whether new or traditional) were considered fixed effects. The herd itself was included as a random effect. Least square means and their standard errors were obtained using PROC MIXED. A significance level of 5% was used in all tests. The statistical model used is represented by the equation:

$$Y_{ijkl} = \mu + C_i + S_j + R_k + u_l + \epsilon_{ijkl}$$

Where $Y_{ijk}$ is the dependent variable (daily milk production, milk production corrected for 180 days in milk, days in milk (DIM), % milk fat, % of milk (total) protein, % lactose, % solids, fat+true protein production, somatic cell count, average age of the animals in the herd, calving interval or days open), μ is the overall mean, $C_i$ is the fixed effect of herd category (new or traditional), $S_j$ is the fixed effect of season of the year (winter, spring, summer or fall), $R_k$ is the fixed effect of breed, and $u_l$ is the random effect of herd, assuming a normal distribution with mean and variance and $\epsilon$ is the residual error, assuming a normal distribution with mean and variance.

## RESULTS

Table 1 and 2 show the descriptive statistics of the variables analyzed. Table 3 shows an analysis of variance (ANOVA) that was generated with the Tukey test at 95% to verify the existence of significant differences between the traditional and new herds on DHI service.

Table 1. Descriptive statistics from traditional DHI herds.

| **Variable** | **Obs.** | **Mean** | **sd** | **Min.** | **Max.** |
|---|---|---|---|---|---|
| Milk yield, kg/day | 1634 | 33.40 | 6.90 | 14.50 | 49.02 |
| Corrected 180 DIM MY, kg/d | 1626 | 35.90 | 7.39 | 16.62 | 65.83 |
| Days in milk, d | 1626 | 215.2 | 66.7 | 62 | 673 |
| Milk fat, % | 1633 | 3.80 | 0.59 | 1.96 | 6.00 |
| Milk protein, % | 1633 | 3.33 | 0.18 | 2.88 | 4.18 |
| Milk lactose, % | 1633 | 4.62 | 0.10 | 4.22 | 4.89 |
| Milk total solids, % | 1633 | 12.74 | 0.68 | 10.72 | 15.28 |
| Somatic cell count, cellsx$10^3$/mL | 1634 | 259 | 147 | 44 | 1458 |
| Cow's average age, mo | 1622 | 48.3 | 14.8 | 32.0 | 120.0 |
| Calving interval, d | 1325 | 435.0 | 40.0 | 350 | 645 |
| Days open, d | 1325 | 152.6 | 40.0 | 68 | 363 |

Obs: number of reports

Table 2. Descriptive statistics from new DHI herds.

| Variable | Obs. | Mean | sd | Min. | Max. |
|---|---|---|---|---|---|
| Milk yield, kg/d | 1395 | 23.86 | 6.41 | 6.63 | 49.11 |
| Corrected 180 DIM MY, kg/d | 1261 | 27.25 | 7.68 | 3.92 | 58.37 |
| Days in milk, d | 1261 | 227.0 | 77.8 | 44 | 694 |
| Milk fat, % | 1391 | 3.98 | 0.61 | 1.21 | 6.47 |
| Milk protein, % | 1391 | 3.39 | 0.19 | 2.75 | 4.11 |
| Milk lactose, % | 1391 | 4.52 | 0.14 | 3.93 | 4.90 |
| Milk total solids, % | 1391 | 12.89 | 0.72 | 10.23 | 15.60 |
| Somatic cell count, cellsx$10^3$/mL | 1391 | 314 | 187 | 35 | 1381 |
| Cow's average age, mo | 1309 | 58.4 | 18.9 | 21 | 131 |
| Calving interval, d | 864 | 439.2 | 58.8 | 343 | 651 |
| Days open, d | 871 | 158.2 | 65.0 | 61 | 996 |

Table 3. Zootechnical indexes from new and traditional DHI herds.

| Variable | New-DHI Herds | Traditional-DHI Herds | P-value |
|---|---|---|---|
| Milk yield, kg/d | 20.98 ± 0.46b | 30.76 ± 0.62a | < 0.01 |
| Corrected 180 DIM MY, kg/d | 25.26 ± 0.55b | 33.81 ± 0.74a | < 0.01 |
| Days in milk, d | 240.1 ± 5.6a | 222.9 ± 7.5a | < 0.05 |
| Milk fat, % | 4.05 ± 0.03a | 3.97 ± 0.04a | = 0.14 |
| Milk protein, % | 3.43 ± 0.01a | 3.43 ± 0.01a | = 0.79 |
| Milk lactose, % | 4.47 ± 0.00b | 4.57 ± 0.01a | < 0.01 |
| Milk total solids, % | 12.96 ± 0.04a | 12.97 ± 0.05a | = 0.87 |
| Milk fat + true protein, kg/d | 1.52 ± 0.03b | 2.18 ± 0.04a | < 0.01 |
| Somatic cell count, cellsx$10^3$/mL | 346 ± 12b | 272 ± 16a | < 0.01 |
| Cow's average age, mo | 63.1 ± 1.4b | 51.9 ± 1.9a | < 0.01 |

| | | | |
|---|---|---|---|
| Calving interval, d | 444.7 ± 4.8a | 439.6 ± 5.9a | = 0.54 |
| Days open, d | 163.6 ± 4.9a | 157.1 ± 6.1a | = 0.36 |

P < = P value; Means followed by common letters in the column do not differ statistically at 0.05 significance level by Tukey test.

**Daily milk production and corrected milk production**

Traditional herds in DHI showed a higher (P<0.01) milk production than new herds. Milk production corrected for 180 days in milk also showed higher yields (P<0.01) in traditional herds.

**Days in Milk**

Significant differences were found for the variable days in milk (P<0.05), where traditional herds in DHI showed DIM 18 days shorter than the new herds, suggesting better indexes. However, both categories presented DIM higher than the ideal 180 DIM.

**Milk Fat, Protein and Solids contents**

No differences for milk composition were found (P>0.05) between new and traditional herds, with the exception of % milk lactose. This lack of effect suggests that the payment system for milk solids adopted by Pool Leite in the state of Paraná, benefits both large herds that have already have been carrying out DHI for decades, as well new small/medium herds that have recently started milk-recording.

**Fat+True Protein production**

The variable fat plus true protein production obtained significant values for fixed effect of herd category (P<0.01), where traditional herds produced higher values than new herds.

## Lactose and Somatic Cell Score

Lactose content was higher (P<0.01) and somatic cell count was lower (P<0.01) on traditional herds comparing with the new herds.

## Average age of the cows

New herds have longer-living cows and had a higher average age (P<0.01) than traditional herds.

## Calving interval and days open

These two reproductive indexes are directly linked to each other and presented the same results. No significant values (P>0.05) were found between traditional and new DHI herds.

# DISCUSSION

Previous studies, from the oldest to the most current, have shown that, typically, the size of the herd will affect daily production, and larger herds produced more milk daily when compared to medium or small herds (Egger-Danner et al., 2020; Kara & Galic, 2022; Smith et al., 2000). Although our emphasis was not on herd size, but herd category on time under DHI milk recording, our study corroborated the results found previously, showing that traditional herds, normally larger-scale and already established, have higher daily milk production than new herds that are still growing.

This superior production can be partially explained by the higher level of technology and improvements adopted in the largest and traditional herds, as well as the more intense selection for higher milk yield (Steyn et al., 2021). Furthermore, established herds generally have an already trained team with greater technical knowledge, which directly influences the farm's productivity, encouraging it to reach its maximum potential (Njuki, n.d.).

This study showed that Spring, followed by Winter, were the most productive seasons of the year. Similar results were found in previous studies, demonstrating that the heat stress compromise milk yield (Almeida et al., 2003; Henrichs et al., 2014; Stojnov et al., 2024).

Season of the year will affect milk daily production, mostly because dairy cows produce a high metabolic heat, that will lead to decreased feed intake, since lactating animals are very sensitive to high ambient temperatures (Liang et al., 2013; Toledo et al., 2024). Heat stress is a well-known problem in dairy herds, previous studies showed that decline in production can reach 14% in early lactation and 35% during mid-lactation (Fournel et al., 2017).

The variable days in milk did not show significant differences in the present study. Both traditional and new herds presented values above 180 DIM, which is considered an ideal benchmark for dairy herds. A previous study compared the effect of USA region of different sizes, where it was also recorded that DIM values did not differ between small and large herds (Smith et al., 2000).

The season effect was significant for DIM, with lower DIM means found in the winter and higher DIM values in the summer. This can be explained by the concentration of calvings during the winter, a common practice in dairy herds especially in the South of Brazil, since this period is the most comfortable for a dairy cow to go through the challenges of the transition period and immediate postpartum, in addition to presenting a good conception rate and being considered a good period to initiate a successful lactation (Huang et al., 2009; Soares et al., 2021).

The Campos Gerais region, located in Paraná, adopts a milk payment system based on the milk quality of the herds, considering the fat and protein contents, besides milk quality parameters, such as somatic cell count and total bacterial count, bulk tank temperature, absence of antibiotics and cryoscopic index. This system, which integrates three large cooperatives in the state, so called Pool Leite, aims to encourage the production of quality milk, rewarding the herds that maintain their superior standards of composition and hygiene (*Pool Leite*, n.d.).

We did not find differences on milk composition parameters (milk fat, milk protein, and milk total solids contents) between herds' category, demonstrating that both traditional and new herds are benefiting from the payment system for milk components adopted by Castrolanda cooperative.

The sum of milk fat and milk true protein yields, a very important index for dairy industries focusing in the production of high-quality milk products, were higher on traditional herds, which was expected, considering that daily milk production values were also higher in the traditional herds.

Previous studies have shown that the season of the year greatly affects the production of milk components, where the summer season shows the lowest results for fat and protein contents. The current study presented similar results, which can be seen in Figures 2 and 3 (Fournel et al., 2017; Stojnov et al., 2024).

The lactose percentage represents an indirect indicator of mammary gland health and microbiological quality of milk (Ingham et al., 2011). Previous studies (Werncke et al., 2016) demonstrated that lower lactose content are found in bulk tank milk samples from herds with high SCC and TBC. A relationship between herd size and SCC was previously found (Bauman et al., 2018; Rodrigues et al., 2005), where smaller herds had higher SCC, and consequently, lower milk lactose content. The higher lactose percentage and the lower SCC suggest that traditional DHI herds, deliver milk with superior quality, which can be explained due to the years of monitoring these indexes, allowing the early identification and treatment of infections such as subclinical mastitis, resulting in the higher milk quality delivered to the industry.

Our study also demonstrated that newer herds, still in development, have older animals than traditional herds. Traditional herds are mostly larger, and tend to cull cows earlier than small or medium herds (Hadley et al., 2006; Nor et al., 2014), either because they are already stabilized or because they adopt a higher herd replacement rate. Developing herds tend to hold the decision of cull a cow, either for emotional reasons, or for the desire to fill the property in a faster manner. A third reason could be a negative association between milk yield and longevity, because new herds showed more modest productions, which are associated with an expectation of lower incidence of diseases and locomotion problems, important reasons to cull cows worldwide.

Regarding reproductive rates, no significant differences were found, however, traditional herds had a tendency to present shorter calving intervals and, consequently, shorter days open when compared to new herds. A previous study also found that large herds work with better reproductive rates, and the calving intervals and days open are shorter (Raboisson et al., 2011). By other hand, this should not be considered a rule, as another study did not find associations of reproductive efficiency with herd size (De Vries et al., 2005).

The reproductive success of a herd depends on numerous factors, and the farm size could positively impact reproductive rates, as these herds are investing more in the reproductive management of the animals, such as carrying out a reproductive protocol accompanied by a veterinarian, monitoring reports with the insemination date, expected birth date, investing in good quality genetic materials as well as selection for reproductive traits. However, a small or medium herd has as much potential as a large one for achieve optimal reproductive levels.

Our results are, for the most part, in accordance with results previously found in the literature, however, there are no records that another study compared traditional DHI herds with new and developing DHI herds in Brazil, since Cooperative Castrolanda is the first cooperative to encourage the practice of monthly DHI milk recording and measurement of zootechnical indexes in 100% of its associated herds.

## CONCLUSION

Zootechnical indexes can provide valuable information to dairy herds, enabling improvements in animal productivity and health, in addition to contributing to the economic management of the farms. Herds that have been carrying out this DHI milk recording for a longer time showed better indexes when compared to herds that just started recently. These results suggest that it is possible to evolve and advance in the productivity and profitability of the herd when the zootechnical indexes are measured.

## ACKNOWLEDGMENTS

The authors wish to express their appreciation for the support provided by Castrolanda Cooperativa Agroindustrial and producers and technicians from Associação Paranaense de Criadores de Bovinos da Raça Holandesa (APCBRH).

## REFERENCES


Almeida, R. de, Pimpão, C. T., Ribas, N. P., Degasperi, S., & Marcondes, E. A. (2003). Estudo do efeito de fatores de meio ambiente sobre as produções de leite, gordura e proteína em vacas da raça Pardo-suíça no estado do Paraná. *Revista Acadêmica Ciência Animal, 1(1), Article 1.* https://doi.org/10.7213/cienciaanimal.v1i1.14877

*Anuario Leite 2018 | PDF | Leite | Brasil*. (n.d.). Retrieved February 2, 2025, from https://pt.scribd.com/document/386731454/Anuario-leite-2018

Bauman, C. A., Barkema, H. W., Dubuc, J., Keefe, G. P., & Kelton, D. F. (2018). Canadian National Dairy Study: Herd-level milk quality. *Journal of Dairy Science*, *101*(3), 2679–2691. https://doi.org/10.3168/jds.2017-13336

*Bovinocultura de Leite. (n.d.). Instituto de Desenvolvimento Rural do Paraná.* Retrieved February 11, 2025, from https://www.idrparana.pr.gov.br/Pagina/Bovinocultura-de-Leite

de Vries, A., Steenholdt, C., & Risco, C. A. (2005). Pregnancy rates and milk production in natural service and artificially inseminated dairy herds in Florida and Georgia. *Journal of Dairy Science*, *88*(3), 948–956. https://doi.org/10.3168/jds.S0022-0302(05)72762-4

*Economic selection index in small rural dairy farms | Journal of Dairy Research | Cambridge Core*. (n.d.). Retrieved June 9, 2024, from https://www.cambridge.org/core/journals/journal-of-dairy-research/article/abs/economic-selection-index-in-small-rural-dairy-farms/8366492F77C7F5AB55D665AC27F7E2BD

Egger-Danner, C., Köck, A., Fuchs, K., Grassauer, B., Fuerst-Waltl, B., & Obritzhauser, W. (2020). Use of benchmarking to monitor and analyze effects of herd size and herd milk yield on cattle health and welfare in Austrian dairy farms. *Journal of Dairy Science*, *103*(8), 7598–7610. https://doi.org/10.3168/jds.2019-16745

*Faturamento da Castrolanda atinge valor recorde de R$ 7 bi* |. (n.d.). Retrieved February 2, 2025, from https://www.castrolanda.coop.br/faturamento-da-castrolanda-atinge-valor-recorde-de-r-7-bi/

Ferrazza, R. D. A., Lopes, M. A., Bruhn, F. R. P., & Moraes, F. D. (2018). Zootechnical and economic performance indexes of dairy herds with different production scales. *Semina: Ciências Agrárias*, *39*(1), 287. https://doi.org/10.5433/1679-0359.2018v39n1p287

Fournel, S., Ouellet, V., & Charbonneau, É. (2017). Practices for alleviating heat stress of dairy cows in humid continental climates: A literature review. *Animals*, *7*(5), Article 5. https://doi.org/10.3390/ani7050037

Hadley, G. L., Wolf, C. A., & Harsh, S. B. (2006). Dairy cattle culling patterns, explanations, and implications. *Journal of Dairy Science*, *89*(6), 2286–2296. https://doi.org/10.3168/jds.S0022-0302(06)72300-1

Henrichs, S. C., Macedo, R. E. F. de, & Karam, L. B. (2014). Influência de indicadores de qualidade sobre a composição química do leite e influência das estações do ano sobre esses parâmetros. *Revista Acadêmica Ciência Animal, 12(3), Article 3.* https://doi.org/10.7213/academica.12.03.AO05

Huang, C., Tsuruta, S., Bertrand, J. K., Misztal, I., Lawlor, T. J., & Clay, J. S. (2009). Trends for conception rate of Holsteins over time in the Southeastern United States. *Journal of Dairy Science*, *92*(9), 4641–4647. https://doi.org/10.3168/jds.2008-1982

Ingham, S. C., Hu, Y., & Ané, C. (2011). Comparison of bulk-tank standard plate count and somatic cell count for Wisconsin dairy farms in three size categories. *Journal of Dairy Science*, *94*(8), 4237–4241. https://doi.org/10.3168/jds.2011-4310

Kara, N. K., & Galic, A. (2022). Effects of herd size and bedding surfaces on milk yield and some health problems in dairy cow farms. *Large Animal Review*, *28*(1), Article 1.

Liang, D., Wood, C. L., McQuerry, K. J., Ray, D. L., Clark, J. D., & Bewley, J. M. (2013). Influence of breed, milk production, season, and ambient temperature on dairy cow reticulorumen temperature. *Journal of Dairy Science*, *96*(8), 5072–5081. https://doi.org/10.3168/jds.2012-6537

Marta. (2023, April 24). ¿Quién es el mayor productor mundial?, ¿los Top5? ¿el mayor exportador?... Descúbralo aquí. *Agrodigital*. https://www.agrodigital.com/2023/04/24/quien-es-el-mayor-productor-mundial-los-top5-el-mayor-exportador-descubralo-aqui/

Matte Júnior, A., & Jung, C. (2017). Produção leiteira no Brasil e características da bovinocultura leiteira no Rio Grande do Sul. *Ágora*, *19*, 34. https://doi.org/10.17058/agora.v19i1.8446

Njuki, E. (n.d.). *Sources, Trends, and Drivers of U.S. Dairy Productivity and Efficiency*.

Nor, N. M., Steeneveld, W., & Hogeveen, H. (2014). The average culling rate of Dutch dairy herds over the years 2007 to 2010 and its association with herd reproduction, performance and health. *Journal of Dairy Research*, *81*(1), 1–8. https://doi.org/10.1017/S0022029913000460

*Pool Leite*. (n.d.). Retrieved January 31, 2025, from https://www.poolleite.com.br/?utm_source=chatgpt.com

*Produção de Leite no Brasil | IBGE*. (n.d.). Retrieved February 2, 2025, from https://www.ibge.gov.br/explica/producao-agropecuaria/leite/br

Raboisson, D., Cahuzac, E., Sans, P., & Allaire, G. (2011). Herd-level and contextual factors influencing dairy cow mortality in France in 2005 and 2006. *Journal of Dairy Science*, *94*(4), 1790–1803. https://doi.org/10.3168/jds.2010-3634

*Replacement Heifer Prices Hit Monumental Highs.* (2024, November 7). Dairy Herd. https://www.dairyherd.com/news/business/replacement-heifer-prices-hit-monumental-highs

Rodrigues, A. C. O., Caraviello, D. Z., & Ruegg, P. L. (2005). Management of Wisconsin dairy herds enrolled in milk quality teams. *Journal of Dairy Science*, *88*(7), 2660–2671. https://doi.org/10.3168/jds.S0022-0302(05)72943-X

Silva, M. F. da, Pereira, J. C., Gomes, S. T., Nascif, C., & Gomes, A. P. (2015). Avaliação dos indicadores zootécnicos e econômicos em sistemas de produção de leite. *Revista de Política Agrícola*, *24*(1), Article 1.

Smith, J. W., Ely, L. O., & Chapa, A. M. (2000). Effect of region, herd size, and milk production on reasons cows leave the herd. *Journal of Dairy Science*, *83*(12), 2980–2987. https://doi.org/10.3168/jds.S0022-0302(00)75198-8

Soares, S. R. V., Reis, R. B., & Dias, A. N. (2021). Fatores de influência sobre o desempenho reprodutivo em vacas leiteiras. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia*, *73*, 451–459. https://doi.org/10.1590/1678-4162-11689

Steyn, Y., Gonzalez-Pena, D., Rubio, Y. L. B., Vukasinovic, N., DeNise, S. K., Lourenco, D. a. L., & Misztal, I. (2021). Indirect genomic predictions for milk yield in crossbred Holstein-Jersey dairy cattle. *Journal of Dairy Science*, *104*(5), 5728–5737. https://doi.org/10.3168/jds.2020-19451

Stojnov, M., Penev, T., Dimov, D., & Marinov, I. (2024). Effect of calving season on productive performance of dairy cows. *Dairy*, *5*(1), Article 1. https://doi.org/10.3390/dairy5010018

Toledo, I. M., Casarotto, L. T., & Dahl, G. E. (2024). Seasonal effects on multiparous dairy cow behavior in early lactation. *JDS Communications*, *5*(5), 379–383. https://doi.org/10.3168/jdsc.2022-0358

*Uso de Ferramentas de gestão na atividade leiteira: Estudo de caso*. (n.d.). Retrieved June 9, 2024, from https://professormarcosaurelio.com.br/wp-content/uploads/2018/02/7-3-156-Uso-de-ferramentas-de-gestao-na-atividade-leiteira.pdf

Werncke, D., Gabbi, A. M., Abreu, A. S., Felipus, N. C., Machado, N. L., Cardoso, L. L., Schmid, F. A., Alessio, D. R. M., Fischer, V., & Thaler Neto, A. (2016). Qualidade do leite e perfil das propriedades leiteiras no sul de Santa Catarina: Abordagem multivariada. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia, 68, 506–516.* https://doi.org/10.1590/1678-4162-8396

# CAPÍTULO 2

**A comparative study between Holstein, Jersey, and mixed herds under official milk-recording**

Marianna Marinho Marquetti[a], José Augusto Horst[b], Altair Antonio Valloto[b], Daiana Rosa Oliveira[c], Laila Talarico Dias[a], Rodrigo de Almeida[a*]

[a]Programa de Pós-graduação em Zootecnia, Universidade Federal do Paraná – UFPR, Curitiba, Paraná, Brazil.

[b]Associação Paranaense de Criadores de Bovinos da Raça Holandesa – APCBRH, Curitiba, Paraná, Brazil.

[c]Castrolanda Cooperativa Agroindustrial – Castrolanda, Castro, Paraná, Brazil

*Corresponding author. Current address: Universidade Federal do Paraná, Departamento de Zootecnia, Rua dos Funcionários, 1540, CEP 80035-050, Curitiba, Paraná, Brazil. E-mail address: ralmeida@ufpr.br (Rodrigo de Almeida).

**ABSTRACT**

Holstein and Jersey are among the three most popular breeds in the Brazilian milk production industry. This study aimed to compare the results of zootechnical indexes in Holstein, Jersey, and mixed herds in the official milk-recording service. DHI reports (n = 3,029) were compiled containing information on the zootechnical indexes of 279 herds (170 Holstein, 74 Jersey, and 35 mixed herds), during a 18-month period (from July 2023 to December 2024). Twelve zootechnical indexes were evaluated and compared among herds from different genetic groups. Statistical analysis was performed using the MIXED procedure of the SAS. Breed, season, and herd category (DHI-new or traditional) were considered fixed effects, and herd itself was included as a random effect. Statistical differences were found between the majority of zootechnical indexes measured. Daily milk yield was higher for Holstein herds than for Jersey or mixed herds (29.63, 24.26, and 23.70 kg/d, respectively; $P<0.01$). Days in milk (DIM) showed a tendency of higher values for the mixed herds (225.63, 217.44, and 251.48 d for Holstein, Jersey, and mixed, respectively; $P<0.05$). As expected, differences were found among Holstein, Jersey, and mixed herds for milk fat content (3.71, 4.38, and 3.95%; $P<0.01$), milk protein content (3.28, 3.58, and 3.44%; $P<0.01$) and milk total solids (12.54, 13.46, and 12.88%; $P<0.01$). Fat plus true protein production was higher for Holstein herds than for Jersey and mixed herds (2.00, 1.87, and 1.68 kg/d, $P<0.01$). Differences were also found between lactose content (4.58, 4.48, and 4.49%; $P<0.01$) and a tendency for somatic cell count (301.4, 267.4, and 358.1 cells$\times 10^3$/mL; $P<0.05$) for Holstein, Jersey, and mixed herds, respectively. The average age of the cows was higher for Jersey and mixed herds (52.17, 58.41, and 61.90 months; $P<0.01$), suggesting that Holstein herds have higher culling rates than Jersey and mixed herds. No differences were found for calving interval (437.9, 444.4, and 444.1 days; $P=0.42$) and days open (156.1, 163.9, and 161.0 days; $P=0.38$)

among genetic groups. In conclusion, results demonstrated that Holstein and Jersey herds showed better performance than mixed herds, however, with distinct differences between them; Holstein herds with higher productivity, and Jersey herds with higher solids contents and more longevity.

Keywords: zootechnical indexes, dairy herd improvement, dairy cattle

## INTRODUCTION

When a dairy business began, several factors need to be taken into consideration. One of the most important factors, which will affect the profitability of the herd, is the breed you want to work with, considering that each one will have its own particularities, advantages, and disadvantages. Among the world most popular dairy breeds are the Holstein and Jersey breeds.

Castro county, located in Campos Gerais region, Paraná State, is known for its large and traditional milk-producing herds. The region is the municipality with the largest milk production in Brazil, delivering a total of 454.0 million liters in 2023, generating R$1.3 billion in production (IBGE, 2023). Most of the herds located in this region works with Holstein animals. However, over the years, the Jersey breed has been gaining ground in the region.

While the Holstein breed continues to be known for its remarkable daily milk production and its milk components yields, the Jersey breed draws attention for the high contents of milk components, greater resistance to high temperatures and its known longevity, which has been addressed in several previous studies (Downey & Tucker, 2023; Garcia-Peniche et al., 2006; Smith et al., 2013). Another factor that has also been discussed is the superior reproductive performance of Jersey animals when compared to Holstein cows (Auldist et al., 2007; McClearn et al., 2020).

Over the years, several herds have chosen to work exclusively with the Jersey breed, and also there are some herds that have decided to cross the breeds or to work with both Holstein and Jersey animals on their farms, a strategy commonly used when a producer wants to combine the large volume of milk produced by the Holstein breed with the high solids content in the milk obtained by the Jersey breed. A previous study reported that for a herd to be considered purebred, it must have at least 85% of just one genotype present, either Holstein or Jersey; herds with lower percentages of a single breed would be considered mixed (Kristensen et al., 2015).

Zootechnical indexes, based on quantitative and qualitative data, are used to measure the performance and productivity of herds, providing important information that can help with animal health and also with the profitability of the activity (*Anuario Leite 2018 | PDF | Leite | Brasil*, n.d.).

Several indexes can be monitored to evaluate the performance of dairy herds, and, consequently, it is also possible to make a comparison between Holstein, Jersey, and also the mixed herds. Zootechnical indexes are officially monitored in the Paraná State by the Associação Paranaense de Criadores de Bovinos da Raça Holandesa (APCBRH), where a specialized technician visits the herds monthly and gathers information such as daily milk production, number of animals in the herd (lactating animals, dry animals, heifers and calves), calving dates, insemination dates, dry-off dates, among other information. In addition, a composite milk sample (from the 2 or 3 daily milkings) is collected and analysed for fat, protein, lactose total solids, and somatic cell count in a centralized milk laboratory.

Previous studies have compared the productive, reproductive, behavioral, and other performance data of Holstein, Jersey, and mixed breeds, among other indexes. However, the current study is the first, as far our knowledge goes, to compare herds that work with different breeds, monitored by an official milk-recording, within a dairy cooperative. Moreover, almost 100% of the dairy herds from this region were included in this study in the 18-month period, so our results are not biased by a restricted adoption of the DHI milk recording. The goal of this study is to compare predominantly Holstein herds with predominantly Jersey or mixed herds enrolled in the official milk recording program carried out by the Associação Paranaense de Criadores de Bovinos da Raça Holandesa (APCBRH), which is the most important DHI (Dairy Herd Improvement) organization in Brazil, with almost 70% of all Brazilian official milk-recorded cows.

## MATERIALS AND METHODS

### Data Set

This study had initially 3,095 reports from 318 herds; after an edition step where the herds with only 1 or 2 monthly controls were excluded, the final number of reports was 3,029 from 277 herds. Of the 3,029 reports analyzed, the herds had an average of 199 lactating cows and 55 dry cows.

The study compiled data from the official DHI service, from July 2023 to December 2024, from 279 dairy herds associated with Cooperativa Castrolanda, this number has two herds of difference because they had both breeds on the same farm, but separated as different herds. From these 279 herds, 170 were Holstein herds, 74 Jersey, and 35 were categorized as mixed herds. Monthly reports (n = 3,029) were analyzed; 2,008 came from Holstein herds (66.3%), 675 from Jersey herds (22.3%), and the remaining 346 reports (11.4%) from mixed herds. We're categorized a herd as mixed when it did not reach a minimum of 80% of the animals being of a single breed, Holstein or Jersey.

Within the DHI reports, these were the indexes considered the most important to be measured: daily milk production, milk production corrected for 180 days in milk, days in milk, % milk fat, % of milk protein, % lactose, production of fat+true protein, % solids, somatic cell count, average age of the animals in the herd, calving interval and days open. The data of the reports and the category of the herd were also compiled.

**Statistical analysis**

SAS software version 9.4 (SAS Institute Inc., Cary, NC) was used for data editing and analysis. Breed, season, and category (DHI-New or Traditional) were considered fixed effects, whereas the herd itself was considered a random effect. General means were obtained using the MEANS procedure. Least square means and their standard errors were obtained using the MIXED procedure. A significance level of 5% was used in all tests. The statistical model used is represented by the equation:

$$Y_{ijkl} = \mu + C_i + S_j + R_k + u_l + \epsilon_{ijkl}$$

Where $Y_{ijk}$ is the dependent variable : daily milk production, milk production corrected for 180 days in milk, days in milk, % milk fat, % of milk protein, % lactose, production of fat+true protein, % solids, somatic cell count, average age of the animals in the herd, calving interval and days open, μ is the overall mean, $C_i$ is the fixed effect of herd category (new or traditional), $S_j$ is the fixed effect of season of the year (winter, spring, summer or fall), $R_k$ is the fixed effect of breed, and $u_l$ is the random effect of herd, assuming a normal distribution with mean and variance and $\epsilon$ is the residual error, assuming a normal distribution with mean and variance.

## RESULTS

Table 4 shows an analysis of variance (ANOVA) that was generated with the Tukey test at 95% to verify the existence of significant differences between the levels of the variables tested for the fixed effects of breed.

Table 4. Zootechnical indexes from Holstein, Jersey, and mixed herds.

| **Variable** | **Holstein Herds** | **Jersey Herds** | **Mixed Herds** | ***P* <** |
|---|---|---|---|---|
| Milk yield, kg/d | 29.63 ± 0.39a | 24.26 ± 0.50b | 23.70 ± 0.96b | < 0.01 |
| Corrected 180 DIM MY, kg/d | 32.86 ± 0.47a | 27.03 ± 0.63b | 28.72 ± 1.14ab | < 0.01 |
| Days in milk, d | 225.6 ± 4.82a | 217.4 ± 6.70a | 251.5 ± 11.64a | < 0.05 |
| Milk fat, % | 3.71 ± 0.03b | 4.38 ± 0.04a | 3.95 ± 0.07ab | < 0.01 |
| Milk total protein, % | 3.28 ± 0.00a | 3.58 ± 0.01b | 3.44 ± 0.02b | < 0.01 |
| Milk lactose, % | 4.58 ± 0.00a | 4.48 ± 0.01b | 4.49 ± 0.01b | < 0.05 |
| Milk total solids, % | 12.54 ± 0.03a | 13.46 ± 0.05b | 12.88 ± 0.08a | < 0.01 |
| Fat+true protein yield, kg/d | 2.00 ± 0.02a | 1.87 ± 0.037b | 1.68 ± 0.07b | < 0.01 |
| Somatic cell count, cellsx$10^3$/mL | 301.4 ± 10.26a | 267.4 ± 15.07a | 358.1 ± 24.25a | < 0.05 |
| Cow's average age, mo | 52.17 ± 1.19b | 58.41 ± 1.54ab | 61.90 ± 2.92a | < 0.05 |
| Days open, d | 156.1 ± 3.92a | 163.9 ± 5.71a | 161.0 ± 10.03a | = 0.42 |
| Calving interval, d | 437.9 ± 3.77a | 444.4 ± 5.33a | 444.1 ± 9.69a | = 0.38 |

*P* < = *P* value; means followed by common letters in the same line do not differ statistically at 0.05 significance level by Tukey test.

### Daily milk production and 180-DIM corrected milk production

Predominantly Holstein herds had higher (P<0.01) daily milk yields than predominantly Jersey and mixed herds. Milk production corrected for 180 DIM was also higher (P<0.01) on predominantly Holstein herds when compared with Jersey and mixed herds.

### Days in milk

The variable days in milk presented significant values (P<0.05) for the breed effect, where Jersey animals showed a smaller and desirable value for DIM than the other two genetic groups. For season effect, significant differences were also found (P<0.01).

**Milk fat, milk protein, and milk solids contents**

Milk composition differences were obtained comparing Holstein, Jersey, and mixed herds for milk fat content (P<0.01), milk protein content (P<0.01), and milk total solids content (P<0.01). While Holstein cows are superior in daily milk production, Jersey cows produce milk with higher percentages of milk fat, protein and total solids. Milk components are crucial factors which have a direct effect on the yield and quality of dairy products.

Another factor to be considered is that producers in the Castro region, included in this study, receive bonus for higher concentrations of milk fat and protein by the milk payment system adopted by Pool Leite (an integrated system of the three main cooperatives in the region).

**Fat plus true protein production**

The variable fat plus true protein production had obtained significant differences (P<0.01) for breed category effect, where Holstein herds had higher values for fat plus true protein production than Jersey or mixed herds.

**Milk lactose and somatic cell count**

Holstein herds showed higher (P<0.01) lactose content than Jersey or mixed herds. Somatic cell count also differ (P<0.05) among herds with distinct genetic groups; Jersey herds showed lower SCC values when compared to Holstein or mixed herds.

**Average age of the herd**

Mixed breed herds showed greater (P<0.01) average age of the cows, suggesting greater longevity and lower culling rates, when compared to Holstein or Jersey herds.

**Calving interval and Days open**

These two reproductive indexes are directly linked, because days open plus gestation length equals calving interval. No significant differences (P>0.05) were found between Holstein, Jersey, or mixed herds.

## DISCUSSION

Previous studies show that breed greatly influences a herd's production. Holstein herds had significantly higher daily milk production than Jersey and mixed herds (Kristensen et al., 2015; Lim et al., 2020), a result similar to what was found in the present study. However, other studies have also shown that the Holstein breed, despite being more productive, is less resistant when it comes to heat stress. Their daily production tends to decrease in warmer periods of the year, while Jersey animals were able to maintain their production at higher temperatures (Smith et al., 2013).

While Holstein cows are superior in daily milk production, Jersey animals compensate their lower daily milk yields with significantly higher contents of milk fat, protein, and solids (Bland et al., 2015; Jensen et al., 2012; McClearn et al., 2020). This study presented results that corroborate the literature, where Jersey animals showed higher milk components.

Milk components are important factors that have a direct effect on the yield and quality of dairy products (Yoo et al., 2019). Producers from Castro county at Paraná State receive bonus for higher contents of milk fat and protein, a milk payment system that have been inspired by the payment system adopted in Canada. The milk component bonus system adopted in the Campos Gerais region is called Pool Leite and it was developed in a partnership between the three main cooperatives in the region, where producers receive a bonus value on the base price when they exceed average values of milk fat and protein, besides good milk quality parameters such as low SCC and TBC. The system aims to encourage the production of quality milk, rewarding the herds that maintain their superior standards of composition and hygiene (*Pool Leite*, n.d.).

Although the milk component contents are higher in the Jersey breed, milk fat plus true protein production is higher in Holstein herds when compared to Jersey and mixed herds. This is explained because milk fat plus true protein is the sum of milk fat and protein values, adjusted according to milk production and its dilution, therefore they are strongly correlated with milk production.

The season effect also impacted the milk composition, where fat contents were lower during the summer. In some studies, Jersey cows showed greater resistance to heat stress, where their fat and protein productions were not affected during the warmer months of the year. The present study had a higher number of predominantly Holstein herds, which may have led to a more pronounced drop in milk components during the heat stress period (Armstrong, 1994; Lievaart et al., 2007).

The Jersey breed showed lower SCC in previous studies (Lim et al., 2020), but in the present study the SCC results were similar among the genetic groups. The season effect was also observed on the somatic cell count, with higher SCC values in the fall and in the summer, findings that were corroborated by the literature. In the summer, there are ideal conditions for the proliferation of pathogens which cause mastitis and also a decrease in the immunity of animals, making them more susceptible to these pathogens. In the fall season, a pronounced decrease in daily milk production is observed, which may have led to an increase in the somatic cell count (Barbano et al., 2006; *Lymphocyte Functions in Dairy Cows in Hot Environment | International Journal of Biometeorology*, n.d.; Smith et al., 2013).

It has been shown in previous studies that the Jersey breed has a longer productive life when compared to the Holstein breed (Bascom & Young, 1998; Bjelland et al., 2011). The present study also found differences in the average age of the cows from Jersey herds, confirming that Jersey cows tend to last longer within herds.

Studies comparing purebred herds with mixed ones are scarcer. One study compared the culling incidence between Holstein, Jersey and mixed herds, and the result was that mixed herds culled less than other breeds. It can be concluded that mixed herds tend to have a higher average herd age than Holstein or Jersey herds (Pinedo et al., 2014). The present study found a similar result, with mixed herds having a significantly higher average age in months than purebred herds.

Contrary to previous studies where Jersey animals showed greater reproductive rates (Auldist et al., 2007; McClearn et al., 2020), the present study did not find significant differences for calving interval and days open among breeds, showing that the reproductive success of a herd depends on numerous factors, not just the predominant breed on these herds.

Our results are, for the most part, in accordance with results previously found in the literature. However, as far our knowledge goes, there are no previous studies which compared official milk-recorded Holstein, Jersey and mixed herds in Brazil, since Castrolanda dairy cooperative is the first one to encourage the practice of official milk recording on all associated dairy herds.

## CONCLUSIONS

Holstein herds showed higher daily milk production, however, Jersey herds produce milk with higher milk solids, mainly milk fat and protein. The decision to choose one of these two breeds is dependable of the producer's preference but even more important, the adoption of a milk payment system based on milk volume, quality and composition.

## ACKNOWLEDGMENTS

The authors wish to express their appreciation for the support provided by Castrolanda Cooperativa Agroindustrial and producers and technicians from Associação Paranaense de Criadores de Bovinos da Raça Holandesa (APCBRH).

## REFERENCES


*Anuario Leite 2018 | PDF | Leite | Brasil*. (n.d.). Retrieved February 2, 2025, from https://pt.scribd.com/document/386731454/Anuario-leite-2018

Armstrong, D. V. (1994). Heat stress interaction with shade and cooling. *Journal of Dairy Science*, *77*(7), 2044–2050. https://doi.org/10.3168/jds.S0022-0302(94)77149-6

Auldist, M. J., Pyman, M. F. S., Grainger, C., & Macmillan, K. L. (2007). Comparative reproductive performance and early lactation productivity of Jersey × Holstein cows in predominantly Holstein herds in a pasture-based dairying system. *Journal of Dairy Science*, *90*(10), 4856–4862. https://doi.org/10.3168/jds.2006-869

Barbano, D. M., Ma, Y., & Santos, M. V. (2006). Influence of raw milk quality on fluid milk shelf life. *Journal of Dairy Science*, *89*, E15–E19. https://doi.org/10.3168/jds.S0022-0302(06)72360-8

Bascom, S. S., & Young, A. J. (1998). A summary of the reasons why farmers cull cows. *Journal of Dairy Science*, *81*(8), 2299–2305. https://doi.org/10.3168/jds.S0022-0302(98)75810-2

Bjelland, D. W., Weigel, K. A., Hoffman, P. C., Esser, N. M., Coblentz, W. K., & Halbach, T. J. (2011). Production, reproduction, health, and growth traits in backcross Holstein × Jersey cows and their Holstein contemporaries. *Journal of Dairy Science*, *94*(10), 5194–5203. https://doi.org/10.3168/jds.2011-4300

Bland, J. H., Grandison, A. S., & Fagan, C. C. (2015). Effect of blending Jersey and Holstein-Friesian milk on Cheddar cheese processing, composition, and quality. *Journal of Dairy Science*, *98*(1), 1–8. https://doi.org/10.3168/jds.2014-8433

Downey, B. C., & Tucker, C. B. (2023). Breed differences in oral behaviors in feed-restricted dairy heifers. *Journal of Dairy Science*, *106*(12), 9440–9450. https://doi.org/10.3168/jds.2022-23208

Garcia-Peniche, T. B., Cassell, B. G., & Misztal, I. (2006). Effects of breed and region on longevity traits through five years of age in Brown Swiss, Holstein, and Jersey cows in the United States. *Journal of Dairy Science*, *89*(9), 3672–3680. https://doi.org/10.3168/jds.S0022-0302(06)72407-9

Jensen, H. B., Poulsen, N. A., Andersen, K. K., Hammershøj, M., Poulsen, H. D., & Larsen, L. B. (2012). Distinct composition of bovine milk from Jersey and Holstein-Friesian cows with good, poor, or noncoagulation properties as reflected in protein genetic variants and isoforms. *Journal of Dairy Science*, *95*(12), 6905–6917. https://doi.org/10.3168/jds.2012-5675

Kristensen, T., Jensen, C., Østergaard, S., Weisbjerg, M. R., Aaes, O., & Nielsen, N. I. (2015). Feeding, production, and efficiency of Holstein-Friesian, Jersey, and mixed-breed lactating dairy cows in commercial Danish herds. *Journal of Dairy Science*, *98*(1), 263–274. https://doi.org/10.3168/jds.2014-8532

Lievaart, J. J., Barkema, H. W., Kremer, W. D. J., Van Den Broek, J., Verheijden, J. H. M., & Heesterbeek, J. A. P. (2007). Effect of herd characteristics, management practices, and season on different categories of the herd somatic cell count. *Journal of Dairy Science*, *90*(9), 4137–4144. https://doi.org/10.3168/jds.2006-847

Lim, D.-H., Mayakrishnan, V., Lee, H.-J., Ki, K.-S., Kim, T.-I., & Kim, Y. (2020). A comparative study on milk composition of Jersey and Holstein dairy cows during the early lactation. *Journal of Animal Science and Technology*, *62*(4), 565–576. https://doi.org/10.5187/jast.2020.62.4.565

*Lymphocyte functions in dairy cows in hot environment | International Journal of Biometeorology*. (n.d.). Retrieved February 1, 2025, from https://link.springer.com/article/10.1007/s00484-005-0273-3

McClearn, B., Delaby, L., Gilliland, T. J., Guy, C., Dineen, M., Coughlan, F., Buckley, F., & McCarthy, B. (2020). An assessment of the production, reproduction, and functional traits of Holstein-Friesian, Jersey × Holstein-Friesian, and Norwegian Red × (Jersey × Holstein-Friesian) cows in pasture-based systems. *Journal of Dairy Science*, *103*(6), 5200–5214. https://doi.org/10.3168/jds.2019-17476

Pinedo, P. J., Daniels, A., Shumaker, J., & Vries, A. D. (2014). Dynamics of culling for Jersey, Holstein, and Jersey × Holstein crossbred cows in large multibreed dairy herds. *Journal of Dairy Science*, *97*(5), 2886–2895. https://doi.org/10.3168/jds.2013-7685

*Pool Leite*. (n.d.). Retrieved January 31, 2025, from https://www.poolleite.com.br/?utm_source=chatgpt.com

Smith, D. L., Smith, T., Rude, B. J., & Ward, S. H. (2013). Short communication: Comparison of the effects of heat stress on milk and component yields and somatic cell score in Holstein and Jersey cows. *Journal of Dairy Science*, *96*(5), 3028–3033. https://doi.org/10.3168/jds.2012-5737

*Valor da produção da pecuária e aquicultura chega a R$ 122,4 bilhões em 2023 | Agência de Notícias*. (2024, September 19). Agência de Notícias - IBGE. https://agenciadenoticias.ibge.gov.br/agencia-noticias/2012-agencia-de-noticias/noticias/41352-valor-da-producao-da-pecuaria-e-aquicultura-chega-a-r-122-4-bilhoes-em-2023

Yoo, J., Song, M., Park, W., Oh, S., Ham, J., Jeong, S., & Kim, Y. (2019). A comparison of quality characteristics in dairy products made from Jersey and Holstein milk. *Food Science of Animal Resources*, *39*(2), 255–265. https://doi.org/10.5851/kosfa.2019.e20

## REFERÊNCIAS


**ALMEIDA, R. de et al.** Estudo do efeito de fatores de meio ambiente sobre as produções de leite, gordura e proteína em vacas da raça Pardo-suíça no estado do Paraná. *Revista Acadêmica Ciência Animal*, v. 1, n. 1, art. 1, 2003. DOI: https://doi.org/10.7213/cienciaanimal.v1i1.14877.

**ANUARIO leite 2018**. [S.l.: s.n.], [2018?]. Disponível em: https://pt.scribd.com/document/386731454/Anuario-leite-2018. Acesso em: 2 fev. 2025.

**ARMSTRONG, D. V.** Heat stress interaction with shade and cooling. *Journal of Dairy Science*, v. 77, n. 7, p. 2044–2050, 1994. DOI: https://doi.org/10.3168/jds.S0022-0302(94)77149-6.

**AULDIST, M. J. et al.** Comparative reproductive performance and early lactation productivity of Jersey × Holstein cows in predominantly Holstein herds in a pasture-based dairying system. *Journal of Dairy Science*, v. 90, n. 10, p. 4856–4862, 2007. DOI: https://doi.org/10.3168/jds.2006-869.

**BAUMAN, C. A. et al.** Canadian National Dairy Study: Herd-level milk quality. *Journal of Dairy Science*, v. 101, n. 3, p. 2679–2691, 2018. DOI: https://doi.org/10.3168/jds.2017-13336.

**BARBANO, D. M.; MA, Y.; SANTOS, M. V.** Influence of raw milk quality on fluid milk shelf life. *Journal of Dairy Science*, v. 89, p. E15–E19, 2006. DOI: https://doi.org/10.3168/jds.S0022-0302(06)72360-8.

**BASCOM, S. S.; YOUNG, A. J.** A summary of the reasons why farmers cull cows. *Journal of Dairy Science*, v. 81, n. 8, p. 2299–2305, 1998. DOI: https://doi.org/10.3168/jds.S0022-0302(98)75810-2.

**BJELLAND, D. W. et al.** Production, reproduction, health, and growth traits in backcross Holstein × Jersey cows and their Holstein contemporaries. *Journal of Dairy Science*, v. 94, n. 10, p. 5194–5203, 2011. DOI: https://doi.org/10.3168/jds.2011-4300.

**BLAND, J. H.; GRANDISON, A. S.; FAGAN, C. C.** Effect of blending Jersey and Holstein-Friesian milk on Cheddar cheese processing, composition, and quality. *Journal of Dairy Science*, v. 98, n. 1, p. 1–8, 2015. DOI: https://doi.org/10.3168/jds.2014-8433.

**BOVINOCULTURA de leite**. Instituto de Desenvolvimento Rural do Paraná. [S.l.: s.n.], [s.d.]. Disponível em: https://www.idrparana.pr.gov.br/Pagina/Bovinocultura-de-Leite. Acesso em: 11 fev. 2025.

**DE VRIES, A.; STEENHOLDT, C.; RISCO, C. A.** Pregnancy rates and milk production in natural service and artificially inseminated dairy herds in Florida and Georgia. *Journal of Dairy Science*, v. 88, n. 3, p. 948–956, 2005. DOI: https://doi.org/10.3168/jds.S0022-0302(05)72762-4.

**DOWNEY, B. C.; TUCKER, C. B.** Breed differences in oral behaviors in feed-restricted dairy heifers. *Journal of Dairy Science*, v. 106, n. 12, p. 9440–9450, 2023. DOI: https://doi.org/10.3168/jds.2022-23208.

**ECONOMIC selection index in small rural dairy farms**. [S.l.: s.n.], [s.d.]. Disponível em: https://www.cambridge.org/core/journals/journal-of-dairy research/article/abs/economic-selection-index-in-small-rural-dairy-farms/8366492F77C7F5AB55D665AC27F7E2BD. Acesso em: 9 jun. 2024.

**EGGER-DANNER, C. et al.** Use of benchmarking to monitor and analyze effects of herd size and herd milk yield on cattle health and welfare in Austrian dairy farms. *Journal of Dairy Science*, v. 103, n. 8, p. 7598–7610, 2020. DOI: https://doi.org/10.3168/jds.2019-16745.

**FATURAMENTO da Castrolanda atinge valor recorde de R$ 7 bi**. [S.l.: s.n.], [s.d.]. Disponível em: https://www.castrolanda.coop.br/faturamento-da-castrolanda-atinge-valor-recorde-de-r-7-bi/. Acesso em: 2 fev. 2025.

**FERRAZZA, R. D. A. et al.** Zootechnical and economic performance indexes of dairy herds with different production scales. *Semina: Ciências Agrárias*, v. 39, n. 1, p. 287, 2018. DOI: https://doi.org/10.5433/1679-0359.2018v39n1p287.

**FOURNEL, S.; OUELLET, V.; CHARBONNEAU, É.** Practices for alleviating heat stress of dairy cows in humid continental climates: A literature review. *Animals*, v. 7, n. 5, art. 5, 2017. DOI: https://doi.org/10.3390/ani7050037.

**GARCIA-PENICHE, T. B.; CASSELL, B. G.; MISZTAL, I.** Effects of breed and region on longevity traits through five years of age in Brown Swiss, Holstein, and Jersey cows in the United States. *Journal of Dairy Science*, v. 89, n. 9, p. 3672–3680, 2006. DOI: https://doi.org/10.3168/jds.S0022-0302(06)72407-9.

**HADLEY, G. L.; WOLF, C. A.; HARSH, S. B.** Dairy cattle culling patterns, explanations, and implications. *Journal of Dairy Science*, v. 89, n. 6, p. 2286–2296, 2006. DOI: https://doi.org/10.3168/jds.S0022-0302(06)72300-1.

**HENRICHS, S. C.; MACEDO, R. E. F. de; KARAM, L. B.** Influência de indicadores de qualidade sobre a composição química do leite e influência das estações do ano sobre esses parâmetros. *Revista Acadêmica Ciência Animal*, v. 12, n. 3, art. 3, 2014. DOI: https://doi.org/10.7213/academica.12.03.AO05.

**HUANG, C. et al.** Trends for conception rate of Holsteins over time in the Southeastern United States. *Journal of Dairy Science*, v. 92, n. 9, p. 4641–4647, 2009. DOI: https://doi.org/10.3168/jds.2008-1982.

**INGHAM, S. C.; HU, Y.; ANÉ, C.** Comparison of bulk-tank standard plate count and somatic cell count for Wisconsin dairy farms in three size categories. *Journal of Dairy Science*, v. 94, n. 8, p. 4237–4241, 2011. DOI: https://doi.org/10.3168/jds.2011-4310.

**JENSEN, H. B. et al.** Distinct composition of bovine milk from Jersey and Holstein-Friesian cows with good, poor, or noncoagulation properties as reflected in protein genetic variants and isoforms. *Journal of Dairy Science*, v. 95, n. 12, p. 6905–6917, 2012. DOI: https://doi.org/10.3168/jds.2012-5675.

**KARA, N. K.; GALIC, A.** Effects of herd size and bedding surfaces on milk yield and some health problems in dairy cow farms. *Large Animal Review*, v. 28, n. 1, art. 1, 2022.

**KRISTENSEN, T. et al.** Feeding, production, and efficiency of Holstein-Friesian, Jersey, and mixed-breed lactating dairy cows in commercial Danish herds. *Journal of Dairy Science*, v. 98, n. 1, p. 263–274, 2015. DOI: https://doi.org/10.3168/jds.2014-8532.

**LIANG, D. et al.** Influence of breed, milk production, season, and ambient temperature on dairy cow reticulorumen temperature. *Journal of Dairy Science*, v. 96, n. 8, p. 5072–5081, 2013. DOI: https://doi.org/10.3168/jds.2012-6537.

**LIEVAART, J. J. et al.** Effect of herd characteristics, management practices, and season on different categories of the herd somatic cell count. *Journal of Dairy Science*, v. 90, n. 9, p. 4137–4144, 2007. DOI: https://doi.org/10.3168/jds.2006-847.

**LIM, D.-H. et al.** A comparative study on milk composition of Jersey and Holstein dairy cows during the early lactation. *Journal of Animal Science and Technology*, v. 62, n. 4, p. 565–576, 2020. DOI: https://doi.org/10.5187/jast.2020.62.4.565.

**LYMPHOCYTE functions in dairy cows in hot environment.** *International Journal of Biometeorology*, [S.l.], [s.d.]. Disponível em: https://link.springer.com/article/10.1007/s00484-005-0273-3. Acesso em: 1 fev. 2025.

**MARTA.** ¿Quién es el mayor productor mundial?, ¿los Top5? ¿el mayor exportador?... Descúbralo aquí. *Agrodigital*, 24 abr. 2023. Disponível em: https://www.agrodigital.com/2023/04/24/quien-es-el-mayor-productor-mundial-los-top5-el-mayor-exportador-descubralo-aqui/. Acesso em: 14 abr. 2025.

**McCLEARN, B. et al.** An assessment of the production, reproduction, and functional traits of Holstein-Friesian, Jersey × Holstein-Friesian, and Norwegian Red × (Jersey × Holstein-Friesian) cows in pasture-based systems. *Journal of Dairy Science*, v. 103, n. 6, p. 5200–5214, 2020. DOI: https://doi.org/10.3168/jds.2019-17476.

**MATTE JÚNIOR, A.; JUNG, C.** Produção leiteira no Brasil e características da bovinocultura leiteira no Rio Grande do Sul. *Ágora*, v. 19, p. 34, 2017. DOI: https://doi.org/10.17058/agora.v19i1.8446.

**NJUKI, E.** Sources, trends, and drivers of U.S. dairy productivity and efficiency. [S.l.: s.n.], [s.d.].

**NOR, N. M.; STEENEVELD, W.; HOGEVEEN, H.** The average culling rate of Dutch dairy herds over the years 2007 to 2010 and its association with herd reproduction, performance and health. *Journal of Dairy Research*, v. 81, n. 1, p. 1–8, 2014. DOI: https://doi.org/10.1017/S0022029913000460.

**PINEDO, P. J. et al.** Dynamics of culling for Jersey, Holstein, and Jersey × Holstein crossbred cows in large multibreed dairy herds. *Journal of Dairy Science*, v. 97, n. 5, p. 2886–2895, 2014. DOI: https://doi.org/10.3168/jds.2013-7685.

**POOL LEITE.** [S.l.: s.n.], [s.d.]. Disponível em: https://www.poolleite.com.br/?utm_source=chatgpt.com. Acesso em: 31 jan. 2025.

**PRODUÇÃO de leite no Brasil | IBGE.** [S.l.: s.n.], [s.d.]. Disponível em: https://www.ibge.gov.br/explica/producao-agropecuaria/leite/br. Acesso em: 2 fev. 2025.

**RABOISSON, D. et al.** Herd-level and contextual factors influencing dairy cow mortality in France in 2005 and 2006. *Journal of Dairy Science*, v. 94, n. 4, p. 1790–1803, 2011. DOI: https://doi.org/10.3168/jds.2010-3634.

**REPLACEMENT heifer prices hit monumental highs.** *Dairy Herd*, 7 nov. 2024. Disponível em: https://www.dairyherd.com/news/business/replacement-heifer-prices-hit-monumental-highs. Acesso em: 14 abr. 2025.

**RODRIGUES, A. C. O.; CARAVIELLO, D. Z.; RUEGG, P. L.** Management of Wisconsin dairy herds enrolled in milk quality teams. *Journal of Dairy Science*, v. 88, n. 7, p. 2660–2671, 2005. DOI: https://doi.org/10.3168/jds.S0022-0302(05)72943-X.

**SILVA, M. F. da et al.** Avaliação dos indicadores zootécnicos e econômicos em sistemas de produção de leite. *Revista de Política Agrícola*, v. 24, n. 1, art. 1, 2015.

**SMITH, J. W.; ELY, L. O.; CHAPA, A. M.** Effect of region, herd size, and milk production on reasons cows leave the herd. *Journal of Dairy Science*, v. 83, n. 12, p. 2980–2987, 2000. DOI: https://doi.org/10.3168/jds.S0022-0302(00)75198-8.

**SMITH, D. L. et al.** Short communication: Comparison of the effects of heat stress on milk and component yields and somatic cell score in Holstein and Jersey cows. *Journal of Dairy Science*, v. 96, n. 5, p. 3028–3033, 2013. DOI: https://doi.org/10.3168/jds.2012-5737.

**SOARES, S. R. V.; REIS, R. B.; DIAS, A. N.** Fatores de influência sobre o desempenho reprodutivo em vacas leiteiras. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia*, v. 73, p. 451–459, 2021. DOI: https://doi.org/10.1590/1678-4162-11689.

**STEYN, Y. et al.** Indirect genomic predictions for milk yield in crossbred Holstein-Jersey dairy cattle. *Journal of Dairy Science*, v. 104, n. 5, p. 5728–5737, 2021. DOI: https://doi.org/10.3168/jds.2020-19451.

**STOJNOV, M. et al.** Effect of calving season on productive performance of dairy cows. *Dairy*, v. 5, n. 1, art. 1, 2024. DOI: https://doi.org/10.3390/dairy5010018.

**TOLEDO, I. M.; CASAROTTO, L. T.; DAHL, G. E.** Seasonal effects on multiparous dairy cow behavior in early lactation. *JDS Communications*, v. 5, n. 5, p. 379–383, 2024. DOI: https://doi.org/10.3168/jdsc.2022-0358.

**USO de ferramentas de gestão na atividade leiteira: estudo de caso.** [S.l.: s.n.], [s.d.]. Disponível em: https://professormarcosaurelio.com.br/wp-content/uploads/2018/02/7-3-156-Uso-de-ferramentas-de-gestao-na-atividade-leiteira.pdf. Acesso em: 9 jun. 2024.

**VALOR da produção da pecuária e aquicultura chega a R$ 122,4 bilhões em 2023.** *Agência de Notícias - IBGE*, Rio de Janeiro, 19 set. 2024. Disponível em: https://agenciadenoticias.ibge.gov.br/agencia-noticias/2012-agencia-de-noticias/noticias/41352-valor-da-producao-da-pecuaria-e-aquicultura-chega-a-r-122-4-bilhoes-em-2023. Acesso em: 1 fev. 2025.

**WERNCKE, D. et al.** Qualidade do leite e perfil das propriedades leiteiras no sul de Santa Catarina: Abordagem multivariada. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia*, v. 68, p. 506–516, 2016. DOI: https://doi.org/10.1590/1678-4162-8396.

**YOO, J. et al.** A comparison of quality characteristics in dairy products made from Jersey and Holstein milk. *Food Science of Animal Resources*, v. 39, n. 2, p. 255–265, 2019. DOI: https://doi.org/10.5851/kosfa.2019.e20.