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Impact of lameness on production, reproduction and health of dairy cows

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ABSTRACT

In order to investigate the consequences of lameness on dairy cattle productive, reproductive efficiency, and health, records from the software of 6 dairy farms located in central Argentina were studied. Two randomly chosen cow groups were compared: lame group (LG; n= 510) and healthy control group without lameness (CG; n= 510). Milk liters at 305 days (L/305), total milk liters (TL), days in milk (DIM), open days (OD) insemination number (IN), calving intervals (CI), health disorders and culled or death cows were recorded. Parameters were taken in the initial lactation (IL) in which the lame occurred in LG or not in the CG and in their corresponding subsequent later lactation (LL). For the analysis a generalized mixed linear model, the chi-square test and Odds Ratio (OR) were used. Differences were found respectively in IL ($p<0.0018$) and LL ($p<0.0017$) in L/305 production between the LG (10939.3 and 10479.6 l) and CG (11542.8 and 11110.9 l). Regarding TL, in IL there were no significant differences ($p<0.16$), but in LL the TL was higher ($p<0.001$) in CG cows than in LG. In the IL, the OD, IN and CI of the LG exceeded ($p<0.0001$) those of the CG, but no differences were found in LL. During the IL, infertility problems ($p<0.0001$) and genital tract infections ($p<0.007$) were higher in the LG. In the LL, the number of lame cows (45.4%) was higher ($p<0.0001$) in the LG group than those of CG (9.26%). In the IL and LL, a greater number of cows ($p<0.0001$) in the LG had a higher probability of being culled or dead than those in the CG, IL: OR= 7.51, CI 4.7-11.8 and LL: OR= 5.82; CI 3.28 -10.3. The present study shows the damage caused by lameness to productive, reproductive and health indices of central Argentina dairy farms.

Keywords: dairy cow, lameness, milk production and health.

RESUMEN

El objetivo de este trabajo fue determinar el impacto de las afecciones podales (AP) sobre la eficiencia productiva, reproductiva, la salud en vacas lecheras. A partir de los registros de los softwares de 6 tambos ubicados en las provincias de Córdoba y Entre Ríos, se conformaron 2 grupos de 510 vacas cada uno: grupo con AP (GAP) y grupo control sano (GCS). Se registraron la lactancia inicial en la que ocurrió o no el problema podal (LI) y en la lactancia posterior (LP), los litros de leche en 305 días (L/305), la leche total (LT), días abiertos (DA), número de inseminaciones (NI), intervalos entre partos (IPP), número de eventos de salud (ES) y número de vacas que continuaban en el tambo, vacas descartadas y muertas o sacrificadas. Para el análisis de las variables se utilizó un modelo lineal generalizado mixto y la prueba de chi cuadrado y el Odds Ratio (OR). Se encontraron diferencias en LI ($p<0,0018$) y LP ($p<0,0017$) en la producción L/305 respectivamente entre los grupos GAP (10939,3 y 10479,6 l) y GCS (11542,8 y 11110,9 l). En cuanto a la LT, en la LI no hubo diferencias significativas ($p<0,16$) entre grupos, pero sí en la LP la PT fue mayor ($p<0,001$) en las vacas del GCS que en las del GAP. En la lactancia LI, los DA, el NI y el IPP del GAP superaron ($p<0,0001$) a los de GCS, pero no se hallaron diferencias en la LP. Durante la LI, los problemas de infertilidad ($p<0,0001$) e infecciones del tracto genital en el gap($p<0,007$) fueron más elevados en el GAP que en el GCS, pero sin diferencias ($p<0,16$) en cuanto a las mastitis. En la LP, el número de vacas del GAP que presentaron afecciones podales (45,4%) fue superior ($p<0,0001$) al número de vacas del GCS (9,26%). En la LI y la LP, un mayor número de vacas ($p<0,0001$) del GAP tuvo una mayor probabilidad de ser descartadas o muertas que las del GCS, LI: OR= 7,51, IC 4,7 - 11,8 y LP: OR= 5,82; IC 3,28 - 10,3. Estos resultados evidencian los daños productivos y sanitarios que causan las afecciones podales en los tambos del centro de la Argentina.

Palabras clave: *vaca lechera, afección podal, producción lechera y salud.*

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INTRODUCTION

Lameness is one of the main problems in dairy cattle. Multiple causes and risk factors are cited in the international literature, including environment and facilities, hygiene, management, lack of preventive sanitary measures, nutrition and genetics (Acuña *et al*., 2004; Barker *et al*., 2010; Solano *et al*., 2015).

Regarding the average prevalence of lameness in Argentine dairy farms, there is no information from scientific studies carried out in the main dairy basins of the country, only a report by Greenough and Acuña (2002) mentions that 13% of animals culled from dairy farms are a consequence of lameness. Additionally, data collected from dairy farms in Santa Fe and Buenos Aires indicate an incidence between dry off and 90 days postpartum period of 11.1% in multiparous cows and 13.9% in primiparous cows and those recorded in Salta, which showed an average of 21.2% of cows with lameness per farm (Corbelini *et al*., 2009; Suarez and Martínez, 2015).

Regarding South America, a lameness prevalence of between 29.7 and 30.3% was reported in Brazil (Molina *et al*., 1999; Silva *et al*., 2001), while in Chile, Flor and Tadich (2008) indicate that the prevalence in large and small herds in Region X was 33.12% and 28.7% respectively.

In other regions of the world surveys indicate that in the Netherlands, the prevalence of cows with lameness is 30% (Somers *et al*., 2003); in Spain, it is reported that 1/3 of Holstein cows milking in dairy farms have suffered at least one lameness per year (Charfeddine and Pérez-Cabal, 2017); in the United Kingdom, the average prevalence of cows with lameness was 31.6% (Griffiths *et al*., 2018), and in USA it was 26.6% (Salfer *et al*., 2018). Finally, a review by Thomsen *et al*. (2023) indicates a world global average reported prevalence of 22.8%, with extremes ranging from 5% to 45%.

The effects of lameness include losses in milk production, reproductive failure, treatment costs, culling, deaths or premature slaughter, and costs in heifer replacement (Archer *et al*., 2010; Sulayeman and Fromsa, 2012; Randall *et al*., 2016; Charfeddine and Pérez-Cabal, 2017). It also represents a welfare issue for cows, since the association between hoof tissue damage and pain hinders movement and standing, causing stress due to the inability to compete for food and shade (Webster, 2001; Martínez and Suarez, 2019).

Considering the relevance of dairy farming in Argentina and the importance of lameness in milk production, the existing scientific knowledge about this problem in the country is insufficient, since only a few investigations report information on its effects and welfare (Corbelini *et al*., 2009; Martínez and Suarez, 2019; Chiozza Logroño *et al*., 2021). Due to this lack of information, the aims of the present study were to determine in the lactation where the lameness was recorded and in its subsequent lactation, the impact of these events on productivity, reproductive efficiency, health, and culling or death in dairy herds in the central region of Argentina.

MATERIALS AND METHODS

Location and characteristics of dairy farms

The study was conducted on six commercial dairy farms located in the basins of the central region of Argentina in the provinces of Córdoba and Entre Ríos. The information was gathered from the software (Dairycomp) of the dairy farms. The study was carried out from February 2015 to June 2019. The location of the dairies, the production system, the breed, and the average number of dairy cows during the studied years are indicated in table 1. All dairy farms had similar management practices, with regular veterinary advice, vaccinations and continuous service through artificial insemination. For hoof care, all six dairies trimmed and treated hoof afflictions under veterinary guidance. In dairy farms 1, 2, 3 and 4, the cows were milked three times a day and in dairy farms 5 and 6 twice a day (table 1). Pregnancy diagnosis was performed by ultrasound between 35 and 45 days after insemination.

Design and observations

A total of 1020 randomly selected milking cows from the six dairies (ranging from 147 to 195 cows per herd) were analyzed. The number of cows according to their lactation number were 306, 269, 253, 142, and 50 for the 1st, 2nd, 3rd, 4th, and 5th lactations, respectively. The cows were divided into two equal groups: the group with lameness (LG) and the healthy control group without lameness (CG). Only cows with a healthy calving, without retained placenta or genital tract infections up to 60 days postpartum or abortions were recorded. For the analysis, claw disorders were considered in general without distinguishing the cause or diagnosis.

The data recorded were on the productive, reproductive efficiency, and health of each cow in the initial lactation in which the foot problem occurred or not (IL) and in the subsequent

Dairy farm	Location	System	Biotype	Number of Cows
1	Southwest **Córdoba**	Dry-lot	Holstein	560
2	Southwest **Córdoba**	Dry-lot	Holstein	580
3	Southeast **Córdoba**	Dry-lot and free stall	Holstein	980
4	Southeast **Córdoba**	Free stall	Holstein	500
5	East Entre Ríos	Pasture-based	Holstein	1200
6	East Entre Ríos	Pasture-based	Holstein x Jersey and Montbeliarde	960

Table 1. Characteristics of dairy farms and their provincial location.

later lactation (LL) of both groups. Dairy farm identification, cow identification, and lactation number were included. From the databases, calving date, date of the first record of the lameness, number of inseminations, conception date, dry-off date, milk production at 305 days, lactation total milk production and health disorders were collected. Based on these data, indicators of productive, reproductive, and health were compared between both groups. It was also recorded whether the cow continued in lactation or was culled, involuntarily slaughtered, or died, either in IL or LL.

Variable definitions

Both in the IL and LL, the production of milk fixed at 305 days (L/305), the total production of liters of milk (TL) and the days in milk (DIM) were recorded as productive indices. Reproductive indicators were recorded as open days (OD) or days without pregnancy, calculated as the length of the interval between calvings minus the length of gestation, the number of inseminations to conception (IN) and the calving interval (CI). Health events were recorded as infertility, mastitis, uterine diseases in the IL, and in the LL retained placenta, abortions and foot problems were added. Data on culled cows and cows that died or were involuntarily slaughtered were also recorded in the IL and LL. Disease recording was based on the veterinarian diagnosis or from the recording of signs by the operators. Uterine diseases such as metritis were defined as a uterus inflammation, usually due to a microbial infection. Infertility grouped disorders mainly due to causes of anovulatory anestrus, lack of cycle and estrus visualization, irregular cyclicity of estrus, ovarian cysts and abnormal development of the embryo. Retained placenta was defined as the inability to expel all or part of the placenta within 24 to 48 h after parturition. Mastitis was defined as the presence of milk abnormalities or any inflammation of the mammary quarter reported by the veterinarian or by those in charge of milking.

Statistical analysis

The effects of lameness on milk production, reproductive performance, health, culling and deaths were compared during the IL where the foot problem occurred or not in the controls and during their subsequent lactation. A mixed generalized linear model was used for data analysis. The variables L/305, TL, DIM, OD, IN and CI were modeled as Gaussian variables. Fixed effects offered to the model were dairy farm, number of cow lactation, and calving season and their interactions. Results were reported as estimated least squares means ± standard error (SE). Means were compared using Fisher's LSD test. For discrete variables, the chi-square test and the Odds Ratio (OR) and its 95% Wald confidence intervals (95% CI) were used. For all analyses, a p value <0.05 was considered significant and was performed using the InfoStat program (Di Rienzo *et al*., 2020).

RESULTS

Claw disorders

Claw disorders recorded in the dairy farm software were digital dermatitis (27%), sole ulcer (23%), white line disease (19%), sole hemorrhage (17%), heel erosion (5%), laminitis (2%), and the consequences of these problems included records of axial fissure, sole fracture, luxation, and arthritis (8%). In autumn, winter spring and summer, 36%, 23%, 16% and 25% of the claw disorders respectively occurred.

Productive consequences

Table 2 shows the productive parameters L/305, TL and DIM of both groups during the IL and LL lactations. Differences were found in IL ($p<0.0018$) and LL ($p<0.0017$) in the production of milk at L/305 between the LG and CG groups, considering the dairy farm and the number of lactations. On average, the LG group produced 5.51 and 6.02% less milk than the CG group during IL and LL respectively.

However, during the IL, there were no significant differences ($p<0.16$) in total milk production between groups, but the TL was higher ($p<0.001$) in CG cows than in the LG group in the LL. When analyzing the differences between total productions of IL and LL, these showed significant differences ($p<0.0001$), as CG cows significantly increased their yield in LL compared to their IL by an average of 562.7 ± 3686 liters, while LG cows reduced it by 1019.4 ± 4493 liters.

Productive Parameters	Studied Lactation	LG			CG		
		n	Mean	SD	n	Mean	SD
L/305	IL	510	10939.33 a	3131.1	508	11542.85 b	2623.2
	LL	327	10479.63 a	2956.7	456	11110.96 b	2833.5
TL	IL	509	9945.62 a	4057.6	508	10371.81 a	3045.8
	LL	327	9773.82 a	3885.6	456	10870.54 b	3572.1
DIM	IL	505	268.88 a	1925.7	507	340.16 b	77.1
	LL	331	324.54 a	112.9	457	344.72 b	93.1

Means with a common letter are not significantly different ($p > 0.05$)

Table 2. Means and SD of milk production standardized to 305 days (L/305), total milk production (TL), and days in milk (DIM) of groups of cows with lameness (LG) and control cows without podal problems (CG) during initial lactation (IL) and subsequent later lactation (LL).

Regarding days in milk, there were significant differences between groups (p<0.0016 and p<0.05 respectively) in IL and LL, with LG cows having shorter lactations.

Reproductive consequences

The results related to reproductive parameters are included in table 3. In the IL lactation, the open days of LG significantly exceeded (p<0.0001) those of CG, as did the number of inseminations of LG, which was higher (p<0.0001) than that of CG. There were no differences in these reproductive parameters during LL between groups.

Significant differences (p<0.0001) were found between LG and CG cows in the duration of the calving interval, with LG cows having an average interval 42.3 days longer than CG cows. No differences were found between groups during LL (table 3). When classifying cows between those below and above a calving interval of 400 days, it is observed that LG cows have a significantly higher probability (p<0.0001) of 2.21 times (OR 2.21; CI 1.68-2.91) of having a calving interval of more than 400 days compared to cows without claw disorders.

Health consequences

Health problems that occurred during the IL and LL lactations are shown in tables 4 and 5. During IL, the percentage of health problems in LG and CG were 31.7% and 25.9% of the total cows studied, respectively, showing significant differences. The occurrence of these health events in lameness cows showed that they had a higher (*X*2 4.2; p<0.04) risk of reproductive health disorders compared to control cows (OR= 1.33, CI 1.01-1.74). Events related to infertility problems and genital tract infections were higher in LG than in CG, but there were no differences in mastitis occurrence (table 4).

During LL, the total occurrence of health events in lameness cows was significantly (X2 15.2; p<0.001) higher than those recorded in control cows and showed that LG cows had a 1.44% higher risk of reproductive-related health events compared to CG cows (OR= 1.44, CI 1.2-1.75).

The events in the later lactation period that were significantly more numerous in the LG were those related to infertility and lameness (table 5). The percentage of cows in the LL that presented lameness was 45.4%, higher than that recorded in the CG cows (9.26%) and 8.1 times higher likelihood of recurrence of these events.

Culls and deaths

Significant differences (p<0.02) were found between primiparous and multiparous cows in both groups in terms of the number of cows culled and those that died or were involuntarily slaughtered (figure 1).

Culling in the LG during IL and LL originated respectively from lameness (50.9% and 31.2%), reproductive events (17.6% and 23.4%), low production (6.28% and 4.9%), mastitis (3.1% and 7.1%), and other causes (22% and 33.3%). In the CG, culling was due to reproductive events (50% and 30.4%), low production (4.17% and 6.5%), mastitis (4.17% and 3.2%), other causes (41.6% and 44.6%), and lameness in LL (15.2%).

Regarding cows that died or were involuntarily culled in the LG during IL and LL, the causes were lameness (64.5% and 26.0%), reproductive events (3.23% and 10.1%), mastitis (3.23% and 8.0%), and other causes (29.1% and 56.3%). In the CG, the causes were reproductive events (0% and 6.52%), mastitis (0% and 4.35%), various other causes (100% and 82.6%), and lameness in LL (6.52%).

The number of cows that remained in milking, were culled, dead or were slaughtered from the groups during the two lactation studies are indicated in table 6. The percentages of cows culled plus dead ones during the initial lactation under study were 27.1% and 4.7% for the LG and CG groups respectively, showing significant differences (X2 95.3; p<0.0001) between groups. For cows that suffered from lameness, there was a 7.5 times higher probability (OR= 7.51, CI 4.7-11.8) of being removed from the herd whether by culling, death, or slaughter.

When analyzing the subsequent later lactation of those LG cows that remained on the dairy, a higher number (X2 23.05; p<0.0001) of combined culling and mortality rates were also observed in the LG (43.8%) than in the CG (27.2%) and a 2.08 times higher probability (OR= 2.08; CI 1.53-2.81) of being culled or ha-

Reproductive Parameters	Studied Lactation	LG			CG		
		n	Mean	SD	n	Mean	SD
OD	LI	408	168.6 a	101.2	493	122.6 b	78.0
	LP	249	140.0 a	88.5	399	138.7a	88.9
IN	LI	454	3.57 a	2.56	506	2.69 b	2.3
	LP	295	3.55 a	2.96	444	3.39 a	2.7
CI	LI	371	441.4 a	100.4	487	399.1 b	80.1
	LP	228	415.2 a	88.1	372	413.6 a	87.1

Means sharing a common letter are not significantly different (p > 0.05)

Table 3. Means and SD of open days (OD), number of inseminations (IN), and calving interval (CI) of groups of cows with lameness (LG) and control cows without lameness problems (CG) during initial lactation (IL) and subsequent later lactation (LL).

Health events in IL	LG		CG		X^2		Odds Ratio	LI 95% - LS 95%
	Negative	Positive	Negative	Positive		p		
Infertility	443	67	481	28	17.5	≤ 0.0001	2.6	1.65 - 4.1
Metritis	494	16	505	4	7.32	≤ 0.007	4.08	1.35 - 12.3
Mastitis	347	163	325	184	1.9	≤ 0.16	0.62	0.84 - 1.07

Table 4. Health events recorded during initial lactation (IL) in groups of cows with lameness (LG) and control cows without lameness problems (CG). Metritis refers to these or other uterine diseases occurring 60 post-partum days.

Health Events in LL	LG		CG		X^2	p	Odds Ratio	LI 95% - LS 95%
	Negative	Positive	Negative	Positive				
Infertility	313	59	438	48	6.91	≤ 0.009	1.72	1.14 - 2.58
Metritis	329	43	428	58	0.03	≤ 0.86	0.96	0.63 - 1.46
Abortions	313	59	427	59	2.46	≤ 0.11	1.36	0.92 - 2.01
Retained placenta	352	20	464	22	0.33	≤ 0.56	1.19	0.64 - 2.23
Mastitis	228	144	272	214	2.46	≤ 0.11	0.8	0.61 - 1.06
Lameness	203	169	441	45	147.2	≤ 0.0001	8.1	5.6 - 11.7

Table 5. Health events recorded during the subsequent later lactation (LL) in the groups of cows with lameness (LG) and control cows without claw disorders (CG).

Lactations studied	Animals that remain in milking or not	LG	CG	X^2	p	Odds Ratio	LI 95% - LS 95%
IL	Cows that remain in milking	372	486	77.8	≤ 0.0001	7.25	4.44 - 11.8
	Culled cows	111	20				
LL	Cows that remain in milking	230	366	17.9	≤ 0.0001	2.06	1.4 - 2.89
	Culled cows	101	78				
IL	Cows that remain in milking	373	482	48.6	≤ 0.0003	8.72	3.02 - 25.1
	Dead cows	27	4				
LL	Cows that remain in milking	234	365	4.18	≤ 0.041	1.6	1.03 - 2.50
	Dead cows	44	43				

Table 6. Number, Chi-square and Odds ratio of cows of lameness group (LG) and control group (CG) that remained in milking, were culled, dead or were involuntarily slaughtered during the initial lactation under study (IL) and during the subsequent later lactation (LL).

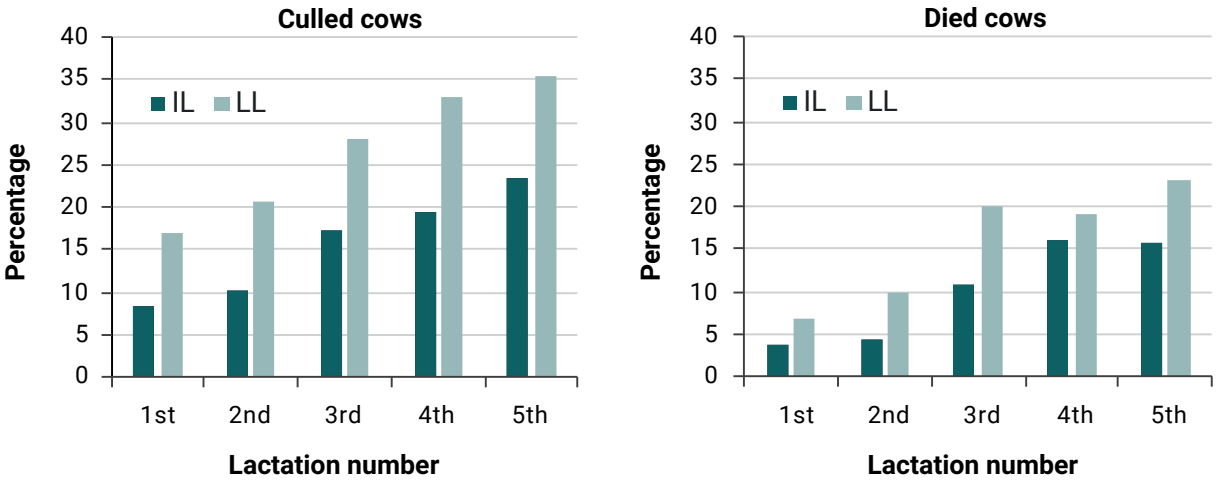

Figure 1. Percentage of cows culled and those that died or were slaughtered according to the number of lactations they were in, during the initial studied lactation (IL) and the subsequent later lactation (LL).

ving died. Only 186 cows from the LG finished their subsequent later lactation and calved, while 323 cows from the CG did.

During the LL, cullings or deaths due to lameness in the LG (n= 57) were significantly (X2 43.5; p<0.0001) higher than those in the CG (n= 17), and a 5.82-fold higher probability of experiencing claw disorders in cows that had lameness in their previous lactation (OR= 5.82; CI 3.28-10.3).

DISCUSSION

Claw disorders are responsible for 90 to 99% of total lameness cases, and the main causes described in dairy cows include non-infectious diseases such as sole ulcers and hemorrhages, white line disease and infectious diseases such as digital dermatitis (Robcis *et al*., 2023), which coincide with the pathologies found in the present study.

Milk production (L/305 and LT) was affected by lameness, with a reduction of 1.98 and 2.07 liters per day respectively during IL and LL in LG cows. These data are in line with those of Charfeddine and Pérez-Cabal (2017), where a severe lesion of sole ulcer or white line disease results in losses of 1.47 to 2.66 kg/day of energy-corrected milk, which constitute double the losses of a mild claw disorder. Previous studies by Martínez and Suarez (2019) in Salta (Argentina) with stony soils show losses in cows with severe lameness of 3.05 liters/cow per day. A study in dairy farms in the central dairy basin of Argentina found losses from dry period to 90 days in milk of 562 liters in 305 days, similar to the present trial where average losses were 603.5 and 631.3 liters/305 days respectively in IL and LL. Similarly, in Great Britain, lame cows showed a reduction fixed at 305 days of lactation of 360 kg of milk (Green *et al*., 2014), in Thailand, primiparous cows lost an average of 1,266.2 kg of milk (Prasomsri, 2022). It has been observed that higher milk production is genetically correlated with a higher incidence of lameness, which is relevant since high-producing dairy herds have a high prevalence of lameness (Amory *et al*., 2008; Green *et al*., 2014).

Regarding the length of lactations, lameness significantly reduced the days in milk in the LG group, both in IL (71.2 days) and to a lesser extent in LL (20.2 days) due to causes such as a decrease in production or reproductive failures that force the animals to dry off.

Also, in accordance with our results on the effects of claw disorders on cow reproduction, Charfeddine and Pérez-Cabal (2017) observed that sole ulcers or white line disease in early lactation were associated with more open days, more inseminations, and longer calving-to-conception intervals. Our data regarding a higher average number of open days (45.9 days) and inseminations (0.88 more) are consistent with the findings of Chiozza Logroño *et al*. (2021), who concluded that cows with lameness have a lower probability of being inseminated and pregnant by 80 days postpartum and a higher probability of remaining open at 200 days in milk. The same authors also observed that when lameness occurs before conception, the effects are more detrimental. In grazing cows, Somers *et al*. (2015) found that reproductive efficiency was lower in cows with lameness acquired before or during the breeding season compared to cows without lameness. Sprecher *et al*., 1997 found that cows with a lameness score >2 had increased intervals between calving and first service, the open days, and the number of services.

One of the causes included in the problems associated with infertility in the present research was the abundance of ovarian cysts, coinciding with the findings of Melendez *et al*. (2003), where cows with lameness had a lower conception rate at first service (17.5% vs. 42.6%) and a higher incidence of ovarian cysts (25% vs. 11.1%) compared to healthy control cows. This increased risk of ovarian cysts in lame cows may be due to a delay or inhibition of the luteinizing hormone peak (Melendez *et al*., 2003; Morris *et al*., 2009). Clinical lameness is a chronic stress factor that reduces progesterone concentrations before estrus, leading to reduced sexual behavior and decreased mounting activity; however, lame cows have the same potential estrus period compared to non-lame cows (Olechnowicz and Jaskowski, 2011; Walker *et al*., 2008). Lame cows were found to delay the onset of ovarian cyclicity by up to 18 days and the onset of estrus by 24 days compared to non-lame cows (Garbarino *et al*., 2004; Petersson *et al*., 2006).

During IL, a 4.08 times higher probability of suffering from metritis and other uterine infectious diseases was observed,

which coincided with the results of Daros *et al*. (2020), where lameness at the time of drying off was associated with the occurrence of metritis and other pathologies related to the transition period such as retained placenta, hypocalcemia, and abomasum displacement, but not ketosis.

Regarding the observations during LL, where the probability of presenting recurrences or recurrent lameness was high, studies in the United Kingdom by Randall *et al*. (2018) suggest that between 79% and 83% of lameness cases in in herds was attributable to previous lameness events (regardless of when they occurred), confirming that previous claw disorders are an important risk factor. In addition, they believe that this could be because certain cows are initially susceptible and remain susceptible, due to the greater risk associated with previous lameness events, or due to interactions with environmental factors.

The importance of lameness on the early culling of cows was evidenced in the present study. In the United States, regarding the costs associated with lameness, it was estimated that culling and deaths are the most important secondary consequences, representing 48.2% and 14.4% of total costs, respectively (Guard, 2006). The occurrence of a case of sole ulcer or white line disease in the first lactation had a significant effect on longevity, reducing up to 71 days of productive life in cows with severe lesions (Charfeddine and Pérez-Cabal, 2016). Sprecher *al*. (1997) observed that cows with a lameness score >2 were 8.4 times more likely to be culled than healthy cows, which was very similar to the estimates in the present trial.

Charfeddine and Pérez-Cabal (2016) observed that, particularly in severe claw disorders, there was a significant reduction in productive life due to premature and involuntary culling. The increased risk of early culling of cows with chronic and severe lameness increases animal replacement costs and reduces the profit generated by an animal throughout its productive life, with culling and deaths accounting for 50.8% of total expenses. However, as recorded by Martínez and Suarez (2019) in Salta, where severe lameness was much less frequent, they cause economic losses three times greater than those associated with mild lameness (Charfeddine and Pérez-Cabal, 2016).

Regarding the mortality rate in cows with lameness, a study of dairy farms with a high prevalence of this condition (≥16%) showed 2.9 times higher chances of death or culling compared to farms with a low prevalence of claw disorders (McConnel *et al*., 2008). In the present study, it was not possible to determine the origin of deaths or culling in many cases, but evidently, the stress and pain caused by lessions are predisposing factors for reproductive problems or other health issues in cows (Varlyakov *et al*., 2012; Bicalho *et al*., 2009).

Although lameness has been studied from the perspective of etiological, pathological, reproductive, and productive factors, there are fewer studies on the association between tissue damage and pain, difficulty in moving, standing, and the stress caused by the inability to compete for food, shade, and overall animal welfare (Webster, 2001; Suarez and Martinez, 2020). Certain studies show that as the genetic selection of cows progresses towards increased productivity, the negative impacts on their health and welfare also increase. Therefore, selection objectives should be directed towards cows that are more resistant to diseases, have greater longevity, and factors related to animal welfare (Oltenacu and Broom, 2010).

CONCLUSIONS

On the one hand, the present results show the importance of lameness in dairy cows in Argentina, where production losses, combined with those due to increased replacement of females, insemination costs, labor costs, veterinary costs, those associated with increased calving intervals, and the consequences on health, culling, deaths, and the delay of genetic progress, reduce the efficiency of farms. On the other hand, this research highlights the need to deepen studies on risk factors, causes, and solutions for claw disorders in both confined and pasture-based dairy farms in different dairy regions of the country, due to their importance in the sustainability of dairy farms.

Additionally, previous studies in Salta (Martínez and Suarez, 2019) show that indirect costs related to milk losses, reproductive issues, or culling are not as evident to dairy farmers, leading us to conclude that if they were more aware of the economic implications of lameness, they might be more inclined to adopt preventive measures such as routine hoof trimming twice a year, early identification of lame cows through locomotion scoring, or implement the use of preventive footbaths.

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