ISTANBUL UNIVERSITY CERRAHPAŞA

Abortion Effects on Production, Reproductive Performance, and Health of Dairy Cattle

Víctor Humberto SUAREZ[1], Gabriela Marcela MARTÍNEZ[1], Sebastián WIRSH[2]

[1]Department of Animal Production, Instituto Nacional de Tecnologia Agropecuaria, Estación Experimental Agropecuaria Salta, Salta, Argentina
[2]Department of Animal Production, Universidad Nacional de Rosario, Santa Fe, Argentina

Cite this article as: Suarez, V.H., Martínez, G.M., & Wirsh, S. (2024). Abortion effects on production, reproductive performance, and health of dairy cattle. *Acta Veterinaria Eurasia*, 50(2), 87-93.

Abstract

In order to investigate the consequences of abortions on dairy cattle performance, records from the software of seven dairy farms in Argentina were studied between February 2015 and June 2019. Two randomly chosen groups were compared in terms of aborted cows ($n = 264$) and normal calving cows without abortion ($n = 245$). Milk liters at 305 days (L/305), total milk production, days in milk, open days, insemination number, calving intervals, number of postabortion reproductive health disorders, and number of cows that continued in the farm, culled, died, or were slaughtered were recorded. The parameters were taken in the lactation in which the abortion occurred in aborted cows and in that with the same characteristics (lactation number and date) in the normal calving cow animals and in their corresponding subsequent lactations of the 2 groups. As a result, higher L/305 production in normal calving cows was found in the first lactation ($p = .013$) and last lactation ($p = .003$) than that of aborted cows. In first lactation, the aborted cow group showed longer ($p = .001$) days in milk, more ($p = .0001$) open days, higher ($p = .0001$) insemination, and longer calving interval ($p = .0001$) than those of the normal calving cows. In first lactation, aborted cows had a higher ($p = .0001$) probability of suffering from, respectively, reproductive health disorders (OR = 5.7, 95% CI, 4.07–8.06) and culls plus deaths/slaughters for reproductive reasons (OR = 27.5, 95% CI, 11.7–64.5) than normal calving cows. In last lactation, aborted cows suffer more ($p < .05$) infertility, mastitis, and abortion problems than normal calving cows. Only, 59.4% of the aborted cows finished their last lactation and calved, while 85.1% of the normal calving cows cows did. These results show the serious negative effects of abortions on milk production, reproductive performance, and the health of dairy cows.

Keywords: Abortion effect, dairy cattle, health events, production, reproduction

Introduction

Reproductive indices are one of the major factors influencing the profitability of a dairy farm because they affect milk production, breeding costs, rates of culling, and genetic progress. Breeding efficiency is highly influenced by the farm's general management and the staff involved with herd health, feeding, and insemination (De Vries, 2006; LeBlanc, 2007). Specifically, poor reproductive performance may be due to a deficiency in heat detection, problems associated with fertility, or losses during pregnancy (Melendez & Pinedo, 2007).

Within pregnancy losses, abortion is an important determining factor of the good reproductive, productive, and health performance of dairy cows. Previous studies indicate its effects on the cows by decreasing their productivity, increasing sanitary problems and animal culls, increasing feeding, reproduction, the number of replacement heifers, and veterinary and labor costs (Ealy & Seekford, 2019; Gädicke et al., 2010). In general, abortion during early pregnancy leads to an increased calving interval, while abortion at the later stages of pregnancy leads to an increase in an earlier culling time, resulting in augmented cow replacement (Albaaj et al., 2023).

Abortion in cattle is defined as fetal death and uterine expulsion of the fetus between 42 and 260 days into pregnancy (Peter, 2000). Although an abortion rate of 3–5% is considered acceptable (Norman et al., 2012; Peter, 2000), studies worldwide show that the abortion rate in dairy farms varies between 8% and 14% depending on the moment of gestation in which the pregnancy was diagnosed, the cow biotypes, and dairy herd management (Catalino et al., 2017; El-Tarabany, 2015; Thurmond et al., 2005).

Argentina ranks as the second largest producer of raw milk in Latin America and tenth in the world order (Statista, 2023), and most of its production is located in the central area of the country, where most of the dairy enterprises are located (Castellano et al., 2009).

Despite the fact that it covers the most important dairy basins, it has many limiting factors, both in terms of reproduction, health, and animal welfare. For example, in the case of the frequency and consequences of abortions, there is very little information about their incidence and effects on the dairy herds of Argentina. Only one survey indicates an average of 7.8 ± 4.2% of abortions in the dairy basin of the province of Salta (Suarez & Martínez, 2015).

In Argentina, only one study points to the harmful effects of abortions on milk production, and it was conducted on herds located in a small basin in the northwestern part of the country (Suarez and Martínez, 2021). Therefore, to highlight the economic relevance of this problem, the objective of this study was to characterize the effect

Corresponding Author: Víctor Humberto SUAREZ • **E-mail:** suarez.victor@inta.gob.ar

Received: October 11, 2023 • **Revision requested:** November 30, 2023 • **Last revision received:** December 11, 2023 • **Accepted:** December 25, 2023 • **Publication Date:** March 19, 2024 • DOI: 10.5152/actavet.2024.23076

Available online at actavet.org

This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

of abortion on productive performance, reproduction, and health in dairy farm herds located in the main dairy regions of Argentina.

Materials and Methods

Location and Characteristics of the Dairy Farms

The study was carried out on seven commercial dairy farms, located six in the basins of the central region of Argentina in the provinces of Córdoba and Entre Ríos and one in the northwest, in the province of Salta. The information was based on data from the dairy software.

The cows of four dairy farms are kept indoors (free stall and dry lot systems) and three on a pasture-based system that covered between 25% and 30% of their diet. All farms had similar management practices, with regular veterinary service, vaccinations, and continuous breeding by artificial insemination. In farms 1, 2, 3, and 4, cows were milked three times per day, and in 5, 6, and 7 two times per day (Table 1). Ultrasound pregnancy diagnosis was performed between 35 and 45 postinsemination days. The dairy farm's location, the productive system, the breed and number of milking cows, and the average percentage of abortions during the studied years are indicated in Table 1.

Data and Experimental Design

In total, the performance of 509 cows (70–72 animals from each dairy farm in the center of Argentina and 45 cows from the northwest of Argentina) was randomly chosen and analyzed. Data used in the study were collected for 291 primiparous cows and 218 multiparous cows of second ($n = 193$) and third ($n = 25$) lactation, which calved between February 2015 and June 2019. Only primiparous and multiparous cows up to the thirdcalving were analyzed because there was more opportunity to assess their subsequent lactation. This information was retrieved from the dairy farm management database software ("Dairycomp" and "DIRSA" management programs).

An abortion was established if there was fetal death or new return to estrus occurred between 42 and 260 days of pregnancy (Peter, 2000). There was no differentiation between abortions due to infectious or non-infectious causes. Based on these premises, a group of aborted cows (AC; $n = 264$) was randomly formed. This information was also recorded from 245 normal calving cows (NCC group) without abortion events, randomly selected according to the number of lactations and season and year of calving paired to that of the AC cows.

Information regarding the productive and reproductive efficiency for individual cows of the lactation in which the abortion occurred or not first lactation (FL) and in the following later lactation (LL) of both groups, including herd identification, cow identification, lactation number, calving date, conception date, abortion date, insemination numbers, dry-off date, 305-day milk yield, total milk production, and reproductive health disorders, was collected from the databases. From these data, indicators of productivity, reproductive efficiency, and health were recorded and compared between both groups.

Variable Definitions

As productive indices, 305-day milk yield (L/305), total milk liter production (TML), and days in milk (DIM) were recorded. As reproductive indicators, open days (OD) or days not pregnant, calculated as calving interval length minus the length of pregnancy, number of inseminations to conception (NI), and calving interval (CI), were recorded. Health reproductive events that occurred after abortion during FL and LL such as infertility, dystocia, retained placenta, mastitis, uterine diseases, and later abortions, were recorded. Cows involuntarily culled from the herd only for reproductive or productive causes (other than age) and dead (undiagnosed deaths were not considered) or involuntarily slaughtered cows were also compared. Disease recording was based on a disease being diagnosed by a herd veterinarian or milking employees. For all diseases, there were two categories: healthy or sick cows. Uterine diseases like metritis were defined as inflammation of the uterus, usually due to microbial infection within 21 days after parturition. Infertility group disorders are due mainly to causes of anovulatory anestrus, failure to cycle and display estrus, irregular estrous cyclicity, ovarian cysts, and abnormal embryo development. Dystocia was noted in cases of difficult calving when there was a need for assistance or a caesarean. A retained placenta was defined as a failure to expel all or part of the placenta within 24–48 hours after calving. Milk abnormalities or any mammary quarter inflammation reported by the farm veterinarian or milking employees were considered mastitis.

Statistical Analysis

The effects of abortion on milk production, reproductive performance, health, culling, and deaths were compared during the current lactation where the abortion occurred or in NCC lactation without abortions (FL) and during their subsequent lactation (LL). A generalized mixed linear model (estimated using the procedure of InfoStat) was used to analyze the data. The outcome variables (L/305, TML, DIM, NI, CI, and CI) were modeled as Gaussian variables.

Table 1.
Dairy Farms Characteristics and Abortion Average Percentages During the Entire Study Period

Dairy Farm	Province Place	Dairy System	Cow Breed	No. of Cows	Mean Abortion Percentages
1	Southwest of Córdoba	Dry lot	Holstein	560	21.5
2	Southwest of Córdoba	Dry lot	Holstein	580	22.0
3	Southeast of Córdoba	Dry lot and free stall	Holstein	980	20.5
4	Southeast of Córdoba	Free stall	Holstein	500	16.3
5	East of Entre Ríos	Pasture based	Holstein	1200	21.9
6	East of Entre Ríos	Pasture based	Holstein × Jersey and Montbeliarde	960	21.3
7	Lerma Valley of Salta	Pasture based	Holstein	292	6.1

Note: Abortion: fetal death occurrence between 42 and 260 days of pregnancy (Peter, 2000).

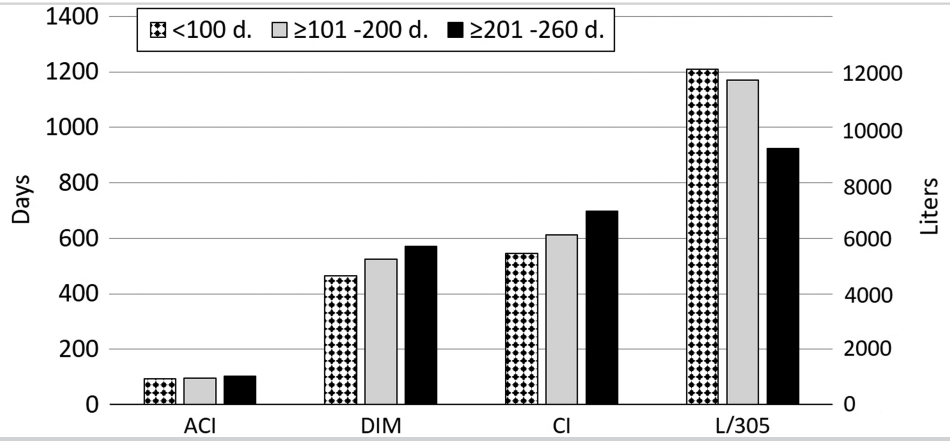

Figure 1.
Means of the abortion conception interval (ACI), days in milk (DIM), calving interval (CI), milk liters accumulated at 305 days (L/305), and total milk production (TML) of the cows that aborted with less than 100, between 100 and 200, and more than 200 days of pregnancy.

Fixed effects offered to the model were herd, cow lactation number, and calving season. Interactions of the AC and NNC with herd, cow lactation number, and calving season were also tested. Results were reported as estimated least square means ± SE. The comparison of means was carried out with the LSD Fisher test. The chi-square test and odds ratio (OR) and its Wald 95% confidence intervals (95% CI) were used for those discrete variables. For all the analyses, there was considered to be significance at $p < .05$ and were conducted using InfoStat (Di Rienzo et al., 2020).

Results

Aborted Cows

No differences ($p = .49$) were found in the days of pregnancy at the time of abortion between cows of first ($\bar{x} = 123.7 \pm 65$ days) and second or more lactation ($\bar{x} = 127.6 \pm 69.1$ days). Figure 1 indicates the parameters recorded in the cows that aborted with less than 100, between 100 and 200, and more than 200 days of pregnancy. The averages of the intervals between conception and abortion of the categorizations were for <100 days of 62.1 ± 21.8 ($n = 106$), between 100 and 200 days of 145.6 ± 21.8 ($n = 112$), and >200 days of 234.7 ± 23.1 ($n = 46$).

Synthesizing what figure 1 shows, it is observed that in most of the parameters, such as DIM, CI, L/305, and TML, the cows that aborted over 200 days of pregnancy show the most negative data. During the lactation in which the abortion occurred (FL), cows that aborted above 200 days of pregnancy ($\bar{x} = 9235.3$ l) produced less ($p = .0001$) L/305 milk than those that aborted before 100 ($\bar{x} = 12089.6$ l.) or less ($p = .0003$) than those that aborted between 101 and 200 ($\bar{x} = 11708.7$ l) days of pregnancy. In the LL, there were no differences. No significant differences ($p = .19$) were found in the FL and LL lactations between primiparous and multiparous cows in the L/305 and TML.

Productive Parameters

Table 2 shows the productive parameters L/305 days TML and DIM of both groups. Differences were found in the FL ($p = .013$) and LL ($p = .003$) in L/305 milk production between AC and NCC groups, considering the dairy farm, calving date and the number of lactation. On average the AC group produced 5.0 and 8.71% less milk than the NCC one during the FL and LL respectively (Table 2).

Conversely, AC total milk production was higher ($p = .0001$) than that of NCC during the FL, but lower in the LL. When analyzing the differences between the total productions of the FL and the LL, these showed significant differences ($p = .0001$), since NCC cows increased significantly their yield in the LL with respect to their FL by 1268.7 liters while the AC reduced it by 2055.4 liters.

Table 2.
Estimated least squares means and standard errors of milk production fixed at 305 days (L/305), the total milk production, and days in milk of both aborted cows and normal calving cows groups during the two studied lactations

Productive Parameters	Studied Lactations	Number of AC Cows	Aborted Cows	Number of NCC Cows	Normal Calved Cows	*p*
L/305	First lactation	264	11169.6 ± 744.3	245	11757.7 ± 749.7	.013
	Later lactation	132	10441.4 ± 225.1	237	11438.4 ± 171.1	.003
TML	First lactation	264	12420.7 ± 240.5	245	9857.4 ± 253.0	.0001
	Later lactation	132	10365.3 ± 330.1	237	11126.1 ± 250.8	.11
DIM	First lactation	261	513.2 ± 8.54	245	345.8 ± 8.93	.001
	Later lactation	126	354.2 ± 9.78	238	359.2 ± 7.24	.67

Note: AC = Aborted cows; DIM = Days in milk; NCC = Normal calving cow; TML = Total milk production.

Table 3.

Estimated Least Squares Means and Standard Errors of Insemination Number, Open Days, and Calving Interval for Both Aborted Cows and Normal Calving Cow Groups During the Two Studied Lactations

Productive parameters	Studied lactations	Number of AC cows	Aborted cows	Number of NCC cows	Normal calved cows	*p*
IN	First lactation	261	5.06 ± 0.18	245	2.71 ± 0.19	.0001
	Later lactation	119	3.49 ± 0.15	235	3.50 ± 0.18	.88
OD	First lactation	138	349.1 ± 16.4	242	126.5 ± 14.3	.0001
	Later lactation	97	142.70 ± 18.4	220	153.3 ± 17.2	.95
CI	First lactation	138	598.3 ± 8.89	242	408.5 ± 6.79	.0001
	Later lactation	82	426.3 ± 10.53	206	432.9 ± 6.71	.99

Note: CI = Calving interval; IN = Insemination number; OD = Open days; NCC, Normal calving cows.

Regarding the DIM, there were no differences between the cows with different numbers of lactations, but there were ($p = .001$) between the cows of the AC and NCC groups, with those of the AC group presenting significantly longer lactations. The results of the DIM analysis were that for the AC, there were more than 167.4 (48.4%) days compared to cows with normal births. No significant differences ($p = .91$) were found in the LL lactations between groups or the number of lactations.

Reproductive Parameters

The results related to reproductive parameters, i.e., open days, insemination number, and calving interval of each group, are included in Table 3. In FL, the open days of the AC group significantly ($p = .0001$) exceeded those of the NCC group, and the number of inseminations in the AC group was also greater ($p = .0001$) than in the NCC. There were no differences in these parameters during the LL between groups.

Significant differences were found ($p = .0001$) between the cows of AC and NCC in the length of the calving interval, presenting the AC with a mean interval of 189.8 days greater than those of the NCC. No differences were found between groups in LL (table 3). When classifying the cows between those below and above a CI of 400 days, it is observed that that of the AC group present a significant ($p = .0001$) probability of 81 times higher (OR 81.6; 95% CI, 27.3–243.5) of having a CI for more than 400 days than cows that had normal births.

Health Parameters

The number of sanitary events registered after abortions in AC and in the milking of NCC during the FL lactations is indicated in Table 4. During the FL, the total percentage of sanitary problems related to reproduction was respectively in AC and NCC of 53.3% and 14.9%, showing significant differences. The occurrence of health events in aborted cows showed that they had a higher ($X^2 = 107.5$, $p = .0001$) risk of contracting reproductive health disorders compared to those that had normal births (OR = 5.7, 95% CI, 4.07–8.06). In the AC cow's group, 20.8% again aborted, and 1.8% and 0.37% aborted, respectively, for the third and fourth time (Table 4).

Table 5 shows the health events that occurred during the LL in both groups, noting that differences were only recorded in cases of infertility, mastitis and in the occurrence of new subsequent abortions. Regarding of abortions recurrence, there were differences (X^2 9.18, $p = .02$) between groups, since in the AC 3% and 0.75% aborted again for the second and third time respectively, while in the NCC there were no abortion.

No significant differences ($p = .31$) were found between primiparous and multiparous cows of the 2 groups in terms of the number of cows discarded, dead, or euthanized due to both reproductive and other causes. The number of cows that remain in milking, discarded, dead, or slaughtered from the AC and NCC groups during the 2 studied lactations is indicated in table 6. The percentage of cows discarded for reproductive reasons was, respectively, 39.8% and 2.07% for

Table 4.

Number of Cows During the First Lactation Observations That Suffered Health Problems After Abortions in Aborted Cows and in Cows with Normal Births

	AC Cows		NCC Cows				
FL Health Events	Negative	Positive	Negative	Positive	χ^2; *p*	Odds Ratio	LI 95%–LS 95%
Infertility causes	195	69 (26.1%)	238	7 (2.85%)	54.2; .0001	12.03	5.53–26.1
Metritis and other uterine diseases	230	34 (12.8%)	232	13 (5.31%)	8.69; .0032	2.64	1.37–5.08
Retained placenta	251	13 (4.92%)	242	3 (1.22%)	5.71; .016	4.18	1.27–13.7
Mastitis	172	92 (34.8%)	184	61 (24.9%)	5.52; .018	1.61	1.09–2.37

Note: The causes of infertility were mostly anovulatory anestrus, failure to cycle and display estrus, irregular estrous cyclicity, ovarian cysts, and abnormal embryo development.
AC = Aborted cow; FL = First lactation; NCC = Normal calving cows.

Table 5.

Number of Cows During the Later Lactation Observations That Suffered Health Problems in Aborted Cows and in Cows with Normal Births

	AC Cows		NCC Cows				
LL Health Events	**Negative**	**Positive**	**Negative**	**Positive**	**χ^2; *p***	**Odds Ratio**	**LI 95%–LS 95%**
Infertility	108	25 (18.8%)	225	16 (6.63%)	12.9; .0003	3.26	1.68–6.3
Metritis and other uterine diseases	106	28 (20.9%)	207	35 (14.4%)	2.56; .109	1.56	0.91–2.7
Abortions	111	32 (28.8%)	218	24 (9.92%)	11.2; .0008	2.61	1.47–4.6
Retained placenta	126	7 (5.26%)	227	14 (5.80%)	0.05; .82	4.18	1.27–13.7
Mastitis	68	67 (49.6%)	147	94 (39.0%)	3.99; .045	1.5	1.01–2.35

Note: The causes of infertility were mostly anovulatory anestrus, failure to cycle and display estrus, irregular estrous cyclicity, ovarian cysts, and abnormal embryo development.
AC = Aborted cows; LL = Later lactation; NCC, Normal calving cow.

the AC and NCC groups, showing significant differences ($p = .0001$) between the groups. Similarly, in the case of deaths or sacrifices due to reproductive causes, the percentage was higher ($p = .017$) in AC cows (3.6%) when compared to NCC cows (0.42%). Significant differences were also found during LL in favor of the NCC group, which had fewer discarded cows (Table 6).

The occurrence of health events in the aborted cows (AC) showed that they had a higher (χ^2 104.7; $p = .0001$) risk of being culled, dying, or being involuntarily euthanized for reproductive causes than those with NCC (OR = 27.5; 95% CI, 11.7–64.5). In the same way, during LL, the risk of discards plus deaths or involuntary sacrifices of the AC was significantly (χ^2 17.7; $p = .0001$) higher than in the NCC (OR = 3.68; 95% CI, 1.95–6.94).

When observing how many cows in each group were able to have a later lactation, only 52.8% of those in AC, compared to 98.6% of NCC, had to be culled, killed, or euthanized. For the same reasons, 59.4% of the AC cows finished their later lactation and calved, while 85.1% of the NCC cows did.

Discussion

The results of this study have the strength that they were obtained from the records of seven dairy farms with different cow management and located in distant regions of Argentina, and also due to the scarcity of research on this topic in our country and generally in countries where dairy is an important activity. These results show that not only calves are lost from abortions, but they also have consequences for productive, reproductive, and health performance.

It is probable that the abortion rate registered is underestimated due to the difficulty of diagnosing small abortions (Peter, 2000), since the greatest risk of fetal loss is during the first trimester of gestation and then progressively decreases as the pregnancy progresses, with a slight increase in risk towards the last month of gestation (Albaaj et al., 2023; Wiltbank et al., 2016).

The present findings show that abortion is associated with a reduction in the yield in liters of milk fixed at 305 days, especially in cows that aborted over 200 days of pregnancy. This lower milk yield associated with cows aborted towards the end of gestation could be related to the lack of development of the mammary glands due to an early restart of lactation compared to what would occur in cows with normal births, where the greater development of these occurs in the last 35 days before birth (Collier et al., 2012). Previous studies also show lower productive performance in dairy cows after abortions and stillbirths (Bartels et al., 2006; El-Tarabany, 2015; Gädicke et al., 2010). A study carried out in Iran on Holstein cows showed that cows with normal calvings had a higher yield set at 305 days, as well as a higher percentage of fat and protein in milk than cows that suffered abortions (Hossein-Zadeh & Ardalan 2011; Keshavarzi et al., 2020). Bartels et al. (2006) also reported a daily decrease of 0.72 kg of milk during the first 100 days of postabortion lactation. On the contrary, Suarez and Martínez (2021) did not find differences between the liters of milk fixed in 305 days between aborted cows that continued lactating (8498 l) and nonaborted cows (8640 l), but

Table 6.

Number of Cows that Continue to Milk, Cows Culled, Dead, or Slaughtered for Reproductive Reasons of Aborted Cow and Normal Calving Cow Groups During the First and Later Lactation Studied

Studied Lactations	**Groups**	**Cows That Continue**	**Reproductive Culled Cows**	**χ^2**	***p***	**Reproductive Dead Cows**	**χ^2**	***p***
First lactation	AC	133	88 (39.8%)	102.1	.0001	5 (3.62%)	5.67	.017
	NCC	236	5 (2.07%)			1 (0.42%)		
Later lactation	AC	82	28 (25.4%)	20.8	.0001	1 (1.20%)	0.21	.64
	NCC	195	15 (7.04%)			4 (2.01%)		

Note: AC = Aborted cow; NCC = Normal calving cow.

they did between the latter and cows that aborted at the end of pregnancy and started a new lactation (5742 l).

Regarding the greater AC cow total milk production in the FL, it would be the consequence of the greater length of days in milk. Keshavarzi et al. (2020) and Suarez and Martínez (2021) obtained similar results to those of the present trial, observing that the aborted cows had higher days in lactation than those cows without abortions.

Reproductive variables were markedly affected by the type of abortion, with a higher total number of inseminations to definitive conception and, consequently, a longer calving to definitive conception postabortion interval, and a longer calving interval in AC cows compared to NCC cows.

Regarding the effect of abortion on open days and consequently to a large extent on the CI, analyzing stillbirths and abortions, El-Tarabany (2015) found that Holstein cows had longer CI and open days (475 and 198 days and 427 and 151 days, respectively) after having suffered stillbirths and abortions than cows with normal births (381 and 149 days). Previous data obtained in northwestern Argentina showed similar results with longer calving intervals (741.2 days) in aborted cows than those (476.7 days) of cows with normal lactations (Suarez & Martínez, 2021).

However, the results of the number of inseminations needed to achieve conception in cows with fetal losses have been controversial. El-Tarabany (2015) found an increase in the number of inseminations per calving of 2.1 in aborted cows ($n = 5.3$) compared to those with normal births ($n = 3.2$), while on the contrary, Bartels et al. (2006) reported that abortion had no effect on any of the reproductive variables, such as the number of inseminations per conception. Contemplating all the expenses involved in all the factors related to a longer interval between births, Rafati et al. (2010) report that calving intervals of more than 425 days will produce losses of more than 10% in the average production of dairy farms.

The present work also evidenced an important effect of abortions on the health and well-being of cows, based on a greater probability of suffering reproductive health events after fetal loss. The results of this investigation indicate the various causes of infertility and uterine inflammation as the pathologies with the highest incidence (Table 4).

Metritis and endometritis in dairy production are of great importance, mainly because they increase the calving-conception interval and decrease milk yield (Fourichon et al., 2000). Uterine infection causes infertility, and the causative links between uterine infection and infertility include a hostile uterine environment, disrupted neuroendocrine signaling, and perturbations in ovarian function and oocyte development (Abraham, 2017; Bromfield et al., 2015). Previous studies showed that aborted cows had a higher risk of presenting metritis, accompanied by its indirect effects on general health and milk production (Giuliodori et al., 2013); in the same sense, Salasel et al. (2010) concluded that abnormal calving, including abortions, may be associated with a higher prevalence of subclinical endometritis as indicated by increased neutrophils in uterine lavage samples. The studies by Gröhn et al. (1990) estimated that cows that abort are 19.8, 3.7, and 2.1 times more likely to have retained placenta, metritis, and silent heat, respectively. Also in our case, AC cows are 4.18 times more probable to have retained placenta. Besides, AC cows are 1.61 times more likely to suffer subclinical and clinical mastitis than NCC (Table 4).

As indicated in Table 5, during the later lactation of LF, the probabilities of infertility, metritis, and abortion occurrence were higher in AC cows. In the case of later abortions, the probability of repeat was 2.61 times higher in the AC group, according to Thurmond et al. (2005), who indicated that previous fetal loss is the main factor in abortion and showed that the risk of abortion is 2.5 times higher in cows with previous abortions. The explanation of why previous abortions are one of the major risk factors would be given in part by subsequent metritis, which would leave a damaged uterine environment (Hanson et al., 2003), as well as other external factors such as agents of certain infectious diseases. For example, cows previously infected with *Neospora caninum* would have a higher risk of repeat abortions (Anderson et al., 2012), and this could be an important factor for abortion in Argentina's dairy basins due to the high seroprevalence of *Neospora caninum* found in their dairy herds (Moore et al., 2002; Pereyra et al., 2020).

The highest observed percentage of discards and deaths/slaughters in cows that aborted coincided with the results of Bartels et al. (2006), where the probability of slaughter increased 1.19 times for cows with abortions. Similarly, Keshavarzi et al. (2020) estimated that cows that started lactation after abortion had a 2.41 times higher probability of being slaughtered due to reproductive problems compared to cows that had normal births. Other studies showed that cows that abort would have 3.2 times more risk of being discarded than those that end a normal pregnancy (Hossein-Zadeh, 2013). The study carried out in dairy farms in northwestern Argentina showed that the aborted cows had a higher probability of respectively contracting sanitary disorders and reproductive disorders (OR = 6.5; 95% CI, 3.2–24.3) and discards plus deaths/slaughters (OR = 6.72; 95% CI, 2.9–15.1) compared to those not aborted (Suarez & Martínez, 2021).

Conclusion and Recommendations

The results of this study exhibit the magnitude of abortions in dairy cows, where inefficiency and production losses to calf loss and female replacements also involve the costs of insemination, staff labor, feeding, and the productive losses associated with an increase in the calving interval, side effects such as infertility, embryonic losses, cullings, deaths and a brake on genetic progress (Gädicke et al., 2010; Rafati et al., 2010; Thurmond et al., 2005). All these harmful effects on the budget and sustainability of dairy companies justify undertaking new studies on the economic impact of abortions. Moreover, this research shows, based on its importance to the efficiency and sustainability of dairy farms, the need to deepen studies on the causes and solutions for abortions as well as for embryonic losses and premature births.

Ethics Committee Approval: This study did not involve any invasive procedures on animals; therefore, ethics committee approval was not obtained.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – V.H.S., G.M.M., S.W.; Design – V.H.S.; Supervision – G.M.M., V.H.S.; Resource – S.W.; Materials – S.W.; Data Collection and/or Processing – S.W., V.H.S.; Analysis and/or Interpretation – V.H.S., G.M.M.; Literature Search – G.M.M., V.H.S.; Critical Review – G.M.M., S.W.

Acknowledgements: The authors thank the staff and owners of the dairy farms for allowing them access their software data and collaborating with this study.

Declaration of Interests: The authors have no conflict of interest to declare.

Funding: This research was funded by the Dairy Project 2014-2017 of the National Institute of Agricultural Technology of Argentina.

References

Abraham, F. (2017). An overview on functional causes of infertility in cows. *Journal of Fertilization: In Vitro – IVF-Worldwide, Reproductive Medicine, Genetics and Stem Cell Biology*, *5*(2), 203. [CrossRef]

Albaaj, A., Durocher, J., LeBlanc, S. J.,. & Dufour, S. (2023). Meta-analysis of the incidence of pregnancy losses in dairy cows at different stages to 90 days of gestation. *JDS Communications*, *4*(2), 144–148. [CrossRef]

Anderson, M., Barr, B., Rowe, J., & Conrad, P. (2012). Neosporosis in dairy cattle. *Japanese Journal of Veterinary Research*, *60*(Suppl.), S51–S54. [CrossRef]

Bartels, C. J. M., Van Schaik, G., Veldhuisen, J. P., Van den Borne, B. H. P., Wouda, W., & Dijkstra, T. (2006). Effect of *Neospora caninum* serostatus on culling, reproductive performance and milk production in Dutch dairy herds with and without a history of *Neospora caninum*-associated abortion epidemics. *Preventive Veterinary Medicine*, *77*(3–4), 186–198. [CrossRef]

Bromfield, J. J., Santos, J. E. P., Block, J., Williams, R. S., & Sheldon, I. M. (2015). Physiology and endocrinology symposium: Uterine infection: Linking infection and innate immunity with infertility in the high-producing dairy cow. *Journal of Animal Science*, *93*(5), 2021–2033. [CrossRef]

Castellano, A., Issaly, L. C., Iturrioz, G. M., Mateos, M., & Terán, J. C. (2009). *Análisis de la cadena de la leche en Argentina*. Estudios Socioeconómicos de los Sistemas Agroalimentarios y Agroindustriales No4, Ediciones INTA.

Catalino, M. B., Casaro, B. G., & Daglio, M. C. (2017). *Cuantificación de pérdidas de gestación entre los días 35–100 en vacas de tambo de la Cuenca Mar y Sierras*. Tesina para optar al grado de Veterinario, F.C. Veterinarias, UNCPBA, Tandil, 27p.

Collier, R., Hall, L., Rungruang, S.,& Zimbelman, R. (2012, January 1). *Quantifying heat stress and its impact on metabolism and performance*. Proceeding of Florida Ruminant Nutrition Symposium, https://www.researchgate.net/publication/267844201

De Vries, A. (2006). Economic value of pregnancy in dairy cattle. *Journal of Dairy Science*, *89*(10), 3876–3885. [CrossRef]

Di Rienzo, J. A., Casanoves, F., Balzarini, M. G., Gonzalez, L., Tablada, M., & Robledo, C. W. (2020). *InfoStat, versión 2020*. Grupo InfoStat, FCA, Universidad Nacional de Córdoba.

Ealy, A. D., & Seekford, Z. K. (2019). Symposium review: Predicting pregnancy loss in dairy cattle. *Journal of Dairy Science*, *102*(12), 11798–11804. [CrossRef]

El-Tarabany, M. S. (2015). Impact of stillbirth and abortion on the subsequent fertility and productivity of Holstein, Brown Swiss and their crosses in subtropics. *Tropical Animal Health and Production*, *47*(7), 1351–1356. [CrossRef]

Fourichon, C., Seegers, H., & Malher, X. (2000). Effect of disease on reproduction in the dairy cow: A meta-analysis. *Theriogenology*, *53*(9), 1729–1759. [CrossRef]

Gädicke, P., Vidal, R., & Monti, G. (2010). Economic effect of bovine abortion syndrome in commercial dairy herds in Southern Chile. *Preventive Veterinary Medicine*, *97*(1), 9–19. [CrossRef]

Hossein-Zadeh, N. G. (2013). Effects of main reproductive and health problems on the performance of dairy cows: A review. *Spanish Journal of Agricultural Research*, *11*(3), 718–735. [CrossRef]

Hossein-Zadeh, N. G., & Ardalan, M. (2011). Evaluation of the potential effects of abortion on the productive performance of Iranian Holstein dairy cows. *Animal science journal = Nihon chikusan Gakkaiho*, *82*, 117–121. [CrossRef]

Giuliodori, M. J., Magnasco, R. P., Becu-Villalobos, D., Lacau-Mengido, I. M., Risco, C. A., & de la Sota, R. L. (2013). Metritis in dairy cows: Risk factors and reproductive performance. *Journal of Dairy Science*, *96*(6), 3621–3631. [CrossRef]

Gröhn, Y., Erb, H. N., McCulloch, C. E., & Saloniemi, H. S. (1990). Epidemiology of reproductive disorders in dairy cattle: Associations among host characteristics, disease and production. *Preventive Veterinary Medicine*, *8*(1), 25–39. [CrossRef]

Hanson, T., Bedrick, E. J., Johnson, W. O., & Thurmond, M. C. (2003). A mixture model for bovine abortion and foetal survival. *Statistics in Medicine*, *22*(10), 1725–1739. [CrossRef]

Keshavarzi, H., Sadeghi-Sefidmazgi, A., Ghorbani, G. R., Kowsar, R., Razmkabir, M., & Amer, P. (2020). Effect of abortion on milk production, health, and reproductive performance of Holstein dairy cattle. *Animal Reproduction Science*, *217*, 106458. [CrossRef]

LeBlanc, S. (2007). Economics of improving reproductive performance in dairy herds. *WCDS Advances in Dairy Technology*, *19*, 201–214.

Melendez, P., & Pinedo, P. (2007). The association between reproductive performance and milk yield in Chilean Holstein cattle. *Journal of Dairy Science*, *90*(1), 184–192. [CrossRef]

Moore, D. P., Campero, C. M., Odeón, A. C., Posso, M. A., Cano, D., Leunda, M. R., Basso, W., Venturini, M. C., & Späth, E. (2002). Seroepidemiology of beef and dairy herds and fetal study of *Neospora caninum* in Argentina. *Veterinary Parasitology*, *107*(4), 303–316 [CrossRef]

Norman, H. D. R., Miller, R. H., Wright, J. R., Hutchison, J. L., & Olson, K. M. (2012). Factors associated with frequency of abortions recorded through Dairy Herd Improvement test plans. *Journal of Dairy Science*, *95*(7), 4074–4084. [CrossRef]

Pereyra, W. R., Suarez, V. H., Cardoso, N., Gual, I., Martínez, G. M., Capozzo, A. V., & Mansilla, F. C. (2020). Prevalencia sérica de *Neospora caninum* y factores de riesgo asociados a su transmisión en tambos de la provincia de Salta, Argentina. *Revista Argentina de Microbiología*. [CrossRef]

Peter, A. T. (2000). Abortions in dairy cows: New insights and economic impact. *WCDS Advanced Dairy Science and Technology*, *12*, 233–244.

Rafati, N., Mehrabani-Yeganeh, H., & Hanson, T. E. (2010). Risk factors for abortion in dairy cows from commercial Holstein dairy herds in the Tehran region. *Preventive Veterinary Medicine*, *96*(3–4), 170–178. [CrossRef]

Salasel, B., Mokhtari, A., & Taktaz, T. (2010). Prevalence, risk factors for and impact of subclinical endometritis in repeat breeder dairy cows. *Theriogenology*, *74*(7), 1271–1278. [CrossRef]

Statista (2023). *FAO; US Department of Agriculture*. USDA-Dairy World Trade Markets and Trade- 2022[CrossRef]14p.

Suarez, V. H., & Martínez, G. M. (2015). *Caracteristicas y Problematicas Productivas - Sanitarias de la Lecheria del Valle de Lerma, Salta*, Colección Investigación, Desarrollo e Innovació, INTA Ediciones.

Suarez, V. H., & Martínez, G. M. (2021). Consecuencias reproductivas y sanitarias de los abortos bovinos en la cuenca lechera del Valle de Lerma, Salta, Argentina. *FAVE Sección Ciencias Veterinarias*, *20*(2), 68–75. Online version 2362-5589. [CrossRef]

Thurmond, M. C., Branscum, A. J., Johnson, W. O., Bedrick, E. J., & Hanson, T. E. (2005). Predicting the probability of abortion in dairy cows: A hierarchical Bayesian logistic-survival model using sequential pregnancy data. *Preventive Veterinary Medicine*, *68*(2–4), 223–239. [CrossRef]

Wiltbank, M. C., Baez, G. M., Garcia-Guerra, A., Toledo, M. Z., Monteiro, P. L., Melo, L. F., Ochoa, J. C., Santos, J. E., & Sartori, R. (2016) Pivotal periods for pregnancy loss during the first trimester of gestation in lactating dairy cows. *Theriogenology*, *86*(1), 239–253. [CrossRef]