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The dairy cow: Understanding
the sustainable production

Postpartum Pathologies and Origin of Infertile Cows in Dairy Cattle in the Mexican Highlands

Patologías Posparto y Origen de Vacas Infértiles en Ganado Lechero en el Altiplano Mexicano

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Abstract

Infertility in dairy cows under intensive productive systems is a growing problem and is one of the main causes of culling. The objective was to determine the origin of infertility in dairy cows under intensive productive systems from the Mexican highlands with postpartum pathologies. In this experiment 1,110 housed Holstein cows were studied. Cows were divided by calving number: First (n=389); Second (n=296) and three or more (n=425). Statistical analysis: comparison of means (Anova model) and univariate analysis. High percentage of the cows remained healthy after calving (80.5%); however, 15.6% of these cows were infertile. The prevalence of pathologies was 19.5%, and 26.3% of these cows were infertile. Cows with reproductive pathologies had a higher percentage ($p < 0.05$) of infertile cows (25.0%). The infertility increased with the number of calvings, cows with three or more calvings and with reproductive pathologies had the highest percentage of infertile cows compared with those of second and first calving (39.0%, 30.0% and 14.0%, respectively). Second calving cows (OR: 2.24 95% CI: 1.06-4.95) and cows of three or more calvings and that presented reproductive pathologies (OR: 1.95 95% CI: 1.03-3.71) were identified as risk factors. In conclusion, cows that presented reproductive pathologies had the highest percentage of infertile cows and the risk of remaining infertile increased up to 4 times, especially if they presented more than 2 calvings. The percentage of infertile cows with postpartum pathologies could not be fully explained, leaving 15.6% of infertile cows with different origins.

Keywords: Infertility, metabolic problems, dairy cows, housed cows, highlands.

Resumen

La infertilidad en vacas lecheras estabuladas es un problema creciente y una de las principales causas de desecho. El objetivo fue determinar el origen de infertilidad en vacas lecheras estabuladas del altiplano mexicano con patologías posparto. Se estudiaron 1,110 vacas Holstein estabuladas y divididas por número de parto: primero (n=389); segundo, (n=296) y tres o más (n=425). El análisis estadístico se realizó haciendo una comparación de medias (modelo ANOVA) y factores de riesgo (Odds Ratio). El 80.5% de las vacas permanecieron sanas después del parto, 15,6% resultaron infértiles y el 3,9% no presentó cambios. La prevalencia de patologías fue del 19,5% encontrando que el grupo de vacas con patologías reproductivas tuvieron mayor porcentaje ($p<0,05$) de infertilidad (25,0%). Se incrementó el problema de infertilidad con el número de partos, siendo el grupo de vacas de tres o más partos y con patologías reproductivas las de mayor porcentaje de vacas infértiles comparadas con las de segundo y primer parto (39,0%, 30,0% y 14,0%; $p<0,05$, respectivamente). Se identificaron como factores de riesgo vacas de segundo parto (OR: 2,24 IC95%: 1,06-4,95) y aquellas con más de tres partos que presentaron patologías reproductivas (OR: 1,95 IC95%: 1,03-3,71). En conclusión, las vacas que presentaron patologías reproductivas tuvieron el mayor porcentaje de infertilidad, el cual incrementó hasta cuatro veces el riesgo de quedar vacías, especialmente si presentaban más de dos partos. No se pudo explicar por completo el porcentaje de vacas infértiles con las patologías posparto, quedando un 15.6% de vacas infértiles con diferente origen.

Palabras clave: Infertilidad, problemas metabólicos, vacas lecheras, vacas estabuladas, altiplano.

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1 Introduction

Over the past 70 years, the high yields of milk production specialized in dairy cows have been the result of an intense genetic selection (Oltenacu and Algers, 2005; Miglior et al., 2017), and specially of the genomic evaluation of young bulls. However, genetic selection has had problems since highly producing cows have drastically reduced their fertility (Diskin et al., 2006; Sheldon et al., 2009a,b); thus, health problems have increased during the first postpartum weeks (LeBlanc, 2010). However, despite progress in dairy cattle, there are still health problems (Esposito et al., 2014). LeBlanc (2010) reported a high prevalence of postpartum conditions concluding that one out of two dairy cows had some pathology, so the increase in diseases will have a negative impact on the reproduction (Barker et al., 1998; Lammoglia et al., 2015; Sheldon, 2020). Cows with some postpartum pathology, whether metabolic (ketosis, hypocalcemia, abomasum displacement, etc), or immunological (placenta retention, metritis, mastitis, etc) had a lower production as well as a lower fertility rate, increasing their risk of being discarded from the herd (Walsh et al., 2007; Dubuc et al., 2012; Hudson et al., 2012; Vieira-Neto et al., 2014; Denis-Robichaud and Dubuc, 2015; Vallejo-Timarán et al., 2017).

It has been mentioned that the consequences of reproductive pathologies during postpartum are also medium-term, as they affect fertility in the first calving and increase the open and rest period between calving; but these aspects are very expensive for any production system, mainly intensive livestock farming. Sheldon (2020) found that some of the infertility originated due to the infection of the uterus, since the bacteria, toxins and lipopolysaccharides could reach the ovary by using the circulation of the uterine-ovarian vascular pedicle system as transport. Once in the ovary, it causes an inflammatory process that can last for weeks or even months, causing oophoritis (damage to the corpus luteum) to the oocyte and ovarian dysfunction. The aim of the research was to determine the origin of infertility in dairy cows in the Mexican highlands with postpartum pathologies.

2 Materials and methods

The study was carried out in a specialized dairy cattle farm, located in the Mexican highland, in Hidalgo, Mexico (24°N 103°W, 24°N 103°W) at an altitude of 1980 masl, with a semi-dry temperate climate, with average temperature of 14.5°C, maximum temperature 24.4°C and minimum temperature of 5.3°C, average relative humidity of 65.6%, (maximum relative humidity of 93.5% and minimum relative humidity of 30.4%).

2.1 Catalytic preparation

The livestock production unit has 1 058 Holstein dairy cows, with an average of 36.5 $\pm$ 1.5 L/cow/day. Cows are in a poultry and are milked three times a day, and an average of 110 $\pm$ 15 calving occur monthly.

The management of cows consisted on: cows after calving were milked three times a day and were kept 21 days in a poultry under comfortable conditions (fresh vessels, individual and wide hatcheries) ($\pm$7 m^2), clean and abundant sand, fresh water with free access, exercise area with ground floor ($\pm$8 m^2), and a low number of cows per poultry ($\pm$25)) in a transition phase that consisted on the same prepared food ration (Alfalfa 87%, corn 88%, silo oat 44%), without anion salts, later cows were introduced again into the high production paddocks.

For 10 consecutive days after calving, rectal temperature was measured daily and records were taken as an indicator of an ideal health status. Cows were grouped according to the conditions they presented from day 0 to 45 postpartum. The diagnoses and treatments of each condition were carried out by a clinical specialist in dairy cattle.

Information was obtained from 1 110 cows under the Dairy-Com 305® administrative software program for dairy farms, distributed in cows with one, two and three or more calving; they were also classified as healthy, with reproductive, food, metabolic, locomotive and sanitary problems (Table 1).

Because of the low number of animals in the different categories, except reproductive problems, cows were located in a category called "other" so that the statistical analysis had a higher number of cows within this variable; however, some characteristics such as body condition, post-partum health condition or level of dairy production were not evaluated during the investigation because it was not part of this research.

Table 1. Categorization of the animal by number of calving and health status.

Categories	First Calving	Second Calving	Three or more Calving	Total Cows
Healthy	309	254	330	893
Reproductive	64	20	44	128
Food	4	5	8	17
Metabolic	3	1	10	14
Locomotive	3	6	10	19
Sanitary	6	10	23	39
Total	389	296	425	1110

The statistical analysis consisted of comparing means using ANOVA with Tukey test and multivariate analysis using the Statistical software version 10®. The risk determination was calculated using Odds Ratio (OR) with the Win Episcope program 2.0® (Thrusfield et al., 2001) where the interpretation of risk characteristics according to the number of calving was considered, as well as categories with 95% confidence intervals (IC95%).

3 Results and Discussion

3.1 Results

A prevalence of 19.5% was found from a total of 1 110 cows with health problems after calving. Females with pathologies after calving are those that showed lower fertility percentages ($p < 0{,}05$) compared to cows that did not get sick (Table 2). Cows that presented reproductive pathologies after calving, such as retention of fetal membranes and/or metritis, showed lower fertility ($p < 0{,}05$) compared to other conditions (Table 2). The number of calving affected (p<0.05) the fertility of healthy cows. Primaparous dairy cows had the best fertility rate, and cows with three or more calving had the lowest fertility rate of all groups (Figure 1).

Reproductive pathologies affected the fertility of cows ($p < 0{,}05$). Primaporous cows with postpartum reproductive pathologies had 6.2% less fertility rate ($p < 0{,}05$) compared to healthy cows; likewise, cows with two calving and cows with three or more calving with reproductive postpartum pathologies had 15% less fertility rate than cows that remained healthy. However, reproductive pathologies had a minor effect ($p < 0{,}05$) on the fertility of primaporous cows compared with cows with two and three or more calving (Figure 2).

The univariate analysis to determine risk factors showed that cows with three or more calving with reproductive pathologies had up to four times more risk (OR 1.95%; $IC_{95\%}$ 4) to remain empty (Table 3), and cows with more than two calving had up to five times less chance of becoming pregnant (OR 2.24%; $IC_{95\%}$ 5; Table 3). It was found that the conditions in the first 30 postpartum days increase infertility in primarous cows, and in cows with two, three or more calving, although this does not fully explain the causes of infertility.

Table 2. Fertility percentage of cows ($p < 0{,}05$) affected by postpartum pathologies and by the number of calving.

Condition of cows	Number of calving			
	One	Two	Three or more	$p < 0{,}05$
Healthy	92.2^a	85.8^b	76.0^c	0.05
Reproductive pathologies	86.0^a	70.0^b	61.0^c	0.05
Others	87.5^a	59.0^b	72.5^c	0.05

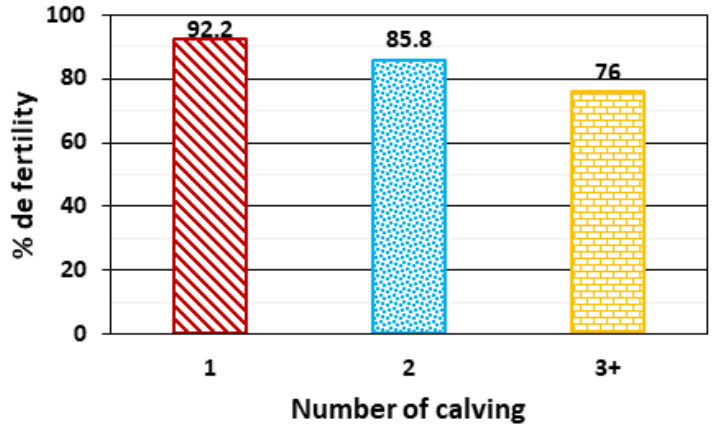

Figure 1. Number of calving and its effect on the fertility of dairy cows.

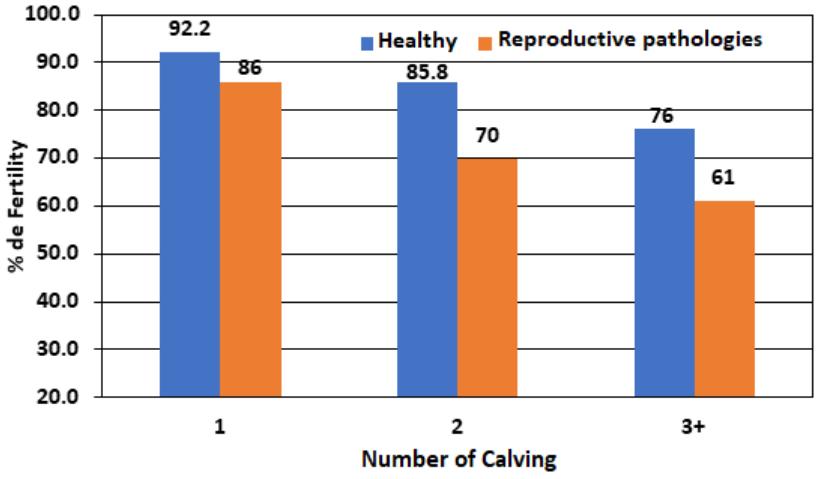

Figure 2. Effect of postpartum reproductive pathologies on the fertility of dairy cows in the Mexican highland.

3.2 Discussion

Based on the results, it can be inferred that the prevalence of postpartum pathologies of the dairy herds analyzed in the Mexican highland was 19.5%, i.e., one in five cows suffered some pathology during postpartum. These results are lower than the reported by LeBlanc (2010) where the prevalence of postpartum disease was one in two dairy cows with some pathology. Dubuc and Denis-Robichaud (2017) found in 126 dairy cows a prevalence of postpartum diseases from 0 to 80%, raising the need to continue researching due to the significant difference in the prevalence of postpartum disease between herds.

The prevalence of postpartum pathologies found in this study was also lower than the one reported by Santos et al. (2010)in a study with 5 179 cows, where they found 44.2% of cows with pathologies. Postpartum pathologies are caused by multiple factors, such as the dry period to the fresh period (Chebel et al., 2018). For example, a loss of body condition during the dry period may have a marked health effect during postpartum (Chebel et al., 2018). It should be noted that the estrus in dairy cows is longer in winter, while in summer it is usually lower, making it difficult to detect the estrus correctly. This characteristic is triggered by the thermal stress suffered by dairy cows, especially Holstein cows (Castaño et al., 2014).

Table 3. Risk of infertility by categories of postpartum pathologies associated with the number of calving.

Primarous cows	**OR**	$IC_{95\%}$
Healthy pregnant	1.98	0.93-4.20
Healthy empty	0.51	0.24-1.08
Reproducive Problems (Pregnant)	0.51	0.23-1.14
Reproductive Problems (Empty)	1.96	0.88-4.37
Other problems (Pregnant)	0.66	0.14-3.00
Other problems (Empty)	1.52	0.33-6.92
Cows with two calving	**OR**	$IC_{95\%}$
Healthy pregnant	**2.24**	**1.06-4.95**
Healthy empty	0.45	0.20-0.98
Reproducive Problems (Pregnant)	0.40	0.15-1.08
Reproductive Problems (Empty)	2.48	0.92-6.64
Other problems (Pregnant)	0.59	0.18-1.87
Other problems (Empty)	1.70	0.53-5.41
Cows with three claving	**OR**	$IC_{95\%}$
Healthy pregnant	1.54	0.94-2.53
Healthy empty	0.65	0.40-1.07
Reproducive Problems (Pregnant)	0.51	0.27-0.97
Reproductive Problems (Empty)	**1.95**	**1.03-3.71**
Other problems (Pregnant)	0.91	0.47-1.76
Other problems (Empty)	1.10	0.57-2.12

The prevalence of postpartum pathologies may have been lower than the results published by other authors due to the difference in the management of cows that started from the dry period to the cool period.

The results of the research indicate that the number of calving affected the prevalence. Primarous cows had a lower prevalence. These results are corroborated by Wittrock et al. (2011) who reported a lower incidence of postpartum pathologies in primarous cows than in multiparous. The low prevalence of postpartum pathologies in these cows may be due to the fact that primarous cows have better metabolic adaptation and less loss of body condition than cows with two or more calving (Adrien et al., 2012; Wathes et al., 2007). Among the main causes of infertility in cattle are genetic disorders, including chromosomal abnormalities, congenital malformations, or freemartinism; similarly, hormonal factors result in the cyclic disability of females (Córdova et al., 2002).

Reproductive problems caused by retention of fetal membranes, metritis or the combination of both pathologies, affected the percentage of pregnant cows regardless the number of calving. These results are confirmed by Melendez et al. (2009) and Deori and Phookan (2015) who mention that postpartum reproductive pathologies reduced fertility in dairy cows. Also, Santos et al. (2010) found that females with postpartum metritis or endometritis had lower fertility rate than healthy cows. Sheldon (2020) found a possible explanation of the physiological cause by mentioning that because cows have a unique circulation between the uterus and ovaries (uterine-ovarian vascular pedicle system), it has a very important structural relationship of arterial and venous irrigation in the establishment of coordinated physiological mechanisms of the uterus and ovaries. In the apposition area, there is a decrease in the thickness of the walls between the ovarian artery and the uterine vein, although no direct vascular connection between the artery and the vein has been demonstrated, and this is where the exchange of molecules such as prostaglandin $F2\alpha$ occurs, passing from the uterine venous system to the ovarian arterial system.

There are two mechanisms for exchanging molecules; the first is the diffusion through the uterine-ovarian lymph vessels (the lymph vessels attach closely to the venous and arterial vessels in the ligament of the ovary) and the second by the transportation proteins. In this way, the bacteria, their toxins and lipopolysaccharides reach the ovary, produ-

cing an inflammatory reaction that interferes with the health of the oocytes and the production of hormones, both belonging the corpus luteum and the follicles, thus affecting the fertility of cows (Sheldon, 2020; Fabian et al., 2010; Chebel, 2007).

The percentage of pregnant cows was also affected by the number of calving, where cows with the highest number of calving were more likely to become empty, regardless whether they had health problems during postpartum. These results are corroborated by other studies published by Lucy et al. (2014), who relate dairy production in females with more calving; in other words, when producing more milk, it is common to find a greater number of these cows with negative energy balance and with high concentrations of both β-hydroxybutyrate and non-esterified fatty acids. Negative energy balance during postpartum in dairy cow is associated with a reduction in GnRH and LH, affecting follicle growth, maturation and ovulation, resulting in a low fertility rate (Crowe et al., 2014), which would explain why not all cows that remained healthy during postpartum became pregnant.

Similarly, the explanation for the results of healthy cows that were empty may be due to causes other than health problems such as metabolic problems (negative energy balance, increased concentrations of β-hydroxybutyrate and non-esterified fatty acids) that contribute to the infertility of healthy cows. Trevisi et al. (2011) also concluded that subclinical proinflammatory processes postpartum in dairy cows have long-term effects, including reducing or increasing the risk of infertility rate in dairy cows.

4 Conclusions

Reproductive pathologies had the greatest impact on fertility and increased the risk of empty cows, especially those with more than two calving. Although the number of calving affected fertility and increased the risk of being empty, infertility due to postpartum pathologies could not be fully determined. It is recommended to maximize cow´s care in the transition period in order to reduce the presence of diseases and decrease the percentage of cow problems.

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