Estudio 2

Influence of management factors on pregnancy attrition In dairy cattle

J. Labèrnia,[1] F. López-Gatius,[1] P. Santolaria,[1] M. López-Béjar[2] and J. Rutllant[2]

[1]Producción Animal, Universidad de Lleida, Lleida, Spain
[2]Anatomía, Universidad Autónoma de Barcelona, Bellaterra, Spain

Theriogenology, 45:1247-1253, 1996

ABSTRACT

The present study was conducted to determine the influence of management factors on pregnancy attrition in dairy cattle. Data from 3162 diagnosed pregnancies in parous cows and 1050 in heifers at 9 commercial dairy herds in northeastern Spain were used. Pregnancy diagnosis by palpation per rectum was performed from 30 to 70 d post insemination. Pregnancy attrition was registered when pregnancy diagnosis resulted negative in a second palpation carried out between 120 and 150 d following insemination. Overall proportion of pregnancy losses was 7.9% (9.6% in parous cows and 2.8% in heifers). Data analysis was performed by multiple logistic regression methods. For all animals, effect of time of pregnancy diagnosis was shown (Odds ratio=0.97 for 1 d increase; P=0.0042). Conceptus loss in heifers was lower than in parous cows (Odds ratio=0.28; P=0.0001), and a higher proportion of pregnancy attritions was detected in animals inseminated in spring, summer and winter, compared to those inseminated in autumn (P<0.04). Herd effect on pregnancy attrition was also significant. Similar results were observed in the subanalysis for parous cows and, furthermore, no effect of lactation number and of interval from previous calving to pregnancy was shown in this group. In heifers, no effect of time of pregnancy diagnosis and of insemination season on pregnancy attrition was shown, and only a herd effect was observed. Our data suggest that the influence of parity status (heifer vs cow) could affect the proportion of pregnancy attrition rather than early diagnosis, and, in pregnant cows, adaptation to seasonal changes associated with temperature decreases seem more efficient.

Key words: pregnancy attrition, management factors, pregnancy diagnosis, dairy cattle.

INTRODUCTION

The reduction of days open is a major objective in dairy cattle industry (15). Early and accurate pregnancy diagnosis allows adequate decision-making in a herd reproductive management program and reduces economic losses due to delayed conceptions.

Because of the high accuracy of the method, pregnancy in cattle is generally diagnosed by palpating the uterus and its contents per rectum (8). Uterine changes indicating pregnancy, including fluctuation of fluids in the uterus, chorioallantoic slip, and a palpable amniotic vesicle can be detected as early as 30 days postbreeding (5).

Some studies have suggested a possible adverse effect of early rectal palpation after insemination (1, 7). Significant effects of palpation methods to diagnose pregnancy (1, 23), technician

(1) and days after insemination (16, 23-25) upon fetal loss have been reported. In contrast, recent studies (2, 20, 21) have shown a small effect of the day of first rectal palpation after insemination on calving rate. Nevertheless, the observed pregnancy losses can be due to diagnosis errors (24), to fetal or embryonic mortality induced by palpation (1, 4, 7, 17, 24) or environmental causes (12) and to spontaneous embryonic mortality (10).

With the objective of understanding more about pregnancy losses in dairy cattle, the influence of management factors on pregnancy attrition was evaluated.

MATERIALS AND METHODS

Animals

Data from 4212 diagnosed pregnancies in Friesian parous cows (n=3162) and heifers (n=1050) recorded from 1987 to 1994 in 9 herds in northeastern Spain were studied. In all 9 herds, cows and heifers were in open stalls and were fed the same diets according to current requirements (14).

All cows and heifers were bred using artificial insemination. Confirmation of estrus was performed by palpation per rectum (11) and no cows with clinical disorders were inseminated. Abnormal genital discharges, pathological abnormalities of the reproductive tract detectable by palpation per rectum and ovarian cysts were considered to be clinical disorders at insemination.

Pregnancy Diagnosis

A careful palpation per rectum of the uterus for fluctuation of fluids and of the ovaries for a corpus luteum were performed to diagnose pregnancy between 30 and 70 d after insemination, with an average of 41.5 $\pm$ 0.11 d. A second rectal palpation for assessment of normal increase of uterine size and then for membrane slip was performed 120 to 150 d after insemination. Pregnancy attrition was registered when pregnancy diagnosis resulted negative in the second palpation. All palpations were performed by the same practitioner.

Data Collection and Analysis

Data on pregnancy attrition, insemination to pregnancy diagnosis interval, parity (parous or nonparous), meteorological season of insemination, and herd were recorded for each animal. Interval from previous calving to pregnancy and lactation number were also recorded in parous cows.

Multiple logistic regression with pregnancy attrition as the dependent variable and with parity (cow or heifer), insemination to first pregnancy diagnosis interval, insemination season and herd as

factors, was performed for all animals. Two-way interaction terms among factors were also considered. Factors and interactions significantly related to pregnancy loss ($P<0.05$) remained in the final model.

Logistic regression subanalyses were also carried out for cows and for heifers. In parous cows, calving to pregnancy interval and lactation number were added as factors.

The regression coefficients from logistic regression were exponentiated to obtain the odds ratio and its 95% confidence interval associated to each factor. Significantly higher (or lower) than 1 odds ratio for a factor implies an increased (or reduced) risk of pregnancy loss with 1 unit increase of the value of this factor, when referred to a continuous variable. For class variables, one class in each variable was considered as the reference, and significantly higher (or lower) than 1 odds ratio for any other class of this variable implies an increased (or reduced) risk of pregnancy loss when compared to the reference class.

Data analysis was carried out by means of the logistic regression model (SAS software, LOGISTIC procedure; 18) according to the method described by Hosmer and Lemeshow (9).

RESULTS

In parous cows, the mean interval from calving to first insemination was 82.3 ± 1.3 d ($x \pm SEM$) and from calving to pregnancy was 119.4 ± 1.33 d, (ranged from 30 to 130 and from 30 to 500 d respectively). The mean lactation number was 2.2 ± 0.03 and ranged from 1 to 10 lactations.
From the 4212 diagnosed pregnancies included in the study, 333 (7.9%) pregnancy attritions were registered. The proportion of pregnancy attrition was 2.8% for heifers and 9.6% for parous cows. Table 1 shows the variables which were finally included in the logistic model for all animals. No interaction terms were found significant.

As it is shown in Table 1, heifers were almost 4 times less likely to pregnancy attrition than parous cows (Odds Ratio=0.28; P=0.0001). The increase in the insemination to pregnancy diagnosis interval decreased pregnancy loss (P=0.0042) so that a 1 d increase in this interval decreased pregnancy attrition by a 0.97 ratio. Higher proportion of pregnancy attrition was detected in cows inseminated in spring, summer or winter, compared to those inseminated in autumn. Herd had a significant effect on pregnancy attrition (P=0.014).

Table 2 shows the variables which were finally included in the logistic model for parous cows. No significant interactions were found. Calving to conception interval and lactation number were not related to pregnancy attrition. Insemination to pregnancy diagnosis interval had a significant effect on pregnancy loss (Odds ratio=0.97 for 1 day increase; P=0.0027). Parous cows inseminated in summer

and winter were more likely to pregnancy attrition than those inseminated in autumn and a tendency was shown in parous cows inseminated in spring. Herd effect was also significant (P=0.031).

Logistic regression methods applied to heifers showed no significant effects of insemination to pregnancy diagnosis interval (P=0.94) and of insemination season (P>0.4). In 2 of the 9 studied herds, no pregnancy attritions were recorded in heifers. Fetal or embryo loss in heifers ranged from 0 to 5% in the studied herds.

Table 1. Odds ratios of variables included in the final logistic regression model for pregnancy attrition (all animals)

Factor	Class	n	Odds ratio	95% Confidence interval		P
Interval insemination-diagnosis (days)	(continuous)	4212	0.97	0.96	0.99	0.0042
Parity						
	Cow	3162	1			
	Heifer	1050	0.28	0.19	0.41	0.0001
Season						
	Autumn	1136	1			
	Winter	1085	1.44	1.05	1.99	0.025
	Spring	998	1.45	1.04	2.03	0.027
	Summer	993	1.44	1.03	2.01	0.034
Herd	(9 classes)					0.014[a]

[a]Reflects the probability level of no relationship between herd effect and pregnancy attrition. Odds ratios for comparisons among herds are not included.

Likelihood ratio test = 107.2, 13df, P=0.0001 (without random effect).

Hosmer and Lemeshow Goodness of Fit Statistic = 9.64, 8 df, P=0.291 (the model fits).

Table 2. Odds ratios of variables included in the final logistic regression model for pregnancy attrition (parous cows)

Factor	Class	n	Odds ratio	95% Confidence interval		P
Interval insemination-diagnosis (days)	(continuous)	3162	0.97	0.95	0.99	0.0027
Season						
	Autumn	888	1			
	Winter	851	1.44	1.03	2.01	0.033
	Spring	727	1.41	0.99	2.00	0.055
	Summer	696	1.49	1.05	2.11	0.026
Herd	(9 classes)					0.031[a]

[a]Reflects the probability level of no relationship between herd effect and pregnancy attrition. Odds ratios for comparisons among herds are not included.
Likelihood ratio test = 43.6, 12df, P=0.0001 (without random effect).
Hosmer and Lemeshow Goodness of Fit Statistic = 9.67, 8 df, P=0.289 (the model fits).

DISCUSSION

In the present study, proportion of heifers with pregnancy attrition was lower than of parous cows (2.8% vs. 9.6%). Furthermore, no significant relationship was found between the interval from insemination to pregnancy diagnosis by palpation per rectum and pregnancy attrition in heifers. However, this relationship was significant in parous cows, so that the increase of the interval from insemination to pregnancy diagnosis decreased the proportion of pregnancy attrition. Numerous studies have related early rectal palpation of the uterus with a detrimental effect on pregnancy development (1, 4, 7, 16, 17, 23). In contrast, other studies have reported small influence of age of conceptus at palpation on pregnancy attrition (2, 20, 21). Our data are partly in agreement with the latter works, early palpation is not necessarily related with pregnancy loss. The influence of parity status (heifer/cow) could affect the proportion of pregnancy attritions rather than early diagnosis. It has been suggested that pregnancy and calving make the uterus less efficient in taking part in the development of subsequent pregnancy (3, 22).

In the present study herd had a significant effect on pregnancy losses, in agreement with previous reports (20, 21). Characteristic management and man-cow interactions in each farm appear to affect the normal evolution of pregnancy.

No effects of lactation number and of interval previous parturition to pregnancy upon pregnancy attrition were found in parous cows. It has been reported that older cows have a higher proportion of abortions (3, 22, 26). The interval from calving to uterine involution ranges from 12 to 56 d (13), and incomplete uterine involution can be a cause of abortion if fertilizing insemination is conducted early after parturition (6). In our study, although cows were often bred early post partum, gynecological examination was performed at estrus so that only cows with normal uterine involution and ovarian structures were inseminated. This reproductive management routine could have been related with no effects of the variables lactation number and interval from previous parturition to pregnancy on pregnancy attrition rates.

Physiological responses to seasonal climatic variations, especially heat stress, affect reproductive functions in cows. High temperatures have been related to lower conception rates (19). Little is known about the effect of season on pregnancy losses of previously diagnosed pregnancies. In the present study, pregnancy losses were lower in parous cows inseminated in autumn. Therefore, adaptation of pregnant cows to seasonal changes seems more efficient with temperature decreases.

ACKNOWLEDGMENTS

The present study received financial support from CTT of University of Lleida (Convenios C-0018 and C-0019). Jordi Labèrnia was supported by a Grant from Generalitat de Catalunya nº FI-94/43704027. The authors thank Paqui Homar for help with the collection of the data used in this study.

REFERENCES

1. Abbit B, Ball L, Kitto GP, Sitzman CG, Wilgenburg B, Raim LW, Seidel GEJr. Effect of three methods of palpation for pregnancy diagnosis per rectum on embryonic and fetal attrition in cows. J Am Vet Med Assoc 1978;173:973-977.
2. Alexander BM, Johnson MS, Guardia MO, Van de Graaf WL, Senger PL, Sasser RG. Embryonic loss from 30 to 60 days post breeding and the effect of palpation per rectum on pregnancy. Theriogenology 1995;43:551-556.
3. Ball PHJ. The relationship of age and stage of gestation to the incidence of embryo death in dairy cattle. Res Vet Sci 1978;25:120-122.
4. Ball L, Carroll EJ. Induction of fetal death in cattle by manual rupture of the amniotic vesicle. J Am Vet Med Assoc 1963;142:373-374.
5. Bondurant RH. Examination of the reproductive tract of the cow and heifer. In: Morrow DA

(ed.), Current Therapy in Theriogenology 2 ed. WB Saunders Co, Philadelphia, 1986;95.

6. De Kruif A. Factors influencing the fertility of a cattle population. J Reprod Fert 1978;54:507-518.
7. Franco OJ, Drost M, Thatcher MJ, Shille VM, Thatcher WW. Fetal survival in the cow after pregnancy diagnosis by palpation per rectum. Theriogenology 1987;27:631-644.
8. Hickey GJ. Pregnancy diagnosis in dairy cattle: present status and future prospects. Cornell Vet 1990;80:299-302.
9. Hosmer DW, Lemeshow S. Applied Logistic Regression. New York: Wiley, 1989.
10. Kastelic JP, Northey DL, Ginther OJ. Spontaneous embryonic death on days 20 to 40 in heifers. Theriogenology 1993;35:351-363.
11. López-Gatius F, Camón-Urgel J. Confirmation of estrus rates by palpation per rectum of genital organs in normal repeat dairy cows. J Vet Med A 1991;38:553-556.
12. Miller RB. Bovine abortion. In: Morrow DA (ed), Current Therapy in Theriogenology. Philadelphia: WB Saunders Co, 1986; 291-300.
13. Morrow DA, Roberts SJ, McEntee K. A review of postpartum ovarian activity and involution of the uterus and cervix in cattle. Cornell Vet 1969;59:134-154.
14. National Research Council of The National Academy of Science. Nutrient Requirements of Dairy Cattle. Washington DC, 1978.
15. Olds D, Cooper T, Thrift FA. Effect of days open on economic aspects of current lactation. J Dairy Sci 1979;62:1167-1170.
16. Paisley LG, Mickelsen WD, Frost OL. A survey of the incidence of prenatal mortality in cattle following pregnancy diagnosis by rectal palpation. Theriogenology 1978;9:481-491.
17. Rowson LEA, Dott HM. A hazard of pregnancy diagnosis in cattle: early foetal size. Vet Rec 1963;75:865-866.
18. SAS. Technical Report: Release 6.07. SAS Institute Inc, 1992.
19. Thatcher WW, Collier RJ. Effects of climate on bovine reproduction. In: Morrow DA (ed), Current Therapy in Theriogenology 2. Philadelphia: WB Saunders Co, 1986;301-309.
20. Thompson JA, Marsh WE, Calvin JA, Etherington WG, Momont HW, Kinsel ML. Pregnancy attrition associated with pregnancy testing by rectal palpation. J Dairy Sci 1994;77:3382-3387.
21. Thurmond MC, Picanso JP. Fetal loss associated with palpation per rectum to diagnose pregnancy in cows. J Am Vet Med Assoc 1993;203:432-435.
22. Thurmond MC, Picanso JP, Jameson CM. Considerations for use of descriptive epidemiology to investigate fetal loss in dairy cows. J Am Vet Med Assoc 1990;197:1305-1312.
23. Vaillancourt D, Bierschwal CJ, Ogwu D, Elmore RG, Martin CE, Sharp AJ, Youngquist RS.

Correlation between pregnancy diagnosis by membrane slip and embryonic mortality. J Am Vet Med Assoc 1979;175:466-468.

24. White ME, LaFaunce N, Mohammed HO. Optimal time postbreeding for pregnancy examination in dairy cattle. Can Vet J 1989;30:147-149.
25. White ME, LaFaunce N, Mohammed HO. Calving outcomes for cows diagnosed pregnant or nopregnant by per rectum examination at various intervals after insemination. Can Vet J 1989;30:867-870.
26. Withers FW. Wastage and disease incidence in dairy herds. Vet Rec 1957;69:446-453.

Estudio 3

Effect of reproductive disorders previous to conception on pregnancy attrition in dairy cows

F. López-Gatius,[1] J. Labèrnia,[1] P. Santolaria,[1] M. López-Béjar[2] and J. Rutllant[2]

[1]Producción Animal, Universidad de Lleida, Lleida,Spain

[2]Anatomía, Universidad Autónoma de Barcelona, Bellaterra, Spain

Theriogenology, 46:643-648, 1996

ABSTRACT

This study was undertaken to determine whether reproductive disorders previous to conception influence pregnancy attrition in dairy cows. Reproductive disorders were registered and pregnancy diagnoses were performed as a part of a reproductive health program at 9 commercial dairy herds in northeastern Spain. Data from 3022 diagnosed pregnant lactating cows were used. Pregnancy diagnosis by palpation per rectum was performed from 33 to 70 d post insemination. Pregnancy attrition was registered when the pregnancy diagnosis was negative at the second palpation carried out between 120 and 150 d following insemination. Data analysis was performed by multiple logistic regression methods. Pregnancy attrition rates were 2.6 and 1.8 times higher in cows with previous pyometra and retained placenta, respectively, than in cows without these disorders. No effect of endometritis, ovarian cysts and repeat breeding was shown on pregnancy attrition. Our results suggest that additional efforts to reduce the risk of retained placenta and pyometra should decrease the incidence of pregnancy attrition in dairy cows.

Key words: pregnancy attrition, reproductive disorders, pregnancy diagnosis, dairy cows

INTRODUCTION

Prenatal loss is probably the single most important factor affecting the profitability of the animal production industry. In cattle, fertilization rates following either natural or artificial insemination are close to 90%, but calving rates to a single service are rarely higher than 55 to 60% (4). As defined by the Committee on Bovine Nomenclature (3), the embryonic period of gestation extends from conception to the completion of the differentiation stage (about 45 d); the fetal period extends from 45 d until parturition. Most of the prenatal losses occur during the early embryonic period (4, 11). Embryonic mortality in cattle has been estimated to be about 38% (13). However, the frequency of losses after the embryonic period appears to increase under intensive systems of dairy management (5). Fetal loss may exceed 10%, and the increased risk of fetal death continues up to the fetal age of 6 to 18 wk (14).

Pregnancy diagnosis by palpation per rectum is routine in reproductive management programs, and it is generally performed between 35 and 70 d of gestation (1). Thus, the measurement of the risk of pregnancy attrition following pregnancy diagnosis includes late embryonic and early fetal periods. Little is known about the causes of pregnancy attrition during this time. In a recent study (9), we evaluated the influence of management factors on pregnancy attrition following pregnancy diagnosis, and the frequency of pregnancy loss in parous cows (9.6%) was much higher than in heifers (2.8%). The present study was undertaken to determine whether there is any correlation between reproductive disorders previous to conception, such as retained placenta, pyometra, ovarian cysts, endometritis and

the repeat-breeder syndrome, and pregnancy attrition in lactating dairy cows.

MATERIALS AND METHODS

Animals and Reproductive Health Management

Data used for this study were collected from 9 dairy herds between 1987 and 1994. The animals were Friesian lactating cows (n = 3022) that were registered as pregnant.

The cows were kept in open stalls and were maintained on a weekly reproductive health program. They were examined between 30 and 36 d post partum for normal uterine involution. The cows were also examined between 70 and 76 d post partum if they had not exhibited estrus previously.

Reproductive disorders were registered following calving (retained placenta); at the postpartum gynecological examination (pyometra); and at the subsequent period previous to conception (ovarian cysts, endometritis and repeat-breeder syndrome). Retained placenta was registered if cows had retained fetal membranes longer than 12 h after calving. Cows were considered to have pyometra if purulent fluid in the uterus and a corpus luteum (CL) were detected at the postpartum gynecological examination. An ovarian cyst was diagnosed when a structure 25 mm in diameter or larger in either or both ovaries persisted for at least 7 d in the absence of a palpable CL. Endometritis was diagnosed if vaginal fluid was observed with floating droplets of pus (<50% pus) at estrus, and abnormalities of the uterus were not detectable per rectum. A cow was considered to be a repeat breeder if the number of inseminations higher than 4 was needed to effect pregnancy.

If possible, gentle removal of fetal membranes was performed in cows with a retained placenta, and boluses containing oxytetracicline were always administered into the uterus. Cloprostenol was the luteolytic agent used to treat pyometra, and at least 1 estrous cycle period of reproductive rest was established as treatment of endometritis. Manual rupture of the cystic structure per rectum was carried out for the treatment of ovarian cysts, while no therapeutic agents were used for repeat-breeder syndrome.

Estrus was confirmed by examination per rectum at the time of insemination (10) and vaginal fluid was also examined. Insemination was only performed in cows that were free of clinical disorders. When endometritis or possible ovarian cysts were detected at estrus, this data was recorded, but the cows were not inseminated. Cows with other clinical disorders at the time of insemination were excluded from the study.

Pregnancy Diagnosis

Careful palpation per rectum of the uterus for fluctuation of fluids and of the ovaries for the presence of a CL was performed to diagnose pregnancy between 33 and 70 d after insemination. The

average interval between insemination and pregnancy diagnosis was 42.1 + 0.12 d. A second palpation for assessment of normal increase in uterine size and for membrane slip was performed 120 to 150 d after insemination. Pregnancy attrition was recorded when a second palpation resulted in a negative pregnancy diagnosis.

All artificial inseminations and palpations were performed by the same veterinarian.

Data Collection and Analysis

Data on pregnancy attrition, management variables and reproductive disorders were recorded for each animal. Retained placenta, pyometra, ovarian cysts, endometritis and repeat breeding were coded as dichotomous variables, where 1 means presence and 0 means absence of the disorder during the interval from calving to conception. Recorded data on management factors included interval from previous calving to pregnancy, interval from insemination to pregnancy diagnosis, lactation number, meteorological season of insemination, and herd. To evaluate relationships between pregnancy attrition and reproductive disorders, multiple logistic regression analysis was performed for all animals. In a previous study (9), management factors such as the interval from insemination to pregnancy diagnosis, insemination season, and herd were found to have a significant effect on pregnancy attrition in parous cows. For this reason, the above mentioned management factors were included in the logistic regression analysis as the control variables.

The regression coefficients from logistic regression were exponentiated to obtain the odds ratio and its 95% confidence interval associated to each factor. Significantly higher (or lower) than 1 odds ratio for a reproductive disorder implies an increased (or reduced) risk of pregnancy loss if that disorder occurs.

Data analysis was carried out by means of the logistic regression model (SAS software, LOGISTIC procedure; 12) according to the method described by Hosmer and Lemeshow (8).

RESULTS

The mean interval from calving to first insemination was 82.1 $\pm$ 1.3 d (x $\pm$ SEM), and from calving to pregnancy it was 118.4 $\pm$ 1.4 d (ranges were from 30 to 130 and from 30 to 496 d, respectively). The mean lactation number was 2.2 $\pm$ 0.03 and ranged from 1 to 10 lactations. Of the 3022 diagnosed pregnancies, 291 (9.6%) attritions were registered. The average number of inseminations per pregnancy was 2.1 $\pm$ 1.6 (x $\pm$ SEM) and ranged from 1 to 13 inseminations. The number of animals with the following clinical disorders was 192 (6.3%) for retained placenta; 40 (1.3%) for pyometra; 158 (5.2%) for ovarian cysts; 110 (3.6%) for endometritis; and 231 (7.6%) for repeat-breeder cows.

Logistic regression analysis showed no significant effects of endometritis, ovarian cysts or repeat-breeder syndrome on pregnancy attrition. The interval from insemination to pregnancy diagnosis, insemination season, and herd were included in the model as the control variables. Pyometra and retained placenta were the reproductive disorders included in the final model (Table 1). No significant interactions were found. Cows with retained placenta were 1.8 times more likely to undergo pregnancy loss than cows without the disorder. The risk of pregnancy attrition was 2.6 higher in cows with previously recorded pyometra.

Table 1. Odds ratios for reproductive disorders that were included in the final logistic regression model for pregnancy attrition.[a]

Factor	Class	n	Odds ratio	95% Confidence interval		P
Pyometra						
	No	2982	1			
	Yes	40	2.6	1.2	5.5	0.018
Retained Placenta						
	No	2830	1			
	Yes	192	1.8	1.2	2.7	0.005

[a]Interval from insemination to diagnosis, insemination season, and herd were included in the model as the control variables.
Likelihood ratio test = 56.24, 14 df, P=0.0001 (without a random effect).
Hosmer and Lemeshow Goodness of Fit Statistic = 4.77, with an 8 df, P=0.78 (the model fits).

DISCUSSION

In this study endometritis was defined as the presence of a purulent vaginal discharge in cows free of uterine disease as determined per rectum at estrus. We did not find any association between endometritis and pregnancy attrition. Similar results have been obtained when the influence of nonspecific infections or endometritis on fertility (6) and embryo survival (7) was studied. Thus, nonspecific uterine infections seem to have only a negligible effect on reproductive function in clinically normal cows. However, the other uterine-related reproductive disorders that were considered

in this study (i.e., retained placenta and pyometra) were associated with pregnancy attrition. Although only clinically normal cows were inseminated, previous retained placenta or pyometra could have caused alterations in the uterine environment that resulted in subsequent pregnancy loss. These alterations could particularly be critical during the implantational process, a period which coincides with early pregnancy diagnosis. During this period, maternal-conceptus interactions are closer, with the trophoblast gradually attaching to the uterine mucosa between 28 and 35 d of gestation, and the nutrition of the embryo becomes primarily hematotropic by means of placentomes (3). Traces of uterine disease could interfere with the course of attachment, and this in turn could explain why there is a relationship between the time of pregnancy diagnosis and conceptus loss in parous cows, as has been extensively reported (9, 15, 16, 17), as well as why this relationship is rarely observed in heifers (2, 9), since they are less likely to develop uterine disease.

Ovarian cysts can be the cause of reproductive failure, which, depending on its prevalence in a herd, can be an important economic factor for the dairy producer. However, as our data show, pregnancy attrition rates were not affected by previous cystic ovarian degeneration in the cow. Similarly, even though there is a clear association between repeat-breeder syndrome and early embryonic death (13), the maintenance of pregnancy following diagnosis was similar between cows with a normal reproductive history and the repeat-breeder cows.

A high proportion of late embryo or early fetal loss goes undetected under typical farm conditions (5). Therefore, it is difficult to determine the etiology of pregnancy attrition at this stage. In our study the previous reproductive disorders of retained placenta and pyometra appeared to be detrimental for subsequent pregnancies. Thus, efforts to reduce the risk of these reproductive disorders should decrease the incidence of pregnancy attrition in dairy cows.

ACKNOWLEDGMENTS

The present study received financial support from CTT of University of Lleida (Convenios C-0018 and C-0019). Jordi Labèrnia was supported by a Grant from Generalitat de Catalunya nº FI-94/43704027. The authors thank Paqui Homar for help with the collection of the data used in this study.

REFERENCES

1. Abbit B, Ball L, Kitto GP, Sitzman CG, Wilgenburg B, Raim LW, Seidel GEJr. Effect of three methods of palpation for pregnancy diagnosis per rectum on embryonic and fetal attrition in cows. J Am Vet Assoc 1978;173:973-977.
2. Alexander BM, Johnson MS, Guardia MO, Van de Graaf WL, Senger PL, Sasser RG. Embryonic loss from 30 to 60 days post breeding and the effect of palpation per rectum on pregnancy.

Theriogenology 1995;43:551-556.

3. Committee on Bovine Reproductive nomenclature. Recommendations for standardizing bovine reproductive terms. Cornell Vet 1972; 62:216-237.
4. Diskin MG, Sreenan JM. Fertilization and embryonic mortality rates in beef heifers after artificial insemination. J Reprod Fertil 1980;59:463-468.
5. Forar AL, Gay JM, Hancock DD. The frequency of endemic fetal loss in dairy cattle: a review. Theriogenology 1995;43:989-1000.
6. Griffin JFT, Hartigan PJ, Nunn WR. Non-specific uterine infection and bovine fertility II. Infection patterns and endometritis before and after service. Theriogenology 1974;1:107-114.
7. Hawk HW, Kiddy CA, Wilson JB, Esposito M, Winter AJ. Bacteriological studies of clinically normal cows for low fertility. J Dairy Sci 1958;41:120-128.
8. Hosmer DW, Lemeshow S. Applied Logistic Regression. New York: Wiley, 1989.
9. Labèrnia J, López-Gatius F, Santolaria P, López-Béjar M, Rutllant J. Influence of management factors on pregnancy attrition in dairy cattle. Theriogenology 1996;45:1247-1253.
10. López-Gatius F, Camón-Urgel J. Confirmation of estrus rates by palpation per rectum of genital organs in normal repeat dairy cows. J Vet Med A 1991;38:553-556.
11. Roche JF, Boland MP, McGeady TA. Reproductive wastage following artificial insemination of heifers. Vet Rec 1981;109:401-403.
12. SAS. Technical Report: Release 6.07. SAS Institute Inc, Cary, NC, 1992.
13. Sreenan JM, Diskin MG. The extent and timing of embryonic mortality in the cow. In: Sreenan JM, Diskin MG (eds), Embryonic Mortality in Farm Animals. Brussels: Martinus Nijhoff Publishers, 1986;1-11.
14. Thurmond MC, Picanso JP, Jameson CM. Considerations for use of descriptive epidemiology to investigate fetal loss in dairy cows. J Am Vet Med Assoc 1990;197:1305-1312.
15. Vaillancourt D, Bierschwal CJ, Ogwu D, Elmore RG, Martin CE, Sharp AJ, Youngquist RS. Correlation between pregnancy diagnosis by membrane slip and embryonic mortality. J Am Vet Med Assoc 1979;175:466-468.
16. Warnick LD, Mohammed HO, White ME, Erb HN. The relationship of the interval from breeding to uterine palpation for pregnancy diagnosis with calving outcomes in Holstein cows. Theriogenology 1995;44:811-825.
17. White ME, LaFaunce N, Mohammed HO. Calving outcomes for cows diagnosed pregnant or nopregnant by per rectum examination at various intervals after insemination. Can Vet J 1989;30:867-870.

Conclusiones generales

- La estación de parto influyó sobre las interacciones entre las disfunciones reproductivas previas a la gestación en la vaca de modo que un ambiente frío en la época de parto disminuyó los efectos negativos subsiguientes de dichas disfunciones, especialmente en animales de mayor edad.

- En animales gestantes, las vacas que habían desarrollado previamente alguna gestación a término presentaron mayor probabilidad de sufrir una pérdida fetal que las nulíparas.

- En vacas gestantes que ya habían desarrollado gestaciones previas a término, el riesgo de pérdida de gestación se incrementó a medida que disminuía el intervalo entre la inseminación fértil y el diagnóstico de gestación por palpación rectal. Sin embargo, en animales primigestantes (novillas) no se observó efecto de la práctica del diagnóstico de gestación sobre la pérdida de gestación.

- En vacas gestantes inseminadas en otoño se detectó menor incidencia de pérdida fetal que en las inseminadas en otras estaciones.

- En vacas en lactación, disfunciones reproductivas previas a la concepción tales como quistes ováricos, endometritis y síndrome de vaca repetidora no influyeron sobre la subsiguiente incidencia de pérdida de gestación. En cambio, la retención de placenta y la piómetra sí incrementaron el riesgo de subsiguiente pérdida de gestación.

Consideraciones prácticas

Las estrategias de manejo relacionadas con la reducción de la incidencia de la retención de placenta pueden reducir la incidencia de subsiguientes pérdidas de gestación y el intervalo entre partos. Así, serían aconsejables el establecimiento de programas higiosanitarios en las instalaciones de pre- y post-parto, controles de la calidad de la dieta en el período preparto, y mejora de las condiciones ambientales, tales como la adopción de medidas para la reducción del estrés térmico calórico.

Un programa de intensificación reproductiva que incluya el control de la involución uterina y la actuación sobre las anomalías del aparato genital en un período previo a la inseminación artificial, permite disminuir el intervalo entre parto e inseminación y, por tanto, el intervalo entre parto y gestación.

Perspectivas

Teniendo en cuenta la importancia que está adquiriendo la incidencia de la pérdida de gestación durante el período de implantación y en los primeros meses del período fetal, a medida que se incrementa la intensificación de las explotaciones de ganado vacuno lechero, sería de gran utilidad determinar el momento preciso en que se produce esta pérdida, con ayuda de técnicas ecográficas. Con dichos métodos se facilitaría, por una parte, caracterizar y comprender mejor el proceso y, por otra, estudiar la relación de la muerte embrionaria o fetal con las condiciones ambientales y de manejo con mayor concreción.

Tal y como se ha descrito, se observa un efecto estacional sobre la pérdida de gestación en vacas lecheras, de modo que, en las estaciones cálidas, se incrementa el riesgo de pérdida. Considerando la problemática del estrés por calor en verano en nuestro ámbito geográfico, sería interesante estudiar con mayor detalle la influencia de diversas variables meteorológicas sobre esta patología.

Respecto a los factores de manejo, el nivel de producción lechera y el estado nutricional de la vaca gestante podrían tener una importante relación con esta disfunción.

Estos estudios serían posiblemente de interés para su aplicación en la toma de decisiones en explotaciones ganaderas comerciales de ganado vacuno lechero.

Extracto

INTRODUCCIÓN

El éxito reproductivo condiciona la rentabilidad en una explotación de vacuno lechero y está influido por múltiples variables. Debido a la diversidad de estas variables y a la posibilidad de existencia de interacciones entre ellas, se obtiene mayor información cuando se estudian de forma conjunta. La intensificación de los procesos productivos en las explotaciones ganaderas determina una mayor influencia de los factores de manejo sobre dichos procesos. Sin embargo, pocos estudios han utilizado variables relacionadas con el manejo para analizar los parámetros reproductivos.

El presente estudio se ha dividido en tres apartados:

1. Influencia de la estación de parto sobre las interacciones entre disfunciones reproductivas en vacas lecheras.
2. Influencia de factores de manejo sobre la pérdida de gestación en vacuno lechero.
3. Efecto de las disfunciones reproductivas previas a la concepción sobre la pérdida de gestación en vacas lecheras.

ESTUDIO 1.
Influencia de la estación de parto sobre las interacciones entre disfunciones reproductivas en vacas lecheras.

El objetivo de este estudio fue la evaluación de la influencia de la estación de parto sobre las interacciones entre disfunciones reproductivas previas a la concepción y su efecto sobre los parámetros reproductivos subsiguientes en vacas lecheras. Se analizaron datos de 3170 lactaciones de vacas Frisonas que posteriormente desarrollaron una gestación, que pertenecían a 9 explotaciones de ganado vacuno lechero ubicadas en el Valle del Ebro. Utilizando técnicas de análisis de rutas (*path analysis*), se
desarrollaron 2 modelos: uno para vacas que habían parido entre Mayo y Septiembre (estación cálida), y otro para vacas que habían parido entre Octubre y Abril (estación fría). Los modelos de rutas incluyeron como variables el número de lactación, el parto gemelar, la retención de placenta, la metritis, el quiste ovárico, el intervalo entre parto y gestación y el síndrome de vaca repetidora

(registrado en vacas que precisaron de más de 4 inseminaciones para concebir).

Las tasas de incidencia de disfunciones reproductivas en relación al número de lactaciones fueron 6.4% de retención de placenta, 3.7% de metritis, 5.4% de quiste ovárico y 7.9% de vaca repetidora, y no se encontraron diferencias en dichas tasas de incidencia al comparar lactaciones cuyo parto se registró en la estación cálida (entre Mayo y Septiembre) , con lactaciones cuyo parto se registró en la estación fría (entre Octubre y Abril). Sin embargo, nuestro estudio muestra que la estación de parto influyó sobre las interrelaciones entre disfunciones y parámetros reproductivos. Así, el número de lactación no se mostró relacionado con ninguna de las variables del modelo para vacas con parto en la estación fría, y tampoco en esta estación la retención de placenta influyó directamente sobre el riesgo de síndrome de vaca repetidora o sobre el riesgo de quiste ovárico. En contraste, en vacas paridas en los meses más cálidos, las vacas más viejas experimentaron un mayor riesgo de retención de placenta, quistes ováricos y aumento del intervalo entre parto y gestación, y la retención placentaria fue un factor de riesgo directo para quistes ováricos y síndrome de la vaca repetidora. Es posible que la ausencia de estrés en las condiciones meteorológicas de la estación fría pudiera ser la causa de la ausencia de efectos adversos de la edad sobre los parámetros reproductivos tras el parto y, por otra parte, de la disminución en las repercusiones negativas de la retención placentaria.

Nuestros resultados indican que un ambiente frío mejora la capacidad de afrontar disfunciones reproductivas previas a la concepción, principalmente en animales de mayor edad.

ESTUDIO 2.

Influencia de factores de manejo sobre la pérdida de gestación en vacuno lechero

El presente estudio se llevo a cabo para determinar la influencia de factores de manejo sobre la pérdida de gestaciones diagnosticadas en vacuno lechero. Se utilizaron datos de 3162 gestaciones diagnosticadas en vacas en lactación y 1050 diagnosticadas en novillas, todas ellas pertenecientes a 9 explotaciones de ganado vacuno lechero ubicadas en el Valle del Ebro. El diagnóstico de gestación se realizó mediante palpación rectal entre 30 y 70 días después de la inseminación. Cuando el diagnóstico de gestación resultaba negativo en una segunda palpación, realizada entre 120 y 150 días tras la inseminación, se registró como pérdida de gestación.

La proporción total de pérdidas de gestación fue del 7.9% (9.6% en vacas con gestación previa a término y 2.8% en novillas). El análisis estadístico de los datos se realizó mediante métodos de regresión logística múltiple, considerando la pérdida de gestación como variable dependiente, y el número de parto, el intervalo entre inseminación y primer diagnóstico de gestación, la estación de inseminación y el rebaño como factores. Para el conjunto de la población, se detectó un efecto del momento de diagnóstico de gestación, de modo que, en el intervalo comprendido entre 30 y 70 días post-inseminación, el riesgo de pérdida de gestación por practicar el diagnóstico en un determinado día

era el 97% del riesgo en el día anterior (*Odds ratio*=0.97 para un aumento de 1 día; P=0.0042). El riesgo de pérdida fetal en novillas fue alrededor de cuatro veces menor que en vacas (*Odds ratio*=0.28; P=0.0001). Por otra parte, se detectó una mayor probabilidad de pérdidas de gestación en vacas inseminadas en primavera, verano e invierno, comparadas con vacas inseminadas en otoño (P=0.04). El efecto del rebaño sobre la pérdida de gestaciones fue significativo, posiblemente indicando que el manejo y las interacciones hombre-animal característicos de cada explotación afectan a la evolución normal de la gestación. En el análisis particular de vacas que habían experimentado gestaciones previas a término, se utilizó el mismo modelo de regresión logística, añadiendo el intervalo entre parto e inseminación fecundante como factor. Los resultados fueron similares a los del conjunto de animales y, por otra parte, en dicho grupo no se detectó variación en el riesgo de pérdida fetal debido al número de lactación o al intervalo entre parto e inseminación fecundante. La realización de un examen ginecológico en el momento del estro, de modo que solamente fueran inseminadas vacas con estructuras ováricas e involución uterina normales podría explicar la ausencia de efecto del intervalo entre parto e inseminación y del número de lactación. En novillas, sin embargo, no se detectó efecto del momento de realización del diagnóstico de gestación por palpación rectal ni de la estación de inseminación, y sólo se observó un claro efecto del rebaño o explotación.

Los resultados obtenidos sugieren que la influencia de los partos previos (comparación entre vacas y novillas) puede afectar a la proporción de pérdidas de gestación en mayor medida que la práctica del diagnóstico precoz de gestación por palpación rectal y que, en vacas gestantes, la adaptación a cambios estacionales parece más eficaz cuando se asocian a descensos de temperatura.

ESTUDIO 3.

Efecto de las disfunciones reproductivas previas a la concepción sobre la pérdida de gestación en vacas lecheras

Este estudio se llevó a cabo para determinar si las disfunciones reproductivas previas a la concepción influían sobre la pérdida de gestaciones diagnosticadas en vacas lecheras. Durante el período comprendido entre 1987 y 1994 se anotaron registros de disfunciones reproductivas y se realizaron diagnósticos de gestación como parte de un programa de salud reproductiva desarrollado en 9 explotaciones comerciales de vacuno lechero en el Valle del Ebro. Se utilizaron datos de 3022 vacas en lactación diagnosticadas gestantes. El diagnóstico de gestación se realizó entre 33 y 70 días tras la inseminación. Cuando el diagnóstico de gestación resultaba negativo en una segunda palpación, realizada entre 120 y 150 días tras la inseminación, se registró como pérdida de gestación.

El análisis estadístico de los datos se realizó mediante métodos de regresión logística múltiple, considerando la pérdida de gestación como variable dependiente, y las disfunciones reproductivas retención de placenta, endometritis, piómetra, quistes ováricos y el síndrome de la vaca repetidora como factores a evaluar. El intervalo entre inseminación y diagnóstico de gestación, la estación de inseminación y el efecto rebaño se incluyeron en el modelo como variables de control, teniendo en

cuenta los resultados del estudio previo (Estudio 2 de la presente Tesis). El riesgo de pérdida de gestación fue 2.6 y 1.8 veces superior en vacas que habían experimentado previamente piómetra y retención de placenta, respectivamente, que en vacas que no experimentaron dichas disfunciones. No se observó efecto de la endometritis, los quistes ováricos y el síndrome de la vaca repetidora (registrado en vacas que precisaron de más de 4 inseminaciones para lograr la gestación) sobre la pérdida de gestación. Aunque sólo se inseminaron vacas clínicamente normales, la afección previa de retención de placentaria o de piómetra podrían haber causado alteraciones en el ambiente uterino, particularmente críticas durante el período de implantación, período que coincide con el diagnóstico precoz de gestación.

Nuestros resultados sugieren que la incidencia de pérdida embrionaria tardía o fetal en vacas lecheras debería reducirse con estrategias de manejo para reducir el riesgo de retención de placenta y piómetra.

CONCLUSIONES

- La estación de parto influyó sobre las interacciones entre las disfunciones reproductivas previas a la gestación en la vaca de modo que un ambiente frío en la época de parto disminuyó los efectos negativos subsiguientes de dichas disfunciones, especialmente en animales de mayor edad.

- En animales gestantes, las vacas que habían desarrollado previamente alguna gestación a término presentaron mayor probabilidad de sufrir una pérdida fetal que las nulíparas.

- En vacas gestantes que ya habían desarrollado gestaciones previas a término, el riesgo de pérdida de gestación se incrementó a medida que disminuía el intervalo entre la inseminación fértil y el diagnóstico de gestación por palpación rectal. Sin embargo, en animales primigestantes (novillas) no se observó efecto de la práctica del diagnóstico de gestación sobre la pérdida de gestación.

- En vacas gestantes inseminadas en otoño se detectó menor incidencia de pérdida fetal que en las inseminadas en otras estaciones.

En vacas en lactación, disfunciones reproductivas previas a la concepción tales como quistes ováricos, endometritis y síndrome de vaca repetidora no influyeron sobre la subsiguiente incidencia

de pérdida de gestación. En cambio, la retención de placenta y la piómetra sí incrementaron el riesgo de subsiguiente pérdida de gestación.

Apéndice

INTRODUCCION AL CONCEPTO E INTERES DE LA EPIDEMIOLOGIA VETERINARIA

La Epidemiología se define como el estudio de la frecuencia, la distribución y los factores determinantes de la salud y de las patologías en las poblaciones. Es, por tanto, una ciencia fundamental para la medicina de poblaciones (Martin, Meek y Willeberg, 1987). Dicha ciencia puede ser desglosada en epidemiología descriptiva y epidemiología analítica (Agger, 1993). En epidemiología descriptiva, los aspectos a determinar son la definición de la patología y de su diagnóstico, el tipo de animales afectados, la localización espacial y temporal de la patología, y su frecuencia de aparición. En definitiva, abarca la caracterización de la patología a estudiar. En epidemiología analítica, por otra parte, el objetivo es determinar los factores de riesgo, lo que equivale a buscar las causas que provocan el problema o patología.

En el campo de la Medicina Veterinaria, la Epidemiología ha experimentado un desarrollo reciente que ha sido definido por Schwabe (1982) como un ejemplo de revolución del conocimiento en dicho campo. En este sentido, y de acuerdo con el concepto propuesto por Kuhn (1962). Según Kuhn, cada área del conocimiento ha experimentado diversas fases, cada una de ellas caracterizada por un determinado paradigma, definido como un modelo o patrón aceptado por una parte importante de los investigadores en esa disciplina, para obtener soluciones a los problemas que se relacionan con dicha área. Cada fase de una ciencia se distingue por el conjunto de teorías previas aceptadas, objetivos a corto y largo plazo, motivación social y otras creencias o valores, así como las infraestructuras, estrategias, tácticas o técnicas que comparten sus miembros (matriz disciplinar). En un determinado momento, el paradigma establecido puede entrar en crisis, debido a defectos observados en la matriz disciplinar aceptada. Este hecho dará lugar a la aparición y desarrollo de una nueva fase, en la cual no se eliminarán necesariamente las estrategias, objetivos e infraestructuras previos, sino que, si todavía son válidos, se subordinarán a los de la nueva fase.

En el caso de la Medicina veterinaria, Schwabe (1982) describe la existencia de varias fases en la ciencia del manejo de enfermedades animales. Entre estas fases, la iniciada a finales del siglo XIX, con el apoyo del desarrollo de la
Microbiología, se destacó por dar lugar a los grandes programas de control de enfermedades infecciosas. En este período, el objetivo básico fue encontrar y eliminar la causa "necesaria y suficiente" de cada enfermedad, es decir, el patógeno. La aplicación de estrategias en este sentido tuvo gran aplicación práctica.

Sin embargo, dicha fase experimenta una crisis importante debido a la inefectividad de las campañas de erradicación de patologías en "rebaños problema", la creciente necesidad de evaluación económica del efecto de enfermedades específicas, la ausencia de control efectivo en casos de complejos de enfermedades y de las enfermedades de producción y, en consecuencia, dificultad para afrontar la creciente intensificación de la producción animal. Se hace necesaria, por tanto, una metodología para la identificación, cuantificación y examen detallado de los factores determinantes de la enfermedad (múltiples, causales directa o indirectamente, a menudo interaccionando entre ellos). Desde este punto, se potencia la Epidemiología Veterinaria, que constituye un enfoque globalista o sintético de la Medicina Veterinaria, en contraste con la visión reduccionista o analítica de la etapa anterior (Bigras-Poulin, 1993). La Epidemiología Veterinaria resalta la importancia de la salud y la productividad del rebaño, por encima del caso patológico individual.

En definitiva, el desarrollo de la epidemiología veterinaria ha permitido el control sanitario en las producciones animales en explotación intensiva. En particular, la gestión del rebaño de vacuno lechero según programas de medicina preventiva, cada vez más generalizada, es un claro ejemplo de este hecho. Las tácticas de diagnóstico empleadas en epidemiología veterinaria, entre las cuales se incluye el desarrollo en la aplicación de técnicas estadísticas, pueden permitir medir y caracterizar de forma más útil la producción lechera (según las condiciones del animal y su ambiente en cada momento; Ruegg, 1992) y, por otra parte, proporcionan una metodología eficaz en la investigación de los problemas del rebaño (Ruegg, 1993). La verificación de la existencia de un problema determinado en el rebaño, ya sea patología clínica o subclínica o error de manejo, y la caracterización de la disfunción se realizan mediante métodos de epidemiología descriptiva. Los métodos analíticos se utilizan para determinar las situaciones de riesgo, analizar hipótesis sobre las causas del problema, y determinar acciones de respuesta (ya sea de resultados inmediatos o a largo plazo) frente al problema.

El interés de la Epidemiología en relación con la presente Tesis Doctoral se centra en la utilización de métodos epidemiológicos para caracterizar qué factores influyen sobre los desórdenes reproductivos en vacas de aptitud lechera.

BIBLIOGRAFÍA

AGGER, J.F., 1993: Epidemiological methods for identification and management of risk factors for production diseases in the dairy cow. Acta vet. scand. Suppl.89:69-70.

BIGRAS-POULIN, M., 1993. L'épidémiologie vétérinaire, une nouvelle science?. Ann. Méd. Vét. 137:104-405.

KUHN, T.S., 1962. La estructura de las revoluciones científicas. Fondo de Cultura Económica, 1971, 319 págs. Trad. de: Kuhn, T.S., The structure of scientific revolutions.

MARTIN, S.W., A. MEEK, P. WILLEBERG, 1987. Veterinary Epidemiology: Principles and Methods.

Iowa State University Press, Ames, Iowa, 343 pp.

RUEGG, P.L., 1992. Use of basic epidemiological principles in dairy production medicine. Part I. Assessing production. Compend. Cont. Educ. Pract. Vet. 14:1535-1555.

RUEGG, P.L., 1993. Use of basic epidemiological principles in dairy production medicine. Part II. Investigating herd problems. Compend. Cont. Educ. Pract. Vet. 15:309-313.

SCHWABE, C., 1982. The current epidemiological revolution in veterinary medicine. Part 1. Prev. Vet. Med. 1:5-15.

Curriculum vitae

Jordi Labèrnia Descarrega, nacido en Lleida en Abril de 1968, inició los estudios de Ingeniería Técnica Agrícola en la Escola Tècnica Superior D'Enginyeria Agrària de Lleida, entonces perteneciente a la Universitat Politècnica de Catalunya, en el curso 1986-87. Obtuvo el título de Ingeniero Técnico Agrícola en Explotaciones Agropecuarias en Noviembre de 1990. Tras finalizar el 2º ciclo y defender el proyecto de fin de carrera en la misma Escuela, obtuvo el título de Ingeniero Agrónomo (Especialidad Zootecnia) por la Universidad de Lleida en Julio de 1993.

Simultáneamente a sus estudios de 2º ciclo, obtuvo una Beca adscrita a los contratos/convenios de investigación con referencia CTT/UPC C-1425 (desde Octubre de 1991 hasta Septiembre de 1992), y con referencia CTT/UdL C-0019 (durante 1993). Posteriormente, desde Enero de 1994, disfruta de una Beca Predoctoral para Formación de Investigadores concedida por el Comissionat d'Universitats i Recerca de la Generalitat de Catalunya.

Otras publicaciones

1997 LÓPEZ GATIUS, F., J. LABERNIA, P. SANTOLARIA, J. RUTLLANT, M. LÓPEZ BÉJAR. The relationship of rheological behavior of the vaginal fluid at the time of insemination to pregnancy rate in dairy cows. Theriogenology (Aceptado para publicación).

1997 LÓPEZ BÉJAR, M., F. LÓPEZ GATIUS, J. CAMÓN, J. RUTLLANT, J. LABERNIA, P. SANTOLARIA. Rapid freezing of rabbit embryos has a negative influence on embryo morphology. Reproduction in Domestic Animals (En prensa).

1996 LÓPEZ BÉJAR, M., F. LÓPEZ GATIUS, J. RUTLLANT, J. CAMÓN, J. LABERNIA, P. SANTOLARIA. Development in vivo of rabbit morulae after freezing by a two-step cooling method. Reproduction in Domestic Animals 31:661-664.

1996 LÓPEZ GATIUS, F., J. RUTLLANT, J. LABERNIA, A. IBARZ, M. LÓPEZ BÉJAR, P. SANTOLARIA. Rheological behavior of the vaginal fluid of dairy cows at estrus. Theriogenology 46:57-63.