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Risk Factors for Postpartum Uterine Infections in Dairy Herds

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Abstract

The association between some risk factors and the presentation of post-partum uterine infections in dairy cattle has been established. However, this association is not comprehensive and the role of other factors has not been widely studied. Here the importance of age, parity, calving season, dystocia and retained foetal membranes (RFMs) was established as some of the potential risk factors for uterine infections. Cases studied occurred at two English dairy farms: Farm A (n= 463) and Farm B (n=361) that had calved between January and December 2009. It was found that Farm B reported a higher prevalence of uterine infections based on age, parity and calving season (24% vs. 16%). Farm A reported a higher prevalence of uterine infections based on retained foetal membranes (8.9% vs. 5%) and dystocia (11.9% vs. 6.9%). Both farms reported significant effect on age (χ^2 = 19.35, df 2, p<0.001 and χ^2 = 19.82, df 2, p<0.001), calving season (χ^2 = 9.61, df 3, p<0.02 and χ^2 = 80.06, df 3, p<0.001) and dystocia (χ^2 = 12.98, df 1, p<0.001 and χ^2 = 7.56, df 1, p<0.01) on the presentation of uterine infection while parity and RFMs were not significant. The findings of this study may be useful for helping to set up protocols in dairy herd health management that prompt livestock owners, breeders and veterinarians to take quick action to avoid the consequences caused by postpartum uterine infections. In addition, it could help in the formulation of correct post-calving health monitoring strategies within a dairy herd.

Key words: Dairy Cattle Health; Postpartum; Risk Factors; Uterine Infection

Introduction

Several studies have looked into the various risk factors linked with postpartum uterine infections and their consequences on dairy cow reproductive performance (Bell and Roberts, 2007; Gautam *et al*., 2010). The occurrence of endometritis, pyometra and metritis has been associated with factors such as vulva angle, sex of the calf, abortion and twin births (Gunduz *et al*., 2010; Jeremejeva *et al*., 2010; Potter *et al*., 2010). However, other researchers have failed to establish any significant link between risk factors such as calving season, age and parity in the presentation of uterine infections (Barlett *et al*., 1986).

Sheldon *et al*., (2008) and Beagley *et al*., (2010) reported that necrotic material arising from retained foetal membranes (RFMs) provide a favourable environment for bacterial growth hence, an increased likelihood of uterine infection. Also, RFMs delay the expulsion of lochia (reddish-brown uterine discharge), the regression of the endometrium and uterine involution (Gautam *et al*., 2009; Potter *et al*., 2010). Dystocia, especially in young cows, has been linked to some degree of injury to the female genital tract around the time of calving; predisposing the cows to uterine infection (Han and Kim, 2005). Buckley *et al*., (2010) found that cases of dystocia resulted in higher incidences of RFMs and uterine infections while Kwashima *et al*., (2007) showed that clinical abnormalities in older cows were the result of high milk yield. This suggested that age could be one of the potential risk factors for uterine infections in the early postpartum period. Calving season has been associated with postpartum uterine infection (Smith and Risco, 2002; Gautam *et al*., 2010). A study by Buckley *et al*., (2010) in Northern Ireland found increased incidences of RFMs and uterine infections of 3% in the late winter months (January and February), 1.6% in early spring (March) and 1.8% for April or later.

Postpartum uterine infections have been reported as posing a great economic impact on the dairy industry (Dolezel *et al*., 2008; Durrani and Kamal, 2009). Williams *et al*., (2008) showed that cases of clinical endometritis were significant, with 20% reduced conception rates and about 3% cases of infertility in dairy cows. Gautam *et al*., (2009) and Kaufmann *et al*., (2009) found lower rates of pregnancy in first service conception in primiparous cows with clinical and subclinical endometritis while Kim and Kang (2003) estimated the cost incurred by producers for handling cases of endometritis in each lactating dairy cow was US $106.

Uterine infections therefore, impose a significant economic pressure to the dairy industry worldwide (Gunduz *et al*., 2010). As a result it is important to identify factors which may predispose a cow to suffer from a uterine infection. This may be useful in dairy herd health management by encouraging livestock owners, breeders and veterinarians to take quick action in order to avoid the consequences of uterine infections and the financial losses associated with them. In addition, it can help in the formulation of post-calving health monitoring strategies. Therefore the aim of this study was to look for associations between age, dystocia, retained placenta, calving season and parity in the presentation of bovine postpartum uterine infection cases that had occurred at two dairy farms in England between January and December 2009.

Material and methods

Animals and data collection

This study was carried out using calving records from two dairy herds (farm A farm B) from January to December, 2009. Both farms possessed a good recording system with herdsmen involved in both the recording and the management of the data using herd health computer software (Farm A - Orchid Data Systems Limited UK, Farm B - InterHerd, UK). In both farms, cows were confined in free stall barns with sawdust bedding; cattle received a total mixed ration (TMR), while calving occurred all year round. Cows were milked twice a day with a herd average of over 10,000 litres per lactation period (305 days). A study period of 3 to 30 days postpartum was chosen so as to include mainly cases where clinical symptoms were present, with recorded remarks such as 'white endometritis' (cows with predominantly clear mucus with some flakes of pus) and 'dirty septic metritis' (cows with purulent discharge) in farm A while farm B had only a single remark such as 'metritis' as previously used by Guatam *et al*., (2009). A total of 463 and 361 cows from farm A and B with an age range of 2 to10 years and parity of 1 to 8 lactations were included in the study.

Predisposing factors

Dystocia was defined and recorded on a 5 point scale where 1 to 3 was termed as a calving which required simple traction while 4 to 5 meant a hard pull or veterinary-assisted calving as previously described by Benzaquen *et al*., (2007). Foetal membranes in both cows and heifers lasting beyond 24 hours after calving were considered to be retained (Abdelhameed *et al*., 2009). Calving season with months between September to October (autumn), March to May (spring), November to February (winter) and June to August (summer), parity, age of cows and heifers and the occurrence of dystocia were analysed.

Statistical analysis

Data from the 824 cows were used for the analysis of risk factors for postpartum uterine infections with a comparison between the two farms where cases of RFMs, dystocia, parity, age and calving season were represented on contingency tables and analysed using a Pearson's chi-square test. The prevalence of uterine infections based on a specific risk factor was also determined and expressed as percentage of total calvings. The occurrence of uterine infections during the different seasons (winter, spring, summer and autumn) was compared using the chi-square test. This analysis was performed to determine whether incidents of uterine infection were dependent upon season. The incidence of retained placenta on cows and heifers was also compared while data on age and parity was analysed using a range of 2 to 10 years of age and 1 to 8 lactations respectively. The prevalence of uterine infections was expressed as proportion of affected animals out of total calvings expressed into percentage. The expected frequencies and chi-square values were then analysed with PASW Statistics ver.18.

Results

Prevalence of uterine infections was 16% (74/463) in farm A and 23.8% (86/361) in farm B. Prevalence based on specific risk factors and from the Pearson's chi-square test results for risk factors are shown in tables 1 and 2. Results from farm A showed that cows between 4 and 5 years of age had the highest prevalence of 8.6% (40/463) of uterine infections whilst cows between 6 and 10 years of age had the lowest prevalence of 1.3% (6/463). Farm B showed a higher prevalence of 18% (65/361) in cows between 1 and 3 years of age while cows between 6 and 10 years recorded the lowest prevalence of 0.6% (2/361). Results for farm A and B showed that cows in their first and second parity recorded the highest number of uterine infections with a prevalence of 8.2% (38/463) and 13% (47/361) respectively. Cows in their sixth to eighth lactations had the least prevalence (0.9%, 4/463 and 0.8%, 3/361 respectively). Calving season showed that winter months had the highest number of uterine infections with a prevalence of 8.0% (37/463) for farm A while farm B recorded highest prevalence of 7.8% (28/361) in spring months. The autumn months had the lowest prevalence of 0.4% (2/463) and 1.4% (5/361) respectively.

Results from farm A on dystocia as a risk factor for uterine infection showed that spring and summer months showed the highest incidence with a prevalence of 7.3% (34/463) whilst autumn and winter months had a prevalence of 4.5% (21/463). Farm B reported a prevalence of 4.4% (16/361) during autumn-winter months and 2.5% (9/361) in spring-summer. Cases of RFMs were tabulated with a comparison of the occurrences in cows against heifers (Tables 1 and 2). It was found that cows from both farms had the highest incidence of uterine infections with a prevalence of 5.6% (26/463) against 3.2% (15/463) for heifers in farm A, 4.2% (15/361) and 2.5% (9/361) for farm B.

Table 1: Farm A: Results for risk factors for uterine infections (n=463)

Variable	Cases	Non cases	Prev (%)	χ^2	df	p
Age (years)						
1-3	28	22	6.6	19.35	2	0.001
4-5	40	109	8.6			
6-10	6	54	1.3			
Parity						
1-2	38	248	8.2	4.5	2	NS
3-5	32	128	6.9			
6-8	4	12	0.9			
Calving season						
Autumn	2	62	0.4	9.61	3	0.02
Spring	16	73	3.5			
Winter	37	179	8.0			
Summer	19	71	4.1			
Retained placenta						
Cows	26	276	5.6	0.66	1	NS
Heifers	15	146	3.2			
Dystocia						
Autumn – Winter	21	259	4.5	12.98	1	0.001
Spring – Summer	34	149	7.3			

Cases = uterine infection present, Non-cases = uterine infection absent Prev = percentage

Table 2: Farm B: Results for risk factors for uterine infections (n=361)

Variable	Cases	Non cases	Prev (%)	χ^2	df	*p*
Age (years)						
1-3	65	136	18	18.82	2	0.001
4-5	19	103	5.3			
6-10	2	36	0.6			
Parity						
1-2	47	120	13	3.21	2	NS
3-5	36	144	10			
6-8	3	11	0.8			
Calving season						
Autumn	5	50	1.4	80.06	3	0.001
Spring	28	51	7.8			
Winter	45	39	12.5			
Summer	7	135	1.9			
Retained placenta						
Cows	15	268	4.2	0.27	1	NS
Heifers	9	214	2.5			
Dystocia						
Autumn – Winter	16	122	4.4	7.56	1	0.01
Spring – Summer	9	214	2.5			

Cases = uterine infection present, Non-cases = uterine infection absent, Prev (%) = percentage prevalence, df = degrees of freedom.

Discussion

Several risk factors have been reported to be linked with uterine infection in dairy cattle soon after calving with about 20% of animals showing signs of clinical uterine disease (LeBlanc *et al*., 2007), thus affecting health and welfare, with a great economic impact on the dairy industry. The present study found that the most significant risk factors associated with uterine infections in both farms were age, calving season and dystocia. The reported variations in prevalence between farms could be associated with differences in the diagnostic methods. Parity and retained foetal membranes were not significant in the presentation of postpartum uterine infections.

Age of the cow

Age was strongly associated with the presentation of uterine infections in both farms. The overall prevalence of age related uterine infection was higher in farm B (23.8%), with 18% reported in cows between 1 and 3 years of age, compared with Farm A which reported an overall prevalence of 16%, with 8.6% in cows between 4 and 5 years of age, whilst cows from 6 and 10 years had the lowest prevalence of 1.3%. A highly significant effect of age on the presentation of uterine infections was found in both farms (χ^2 = 19.35, d.f 2, *p*<0.001 and χ^2 = 19.82, d.f 2, *p*<0.001). Similar overall age related uterine infection prevalence rates and variation between farms have been reported previously (Gunduz *et al*., 2010) while others have reported no effect of age on the presentation of uterine infections (Emanuelson *et al*., 1993; Pugh *et al*., 1994). Markusfeld (1987) and Bruun *et al*., (2002) recorded high incidences of uterine infection at an early age which is in agreement with the findings from farm B but in contrast to farm A. Smith and Risco (2002) found the lowest incidence of postpartum metritis occurred in cows between 2 and 4 years of age, and the highest in cows older than 7 years with the risk increasing steadily with age which seems to be closely similar to findings from farm A. Other reports lack a distinct association between age and prevalence of postpartum uterine infections (Bruun *et al*., 2002). The exact cause of the high prevalence rate reported in farm B compared to farm A is unknown though this might have been due to variation in management practices. Results from farm B showed a higher prevalence rate (18%) reported in young cows (1 and 3 years) compared to 6% from farm B which is in agreement with most research that young cows are more prone to uterine injuries, especially during assisted calving, thus predisposing them to uterine infections (Konyves *et al*., 2009; Tsousis *et al*., 2009), while others have reported that young cows have a small pelvis compared to older cows, hence the greater degree of uterine damage (Potter *et al*., 2010).

There were almost twice the number of cows (65) between 1 to 3 years of age calving from farm B compared to only 28 cows from farm A which could support the high prevalence rate reported in farm B as Gautam *et al*., (2009) stated that a small number of cows often may not add up to a reasonable statistical power. Other probable causes for the observed prevalence differences could have been due to calving stall hygiene and the design of calving pens, albeit this study did not extend to looking into stall design and general hygiene. However, some studies have reported an increased incidence of uterine infections when calving was carried out in dirty and congested calving stalls compared to when calving occurred in clean and well-spaced calving stalls (Lewis, 1997; Plontzke *et al*., 2010). Bell and Roberts (2007) and Huzzey *et al*., (2007) reported that diagnostic methods, poor cow comfort and general herd health management can all contribute to variations on the prevalence of uterine infections between farms.

Erb and Martin (1980), Moss *et al*., (2002b) and Gunduz *et al*., (2010) also found that age was highly significant in the presentation of uterine infections. The significant effect of age on the presentation of uterine infection might be explained by a number of factors, where older cows (4 years and above) have been shown to have a reduced immunity (Opsomer and Kruif, 2009). Young cows (1 and 3 years) may have experienced damage to the uterus, especially where calving assistance was required (Konyves *et al*., 2009). Moreover, it has been reported that new strains of pathogens and metabolic disturbances, such as milk fever and ketosis developed during the transition period if cows were not well nutritionally managed, might contribute to age associated uterine infections (Moss *et al*., 2002b; Melendez *et al*., 2004).

Findings from the present study could help with the formulation of a reproductive management program which should target cows younger than 5 years of age, through carrying out routine postpartum examinations so that reproductive tract problems and other management factors can be addressed.

Calving season

The overall herd seasonal prevalence of uterine infections for farm A and B was 16% and 23.8% respectively where uterine infections were highest in farm A during winter months (November to February) with a prevalence of 8% whilst autumn months (September to October) had the lowest with prevalence of 0.4%. In contrast, highest prevalence (7.8%) of uterine infections in farm B was reported during spring months (March to May) consistent with findings by Dolezel *et al*., (2008). Autumn months (September to October) had the lowest with prevalence of 1.7%. The overall prevalence was close to the range of (18.8-32.2%) reported by Ghanem *et al*., (2002) and Gautam *et al*., (2010) but higher than those reported by (Huffman *et al*., 1984) although much lower than findings by Dolezel *et al*., (2008) who recorded a prevalence rate of 50%. The exact reason for the reported season associated higher prevalence of uterine infections from farm B was not known. However, some studies have shown that variations in seasonal calving management factors such as efficiency in monitoring of calving activities during cooler and warmer months, frequency in changing of beddings, stall condition and general calving hygiene may all influence the incidence of uterine infections within a farm (Larson and Tyler, 2005; Sheldon *et al*., 2008; Keyserlingk *et al*., 2009). The prevalence reported in farm A agrees with the study of Bruun *et al*., (2002) which showed that winter calvings were linked with poor hygienic conditions and reduced feed intake resulting in a decreased immune function, thus increasing the risk of uterine infections.

Calving season had a significant effect on the presentation of postpartum uterine infections (χ^2 = 9.61, d.f 3, p<0.02 and χ^2 = 80.06, d.f 3, p<0.001) hence it can be deduced that calving season was a potential risk factor for uterine infections in both farms, which agreed with a report by Gautam *et al*., (2010) though they reported highest prevalence in summer calvings. Summer and winter months calvings cause stress to animals by reducing feed intake and have been associated with increseased postpartum uterine disorders such as metritis and anovulation (Walsh *et al*., 2007). Markuesfeld (1984) established a link with cases of uterine infections in cows during spring and winter months while Erb and Martin (1980) found an association between calving season and the incidence of uterine infections with an overall autumn-winter peak in the risk of uterine infections. Interestingly, Huffman *et al*., (1984) and LeBlanc *et al*., (2002) did not find any statistical association between calving season and the the incidence of uterine infections although the probability of three consecutive spring seasons had the greatest frequency of postpartum uterine disease. Similarly, Gautam *et al*., (2009) found no significant effect of calving season on the presentation of clinical endometritis.

The positive association between calving season and cases of uterine infections reported could have been due to reduced immunity caused by low temparature stress during winter months resulting in reduced feed intake (O'Connor, 2009). Other studies that recorded a positive association between calving season and clinical cases of uterine infections gave a probable cause to be the dampening effect of the spring-winter months (Erb and Martin, 1980). Furthermore, winter months and stabling can mean lack of grazing, increased energy expenditure for maintenance, different feed, overcrowding, reduced excercise and less access to sunlight all of which may affect cow health and welfare thus increased risk of postpartum uterine disease (Cady, 2010).

Seasonal occurrence of RFMs has been strongly associated with cases of uterine infections which may further support the current findings. Bohanar *et al*., (2009), Quiroz-Rocha *et al*., (2009) and Buckley *et al*., (2010) established a positive association between RFMs with a seasonal pattern on the incidence of uterine infections. Buckley *et al*., (2010) found that RFMs and uterine infections were higher in late winter months (January to February) compared to early spring months (March to April). In contrast, Smith and Risco (2002) showed that higher cases of RFMs occur in the USA during fall-winter months (October to December) and the results can be related to the fact that more calvings occured just before this time period. However, a comparison of calving from three summer months (June through August) with three winter months (December through February) found that cows that calved in the summer were twice more likely to have RFMs but with less risk to develop postpartum uterine infections (Smith and Risco, 2002). Contrastingly, Bahonar *et al*., (2009) found no distinct link between calving season in the presentation of uterine infections while Lewis (1997) suggested that management factors such as dry cow management during the transition period rather than season could be one of the possible causes of postpartum uterine infections.

The results in this study suggested that a herd management strategy should aim at a more close supervision of calving during summer and autum to minimise on the incidence of uterine infections. General periparturient hygiene and nutritional management are paramount at any given season for best results in dairy farms.

Dystocia

The overall herd prevalence of uterine infections in farm A and B after dystocia was 11.9% and 6.9% respectively. Farm A reported a high incidence of 7.3% in spring and summer months while autum and winter months had a prevalence of 4.5% compared to farm B which showed the highest incidence of 4.4% during autumn and winter while spring and summer had the lowest incidence of 2.5%. Overall prevalence figures were close to the 13.8% reported by Bell and Roberts (2007) but lower than 36.4% and 29%

reported by Gautam *et al*., (2010) and Gunduz *et al*., (2010) respectively. The high prevalence rate reported from farm A might have been due to the higher number of cows being assisted, either due to a relatively oversize calf, malpresentation or under developed pelvic bones, resulting in damage to the uterus and predisposing the cow to postpartum uterine infection (Gunduz *et al*., 2010).

The study established a significant effect of dystocia on the presentation of uterine infection (χ^2 = 12.98, d.f 1, p<0.001 and χ^2 = 7.56, d.f 1, p<0.01). The significant association between dystocia and uterine infection reported in the current study agreed with those reported by Ghanem *et al*., (2002), Bell and Roberts (2007), Gautam *et al*., (2010), Hossein-Zadeh (2010) and Potter *et al*., (2010) who reported that dystocia was highly significant in the presentition of uterine infections but contradict the findings by LeBlanc *et al*., (2002) and Gautam *et al*., (2009) who did not establish a significant link between the two. Cases of dystocia, especially where the calf is oversize or malpresented, can cause injuries to the genital tract during traction and retropulsion and thus create septic conditions which may result in infections (Zaborski *et al*., 2009). Morover, dystocia delays the process of complete parturation, distubing the loosening events that must occur for complete expulsion of RFMs, resulting in placenta retention and predisposing cows to uterine infection (Smith and Risco, 2002).

From the present findings it can be suggested that management decisions are necessary to minimise cases of dystocia linked with postpartum uterine problems. Multifaceted efforts such as the selection of an appropriate sire for ease of calving should be practised if not currently in place, though not for too long, so as to avoid getting smaller cows over time, as previously reported by Senger (2003), carrying out pelvic area measurement for the right pelvic diameter in heifers prior to first breeding (Larson and Tyler, 2005), use of sexed semen (as bull calves are often associated with dystocia as opposed to heifer calves (Bell and Roberts, 2007), appropriate monitoring of calving, postpartum hygiene and attention to sanitation, especially with calving equipment, could all help minimise cases of postpartum uterine infections.

Conclusion

This study evaluated the association of a series of risk factors for uterine infections in postpartum dairy cattle.. The findings of this study suggest that age is indeed a potential risk factor in the presentation of postpartum uterine infections. Both studied farms reported a high prevalence of the condition in cows in their first and second parity. Interestingly, parity was not a risk factor for uterine infection in either farms. Findings regarding seaonal occurance for uterine infection concluded that season is a potential risk factor.

Finally the study found that dystocia is also significant risk factor within dairy farms. A relatively high prevalence of uterine infection was reported in farm A and B where cows were found to have a higher incidence of RFMs as oppossed to heifers. However, RFMs themselves were not significant in the presentantion of uterine infection. This subject is complex, has great depth and has many areas that could be investigated further. These could include factors such as the microbes associated with uterine infection, immunology of the uterus and transgenenic cows with improved uterine immunity. In summary, this study has established that the age of the cow, calving season, and dystocia are important risk factors that must be considered when attempting to prevent uterine infections in dairy cattle.

Conflict of interest statement

The authors report no conflict of interest.

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References

1. Abdelhameed, A. R., Ahmed, W. M., Ekhnawy, K. I., and Khadrawi, H. H. 2009. Strategy trials for prevention of retained foetal membranes in a Friesian herd in Egypt. Global Veterinaria. 3: 63 – 68.
2. Bahonar, A. R., Azizzadeh, M., Stevenson, M. A., Vojgani, M., and Mahmoudi, M. 2009. Factors affecting days open in Holstein dairy cattle in Khorasan Razavi Province. Journal of Animal and Veterinary Advances 8. 747 – 754.
3. Bartlett, P. C., Kirk J. H., Wilke, M. A., Kaneene, J. B., and Mather, E. C. 1986. Metritis complex in Michigan Holstein-Friesian cattle: incidence, descriptive epidemiology and estimated economic impact. Preventive Veterinary Medicine 4. 235 – 248.
4. Beagley, J. C., Whitman, K. J., Baptiste, K. E., Scherzer, J. 2010. Physiology and treatment of retained foetal membranes in cattle. Journal of Veterinary Internal Medicine 24, 261 – 268.
5. Bell, M. J., and Roberts, D. J. 2007. The impact of uterine infection on a dairy cow's performance. Theriogenology 68. 1074 – 1079.
6. Benzaquen, M. E., Risco, C. A., Archbald, L. F., Melendez, P., Thatcher, M. J., and Thatcher, W. W. 2007. Rectal temperature, calving-related factors, and the incidence of puerperal metritis in postpartum dairy cows. Journal of Dairy Science 90, 2804 – 2814.
7. Bruun, J., Ersbull, A. R., and Alban, L. 2002. Risk factors for metritis in Danish dairy cows. Preventive Veterinary Medicine 54. 179 – 190.
8. Buckley, F., Dillon, P., and Mee, J. F. 2010. Major management factors associated with the variation in the reproductive performance in Irish dairy herds. Final Report Project 5070. http://www.agresearch.teagasc.ie/moorepar. [Accessed 11 May 2010].
9. Cady, R. A. 2010. Dystocia – difficult calving, what it costs and how to avoid it. Dairy Intergrated Reproductive Management 20. 1 – 5.
10. Dolezel, R., Vecera, M., Palenik, T., Cech, S., and Vyskosil, M. 2008. Systematic clinical examination of early postpartum cows and treatment of puerperal metritis did not have any beneficial effect on subsequent reproductive performance. Veterinary Medicine 53. 59 – 69.
11. Durrani, A. Z., and Kamal, N. 2009. Prevalence of genital tract problems in clinical cases of various species of animals. Journal of Animal and Plant Sciences 19. 160 – 162.
12. Emanuelson, U., Oltenacu, P. A., Grohn, Y. T. 1993. Nonlinear mixed model analyses of five production disorders of dairy cattle. Journal of Dairy Science 76. 2765 – 2772.

13. Erb, H. N., and Martin, S., W. 1980. Interrelationship between production and reproductive diseases in Holstein cows: Age and seasonal patterns. Journal of Dairy Science 63. 1918 – 1924.
14. Gautam, G., Nakao, T., Yusuf, M., and Koike, K. 2009. Prevalence of endometritis during postpartum period and its impact on subsequent reproductive performance in two Japanese dairy herds. Animal Reproduction Science 116. 175 – 187.
15. Gautam, G., Nakao, T., Koike, K., Long, S. T., Yusuf, M., Kanasinghe, R. M. S. B. K., and Hayashi, A. 2010. Spontaneous recovery or persistence of postpartum endometritis and risk factors for its persistence in Holstein cows. Theriogenology 73. 163 – 179.
16. Ghanem, M., Shalaby, A. H., Sharawy, S. and Saleh, N. 2002. Factors leading to endometritis in dairy cows in Egypt with special reference to reproductive performance. Journal of Reproductive Development 48. 371 – 375.
17. Gunduz, M. C., Sabuncu, A., Ucmak, M., Kasikci, G., and Tek, C. 2010. Postpartum reproductive problems and therapy in dairy cows. Journal of Animal and Veterinary Advances 9. 1952 – 1954.
18. Hossein-Zadeh N. G. 2010. The effect of twinning on milk yield, dystocia, calf birth weight and open days in Holstein dairy cows. Journal of Animal Physiology 94, 780-787.
19. Huffman, E. M., Mortimer, R., Olson, J. D., Ball, L., and Farin, P. W. 1984. Risk factors for prebreeding pyometra on four Colorado dairy farms. Preventive Veterinary Medicine 2. 785 – 790.
20. Huzzey, J. M., Viera, D. M., Weary, D. M., and Keyserlink, M. A. G. 2007. Prepartum behaviour and dry matter intake identify dairy cows at risk for metritis. Journal of Dairy Science 90. 3220 – 3233.
21. Jeremejeva, J., Orro, T., Valdmann, M., Kask, K. 2010. Bacteriological and cytological findings during the late puerperal period after two different treatments of retained placenta followed by acute puerperal metritis. Acta Veterinaria Scandinavia 52. 41 – 44.
22. Kaufmann., T. B, Drillich, M, Tenhagen, B. A, Forderung, D, Heuwieser, W. 2009. Prevalence of bovine subclinical endometritis 4h after insemination and its effects on first service conception rate. Theriogenology 71. 385 – 389.
23. Keyserlingk, M. A. G., Rushen, J., Passille, A. M., and Weary, D. M. 2009. The welfare of dairy cattle: key concepts and the role of science. Journal of Dairy Science 92, 4101 – 4111.
24. Kim, I., and Kang, H. 2003. Risk factors for post partum endometritis and effect of endometritis on reproductive performance in dairy cows in Korea. J. Reprod. Dev. 49, 485 – 491.
25. Konyves, L., Szenci, O., Jurkovich, V., Tegzes, L., Tirian, A., Solymosi, N., Gyulay, G., and Brydl., E. 2009a. Risk assessment of postpartum uterine disease and consequences of puerperal metritis for subsequent metabolic status, reproduction and milk yield in dairy cows. Acta Veterinaria Hungarika 57. 155 – 169.
26. Larson, R. L., and Tyler, J. W. 2005. Reducing calf losses in beef herds. Food Animal Practise 21. 569 – 584.
27. LeBlanc, S. J., Duffield, T. F., Leslie, K. E., Keefe, G. P., Walton. J. S., and Johnson, W. H. 2002. Defining and diagnosing clinical endometritis and its impact on reproductive performance in dairy cows. Journal of Dairy Science 85, 2223 – 2236.
28. LeBlanc, S. J. 2007. Prevention of postpartum uterine disease. Journal Advances in Dairy Technology 19. 145 – 155.
29. Lewis, G. S. 1997. Uterine health and disorders. Journal of Dairy Science 80, 984 – 994.
30. Markusfeld, O.1984. Factors responsible for post-partum metritis in dairy cattle. Veterinary Record 14. 539 – 542.
31. Markusfeld, O.1987. Periparturient traits in seven high dairy herds. Incidence rates, association with parity and interrelationships among traits. Journal of Dairy Science 70, 158 – 166.
32. Melendez, P., McHale, J., Bartolome, J., Archbald, L. F., Donovan, G. A. 2004. Uterine involution and fertility of Holstein cows subsequent to early postpartum $PGF2_{\alpha}$ treatment for acute puerperal metritis. Journal of Dairy Science 87. 3238 – 3246.

33. Moss, N., Lean, L. J., Reid, S. W. J., and Hodgson, D. R. 2002a. Risk factors for repeat breeder syndrome in New South Wales dairy cattle. Preventive Veterinary Medicine 54. 91–103.
34. Moss, N., Lean, L. J., Reid, S. W. J., and Hodgson, D. R. 2002b. The epidemiology of subfertility in non-seasonal calving dairy herds in the Camden region of New South Wales: preliminary investigation of risk factors. Australian Veteterinary Journal 80. 432 – 436.
35. O'Connor, M. L. (2009). Factors causing uterine infections in cattle. Department of animal and dairy science. Pennsylvania State University, USA. http://das.psu/teamdairy [Accessed 25 April 2010].
36. Opsomer, G., and Kruif, A. 2009. Metritis and endometritis in high yielding dairy cows. Vlaams Diergeneeskundig Tijdschrift 78. 83 – 88.
37. Plontzke, J., Madoz, L. V., De la Sota, R. L., Drillich, M., and Heuwieser, W. 2010. Subclinical endometritis and its impact on reproductive performance in grazing dairy cattle in Argentina. Animal Reproduction Science 122. 52-57.
38. Potter, T. J., Guitian, J., Fishwick, J., Gordon, P. J., and Sheldon, I. M. 2010. Risk factors for clinical endometritis in postpartum dairy cattle. Theriogenology 74, 127– 134.
39. Pugh, D. G., Lawder, M. Q., Wenzel, J. G. W. 1994. Retrospective analysis of the management of 78 cases of postpartum metritis in the cow. Theriogenology 42. 455 – 463.
40. Quiroz-Rocha, G. F., LeBlanc, S., Duffield, T., Wood, D., Leslie, K. E, Jacobs, R. M. (2009). Evaluation of prepartum serum cholesterol and fatty acids concentrations as predictors of postpartum retention of the placenta in dairy cows. Journal of American Veterinary Medical Association 15, 790 – 793.
41. Senger, P. L. 2003. Fertility factors – Which ones are really important? Proceedings of the 6th Western Dairy Management Conference March 12-14, Washington State Universityhttp://www.wdmc.org [Accessed 29 August 2010].
42. Sheldon, I. M., Williams, E. J., Miller, A. N. A., Nash, D. M., and Herath, S. 2008. Uterine diseases in cattle after parturition. Veterinary Journal 176. 115 – 121.
43. Smith, B. I., and Risco, C. A. 2002. Predisposing factors and potential causes of postpartum metritis in dairy cattle. Compendium Continuing Education 24. 74 – 79.
44. Tsousis, G., Sharifi, R., and Hoedemaker, M. 2009. Association between clinical signs of chronic endometritis with ovarian cysts and body condition loss in German Holstein Friesian cows. Journal of Veterinary Sciences 10. 337 – 341.
45. Walsh, R. B., Kelton, D. F., Duffield, T. F., Leslie, K. E., Walton, J. S., and LeBlanc, S. J. 2007. Prevalence and risk factors for postpartum anovulatory condition in dairy cows. Journal of Dairy Science 90. 315 – 324.
46. Williams, E. J., Herath, S., England, G. C. W., Dobson, H., Bryant, C. E., and Sheldon, I. M. 2008. Effect of *Escherichia coli* infection of the bovine uterus from the whole animal to the cell. Animal Consortium 2. 1153 – 1157.
47. Zaborski, D., Grzesiak, W., Szatkowska, I., Dybus, A., Muszynska, M., and Jedrzejczak, M. 2009. Factors affecting dystocia in cattle. Reproduction in Domestic Animals 44. 540 – 551.