



Incidence of Clinical Mastitis and its Influence on Reproductive Performance of Dairy Cows

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ABSTRACT

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The objectives of this study were to determine the incidence of clinical mastitis (CM) in relation to some risk factors and its impact on reproductive performance of Holstein cows. Lactation records (n = 1875) were obtained from Dina farms covering the period between 2013 and 2016. One third of cows (647/1875) had contracted at least one episode of CM throughout the entire lactation. Frequency of CM decreased progressively with the month of lactation, and approximately half of the cases occurred within the first three months postpartum. Incidence decreased ($P < 0.001$) with level of milk yield, but increased ($P < 0.001$) with parity. CM significantly ($P < 0.05$) increased calving to first estrus (+ 7.7 days), and to calving first insemination intervals (+6.5 days) compared to non-affected ones. Furthermore, cows contracted CM before conception required 31 days more and +0.47 inseminations to conceive than cows without mastitis. In brief, CM has a negative impact on reproductive performance of Holstein cows, and its occurrence is associated with level of milk yield, lactation order and stage of lactation.

1. INTRODUCTION

Mastitis, an inflammatory reaction of the mammary tissues, generally is caused by infection. It is the most frequently occurring disease in dairy industry worldwide. The incidence of clinical mastitis (CM) was estimated to range between 16 and 48 cases per 100 cows (Kvapilík et al., 2014), and the prevalence of subclinical mastitis was reported to be 20 to 80% globally (Contreras and Rodríguez, 2011). Mastitis is a major source of economic loss in dairy farms, costs the dairy industry billions of dollars annually (National Mastitis Council, 2005). The cost of mastitis ranges from \$16.43 to \$572.19 per cow (Holland et al., 2015). Economic losses of mastitis come in a variety of forms including discarded milk from infected cows, antibiotic therapies, culling cows, and extra labor costs for time spent treating and caring for susceptibles (Akers and Nickerson, 2011). Besides

these economic aspects, another important consequence of mastitis is the higher susceptibility to other mastitis episodes in the same or next lactation, and to other diseases (Lehtolainen et al., 2003). Differences in incidence and severity of CM in dairy cows are associated with risk factors such as parity, month of lactation, season and calving year (Steenekveld et al., 2008; Breen et al., 2009; Sharma et al. 2013).

Mastitis is the second most common being in the reproductive insufficiency. The higher incidence of CM is associated with lower reproductive performance. Cows with mastitis had a longer interval from calving to first artificial insemination (AI), longer days open (DO) and higher number of services per conception (SC) compared to cows with no mastitis (Ahmadzadeh et al., 2009; Nava-Trujillo et al., 2010). In a study by Bouamra et al. (2017), cows

with signs of CM before the first insemination had greater days to first insemination (DFI) and DO than cows that exhibited CM after the first insemination or cows without signs of CM. Under Egyptian condition, Elmaghraby et al. (2004) reported that cows affected with CM prior to conception required 10 days more from calving to first insemination, 18 days more and 0.33 extra inseminations to conceive compared to their unaffected counterparts. This study aims to explore the lactational and annualized incidence of clinical mastitis in relation to some risk factors, and its potential impact on reproductive performance of Holstein cows.

2. MATERIALS AND METHODS

2.1. Animals and farm management

The data of this study were obtained from the performance records of 1875 Holstein cows covering the period between 2013 and 2016. Animals were raised in a large commercial herd belonging to the Modern Agricultural Development Company (Dina farms), located about 82 km on Cairo-Alexandria desert road, Egypt. Animals were housed free in fenced yards with shades. Sheds were supported with a cool spraying system (Korral Kool System®) to be used in hot months. Lactating cows were grouped according to their milk production, and concentrate feeding was calculated accordingly. Cows were fed a total mixed ration (TMR) throughout the year. The TMR consisted of concentrates, corn silage, alfalfa hay, wheat bran, vitamins, minerals and calcium bicarbonate. Rations were offered twice a day. Heifers were artificially inseminated for the first time when about 360 kg of body weight. Estrus was detected twice daily by visual observation. Inseminations started almost 50 to 60 days postpartum. Pregnancy was detected by rectal palpation on day 42 after the last service. Cows were machine milked three times daily at eight hours intervals starting at 06:00 a.m. and milk yield was recorded for individual cows daily via computerized milking units.

2.2. Data and variables

Data of CM and performance parameters were retrieved from the farm home-kept records (VAS Dairy Comp software). Milk production parameters were standardized 305-day milk yield (305-d MY), and days in milk (DIM). Reproductive data included calving to first estrus interval (DFE), calving to first insemination interval (DFI), calving to conception interval (days open, DO), and number of services per

conception (SC). Cow and lactation characteristics e.g. birth date, lactation number, and calving date were recorded for each cow. Original files were edited to obtain appropriate data sets for the statistical analyses. Restrictions and rules for validation were applied to ensure the quality of production and reproductive data. Records meeting the following criteria were retained in the final dataset: 305-days between 2940 to 17660 kg, 160 to 610 DIM, and 35 to 400 DO.

Clinical mastitis was diagnosed by herd personnel in the milking parlor if milk from one or more quarters was abnormal in color, viscosity, or consistency in addition to inflammatory signs of the udder. When studying CM on reproductive parameters, only clinical cases occurring prior to the date of the study variable were considered. Frequency distribution of CM by month postpartum was calculated. Incidence of CM is presented as cases per cow per year, i.e. annualized CM incidence rate, CMIR= [(total number of cases *365/total number of milking days). Owing to substantial positive skewness (many zeros) of CMIR distribution, it was log transformed as LCMIR= Log₂ (CMIR + 1).

2.3. Statistical analysis

All data were analyzed using the statistical analysis software SAS Version 9.1 (SAS Institute Inc., Cary, NC, USA). For multiple mean comparisons, we considered a P<0.05 statistically significant. Count data were analyzed with the chi square test. Association of CMIR with some risk factors, and influence of CM on reproductive parameters were assessed with the GLM procedure and least squares means were compared with the PDIF option. The analysis models included the following factors in addition to their significant two-way interactions: milk level, (low, herd average -0.5 standard deviation (SD), moderate, herd average ± 0.5 SD, and high, herd average + 0.5 SD), parity (primiparous and pluriparous), season of calving (summer, March to August, and winter, September to February), and year of calving (2013 through 2016).

3. RESULTS

Monthly distribution and lactation incidence of clinical mastitis

The occurrence of CM decreased with the advance of lactation stage (Fig. 1). It was highest (20.8%) during the first month post calving and (0.62%) at >16

months of lactation. The overall lactational incidence of CM in the present study was 34.51%. Among cows suffered CM, 54.4% (n=352) suffered single episode, whereas 45.6% animals (n=295) had multiple episodes. Fig (2) shows that the incidence of CM was higher ($P<0.001$) in low- (42.65%) and moderate yielders (35.76%), compared to high yielders (25.42%). Also, annual CMIR was significantly ($P<0.05$) higher in low (0.94) and moderate (0.73) yielders compared to 0.31 for high yielders (Table 1).

Incidence of CM significantly increased with parity (Fig. 3).

Results in Table (1) show that annual CMIR was significantly ($P<0.05$) lower in primiparous cows (0.49) and higher (0.82) in multiparous cows. CMIR was similar in lactations initiated during summer and winter months. However, there was a year trend ($P<0.05$) with the highest rate (0.82) was recorded during 2016 and lowest (0.52) during 2014.

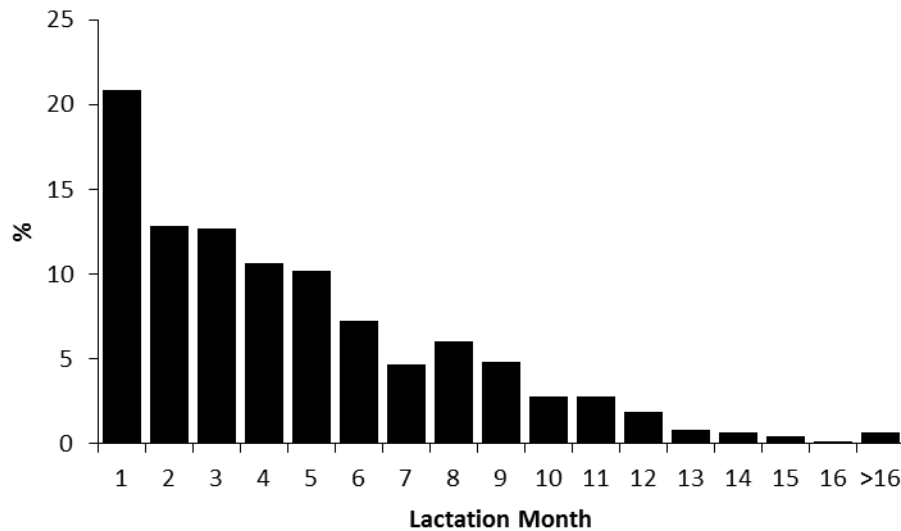


Fig. 1 Frequency distribution of clinical mastitis in Holstein cows by month of lactation.

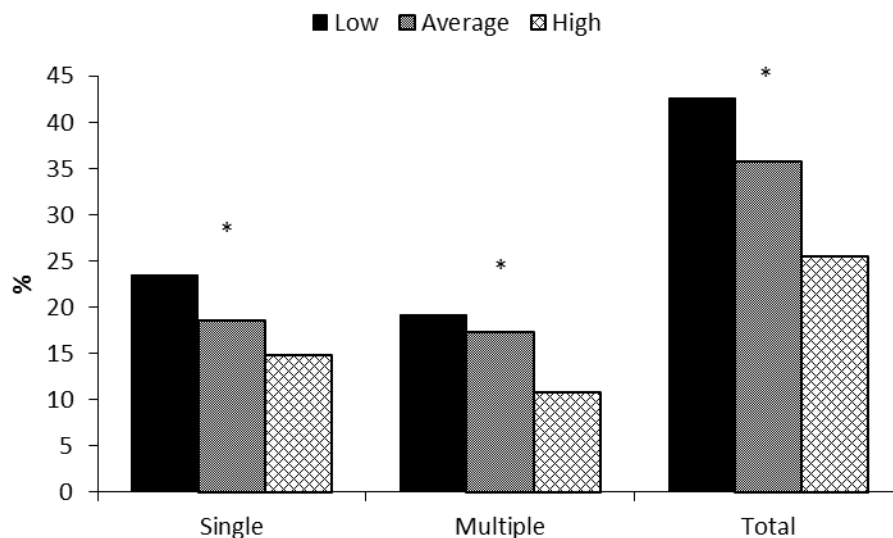


Fig. 2 Lactation incidence of single and multiple episodes of clinical mastitis in Holstein cows in relation to level of milk yield (low, average and high). Chi square test * $P<0.001$.

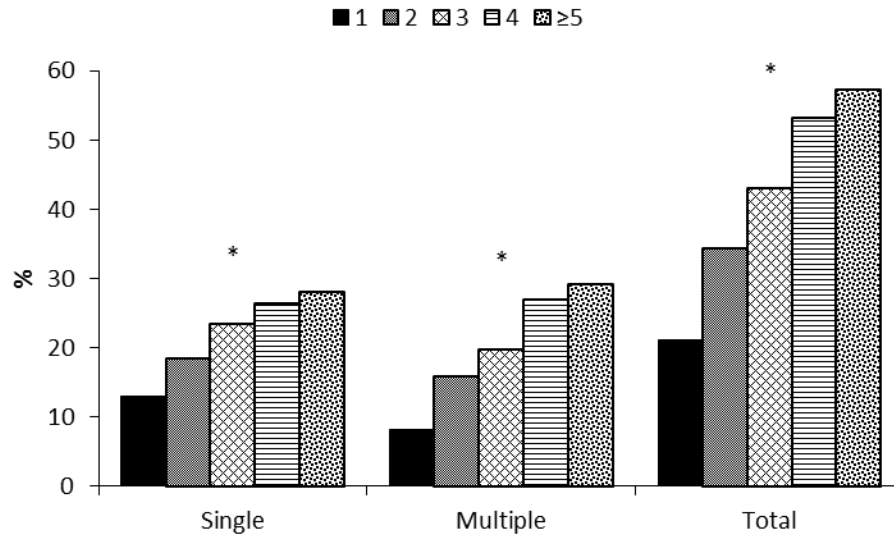


Fig. 3 Lactation incidence of single and multiple episodes of clinical mastitis in Holstein cows in relation to lactation order (1, 2, 3, 4 and 5 or more). Chi square test * $P < 0.001$.

Table 1 Least squares means and standard errors for the anti-log of the annualized incidence rate of clinical mastitis (CMIR) in relation to some risk factors

Classification	CMIR
Level of Milk yield	
Low	0.94 ± 0.08^a
Moderate	0.73 ± 0.05^a
High	0.31 ± 0.04^b
Parity	
Primiparous	0.49 ± 0.04^b
Multiparous	0.82 ± 0.04^a
Season of calving	
Summer	0.62 ± 0.05^a
Winter	0.70 ± 0.04^a
Calving year	
2013	0.60 ± 0.09^b
2014	0.52 ± 0.10^b
2015	0.69 ± 0.04^{ab}
2016	0.82 ± 0.07^a

Means without a common superscript within a classification differ significantly ($P < 0.05$).

3.2. Effect of clinical mastitis on reproductive performance (Table 2)

CM significantly increased FDE, DFI, DO, and SC. Overall, affected cows required 7.7 days to exhibit first estrus more than non-affected ones. Occurrence of CM prior to first insemination significantly ($P < 0.05$) increased DFI (73.4 vs. 66.9). Furthermore, cows contracted CM at any stage before conception

required 31 days and 0.47 inseminations to conceive more than those without mastitis.

CM adversely affected reproductive parameters regardless of level of milk yield. DFE and DFI in low yielders were significantly ($P < 0.05$) increased by mastitis (+13.7 and +9.9 days). Furthermore, DO was increased by CM but the difference was not significant. For moderate yielders, DFE, DFI, and DO

were significantly ($P<0.05$) increased by mastitis (+7.1, +6.3, and +37 days). DO and SC were significantly ($P<0.05$) increased by mastitis in high yielders (+35 days and +0.84 insemination) relative to non-affected cows.

Reproductive performance of both primiparous and pluriparous cows was adversely affected by CM. Mastitis significantly ($P<0.05$) delayed DFE, DFI and DO by +9.5, +8.0, and +29 days, respectively in primiparous cows. Similarly, affected pluriparous cows required +5.8 DFE, +4.9 DFI, +33 days open and +0.53 services to conceive, respectively ($P<0.05$) compared to non-affected cows.

DFI and DO of summer-calving cows, and DFE, DO and SC of winter-calving ones were higher ($P<0.05$) in affected cows. When CM occurred prior to first service, there was a significant delay of 6.5 days to first service for cows initiated their lactations in summer months. In addition, CM significantly delayed conception by 34 and 29 day ($P<0.05$) when mastitis affected winter-and summer-calving cows, respectively. Also, winter-calving cows affected with CM required significantly more (0.61) inseminations to conceive and 10.3 days to show first heat compared to their non-mastitis controls.

Considering year of calving, the delay to first insemination and to conception due to CM were 6.8 and 29 days ($P<0.05$) for cows calved during 2013. During 2015, there were +10.9 DFE, +9.1 DFI, +40 DO, and 0.65 more SC ($P<0.05$), respectively in affected cows compared to the non-affected ones. Affected cows that calved during 2016 required 46 days more to conception and +1.42 insemination ($P<0.05$) compared to non-affected ones.

4. DISCUSSION

One-third (647/1875) of cows under investigation had contracted at least one episode of clinical mastitis throughout the entire lactation. Similar finding was reported by Nielsen et al. (2009) and Moosavi et al. (2014). Also, Santman-Berends et al. (2015) recorded an incidence of 32.5 cases per 100 cows per year for all Dutch dairy herds. It was clear that CM is a highly recurrent event. Many cows (45.6%) under

investigation had multiple lactational episodes of CM. The reason for recurrent mastitis can be either a persistent infection of the bovine mammary gland by a mastitis pathogen or a reinfection of a quarter or udder after bacteriological cure. Similar finding was reported by Lehtolainen et al. (2003), Grieger et al., (2014) and Kumar et al. (2016).

The incidence rate of CM was higher in low and moderate yielders than high yielders. Jingar et al. (2015) similarly reported a high incidence of mastitis in animals having lower milk yield. According to the current study, affection with CM increased with parity. It was significantly higher in pluriparous cows compared to primiparous ones. Older animals are more susceptible to mastitis than younger ones because with advancing age, the udder becomes more pendulous, increasing the risk of being injured, its glandular becomes sensitive to inflammation, and the defense mechanisms of aged cows is poorer than in younger ones (Radostits et al., 2000; Fleischer et al., 2001 and Dego and Tareke, 2003).

The frequency of CM was highest in early postpartum then decreases with the advance of lactation. About 20% of cases of CM were diagnosed during the first month, and half of cows had contracted at least one episode of CM by the third month of lactation. Grohn et al. (2004), Biffa et al. (2005), Kocak (2006), Fadlemula et al. (2009) and Sharma et al. (2011) reported similar trends.

Annualized CMIR was numerically higher in winter-than in summer-calving cows. Other studies (Dego and Tareke, 2003; Rahman et al., 2009) showed that winter and wet conditions are more favorable than summer and dry conditions for growth and flaring up of most types of mastitis microorganisms. Differences in weather conditions, management and hygiene conditions, and prevalence of some pathogens among calving seasons and years may partly affect the occurrence and severity of mastitis. Østergaard et al. (2005) concluded that the risk factors for the occurrence of mastitis in dairy cows include lactation stage, parity, yield level, and calving season.

Table 2 Least square means and standard errors for the effect of clinical mastitis on reproductive performance in relation to some risk factors

Classifications	DFE	DFI	DO	SC
Overall				
Non-affected	41.4 ± 0.63 ^b	66.9 ± 0.43 ^b	203 ± 2.85 ^b	4.65 ± 0.08 ^b
Affected	49.1 ± 1.71 ^a	73.4 ± 1.13 ^a	234 ± 4.76 ^a	5.12 ± 0.13 ^a
Milk yield				
Low				
Non-affected	36.9 ± 1.35 ^b	65.4 ± 1.09 ^b	215 ± 5.41 ^a	4.53 ± 0.15 ^a
Affected	50.6 ± 2.92 ^a	75.3 ± 1.86 ^a	237 ± 7.41 ^a	4.57 ± 0.18 ^a
Moderate				
Non-affected	43.9 ± 1.01 ^b	68.1 ± 0.70 ^b	192 ± 4.52 ^b	4.52 ± 0.12 ^a
Affected	51.0 ± 2.46 ^a	74.4 ± 1.71 ^a	229 ± 7.32 ^a	5.07 ± 0.20 ^a
High				
Non-affected	43.4 ± 0.98 ^a	67.3 ± 0.59 ^a	202 ± 4.85 ^b	4.89 ± 0.14 ^b
Affected	45.8 ± 3.80 ^a	70.6 ± 2.40 ^a	237 ± 9.93 ^a	5.73 ± 0.30 ^a
Parity				
Primiparous				
Non-affected	43.0 ± 0.90 ^b	67.7 ± 0.60 ^b	201 ± 3.72 ^b	4.67 ± 0.11 ^a
Affected	52.5 ± 3.56 ^a	75.7 ± 3.01 ^a	230 ± 8.53 ^a	5.09 ± 0.26 ^a
Pluriparous				
Non-affected	39.9 ± 0.83 ^b	66.2 ± 0.59 ^b	206 ± 4.32 ^b	4.62 ± 0.12 ^b
Affected	45.7 ± 1.94 ^a	71.1 ± 1.10 ^a	239 ± 5.71 ^a	5.15 ± 0.16 ^a
Season of calving				
Summer				
Non-affected	40.1 ± 0.95 ^a	65.3 ± 0.71 ^b	212 ± 3.93 ^b	4.83 ± 0.11 ^a
Affected	45.2 ± 2.53 ^a	71.8 ± 2.13 ^a	241 ± 6.65 ^a	5.18 ± 0.18 ^a
Winter				
Non-affected	42.7 ± 0.83 ^b	68.6 ± 0.53 ^a	194 ± 3.99 ^b	4.46 ± 0.11 ^b
Affected	53.0 ± 2.20 ^a	75.0 ± 1.32 ^a	228 ± 6.52 ^a	5.07 ± 0.19 ^a
Calving year				
2013				
Non-affected	37.6 ± 1.13 ^a	71.8 ± 0.80 ^b	131 ± 3.48 ^b	2.88 ± 0.11 ^a
Affected	42.2 ± 4.00 ^a	78.6 ± 3.40 ^a	160 ± 6.58 ^a	3.21 ± 0.20 ^a
2014				
Non-affected	39.0 ± 2.47 ^a	62.0 ± 2.24 ^a	322 ± 13.4 ^a	7.72 ± 0.42 ^a
Affected	51.2 ± 9.20 ^a	69.8 ± 3.41 ^a	332 ± 17.6 ^a	7.22 ± 0.48 ^a
2015				
Non-affected	41.2 ± 0.87 ^b	63.5 ± 0.61 ^b	179 ± 4.21 ^b	4.42 ± 0.12 ^b
Affected	52.1 ± 2.17 ^a	72.6 ± 1.26 ^a	219 ± 6.48 ^a	5.07 ± 0.18 ^a
2016				
Non-affected	47.9 ± 1.51 ^a	70.5 ± 0.81 ^a	181 ± 6.55 ^b	3.57 ± 0.16 ^b
Affected	50.9 ± 3.88 ^a	72.6 ± 2.12 ^a	227 ± 10.9 ^a	4.99 ± 0.27 ^a

DFE, calving to first estrus interval; DFI, calving to first insemination interval; DO; calving to conception interval, SC, number of services per conception.

Means without a common superscript within a classification differ significantly (P<0.05).

Maximum number of records = 1875.

According to the results of the present study, occurrence of CM has a negative effect on reproductive performance of dairy cows. These findings come in accordance with those recorded in previous studies (Elmaghraby et al., 2004; Gunay and Gunay, 2008; Nava-Trujillo et al., 2010; Yang et al., 2012). Nava-Trujillo et al. (2010) reported that cows with CM needed 43 days more from calving to conception in comparison to clinically non-mastitis ones. Also, Bouamra et al. (2017) found that cows with signs of clinical mastitis before the first insemination had greater calving to first insemination and calving to conception intervals than cows that exhibited CM after the first insemination or cows without signs of CM.

Regarding the association with parity, CM adversely affected the reproductive performance of both primiparous and pluriparous cows. It significantly ($P<0.05$) delayed DFE, DFI and DO in both parity groups. Similarly, Bouamra et al. (2017) concluded that CM had a negative effect on fertility of cows irrespective of lactation order.

Generally, fertility indices were deteriorated both in summer and winter calving cows, with the latter group showed relatively more severe response to CM. Probably; this is due to higher rate of some disorders such as CM, lameness and lower sanitation during winter. Similarly, Elmaghraby et al. (2004) reported that winter-calving cows affected with CM had the longest DFI and DO, and required more SC compared to other seasons. Also, Chegini et al. (2016) reported that winter calvers had the longest DFE, DFI, DO, and the highest SC. According to calving year, the significant effect of CM on reproductive performance was evident except for the year 2014. In general, the effect of year of calving may be due to variation in nutritional and other management conditions from year to another.

The negative effects of CM on reproduction might be attributed to the secretion of several bacterial toxins that may induce the secretion of inflammatory mediators such as prostaglandin F2 α (PGF2 α). A high concentration of PGF2 α may cause a premature luteolysis, a decrease in progesterone levels and the death of the embryo (Huszenicza et al., 2005). CM is often accompanied with fever which may disrupt feed intake. In turn, reduced feed intake may lead to worsening of body condition and prolongation of energy deficit, resumption of ovarian cycles and

delaying of follicular maturation (Santos et al., 2004). Excessive mobilization of body reserves may also lead to decreased synthesis of immune proteins (globulins) and increased susceptibility to infections. These aforementioned factors could further explain the reduction of the reproductive efficiency in cows with clinical mastitis.

In conclusion, incidence of CM was high in low and moderate milk producing, in pluriparous cows, and was more frequent during early lactation. It negatively affects reproductive performance of dairy cows. CM delayed calving to first estrus, calving to first insemination, calving to conception intervals, and increased the number of inseminations per conception. Therefore, mastitis control programs should be a part of any fertility enhancing approach particularly during the critical early months of lactation.

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