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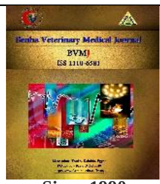

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Some risk factors affecting the pregnancy rate of Holstein-Friesian cows under Egyptian conditions and the economic impact of the first service failure.

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ABSTRACT

Insemination efficiency depends on several genetic and non-genetic factors. This work was done to assess the impact of some non-genetic factors (age at 1st service (AFS), parity, days from calving to 1st service (DFS), number of services per conception (S/C), 305 milk yield (305-MY), and incidence of mastitis before 1st AI) on the pregnancy rate (PR) of Holstein Friesian cows with estimating the economic losses of 1st AI failure. Our study was carried out through field surveys on 3729 Holstein cows during the period between winter 2017 to summer 2022. The overall PR was 46%, it differed significantly among the parity, AFS, DFS, and S/C. The PR was significantly higher for cows at age ≤ 3 y, and for primiparous ones, and when AI was performed during the early stage of lactation (≤ 60 d), also the higher the number of S/C the higher the PR, but this adversely affects the farm profitability. Failure of the 1st AI resulted in extra costs of $168.39/extra one day of days open (DO) with $15.39 for an extra S/C. Finally, we recommend the owner to replace the old cows, with a regular cow supervision to inseminate cows in the estrus shortly after calving, with cost-benefit analysis on their dairy farms regularly.

1. INTRODUCTION

Reproductive performance is necessary for keeping the dairy farm profitability (Drackley and Cardoso, 2014). The success of the 1st artificial insemination (AI) is a key to optimal reproductive performance in dairy cows (Inchaisri et al., 2010). Every lactation cycle starts with the birth of a calf, which results from conception. Any delay in conception brought on by improper control of reproductive function results in a loss of production (Singh et al., 2017). Several factors like parity, and DFS decrease the efficiency of 1st AI success (Siddiqui et al., 2013). The low PR either due to a reproductive problem or a higher no of S/C results in prolonged calving interval (CI) (Bansal et al. 2019). The dairy cow fertility is strongly affected by the milk production level (López-Gatius, 2012). Bittante et al. (2020) reported that cows with a higher level of milk production had a better PR than cows with lower productivity in Italy. Estimation of the economic effect of the success or failure of the 1st AI might provide useful information for dairy farmers. Although, such an assessment is challenging due to several factors, such as variations in the animal cost, reproductive efficiency, feed, and labor in different countries. AI has several advantages over natural insemination including worldwide gene improvement. The efficiency of insemination depends on several genetic and non-genetic factors, therefore this study was conducted to assess the effect of some non-genetic risk factors (AFS, parity, DFS, 305-MY, S/C, and mastitis before 1st AI) on the PR of Holstein Friesian cows with estimating the economic losses of a higher number of AI doses, palpation cost and other additional costs (Replacement cost, nutrition,, calf price, labor, and milk loss).

2. MATERIAL AND METHODS

Ethical statement
The study was conducted following the guidelines of the Animal Welfare Committee, and the protocols were approved by the Research Ethics Committee, Faculty of Veterinary Medicine, Benha University (Approval number BUFVTM 10-12-22).

2.1 Study period
Our study was carried out through field surveys on 3729 Holstein cows from dairy farms during the period from winter 2017 to summer 2022.

2.2 Animals and management
The data utilized in this study were estimated from 3729 lactation records of Holstein cows. All animals on the farm were kept in free-stall shaded open yards. AI was used for cow fertilization, and pregnancy diagnosis (PD) was done by palpator at the 50th day of insemination. The sample size was determined by the availability of artificially inseminated cows in the study farms.

2.3 Data exploration and editing
Data exploration and editing were performed by using Microsoft Excel. Several new variables as indicators of

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reproductive efficiency and performance were derived from the initial data. These include AFS, parity, DFS, S/C, postpartum conception, CI, previous 305-MY for multiparous cows, and incidence of mastitis before the 1st AI. The pregnancy rate was calculated by dividing the total number of conceived cows by the total number of inseminated cows during that period.

2.4 Evaluation of the economic impact of the failure of the 1st AI

The costs related to the success or failure of first service conception were calculated by ($= 19.49 EGP), they include the costs of AI and PD both for the cows that conceived at the 1st AI and those that conceived at the 2nd AI, and the costs of additional management practices for cows that failed to conceive at the 1st AI but they conceived at the 2nd AI, as well as for cows that conceived by more than two AI. The additional economic losses and costs for cows that weren't able to conceive at their 1st AI were due to the costs of replacement heifers, the value of extra feed, labor, breeding and the value of calf and milk losses that are connected to a higher no of DO. The costs and losses resulting from various factors were calculated using the following formulas according to Kim and Jeong (2019).

1. Number (no) of Extra DO = (Total no of DO for cows conceived by 2nd and more than two services – total no of days from calving to 1st service) / no of cows conceived by 2nd and more than two services.
2. The Costs of replacement= costs of replacement / cow/d*extra DO= (difference the price of a replaced cow and culled cow * percentage of culling because of infertility) * extra DO/CI).
3. The price of calf= Calf price/cow/day * extra DO= (the price of calf/ CI) * extra DO.
4. Nutrition cost=Cost of nutrition / cow/day * extra DO.
5. Labor cost= extra DO * daily labor cost.
6. Milk cost= extra DO * average DMY of that cow * milk price/litter.
7. AI cost= inseminations no * cost of single insemination.
8. Palpation cost= palpations no * palpation cost.

2.5 Classification of data

Our data were classified to check any association between different risk factors and the pregnancy rate into several categories, they were classified according to AFS, parity, DFS, S/C number, and previous 305-MY for Multiparous cows into: three age categories (< 3, 3-6, > 6y), and two parity categories (Primiparous and multiparous) according to Hamid et al. (2021), DFS was categorized into 3 categories (≤60, 61-81, > 81 DIM), while S/C was categorized into three categories (1, 2, ≥3) according to Kiyici et al. (2020). Finally, the 305-MY for multiparous cows was categorized in to low-producing cows < 9100 kg, and high-producing cows≥ 9100 kg).

2.6 Statistical Analysis

The statistical procedures were done by using the computer programs SPSS/PC+ "version 23" (SPSS 2015). Descriptive statistics such as frequency distribution and percentages were used to determine the PR with different factors. Chi-square and multiple logistic regressions were used to check the presence of any association between different risk factors and the PR according to the following statistical model:

$V_{fnicy}= \mu+A_f+P_n+D_i+S_c+M_y+e_{fnicy}$

V_{fnicy}= The response variable.

μ = The overall mean of population.

A_f= Age at first service.

P_n= Parity number.

D_i= Days to the first insemination.

S_c= Service per conception number.

M_y= 305 Milk yield.

e_{fnicy}= Un explained error term.

In all analyses, the confidence level was held at 95%. The economic losses were analyzed descriptively.

3. RESULTS

In this study, the overall PR was 46.0% (*n* = 1716 pregnant cows). As showed in tables (1) and (2), in responding to AFS, the PR showed a significant reduction with increasing the cow age (≤ 3 y, 3-6 y, and > 6 y), it was (49.3%, 43.8%, and 38.6%, respectively). By using multiple logistic regression with 95% confidence interval for the odds ratio, the PR for cows that ranged from 3-6 y decreased significantly by 20% compared with those lower than 3 y, while it decreased significantly by 35% for cows above 6 y. Regarding parity, primiparous cows had a higher PR (50.3%) than multiparous cows (43.3%). By using multiple logistic regression, multiparous cows had a significant reduction in the PR by about 24% compared with primiparous cows.

By using multiple logistic regression, the PR for cows that inseminated in the winter decreased significantly by 74% in comparison with those inseminated in the summer.

Based on DFS, the PR had a significant reduction with increasing DFS (≤ 60 d, 61-81 d, and > 81 d), it was (48.1%, 46.9%, and 32.3%, respectively). By using multiple logistic regression, the PR had a reduction (5%) with (61-81) DFS than cows with lower than 60 d, while it decreased significantly by 49% for cows above 81d. Regarding the number of S/C, cows that inseminated once had the lowest PR (36.1%) than those inseminated twice (45.2%) or more than two times (51.2%). In responding to 305-MY, the PR had a non-significant increase for high-producing cows (43.8%) compared to low-producing ones (42.0%).

Concerning mastitis before 1st service, healthy cows had a higher PR (47%) than those exposed to mastitis (43.6%).

The expense of an extra service with pregnancy diagnosis needed till conception in cows that did not conceive at their 1st AI was presented in table (3). Cows conceived by the 2nd service needed an extra $15.39 due to additional semen and palpation costs than those conceived at their 1st AI. The culling rate due to infertility in cows that did not conceive at their 1st AI was 49.5% (1370/2770), if cows conceived at their 1st AI (0/346), they were not culled. Our analysis revealed that 54% of the cows were not followed because they were either sold, died, or did not conceive until the study's final years. The mean calving to conception delay was 28 days longer for cows that conceived by the 2nd AI and about 65 days for cows conceived by more than two AI compared with those conceived at their 1st AI. Failure of the 1st AI results in extra costs of $168.39 per extra one day of days open, so the total of additional expenses of reproductive management and other management required to achieve conception for cows that conceived at their 2nd AI were about $4714.92/y per cow, while the additional expenses for cows that conceived by more than two AI were about $10945.35/y per cow, these are huge costs compared to cows, which conceived at their 1st service as showed in (table 4).

4. DISCUSSION

Responding to AFS, the PR had a significant reduction with increasing the cow age. These findings were lower than those of Hamid et al. (2021) who reported that the PR of cows was (57.9%) in cows with age of <3y, (64.1%) in cows aged 3–6y, and (60%) in cows aged above 6–9y, but higher than Alam and Sarader (2010), who noted 33.33%, 38.5%, and 29.8% PR in dairy cows of <3y, 4.6–6y, and >6y, respectively.

Regarding parity, primiparous cows had a higher PR (50.3%) than multiparous cows (43.3%). That agreed with Hamid et al. (2021) who noted that the PR of cows was 59.1% in multiparous cows and 61.7% in primiparous cows. Also, Tiezzi et al. (2012) reported that heifers were more fertile than lactating dairy cows. This is due to the effect of environment and feeding was controlled beside the heifers had a lesser negative energy balance (Friggens et al., 2007). Whereas Abeygunawardena et al. (2001) stated that the PR was higher in multiparous cows.

Table 1 Efficiency of pregnancy rate in relation to different factors.

Variables (Factors)	Code	Frequency	Pregnant Cows (%)	Chi-square(X^2)	P value
AFS	< 3 y	1830	903 (49.3%)		
	> 3-6 y	1534	672 (43.8%)		
	> 6 y	365	141 (38.6%)	19.19	0.0001
	Total	3729	1716 (46.0%)		
Parity	Primiparous	1431	720 (50.3%)		
	Multiparous	2298	996 (43.3%)	17.26	0.001
		3729	1716 (46.0%)		
DFS	≤ 60 d	1836	884 (48.1%)		
	61-81 d	1509	708 (46.9%)		
	> 81 d	384	124 (32.3%)	32.87	0.001
	Total	3729	1716 (46.0%)		
S/C	1	959	346 (36.1%)		
	2	798	361 (45.2%)	59.4	0.001
	≥ 3	1972	1009 (51.2%)		
	Total	3729	1716 (46.0%)		
305- MY	Low	640	269 (42.050)		
	High	1658	7279 (43.8%)	0.62	0.4
	Total	2298	996 (43.3%)		
Mastitis before 1st service	Healthy	2650	1246 (47.0%)		
	Diseased	1079	470 (43.6%)	3.7	0.05
	Total	3729	1716 (46.0%)		

AFS: age at first service, DFS: days to first service, S/C: service per conception, 305- MY: 305- milk yield.

Table 2 The multiple logistic regression results indicate the association of pregnancy rate with different factors.

Variables (Factors)	Code	B	Sig. (P value)	EXP (B) (Odds ratio)	95% confidence interval for EXP (B)
AFS	< 3 y	Ref.	-	-	-
	3-6 y	-0.22	0.001	0.80	(0.70-0.92)
	> 6 y	-0.44	0.000	0.65	(0.51-0.81)
Parity	Primiparous	Ref.	-	-	-
	Multiparous	-0.28	0.001	0.76	(0.66-0.86)
DFS	≤ 60 d	Ref.	-	-	-
	61-81 d	-.049	0.48	0.95	(0.83-1.09)
	> 81 d	-0.66	0.001	0.51	(0.41-0.65)
S/C	1	Ref.	-	-	-
	2	0.38	0.001	1.46	(1.2-1.8)
	≥ 3	0.62	0.001	1.86	(1.6-2.2)
305- MY	Low	Ref.	-	-	-
	High	0.074	0.4	1.077	(0.896-1.295)
Mastitis before 1st service	Healthy	Ref.	-	-	-
	Diseased	-0.14	0.06	0.87	(0.75-1.003)

The reference category is the non-pregnant cows. AFS: age at first service, DFS: days to first service, S/C: service per conception, 305- MY: 305- milk yield.

Table 3 Costs of AI and palpation per cow for conception in cows that did or did not conceive at their 1st AI ($)

Item	Unit	Dose value ($)	Cows that conceived at 1st AI(*no*= 346)	Cows that conceived at 2nd AI(*no*= 361)
AI	One straw	10.26	1*10.26=10.26	2*10.26=20.52
Palpation	One time	5.13	1*5.13=5.13	2*5.13=10.26
Total			$ 15.39	$ 30.78

Table 4 Additional costs cows that failed to conceive at their 1st AI due to an extra no of DO.

Item	Additional costs/cow/ extra one day of DO	Additional costs/cow/extra DO (28d) for cow that conceived by 2nd AI	Additional costs/cow/ extra DO (65d) for cow that did not conceive by 2nd AI but conceive by >2 AI
Replacement	Difference between the value of cull cows($1795.8) and Replacement heifers (cows) ($3078.5)* Replacement cost/cow/day =(1282.7*49.5% [a] /460d[b])= $ 138	Mean extra DO * Replacement/cow/d=28d*$138=$ 3864	Mean DO * Replacement cost/ cow/d =65d*$138=$ 8970
Nutrition	Nutrition cost/cow/d:$ 10.26	Extra DO * Nutrition cost/ cow/d=28d*$10.26=$ 287.28	Extra DO * Nutrition cost/ cow/d=65d*$10.26=$666.9
Calf price	Calf price/cow/d: ($410.5/460 days)=$ 0.89	Extra DO * Calf price/cow/d= 28*$0.89=$24.92	Extra DO * Calf price/cow/d=65d*$0.89=$57.85
Labor	Labor cost/cow/d: $3	Extra DO * Labor cost/cow/d= 28*$3=$84	Extra DO * Labor cost/cow/d= 65d*$3=$195
Milk loss	Milk lost/cow/d: (29Litter*$0.56)=$16.24	Extra DO * Milk lost/cow/d=28*$16.24=$454.72	Extra DO * Milk lost/cow/d= 65d*$16.24=$1055.6
Total	$168.39	$4714.92	$ 10945.35

a) Culling because of infertility in cows that failed to conceive at 1st service: 1370/2770 (49.5%). b) CI in this study (460d).

Concerning the DFS, the PR had a significant reduction with increasing DFS. However, Kim and Jeong (2019) showed that shorter calving to AI intervals resulted in reduced PR in cows (<80 d (41%) and ≥80 d (43%)). In responding to 305-MY, the PR had a non-significant increase for high-producing cows (43.8%) than low-producing ones (42.0%). The above results agreed with those of Leblanc (2010) who showed that higher-producing cows became pregnant a few days sooner than lower-producing cows. This association might be due to good nutrition. While these results disagreed with Bittante et al. (2020) who stated that cows with high milk production exhibited a lower PR than low-producing ones. Concerning mastitis before 1st service, healthy cows had a higher PR (47%) than those exposed to mastitis (43.6%). Our result agreed with Smulski et al. (2020) noted that the animals with mastitis showed a lower PR than the healthy ones. This might be due to prolonged treatment for more than 7–10 d and the inflammation process due to the low efficiency of microbial therapy or lack of supportive treatment. Regarding the number of S/C, cows that inseminated once had the lowest PR (36.1%) than those inseminated twice (45.2%) or more than two times (51.2%).

The above results agreed with those of Tadesse et al. (2022), who reported that cows inseminated for the third time had a higher PR (70%) than for the first (58.54%) and the second time (61.10%). Concerning the economic impact of the 1st AI failure, the total of additional expenses of reproductive management and other management required to achieve conception for cows that conceived at their 2nd AI were about \$4714.92/y per cow, while the additional expenses for cows that conceived by more than two AI were about \$10945.35/y per cow, these are enormous costs as we compare with cows that conceived at their 1st service (\$168.39), the losses were due to extra no of S/C, palpation cost, and costs of replacement heifers, nutrition, calf price, labor, and milk. According to a prior study, Kim and Jeong (2019) reported that the total economic losses because of the failure of 1st AI in Korea were about \$622.40/animal, also Tadesse et al. (2022) recorded that the total economic losses were about \$541.63 for cows that weren't able to conceive at their 1st AI but conceived by 2nd and 3rd AI. It is difficult to compare the economic losses between the previous studies (Sheldon et al., 2006) and ours directly because of the different study designs and price variation. However, the results of our current study and the earlier ones stated that there was a direct relationship between the S/C no and the economic losses.

5. CONCLUSIONS

The overall PR was 46%. It differed significantly among the AFS, parity, DFS, and S/C. The probability of high PR was significantly higher for cows at age ≤3y, and for primiparous ones, also when AI performed during the early stage of lactation (≤60d) postpartum. Regarding the number of S/C, the higher the number of S/C the higher the PR, but this adversely affects the farm profitability. Failure of 1st AI resulted in extra costs of \$168.39 per extra no of days open and \$15.39 for an extra service until conception.

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