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Fertility of Holstein Cattle in a Subtropical Climate of Egypt

Research Article

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ABSTRACT

The pregnancy results of 17337 inseminations carried out in a dairy herd near Cairo over a period of 12 years were retrospectively analyzed in relation to environmental temperature and temperature-humidity index (THI). The overall average of pregnancy rates to all inseminations was significantly (P<0.01) lower in pluriparous cows (31.0%) than in heifers (63.5%). Stress of lactation, propensity for clinical and sub-clinical mastitis and problems associated with calving are possible underlying causes. In cows, the month of insemination significantly (P<0.05) influenced the pregnancy rate. A substantial decrease of pregnancy rates from 34.1% in May to 15.7% in July as the maximum environmental temperature increased from 33.3 ˚C to 36.3 ˚C and mean THI increased from 69 to 74 was recorded. In spite of the slight increase in pregnancy rates after July, it remained low during autumn referring to the carryover effects of the summer heat load. This resulted in significantly (P<0.05) lower pregnancy rates during summer (21.2%) and autumn (24.4%) than in winter (39.1%) and spring (37.2%). Maximum environmental temperature and mean THI accounted for 72% and 82%, respectively, of the variations in pregnancy rates. The average number of inseminations per conception was the lowest between January and April (2.4±0.2 to 2.6±0.2). This was followed by a significant (P<0.05) increase in this parameter (from 2.9±0.6 in May to 6.4±1.9 in July) coinciding with increased maximum environmental temperature to reach its peak in July. The overall average number of inseminations per conception in cows was 3.2±0.4. In heifers, the pregnancy rate was high (56.9 to 69.8%) throughout the year with no significant differences between months or seasons of insemination. Better efficiency of heifers at thermoregulation compared with pluriparous cows may be implicated. The average number of inseminations per conception in heifers was 1.6±0.04.

KEY WORDS environmental temperature, Holstein cattle, pregnancy rate, subtropics, temperature-humidity index.

INTRODUCTION

The growing animal protein deficit in developing countries associated with the ever increasing human population resulted in importation of high milk producing European cattle raised as purebreds or crossbreds with the native cows. Nevertheless, severe reproductive problems following importation have been reported irrespective of the breed, origin and location (Vaccaro, 1973). Studies on the reproductive performance of the imported breeds in tropics had been compiled in a series of review articles by Galina and Arthur (1989a), Galina and Arthur (1989b), Galina and Arthur (1989c), Galina and Arthur (1990a), Galina and Arthur 1990b) and Tibbo *et al.* (1994). Poor nutrition, inappropriate management and environmental conditions have a significant negative influence on reproductive efficiency of cattle (Fair, 2010; Walsh *et al.* 2011). In Egypt, importation of European cattle started in 1928 with a small number of Jersey cows and bulls (Khishin and El-Issawi, 1954). Since 1954, large numbers were imported and many Governmental Jersey, Friesian and Holstein-Friesian herds were built up in the delta region with an average summer temperature of about 25 ˚C (El-Itriby and Asker, 1958; Ragab and Asker, 1959) and in upper Egypt where maximum temperatures reach about 36 ˚C (El-Itriby *et al*. 1963). Most of the studies on these herds were mainly concerned with the reproductive performance of the imported cows compared with their locally born daughters and the crossbreds with native cows (El-Keraby and Aboul-Ela, 1982; Afifi *et al*. 1992; Abdel-Bary *et al*. 1992). In the last three decades several private dairy herds of home-raised Jersey, Holstein and Holstein Friesian cows were established and contribute substantially to the dairy industry in the country. Because reproductive efficiency is the primary determinant of herd profitability, regular assessment of the influencing factors and corrective measures seemed crucial if better fertility is contemplated. The current study was devoted to assess the impact of summer heat stress on pregnancy rate of home raised Holstein cattle under the subtropical environment of Egypt. This could encourage further research on the effects of management and disease factors on fertility of dairy cattle in this country.

MATERIALS AND METHODS

Herds and animals

Pregnancy results for 17337 artificial inseminations of 6085 home raised Holstein heifers (1381) and cows (4704) from a commercial dairy herd located about 120 km southwest of Cairo (30' 03" N 31' 13" E) over a period of twelve years (1999-2010 inclusive) were retrospectively analyzed. The overall monthly average pregnancy rates and number of inseminations per conception over the period of study were calculated. Heifers were kept in open lots and were inseminated at an average body weight of 380-400 kg and average age of 16 months. The cows (parity 1-8) were kept in open half-shaded yards equipped with large overhead electric fans. They were fed a total mixed ration consisting of corn silage, Egyptian clover and concentrates. The ration contained 16-17% crude protein, 19-21% acid detergent- and 30-32 neutral detergent-fibers with 70-72% total digestible nutrients. The dry matter intake was 21-26 kg per cow depending on milk production and the dietary energy concentration was 1.6-1.7 Mcal/kg of diet (NRC, 1994). Free choice trace mineral salt licks were provided in locations that animals will consume it. The cows were milked twice daily and the average 305 day milk production was between 8600 + 102 and 9400±132 kg. Estrus was detected twice daily by visual observation in the early morning and late evening for periods of 30 minutes each. Inseminations were done on the basis of the AM/PM rule using imported frozen semen, of proven Holstein sires, after thawing. Semen from the same bulls was used throughout the year. Pregnancy was diagnosed by palpation per rectum of the uterine contents at 6-8 weeks after AI. During the hot months of the year (June through September) a cooling system was operated for lactating cows. The latter comprised forced ventilation by fans fitted in the shaded areas of the yards between 11 h00 and 21 h00 h and evaporative cooling (overhead water sprinkling and forced ventilation) in the holding area adjacent to the milking parlor twice daily before milking each for 30 minutes. Climatic data were obtained from the Meteorological Authority in Cairo. Information included monthly averages of daily mean, minimum and maximum temperatures in Celsius degrees and mean relative humidity as a percentage for each of the twelve years of study. This information was used to calculate the overall monthly average of mean, minimum and maximum temperatures and mean relative humidity for the period of study. The mean temperature- humidity index (THI) for each month was calculated using the following equation (Nagamine and Sasaki, 2008):

$$\text{T-H index} = 0.81\ T + 0.01\ RH\ (0.99\ T - 14.3) + 46.3$$

Where:
T: mean air temperature ˚C.
RH: mean relative humidity %.

Statistical analysis

Correlation analysis (Microsoft Excell, 2003) and chi-squared test (http//www.physics.Csbsju.edu.) were used. All results are considered to be statistically significant at P<0.05 unless otherwise stated.

RESULTS AND DISCUSSION

Values for the overall average of mean, minimum and maximum temperatures mean relative humidity and mean temperature humidity index (THI) during the 12 years period of study are given in Table 1.

Table 1 Monthly temperatures (mean, min. and max., ˚C), mean relative humidity (RH %) and mean temperature humidity index (THI %) during the study period

Months	Temperature ˚C			Mean RH %	Mean THI
	Mean	Min	Max		
Jan	14.2	9.5	19.7	43.1	58
Feb	15.1	10.8	22.1	39.1	59
March	18.7	10.2	23.4	34.0	63
April	21.9	14.6	27.6	28.0	66
May	24.7	17.9	33.3	25.5	69
June	28.5	20.6	34.9	28.0	73
July	29.1	24.2	36.3	31.3	74
Aug	28.8	24.3	35.8	34.9	75
Sept	27.2	21.6	33.9	37.3	73
Oct	24.2	18.3	29.0	37.8	70
Nov	20.3	14.3	24.7	43.1	68
Dec	15.4	12.7	20.6	46.4	59

The hottest months are June through September with the highest mean, minimum and maximum temperatures and mean THI.

The mean and maximum temperatures were highly correlated (r=0.98) for the trial period. Mean relative humidity was highest from November to January. The pregnancy rate for all the inseminations was not significantly different among the years of study. Nevertheless it was significantly ($P<0.05$) influenced by month of insemination in cows, but not in heifers (Figure 1).

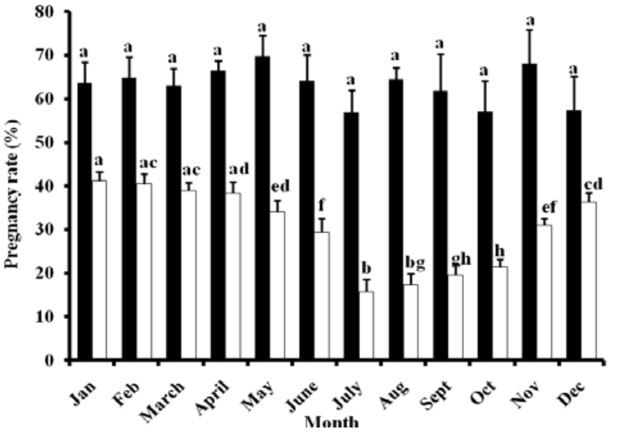

Figure 1 Monthly variations of pregnancy rates in Holstein heifers (black bars) and cows (open bars)
Bars with different superscripts are significantly different at $P<0.05$

In cows the pregnancy rates dramatically decreased from 34.1% in May to 15.7% during July as the maximum environmental temperature increased from 33.3 ˚C to 36.3 ˚C. A corresponding increase of the environmental heat load expressed by THI from 69 to 74% occurred during the same period. In spite of a slight increase, pregnancy rates in the following months were generally low until November (17.4-31.0%). This resulted in a clear seasonal pattern with lower pregnancy rates in summer followed by autumn (Table 2). The pregnancy rate in heifers was high throughout the year (56.9-69.8%) with no significant differences between months (Figure 1) or seasons (Table 2) of insemination. The relationships between monthly maximum ambient temperature and mean THI and decrease of pregnancy rates are illustrated in Figures 2 and 3. Maximum environmental temperature and mean THI accounted respectively for 72% and 82% of the variations in pregnancy rates in cows. The average number of inseminations per conception was the lowest between January and April (2.4±0.2 to 2.6±0.2); this period was followed by a significant ($P<0.05$) increase in the average number of AI/conception from May (2.9±0.6) on reaching its highest value in July (6.4±1.9) that parallel the increase in maximum environmental temperatures (Table 3). The overall average of pregnancy and number of inseminations per conception was 31.0% (Table 2) and 3.2±0.4 (Table 3). The overall average pregnancy rate in heifers was 63.5 % and the average number of inseminations per conception was 1.6±0.04 (Table 3). The overall pregnancy rate of Holstein cows found in the current study (31.0%) agreed with the average conception rate reported for Holstein cows in 108 US herds (32.2 %, range 20-44%)

Table 2 Seasonal variations in pregnancy rates of Holstein heifers and cows[1]

Season	Heifers			Cows		
	No. Insem	No. Pregnant	%	No. Insem	No. Pregnant	%
Winter	562	352	62.6	4088	1598	39.1[a]
Spring	812	537	66.0	3854	1433	37.2[a]
Summer	540	332	61.5	2749	584	21.2[b]
Autumn	258	160	62.0	4472	1089	24.4[c]
Total / Mean	2174	1381	63.5	15163	4704	31.0

The means within the same column with at least one common letter, do not have significant difference ($P>0.05$).

Table 3 Number of Inseminations and Inseminations per conception in Holstein heifers and cows[1]

Month	Heifers		Cows	
	No. Insem	Insem / Concept	No. Insem	Insem / Concept
Jan	193	1.6±0.1[ab]	1282	2.4 ± 0.2[a]
Feb	228	1.5±0.1[ab]	1231	2.5 ± 0.1[a]
March	332	1.6±0.1[ab]	1323	2.6 ± 0.1[ac]
April	250	1.5±0.1[ab]	1301	2.6 ± 0.2[ac]
May	232	1.4±0.3[b]	1230	2.9 ± 0.6[b]
June	184	1.6±0.2[ab]	996	3.4 ± 1.0[d]
July	204	1.8±0.1[ac]	827	6.4 ± 1.9[e]
Aug	152	1.6±0.1[ab]	926	5.8 ± 2.8[f]
Sept	110	1.6±0.2[ab]	1280	5.1 ± 1.9[g]
Oct	79	1.8±0.2[ab]	1568	4.7 ± 0.3[h]
Nov	69	1.5±0.2[ab]	1624	3.2 ± 0.2[i]
Dec	141	1.7±0.2[ab]	1575	2.8 ± 0.2[bc]
Total / Mean	2174	1.6±0.04	15163	3.2 ± 0.4

The means within the same column with at least one common letter, do not have significant difference ($P>0.05$).

reported by Schefers *et al.* (2010). Also the average pregnancy rate of heifers was in accordance to the conception rate (64%) noted by Kuhn and Hutchinson (2005) from over 330000 inseminations to over 220000 Holstein heifers.

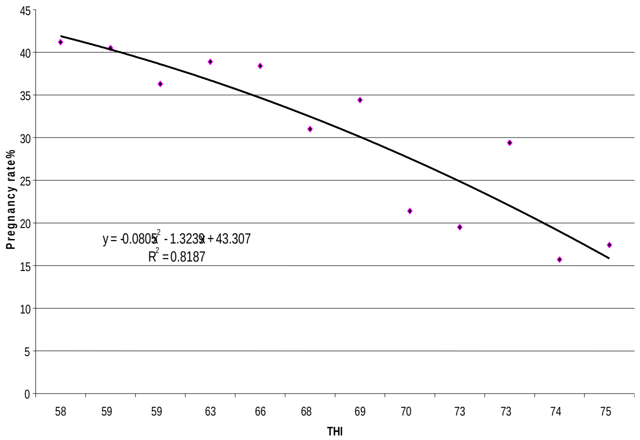

Figure 2 Relationship of monthly temperature-humidity index (THI) and pregnancy rates in Holstein cows

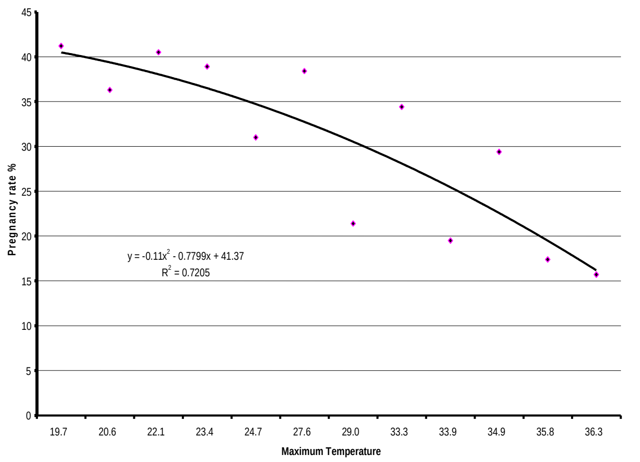

Figure 3 Relationship between maximum monthly temperature and pregnancy rates in Holstein cows

Higher conception rate in heifers compared to multiparous cows with similar genetic merit for milk production has been repeatedly emphasized (Ron *et al.* 1984; Badinga *et al.* 1985; Pursley *et al.* 1997). Stress of lactation, propensity for clinical and subclinical mastitis and problems associated with calving in pluriparous cows are possible causes for the differences found between cow and heifer segments (Wolff and Monty, 1974; Gwazdauskas *et al.* 1981; Grohn and Rajala-Schultz, 2000; Schrick, *et al.* 2001; Santos *et al.* 2004). The reproductive tract of lactating dairy cows may provide a less favorable environment for very early embryo development than that of the heifers (Rizos *et al.* 2010). Also the quality of embryos is higher in non lactating Holstein Friesian heifers than in lactating cows (Leroy *et al.* 2005; Sartori *et al.* 2010). During the hot months (Table 1) which extended from June through September both the mean and maximum environmental temperatures exceeded the upper critical temperature for heat stress (25-26 ˚C) reported by Berman *et al.* (1985). In bovine the average rectal temperature was 38.7 ˚C when the ambient temperature was between 18 and 24 ˚C (Bianca, 1968). Cows exposed to temperatures above 26 ˚C have elevated respiration rate and rectal temperature which might result in impaired metabolism and reproductive performance (Kadzere *et al.* 2002). Highly significant (P<0.01) negative correlations were found between conception rate and both the rectal temperature and the respiration rate (Dunlap and Vincent, 1971). Cows are more susceptible to the depressing effects of heat stress on fertility near the time of breeding (Vincent, 1972). Increased heat load at estrus or following insemination tend to increase body temperature of cows with adverse effects on conception rate (Gwazdauskas *et al.* 1973; Zakari *et al.* 1981).

Chebel *et al.* (2004) stated that cows exposed to maximum temperature above 29 ˚C for at least 1 day prior to AI showed lower conception rate than non- exposed cows. Ulberg and Burfening (1967) reported a drastic decrease of pregnancy rate of cattle 35 to 42 days after breeding from 61 to 45% when rectal temperature increased 1 ˚C at 12 h post insemination. In Holstein cattle rectal temperature increased 1.4 ˚C when the ambient temperature was between 32 and 35 ˚C (Branton *et al.* 1953) and consistently low fertility was reported when maximum temperatures on the day of breeding were ≥33 ˚C (Cavestany *et al.* 1985). In the study presented herein the heat load expressed by the mean THI during the hot months in the current study increased from 69 to 74% which surpassed the limit for heat stress (72%) defined by Armstrong (1994).

Lower conception rates were reported in cows during the months with increased THI (Ingraham *et al.* 1974; McGowan *et al.* 1996). The above- mentioned facts could have contributed to the dramatic decline of pregnancy rate from 34.1% in May to reach a nadir (15.7%) in July. These findings are in line with the tendencies observed in other studies on dairy cattle exposed to high heat load before and or after AI not only in tropical and subtropical regions (Cavestany *et al.* 1985; Orr *et al.* 1993; Lopez-Gatius, 2003; Garcia-Ispierto *et al.* 2007; Morton *et al.* 2007) but even in temperate areas (Alnimer *et al.* 2002; Nagamine and Sasaki, 2008). Higher risks for ovulatory failure (Lopez- Gatius *et al.* 2005), impaired oocyte quality, or embryo development, reduced progesterone production, increased embryo mortality, endometrial dysfunction as well as reduced uterine blood flow under heat stress are possible involved factors (Wolfenson *et al.* 2000; Roth *et al.* 2001; De Rensis and Scaramuzzi, 2003).

In spite of the measures undertaken during the summer months to ameliorate the adverse effects of heat load in the present study, absence of contemporary controls and the impossibility to quantify the adequacy of the cooling system prohibited critical evaluation of the efficiency of these measures. Nevertheless, intense and frequent use of sprinkling and ventilation cooling under experimental farm conditions (Flamenbaum *et al.* 1986) seemed able to restore the summer conception rate to that noticed in the winter (Wolfenson *et al.* 1988). Nevertheless, management interventions to ameliorate the effects of heat load on conception rate should be implemented at least 5 weeks before anticipated service and should continue until at least 1 week after service (Morton *et al.* 2007).

Low pregnancy rate during autumn was described in previous studies by Cavestany *et al.* (1985); Wolfenson *et al.* (2000) and Huang *et al.* (2008) and could be ascribed to the detrimental effects of heat stress on oocyte competence. Adverse effects of heat stress involving the early stages of folliculogenesis leading to carryover effects on ovulated oocytes of low quality up to 3 months after the insult have been described (Roth *et al.* 2001; Chebel *et al.* 2004; Torres-Junior *et al.* 2008; Fair, 2010). Maintenance of fairly high pregnancy rates in heifers in the current study, even during the hot months, using the same source of frozen semen is in agreement with Folman *et al.* (1979) hypothesis and could be associated to better efficiency of heifers at thermoregulation (Ferreira *et al.* 2011). Lactating cows have greater increase in body temperature than the heifers in response to the increase of environmental temperatures (Sartori *et al.* 2002) with adverse effects on the fertilization rate (55.6% in cows *versus* 100 % in heifers; Sartori *et al.* 2010).

CONCLUSION

This study showed that pregnancy rates of Holstein cows under the subtropical environment of Egypt were substantially compromised by heat load imposed by increasing environmental temperature and temperature-humidity index during the summer months. This is suggestive of the need for a more efficient cooling of lactating cows around the time of breeding particularly between May and September, possibly combined with hormonal therapy. In contrast heifers maintained under the same environmental conditions and inseminated with the same semen had fairly high conception rates throughout the year.

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