www.roavs.com EISSN: 2223-0343
RESEARCH OPINIONS IN ANIMAL & VETERINARY SCIENCES

Effects of age at calving, parity, year and season on reproductive performance of dairy cattle in Tehran and Qazvin Provinces, Iran

M. Khodaei Motlagh*[1], Z. Roohani[2], A. Zare Shahne[2] and M. Moradi[2]

[1]Department of Animal Science, Faculty of Agriculture, Arak University, Arak 38156-8-8349. Iran; [2]Department of Animal Science, Faculty of Agronomy and Animal Science, College of Agriculture and Natural Resource, Tehran University, Iran

Abstract

This study was carried out to evaluate the reproductive performances of Iranian dairy cattle at Tehran and Ghazvin Provinces. Reproductive traits included: calving interval, days open, and service per conception. A total of 2500 cows were used in this trial. Some effective factors were collected by the Animal Breeding Center of Iran from 1993 to 1998. Cows were classified into seven groups according to the age at calving (22 to 23, 24 to 25, 35 to 36, 47 to 48, 59 to 60, 71 to 72 and 93 to 104 months respectively). The effect of age at calving, season, year and parity on reproductive performance was significant ($P<0.05$). Reproductive performance decreased from parity $\geq$ 6. Reproductive performance during summer season was significantly lower than other seasons, specially compared to winter. The result of this study demonstrated that the reproductive performance decreased by increase in age at calving, parity and warm season.

Keywords: Holstein; reproductive performance; Qazvin; Tehran; Iran

To cite this article: Motlagh MK, Z Roohani, AZ Shahne and M Moradi, 2013. Effects of age at calving, parity, year and season on reproductive performance of dairy cattle in Tehran and Qazvin Provinces, Iran. Res. Opin. Anim. Vet. Sci., 3(10), 337-342.

Introduction

Holstein breed of cows was introduced to Iran about 100 years ago, and they are to date is the most dominant dairy cattle breed in the country. The reproductive efficiency of a herd is an important component of dairy cattle productivity in the world. Economic losses because of poor fertility can be attributed to the cost of prolonged calving interval, increased insemination costs, reduced returns from calves born and forced replacements in the event of culling (Nishida et al., 2006). A delay in conception because of poor fertility increases calving interval mostly due to the increase in the number of days from calving to conception (Nishida et al, 2006). The main factors influencing reproductive efficiency in cattle includes age at calving, parity, milk production and calving season (Hammoud et al., 2010).

Fertility in dairy cows is depressed during the summer months in warm areas of the world (Hansen, 1997). Reproductive performance of dairy (Sartori et al, 2002) is reduced during hot seasons. The adverse effects of heat stress on follicular growth (Wolfenson et al, 2000), expression of estrous behavior (Trout et al, 1998), superovulatory response (Gordon et al, 1987; Munro et al, 1986), quality of embryos (Putney et al., 1988), and fertility (Sartori et al, 2002) are well documented in cattle.

Therefore, the aim of this study was to investigate the effect of age at calving, parity and season on reproductive performance of dairy cows reared in Tehran and Qazvin.

Materials and Methods

This study involved Iranian dairy cattle reared in Tehran and Qazvin provinces of Iran (Fig. 1). Feeding

Corresponding author: M. Khodaei Motlagh, Department of Animal Science, Faculty of Agriculture, Arak University, Arak 38156-8-8349. Iran.

management of herds was based on total mixed ration (TMR).

Data collection and analysis

Data on age at calving, parity, year and season and reproductive performance of dairy cattle were collected by the technicians of the farms. Reproductive performance includes service per conception, calving interval and open day. In this study, effects of parity, season, year and age at calving on reproductive performance were used. Parity include 1, 2, 3, 4, 5, 6, seasons were summer (June, July and August), autumn (September, October and November), winter (December, January and February) and spring (March, April and May) and age at calving (22 to 23, 24 to 25, 35 to 36, 47 to 48, 59 to 60, 71 to 72, 93 to 104 months). Data for reproductive traits were not normally distributed. Thus, data were transformed to a logarithmic scale. The model included main effects of age at calving, years, parity and season.

Retrospective data collected from 1993 to 1998 were used to assess the number of services per conception (NSC); days open (DO) and calving interval (CI). After deleting incomplete record a total of 2500 were used to estimate NSC, DO and CI, respectively. The fixed factors studied were calving parity (n=6), season (n=4) and year (n=6), and age at calving (n=7). Data were analyzed using the following General Linear Model (GLM) procedures of the Statistical Analysis System (SAS, 1998).

$Y_{ijkm} = \mu + y_{i} + S_j + A_k + P_m + e_{ijkm}$

Where:

Y_{ijkm} = dependent variables;

μ = overall mean;

y_i = effect of i^{th} year (1993 to 1998);

S_j = effect of j^{th} season;

A_k = age to month (k = 22 to 23, 24 to 25, 35 to 36, 47 to 48, 59 to 60, 71 to 72, 93 to 104);

P_m = the effect of the m^{th} parity of the i^{th} cow;

e_{ijkm} = random error associated with Y_{ijkm} observation.

Results

Least square means and standard errors for DO, NSC, and CI of Holstein cattle in Iran are given in the Table 1.

The average DO, NSC and CI were 111.5 days, 2.1 and 406 days, respectively. Calving year had significant (P<0.05) effect on the DO, NSC and CI. The longest days open (137.3 days) was recorded in 1998. Maximum services per conception over the 6 years period were in 1998 and averaged 2.32. The services per conception, CI and DO had an increasing trend over the 6 year period. Calving interval was between 395.5 and 425.66 days during this study (Table 2).

Table 1: Least squares means (± SE) of number of services per conception (NSC), days open (DO) and calving interval CI)

C.I	NSC.	D.O	
406 ± 95.7	2.1 ± 34	111.5 ± 35.6	General

Table 2: Effect of calving year, season, parity and age at calving on reproductive performance

C.I	Service per conception	D.O	Year
397.7 ± 87.5^{a}	1.9 ± 30^{a}	107.9 ± 34.24^{a}	1993
395.5 ± 90.90^{a}	1.8 ±.27^{a}	104.2 ± 31.26^{a}	1994
400.2 ± 96^{a}	1.95 ±.32^{a}	108.3 ± 34.66^{a}	1995
412.35 ± 94.84^{b}	2.22 ±.39^{b}	126.8 ± 44.40^{b}	1996
412.96 ± 99.11^{b}	2.26 ±.45^{b}	128.8 ± 43.79^{b}	1997
425.66 ± 106.4^{c}	2.32±.37^{c}	137.3 ± 45.31^{c}	1998
C.I	**Service per conception**	**D.O**	**Parity**
422.6 ± 101.4^{b}	2.35 ±.44^{b}	134.6 ± 47.1^{a}	1
408.2 ± 89.8^{a}	2.12 ±.38^{a}	115.2 ± 34.5^{b}	2
406.6 ± 89.45^{a}	2.19 ±.37^{a}	114.6 ± 34.4^{b}	3
410.14 ± 94.32^{a}	2.18 ±.37^{a}	117.5 ± 36.4^{b}	4
405.26 ± 89.15^{a}	2.17 ±.36^{a}	114.4 ± 34.3^{b}	5
426.7 ± 106.67^{b}	2.65 ±.53^{b}	136.4 ± 46.4^{a}	6
C.I	**Service per conception**	**D.O**	**Season**
408 ± 32.52^{a}	1.95 ±.23^{a}	108.65 ± 32.59^{a}	Spring
416.30 ± 136.07^{b}	2.15 ±.34^{a}	118.65 ± 37.96^{b}	Summer
414.1 ± 91.08^{b}	1.2 ±.35^{a}	117.8 ± 35.34^{b}	Fall
404.45 ± 93.02^{a}	1.8 ±.32^{b}	106.5 ± 34.08^{a}	Winter
C.I	**Service per conception**	**D.O**	**Age(month)**
401 88.22^{a}	1.9.32^{a}	125 38.75^{a}	23-22
399 87.78^{a}	1.8.32^{a}	123 39.36^{a}	25-24
390 89.70^{b}	1.95.35^{b}	115 34.5^{b}	36-35
388 89.24^{c}	2.12.42^{c}	112 33.6^{c}	48-47
389 93.36^{c}	2.16.42^{c}	113 36.6^{c}	60-59
405 101.25^{d}	2.23.33^{c}	128 33.5^{d}	72-71
410 102.50^{d}	2.27.38^{c}	133 45.22^{d}	104-93

a*b* c*d* Within variable groups, means followed by the same letter do not differ significantly (P>0.05).

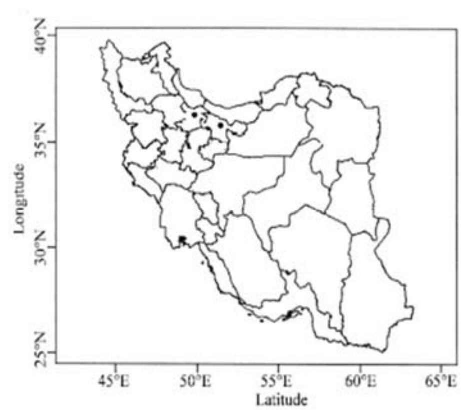

Fig. 1: Map of the provinces of the Islamic Republic of Iran showing the location of the cities of Tehran and Qazvin.

Season had significant (P<0.05) effect on the DO, NSC and CI (Table 2). The longest DO (118.6 days) was recorded in summer. In accordance with this finding, maximum NSC and CI were also observed in summer (2.15 and 416.30 days).

The effect of parity on the days open, services per conception and calving interval was statistically significant (P<0.05). Cattle in first and six lactation had a larger days open (134.6 and 136.4, respectively) than the others (Table 2).

Age at calving had significant effect on reproductive performance (Table 2). With increasing age the trend of DO, CI and NSC increased.

Discussion

Services per conception

The NSC reported for this study is closer to the range given for middle managed herd and similar to the estimates obtained for crosses in Asela farm (Yohannes et al., 2001) and commercial dairy farms (Asseged and Birhanu, 2004). However, larger than the estimates for this breed at Fars province (Ansari-Lari et al., 2005), Holeta Research Centre (Gifawosen et al., 2003; Lobago et al., 2006) and Varamin area (Nikmanesh, 2010) have been reported.

The number of services per conception tends to increase significantly (P<0.05) with increase age (47 to 48 month). The possible cause of the low NSC for younger cows was not clear. Similar report was publlished by Nega and Sendrose (2000) at the Holeta state farm showing that first parity cows had less NSC compared to two and above.

Season of conception had significant effect in this study on the NSC. Mekonnen et al. (1993) and Gifawosen et al. (2003) found a significantly less NSC in the winter season. The differences observed in NSC between the study years could be related to the variation in the feeding and management practices over the years and the same explanations apply to DO and CI. However, year effect as observed in this study was in contrast to the findings of Mekonnen et al. (1993). Mekonnen and Goshu (1987) and Nega and Sendrose (2000) reported a non-significant effect of calving year.

This study showed that a good proportion of conception cases demanded two or more services. This could suggest the presence of repeat breeders in the herd, occurrences of postpartum reproductive problems, erratic heat detection skills, inefficiency of AI and/or poor body condition (level of feeding) in the herd or reproductive disorder. Shiferaw et al. (2005) found that cows with reproductive disorders require more services per conception and had longer intervals from calving to first service and to conception. Proper and accurate heat detection is a key to efficient reproduction, and four to five checks each day to determine the onset of true standing heat gives a better idea when to inseminate.

Services per conception were affected by calving year and parity or season. Similar results were reported by Rajala-Schultz and Frazer (2001) and Ray et al. (1992). They reported that the effect of calving year, lactation number and season was statistically significant. The average services per conception in this research were 2.01. This result was consistent with studies performed by Balcõ (1999) (2.03) and Faust et al (1993). (2.3). However, McNamara et al (2003) and Alejandrino et al. (1999) reported that the average services per conception were 1.5, 1.6 and 1.5, respectively. It was thought that the higher services per conception may be caused by irregular breeding and management practices in the enterprise.

Days open

The DO reported for this study was closer to the range given for well managed herd and lower than the estimates for this breed in Iran (Ansari-Lari et al., 2010), Varamin area (Nikmanesh, 2010) and Khorasane Razvi (Bahonar et al., 2009). Such differences could have been caused by failure of farmers to detect heat signs after calving. As a result, the interval from calving to first service was prolonged, and eventually influencing the numbers of days open. This finding was in agreement with Balcõ (1999). Klaas et al. (2004) and McNamara et al. (2003) who reported short DO. In contrast, Rajala-Schultz and Frazer (2003) reported longer days open (148.9 days) from Ohio dairy enterprises. Poor oestrus detection efficiency was thought to be the major factor causing lengthened days opens in dairy enterprises. Within this context, it has been reported that nearly half of the oestrus periods in large-scale dairy enterprises were undetected (McNamara et al., 2003).

In the current study, cows that calved from 1996 to 1998 had the longest days open (412 to 425 days), while those that calved from 1993 to 1995 had the shortest days open (397 to 400 days). Such findings reflected poor reproductive management by farmers. For all parities studied, animals that calved in parity one and six had higher mean DO (134.6 and 136.4 days, respectively) than the other parities (Table 2). The DO was routinely used to assess reproductive performance and to make economic decision in dairy herds (Farin et al., 1994). Knowledge of factors influencing the fertility of individual cows is important so that they can be managed, where appropriate.

Tadesse and Zelalem (2003) reported that increasing the level of protein supplementation from low (2kg/day) to high (4 kg /day) reduced the post partum interval from 159 to 100 days. Significant age effect as in the present case was also reported by several authors (Yohannes et al., 2001; Gifawosen et al, 2003). The large deviation of DO from the population mean in the first age (22 to 23) and final age (93 to 104) might be related to early abortion (because of various reproductive tract diseases) or lack of experience in skills of reproductive and feeding management.

We found a relationship between season and DO. Season significantly affected the DO. Eicker et al. (1996) found that cows, which calved during the spring, had lower conception rates compared with those that calved in winter (December to February). In the study of Meadows et al. (2006), spring and summer calves had reduced fertility compared to those calving in the winter.

Calving interval

Calving interval reported for this study was closer to the range given for well managed herd and similar to the estimates obtained at Canada. It averaged 411 days in the Netherlands (Fatehi and Schaeffer, 2003). In Iran, it was reported 403 ± 86 days (Ansari-Lari et al., 2010), which was lower than the estimates at the United States (Lucy, 2001).

The decrease in calving interval between the first and subsequent parities (Table 2) confirm earlier studies by Kifaro (1984), Agyemang and Nkhonjera (1986) and Balikowa (1997). This could be associated with improvement in reproductive management and it also indicates that physiological maturity was attained with age of cows. The prolonged calving intervals for first calving has been reported to be physiologically necessary to allow animals to replenish their fat reserves depleted during lactation and this allows them to put on weight prior to the next calving (Mahadevan, 1951). Shiferaw et al. (2005) found that cows with reproductive disorders require more services per conception and had longer intervals from calving to first service and to conception.

The negative effect of postpartum heat stress in dairy cattle reproduction has been widely documented. Holstein cows have exhibited shorter periods of estrus (Hansen and Aréchiga, 1999), reduced intensity of estrus (Rensis and Scaramuzzi, 2003), higher incidence of anestrus (Jordan, 2003), and lower conception rates (Morton et al., 2007), when they were exposed to high ambient temperatures, high relative humidity or both. As a final point, these events depressed the fertility of the postpartum cow. Nevertheless, research on the effect of heat stress during late gestation on postpartum reproductive parameters has been limited. Even though metabolic heat production is lower during the dry period than early lactation, there are essential events occurring in the cow which could be affected by heat stress, such as mammary gland regression and increasing nutrient requirements for the growing fetus. Also, changes in endocrine status during late gestation may lead to alterations in reproductive parameters of the postpartum dairy cow (Kadzere et al., 2002).

The results of this study revealed that calving year, lactation number, age at calving and calving season had statistically significant effect on reproductive performance. Ray et al. (1992) reported that lactation number and calving season had statistical significant effect on the calving interval. The average calving interval was 394.9 days in this study, consistent with studies performed by Balcõ et al. (1999), Ray et al. (1992), Kumlu and Akman (1999), Rajala-Schultz and Frazer (2003) and Alejandrino et al. (1999) who reported that the calving interval in Holstein cattle ranged from 423 and 469 days. It was thought that calving interval length was significantly associated with days open and gestation period.

In conclusion, according to the results related to reproductive parameters, the environmental factors, age at calving, calving year and season had significant effect on the reproductive performance of Holstein cattle in Iran.

References

Nishida, M., Aziz, A., Nishida, S. and Suzuki, J. 2006. Modelling number of services per conception of Japanese Black cattle by random regression. *Animal Breeding and Genetic*, 123: 56-63.

Hansen, P.J. 1997. Effects of environment on bovine reproduction. In: Current Therapy in Large Animal Theriogenology, R.S. Youngquist, ed., WB Saunders, Philadelphia, pp: 403-415.

Sartori, R., Sartor-Bergfelt, R., Mertens, S.A., Guenther, J.N., Parrish, J.J. and Wiltbank, M.C. 2002. Fertilization and early embryonic development lactating and dry cows in winter, *Journal of Dairy Science*, 85: 2813-22.

Wolfenson, D., Roth, Z. and Meidan, R. 2000. Impaired reproduction in heat stressed cattle: basic and applied aspects, *Animal Reproduction Science*, 60/61: 535-47.

Trout, J.P., McDowell, L.R. and Hansen, P.J. 1988. Characteristics of the estrous cycle and antioxidant status in lactating Holstein cows exposed to heat stress. *Journal of Dairy Science*, 81: 1244-50.

Gordon, I., Boland, M.P., McGovern, H. and Lynn, G. 1987. Effect of season on superovulatory responses and embryo quality in Holstein cattle. in Saudi Arabia. *Theriogenology* , 27: 231 (abstr).

Munro, R.K. 1986. The superovulatory response of B. taurus and B. indicus cattle following treatment with follicle stimulating hormone and progesterone. *Animal Reproduction Science*, 11: 91-7.

Sartori, R., Rosa, G.J.M. and Wiltbank, MC. 2002. Ovarian structures and circulating steroids in heifers and lactating cows in summer and in heifers and lactating cows in summer and lactating and dry cows in winter. *Journal of Dairy Science*, 85: 2803-12.

SAS (Statistical Analysis System). 1998 .SAS Institute Inc., Cary, NC, USA.

Yohannes, A., Azage, T. and Tesfu, K. 2001. Reproductive performance of crossbred dairy cows at Asella Livestock Research Station, Arsi, Ethiopia. *Ethiopian Journal of Animal Production*, 1: 1-12.

Ansari-Lari, M., Rezagholi, M. and Reiszadeh, M. 2005. Trends in calving ages and calving intervals for Iranian Holsteins in Fars province, southern Iran. *Tropical Animal Health and Production*, 41: 1283-1288.

Gifawosen, T., Alemu, G., Azage, T., Diediou, M.L. and Hegde, B.P. 2003. Study on reproductive efficiency of Boran and its crosses at Holetta research farm: Effect of genotype, management and environment. *Ethiopian Journal of Animal Production*, 3: 89-108.

Lobago, F., Bekana, M. and Gustafsson, H. 2006. Reproductive performance of dairy cows in small holder production system in Selalle, Central Ethiopia. *Tropical Animal Health and Production*, 38: 333-342.

Nikmanesh, A. 2010. Genetic research of production and reproduction in a herd on Varamin area. *Journal of Iranian Animal Science Research*, 2: 81-89.

Nega, T. and Sendrose, D. 2000. Effect of calving year, season, age and parity classes on production and reproduction performance of Holstein-Friesian cows at Holetta state farm. Pastoralism and agro pastoralism: which way forward. *Proceedings of the 8th annual conference of the Ethiopian Society of Animal Production (ESAP),* 24-25 August (2000), Addis Ababa, Ethiopia.

Mekonnen, H., Keno, B., Tefera, G. and Hiskias, K. 1993. Productivity of Boran cattle and their Friesian crosses at Abernossa ranch, rift valley of Ethiopia. I. Reproductive performance and preweaning mortality. *Tropical Animal Health and Production*, 25: 239-249.

Mekonnen, H. and Goshu, M. 1987. Reproductive performance of Fogera cattle and their Friesian crosses. *Ethiopian Journal of Agricultural Science*, 9: 95-114.

Shiferaw, Y., Merga, B. and Tesfu, K. 2005. Reproductive disorders of crossbred dairy cows in the central highlands of Ethiopia and their effect on reproductive performance. *Tropical Animal Health and Production*, 37: 427-441.

Rajala-Schultz, P.J., Saville, W., Frazer, G.S. and Wittum, T.E. 2001. Association between milk urea nitrogen and fertility in Ohio dairy cows. *Journal of Dairy Science*, 84: 482-489.

Ray, D.E., Halbach, T.J. and Armstrong, D.V. 1992. Season and lactation number effects on milk production and reproduction of dairy cattle in Arizona. *Journal of Dairy Science*, 75: 2976-2983.

Balcõ, F., Yõl, B., sõrasõ, V.E. and buzaÛõlama, M. 1999. Holstein ineklerin bazõ d.lverimi .zelliklerine etkileri. UludaÛ .niv. *The Journal of the Faculty of Veterinary Medicine*, 18: 239-249.

Faust, M. 1993. Capitalizing on dairy herd life. U. S. National Dairy Data base. http://www.inform.umd.edu/EdRes/Topic/AgrEnv/ndd/Accessed 4/26/2003.

McNamara, S., Butler, T., Ryan, D.P., Mee, J.F., Dillon, P., OÕMara, F.P., Butler, S.T., Anglesey, D., Rath, M. and Murphy, J.J. 2003. Effect of offering rumen-protected fat supplements on fertility and performance in spring-calving Holstein-Friesian cows. *Animal Reproduction Science*, 76: 45-56.

Alejandrino, A.L., Asaad, C.O., Malabayabas, B., De Vera, A.C., Herrera, M.S., Deocaris, C.C., Ignacio, L.M. and Palo, L.P. 1999. Constraints on dairy cattle productivity at the smallholder level in the Philippines. *Preventive Veterinary Medicine*, 38: 167-178.

Ansari-Lari, M., Kafi, M., Sokhtanlo, M., Nategh-Ahmadi, H. 2010. Reproductive performance of Holstein dairy cows in Iran. *Tropical Animal Health and Production*, 42: 1277-1283.

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, Iran; A Cox Proportional Hazard Mode. *Journal of Animal and Veterinary Advance*, 8: 747-754.

Klaas, I.C., Wessels, U., Rothfuss, H., Tenhagen, A., Heuwieser, W. and Schallenberger, E. 2004. Factors affecting reproductive performance in German HolsteinÐFriesian cows with a special focus on postpartum mastitis. *Livestock. Production Science*, 86: 233-238.

Rajala-Schultz, P.J. and Frazer, G. 2003. Reproductive performance in Ohio dairy herds in the 1990s. *Animal Reproduction Science*, 76: 127-146.

Farin, P., Slenninq, B., Correa, M. and Britt, J. 1994. Effects of calving season and milk yield on pregnancy risk and income in North Carolina Holstein cows. *Journal of Dairy Science*, 77: 1848-1855.

Tadesse, B. and Zelalem, Y. 2003. Feeding noug '*Guizotia abyssinica*' cake as protein source to lactating Borana Jersey crossbred cows: performances in milk yield, reproduction and feed efficiency. Farm animal biodiversity: status and prospects. *Proceedings of the 11th annual conference of the Ethiopian Society of Animal*

Production (ESAP). 28-30 August 2000, Addis Ababa, Ethiopia.

Eicker, S., Grohn, Y. and Hertl, J. 1996. The association between cumulatie milk yield, days open and days to first breeding in New York Hostein cows. *Journal of Dairy Science*, 79: 235-241.

Meadows, C., Rajala-schultz, R., Frazer, G., Meirin, R. and Hoblet, K. 2006. Evaluation of a contract breeding management program in selected Ohio dairy herds with event-time analysis I. Cox proportional hazards models. *Preventive Veterinary Medicine*, 77: 145-160.

Fatehi, J. and Schaeffer, L.R. 2003. Data management for the fertility project. Report to the Technical Committee of the Canadian Genetic Evaluation Board. http://cgil.uoguelph.ca/dcbgc/Agenda0303/FatehiReport.pdf

Kifaro, G.C. 1984. Production efficiency of Bos taurus cattle in Mbeya region. M.Sc. Thesis. *Sokoine University of Agriculture*, Morogoro, Tanzania. pp: 52-95.

Agyemang, K. and Nkhonjera, L.P. 1986. Evaluation of the productivity of crossbred dairy cattle on smallholder and Government farms in the Republic of Malawi. Research Report No. [12]*International Livestock Centre for Africa, Addis Ababa*, Ethiopia. P: 39. http://www.ilri.org/InfoServ/Webpub/Fulldocs/X5530e/x5530e00.htm

Balikowa, D. 1997. Reproductive and lactation performance of dairy cattle on small holder farms in Iringa and Mbeya regions. *MSc. Thesis. Sokoine University of Agriculture, Morogoro*, Tanzania. P: 177

Mahadevan, P. 1951. The effect of environment and heredity on lactation. *Journal Agricultural Science*, 41: 80-93.

Rensis, F.D. and Scaramuzzi, R.J. 2003. Heat stress and seasonal effects on reproduction in the dairy cow – a review. *Theriogenology*, 60, 1139-1151.

Jordan, E.R. 2003. Effects of heat stress on reproduction. *Journal of Dairy Science*, 86: 104-114.

Morton, J.M., Tranter, W.P., Mayer, D.G. and Johnson, N.N. 2007. Effects of environmental heat on conception rates in lactating dairy cows: critical periods of exposure. *Journal of Dairy Science*, 90: 2271-2278.

Kadzere, C.T., Murphy, M.R., Silanikove, N. and Maltz, E. 2002. Heat stress in lactating dairy cows: a review. *Livestock production science*, 77: 59-91.

Kumlu, S. and Akman, N. 1999. Milk yield and reproductive traits of holstein frisian breeding herds in Turkey. *Journal of Lalah livestock Research Institute*, 39: 1-15.