Reproductive Indices in Determining Regular Calving of Holstein-Friesian Cows Maintained under Intensive and Semi-Intensive Managements in Central Java

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ABSTRACT

Reproductive efficiency of dairy cows can be determined by various reproductive indices (RIs) as essential components of regular calving period. The aims of this research were to assess some RIs, correlate among those RIs and describe possible causes of their variation for Holstein-Friesian (HF) cows maintained under two different conditions in Banyumas district, Central Java. Data of reproduction of HF cows were collected for 458 records from a dairy breeding station (BS), 1992 – 2002, and for 417 records from a number of small dairy holders (SDH), 1996 - 2002. A number of RIs studied were intervals from calving to first service (CFS), first service to conception (FSC), days open (DO) and calving interval (CI). Pearson correlation method was used to correlate (r) among RIs. Simple regression up to the third levels was used to investigate the effects of individual RIs (CFS and FSC) on DO and (CFS, FSC and DO) on CI. Means of each RI of HF cows between the BS and SDH were compared by the least square technique of GLM analysis by considering location, age-, season- and year of calving as dependent variables. Location resulted in very significant effect (P<0.01) on CFS, DO and CI, at a range of 1.58 – 21.56 %. Adjusted means of CFS, FSC, DO and CI in the BS were 78, 22, 134 and 410 d respectively; and those in SDH were 91, 24, 156 and 427 d respectively. For both locations, FSC was a more major factor in affecting DO compared to CFS with the r value of FSC-DO almost twice the strength against CFS-DO (BS= 0.84 vs. 0.48; SDH= 0.82 vs. 0.44 %). Further, DO had the highest effect on CI compared to individual FSC or CFS, r value = 0.98 (the BS) and 0.97 (SDH. Lengthening each day of DO resulted in linearly increased CI of 0.99 d (the BS) and 0.98 (SDH). Major differences in RIs of HF cows in the current study compared to those in temperate and other tropical regions require definite researches in assessing various physiological and environmental factors affecting reproductive performance of HF cows under specific tropical region of Central Java.

Key words: reproductive indices, days open, Holstein-Friesian cows, tropical region

INTRODUCTION

Reproduction plays a key role to achieve profitability in a dairy production as an inefficient reproduction results in many kinds of adverse indicators such as less milk and fewer calves per cow per year, increased culling rates, slow genetic improvement, increased replacement cost, increased breeding cost or AI services and low net returns (Dekkers *et al*., 1998). It is desirable that cows have a good fertility because the more frequently a dairy cow calves, the greater is the amount of milk produced in her lifetime. According to Plaizier *et al*. (1997) inferior reproduction in dairy cattle causes a severe disadvantage in dairy production operation by reducing the amount of milk produced per cow per day of herd life, increasing breeding costs, intensifying the rates of voluntary and involuntary culling and slowing the rate of genetic progress for the traits of economic importance in a dairy herd.

Factors governing reduced reproductive performance in dairy cattle are numerous and often difficult to diagnose. Even under optimal conditions, the reproductive process is less than perfect because of the multiple factors which contribute to produce a live calf (Stevenson, 2001). Overall reproductive performance at a herd level is directly influenced by the reproductive activity of individual cows. A dairy cow is clearly fertile if she has the ability to conceive and maintain pregnancy after service at the appropriate time in relation to ovulation (Darwash *et al*., 1997). Any condition leading to failure in establishing a pregnancy following completion of uterine involution, on the other hand, results in sub-fertile or infertile cows. Failure to establish a pregnancy at the expected time after the peri-parturient period may reflect a number of abnormalities including failure to ovulate, failure to show oestrus, inappropriate pattern of ovarian cyclicity and loss of pregnancy that might be a reflection of dysfunction at the hypothalamic, pituitary, ovarian or uterine level, or in conceptus development (Royal *et al*. 2000). Challenges maintaining efficient reproduction in dairy cattle apparently include a complex process involving various factors of genetic, nutritional, physiological, management and environmental (Stevenson, 2001; Masama *et al*., 2003b; Shiferaw *et al*., 2005). An understanding this multitude of interrelated factors which can result in cows successfully becoming pregnant, therefore, is essential.

Calving interval has been considered as a practical and useful parameter to indicate the reproductive status of individual cows and the reproductive efficiency of a dairy herd. It is supposed that by maintaining optimal calving interval ensures efficient dairy reproductive management. Reproductive efficiency of dairy cows can be determined by calculating the periods of various reproductive indices (RIs) as essential components of the calving interval (Stevenson, 2001). These are mainly for the intervals from calving to first service, from first service to conception, days open and gestation length, besides the calving interval itself. Calculation of the duration of these reproductive parameters allows identification of various limiting factors associated with reproductive disorders which subsequently allows relevant adjustments to be undertaken for the improvement.

The aims of this research were to assess some RIs, correlate among those RIs and describe possible causes of their variation for Holstein-Friesian (HF) cows maintained under two different conditions of the tropical Indonesian climate in Banyumas district, Central Java.

MATERIALS AND METHODS

Materials

This dairy-field research was carried out in one government dairy breeding station (the BS) and a number of small dairy holders (SDHs) in Banyumas district, Central Java. The total area of Banyumas is 5,364 ha (4.04 %) of the total area of 132,759 ha of Central Java located between longitude 108^{o} 39'- 109^{o} 27' east and latitude 7^{o} 15'- 7^{o} 37' south. Almost half of Banyumas district is in the lowland, spreading out from the centre to the south and from the west to the east of the district. Banyumas can be classified into three regions according to its elevation, namely, the altitudes of 25 - 100 m (31.77 %), 100 - 500 m (30.42 %) and the remainder over 500 m (37.71 %) asl

Table 1. General management under the two locations of the BS and SDH

Description	BS	SDH
Dairy breed	Pure Holstein-Friesian.	Pure Holstein-Friesian.
Management	Large scale and intensive.	Small scale and semi intensive. (Group or individual dairy farmers)
Feeding.	Improved forages and recommended concentrate.	Mixture of forages and variable concentrate.
Reproduction.	Visual and recording heat detection, regular heat induction and palpating conception detection.	Visual heat detection, limited heat induction and visual detection on conception.
Calf rearing.	Artificially rearing.	Artificially rearing.
Heifer and cow rearing.	Different houses and feeding based on physiological status.	In similar stall and feeding as available.
Mating	Insemination using HF and Holstein frozen semen from AI institution in central Java.	Insemination using HF and Holstein frozen semen of AI institution in Central Java.
Milking.	Machine and hand - morning and afternoon.	Hand – morning and afternoon.

The dairy breeding station (the BS) was set up on a highland at the slope of Slamet Mountain over 1,500 m asl with an area of approximately 13.5 ha in Baturraden sub-district. Small dairy holders, which were developed under the supervision of the BS, have been located in five sub-districts of the overall 27 sub-districts in Banyumas district. Small dairy husbandries have been entirely developed within 25 villages from the five dairy sub-districts of Pekuncen, Cilongok, Karang Lewas, Baturraden and Sumbang for a total area of 32,960.5 ha, 24.83 % of the area of Banyumas. The development of these dairy villages has mostly been located on the relatively higher regions (above 140 m asl.) rather than those of sub-districts without dairy establishment. Table 1 describes the general management under the two research locations

Investigation into various aspects of reproduction of dairy HF heifers and cows in the present study was conducted in each location of the BS, SDH and Overall combining between two locations. Reproduction records used for the study were for HF cows kept during the period of 1992 - 2002 in the BS and during the period of 1996 - 2002 in SDH. Data were collected from the reproductive database which was recorded under the Breeding and Recording Sub-division of the BS. All these reproductive field data were recorded in daily book records and then entered into the computerized database using the recording packet program of Cow Search by the breeders and recorders under the supervision of the BS. The reproduction data of individual cows mainly consisted of the dates of birth, calving, service (or insemination) and conception as well as the number of services. Knowledge of these dates allowed a range of reproductive indices (RIs) to be calculated as presented in Table 2. There were no data collected on the reproductive physiology of the animals during the current research. The unavailability of physiological reproduction data resulted in constraints making impossible more specific investigation and discussion on the reproductive performance of HF cows in the current study. However it is confidently expected that by utilizing the available service and calving dates, will still yield essential information on the reproduction of HFs in both locations.

Methods

A number of reproductive indices (RIs) as contributing factors to regular calving interval were studied. These were: the intervals of calving to first service (CFS), first service to conception (FSC), days open (DO), gestation length and calving interval (CI) (Table 2). The final observations analyzed for individual RIs of CFS, FSC, DO, gestation and CI are presented in Table 3. They were obtained by extracting data on individual cows that had complete RIs. Outlier data identified through box plot distributions were omitted from the final analyses.

Various correlations between RIs of CFS, FSC, DO, gestation and CI of HF cows within location were calculated by Pearson correlation method. A number of simple regressions, up to the third levels of equation, were analyzed to investigate the effects of individual RIs (CFS and FSC) on DO and (CFS, FSC, DO and pregnancy) on CI for HF cows in each location.

Table 2. Various reproductive indices considered in the current study and their definition

Reproduct. indices (d)	Abbrev.	Definition
Age at first calving (mo)	AFC	Number of days from birth to first calving of animals
Calving - 1st service	CFS	Number of days from calving to first service
1st service – conception	FSC	Number of days from first service to subsequent conception (calculated only for cows that were confirmed pregnant).
Days open	DO	Number of days between parturition and subsequent conception (calculated only for cows that were confirmed pregnant).
Gestation length	-	Number of days from the last conception to subsequent calving
Calving interval	CI	Interval between two consecutive calving.
Services per conception	S/C	Number of services or inseminations required for conception (calculated only for cows that were confirmed pregnant).

Table 3. Reproductive performance (months) of Holstein-Friesian heifers and cows by location

Reproductive performance (days)	N	Mean	Median	SD	Min.	Max.
	Location					
	BS					
Calving - 1st service	458	86	80	39	25	190
1st service – conception	458	49	24	62	0	264
Calving – conception	458	136	120	70	31	334
Gestation	340	275	275	5	262	291
Calving interval	458	408	393	69	393	609
Services per conception*	527	1.84	2.0	1.0	1	6
	SDH					
Calving - 1st service	417	102	95	43	25	215
1st service – conception	417	49	19	66	0	279
Calving – conception	417	150	139	73	25	361
Gestation	253	273	274	6	256	292
Calving interval	417	418	404	74	280	653
Services per conception*	517	1.93	2.0	1.1	1	6
	Overall					
Calving - 1st service	878	94	86	41	25	215
1st service – conception	878	49	22	64	0	279
Calving – conception	878	143	129	72	25	361
Gestation	593	274	274	5	256	292
Calving interval	878	412	398	71	398	653
Services per conception*	1044	1.88	2.0	1.1	1	6

Note : * in score

To compare means of each RIs of HF cows in the BS and SDH, individual RIs was transformed into a normal distribution then analyzed by the least square technique of GLM analysis for unbalanced data with location, age-, season- and year of calving determined as dependent variables.

RESULTS AND DISCUSSION

Description on Reproductive Indices

Data on six reproductive indices (RIs) of HF heifers and cows providing CFS, FSC, DO, gestation length, CI and S/C in the BS, SDH and Overall are presented in Table 3. All these estimated reproductive parameters were calculated from the available information on the dates of services and calving of animals from the computerized reproductive data base in the BS. Following calving, the gravid uterus has to return to a non-gravid state and sexual cycle must be resumed to achieve conception. The efficiency of these two critical reproductive processes, along with the efficiency of artificial insemination, is reflected in estimates of various components of inter-calving interval. The description of each RI, which contributes to calving interval, is essential in quantifying general reproductive performance of Holstein cows within and between locations.

Each RI of CFS, FSC, DO and CI had the same observational number for 417 records. This was because the final data for analyses were obtained by including only animals possessing complete information on all the RIs which are determinant components of CI in order to achieve consistent values. This decision risked under estimation of the respective RIs due to the exclusion of the reproduction data of culled cows. The exclusion of data on incomplete RIs could mean the exclusion of animals which had inherent low fertility and failed to conceive or animals which were culled due to management reasons such as poor milk yield, diseases etc. Excluding animals with low fertility from the analysis is equivalent to truncating/censoring the data. By contrast, the final observations on gestation length of HF cows in both locations were obtained after omitting the identified outlier data of the previous RI completing CI (417 records). The exclusion of the identified outlier gestational data decreased the number of observations, by respectively 25.8 % in the BS (from 458), 39.3 % in SDH (from 417) and 32.5 % in Overall (from 878).

As presented in Table 3, means for CFS, DO and CI of HF cows in the BS (86, 136 and 408 d) were shorter compared to those of HF cows in SDH (102, 150 and 418 d) and the ranges of the respective RIs were also narrower in the BS (25 – 190 d, 31 – 334 and 393 – 609 d) than those in

SDH (25 – 215, 25 – 361 and 280 – 653 d). All these RIs of HF cows in both locations had wide ranges indicating they were highly variable. Means of FSC in both locations were similar (49d), but the range was narrower in the BS (0 – 264 d) compared to SDH (0 – 279 d). Mean of gestation length of HF cows in SDH was slightly shorter than that in the BS (273 vs. 275 d), but its range was longer in SDH than in the BS (256 – 292 d vs. 262 – 291 d). The values for mean and median for the gestation length were the same in the BS (275 d) and similar in SDH (273 vs. 274 d). This indicates that the distribution of gestation of HFs in the current study followed a normal distribution.

Frequencies of the distribution for individual RIs at each location are not given here. However, there was generally a positive skewed pattern of most RIs both in BS and SDH. The typically positive skewed distribution which normally exists for reproduction traits is clearly identified for CFS, DO and CI in both locations. These were marked by the higher values of the mean to the median. Nevertheless, different skewed positive distributions existed for FSC distribution compared to the former with the highest frequency, as would be expected, occurred at the FSC 0 d showing the majority of heifers conceive at the first insemination. The results revealed that reproductive performance of HF cows in the BS was better than that in SDH meaning that generally HF cows in the BS were better in expressing reproductive performance than HF cows in SDH. By combining the two sets of reproduction data the mean and the median of each RI in Overall was in between values for the BS and SDH.

Comparison among Reproductive Indices

Compared to the means of CFS of HFs and other temperate dairy breeds, the mean CFS of HF cows in the BS (86 d) was longer than the range of 70 – 86 d HFs and other temperate breeds maintained under temperate regions of USA (Moore *et al*., 1990; Simerl *et al*., 1991), The Netherlands (Ouweltjes *et al*., 1996) and Sweden (Avel and Örnsro, 2001). This FCS was also longer than the range of 76 – 80 d for HF cows kept under tropical regions of India (Dhaliwal *et al*., 1996), but it was comparable to the CFS range of 63 – 92 d of Friesian kept in temperate regions of Italy (Bagnato and Oltenacu *et al*., 1994). The mean CFS of HF cows in SDH (102 d) was shorter than the range of 106 – 115 of the CFS of various exotic crosses kept in tropical regions of Bangladesh (Islam *et al*., 2002) and Philippines (Alejandrino *et al*., 1999). These results indicate that the CFS of the HFs maintained under intensive management in the BS was comparable to the CFS of HFs raised in some temperate and many tropical regions and the CFS of HF cows kept under SDH were comparable to those of Holsteins maintained in some tropical regions.

Some studies have reported that the period from first service to subsequent conception of HFs and some temperate breeds to be within a range of 22 – 45 d in USA (Simerl *et al*., 1992) and The Netherlands (Ouweltjes *et al*., 1996). A similar range of the FSC of 26 – 49 d was observed for HFs in tropical region of India (Dhaliwal *et al*., 1996). The mean of the FSC of 49 d for HF cows in the present study are within the range of FSC of HFs in India (Dhaliwal *et a*., 1996), but longer than the range for FSC of some temperate breeds in USA (Simerl *et al*., 1992) and The Netherlands (Ouweltjes *et al*., 1996). The median values of FSC for HF cows in the present study were considerably shorter than their means both in the BS (24 vs. 49 d) and in SDH (19 vs. 49 d). As presented in Table 2, this was because the highest frequency of HF cows conceived at the first time they were inseminated in both locations (BS = 45 %, SDH = 45 %).

The means from calving to conception or DO, as the summation of the two periods of CFS and FSC, were shorter in the BS (136 d) than the SDH (150 d). The ranges for DO of HF cows in both locations varied considerably, 31 – 334 d in the BS and 25 – 361 d in SDH. Large variation of DO in both locations was definitely a result of high variation in the two determining indices of CFS and FSC. This was similar for CI in which the range was narrower in the BS than in SDH (BS = 393 – 609 d, SDH = 280 – 653 d). It is likely that the wide ranges in CI were predominantly determined by the large variation in DO rather than gestation length. A previous study pointed out the duration of gestation is fairly constant and can not be shortened significantly without adversely affecting the health or viability of the new born (Bazer and First, 1980). The mean DO of HF cows in the BS was longer compared to those within a range of 72 – 128 d of HFs, temperate breeds and crossbreeds maintained both in temperate and tropical regions in USA (Moore *et al*., 1990; Luna-Dominguez et al., 2000; and Simerl *et al*., 1994), Sweden (Avel and Örnsro, 2001), India

(Dhaliwal *et al*., 1996), Israel (Arbel *et al*., 2001), Tanzania (Msanga and Bryant, 2003), Turkey (Türkyilmaz, 2005) and Tunisia (Salem *et al*., 2006). The mean DO for HF cows in both locations of the BS and SDH were comparable to the values of 134 – 159 d for Holsteins in USA (Oseni *et al*., 2003) and 123 – 154 d in Turkey (Kaya *et al*., 2003). Other studies reported longer DO within a range of 186 – 284 d for HFs and crossbreds in tropical regions of Philippines (Alejandrino *et al*., 1999) and Pakistan (Niazi and Aleem, 2003). These results show that the DO HF cows in both locations were comparable to DO of HFs and crossbreds in some temperate and tropical regions. However, to achieve the recommendation of 90 days open, attention should continue to be focused on reducing both CFS and FSC.

A number of previous studies on temperate dairy breeds either in temperate and tropical regions have reported the mean gestation length in a range of 278 – 282 d. The means of gestation period of HF cows in the present study (BS = 275 d, SDH= 273 d) were lower than this range. Referring to Table 3, various studies have reported CI of both temperate breeds and their crossbreds maintained in temperate regions were between 335 – 445 d, but the CI tended to be longer (436 – 734 d) for temperate dairy breeds and their crossbreds maintained under tropical regions such as in Philippines (Alejandrino *et al*., 1999), Sudan (Ageeb and Hayes, 2000), Pakistan (Niazi and Aleem, 2003), Ethiophia (Shiferaw *et al*., 2005) and Zimbabwe (Ngongoni *et al*., 2006). The mean CI of HF cows in the BS (408 d) and SDH (418 d) were comparable to the HFs and other temperate dairy breeds kept in some temperate and tropical regions.

The number of services required for HFs conceiving either in the BS (mean = 1.84, median = 2.0) and SDH (mean = 1.93, median = 2.0) were high compared to the range of 1.58 – 1.68 for HFs and temperate dairy breeds maintained in temperate regions of USA (Moore *et al*., 1990) and The Netherlands (Ouweltjes *et al*., 1996). The S/C of HFs in both locations were also higher than the means of 1.27 – 1.65 of HFs and exotic breeds reared in some tropical regions of Philippines (Alejandrino *et al*., 1999) and Malawi (Chagunda *et al*., 2004); however they were still comparable to some previous studies in India (Dhaliwal *et al*., 1996), Pakistan (Niazi and Aleem, 2003), Turkey (Türkyilmaz, 2005) and Tunisia (Salem *et al*., 2006).

Phenotypic Correlation and Regression among RIs

Table 4 presents coefficients (R) of the phenotypic correlation between various RIs as determinant factors of regular calving of HF cows for all locations. CFS was correlated negatively to FSC at a low level (BS = -0.09, SDH = -0.15, overall = -0.12), but the correlations were significant ($P<0.05$) both in SDH and Overall. As expected both CFS and FSC were correlated positively to DO with a higher R value resulting from correlating DO to FSC than to CFS across locations. The R value of the FSC and DO correlation resulted in almost twice the strength when compared to that of the CFS and DO correlation for HF cows in each location of the BS (0.84 vs. 0.48 %), SDH (0.82 vs. 0.44 %) and Overall (0.82 vs. 0.47 %). This implies FSC is a more dominant factor in differentiating DO compared to CFS.

Consistently, a similar situation occurred for CI, the two factors of CFS and FSC positively correlated to CI, with the R value for the FSC and CI correlation was higher than the CFS and CI correlation in the BS (0.79 vs. 0.50 %), SDH (0.80 vs. 0.44 %) and Overall (0.80 vs. 0.47 %). In contrast, correlating gestation length to CI resulted in only small R values across locations varying from 0.04 to 0.14, however, the correlation was statistically significant in SDH ($P<0.05$). These results support the previous finding that the two factors of CFS and FSC are the dominant factors affecting CI with FSC being the more important. Gestation had a relatively small effect on CFS and FSC on CI, but it significantly affected on CI of HF cows in SDH ($P<0.05$). As was expected, the DO and CI correlation resulted in the highest R value because DO was resultant from the factors of CFS and FSC. Some possible factors might result in the differentiation on the periods from CFS, FSC and gestation length as the three most important periods in determining the length of calving interval of HF cows in this study.

Table 4. Phenotypic correlation among reproductive indices of Holstein-Friesian cows by location

Reproductive indices (d)	BS			SDH			Overall		
	1st M-C	DO	CI	1st M-C	DO	CI	1st M-C	DO	CI
Calving – 1st service	-0.09[ns]	0.48**	0.50**	-0.15**	0.44**	0.44**	-0.12*	0.47**	0.47**
1st service conception		0.84**	0.79**		0.82**	0.80**		0.82**	0.80**
Days open			0.98**			0.97**			0.98**
Pregnancy			0.04[ns]			0.14*			0.07[ns]

Table 5. Coefficients of the linear regressions to predict days open and calving interval from various reproductive indices of Holstein-Friesian cows by location

Estimator	Predictor	BS			SDH			Overall		
		a	b	R^2 (%)	a	b	R^2 (%)	a	b	R^2 (%)
DO	CFS	61.54	0.858	22.4	72.74	0.762	19.4	66.50	0.812	21.7
	FSC	89.13	0.944	69.6	106.4	0.902	66.8	97.51	0.923	67.4
CI	CFS	333.5	0.857	24.5	341.3	0.783	18.9	336.7	0.825	22.3
	FSC	365.8	0.924	63.0	373.1	0.893	63.9	369.0	0.910	63.5
	DO	277.1	0.988	96.0	272.8	0.981	94.3	275.8	0.981	95.1

A number of simple regressions up to the third levels of equation were analyzed to investigate the effects of individual RIs (CFS and FSC) on DO and (CFS, FSC, DO and pregnancy) on CI of HF cows for each location of the BS, SDH and Overall. Coefficient regressions from various simple linear regressions developed to describe the effects of individual RIs (CFS and FSC) on DO and (CFS, FSC and DO) on CI are presented in Table 5. As both a quadratic and a cubic expression of each corresponding RI resulted in no significant effect on either DO or CI, these equations are not presented here. Based on coefficient determination (R^2) of various simple linear regressions obtained, the effect of the linear regression of FSC, compared to that of CFS, resulted in higher R^2 values in describing the changes on DO and CI. For the respective locations of the BS and SDH, the linear regression of DO on CFS resulted in R^2 values (22.4 and 19.4) which were lower than those of the linear regression of DO on FSC (69.6 and 66.8). Certainly, the highest R^2 values were obtained, for the BS and SDH, by regressing CI on DO (0.99 and 0.98) rather than on CFS (24.5, 18.9) or on FSC (63.0, 63.9). This was, as previously described, due to the fact that DO is the summation of the periods of CFS and FSC.

Various coefficient regressions (b), obtained to describe the changing DO by lengthening of CFS and FSC or to describe the changes in CI by delaying CFS, FSC and DO for the three locations are also presented in Table 5. Based on the coefficient regressions obtained successively for the BS, SDH and Overall, it can be predicted that for each day delay in CFS of HF cows resulted in prolonged DO of 0.86, 0.76 and 0.81 d respectively; whereas for each day delay FSC of HF cows resulted in a prolonged DO of 0.94, 0.90 and 0.92 d respectively. Further for the respective locations, a delay of one day in CFS caused a lengthened CI of 0.86, 0.78 and 0.83; while a one day delay in FSC resulted in a prolonged CI of 0.92, 0.89 and 0.91 d respectively. In the case of DO as a predictor of CI, for each day prolonged DO it can be estimated to lengthen CI by 0.99 d in the BS, 0.98 d in SDH and 0.98 d in Overall.

The Effect of Location on RIs of Holstein-Friesian

Least square analyses for Overall resulted in location was a major factor in affecting CFS, DO, gestation and CI ($P<0.001$) with the exception of FSC which was not significantly influenced by location ($P>0.05$). The contribution of location to the variation in individual RIs, presented by the coefficient of variations or R^2 values (R^2 = variable SS / total SS %), were significant. The R^2 values for the effect of location on CFS, DO, gestation and CI respectively were 3.41, 2.06, 7.16 and 1.50 %. In contrast, a small non-significant location effect resulted for FCS (0.01 %). Adjusted means of CFS, FSC, DO and CI in the BS were 78, 22, 134 and 410 d respectively; and those in SDH were 91, 24, 156 and 427 d respectively.

All these statistics support the previous results that there was a considerable difference in the reproductive performance of HF cows reared under the two dairy production systems of an intensive management in the BS against mainly semi intensive management in SDH. Some factors that may cause the inferior reproduction of HF heifers and cows in the SDH are described. The general inferiority in feeding, management, raising animals, insemination services, health services and treatment, and housing of animals in SDH might be major factors. Daily heat stress was possibly another factor resulting in low reproduction of HF cows in SDH. All these factors might cause cows in SDH to be more susceptible to many kinds of reproductive disorders, such as failed oestrus and ovulation, reduced conception rate, decreased pregnancy rates and increased reproductive diseases. As well as the limited technical aspects, constraints in social factors such as the skill and knowledge of small dairy farmers to take daily decisions about their farms and animals might also be important in reducing both reproduction and production of the animals.

CONCLUSIONS

Reproductive performance of HF heifers and cows in the current study, represented by individual RIs of CFS, FSC, DO and CI, was mostly in a wide range and higher than the recommended values indicating that cows showed delayed calving regularly in each year. FSC was a more important factor in affecting both DO and CI compared to CFS. DO, as the summation of CFS and FSC, had the highest effect on CI compared to individual FSC or CFS, while gestation length had only a minor effect on CI. Any favorable factors of genetics, nutrition, physiology, management and environment could result in reduced individual RIs, whilst unfavorable conditions caused prolonged individual RIs.

Reproductive performance of HF cows in the BS was superior to that in SDH which might be due to higher genetic potential of the animal and better factors of feeding, management, health treatment and services, reproductive treatment and preventive diseases in the BS. More favourable climate and housing management in reducing heat stress could be another factor resulting in better reproductive performance of HF cows in the BS to SDH.

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