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REGULAR ARTICLES

Study on reproductive performance of Holstein x Lai Sind crossbred dairy heifers and cows at smallholdings in Ho Chi Minh City, Vietnam

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Abstract The reproductive performance of Holstein x Lai Sind crossbred dairy heifers and cows was evaluated at smallholdings in Ho Chi Minh City (HCMC). The data of 232 heifers and 244 cows (261 lactations) from 35 small dairy farms was collected over a 2-year period, from 2013 to 2014. The overall mean for age at first service (AFS), days between first and last service (DFLS), and age at conception (AC) of heifers was 479 (±80), 38 (±80), and 517 (±114) days, respectively. Average number of services per conception (NSC), conception rate (CR), and conception rate at first service (CRFS) was 1.8 (±1.4), 55, and 58%, respectively. The overall mean for the waiting period (WP), DFLS, and days open (DO) of cows was 109 (±52), 133 (±114), and 242 (±129) days, respectively. The mean for NSC, CR, and CRFS was 4.3 (±2.7), 23, and 14%, respectively. A very significant decrease in AFS and AC according to the year of birth, and a significant increase in AFS according to body weight at first insemination (>320 kg) were observed. The CRFS of heifers inseminated in 2013 was significantly higher than in 2014. Monthly mean CR in heifers and cows was negatively correlated with THI. The WP, DFLS, DO, and NSC of cows significantly decreased according to the year of calving. Cows that calved in rainy season had a significantly longer WP than in dry season. The occurrence of postpartum (PP) diseases was accompanied by an increase in WP, DO, and NSC. A decrease in body condition score (BCS) between calving and 60th day (C60) and also between 60th and 120th day of lactation resulted in a significant increase in WP and DO. A decrease in BCS between C60 was also accompanied by a considerable reduction in CRFS of cows. Season and BCS at insemination had a significant effect on NSC and CR of cows. Reproductive performance was satisfactory for heifers, but poor for cows. Losses of BCS during the first months of lactation and at insemination were the major risk factors for this poor performance. Moreover, the season had a more negative effect on fertility in cows than in heifers.

Keywords Holstein x Lai Sind crossbred · Reproductive performance · Risk factors · Smallholdings · Vietnam

Introduction

There are 227,600 dairy cattle in Vietnam but total production only meets 26.4% of the country's milk needs estimated at 2086 million tons per year (General Statistics Office of Vietnam 2015).

In Vietnam, nearly half (45.3%) of the national dairy herd is distributed between approximately 8000 small dairy farms around HCMC (GSOVN 2015).

Poor reproductive performance is a major factor responsible for a reduction in the profitability of dairy farms (Grohn and Rajala-Schultz 2000). Many studies were carried out in tropical or subtropical conditions with a similar climate to Vietnam, such as Ghana (Apori and Hagan 2014), Thailand (Buaban et al. 2015), Iran (Ansari-Lari et al. 2009; Atashi et al. 2012), Brazil (Knob et al. 2016), Ethiopia (Fekadu et al. 2011; Tadesse et al. 2010), and China (Wu et al. 2012). They have reported an average birth-first calving interval (AFC) between 801 and 1265 days and a calving interval (CI) between 381

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and 561 days. The average number of insemination per pregnancy of heifers and cows in these environments was between 1.5 and 1.6 (Buaban et al. 2015; Chebel et al. 2007) and between 1.5 and 3.4 (Avendano-Reyes et al. 2010; Buaban et al. 2015; Fekadu et al. 2011; Guo et al. 2014; Inchaisri et al. 2013; Tadesse et al. 2010; Wu et al. 2012), respectively.

Our study, the first to our knowledge done in Vietnam, aims to describe reproductive performance and to evaluate the relationship between individual or environmental factors and the parameters of this performance in small dairy farms in the tropics.

Materials and methods

Study area

The study was conducted in Cu Chi district, HCMC, 10° 35′ N and 106° 30′ E. The area studied is characterized by a tropical monsoon climate with a rainy (RS) (May to October) and a dry season (DS) (November to April). The average highest (31 °C) and lowest (26 °C) temperatures of the year are observed in April, and during December and January, respectively. The average annual rainfall is 1949 mm. Average humidity is between 62% in the DS and 82% in the RS (World Weather Online 2015).

Study population

A total of 35 dairy smallholdings comprising 650 cattle were observed. These farms have an average of nine cows and five heifers aged over 7 months. The animals are kept permanently indoors. Their diet consists of fodder (*Pennisetum purpureum* and natural grass and rice straw) concentrates and by-products (spent grain and cassava waste).

During 2013 and 2014, 232 heifers and 244 cows (261 lactations) were examined by transrectal palpation, ultrasound (KX5200, a linear probe of 6.5 MHz), and vaginoscopy. The diagnostic criteria were as follows: dystocia, which refers to calving that requires manual intervention (Mee 2008); retained placenta (RP) was defined as non-expulsion of fetal membranes 24 h after calving (Beagley et al. 2010); uterine infection (clinical endometritis and pyometra) was defined according to the criteria proposed by Sheldon et al. (Sheldon et al. 2006); an ovarian cyst was defined as the presence of a smooth, more or less compressible structure with a diameter >25 mm and without corpus luteum in the ovaries (Hanzen et al. 2008); urovagina consists of an accumulation of urine in the vaginal cavity (Hanzen et al. 2013); postpartum anestrus (PA) was defined as the lack of expression of oestrus after 50 days PP (Hanzen et al. 2013); and the types of PA were classified according to the criteria defined by Peter et al. (Peter et al. 2009).

Reproductive parameters

The reproductive performance traits were age at first service (AFS), days between first and last service (DFLS), age at conception (AC) (for heifer), waiting period (WP), calving to conception interval or days open (DO) (for cows), number of services per conception (NSC), conception rate (CR) (which reflects the ratio multiplied by 100 of the number of pregnant animals out of the total number of inseminations performed on these animals), and conception rate at first service (CRFS).

Statistical analysis

The dependent variables of this study are all traits of reproductive performance. The independent variables are binary: years of birth or calving, season of birth or calving, weight at first service (WFS), year of AI or calving, season of AI, BCS at calving (BCSC) and at insemination (BCSI), parity, type of calving, retained placenta, uterine infection, a decrease in BCS from calving to 60 day PP (DBCS1), and decrease in BCS from 60 to 120 day PP (DBCS2).

The general linear model procedure (Minitab 17.0) was used to evaluate the effects of independent variables on dependent variables of heifers (AFS, AC, and NSPC) (model 1) and cows (WP, DO, and NSPC) (model 2). The effect of independent variables on DFLS was not analyzed because this variable contains "zero" values, which means a pregnancy was obtained at first insemination. The Chi-square χ^2 test was used to assess the effect of independent variables on CR and CRFS of heifers and cows. The data was transformed into the natural logarithm before analysis because of the usual assumption of homogeneity of variance.

Model 1 (heifers): $Y_{\mathrm{jkln}} = \mu + S_{\mathrm{j}} + A_{\mathrm{k}} + W_{\mathrm{l}} + e_{\mathrm{jkln}}$

Where Y_{jkln} = AFS, AC, and NSPC of *n*th heifer born in *j*th season, in *k*th year and of *l*th WFS; μ = overall mean; S_{j} = effect of *j*th season of birth; A_{k} = effect of *k*th year of birth; W_{l} = effect of *l*th WFS; e_{jkn} = random error.

Model 2 (cows): $Y_{\mathrm{nijqflhkm}} = \mu + P_{\mathrm{n}} + A_{\mathrm{i}} + S_{\mathrm{j}} + T_{\mathrm{q}} + R_{\mathrm{f}} + P_{\mathrm{l}} + B0_{\mathrm{h}} + C1_{\mathrm{k}} + C2_{\mathrm{m}} + e_{\mathrm{nijqflhkm}}$

Where Y_{ijhklm} = WP, DO, and NSPC of *n*th cow in *n*th parity, *i*th year of calving, *j*th season of calving, *q*th type of calving, *f*th presence of RP, *l*th presence of uterine infection, *h*th BCS at calving, *k*th change in BCS from calving to 60 day PP (CH1), and *m*th change in BCS from 60 to 120 day PP (CH2); μ = overall mean; P_{n} = effect of *n*th parity; A_{i} = effect of *i*th year of calving; S_{j} = effect of *j*th season of calving; T_{q} = effect of *q*th type of calving; R_{f} = effect of *f*th presence of RP; P_{l} = effect of *l*th presence of uterine infection; $B0_{\mathrm{h}}$ = effect of

hth BCS at calving; $C1_k$ = effect of kth CH1; $C2_m$ = effect of mth CH2; and $e_{nijqflhkm}$ = random error.

Results

Productive performance and postpartum diseases

The body weight and average daily gain of heifers at 6, 12, and 16 months of age were 159, 280, and 351 kg and 690, 646, and 705 g/day, respectively. The recorded average daily milk yield per cow was 11.6 (±0.5) kg over the 2-year period. This milk yield ranged between 9.1 and 14.4 kg/cow/day depending on the farm. Neither the farm nor the season had a significant effect on milk production.

Postpartum diseases were assessed on the basis of 353 postpartum periods of 302 cows. The frequency of dystocia and RP was 24.4 and 16.4%, respectively. The vaginal examination of 249 cows between 21 days PP to first service identified the presence of abnormal vaginal discharge (clinical endometritis) in 19.2% of cases. Urovagina was identified in 5.6% of cows. More than half (137/251) of the observed cows (54.6%) were not detected in oestrus by the farmer during the first 50 days PP.

Reproductive performance

The reproduction characteristics of heifers and cows are presented in Table 1. The overall mean of AFS, DFLS, and AC of heifers in this study was 479 (±80), 38 (±80), and 517 (±114) days, respectively. Length of pregnancy, measured for 140 heifers, averaged 274 ± 14 days. Thus, the average AFC was 791 days (±114 days) (26.4 months). Mean NSPC, CR, and CRFS for heifers were 1.8 (±1.4), 55, and 58%, respectively.

The reproductive parameters (WP, DFLS, DO, NSPC, CR, and CRFS) of 261 lactations from 244 pregnant cows were determined. The overall mean of WP, DFLS, and DO was 109 (±52), 133 (±114), and 242 (±129), respectively. The mean for NSPC, CR, and CRFS was 4.3 (±2.7), 23, and 14% (Table 1).

Factors affecting reproductive performance of heifers

The results show a significant decrease ($P < 0.001$) in AFS and AC according to the year of birth. An increase in AFS was significantly accompanied by a heavier weight (>320 kg) at first service (481 vs. 441 days). Other variables (season of birth, season of insemination, BCSI) had no significant effect on the reproductive performance traits of heifers. The CRFS was significantly ($P < 0.05$) higher in 2013 than in 2014 (64 vs. 50%). The CR (59 vs. 52%) and CRFS (64 vs. 53%) of heifers born or inseminated in DS were higher than in RS, but the differences were not significant (Table 2). Monthly mean CR in heifers was negatively correlated with the temperature and humidity index (THI) ($r = -0770$, $P = 0.003$) (Table 3).

Table 1 Reproductive performance of Holstein x Lai Sind crossbred dairy heifers and cows

Reproductive traits	Heifers ($n = 232$) ($\bar{X} \pm$ SD)	Cows ($n = 261$) ($\bar{X} \pm$ SD)
AFS/WP (days)	479 ± 80	109 ± 52
DFLS (days)	38 ± 80	133 ± 114
AC/DO (days)	517 ± 114	242 ± 129
NSC	1.8 ± 1.4	4.3 ± 2.7
CR (%)	55	23
CRFS (%)	58	14

AFS age at first service, *DFLS* days between first and last service, *AC* age at conception, *WP* waiting period, *DO* days open, *NSC* number of services per conception, *CR* conception rate, *CRFS* conception rate at first service

Factors affecting the reproductive performance of cows

The reproductive parameters concern 261 lactations of 244 pregnant cows (Table 4). A significant decrease in WP (159 vs. 85 days), DFLS (174 vs. 100 days), DO (333 vs. 185 days), and NSPC (4.9 vs. 3.7) with an increase according to the calving year (2012 vs. 2014) was recorded in this study. A significant increase in WP (116 vs. 101 days) was observed after calving occurring during the RS. These parameters were not significantly different between primiparous and multiparous cows and not influenced by dystocia, RP, or BCSC. Inversely, the presence of PP disorders (puerperal metritis, clinical endometritis, pyometra, or urovagina) was accompanied by an increase in WP (108 vs. 98 days), DO (249 vs. 216 days), and NSPC (4.7 vs. 3.9).

A DBCS1 (≥1 unit) and DBCS2 resulted in a very significant increase in WP and DO (Table 4). A loss of BCS (≥1 unit) during the first 2 months of lactation also leaded to a very significant reduction in CRFS (8 vs. 18%).

The year and season of insemination, BCSI had a very significant effect on NSPC and CR. The mean of NSPC and CR in cows inseminated in 2014 were significantly ($P < 0.001$) lower (3.5 vs. 6.3) and higher (28.7 vs. 15.9%) than in 2013. Similarly, in cows inseminated during the RS, these two parameters were significantly ($P < 0.001$) higher (5.5 vs. 3.4) and lower (18.2 vs. 29.8%) than during the DS. NSC was significantly higher (7.0 vs. 3.3) for cows with a BCSI <2.5 ($P < 0.001$), with a lower CR (14.4 vs. 29.9%) among cows with a BCSI ≥2.5.

There was a negative correlation between monthly CR in cows and THI ($r = -0645$, $P = 0.02$). This rate decreased gradually from January (35%) to July (11%), while THI increased from January (76.6) to May (84) and then slightly decreased from May to July. It was lowest (11%) in July and highest in

Table 2 Factors affecting the reproductive performance of heifers

Factors	No	AFS (days) ($\overline{X} \pm SD$)	DFLS (days) ($\overline{X} \pm SD$)	AC (days) ($\overline{X} \pm SD$)	NSC ($\overline{X} \pm SD$)	CR (%)	CRFS (%)
Total	232	479 ± 80	38 ± 80	517 ± 114	1.8 ± 1.4	55	58
Year of birth							
2011	72	$530^{a} \pm 73$	51 ± 105	$581^{a} \pm 125$	1.9 ± 1.8	53	67
2012	103	$478^{b} \pm 72$	39 ± 78	$517^{b} \pm 100$	1.8 ± 1.1	56	53
2013	57	$417^{c} \pm 52$***	21 ± 34	$438^{c} \pm 64$***	1.8 ± 1.3	57	54
Season of birth							
Rainy	125	473 ± 76	38 ± 78	511 ± 109	1.8 ± 1.2	54	54
Dry	107	486 ± 84	38 ± 83	524 ± 120	1.8 ± 1.5	57	62
WFS							
≤320 kg	63	441 ± 63	47 ± 105	488 ± 130	2.0 ± 1.5	50	46
>320 kg	88	481 ± 84**	34 ± 62	515 ± 98	1.8 ± 1.0	56	53
Year of service							
2013	126				1.8 ± 1.1	54	64
2014	106				1.8 ± 1.6	56	50*
Season of service							
Rainy	122				1.9 ± 1.4	52	53
Dry	110				1.7 ± 1.3	59	64
BCSI							
<3.5	99				1.9 ± 1.2	54	56
≥3.5	133				1.8 ± 1.5	56	59

AFS age at first service, *DFLS* days between first and last service, *AC* age at conception, *NSC* number of services per conception, *CR* conception rate, *CRFS* conception rate at first service, *WFS* weight at first service, *BCSI* body condition score at insemination

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$

December (38%), periods when THI was 80 and 79, respectively (Table 3).

Discussion

According to our study, AFC (791 days) was much lower than that observed in Brazil (847 days) (Knob et al. 2016), Ghana (1146 days) (Apori and Hagan 2014), and Thailand (987 days) (Buaban et al. 2015) for Holstein crossbred heifers. This difference might result from the effect of recommendations for Vietnamese dairy farmers to breed their Holstein crossbred and pure breed heifers from 15 months of age, when they have reached a weight of 280 and 320 kg, respectively (Dairy Vietnam 2012). The average AFC of heifers mainly depends on the AFS. The AFS in this study (479 days) was much earlier than that of Holstein crossbred heifers reported in Thailand (687 days) (Buaban et al. 2015). The fertility of heifers in our study (1.8) expressed by NSC is similar to that observed in Ethiopia (Tadesse et al. 2010) and in China (Guo et al. 2014). The CR is lower than that of Holstein heifers in the USA (60.8%) (Chebel et al. 2007). The CRFS (58%) is lower than that of Holstein crossbred heifers in Thailand (68%) (Buaban et al. 2015). These differences can be explained by the effect of nutritional (Le Cozler et al. 2009) or environmental factors (heat stress) (Bilego et al. 2013). Our study observed a significant decrease in AFS and AC according to year of birth. Similar results were reported by other authors in Iran (Ansari-Lari et al. 2009). This result is probably related to the significant effect of the birth year on WFS. The weight of heifers born in 2011 and 2012 was in fact heavier than that of heifers born in 2013 (340 ± 45 vs. 318 ± 40 kg; $P < 0.01$).

The reproduction parameters of cows (WP, DFLS, and DO) were 109, 133, and 242 days, respectively. Whereas the average length of gestation calculated on the basis of 115 cows

Table 3 Monthly average THI values and CR (%) of heifers and cows during 2013 and 2014

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
THI	76.6	78.6	80.5	82.3	83.6	81.7	80.2	80.8	81.3	81.3	80.9	78.6
CR in heifers (%)	70.8	52.8	54.3	51.5	32.3	53.7	55.3	62.5	43.2	55.6	55.6	70.6
CR in cows (%)	34.9	28.8	23.3	20.8	17.6	13.5	10.8	25.6	25.0	19.4	32.0	37.8

Heifers: $r = -0.770$; $P = 0.003$; Cows: $r = -0.645$; $P = 0.02$

Temperature and humidity index (THI) was calculated as follow: $THI = (1.8 \times T_{db} + 32) - [(0.55 - 0.0055 \times RH) \times (1.8 \times T_{db} - 26.8)]$ (National Research Council 1971)

Table 4 Factors affecting the reproductive performance of cows

Factors	n	WP (days) ($\overline{X} \pm SD$)	DFLS (days) ($\overline{X} \pm SD$)	DO (days) ($\overline{X} \pm SD$)	NSC ($\overline{X} \pm SD$)	CR (%)	CRFS (%)
Total	261	109 ± 52	133 ± 114	242 ± 129	4.3 ± 2.7	23	14
Parity							
Primiparous	117	108 ± 52	130 ± 115	238 ± 133	4.3 ± 2.8	23	16
Multiparous	144	109 ± 51	135 ± 113	245 ± 125	4.3 ± 2.7	23	12
Year of calving							
2012	52	$159^{a} \pm 58$	$174^{a} \pm 130$	$333^{a} \pm 145$	$4.9^{a} \pm 3.1$	20.4	10
2013	139	$102^{b} \pm 44$	$134^{ab} \pm 118$	$236^{b} \pm 129$	$4.3^{ab} \pm 2.8$	23.0	14
2014	70	$85^{b} \pm 32$***	$100^{b} \pm 76$**	$185^{c} \pm 79$***	$3.7^{b} \pm 2.1$*	26.7	17
Season of calving							
Rainy	134	$116^{a} \pm 59$	126 ± 123	242 ± 147	4.1 ± 2.8	24	15
Dry	127	$101^{b} \pm 42$*	140 ± 103	241 ± 107	4.5 ± 2.6	22	13
Type of calving							
Normal	188	103 ± 43	127 ± 111	230 ± 117	4.2 ± 2.6	24	15
Dystocia	44	91 ± 43	115 ± 89	206 ± 106	4.1 ± 2.3	24	11
Retained placenta							
No	196	100 ± 43	126 ± 110	226 ± 118	4.2 ± 2.6	24	15
Yes	36	102 ± 45	119 ± 94	221 ± 104	4.0 ± 2.2	25	8
Uterine infection							
No	165	98 ± 42	119 ± 106	216 ± 115	3.9 ± 2.5	26	17.0
Yes	67	108 ± 44*	141 ± 109	249 ± 114**	4.7 ± 2.7**	21	7.5
BCSC							
<3.5	141	99 ± 45	123 ± 106	222 ± 112	4.1 ± 2.6	24	16
≥3.5	91	102 ± 40	128 ± 109	230 ± 121	4.2 ± 2.5	24	12
DBCS1							
<1	143	86 ± 38	114 ± 106	200 ± 110	4.0 ± 2.6	25	18
≥1	89	124 ± 40***	143 ± 107	267 ± 112***	4.5 ± 2.5	22	8*
DBCS2							
≥0	156	98 ± 41	117 ± 103	214 ± 113	4.0 ± 2.6	25	17
<0	76	106 ± 46*	142 ± 114	248 ± 118*	4.4 ± 2.4	23	9
Year of service							
2013	75				6.3 ± 2.1	15.9	16
2014	186				3.5 ± 2.8***	28.7***	13
Season of service							
Rainy	114				5.5 ± 2.4	18.2	12
Dry	147				3.4 ± 2.9***	29.8***	15
BCSI							
<2.5	61				7.0 ± 2.3	14.4	10
≥2.5	200				3.3 ± 2.8***	29.9***	15

WP waiting period, *DFLS* days between first and last service, *DO* days open, *NSC* number of services per conception, *CR* conception rate, *CRFS* conception rate at first service, *BCSC* body condition score at calving, *DBCS1* decrease in BCS from calving to 60 day PP, *DBCS2* change in BCS from 60 to 120 day PP, *BCSI* body condition score at insemination

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$

was 276 ± 6 days, which means the average CI was 518 days. This figure was greater than that of Holstein crossbred or purebred cows reported in other tropical or subtropical countries such as Iran (403–421 days) (Ansari-Lari et al. 2009, 2010; Atashi et al. 2012), Brazil (381–445 days) (Knob et al. 2016), Ethiopia (446–475 days) (Tadesse et al. 2010; Yalew et al. 2011), Thailand (426 days) (Buaban et al. 2015), Ghana (391 days) (Apori and Hagan 2014), and China (398–448 days) (Guo et al. 2014; Wu et al. 2012).

In agreement with previous reports (Apori and Hagan 2014; Fekadu et al. 2011; Tadesse et al. 2010), a significant improvement in reproductive performance according to the year of calving was observed in this study. There was a positive effect resulting from regular reproductive monitoring at the 35 farms involved in our study.

The increase in WP of cows that give birth during the RS could result from the indirect effect of a significant increase in THI (81.5 vs. 79.9, $P < 0.001$). A similar effect has been observed in Brazil (Bilego et al. 2013). Several studies have shown the negative effects of heat stress on BCS through a reduction in intake capacity, follicular growth (Kornmatitsuk et al. 2008), the resumption of PP ovarian cyclicity (Kornmatitsuk et al. 2008; Rensis and Scaramuzzi 2003), and on the quality of heat detection (Fekadu et al. 2011; Kornmatitsuk et al. 2008). This could result in an increase in DO (Tadesse et al. 2010).

The absence of the negative impact of dystocia and RP on reproductive traits in the present study contradicts previous observations. The negative effect of clinical endometritis and urovagina on fecundity and fertility has also been reported in previous studies (Carneiro et al. 2014; Gautam et al. 2010). BCSC had no effect on fertility in this study. This is in contrast to observations reported in Thailand (Inchaisri et al. 2013). A DBCS1 and DBCS2 resulted in an increase in WP, DFLS, and DO in this study. This observation matches that of several authors (Avendano-Reyes et al. 2010; Carvalho et al. 2014). A loss of BCS in dairy cows reflected a negative energy balance. This was accompanied by an increase in serum non-esterified fatty acid concentration whose negative effect on follicular growth and oocytes quality has been demonstrated (Dominguez 1995).

The NSC in our study was far greater than in Ethiopia (Fekadu et al. 2011; Tadesse et al. 2010), Thailand (Buaban et al. 2015; Inchaisri et al. 2013), Iran (Ansari-Lari et al. 2010), and China (Guo et al. 2014; Wu et al. 2012), which ranged between 1.5 and 2.5. This naturally results in a lower CRFS in the present study than that reported in Thailand (27.2–52.0%) (Buaban et al. 2015; Inchaisri et al. 2013), Brazil (31.2–34.0%) (Knob et al. 2016), China (34%) (Wu et al. 2012), and Iran (41.6%) (Ansari-Lari et al. 2010). The impact of the season and BCSI was more obvious in cows than in heifers. Better fertility was observed in cows inseminated in DS than in RS ($P < 0.001$). Many studies reported that the season had a significant effect in some cases (Avendano-Reyes et al. 2010; Bilego et al. 2013; Fekadu et al. 2011) and less significant in others (Ansari-Lari et al. 2010; Tadesse et al. 2010). This effect is more probably due to a reduction in THI than to a lack of feed in DS. A THI value equal or superior to 73 or 74 is considered the heat stress threshold for German cows (Schuller et al. 2014) or Thai Holstein cows (Boonkum and Duangjinda 2015), respectively. Owing to the climate conditions in Vietnam, this threshold is practically exceeded all year round. An increase in THI is accompanied by a decrease in oestral signs and therefore in their detection. It actually results in a reduction in steroid synthesis by dominant follicles (Rensis and Scaramuzzi 2003). It also leads to a decrease in oocyte quality (Ferreira et al. 2011; Payton et al. 2011) and in early embryo development (Gendelman et al. 2010; Sakatani et al. 2012). In Holstein x Gir crossbred heifers, a negative seasonal effect on the number of follicles, their diameter and the corpus luteum diameter, as well as on serum progesterone concentration was reported (Bilego et al. 2013). At the same time, the favorable impact of an increase in BCSI was also demonstrated (Carvalho et al. 2014). This results from an improvement in oocyte quality (Dominguez 1995).

Conclusion

Reproductive performance was satisfactory for heifers, but poor for cows. Infertility and postpartum anestrus were the major problems. The improvement in reproductive performance over the years may have resulted from the reproductive monitoring program. Losses of BCS during the first months of lactation and at insemination were major risk factors leading to poor reproductive performance. Season had a more negative effect on fertility in cows than in heifers.

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Compliance with ethical standards

Conflict of interest All benefits in any form from a commercial party related directly or indirectly to the subject of this manuscript or any of the authors must be acknowledged. The authors declare that they have no conflict of interest.

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