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Original Article

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Abstract

The objectives of this study were to analyze the potential impact of heat stress on reproduction in different regions of Thailand, to determine the monthly distribution of calving throughout the year and to investigate environmental sources of variation of days-open (DO) in first lactation dairy cows. Data including 13,548 lactation records were collected during 2004 to 2006. Climate data were obtained from the provincial meteorological stations and the corresponding temperature-humidity indexes were calculated. The difference between regions in THI was determined. The geographical regions studied were: Central, Eastern, Northeastern, and Northern. The distribution of calving by month was determined in the 1st to 5th lactation. The effect of month of calving (MOC) on DO was determined only in first lactation dairy cows. The fixed effects in the model included MOC, region and MOC x region. The lowest mean THI was observed in December (72) and the highest mean THI in April (80). THI differed significantly between regions (p<0.0001), and months (p<0.0001). Significant interactions between region and month (p<0.0001) were found for THI. In all regions, minimum THI values were observed in December and January and this effect was more pronounced in the Northeastern and Northern regions. The highest frequency of calving for the first lactation was observed in June (9.96%) and the lowest in February (6.63%). The highest frequencies of calving for the 2nd (13.1%), 3rd (14.1%), and 4th (14.66%) lactation cows were observed in September while for the 5th lactation cows was in October (14.91%). The lowest proportion of calving for 2nd (5.02%) and 4th (4.14%) lactation cows was in February, and in March for the 3rd (4.35%) and 5th (4.85%) lactation cows. The average DO in first lactation cows was 152 days. Significant effects of MOC (p<0.0001) and region (p<0.0001) were found on DO. February calving cows had the longest DO (219±11 days) while cows calving in October and November had a significantly shorter mean DO (133±7 days). The study indicates that the high proportion of cows calving in October and November corresponds to breeding success in the previous months of December and January, which are the coolest months of the year. Cows which calved during hot months had a prolonged DO period of several months.

Keywords: dairy cow, days open, month of calving, region, Thailand

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บทคัดย่อ

ความแตกต่างของช่วงระยะเวลาที่คลอดในภาคและเดือนที่ต่างกันต่อระยะวันท้องว่างในโคนมในประเทศไทย

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การศึกษานี้มีวัตถุประสงค์ เพื่อศึกษาถึงการกระจายของการคลอดของโคนมในแต่ละเดือนในรอบปี และศึกษาถึงผลของเดือนที่คลอดต่อระยะวันท้องว่างในโคนมที่ให้นมครั้งแรก การศึกษานี้ได้รวบรวมข้อมูลระยะการให้นมระหว่างปี พ.ศ. 2547-2549 จำนวน 13,548 ข้อมูล และได้นำข้อมูลสภาพภูมิอากาศจากสถานีตรวจอากาศในจังหวัดที่ทำการศึกษาหรือจังหวัดใกล้เคียงที่สุดมาคำนวณค่า THI (Temparature-Humidity Index) โดยแบ่งเป็นภาคกลาง ภาคตะวันออก ภาคตะวันออกเฉียงเหนือ และภาคเหนือ เพื่อศึกษาความแตกต่างของค่า THI วิเคราะห์การกระจายของการคลอดในแต่ละเดือนในโคที่ให้นมครั้งที่ 1-5 และวิเคราะห์ข้อมูลผลกระทบของเดือนคลอดต่อระยะท้องว่างโดยกำหนดให้เดือนที่คลอด ภาค ความสัมพันธ์ระหว่างเดือนที่คลอดและภาค เป็นตัวแปรคงที่ ผลการศึกษาพบว่า เดือนที่มีค่า THI ต่ำที่สุด คือ เดือนธันวาคม โดยมีค่า THI เฉลี่ยเท่ากับ 72 และเดือนที่มีค่า THI สูงที่สุด คือ เดือนเมษายนโดยมีค่า THI เฉลี่ยเท่ากับ 80 ค่า THI ในแต่ละภาค (p=0.0001) และในแต่ละเดือน (p=0.0001) มีความแตกต่างกัน มีความสัมพันธ์ระหว่างภาคและเดือนต่อค่า THI ในทุกภาค ค่าเฉลี่ย THI ต่ำสุดพบในเดือนธันวาคมและมกราคม ค่า THI ต่ำอย่างชัดเจนในภาคตะวันออกเฉียงเหนือและภาคเหนือ เดือนที่มีความถี่ของการคลอดสูงสุดในโคที่ให้นมครั้งแรก คือ เดือนมิถุนายน (9.96%) และต่ำที่สุดในเดือนกุมภาพันธ์ (6.63%) เดือนที่มีความถี่ของการคลอดสูงสุดในโคระยะให้นมที่ 2 (13.1%) โคระยะให้นมที่ 3 (14.1%) โคระยะให้นมที่ 4 (14.66%) คือ เดือนกันยายน และโคระยะให้นมที่ 5 (14.9%) คือ เดือนตุลาคม เดือนที่มีความถี่ของการคลอดต่ำสุดในโคโคระยะให้นมที่ 2 (5.02%) โคระยะให้นมที่ 4 (4.14%) คือ เดือนกุมภาพันธ์ และมีความถี่ของการคลอดต่ำสุดในเดือนมีนาคมสำหรับโคระยะให้นมที่ 3 (4.35%) โคระยะให้นมที่ 5 (4.85%) ค่าเฉลี่ยวันท้องว่างในแม่โคนมที่ให้นมครั้งแรกเท่ากับ 152 วัน ระยะวันท้องว่างได้รับผลกระทบจากเดือนที่คลอด (p<0.0001) และ ภาค (p<0.0001) โคที่คลอดในเดือนกุมภาพันธ์มีระยะวันท้องว่างยาวที่สุด (219±11 วัน) ส่วนโคที่คลอดในเดือนตุลาคมและพฤศจิกายนมีระยะวันท้องว่างสั้นที่สุด (133±7 และ 133±7 วัน) การศึกษานี้ชี้ให้เห็นว่าความถี่ของการคลอดของโคนมในประเทศไทยสูงในเดือนตุลาคมและพฤศจิกายนซึ่งเป็นผลจากความสำเร็จของการผสมในเดือนธันวาคมและมกราคม เป็นที่น่าสังเกตว่าแม่โคที่คลอดในช่วงอากาศร้อนจะมีระยะวันท้องว่างยาวกว่าแม่โคที่คลอดในช่วงอากาศเย็น

คำสำคัญ: โคนม วันท้องว่าง เดือนที่คลอด ภาค ประเทศไทย

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Introduction

In Thailand, the introduction of extensive dairy development took place in the early 1960s. Typical Thai dairy farm is characterized as a smallholder farm with less than 20 lactating dairy cows. Heat stress becomes the most important limitation for optimizing reproductive efficiency and economic importance of dairy farming (Rodtian et al., 1996; Kornmatitsuk et al., 2008). It was well documented that the adverse effect of heat stress on reproductive efficiency in dairy cows included impaired follicular development, delayed postpartum ovulation, altered intensity and estrus expression, reduced pregnancy rate and higher embryonic loss (De Rensis and Scaramuzzi, 2003). The synthetic Temperature and Humidity Index (THI), which takes into account both ambient temperature and relative humidity, is widely used for measuring heat stress in lactating dairy cows. THI value >72 indicates a situation of mild to extreme heat stress for lactating dairy cows (Armstrong, 1994). In high-yielding dairy cows raised in subtropical climates, the cows were said to be exposed to heat stress when temperatures were above 25 or 26°C (Berman et al., 1985). The impact of season of calving on subsequent reproduction has also been evaluated in many studies. Cows calving in spring and summer have the longest calving to calving intervals, they required more services per conception and presented a longer open period (Ray et al., 1992; Jordan et al., 2002). Days-open (DO) is one of the variables which is most commonly used to measure fertility performance in dairy cattle. This is a complex trait that is affected by many factors such as season of calving, management policies, herd size, production level, lactation number and AI technique (Oseni et al., 2003). DO has become accepted as one of the best single measures of reproductive efficiency in dairy cows (Norman et al., 2002). Due to lack of information on the distribution of calving and the potential effect of heat stress on DO in dairy cows in Thailand, the present study was designed to evaluate the potential impact of heat stress on reproduction in different regions of Thailand, to determine the monthly distribution of calving throughout the year and to investigate environmental sources of variation of days-open (DO) in first lactation dairy cows.

Materials and Methods

Data were obtained from the Bureau of Biotechnology in Livestock Production, Department of Livestock Development, Ministry of Agriculture and Cooperatives. These data contained information from 13,548 lactation records collected over the years 2004 to 2006. Data were initially edited to eliminate duplicate records. Calving intervals (CI) were calculated as the interval between two consecutive calvings. A total of 7,968 calving records including first to fifth lactation were used to determine the frequency of calving by month and express as percentage of calving by month for each lactation. Days Open (DO) was computed using the following equation; DO = CI-280, where 280 represents the gestation period. DO was chosen to be used in the analysis in this study because we wished to place this study in the context of practical dairy farm management and to investigate the proper time to inseminate cows. Only first lactation cows with CI between 320 and 700 days and age at first calving between 720 and 1,080 days were included in the final data set. This procedure resulted in 1,962 records from first lactation cows to be available for analysis. Regions were classified as Central, Eastern, Northeastern, Northern and Southern. However, the Southern region was not included in the analysis since data were only available from one province. The data included in the analysis were obtained from 11, 6, 6, and 8 administrative provinces in the Central, Eastern, Northeastern and Northern regions respectively.

Daily meteorological data obtained over the years 2004-2006 from the 25 official provincial meteorological stations covering 31 provinces were included in the study. The temperature and humidity index (THI) was calculated for each month of calving as follows (García-Ispierto et al., 2007);

THI = (0.8 x Mean Temp) + (RH/100) x (Mean Temp-14.4) + 46.4

Where; Mean Temp = mean temperature (°C) and RH = relative humidity (%)

Statistical analyses: Data were analyzed using Statistical Analysis Systems (SAS Institute Inc., version 9.0, Cary, NC, USA). The effect of regions on THI and the impact of month of calving (MOC) on DO were analyzed by analysis of variance (Procedure GLM). The fixed effect of region, MOC, and the interaction between region and MOC were included in the model. The frequency of calving in each month was expressed as a percentage of the total number of calvings in a year. Significant differences are reported at $p<0.05$.

Results

The overall monthly means of maximum and minimum temperature, relative humidity (RH) and THI throughout the year are shown in Fig 1. Maximum temperatures were observed to range between 30°C in December and up to 36°C in April. Minimum temperatures were in a range between 18°C (December and January) and up to 24°C (April to September). RH ranged from 66% in December to 81% in September and THI ranged from 72 in December to 80 in April.

The monthly means of THI (Fig 2) were different throughout the year ($p<0.0001$) and monthly THI among regions were different ($p<0.0001$). For all regions, THI means were higher ($p<0.0001$) between April and September than in the other months. Also, Central and Eastern regions had very similar THI values which were higher ($p<0.0001$) than those observed in Northeastern and Northern regions from October to April and during this period THI in the Northern region was lower than the Northeastern region ($p<0.0001$). In all regions, minimum THI values were observed in December and January and this effect was more pronounced in Northeastern and Northern regions.

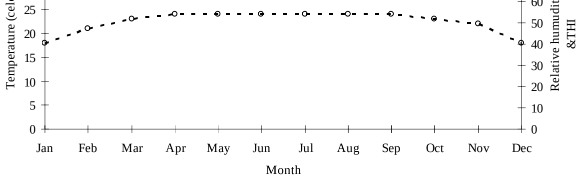

Figure 1 Monthly mean of maximum and minimum temperature, relative humidity (RH) and temperature-humidity index (THI).

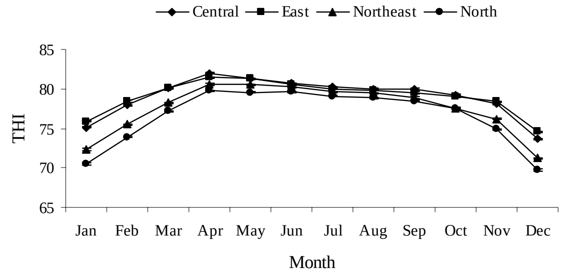

Figure 2 Temperature-humidity index (THI) in the Central, Eastern, Northeastern, and Northern regions in pooled data from the years 2004 to 2006. LSmean±SEM.

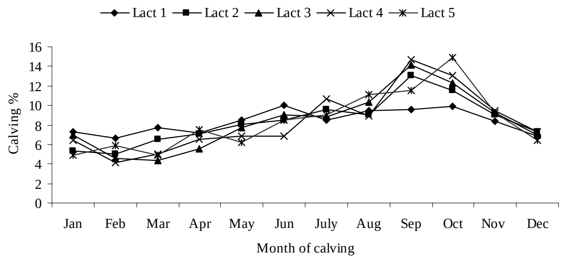

Figure 3 The percentage of calvings throughout the year in dairy cows (lactation 1 to 5), data obtained over the years 2004 to 2006.

The frequency of calving was the lowest from December to February and then increased gradually to reach a maximum in September and October (Fig 3). There was, for all lactation ranks, a marked decline in the percentage of cows that calved in November. The effect of the month on the frequency of calving was less pronounced in the first lactation than the other lactation ranks, the most striking differences in relation to month being observed for ranks 4 and 5.

The average DO in first lactation cows was 152 days. There were also effects of the MOC (p<0.0001) and region (p<0.0001) on the length of DO. There was no interaction between MOC and region on DO (p=0.13). The cows which calved in February had the longest DO (219±11 days) and the cows which calved in October and November had the shortest DO (133±7 days, Fig 4). The mean DO length decreased from February to October/November and then increased in cows calving from December to February. The DO in first lactation cows of the Central, Eastern, Northeastern, and Northern regions were 183±4, 172±7, 177±7 and 138±7 days, respectively. The DO in the Central, Eastern and Northeastern regions were not statistically different but were higher than the DO in the cows in the Northern region (p<0.0001).

Fig 5 presents the distribution of DO in first lactation cows in pooled data, and the "extreme" months, i.e. February vs. October/November. In pooled data, the distribution shows a peak at around 71-100 days followed by a slow decline. For cows calving in October/November, the peak of relatively short DO was more marked and very few cows

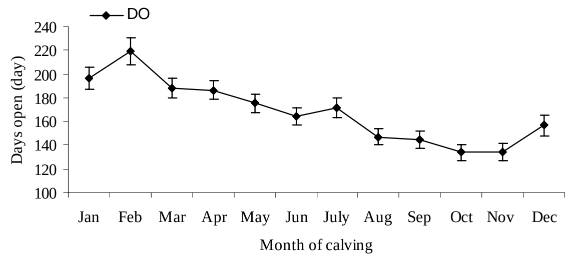

Figure 4 Least square means of days-open (DO) in first lactation cows by month of calving calculated from data over the years 2004-2006. LSmean±SEM.

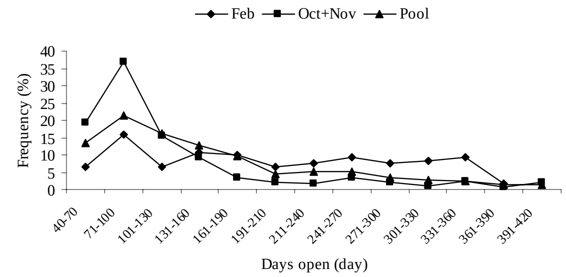

Figure 5 Distribution of days-open in first lactation cows by month of calving. Where; Pool: pooled data from each month of calving, Feb: days-open for a February calving cow representing the month of calving with the highest DO, and Oct + Nov: days-open for an October/November calving cow representing the month of calving with the lowest DO.

conceived after 190 days. On the contrary, for cows that calved in February, a lower percentage of cows were pregnant within a short DO period and the percentage of cows with a long DO remained high even for the longest delay registered. For each class interval of DO between 160 days and 360 days, this percentage was relatively high and close to 10%.

Discussion

The climate data from four regions indicated that dairy cows in Thailand exposed to heat stress throughout the year. Mean THI from October to March fell within the range of mild stress (72 to 78) and mean THI from April to September fell in the range of severe stress (>78 to 89; Armstrong, 1994). Our data also showed that potential heat stress was dependant on regional variations, the cows in the Central and Eastern regions being more exposed than in the Northern and Northeastern regions.

In this study, THI calculated from daily meteorological data might not accurately reflect the degree of heat stress suffered by shed dairy cows. However, in Thailand, most cows are raised in conventional open side barns. Thus, temperature and humidity in the barns follow those observed outside. It has been accepted that there are several factors implicating in the poor reproductive performance. In Thailand, heat stress is considered as one of the main factors affecting reproductive performance in dairy cows (Aiumlamai, 2007).

In the present study, the average days-open (152 d) in first lactation cows was shorter than DO of 183 days reported by Virakul et al. (2001). However, the latter DO was computed from all lactation ranks and the lower value reported here probably just illustrates and confirms the unfavorable effect of ageing or increasing rank of lactation on dairy cow fertility (Humblot et al., unpublished data). The effect of MOC on the frequency of calving was less pronounced in the first lactation than for the other lactation ranks. Thus, the effect of MOC on DO in this study may be slightly underestimated since only first lactation cows were used in the analysis. In addition to this, in the present study, the data set was edited to only include cows with a calving interval between 320 and 700 days. Thus, extreme problem cows which had DO longer than 700 days were excluded from the study and this may have contributed to the shorter DO observed. MOC had a highly significant effect on DO in dairy cows and it was related to tropical climate changes in Thailand. These results are in agreement with those from a previous report in the United States in which DO was longer for spring-calving cows and shorter for fall-calving cows (Oseni et al., 2003). This trend was attributed to depressed fertility during the summer months, when spring calving cows are ready for rebreeding. High ambient temperature during the summer has been implicated in reduced fertility observed in this season (Wolfenson et al., 2000). In the present study, DO was longer for February calving cows and shorter for October/November calving cows. Based on the fact that the voluntary waiting period postpartum before rebreeding is about 50 days, cows which calve in February need to be rebred in April when they are exposed to high temperature and THI, whereas cows calving in October/November reach the time for post-calving rebreeding in the cool months of December or January when mean temperature and THI are low. This is in agreement with numerous studies in which a marked decrease in conception rate has been reported during the hot season (De Rensis and Scaramuzzi, 2003; García-Ispierto et al., 2007). Kornmatitsuk et al. (2008) also observed that dairy cows had higher conception rates during the cool season, required less services per conception and subsequently had a shorter open periods.

An intentional delay by the farmer due to poor conception rates in the summer period, when the late cool-calving cows and early summer-calving cows are to be rebred, is one of the possible reasons to explain long DO. We found that DO were different between regions. The lowest DO was observed in the Northern region. This is logical in view of the fact that the mean THI of the Northern region was lower than the other regions. Our results indicated that the negative effects of heat stress on cow reproduction in this region were lower than the other regions. Conception rate is higher when cows are inseminated during the cool periods compared to hot periods (De Rensis and Scaramuzzi, 2003). The length of DO found in this study (138 days) was similar to the length of DO (131 days) reported previously for the Northern region (Punyapornwithaya and Teepatimakorn, 2004). The mean THI of the Central and Eastern regions was similar throughout the year, but the length of DO in the Eastern region was lower than the Central region, although not statistically so. Even though the mean THI was lower, the length of DO was higher in the Northeastern compared to the Central and Eastern regions. There are several factors implicated in the success of conception (De Rensis and Scaramuzzi, 2003, Chebal et al., 2004). Extended DO in the Northeastern region may be related to insufficient feed supply during the dry season leading to poor nutritional status. Such a situation may exacerbate the adverse effect of heat stress on fertility (Butler, 2003; Humblot et al., unpublished data) due to specific additional effects of these two factors on oocyte quality and early embryonic survival (Leroy et al., 2008).

Considering the calving pattern (Fig 3), it shows that the highest calving rate was obtained around September/October. These cows conceived in the previous December/January period. The conception rate was high in December/January since they are cool months of the year resulting in most cows calving in the subsequent September/October. Calving rate in lactation number 2, 3 and 4 increased dramatically from August and reached the highest rate in September. Similar to the cows in lactation number 5, the calving rate had increased dramatically from September and reached the highest rate in October. The pattern of calving was not similar to those of first lactation cows. Calving rates in August to November were only slightly changed and were lower when compared to the other lactation ranks.

The highest calving rate in first lactation cows occurred in June. The calving pattern in first lactation cows can partly be explained by management. Since a lot of cows reached their expected calving date around August to October, they became dry cows around June. The difference between the percentage of calvings in the highest and the lowest calving months of first lactation cows were low compared to older cows and the profile of calving fluctuated only slightly. This figure indicated that the heifers were inseminated throughout the year and that the conception rates in heifer were not different between months. However, the calving rate of the second lactation cows was highest in September corresponding to the high conception rate in the previous December/January. Therefore, it can be implied that there were some first lactation cows that reached the time for rebreeding after January and had an extended DO until December or next January

The highest frequency of DO in pooled data was observed at 71-100 days post-calving. The rate of decline from 71-100 to 191-210 days was steep and slow thereafter. The representation of the longest and shortest DO according to calving month followed the same pattern as that of the pooled data. For February calving cows, the frequency of DO was around 40 to 130 days and lower than that observed in October/November-calving cows. The frequency in February-calving cows was greater at around 160 days than in October/November-calving cows. This pattern implies that farmers inseminate cows at any period of the year. However, the conception rate in February-calving cows which should be rebred in

April was low and required the highest numbers of services per conception. In Thailand, Pongpiachan et al. (2003) reported that estrus detection rate and success rate of artificial insemination were high from November to January. Others found that the first AI conception rate was high in the cool season of November to February compared to the hot season of March to May (Kornmatitsuk et al., 2008).

Conclusion

In conclusion, there were regional variations in THI which affected the length of DO. A high proportion of cows calved in September corresponds to successful breeding in the previous December/January when THI was low. Cows rebred postpartum in hotter months had longer DO than those rebred in cooler months. From the present study, the authors suggest that dairy cows, especially replacement heifers, should be inseminated from November to February to calve from August to November.

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References

Aiumlamai, S. 2007. Health, production and research in dairy cattle in Thailand. Proceedings of the 33rd Thai Veterinary Medical Association, Bangkok, 31 October- 2 November, 2007, pp 301-317.

Armstrong, D.V. 1994. Heat stress interaction with shade and cooling. J Dairy Sci. 77: 2044-2050.

Berman, A., Folman, Y., Kaim, M., Mamen, M., Herz, Z., Walfenson, D., Arieli, A. and Graber, Y. 1985. Upper critical temperatures and forced ventilation effects for high-yielding dairy cows in subtropical climate. J Dairy Sci. 68(6): 1488-1495.

Butler, W.R. 2003. Energy balance relationships with follicular development, ovulation and fertility in postpartum dairy cows. Livest Prod Sci. 83: 211-218.

Chebel, R.C., Santos, J.E.P., Reynolds, J.P., Cerri, R.L.A., Juchem, S.O. and Overton, M. 2004. Factors affecting conception rate after artificial insemination and pregnancy loss in lactating dairy cows. Anim Reprod Sci. 84(3-4): 235-255.

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

García-Ispierto, I., López-Gatius, F., Bech-Sabat, G., Santolaria, P., Yániz, J.L., Nogareda, C., De Rensis, F. and López-Béjar, M. 2007. Climate factors affecting conception rate of high producing dairy cows in northern Spain. Theriogenology 67: 1379-1385.

Jordan, E.R., Schouten, M.J., Quast, J.W., Belschner, A.P. and Tomaszewski, M.A. 2002. Comparison of two timed artificial insemination (TAI) protocols for management of first insemination postpartum. J Dairy Sci. 85: 1002-1008.

Kornmatitsuk, B., Chantaraprateep, P., Kornmatitsuk, S. and Kindahl H. 2008. Different types of postpartum luteal activity affected by the exposure of heat stress and subsequent reproductive performance in Holstein lactating cows. Reprod Dom Anim. 43: 515-519.

Leroy, J., Van Soom, A., Opsomer, G. and Bols, P. 2008. The interaction between metabolism and fertility at the level of the oocyte. In Proceeding of the 25th World Buiatrics Congres. Factors affecting reproductive performances in the cow. O. Szenci and Bajcsy (eds), pp 172-181.

Norman, H.D., Miller, R.H., VanRaden, P.M. and Wright, J.R. 2002. Genetic relationships among fertility traits of Holsteins and Jerseys. J Dairy Sci. 85 (Suppl. 1): 89 (Abstr.)

Oseni, S., Misztal, I., Tsuruta, S. and Rekaya, R. 2003. Seasonality of days open in US Holsteins. J Dairy Sci. 86: 3718-3725.

Pongpiachan, P., Rodtian, P. and Ota, K. 2003. Effects of tropical climate on reproduction of cross- and purebred Friesian cattle in Morthen Thailand. Aust J Anim Sci. 16(7): 952-961.

Punyapornwithaya, V. and Teepatimakorn, S. 2004. Reproductive efficiency of dairy cows in the northern part of Thailand. Chiang Mai Vet Med J. 2: 3-8.

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. J Dairy Sci. 75: 2976-2983.

Rodtian, P., King, G., Subrod, S. and Pongpiachan, P. 1996. Oestrous behaviour of Holstein cows during cooler and hotter seasons. Anim Reprod Sci. 45: 47-58.

Virakul, P. et al. 2001. Study and correction of reproductive failures and early embryonic loss in dairy cow. Final Report of Thailand Research Fund. 192 pp.

Walfenson, D., Roth, Z. and Meidan, R. 2000. Impaired reproduction in the heart stressed cattle: basic and applied aspects. Anim Reprod Sci. 60-61: 535-547.