รายงานการวิจัยฉบับสมบูรณ์

โครงการ

A Survey of Calving Seasons on

Dairy Reproductive Performance and

Milk Production under Tropical Conditions.

โดย

นางสาวศรีอาภา คงดี

นิสิตโครงการปริญญาเอกกาญจนาภิเษก

มิถุนายน 2551

สัญญาเลขที่ BGJ4680014.

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สนับสนุนโดยสำนักงานกองทุนสนับสนุนการวิจัย

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SRIAPA KHONGDEE

ABSTRACT

Data from 537 crossbred cows (87.5 % Holstein × 12.5% *Bos indicus*) from Sakol Nakhon Research and Breeding Centre, Department of Livestock Development, Ministry of Agriculture and Cooperatives and data from the Department of Meteorology, Ministry of Transport and Communications, during 2000-2002 were utilized to determine the effect of the calving season on reproductive performance and milk production of the cows under tropical climatic conditions. The results revealed that daily variations in meteorological parameters were much less in the rainy season than the other seasons. This means that the cows were heat stressed more consistently in rainy season. The mean THI values ($P<0.01$) for Winter, Summer and Rainy seasons were 71.25, 78.03 and 77.56, respectively.

The results also revealed that the crossbred cows that calved during the summer months had lower milk production and reproduction performance than cows that calved in either the winter or rainy seasons. The FCM 4% values for Winter, Summer and Rainy seasons were 10.70, 9.85, and 9.51 kg/d, respectively and the days open values ($P<0.05$) for Winter, Summer and Rainy seasons were 156.43, 194.46 and 141.86 days, respectively. It is suggested that in the monsoonal area, in order to take advantage of the low maximum air temperature and more availability of green feed, dairy cows should be aimed to calve in the mid rainy season. This will reduce the days open and increase milk production at the same time. Further research should examine ways to increase the performance of heat stressed cows in small scale dairy farms through genetic improvement, by increasing heat tolerance and lowering the ambient temperature of the animal house under the tropical conditions.

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บทคัดย่อ

จากการศึกษา 537 โคนมลูกผสม (87.5% Holstein x 12.5%*Bos. indicus*) จากสถานีวิจัยและทดสอบพันธุ์สัตว์สกลนครตั้งแต่ 2000 – 2002 ถึงฤดูกาลที่โคนมคลอดโดยศึกษาผลของระบบสืบพันธุ์และปริมาณการให้ผลผลิตของโคนมภายใต้สภาพแวดล้อมที่ร้อนชื้น ผลการทดลองมีความแตกต่างกันระหว่างสภาพภูมิอากาศเพียงเล็กน้อยในช่วงฤดูฝนเมื่อเทียบกับฤดูกาลอื่นๆ หมายรวมถึงแม้แต่ในฤดูฝนโคนมยังประสบปัญหาความเครียดเนื่องจากความร้อนแต่ค่า THI มีนัยสำคัญที่ P<0.01 ในฤดูหนาว, ฤดูร้อน และฤดูฝนตามลำดับโดยมีค่าที่ระดับ 71.25, 78.03 และ77.56.

จากผลการทดลองจะเห็นได้ว่าโคนมที่คลอดในช่วงฤดูร้อนจะมีปริมาณการให้ผลผลิตน้ำนมและระบบสืบพันธุ์ต่ำกว่าโคนมที่คลอดช่วงฤดูหนาวและฤดูฝน ค่า FCM 4% ที่ฤดูหนาว ฤดูร้อน และฤดูฝนมีค่า 10.70, 9.85 และ 9.51 กก./วัน เฉพาะฤดูหนาวมีนัยสำคัญทางสถิติของค่า Days open ที่ระดับ P<0.05 มากกว่าฤดูร้อนและฤดูฝนตามลำดับดังนี้ 156.43, 194.46 และ 141.86 วัน แนะนำให้โคนมคลอดช่วงกลางฤดูผลจะมีหญ้าอาหารสัตว์อุดมสมบูรณ์เพียงพอในขณะเดียวเป็นการลดจำนวน Days open และเพิ่มปริมาณผลผลิตน้ำนมไปด้วย งานวิจัยนี้เพื่อการศึกษาการเพิ่มประสิทธิภาพการผลิตของโคนมในฟาร์มขนาดเล็กเพื่อลดความเครียดเนื่องจากความร้อนและพัฒนาไปสู่ genetic ที่ทนต่อสภาพแวดล้อมเครียดโดยการใช้วิธีการดัดแปลงโรงเรือนเพื่อลดอุณภูมิภายใต้สภาพอากาศที่ร้อนชื้น

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A Survey of Calving Seasons on Dairy Reproductive Performance and Milk Production under Tropical Conditions

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ABSTRACT

Data from 537 crossbred cows (87.5 % Holstein × 12.5% *Bos indicus*) from Sakol Nakhon Research and Breeding Centre, Department of Livestock Development, Ministry of Agriculture and Cooperatives and data from the Department of Meteorology, Ministry of Transport and Communications, during 2000-2002 were utilized to determine the effect of the calving season on reproductive performance and milk production of the cows under tropical climatic conditions. The results revealed that daily variations in meteorological parameters were much less in the rainy season than the other seasons. This means that the cows were heat stressed more consistently in rainy season. The mean THI values ($P<0.01$) for Winter, Summer and Rainy seasons were 71.25, 78.03 and 77.56, respectively.

The results also revealed that the crossbred cows that calved during the summer months had lower milk production and reproduction performance than cows that calved in either the winter or rainy seasons. The FCM 4% values for Winter, Summer and Rainy seasons were 10.70, 9.85, and 9.51 kg/d, respectively and the days open values ($P<0.05$) for Winter, Summer and Rainy seasons were 156.43, 194.46 and 141.86 days, respectively. It is suggested that in the monsoonal area, in order to take advantage of the low maximum air temperature and more availability of green feed, dairy cows should be aimed to calve in the mid rainy season. This will reduce the days open and increase milk production at the same time. Further research should examine ways to increase the performance of heat stressed cows in small scale dairy farms through genetic improvement, by increasing heat tolerance and lowering the ambient temperature of the animal house under the tropical conditions.

Keywords: Dairy cows, reproductive performance, milk production, seasons, tropical conditions.

INTRODUCTION

It has long been known that tropical climatic conditions have adverse effects on the dairy industry, particularly resulting in lower quantity and quality of milk produced (Collier *et al*., 1982; Beede and Shearer, 1991: Jordan, 2003). The reproductive performance of dairy cows also has a role in determining the profitability of a dairy herd (Ray *et al*.,1992), since lower reproductive performance would subsequently result in lower milk yield.

The effect of heat stress on general animal performance is likely to become even more important in the future if predictions of global warming prove accurate (Hansen *et al*., 1992) and particularly the seasonal depression in fertility that is caused by heat stress (Al-Katanani *et al*., 1998). At a critical value of Temperature-Humidity Index (THI) above 72, milking performance of purebred Holstein cows will decline (Johnson, 1987) and heat stress is known to have a

negative effect on oestrus and ovulation, and high ambient temperatures also result in reduced feed intake and body condition (Hall *et al*., 1959; Vajrabukka, 1992). To evaluate the amount of lost milk production and income, Thatcher (1973) investigated the seasonal and temperature effect on conception rates when air temperature was increased from 21.1°C in May to 35°C in September. The resulting conception rate decreased from 40 % to 30 %. Similarly, Stott and Williams (1962) found that an increase in ambient temperature from 33° C to 42° C in June resulted in a decrease in reproductive performance from 61.5 % to 31.0% respectively.

This paper examines climatological effects on milking and reproductive performance of dairy cows in the Northeastern area of Thailand. The dairy cow population in Sakol Nakhon Province was utilized for this purpose

Milking and reproductive performance parameters of the Dairy cows were analyzed with climatological data of the area to determine the effect of calving seasons.

MATERIALS AND METHODS

Materials

Data from the DHI (Dairy Herd Improvement) program of Sakol Nakhon Research and Breeding Centre, Department of Livestock Production, Ministry of Agriculture and Cooperatives, was used in conjunction with meteorological data from Sakol Nakhon Weather Station, Department of Meteorology, Ministry of Transport and Communications, to determine the effects of climatic conditions on milking and reproductive performance of dairy cows in the Northeastern region of Thailand.

Animal

All the dairy cows were raised at the Sakol Nakhon Breeding and Training Center (Latitude 17^0 $09'$ N. Longitude 104^0 $08'$ E and at 171 meters above sea level), which is situated approximately 641 km. Northeast of Bangkok. A total of 355 records from dairy crossbred cows (87.5 % Holstein × 12.5% *Bos indicus*) that calved during the period from 2000 – 2002 were selected from 537 records. Cows with a history of dystocia, metritis and mastitis were excluded from analyses. The selected cows were divided according to season when they calved.

Dairy husbandry

On a typical day, at 5:30 am all milking cows were moved to the milking shed to be milked via a bucket-type milking machine and fed with a half-day ration of concentrate (Table 1). The daily concentrate offered to each cow was calculated to provide for the individual cow's requirements based on individual milk production levels (NRC, 1989). After milking, the animals were allowed to graze at pasture. During the dry season they were kept in an open shed and silage of Guinea grass (*Panicum maximum*; Table 1) was offered *ad libitum* as an alternative to pasture (*P. maximum*). Mineral block (Table 1) and water were provided at all times.

At 15:00 hrs, the cows were moved to the milking shed where they were fed with the remaining half-day ration of concentrate and to be milked, after which they were allowed to return to the open shed to be fed with either green feed or silage.

All cows were vaccinated against FMD (Foot and Mouth Disease), and injected with

vitamins A, D and E. The usual postpartum reproductive management at the station was such that the cows were visually checked for signs of oestrus by an experienced stockman. Once the 2nd oestrus had been detected they were artificially inseminated at 2nd heat and conception was confirmed at 60 days thereafter, if the animal did not return to service.

Dairy cow performance data

The data utilized included calving date, days open (d), number service (time), lactation period (d) and milk yield (kg/d). These data were collected and compared according to the season of calving.

Meteorological and Chronological data

The months in each calendar year in monsoonal Thailand were categorized into seasons (Anon, 2007). The seasons are Winter season (November to February), Summer season (March to May) and Rainy season (June to October).

The meteorological data collected from Sakol Nakhon weather station pertained to the years 2000 – 2002. Only Sakol Nakhon meteorological data was used in analyses of the influence of climatic conditions on the performance of dairy cows. Sakol Nakhon weather station is 6.0 km. from Sakol Nakhon Research and Breeding Centre, where the herd of dairy cows was raised. The meteorological data was collected at 3-hourly intervals, and values for each parameter in a given 24 hour period were averaged to represent a daily value. The meteorological data collected were maximum and minimum air temperature, maximum and minimum relative humidity. From the above meteorological parameters, dew points were computed (Thai Department of Meteorology, 2003). The THI was derived from the equation (Armstrong, 1994) below.

$$THI = T_{db} + 0.36(T_{dp}) + 41.2$$

Where: T_{db} = The dry bulb temperature (°C)

T_{dp} = The dew point temperature (°C)

Analysis

Data from the DHI program (DLD, 2003) were extracted and analyzed using the GLM procedures of SAS (SAS, 1998). The model included 3 treatments comprised of summer, rainy and winter. The effects of year and season*year interaction were also included in the model for unbiased adjustment. The statistical model was shown as follow:

$$Y_{ijk} = \mu + S_i + Y_j + S_i*Y_j + \varepsilon_{ijk}$$

where Y_{ijk} = the record of the k^{th} cow of the i^{th} season, the j^{th} year and the i^{th} season*the j^{th} year interactions,

μ = the overall mean,

S_i = effect of the i^{th} season (i = summer, rainy, winter),

Y_j = effect of the j^{th} year (j = 2000, …, 2002),

S_i*Y_j = effect of the i^{th} season* j^{th} year interactions, and

ε_{ijk} = the vector of residuals, which was assumed; ε_{ijk} ~NID (0, σ_e^2).

Comparison of means were tested for differences among groups by the least significant differences (LSD) using SAS program package (SAS, 1998).

RESULTS AND DISCUSSION

The results of chemical composition of the commercial concentrate and the silage of Guinea grass (*P. maximum*) are shown in Table 1.

Table 1. Percentage chemical composition of the feedstuffs.

Feedstuff	MC	DM	CP	CF	EE	NFE	Ash	Ca	P
Concentrate	8.2	91.8	18.2	20.1	3.8	46.6	9.1	1.20	0.62
Silage	77.7	22.3	6.4	32.7	2.7	33.7	16.6	0.57	0.27

MC = moisture content, DM = dry matter, CP = crude protein, CF = Crude fiber, EE =ether extract, NFE = nitrogen free extract.

Mineral block: Calcium = 15.86%, Phosphorus = 1.60 %, Magnesium = 0.24 %, Sulfur = 0.27 %, Manganese = 271.39 mg/100g, Copper = 8.01 mg/100g, Zinc = 46.90 mg/100g, Iron = 308.26 mg/100g and Ca:P = 10:1

From Figure 1 it can be seen that the THI pattern of Sakol Nakhon province imposes heat stress to the dairy cows in most parts of a year, with a brief spell during the cooler months of Winter.

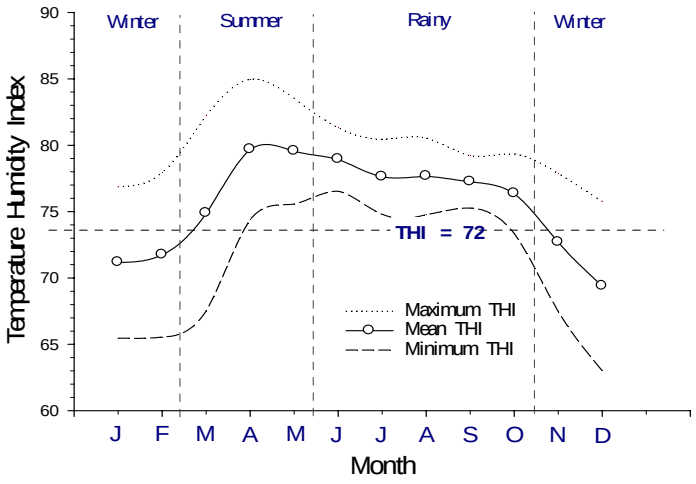

Figure 1. Mean monthly Temperature-Humidity-Index values (2000 -2002) of the Sakol Nakhon Weather Station (Thai Department of Meteorology, 2003).

Table 2. Mean meteorological values during 2000 – 2002 of Sakol Nakhon Research and Training Centre.

	Calving season		
Parameters	Winter	Summer	Rainy
Mean dry bulb temp. (^{o}C)	24.11^{b}	28.41^{a}	26.93^{a}
Mean R.H. (%)	63.45^{c}	73.83^{b}	94.60^{a}
Mean dew pt. temp. (^{o}C)	16.50^{b}	23.40^{a}	26.20^{a}
Mean THI	71.25^{b}	78.03^{a}	77.56^{a}

Means with different superscripts within a row are significantly different (P<0.01).

The seasonal variation (Table 2) shows that the only time that an animal would not be stressed was during Winter time, as indicated by the THI being less than 72 (Figure 1; Johnson, 1987). The THI values indicate that the dairy cows in this area would be heat stressed significantly (P<0.01) more in both summer and rainy seasons. Furthermore, the difference between maximum and minimum THI during Rainy season (Figure 1) appeared to be lower than during both Winter and Summer seasons. This indicated that the dairy cows were exposed to heat stress conditions more consistently and hence become more stressful during Rainy season. Since thermal sensitivity is lower during the night, when cooler part of the day occurs, than during the day. Hence the maintenance of heat balance may be achieved (Mundia and Yamamoto, 1997). A typical day during the rainy season in a monsoon area can be described as hot and sunny from morning till mid afternoon, resulting in high humidity and heavy clouds building up to a thunderstorm in the evening.

Reproductive and milking performances

Mean values of reproductive and milking performances of the dairy cows at Sakol Nakhon Research and Training Centre when using calving date as the commencement of observations are shown in Table 3.

Table 3. Reproductive and production performances of the dairy cows under hot-humid conditions.

Parameters	Winter	Summer	Rainy
Number service (time)	1.63^{b}	2.17^{a}	1.78^{b}
Days open length (d)	156.43^{b}	194.46^{a}	141.86^{b}
Lactation period (d)	294.14	275.49	296.78
MY (kg/d)	10.41	9.58	9.56
Butter fat(%)	4.19	4.19	3.97
FCM 4% (kg/d)	10.70	9.85	9.51

a, b - Means with different superscripts within a row are significantly different (P<0.05).
* Calving date assumed to be the commencement of observations.

FCM = fat corrected milk, 4 % FCM = (kg. milk) × [0.4 + {(butter fat%) × 0.15}] (NRC, 1989).

The results (Table 3) shows that the cows had their days open longer than Holstein cows in Temperate climates. Holstein cows subjected to heat stress usually have their days open lengthened (Cavestany et al., 1985). Purebred Holstein cows in the Southern states of the USA were found to have days open = 139.4 days and Services per conception reaching 2.94 times (Washburn et al., 2002). The results also showed that cows that calved in the summer season had significantly ($P<0.05$) higher days open (194.46 d) and number of services (2.17 times) than those cows calving in the Winter and Rainy seasons. There were no statistical differences ($P>0.05$) in either days open or the number of services between cows calving in the Rainy and Winter seasons. Climatic experiences during pre- and postpartum often influence the reproductive efficiency of dairy cows (Collier et al., 1982; Jordan, 2003; Avendaño-Reyes et al., 2006).

The results of the present survey indicate that heat stress is great enough to have an influence on the reproductive status of the dairy cows in this area, with a higher number of services and longer day open in the Summer season compared with the Rainy and Winter seasons, due to the fact that a lower conception rate would result in longer days open (Risco, 2004). This effect is probably mediated via by the impairment of follicular development in responses to heat stress in Summer (Hansen and Aréchiga, 1999).

However, the cows in the present study that calved in different seasons did not differ significantly in lactation period or in milk production. Extending the number of days open which in turn increases the calving interval will reduce the portion of the animal's lactation cycle (Van Amburgh *et al.,* 1997) hence resulting in a reduction in total milk yield per lactation. Earlier workers (De Bore *et al*., 1989; Barash *et al*., 2001) found depression in milk production in dairy cows subjected to heat stress. It is suggested that part of energy cost for milk production is diverted to operate the cooling mechanism of the cows.

It is possible that nutritional status might interact with the effects observed, since there was no significant difference ($P>0.05$) in THI between Summer and Rainy seasons (Table 3), and yet there was significant difference ($P<0.05$) in the days open between the Summer and Rainy seasons. There was more green feed available during the Rainy season and Wood (1972) has suggested that the lactation curve (and therefore total production) was dependent on the seasonal availability of grass. Thus an increase in milk production per lactation in the Rainy season may be due to an increase in the quality and quantity of grass available (Koonawootrittriron, *et al*., 2001).

CONCLUSION

There were significant reductions in both milking and reproductive performances of the crossbred cows in the Sakol Nakhon province during the Summer calving season. It is suggested that in monsoonal areas, in order to take advantages of low maximum air temperature and more availability of green feed, dairy cows should be aimed to calve in the middle of the rainy season. This will reduce the days open and increase milk production in the same time. Further research should examine ways to increase the performance of heat stressed cows in small scale dairy farms through genetic improvement in increasing heat tolerance and lowering the ambient temperature of animal housing under tropical conditions.

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