TRENDS AND ENVIRONMENTAL EFFECTS OF CONCEPTION RATE IN HOLSTEINS

by

CHYONG-HUOY HUANG

(Under the Direction of Ignacy Misztal)

ABSTRACT

The objective of this study was to investigate environmental effects of conception rate and the trend over time in Holsteins using individual artificial insemination records. Data for cows born from 1988 to 2004 were obtained from Dairy Records Management Systems in Raleigh, NC. Records without calving or birth date, parity >1, days to service after calving <21 or >250, and without next calving date were eliminated. Conception rate was significantly affected by DIM, season, and milk production, and it varied by region. Conception rates increased with DIM, but there was a lag for high milk producing cows. Also, conception rates were negatively affected by heat stress in southeast USA. Conception rate can be improved by increasing the voluntary waiting period, especially for high producing cows. High producing cows in hot climates should be inseminated in spring. Conception rates decreased over the years while milk production increased.

INDEX WORDS: Conception rate, Fertility, Holstein

TRENDS AND ENVIRONMENTAL EFFECTS OF CONCEPTION RATE IN HOLSTEINS

by

CHYONG-HUOY HUANG

B. S., Chinese Culture University, Taiwan, 1999

A Thesis Submitted to the Graduate Faculty of the University of Georgia in Partial Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE

ATHENS, GEORGIA

2006

TRENDS AND ENVIRONMENTAL EFFECTS OF CONCEPTION RATE IN HOLSTEINS

by

CHYONG-HUOY HUANG

Major Professor: Ignacy Misztal

Committee: Romdhane Rekaya
J. Keith Bertrand

Electronic Version Approved:

Maureen Grasso
Dean of the Graduate School
The University of Georgia
May 2006

DEDICATION

I would like to dedicate this work to my Mom and Dad for their support and provided over the years.

ACKNOWLEGEMENTS

I would like to express my deeply appreciation to Ignacy Misztal for his assistance, kindness, patience, and guidance. It has been an experience and honor to work with him these three years. I would like to thank Dr. Rekaya for the education and passion he has provide. Also, I would like to thank Dr. Bertrand for his perspective on study.

I would like to express special thanks to Dr. Shogo Tsuruta for his assistance, knowledge, patience, and friendship. I also would like to express my great appreciation to Dr. Ling-Ling Lo and En-Chung Lin in Taiwan for their education, encouragement, and assistance.

I would like to thanks to graduate students of the Animal and Breeding group: Oseni, Robyn, Travis, Matt, Kelly and Jarmila for help and friendship. In addition, I would like to thank Mike Kelly for his technical assistance; and thank Robin Harvey-Morris for her assistance on so much paper work.

Finally, a special thanks to my family and my fiancé, a deeply thanks for your supporting, tolerance, and love.

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

Page

CHAPTER 1

INTRODUCTION

Holsteins have been known as the most productive breed of dairy cattle. However, their reputation has been slowly changing from very productive to less fertile. Many studies indicate that during the last few decades, selection on milk production may have impaired non-production traits such as fertility and health conditions. In order to maximize dairy profits it is important to not only increase milk yield but also improve fertility performance, decrease veterinary cost and involuntary culling as well.

Reproduction can be affected by a combination of several factors, including milk yield, postpartum diseases, calving ease, energy balance, bST use, herd size, management in terms of service protocols, season, and inbreeding. Some of these effects are counterintuitive, such as bST which can inversely affect fertility. In addition to the effects of the aforementioned factors, fertility can also be defined in many ways, such as calving interval, days open, pregnancy rate, non-return rate, conception rate and number of services per conception. The majority of these traits consider female fertility (directly) and male fertility (indirectly) using daughters' performance tests. A successful conception from an insemination depends on both male and female fertility. A comprehensive evaluation for fertility would need complete insemination records including insemination dates for each mating, AI sires used, and number of times each cow is inseminated.

Heritabilities for fertility traits are generally low, ranging from 1 to 10%, depending on the definition of the trait, the information available and the methodology used for the analysis. The low heritability of fertility indicates strong environmental effects such as seasonal factors and management decisions made by producers. Before conducting a genetic analysis for fertility traits, it is necessary to understand and properly account for environmental effects.

CHAPTER 2

REVIEW OF LITERATURE

According to the USDA report (National Agricultural Statistics Service, 2006), the total milk production in the United States was 65 giga-billion kg in 1985, increasing to 80 giga-billion kg in 2005 (24% increase); the total number of cows decreased from 11 million to 9 million during the same period. This indicates that milk yield per cow increased from almost 6,000 kg to 9,000 kg (50% increase). The increase in milk production was due to a higher peak milk yield, higher persistency and longer lactation. This improvement was the result of a combination of enhanced management, better nutrition, and intense genetic selection (Rajala-Schultz and Frazer, 2003). However at the same time, the reproduction performance has deteriorated. Butler (1998) found that first-service conception rate (CR) in New York dropped from 65% in 1951 to 40% in 1996. In Kentucky, CR dropped from 62% in 1972 to 34% in 1996 (Silvia, 1998). In Florida, the annual pregnancy rate decreased from 22% in 1977 to 12% in 2002 (de Vries and Risco, 2005b). In Southeastern states, Washburn et al. (2002) reported that estrus detection rates declined from 51% in 1976 to 42% in 1999, and days open (DO) increased from 126 d to 169 d. In North Carolina, DO increased 1.1d per year after 1980 (Abdallah and McDaniel, 2000b). In Ohio, days to first service increased from 90 d to 94 d and DO increased from 136 d to 151 d from 1992 to 1998 (Rajala-Schultz and Frazer, 2003). Lucy, (2001) reported that the calving interval increased from 13.5 months in 1970 to 14.9 months in 2000 and the number of services per conception increased from 1.8 to 3.0.

These fertility problems have been reported not only in the USA but worldwide, including Australia (Macmillan et al., 1996), United Kingdom (Royal et al., 2000), Kenya (Ojango et al., 2001), Ireland (Olori et al., 2002), and Spain (Lopez-Gatius, 2003). The main purpose of intense selection for production was to increase profits. However, gains due to increased milk production must be adjusted for economic losses due to the increase of the number of inseminations, veterinary costs and involuntary culling due to low fertility.

Based on the fact that milk production increased while reproductive performance decreased for the last 20-30 years, the declining fertility could be caused by the improvement in milk production. However, as Lucy (2001) pointed out, fertility is affected not only by milk but also by postpartum diseases, calving ease, energy balance, bST use, herd size, management in terms of service protocols, season, and inbreeding. These effects may be intricately related.

Milk production

Many studies have demonstrated the antagonistic relationship between milk production and fertility (Beger et al., 1981; Hansen et al., 1983; Hoekstra et al., 1994; Janson and Andreasson, 1981; Kelm et al., 1997; Kragelund et al., 1979; Lin et al., 1985; Lyons and Freeman, 1991; Mantysaari and Ven Vleck, 1989; M. C. Lucy, 2001; Pryce et al., 1998; Roxström et al., 2001; Weller and Ezra, 1997). Abdallah and McDaniel (2000a,b) reported an unfavorable genetic relationship (0.62) between milk yield and DO and showed that there was an 8 d increase in DO for each 1000 kg increase in milk yield. Brotherstone et al. (2004) found that cows that got pregnant between 30-60 DIM have lower production curves than cows that got pregnant between 120-150 DIM.

Dematawewa and Berger (1998) found positive genetic (0.55, 0.53) and phenotypic (0.27, 0.19) correlations between milk yield and DO and milk yield and the number of services per conception, respectively. Eicker et al. (1996) showed that CR decreased 8% (Hazard ratio) as 60 d cumulative milk yield increased from 1,582 kg to 2,541 kg. There were also several studies that found little to no relationship between milk production and reproduction traits (Farin et al., 1994; Grohn et al., 1986; Harman, 1994; Lee et al., 1989; Nebel and McGilliard, 1993; Snijders et al., 2001; Stevenson, 1999). Marti and Funk (1994) reported that milk production has a negative impact on fertility only up to a point, after which, higher production appears to have little effect on fertility. Weigel and Rekaya (2000) reported the effect of age-adjusted daily milk in the first 100 d of lactation in non-return date at 60 d after insemination was small.

Service protocols

Differences in herd management regarding types of service protocols include the use of estrous synchronization coupled with timed AI, heat detection methods and effectiveness, and experience and skill of artificial insemination (AI) technicians. According to a survey from Hoard's Dairyman Research Department, approximately 10% of US dairy herds used timed AI for breeding (Lucy, 2001). A timed AI protocol coupled with ovulation synchronization can yield a higher pregnancy rate than normal AI without any treatment (Tenhagen et al., 2004). Under timed-AI protocols, differences in pregnancy rate are dependent on the synchronization methods used (Navanukraw et al., 2004; Peeler et al., 2004). Heat detection is an important factor for CR. Failure to detect heat results in poor reproductive performance and reduces the economic impact of AI (Senger, 1994). Dairy cows inseminated at an observed spontaneous estrous have higher

CR than cows inseminated with a timed AI program alone (Nebel and Jobst, 1998). Similarly, Jordan et al. (2002) reported a significant interaction between service protocols and estrous status at insemination. They conducted an experiment in which cows were assigned to two synchronization programs, modified targeted breeding (MTB) and PGF2α 14 d preceding OvSynch (PGOV). Cows in MTB were inseminated following visual estrus signs at 24, 48, or 72 h after two PGF2α and one GnRH treatments. Cows in PGOV received a second GnRH treatment 48 h after the second PGF2α and were inseminated 24 h later. The results showed CR of 45.8% (MTB), 35.4% (PGOV) and 19.2% (MTB), 27.7% (PGOV) of cows with and without estrous at insemination, respectively. This indicates that an appropriate service protocol could have higher CR when coupled with more accurate heat detection. Additionally, Dalton et al. (2004) reported that CR could be greatly improved via professional AI technicians (45%) compared with herdsman inseminators (27%).

Inbreeding

Hermas et al. (1987) showed that every 1% increase in inbreeding led to 0.17 more services per conception, 2 days longer DO and 3.3% lower CR in Guernsey cattle. Lucy (2001) pointed out that inbreeding had increased in the US Holstein population since 1980 and might have an important impact on fertility. This has been confirmed by Wall et al. (2005); an inbreeding coefficient of 10% increased calving interval by 2.8 d, days to first service by 1.7 d, and services per conception by 0.03.

Seasonal

Fertility in lactating dairy cows is very sensitive to season, especially in hot climates. The impact of heat stress on reproductive efficiency has been a topic of many studies

(Fuquay, 1981; Gwazdauskas, 1985; Hansen and Are'chiga, 1999; Hansen et al., 2001; Jordan, 2003; Nardone et al., 1997; Ray et al., 1992; Rutledge, 2001; Thatcher, 1974; Wolfenson, 2000;). Ingraham et al. (1976) reported that CR decreased from 66% to 35% when the temperature humidity index increased from 68 to 78. Al-Katanani et al. (2002) reported summer depression in oocyte quality. de Vries et al. (2005a,b) found that pregnancy rates during winter (17.9%) were significantly higher than during summer (9.0%), and that the pregnancy rate ratio in summer to winter decreased from 56% in the 1970s to 35% in 2002. Lopez-Gatius (2003) found that cows' fertility remained unchanged over time during cool seasons but declined during warm seasons. Oseni et al. (2003) found seasonal variation in DO up to 50d, and season differences in DO varied by region. Silvia et al. (2002) reported that cows calving in summer (July to September) in Kentucky actually had the fewest DO, cows that calved in spring (April to June) had the largest number of days to first service, and cows that calved in winter (January to March) had the fewest days to first service. Ravagnolo and Misztal (2002) showed that the temperature humidity index has the highest effect on non-return rate at 2 days after insemination. Silva et al. (1992) reported significant differences of DO and calving interval between warm and cool season. Wilson et al. (1998a,b) indicated the heat stress has a lag effect on ovarian function.

Parity

Eicker et al. (1996) showed an 8% decrease of CR (Hazard ratio) for first parity compared with second and later parities. As age at breeding increased, fertility declined. This has been confirmed by other studies (Hillers et al., 1984; Matsoukas and Fairchilld, 1975; McGraw, 1980). Marti and Funk (1994) reported that parity effects on DO were larger in later parities, which was similar to the trend reported by Stevenson et al. (1983).

Disease

A cow's health has a large effect on her reproductive performance, as mammary and uterine infections increase the risk of infertility (Emanuelson and Oltenacu, 1998; Goldberg et al., 1992; Kaneene and Miller, 1994; Loeffler et al., 1997, 1999; Risco et al., 1999). Eicker et al. (1996) showed that diseases were significant risk factors for conception. Retained placenta, metritis, and cystic ovary decreased CR by 14%, 15%, 21%, respectively.

Others

Clay and McDaniel (2001) showed that a cow bred before 50 DIM had a 5.5% greater chance of being rebred than a cow bred after 70 DIM; and a cow bred after 139 DIM had a 3.3% less chance of rebreeding than a cow bred at 70-79 DIM. Cole et al. (1991) found that the administration of bST lowered reproductive performance. Collier et al. (1997) conducted a large study that found recombinant bST caused a 16-d increase in DO for primiparous cows but had no effect on multiparous cows. Conversely, Bauman et al. (1999) concluded that bST did not affect the fertility of dairy cows. Luna-Dominguez et al. (2000) showed that using bST to increase milk production might actually reduce the days to first service and DO. Santos et al. (2004) reported similar results; they reported a positive impact of bST on CR when using a resynchronization protocol. Lopez-Gatius et al. (2002) investigated the physiological and endocrine factors affecting pregnancy loss and found a positive association between the formation of additional corpus luteum and the maintenance of pregnancy.

Besides the many factors that affect the reproductive complex, fertility is also defined in various ways. The fertility outcomes can be described as binary, categorical or continuous responses. Binary responses, such as calving status, conception status, and non-return status can be transformed and expressed as a percentage. A frequent categorical response used to describe cow fertility is number of services per conception. Continuous responses, such as calving interval, DO, and days to first services have also been used to describe cow fertility. The majority of traits used are considered to be performance measures of only female fertility. A successful conception event depends on both male and female fertility. However, several studies reported service sire variance (Averill and Rekaya, 2004; Boichard and Manfredi, 1994; Clay, et al. 2001; Weigel and Rekaya, 2000;), which indicates that the sires used in the mating may have an effect on the conception outcome.

Heritabilities of fertility traits are generally low, ranging from 1 to 10 % (Abdallah and McDaniel, 2000b; Badinga et al., 1985; Berger et al., 1981; Brotherstone et al., 2002; Dematawewa and Berger, 1998; Hansen et a., 1983; Hodel et al., 1995; Kragelund et al., 1979; Mari and Funk, 1994; Ojango and Pollott, 2001; Pedersen and Jensen, 1996; Seykora and McDaniel, 1983;). The heritability depends on the trait chosen, the information available and the methodology used for analyses. Low heritability of fertility traits indicates that they are strongly affected by environmental factors such as season and management decisions made by producers. Fertility performance should be included in the selection index to avoid economic losses due to decreased fertility over time (A-Ranberg et al., 2003).

CONCLUSIONS

For many years, selection has been primarily on milk production and fertility and health traits have been virtually ignored. Recently fertility has become a major concern. Improvement of fertility is difficult due to complicated and confounded factors, as well as, the challenge of choosing and defining the trait, incomplete data recording, the complicated methodology for handling binary outcomes, and censored records. As a result, the heritability estimates are very low. To genetically improved fertility traits via the use of predicted genetic values, it is essential to understand and account for non-genetic factors in the analysis of these traits.

REFERENCES

Abdallah, J. M., and B. T. McDaniel. 2000a. Genetic Change in Milk, Fat, Days Open, and Body Weight After Calving Based on Three Methods of Sire Selection. J. Dairy Sci. 83:1359-1363.

Abdallah, J. M., and B. T. McDaniel. 2000b. Genetic Parameters and Trends of Milk, Fat, Days Open, and Body Weight After Calving in North Carolina Experimental Herds. J. Dairy Sci. 83:1364-1370.

Al-Katanani, Y. M., F. F. Paula-Lopes, and, P. J. Hansen. 2002. Effect of Season and Exposure to Heat Stress on Oocyte Competence in Holstein Cows. J. Dairy Sci. 85:390-396.

A.-Ranberg, I. M., B. Heringstad, G. Klemetsdal, M. Svendsen, and T. Steine, 2003. Heifer Fertility in Norwegian Dairy Cattle: Variance Components and Genetic Change. J. Dairy Sci. 86:2706-2714.

Averill, T. A., R. Rekaya, K. Weigel, 2004. Genetic Analysis of Male and Female Fertility Using Longitudinal Binary Data. J. Dairy Sci. 87:3947-3952.

Brotherstone, S., R. Thompson, and I. M. S. White. 2004. Effect of Pregnancy on Daily Milk Yield of Holstein-Friesian Dairy Cattle. Livest. Prod. Sci. 87:265-269.

Butler, W. R. 1998. Review: Effect of Protein Nutrition on Ovarian and Uterine Physiology in Dairy Cattle. J. Dairy Sci. 81:2533-2539.

Clay, J. S., and B. T. McDaniel. 2001. Computing Mating Bull Fertility From DHI Nonreturn Data. J. Dairy Sci. 84:1238-1245.

Dalton, J. C., A. Ahmadzadeh, B. Shafii, W. J. Price, and J. M. DeJarnette. 2004. Effect of Simultaneous Thawing of Multiple 0.5-mL Straws of Semen and Sequence of Insemination on Conception Rate in Dairy Cattle. J. Dairy Sci. 87:972-975.

Dematawewa, C. M. B. and P. J. Berger. 1998. Genetic and Phenotypic Parameters for 305-Day Yield, Fertility, and Survival in Holsteins. J. Dairy Sci. 81:2700-2709.

de Vries, A., C. Steenholdt, and C. A. Risco. 2005a. Pregnancy Rate and Milk Production in Natural Service and Artificially Inseminated Dairy Herds in Florida and Georgia. J. Dairy Sci. 88:948-956.

de Vries, A. and C. A. Risco. 2005b. Trends and Seasonality of Reproductive Performance in Florida and Georgia Dairy Herds from 1976 to 2002. J. Dairy Sci. 88:3155-3165.

Eicker, S. W., Y. T. Gröhn, and J. A. Hertl. 1996. The Association Between Cumulative Milk Yield, Days Open, and Days to First Breeding in New York Holstein Cows. J. Dairy Sci. 79:235-241.

Jordan, E. R., M. J. Schoutent, J. W. Quast, A. P. Belschner, and M. A. Tomaszewski. 2002. Comparison of Two Timed Artificial Insemination (TAI) Protocols for Management of First Insemination Postpartum. J. Dairy Sci. 85:1002-1008.

López-Gatius, F., P. Santolaria, J. Yaniz, J. Rutllant, and M. Lopez-Bejar. 2002. Factors Affecting Pregnancy Loss From Gestation Day 38 to 90 in Lactating Dairy Cows From a Single Herd. Theriogenology. 57:1251-1261.

López-Gatius, F. 2003. Is Fertility Declining in Dairy Cattle? A Retrospective Study in Northeastern Spain. Theriogenology. 60:89-99.

Lucy, M. C. 2001. Reproductive Loss in High-Producing Dairy Cattle: Where Will It End? J. Dairy Sci. 84:1277-1293.

Luna-Dominguez, J. E., R. M. Enns, D. V. Armstrong, and R. L. Ax. 2000. Reproductive Performance of Holstein Cows Receiving Somatotropin. J. Dairy Sci. 83:1451-1455.

Marti, C. F. and D. A. Funk. 1994. Relationship Between Production and Days Open at Different Levels of Herd Production. J. Dairy Sci. 77:1682-1690.

Navanukraw, C., D. A. Redmer, L. P. Reynolds, J. D. Kirsch, A. T. Grazul-Bilska, and P. M. Fricke. 2004. A Modified Presynchronization Protocol Improves Fertility to Timed Artificial Insemination in Lactating Dairy Cows. J. Dairy Sci. 87:1551-1557.

Ojango, J. M. K. and G. E. Pollott. 2001. Genetics of Milk Yield and Fertility Traits in Holstein-Friesian Cattle in Large-Scale Kenyan Farms. J. Anim. Sci. 79:1742-1750.

Olori, V. E., T. H. E. Meuwissen, and R. F.Veerkamp. 2002. Calving Interval and Survival Breeding Values as Measure of Cow Fertility in a Pasture-based Production System With Seasonal Calving. J. Dairy Sci. 85:689-696.

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

Peeler, I. D., R. L. Nebel, R. E. Pearson, W. S. Swecker, and A. Garcia. 2004. J. Dairy Sci. 87:2868-2873.

Pryce, J. E., M. D. Royal, P. C. Garnsworthy, and I. L. Mao. 2004. Fertility in the Heigh-Producing Dairy Cow. Livest. Prod. Sci. 86:125-135.

Rajala-Schultz, P. J. and G. S. Frazer. 2003. Reproductive Performance in Ohio Dairy Herds in the 1990s. Anim. Reprod. Sci. 76:127-142.

Ravagnolo, O. and I. Misztal. 2002. Effect of Heat Stress on Nonreturn Rate in Holsteins: Fixed-Model Analyses. J. Dairy Sci. 85:3101-3106.

Roxström, A., E. Strandberg, B. Berglund, U. Emanuslson, and, J. Philipsson. 2001. Genetic and Environmental Correlations Among Female Fertility Traits, and Between the Ability to Show Oestrus and Milk Production in Dairy Cattle. Acta. Agric. Scand., Sect. A, Animal Sci. 51:192-199.

Santos, J. E. P., S. O. Juchem, R. L. A. Cerri, K. N. Galvão, R. C. Chebel, W. W. Thatcher, C. S. Dei, and C. R. Bilby. 2004. Effect of bST and Reproductive Management on Reproductive Performance of Holstein Dairy Cows. J. Dairy Sci. 87:868-881.

Silva, H. M., C. J. Wilcox, W. W. Thatcher, R. B. Becker, and D. Morse. 1992. Factors Affecting Days Open, Gestation Length, and Calving interval in Florida Dairy Cattle. J. Dairy Sci. 75:288-293.

Silvia, W., 1998. Changes in Reproductive Performance of Holstein Dairy Cows in Kentucky from 1972 to 1996. J. Dairy Sci. 81(Suppl. 1):244. (Abstr.)

Silvia, W. J., R. W. Hemken, and T. B. Hatler. 2002. Timing of Onset of Somatotropin Supplementation on Reproductive Performance in Dairy Cows. J. Dairy Sci. 85:384-389.

Tenhagen, B.-A., M. Drillich, R. Surholt, and W. Heuwieser. 2004. Comparison of Timed AI After Synchronized Ovulation to AI at Estrus: Reproductive and Economic

Considerations. J. Dairy Sci. 87:85-94.

Wall, E., S. Brotherstone, J. F. Kearney, J. A. Woolliams, and M. P. Coffey. 2005. Impact on Nonadditive Genetic Effects in the Estimation of Breeding Values for Fertility and Correlated Traits. J. Dairy Sci. 88:376-385.

Washburn, S. P., W. J. Silvia, C. H. Brown, B. T. McDaniel, and A. J. McAllister. 2002. Trends in Reproductive Performance in Southeastern Holstein and Jersey DHI Herds. J. Dairy Sci. 85:244-251.

Weigel, K. A. and R. Rekaya, 2000. Genetic Parameters for Reproductive Traits of Holstein Cattle in California and Minnesota. J. Dairy Sci. 83:1072-1080.

Wilson, S. J., R. S. Marion, J. N. Spain, D. E. Spiers, D. H. Keisler, and M. C. Lucy. 1998a. Effect of Controlled Heat Stress on Ovarian Function of Dairy Cattle. 1. Lactating Cows. J. Dairy Sci. 81:2124-2131.

Wilson, S. J., C. J. Kirby, A. T. Koenigsfeld, D. H. Keisler, and M. C. Lucy. 1998b. Effect of Controlled Heat Stress on Ovarian Function of Dairy Cattle. 2. Heifers. J. Dairy Sci. 81:2132-2138.

CHAPTER 3

ENVIRONMENTAL EFFECTS ON CONCEPTION RATE OF HOLSTEINS IN NEW YORK AND GEORGIA[1]

[1] C. Huang, S. Tsuruta, I. Misztal. Submitted to J. Dairy Sci (2006).

ABSTRACT

The purpose of this study was to investigate the impact of environmental factors on conception rate (CR) using artificial insemination records of Holsteins in NY and GA. Data were obtained from Dairy Records Management Systems in Raleigh, NC. After removing uncertain and extreme records (records without calving or birth date, with lactation >1, with days to service after calving <21 or >250, and without next calving date), the final data set comprised 298,015 service records for 160,879 cows and 23,366 service records for 12,184 cows in NY and GA from 2000 to 2003, respectively. Using SAS PROC GLM, the model included days in milk (DIM) class, milk production level, service month, the covariate of cow's age at calving and appropriate interactions. In NY (GA), least squares means for CR was 44% (32%) at 50 d postpartum and increased to 62% (53%) at 250 d. The CR was highest in March and lowest in May in NY and highest in March and lowest in September in GA. The CR was higher for low milk producing cows. The CR increased with DIM for all cows, but there was a lag for high producing cows. Also, heat stress affected high producing cows more, and their recovery was slower. Improved conception rate can be obtained by increasing the VWP, especially for high producing cows, to as much as 200 d or more. High producing cows in hot climates should at best be serviced in spring.

Key words: conception rate, fertility, Holstein.

INTRODUCTION

Holsteins have been known as the most productive breed of dairy cattle in the U.S. However, their reputation has been slowly changing from very productive to less fertile.

There have been several studies that reported the decline of fertility of Holsteins in the U.S. (Butler, 1998; Silvia, 1998; Washburn et al., 2002; de Vries and Risco, 2005b). The decline in fertility is partly due to the antagonistic relationship between fertility traits and milk production (Abdallah and McDaniel, 2000a,b; M. C. Lucy, 2001; Roxström et al., 2001). Over the past decades, milk production increased steadily because of a combination of improved management, better nutrition, and intense genetic selection (Rajala-Schultz and Frazer, 2003). However, the genetic selection for fertility has just begun in the U.S. (VanRaden et al., 2004).

Fertility can be affected by a combination of several factors (Lucy, 2001), including not only milk yield but also postpartum diseases, calving ease, energy balance, bST use, herd size, management in terms of service protocols, season, and inbreeding. The impact of some of these factors is counterintuitive. For example, bST use increases the milk production that usually results in decreased fertility, but in fact the conception rate may be improved (Luna-Dominguez and et al., 2000; Silvia and el al., 2002; Santos and et al., 2004).

Fertility can be improved by diligent heat detection and appropriate service protocols such as timed artificial insemination (AI) coupled with synchronization (Jordan et al., 2002; Tenhagen et al., 2004; Dalton et al., 2004; Navanukraw et al., 2004; Peeler et al., 2004), and by longer voluntary waiting periods (VWP). Lawlor et al. (2002) argued that Holsteins are now capable of very long lactations, which could be due to an indirect selection of Holsteins for longer lactations. This, aside from the negative energy balance, could result in indirect selection against fertility at low DIM. An important question in this case is whether fertility at low and high DIM is genetically similar.

Genetic evaluation for fertility in the U.S. involves days open which is converted to pregnancy rate by a linear formula (VanRaden et al., 2004). The trait of days open is very simple to measure; however, it does not account for variation in VWP and also in factors affecting successive inseminations. One of those factors is the effect of seasons. Lopez-Gatius (2003) found that fertility remained unchanged over time during the cool period but declined during the warm period, indicating decrease of heat tolerance. It may also indicate that there is a significant G x E interaction for fertility.

At best, the genetic evaluation for fertility would involve the insemination records if they are available. Accounting for timing of inseminations and for effects during each insemination would result in more accurate evaluation than when using a single measure of pregnancy, such as days open or non-return rates. Such an evaluation was investigated by Averill and Rekaya (2004), who found many challenges in data editing and in developing the model. The first purpose of this study was to analyze individual inseminations using DHI records and determine factors that affect conception rate (CR) changes in moderate and hot environments. The second purpose was to determine whether fertility in different DIM is a similar trait.

MATERIALS AND METHODS

Data

Insemination and production records in NY and GA collected from 2000 to 2003 were obtained from the Dairy Record Management System, Raleigh, NC. Artificial insemination records with birth date, calving date, service date, cow ID and lactation number were considered as valid data. Further edits eliminated service records with < 21

DIM or > 250 DIM, first calving age < 20 mo or > 36 mo, or parity > 1. Because editing strongly influenced the results, very strong selection criteria were adopted to eliminate incomplete records. A subsequent calving record was required to confirm the successful conception; therefore, cows were removed that did not have a calving record linked to a possible breeding event during their first lactation. If a calving record existed, the predicted last service date was calculated from the calving date in the second lactation minus 280 d, and then the last service date at conception was determined. If the difference between reported and calculated conception dates was within ±10 d, the last service date was used as a successful conception date. If the difference was > ±10 but < ±70, the predicted conception date was used as the last service date. If the difference was greater than ±70 d, the record was removed. Three milk production levels (low, medium, high) were classified based the average of the last either two or three test-day milk records before insemination. Cows that had only two milk-test days recorded prior to conceiving had their milk production level assigned based on average of the two-test days; while cows that had at least three test-days recorded prior to conception had their milk production level assigned using the average of the three-test days prior to conception. Cows without test-day milk records before insemination were removed. After these edits, the final data sets consisted of 298,015 service records for 160,879 cows in NY and 23,366 service records for 12,184 cows in GA. The two states were analyzed separately. The numbers of service records in New York and Georgia states are shown in Table 1 by DIM group, service month and milk production level.

Statistical analyses

Data were initially analyzed using both GLM procedure and the LOGISTIC procedure in SAS (1997). Included in the model were the effects of age at calving as a covariate, DIM interval group, service month, milk production level (< mean – 1 SD, between mean ± 1 SD, > mean + 1 SD), and interactions. Because the LOGISTIC procedure was time and memory intensive, and the initial results from the LOGISTIC procedure produced similar trends to those from the GLM procedure; the GLM procedure was used to conduct all subsequent analyses and the results from this procedure are presented. All effects in the model were highly significant (P<0.001). Genetic analysis used a Bayesian procedure via Gibbs sampling, and included fixed effects (herd-year, days in milk group, service month, calving age), the average of first two or three test-day milk records as covariate, and random effects (service sire and sire, sire at different DIM). The total number of iterations was 100,000, with 10,000 treated as burn-in.

RESULTS AND DISCUSSION

DIM

All CR reported here are most likely overestimated as records that were incomplete or from those cows that failed to conceive were eliminated; more accurate editing was difficult using the available information. Average CR was 51% in NY and 45% in GA. The CR increased with DIM in both states, from 44 % at 50 DIM to 62% at 250 DIM in NY, and from 32% at 50 DIM to 53% at 250 DIM in GA (Figure 1). It indicates that cows are less likely to conceive shortly after calving but more likely later. Similar results were reported by Clay and McDaniel (2001) for a cow bred at 139 d after calving having 3.3% less chance to rebreed than a cow bred at 70-79 d after calving; and Averill et al. (2004) found a positive regression coefficient on DIM at insemination (0.003). This result is also supported by physiological occurrences in the cow since dairy cattle can experience negative energy balance during early lactation and need time to recover after calving prior to the next conception. In addition, the CR in NY was higher in any DIM than those in GA even though milk production in NY was only about 2 kg higher than in GA, indicating that factors other than milk production, such as management and seasonal effects, were more influential on CR in GA.

Service month

Milk production and reproduction are affected by seasonal factors such as feeding (pasture, hay, silage) and climate (temperature, humidity, wind). Several studies on different fertility traits have reported that cows under heat stress have longer DO and calving interval (Silva et al., 1992; Marti and Funk, 1994; Oseni et al., 2003, Oseni et al., 2004), and lower non-return, pregnancy and conception rates (Ravagnolo and Misztal, 2002; Jordan, 2003; de Vries and Risco, 2005a,b). Dairy cows in GA have higher heat stress than in NY. Figure 2 shows that CR was highest during cool season (January to April) both in NY (53~55%) and GA (54~57%) but lowest in May in NY (43%) and in September in GA (31%). From January to April, CR in GA was marginally higher than in NY. This could be due to harsh winters in NY compared to mild winters in GA and more availability of lush pasture in GA compared to NY during these months. In GA, the CR started declining dramatically in May until September (about 25%), most likely due to heat stress. In NY, the CR also declined in May and June about 12% but increased in July and kept stable until winter, indicating that in NY, grazing in May and June may have caused lower CR and almost no heat stress in the summer. Fertility in GA does not recover to the NY level until November because the heat stress may cause damage to ova, and it may take about 2 months for the ova quality within the cow to return to normal after heat stress occurs. (Wilson et al., 1998a, b; Al-Katanani et al., 2002).

Milk production level

Milk production levels were assigned using up-to three test-day milk records before each insemination based on ≦mean – 1 SD, between mean ± 1 SD and >mean + 1 SD for low, medium and high levels, respectively. The means and SD were calculated and the milk production levels assigned within DIM group, because test-day milk production changes with DIM. The CR was 55%, 51% and 48% in NY and 47%, 44% and 43% in GA for low, medium and high production levels, respectively (Figure 3). Both in NY and GA, milk production was antagonistic to fertility, especially in NY. For low producing cows, the CR was 8% higher in NY than in GA; however, for high production cows, it was only 5% higher. The decline in CR caused by milk production was higher for cows in NY (7%) than for cows in GA (4%). The unfavorable effect of high milk production on CR agrees several studies that have been reported that cows with high milk production generally have longer DO, long calving interval, more number of services (Marti and Funk, 1994; Eicker and et al., 1996; Dematawewa and Berger, 1998; Ojango and Pollott, 2001), lower non-return rate, lower pregnancy rate, and lower conception rate (Pryce and et al., 2004; Brotherstone and et al., 2004).

DIM for different milk production level

The CR increased with DIM more for low milk producing cows than for high milk producing cows in NY (Figure 4). The CR increased from 45 to 66% for low producing cows and from 43 to 59% for high producing cows. The CR of low producing cows increased linearly while the CR for high producing cows had small changes until 125

DIM and increased linearly after that. The changes among the three milk production levels were different over DIM. The difference was larger between low and medium production levels than between high and medium production levels after 125 DIM. Flat CR curves for DIM ≤ 125 may be due to longer periods of negative energy balance and subsequently slower recovery. In GA, the results were similar to those NY but fluctuated more due to fewer observations. During early lactation, especially under high milk production, dairy cattle experience negative energy balance and are at increased risk for nutritional problems that can impair fertility.

Service month for different milk production level

In NY, the difference between low and high producing cows was smallest (2%) in April and largest (12%) in August (Figure 6). For low producing cows, CR in May was lowest then recovered by July and remained at fairly constant levels from July to April. For high producing cows, the CR in May and June were lowest, then increased in July but not as much as low producing cows; indicating that seasonal effects may have affected CR more in high producing cows. In GA, the declines of CR were large in the summer but small in the remaining seasons (Figure 7). This tendency was clearer for low and medium milk production levels than for high milk producing cows. It appears that depression in CR for more productive cows lasted until November, indicating more long term reduction in fertility in more productive cows. Differences between CR in the highest and the lowest months were 29%, 26% and 31% for low, medium and high milk production levels, respectively. The CR for all three milk production levels were high and similar from January to April and started dropping from May, but each milk production level had a different rate of decrease. Fertility for low milk producing cows under heat stress appears to have deteriorated during the summer time but soon recovered. The recovery was slower for high milk producers. One factor in the lag (or carry over) effect of heat stress may be the damaging effect of heat stress on ova development (Wilson et al., 1998a, b; Al-Katanani et al., 2002).

Genetic analysis

The genetic analysis results of NY are show in Table 2. The heritability obtained from the analysis on NY data using a simple sire model was 1.3%. The heritability estimate was close to the results reported by Pedersen and Jensen (1996) and Hodel et al. (1995), who found heritability estimates of 0.8% and 1.1% for 56 and 90- d nonreturn rate in heifers, respectively. The service variance in NY was 6.8% of the total variance, which appears large relative to other literature estimates which vary greatly (Boichard and Manfredi, 1994; Averill et al., 2004).

When three sire effects were in the model, nested within DIM interval, the heritabilities were 2.0%, 1.7%, and 4.6% for intervals of DIM of 21-100, 101-175 and 176-250, respectively (Table 3). The genetic correlations between intervals 1-2, 2-3, and 1-3 were 0.53, 0.72 and –0.11, respectively. There is a question of why the third interval has much higher heritability and lower genetic correlations than the other intervals. It may indicate that fertility at later DIM is a different trait and can be selected for much more successfully than at earlier DIM. On the other hand, this could be due to simplistic modeling and quality of data or excessive editing of data. These issues will be addressed in subsequent studies.

CONCLUSIONS

Conception rate is relatively low shortly postpartum but gradually improves with time. That improvement has a lag for high producing cows. Fertility in moderate and hot climates is similar during spring but drops much more during the summer time in hot climates and the drop in summer and the recovery is slower in high producing cows. Improved conception rate can be obtained by increasing the VWP, especially for high producing cows, to as much as 200 d. High producing cows in hot climates should at best be serviced in spring. Specific CR obtained in this study is likely an overestimate due to extensive editing necessary to eliminate incomplete records.

REFERENCES

Abdallah, J. M., and B. T. McDaniel. 2000a. Genetic Change in Milk, Fat, Days Open, and Body Weight After Calving Based on Three Methods of Sire Selection. J. Dairy Sci. 83:1359-1363.

Abdallah, J. M., and B. T. McDaniel. 2000b. Genetic Parameters and Trends of Milk, Fat, Days Open, and Body Weight After Calving in North Carolina Experimental Herds. J. Dairy Sci. 83:1364-1370.

Al-Katanani, Y. M., F. F. Paula-Lopes, and, P. J. Hansen. 2002. Effect of Season and Exposure to Heat Stress on Oocyte Competence in Holstein Cows. J. Dairy Sci. 85:390-396.

Averill, T. A., R. Rekaya, K. Weigel, 2004. Genetic Analysis of Male and Female Fertility Using Longitudinal Binary Data. J. Dairy Sci. 87:3947-3952.

Brotherstone, S., R. Thompson, and I. M. S. White. 2004. Effect of Pregnancy on Daily Milk Yield of Holstein-Friesian Dairy Cattle. Livest. Prod. Sci. 87:265-269.

Butler, W. R. 1998. Review: Effect of Protein Nutrition on Ovarian and Uterine Physiology in Dairy Cattle. J. Dairy Sci. 81:2533-2539.

Clay, J. S., and B. T. McDaniel. 2001. Computing Mating Bull Fertility From DHI Nonreturn Data. J. Dairy Sci. 84:1238-1245.

Dalton, J. C., A. Ahmadzadeh, B. Shafii, W. J. Price, and J. M. DeJarnette. 2004. Effect of Simultaneous Thawing of Multiple 0.5-mL Straws of Semen and Sequence of Insemination on Conception Rate in Dairy Cattle. J. Dairy Sci. 87:972-975.

Dematawewa, C. M. B. and P. J. Berger. 1998. Genetic and Phenotypic Parameters for 305-Day Yield, Fertility, and Survival in Holsteins. J. Dairy Sci. 81:2700-2709.

de Vries, A., C. Steenholdt, and C. A. Risco. 2005a. Pregnancy Rate and Milk Production in Natural Service and Artificially Inseminated Dairy Herds in Florida and Georgia. J. Dairy Sci. 88:948-956.

de Vries, A. and C. A. Risco. 2005b. Trends and Seasonality of Reproductive Performance in Florida and Georgia Dairy Herds from 1976 to 2002. J. Dairy Sci. 88:3155-3165.

Eicker, S. W., Y. T. Gröhn, and J. A. Hertl. 1996. The Association Between Cumulative Milk Yield, Days Open, and Days to First Breeding in New York Holstein Cows. J. Dairy Sci. 79:235-241.

Jordan, E. R., M. J. Schoutent, J. W. Quast, A. P. Belschner, and M. A. Tomaszewski. 2002. Comparison of Two Timed Artificial Insemination (TAI) Protocols for Management of First Insemination Postpartum. J. Dairy Sci. 85:1002-1008.

Jordan, E. R. 2003. Effects of Heat Stress on Reproduction. J. Dairy Sci. 86(E. Suppl.):E104-E114.

Lawlor, T. J., S. Tsuruta, L. Klei and I. Misztal. 2002. Use of a Random Regression Model to Investigate Changes in Genetic Parameters Over Time. Proc. 7th World Congr. Genet. Appl. Livest. Prod., Mpntpellier, France. CD-ROM communication 17:06.

López-Gatius, F. 2003. Is Fertility Declining in Dairy Cattle? A Retrospective Study in Northeastern Spain. Theriogenology. 60:89-99.

Lucy, M. C. 2001. Reproductive Loss in High-Producing Dairy Cattle: Where Will It End? J. Dairy Sci. 84:1277-1293.

Luna-Dominguez, J. E., R. M. Enns, D. V. Armstrong, and R. L. Ax. 2000. Reproductive Performance of Holstein Cows Receiving Somatotropin. J. Dairy Sci. 83:1451-1455.

Marti, C. F. and D. A. Funk. 1994. Relationship Between Production and Days Open at Different Levels of Herd Production. J. Dairy Sci. 77:1682-1690.

Navanukraw, C., D. A. Redmer, L. P. Reynolds, J. D. Kirsch, A. T. Grazul-Bilska, and P. M. Fricke. 2004. A Modified Presynchronization Protocol Improves Fertility to Timed Artificial Insemination in Lactating Dairy Cows. J. Dairy Sci. 87:1551-1557.

Ojango, J. M. K. and G. E. Pollott. 2001. Genetics of Milk Yield and Fertility Traits in Holstein-Friesian Cattle in Large-Scale Kenyan Farms. J. Anim. Sci. 79:1742-1750.

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

Oseni, S., I. Misztal, S. Tsuruta, and R. Relaya. 2004. Genetic Components of Days Open Under Heat Stress. J. Dairy Sci. 87:3022-3028.

Peeler, I. D., R. L. Nebel, R. E. Pearson, W. S. Swecker, and A. Garcia. 2004. J. Dairy Sci. 87:2868-2873.

Pryce, J. E., M. D. Royal, P. C. Garnsworthy, and I. L. Mao. 2004. Fertility in the Heigh-Producing Dairy Cow. Livest. Prod. Sci. 86:125-135.

Rajala-Schultz, P. J. and G. S. Frazer. 2003. Reproductive Performance in Ohio Dairy Herds in the 1990s. Anim. Reprod. Sci. 76:127-142.

Ravagnolo, O. and I. Misztal. 2002. Effect of Heat Stress on Nonreturn Rate in Holsteins: Fixed-Model Analyses. J. Dairy Sci. 85:3101-3106.

Roxström, A., E. Strandberg, B. Berglund, U. Emanuslson, and, J. Philipsson. 2001. Genetic and Environmental Correlations Among Female Fertility Traits, and Between the Ability to Show Oestrus and Milk Production in Dairy Cattle. Acta. Agric. Scand., Sect. A, Animal Sci. 51:192-199.

Santos, J. E. P., S. O. Juchem, R. L. A. Cerri, K. N. Galvão, R. C. Chebel, W. W. Thatcher, C. S. Dei, and C. R. Bilby. 2004. Effect of bST and Reproductive Management on Reproductive Performance of Holstein Dairy Cows. J. Dairy Sci. 87:868-881.

Silva, H. M., C. J. Wilcox, W. W. Thatcher, R. B. Becker, and D. Morse. 1992. Factors Affecting Days Open, Gestation Length, and Calving interval in Florida Dairy Cattle. J. Dairy Sci. 75:288-293.

Silvia, W., 1998. Changes in Reproductive Performance of Holstein Dairy Cows in Kentucky from 1972 to 1996. J. Dairy Sci. 81(Suppl. 1):244. (Abstr.)

Silvia, W. J., R. W. Hemken, and T. B. Hatler. 2002. Timing of Onset of Somatotropin Supplementation on Reproductive Performance in Dairy Cows. J. Dairy Sci. 85:384-389.

Tenhagen, B.-A., M. Drillich, R. Surholt, and W. Heuwieser. 2004. Comparison of Timed AI After Synchronized Ovulation to AI at Estrus: Reproductive and Economic

Considerations. J. Dairy Sci. 87:85-94.

VanRaden, P. M., A. H. Sanders, M. E. Tooker, R. H. Miller, H. D. Norman, M. T. Kuhn, and G. R. Wiggans. 2004. Development of a national genetic evaluation for cow fertility. J. Dairy Sci. 87:2285-2292.

Washburn, S. P., W. J. Silvia, C. H. Brown, B. T. McDaniel, and A. J. McAllister. 2002. Trends in Reproductive Performance in Southeastern Holstein and Jersey DHI Herds. J. Dairy Sci. 85:244-251.

Wilson, S. J., R. S. Marion, J. N. Spain, D. E. Spiers, D. H. Keisler, and M. C. Lucy. 1998a. Effect of Controlled Heat Stress on Ovarian Function of Dairy Cattle. 1. Lactating Cows. J. Dairy Sci. 81:2124-2131.

Wilson, S. J., C. J. Kirby, A. T. Koenigsfeld, D. H. Keisler, and M. C. Lucy. 1998b. Effect of Controlled Heat Stress on Ovarian Function of Dairy Cattle. 2. Heifers. J. Dairy Sci. 81:2132-2138.

Table 1. Numbers of service records in New York and Georgia.

	New York	Georgia
Days in milk group		
21~50	13,425	1,307
51~75	72,222	4,430
76~100	63,846	4,558
101~125	49,409	3,847
126~150	36,314	2,912
151~175	25,368	2,286
176~200	17,315	1,645
201~225	11,516	1,317
226~250	8,600	1,064
Service month		
January	29,068	3,228
February	26,544	2,722
March	28,031	2,606
April	23,005	1,852
May	21,188	1,565
June	22,292	1,320
July	26,583	1,309
August	26,637	1,279
September	24,768	1,518
October	25,372	1,556
November	23,556	2,015
December	20,971	2,396
Milk production level		
Low	47,038	3,814
Medium	204,872	15,876
High	46,105	3,676

Table 2. Mean and SD of variance components for service sire, sire and residual in New York.

Variance component	mean	SD
Service sire	0.075	0.005
Sire	0.003	0.0006
residual	1.026	0.004

Table 3 The mean and SD of variance component for service sire, sire and residual at different DIM stage in New York.

Variance component	mean	SD
Service sire	0.0756	0.00486
Sire at 21-100DIM	0.0057	0.00175
Sire at 101-175DIM	0.0048	0.00228
Sire at 175-250DIM	0.0129	0.00534
residual	1.0266	0.00423

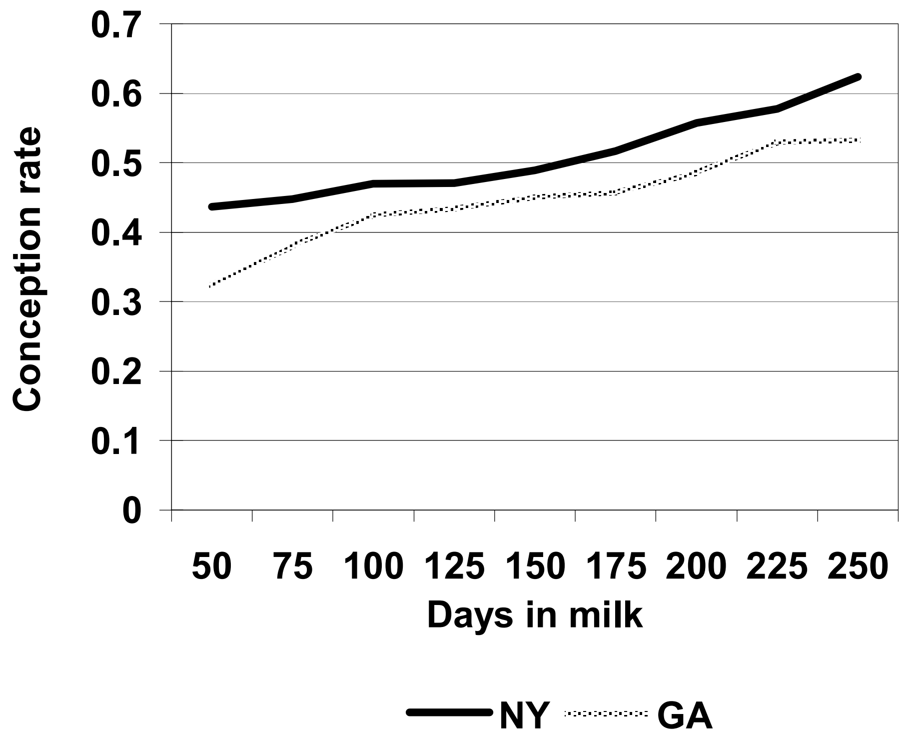

Figure 1. Conception rates across days in milk in Georgia (GA) and New York (NY).

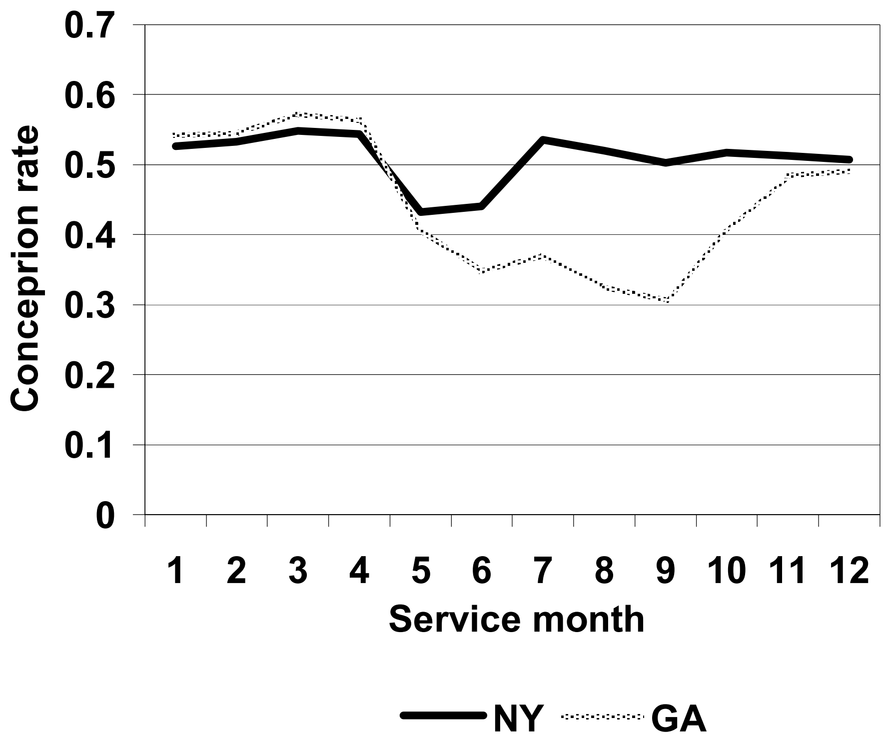

Figure 2. Conception rates across service months in Georgia (GA) and New York (NY).

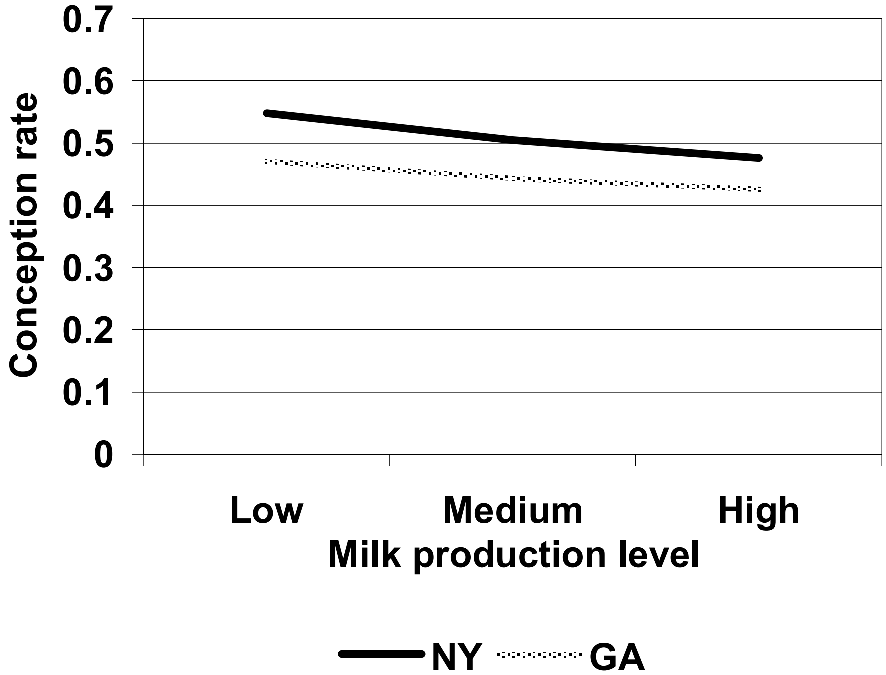

Figure 3. Conception rates for low, medium and high milk production levels in Georgia (GA) and New York (NY).

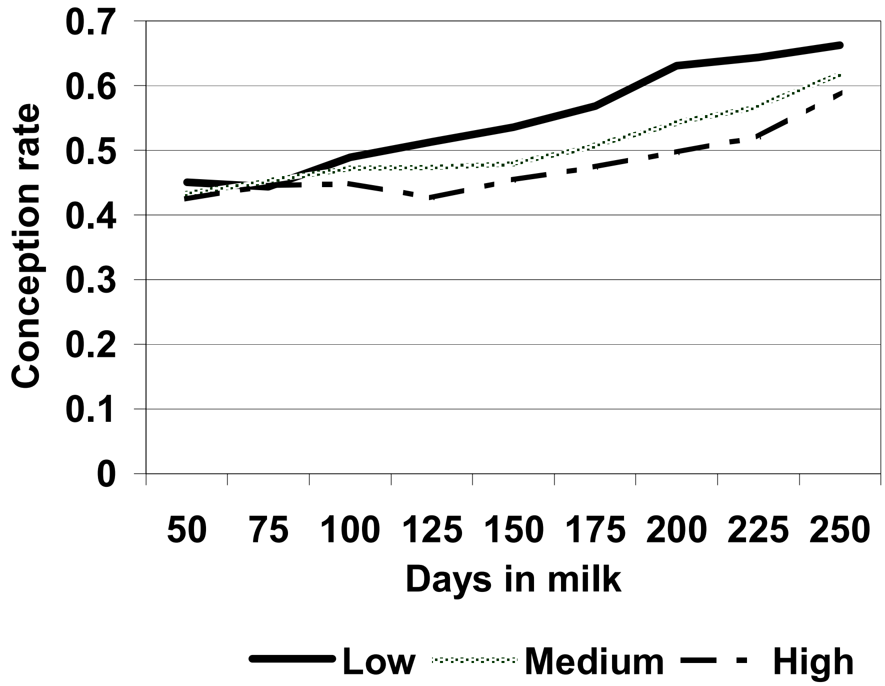

Figure 4. Conception rates across days in milk for low, medium and high milk production levels in New York.

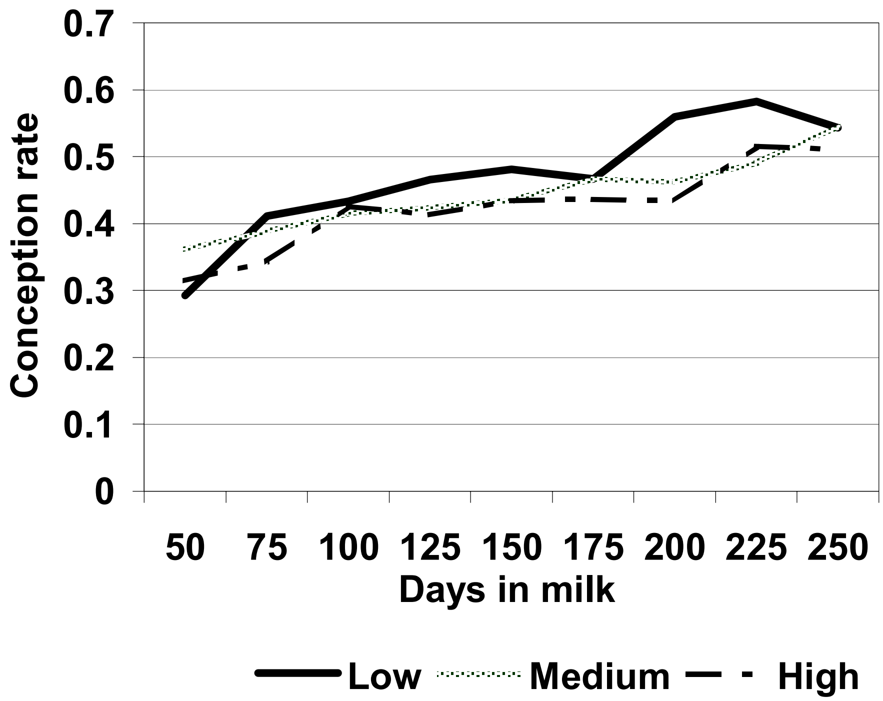

Figure 5. Conception rates across days in milk for low, medium and high milk production levels in Georgia.

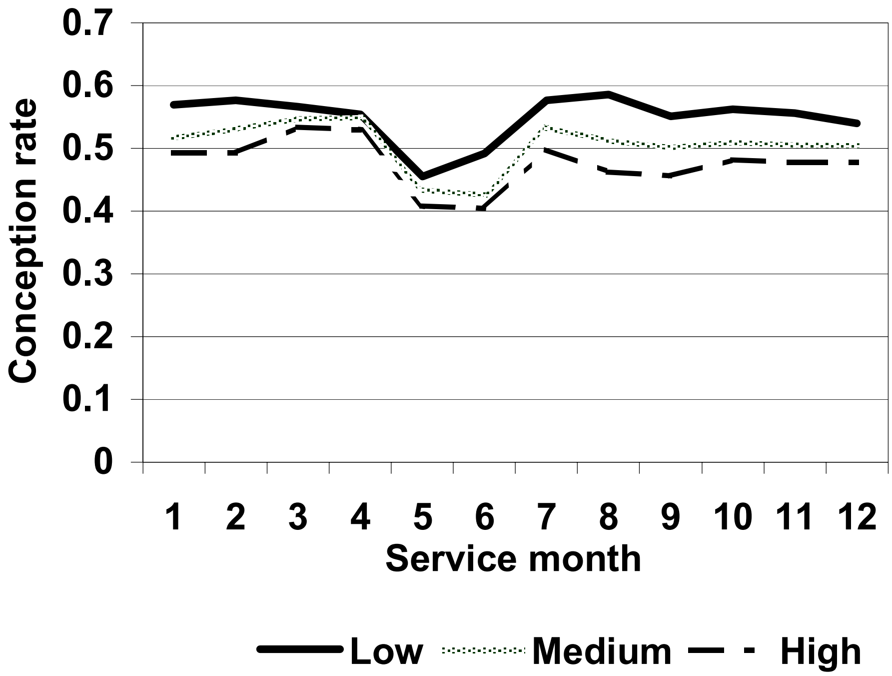

Figure 6. Conception rates across service months for low, medium and high milk production levels in New York.

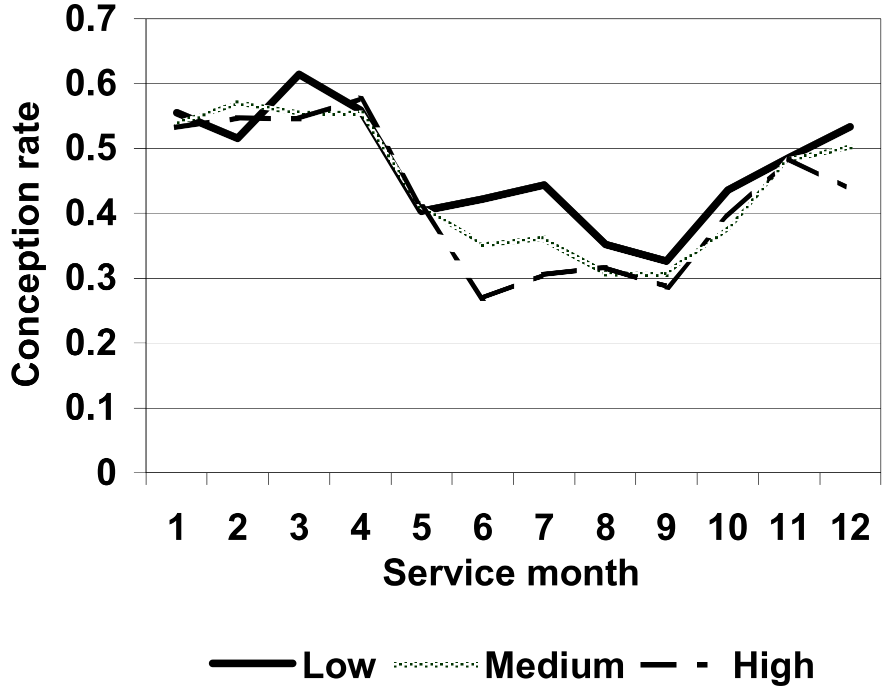

Figure 7. Conception rates across service months for low, medium and high milk production levels in Georgia.

CHAPTER 4

CHANGES FOR CONCEPTION RATE OF HOLSTEINS OVER TIME IN SOUTHEAST USA[1]

[1] C. Huang, S. Tsuruta, I. Misztal. Submitted to Live. Prod. Sci. (2006).

ABSTRACT

The purpose of this study was to estimate trends in conception rate (CR) of Holsteins in Southeast USA as a function of service month and level of milk production. Data were obtained from Dairy Records Management Systems in Raleigh, NC, and included service records from 11 states (VA, KY, NC, SC, TN, GA, FL, AL, MS, LA, TX). Editing eliminated records without calving or birth date, parity >1, days to service after calving <21 or >250, or without next calving date. The final data set included 827,802 AI service records for 424,513 cows born from 1985 to 2000 and in 2,953 herds. Effects included in the model were year of birth (1985-89, 1990-94, 1995-2000), days after calving group, milk production level (< mean – 1 SD, between mean ± 1 SD, > mean + 1 SD), service month, age of cow at calving, and two- and three-way interactions. The average CR decreased from 49% in 1985-89 to 46% in 1995-2000. The decrease over time was mostly concentrated in May-July and was minimal during the winter season. The CR increased over DIM, decreased during the summer time, and decreased due to higher milk production. Decreased fertility over time appears to be caused by the deterioration of heat tolerance due to increased milk yield. This deterioration can be offset by extending the voluntary waiting period by 75-100 d and by avoiding breeding during the summer time.

Key words: conception rate, fertility, Holstein.

INTRODUCTION

A decline in fertility in Holsteins has been reported by many studies (Butler, 1998; Silvia, 1998; Rajala-Schultz and Frazer, 2003; Washburn et al., 2002; de Vries and Risco, 2005b). Lower fertility problem results in longer lactation lengths and economic losses due to increase in the number of inseminations, veterinary costs and involuntary culling (Hansen et al., 1983; Weller, 1989; Taylor et al., 1985; Clay et al., 2001; Lopez-Gatius et al., 2002; Olori et al., 2002).

Deteriorating fertility was attributed to the antagonistic relationship between fertility traits and milk production (Abdallah and McDaniel, 2000a,b; M. C. Lucy, 2001; Roxström et al., 2001). The deterioration is especially strong during the hot season (Silva et al., 1992; Marti and Funk, 1994; Jordan, 2003; de Vries and Risco, 2005a,b). One way reduce the decrease is through genetic selection. The official genetic evaluation for fertility in the U.S. started a few years ago (VanRaden et al., 2004). Several studies looked at improving heat tolerance for fertility through selection (Oseni et al., 2003; Oseni et al., 2004; Ravagnolo and Misztal, 2002).

Because fertility is a complex trait, it is difficult to decide which traits should be considered in genetic evaluation (Lucy, 2001). Traits used include days open, days to first service, pregnancy rate and non-return rates (Silva et al., 1992; Oseni et al., 2004; Ravagnolo and Misztal, 2002; de Vries and Risco, 2005a,b; Washburn et al., 2002). Long days open can be due to a variety of factors, including environmental factors. Averill et al. (2004) suggested analyses of service records; each such record can be adjusted for its environmental factors, potentially increasing the accuracy of selection. Huang et al. (2006) analyzed service records for fertility of NY and GA for cows calving from 2000 to 2003. Conception rate (CR) was mostly affected by milk production in New York, and mostly by heat stress in Georgia; Georgia had a lower average milk yield than NY.

One way producers handle lower fertility is through increasing the voluntary waiting period (VWP) for breeding during the lactation period. The minimum amount of VWP that is necessary to increase the fertility/conception rates in high producing cows is not well established. Another question is whether the decline in fertility over time was solely due to increased milk production, and whether increased VWP can reverse the decline.

Service records over time in the U.S. are scarce. However, the Raleigh DRPC collected information on service records in the Southeast for almost 20 years. The purpose of this study was to analyze those records with emphasis on changes of CR over time across different milk production levels, across different seasons and across different days in milk (DIM) classes. A separate goal was to examine whether CR over time remained the same trait genetically.

MATERIALS AND METHODS

Data

Service records from 1988 to 2004 were obtained from the Dairy Record Management Systems, Raleigh, NC, and contained data from Virginia, Kentucky, North Carolina, South Carolina, Tennessee, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas. The data editing procedures are the same as Huang et al. (2006) with the exception that there only the first three-test day information was available; therefore, the three milk production levels (low, medium, high) were classified based on the first three test-day milk records. Cows without any of the first three test-day milk records were removed. After removing those years with small number of records and small proportion of conceived confirmation, only cows born from 1985 to 2000 were used. The final data sets consisted of 827,802 service records for 424,513 cows from 2,953 herds. The numbers of service records are shown in Table 1 by birth year, DIM group, service month and milk production level.

Statistical analyses

Analyzes were similar to the procedures used by Huang et al. (2006). The model used included the same fixed effects as Huang et al. (2006) except that year of birth group (1985-1989, 1990-1994, 1995-2000) and two- and three-way interactions that included year effects were added.

Similar to Huang et al. (2006), a genetic analysis was conducted using a threshold model via Gibbs sampling, with analyzes running for 100,000 iterations with a burn-in period of 10,000. However, the model in the present study added one more fixed effect for year of birth and the random effects of service sire and sire in three classes of year of birth.

RESULTS AND DISCUSSION

All CR calculated in this study are most likely overestimated because cows without complete conception records were excluded on the editing process. More precise editing was difficult due to limited information. From 1985 to 2000, the CR decreased from 50% to 44% while milk production increased from 26.1 kg to 30.0 kg (Figure 1). The decline of CR in southeastern U.S. agrees with several studies that reported a decline in several different fertility traits (Butler, 1998; Silvia, 1998; Washburn et al., 2002; Rajala-Schultz and Frazer, 2003; de Vries and Risco, 2005b).

Fertility can be affected by a combination of several factors (Lucy, 2001), including not only milk yield but also postpartum diseases, calving ease, energy balance, bST use, herd size, management in terms of service protocols, season, and inbreeding. Over the DIM change from 50 to 250 d, the average CR increased from 36% to 61%, 34% to 60% and 32% to 59% for time periods of 1985~89, 1990~94 and 1995~2000, respectively (Figure 2). This indicates that increased VWP likely results in fewer inseminations. This result agrees with those reported by Clay and McDaniel, (2001) and Averill et al., (2004). Another significant factor was seasonal effects. The CR was the highest during the cool season (55-57% in January to April) and the lowest during the hot season (31-41% in June to September) (Figure 3). The CR was affected by season differently over time; dropping earlier in summer in 1995-2000 than in 1985-1989. The lowest CR during summer was similar for the 16 years time frame represented in this study. This result agrees with several other studies that reported cows under heat stress have longer DO and calving interval (Silva et al., 1992; Marti and Funk, 1994; Oseni et al., 2003, Oseni et al., 2004), and lower non-return, pregnancy and CR (Ravagnolo and Misztal, 2002; Jordan, 2003; de Vries and Risco, 2005a,b).

Three milk production levels were classified using the average of first three test-day milk records. Low level cows were < 1 SD below the mean, medium cows were ± 1 SD from the mean and high level cows were > 1 SD above the mean. The means and SD for cows were calculated separately for each year of birth because test-day milk production increased over time (Figure 1). On average, CR decreased from 50% to 44% as milk production increased from low to high (Figure 4). The differences between CR with high and low milk production were 9%, 6% and 5% for 1985-89, 1990-94, and 1995-2000, respectively. The decline over time was largest for low milk producing cows (5% from 1985 to 2000), but there was almost no change for high milk producing cows, 0.5% for each year period. Generally, high milk producing cows have been reported to have longer DO and calving interval, more number of services (Marti and Funk, 1994; Eicker and et al., 1996; Dematawewa and Berger, 1998; Ojango and Pollott, 2001), and lower non-return rate, pregnancy rate and CR (Pryce and et al., 2004; Brotherstone and et al., 2004). However, it has been observed that DO appears to get larger with higher production up to a point, and then stays about the same (Marti and Funk, 1994). It agrees with our result that low milk producing cows have larger declines in fertility over time compared to high milk producing cows. It could also be that the information used to describe milk production of cows in this study (average of the first three test-day milking records) may not be informative enough to describe milk yield change over time. Weigel and Rekaya, 2000 reported that milk yield during the first 100 d of lactation had no effect on non-return rate at 60 d after insemination.

The CR across DIM for different milk production levels changed over time (Figure 5). During 1985-1989, CR in the early stage of lactation was higher than those for recent years, especially for low milk producing cows. In the last two year groups, the differences of CR among milk production levels were smaller. There was also a noticeable DIM time lag in the improvement in CR for high producing cows over the years. During 1985-1989, high producing cows had a significant increase after 125 DIM but the increase was delayed until after 175 DIM during 1995-2000.

Cows with different milk production levels are affected differently by heat stress over time. As shown in Figure 4, there is an antagonistic relationship between milk production and CR. Figure 6 shows CR across service month for different milk production levels in three year groups. The smallest difference between CR for high and low milk producing cows was 7% in February and 3% in March, and the largest difference was 11% in June and 9% in July for 1985-1989 and 1995-2000, respectively. The CR for each service month was clearly different among milk production levels during 1985-1989, but the difference was shrunk during the cool season in the last year group. These results indicate that, over time, the selection decreased heat tolerance for fertility, with heat tolerance being even lower for high producers; however, CR during cold seasons seems to have deteriorated much less.

The genetic analysis results are show in Table 2. The heritability for CR was estimated at 0.017. This result is similar to hertitabilities reported by Pedersen and Jensen (1996) and Hodel et al. (1995), who found estimates of 0.8% and 1.1% for 56 and 90- d nonreturn rate in heifers, respectively. The ratio of the service sire variance to the total phenotypic variance was close to 0.01, which is similar to other literature reports (Boichard and Manfredi, 1994; Averill et al., 2004). When three sire effects were in the model, each for a time period. The heritabilities were 1.7%, 1.9%, and 1.8% for three time periods of 1985-1989, 1990-1994, and 1995-2000, respectively (Table 3). The genetic correlations between the different time periods were 0.82, 0.95, 0.67 between 1985-1989 with 1990-1994, 1990-1994 with 1995-2000 and 1985-1989 with 1995-2000, respectively. The heritability estimates of the time periods were similar, and the genetic correlations between the time periods were high. These results could be affected by the quality and editing of data and the fact that milk production levels were based on only the first three test-day milking records.

CONCLUSIONS

The decline in CR in the Southeastern U.S. seems to be mostly due to higher milk production and occurs predominantly during the hot seasons of the year. The decline could be stopped or reversed by increasing VWP, concentrating breeding during the winter season, and by genetic selection for fertility particularly under heat stress.

REFERENCES

Abdallah, J. M., and B. T. McDaniel. 2000a. Genetic Change in Milk, Fat, Days Open, and Body Weight After Calving Based on Three Methods of Sire Selection. J. Dairy Sci. 83:1359-1363.

Abdallah, J. M., and B. T. McDaniel. 2000b. Genetic Parameters and Trends of Milk, Fat, Days Open, and Body Weight After Calving in North Carolina Experimental Herds. J. Dairy Sci. 83:1364-1370.

Averill, T. A., R. Rekaya, and K. Weigel, 2004. Genetic Analysis of Male and Female Fertility Using Longitudinal Binary Data. J. Dairy Sci. 87:3947-3952.

Boichard, D., and E. Manfredi. 1994. Genetic Analysis of Conception Rate in French Holstein Cattle. Acta. Agric. Scand. 44:138–145.

Brotherstone, S., R. Thompson, and I. M. S. White. 2004. Effect of Pregnancy on Daily Milk Yield of Holstein-Friesian Dairy Cattle. Livest. Prod. Sci. 87:265-269.

Butler, W. R. 1998. Review: Effect of Protein Nutrition on Ovarian and Uterine Physiology in Dairy Cattle. J. Dairy Sci. 81:2533-2539.

Clay, J. S., and B. T. McDaniel. 2001. Computing Mating Bull Fertility From DHI Nonreturn Data. J. Dairy Sci. 84:1238-1245.

Dematawewa, C. M. B. and P. J. Berger. 1998. Genetic and Phenotypic Parameters for

305-Day Yield, Fertility, and Survival in Holsteins. J. Dairy Sci. 81:2700-2709.

de Vries, A., C. Steenholdt, and C. A. Risco. 2005a. Pregnancy Rate and Milk Production in Natural Service and Artificially Inseminated Dairy Herds in Florida and Georgia. J. Dairy Sci. 88:948-956.

de Vries, A. and C. A. Risco. 2005b. Trends and Seasonality of Reproductive Performance in Florida and Georgia Dairy Herds from 1976 to 2002. J. Dairy Sci. 88:3155-3165.

Eicker, S. W., Y. T. Gröhn, and J. A. Hertl. 1996. The Association Between Cumulative Milk Yield, Days Open, and Days to First Breeding in New York Holstein Cows. J. Dairy Sci. 79:235-241.

Hansen, L. B., A. E. Freeman, and P. J. Berger. 1983. Variances, Repeatabilities, and Age Adjustments of Yield and Fertility in Dairy Cattle. J. Dairy Sci. 66:281-292

Hodel, F., J. Moll, and N. Kuenzi. 1995. Analysis of fertility is Swiss Simmental cattle—Genetic and environmental effects on female fertility. Livest. Prod. Sci. 41:95–103.

Huang, C., S. Tsuruta, and I. Misztal. 2006. Environmental effects on conception rate of Holsteins in New York and Georgia. J. Dairy Sci. Submitted.

Jordan, E. R. 2003. Effects of Heat Stress on Reproduction. J. Dairy Sci. 86(E. Suppl.):E104-E114.

López-Gatius, F., P. Santolaria, J. Yaniz, J. Rutllant, and M. Lopez-Bejar. 2002. Factors Affecting Pregnancy Loss From Gestation Day 38 to 90 in Lactating Dairy Cows From a Single Herd. Theriogenology. 57:1251-1261.

Lucy, M. C. 2001. Reproductive Loss in High-Producing Dairy Cattle: Where Will It End?

J. Dairy Sci. 84:1277-1293.

Marti, C. F. and D. A. Funk. 1994. Relationship Between Production and Days Open at Different Levels of Herd Production. J. Dairy Sci. 77:1682-1690.

Ojango, J. M. K. and G. E. Pollott. 2001. Genetics of Milk Yield and Fertility Traits in Holstein-Friesian Cattle in Large-Scale Kenyan Farms. J. Anim. Sci. 79:1742-1750.

Olori, V. E., T. H. E. Meuwissen, and R. F.Veerkamp. 2002. Calving Interval and Survival Breeding Values as Measure of Cow Fertility in a Pasture-based Production System With Seasonal Calving. J. Dairy Sci. 85:689-696.

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

Oseni, S., I. Misztal, S. Tsuruta, and R. Rekaya. 2004. Genetic Components of Days Open Under Heat Stress. J. Dairy Sci. 87:3022-3028.

Pedersen, J., and J. Jensen. 1996. Evaluation of Female fertility of Danish Dairy Sires. Pages 72-77 in Proc. Int. Workshop on Genetic Improvement of Functional Traits in Cattle. Gembloux, Belgium, January 1996. INTERBULL Bull. no. 12, Int. Bull. Eval. Serv., Uppsala, Sweden.

Rajala-Schultz, P. J. and G. S. Frazer. 2003. Reproductive Performance in Ohio Dairy Herds in the 1990s. Anim. Reprod. Sci. 76:127-142.

Ravagnolo, O. and I. Misztal. 2002. Effect of Heat Stress on Nonreturn Rate in Holsteins: Fixed-Model Analyses. J. Dairy Sci. 85:3101-3106.

Roxström, A., E. Strandberg, B. Berglund, U. Emanuelson, and J. Philipsson. 2001. Genetic and Environmental Correlations Among Female Fertility Traits, and Between the Ability to Show Oestrus and Milk Production in Dairy Cattle. Acta.

Agric. Scand., Sect. A, Animal Sci. 51:192-199.

Silva, H. M., C. J. Wilcox, W. W. Thatcher, R. B. Becker, and D. Morse. 1992. Factors Affecting Days Open, Gestation Length, and Calving interval in Florida Dairy Cattle. J. Dairy Sci. 75:288-293.

Silvia, W., 1998. Changes in Reproductive Performance of Holstein Dairy Cows in Kentucky from 1972 to 1996. J. Dairy Sci. 81(Suppl. 1):244. (Abstr.)

Taylor, J. F., R. W. Everett, and B. Bean. 1985. Systematic Environmental, Direct, and Service Sire Effects on Conception Rate in Artificially Inseminated Holstein Cows. J. Dairy Sci. 68:3004-3022.

VanRaden, P. M., A. H. Sanders, M. E. Tooker, R. H. Miller, H. D. Norman, M. T. Kuhn, and G. R. Wiggans. 2004. Development of a national genetic evaluation for cow fertility. J. Dairy Sci. 87:2285-2292.

Washburn, S. P., W. J. Silvia, C. H. Brown, B. T. McDaniel, and A. J. McAllister. 2002. Trends in Reproductive Performance in Southeastern Holstein and Jersey DHI Herds. J. Dairy Sci. 85:244-251.

Weigel, K. A. and R. Rekaya, 2000. Genetic Parameters for Reproductive Traits of Holstein Cattle in California and Minnesota. J. Dairy Sci. 83:1072-1080.

Weller, J. I. 1989. Genetic Analysis of Fertility Traits in Israeli Dairy Cattle. J. Dairy Sci. 72:2644-2650.

Table 1. Numbers of service records in year of birth, days in milk group, service month and milk production level.

Year of birth		Days in milk group	
1985	9,923	21~50	45,620
1986	17,078	51~75	189,712
1987	18,479	76~100	176,182
1988	20,460	101~125	131,969
1989	21,146	126~150	96,856
1990	23,981	151~175	70,349
1991	23,243	176~200	50,994
1992	29,190	201~225	37,058
1993	40,089	226~250	29,062
1994	38,707		
1995	34,194	**Service month**	
1996	32,470	January	87,154
1997	30,273	February	70,717
1998	31,871	March	68,712
1999	30,958	April	58,856
2000	22,451	May	51,904
		June	43,450
Milk production level		July	47,208
Low	120,958	August	56,482
Medium	573,122	September	69,174
High	133,722	October	87,248
		November	94,705
		December	92,192

Table 2. Mean and standard deviation of variance component for service sire, sire and residual.

Variance component	mean	SD
Service sire	0.0098	0.00153
Sire	0.0045	0.00087
residual	1.0240	0.00264

Table 3 The mean and SD of variance component for service sire, sire and residual at different time periods.

Variance component	mean	SD
Service sire	0.0098	0.00093
Sire on 1985-1989	0.0046	0.00091
Sire on 1990-1994	0.0050	0.00069
Sire on 1995-2000	0.0047	0.00072
residual	1.0239	0.00267

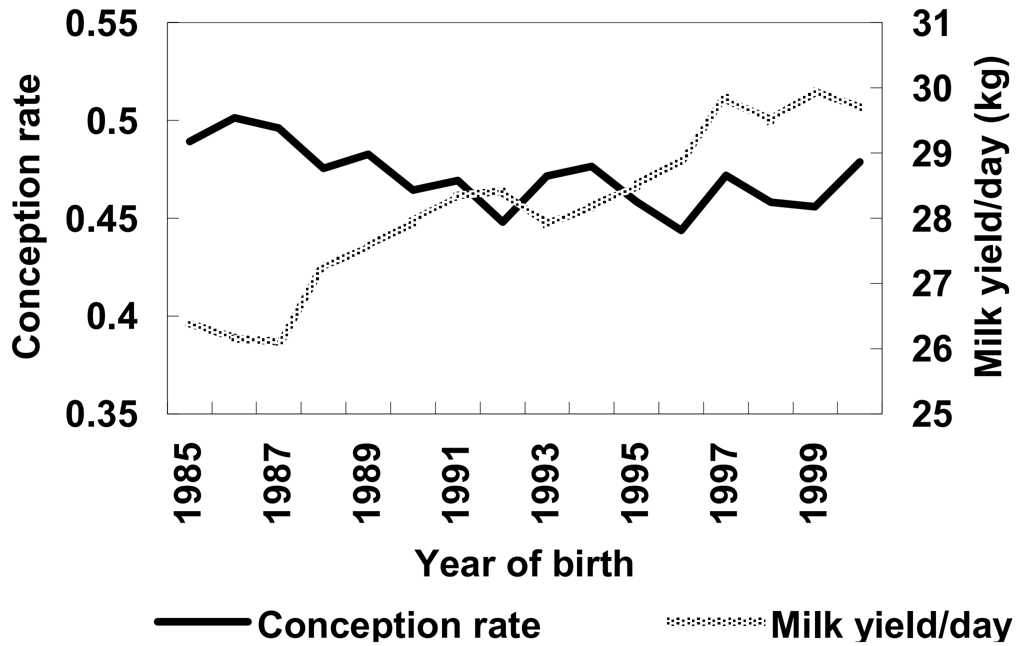

Figure 1 Conception rate and simple mean of first three test-day milking records over year of birth.

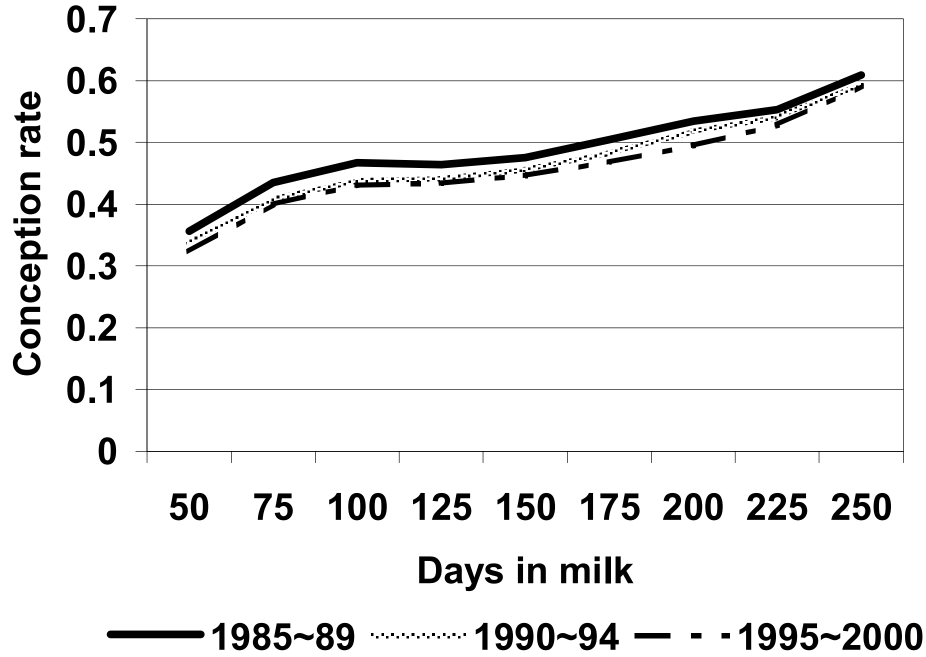

Figure 2 Conception rates across days in milk from 1985 to 1989, 1990 to 1994 and 1995 to 2000.

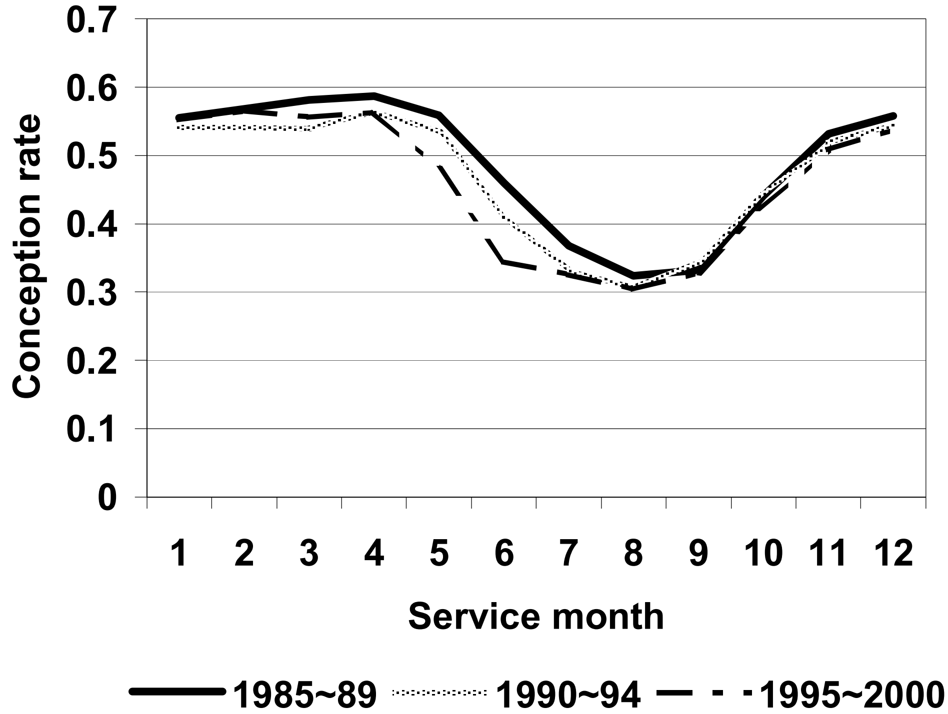

Figure 3 Conception rates across service months from 1985 to 1989, 1990 to 1994 and 1995 to 2000.

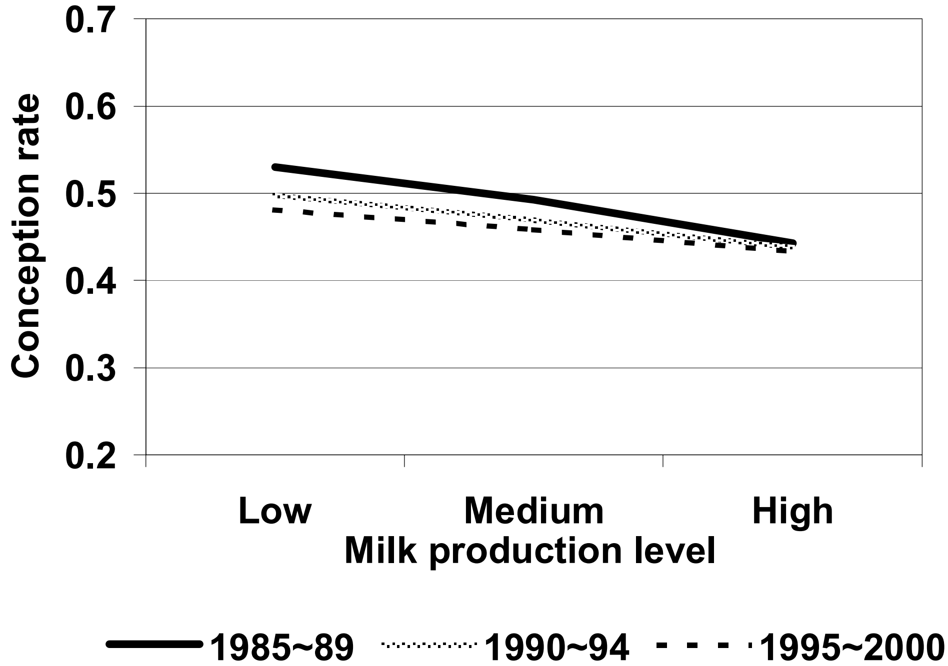

Figure 4 Conception rates for low, medium and high milk production levels from 1985 to 1989, 1990 to 1994 and 1995 to 2000.

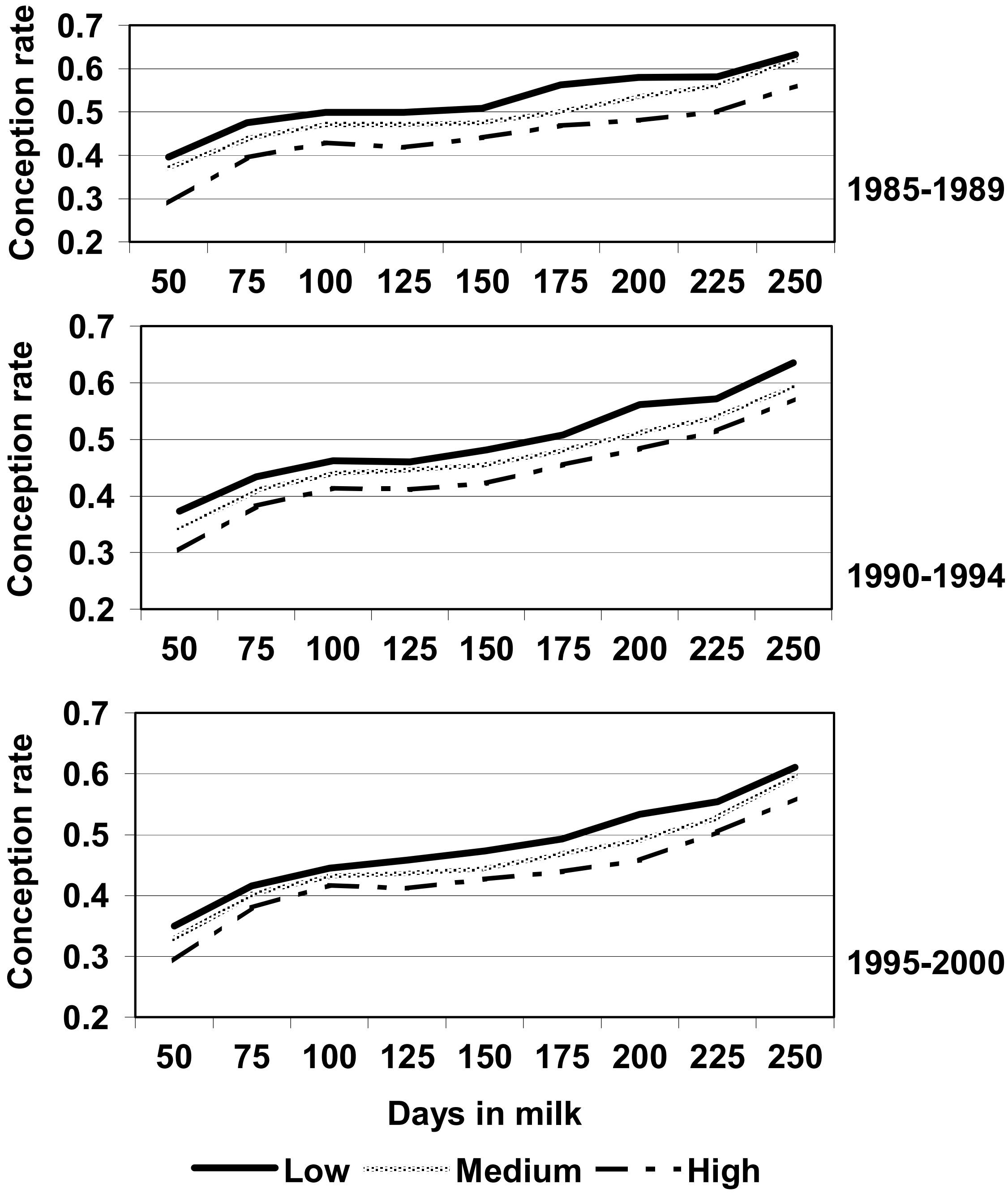

Figure 5 Conception rates across days in milk for low, medium and high milk production levels from 1985-1989, 1990-1994 and 1995 to 2000.

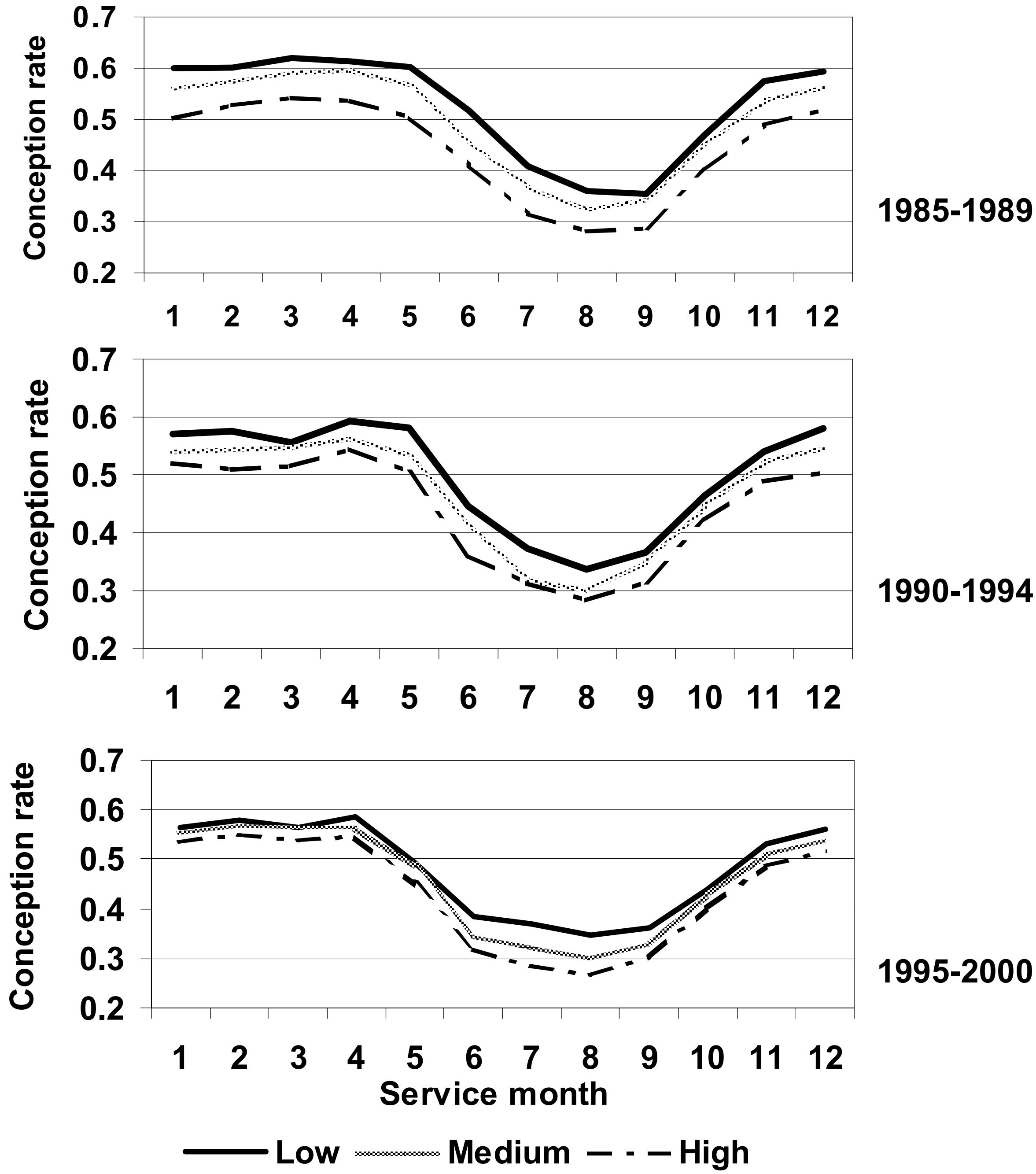

Figure 6 Conception rates across service month for low, medium and high milk production levels from 1985-1989, 1990-1994 and 1995 to 2000.

CHAPTER 5

CONCLUSIONS

In the dairy industry, Holsteins are the most productive breed. They have been selected intensely for production for several decades. Profitability of Holsteins depends on several functions, including the ability to get pregnant. Long-term selection on production has been successful, but selecting for production could indirectly impair fertility performance; genetic selection for fertility was not available until 2003.

When all insemination records are available, conception rate can be accurately measured across DIM and service month so that the effects of these two environmental factors can be clearly shown. All conception rates used in this study were most likely overestimated because of incomplete records and the removal of cows that did not conceive. Conception rates were significantly affected by season, stage of lactation and milk production but varied by regions. Conception rates gradually improve with time after calving; however, there is a larger time lag in improvement for high producing cows compared to low producing cows. Conception rates in NY and GA were similar during spring but conception rates in GA were much lower during the summer, and the conception rate recovery time after the summer season was longer in GA compared to NY. This indicates that heat stress has a negative impact on reproduction, particularly in high producing cows, and that recovery from this stress can take time. The long-term decline in conception rate in the Southeastern U.S. seems to be mostly due to higher milk production and occurs predominantly in the hot season.

Thus, conception rate can be improved by increasing the voluntary waiting period, especially for high producing cows. The conception rates of high producing cows could be improved in hot regions.