CHAPTER 1

INTRODUCTION

Thailand is located in a tropical area with high temperature and humidity. Crossbred Holstein dairy cattle are popular because, during times of high environmental thermal stress, their milk production and reproductive efficiency is not depressed as it is with purebred Holstein cattle. However, these crossbred cattle have been inseminated with purebred Holstein frozen semen to improve milk production. Although the genetic potential for milk yield has improved, the predominant dairy breed has now become Holstein and the impact of heat stress on production and reproduction has increased.

Climatic conditions in the tropics are such that the hot season is relatively long, there is intense radiant energy for an extended period of time, and there is generally high relative humidity. Thus heat stress is chronic in nature, there is often little relief from the heat during the night, and intense bursts of combined heat and humidity depress performance. Lactating dairy cows create a large quantity of metabolic heat and accumulate additional heat from radiant energy. Heat production and heat accumulation, coupled with a compromised cooling capability, because of environmental conditions, causes heat load in the cows to increase to a point when body temperature rises, feed intake declines and ultimately the cow's productivity falls.

During period of elevated temperature, animals show less physical activity and seek shelter to decrease radiant heat exposure. Elevated body temperatures will rapidly trigger adaptive mechanisms to restore body temperature to normal. These adaptations, including panting, sweating, reduced feed intake and lowered metabolism, may be necessary for survival, but they are not generally favorable to milk production (Stott, 1981). Moreover, because of their relative size and their high metabolic rate, associated with milk production, dairy cows are particularly susceptible to the effects of heat stress.

Heat stress has a significant impact on dairy cattle in hot and humid climates. Environmental factors, which contribute to heat stress, include high temperatures, radiant energy, and high humidity, all of which compromise the cow's ability to dissipate body heat. When the cow cannot dissipate sufficient heat to maintain thermal balance, body temperature rises and heat stress occurs. Temperature is a major component of heat stress, but humidity must also be considered because evaporative heat loss is more effective when humidity is low. The temperature-humidity index (THI) combines these two factors into an indicator of cow comfort. Cows are beginning to be stressed when the THI exceeds 72 (Armstrong, 1994).

Dairy cows have several mechanisms to help dissipate body heat and maintain body temperature, such as; conduction, convection, radiation and evaporation. Conduction, convection, and radiation depend on a relatively large differential between the body and the environmental temperature, and evaporation works bests at a low relative humidity. When the environmental temperature nears the cow's body temperature and is coupled with high relative humidity, all the cow's cooling mechanisms are impaired. As a result the cow's body temperature rises and the cows exhibits physiological responses to hot weather. Cows in hot climates generally produce additional heat, compared to those in cool climates, because of greater physical activity (such as panting) which is necessary to enhance cooling in hot conditions. In addition lactating dairy cows produce large amounts of heat from both ruminal fermentation and metabolic processes. As production increases, the total amount of heat produced increases. In order to maintain body temperature within the normal range, dairy cows must exchange this heat with the environment. The most noticeable response to heat stress is reduced feed intake, reduced milk yield, reduced activity, and increased respiration rate and water intake.

Heat stress affects reproductive performance both by direct action on reproduction and by indirect actions mediated through alterations in energy balance. There is an interaction between DMI, stage of lactation, milk production, energy balance and heat stress, that results in reduced luteinizing hormone (LH) secretion and a decreased diameter of the dominant follicle in the postpartum period (Jonsson et al., 1997), this results in reduced oestradiol secretion from the dominant follicle, leading to poor expression of oestrus. In heat stressed cows, motor activity and other manifestations of oestrus are reduced (Nobel et al., 1997) and the incidence of anoestrus and silent ovulation are increased (Gwazdauskas et al., 1981).

There is a decrease in fertility in lactating dairy cows during summer in hot climate (Hansen, 1997). The magnitude of the depression depends on the geographical location and the milk yield (Badinga et al., 1985a; 1985b; Al-Katanani et al., 1999). In tropical climates, high ambient temperatures and humidity are important determinants of reproductive performance. Heat stress decreases the intensity and duration of oestrus, which in turn reduces both the number of inseminations and the pregnancy rates(Hansen, 1994 cited by Thompson et al., 1996). Heat stress alters the concentration of circulating hormones by increasing the circulating concentration of corticosteroids (Roman-Ponce et al., 1977) and by reducing progesterone concentration (Howell et al., 1994). The viability of pre-fixation embryos is reduced (Ealy et al., 1993), and the uterine environment is altered by a decreased blood flow (Roman-Ponce et al., 1978) and increased uterine temperature (Gwazdauskas et al., 1973). These changes are associated with increased early embryonic loss and a reduced proportion of successful inseminations. Cows exposed to heat stress have a high incidence of early embryonic mortality (Putney et al., 1988; Ealy et al., 1993), and some of this effect is due to the direct effect of elevated temperature on the embryo (Rivera and Hansen, 2001).

Reducing heat stress in dairy cattle requires a multi-disciplinary approach. It involves breeding for improved heat tolerance and improved nutrition for the animals, and improved the structural design and the environmental control of their housing.

Heat stress reduces milk production and reproductive efficiency. In an attempt to minimize these effects, modifications to dairy cattle housing environments have been implemented to alleviate thermal stressors and improve cow comfort (Younas et al., 1993; Fuquay, 1981; Roman-Ponce et al., 1981). The major objective of any cooling system is to keep the cow's body temperature as close to normal for as much of the day as possible. An acceptable range in rectal temperature is 38.5-39.3 $^{\circ}$C. There are two general approaches to cooling dairy cows. One is to modify the environment to prevent heat stress or to utilize methods that increase heat dissipation from the skin surface of cattle. The easiest and most obvious way to help heat-stressed cows is to provide shade. Direct sunlight adds a tremendous heat load to the cow and can be blocked by shades, but shade alone is inadequate to reduce the effect of heat stress. A more economical method to reduce the effect of heat stress is by evaporative cooling. Evaporative cooling can be accomplished by two approaches; 1) direct evaporation from the skin surface of the cows (fan and sprinkler combinations) and 2) indirect evaporation which involves cooling the micro-environment of the cows, with cooling pads and fans, in an enclosed barn. When water evaporates it absorbs heat, there by reducing the temperature and increasing heat dissipation from the skin of cattle. When water evaporates it also increases the relative humidity, due to the increased level of water vapor present. In hot and humid regions, evaporative cooling always requires the use of forced ventilation.

A number of studies have shown that housing systems in hot climates can be modified by the use of evaporative cooling to improve both milk production and reproductive efficiency of dairy cows (Armstrong et al., 1988, 1993; Flamenbaum et al., 1986; Ryan et al., 1992; Smith et al., 1993a). There is a great potential to reduce temperature and THI. However, as relative humidity increases and or temperature decreases, the potential for evaporative cooling to modify the environment decreases. In hot-humid climates, high relative humidity reduces the potential of evaporative cooling. Therefore, there are questions regarding the effectiveness of evaporative systems in climates with high relative humidity.

The objective of this trial was to study the impact of heat stress on postpartum reproductive performance and milk production and evaluate the effects of utilizing tunnel ventilation and an evaporative cooling system for improving cow comfort, energy balance, postpartum reproductive performance and milk production of early lactating dairy cows in a hot and humid climate. We hypothesized that the modified environment would increase cow comfort, increase postpartum reproductive performance and milk production of dairy cows under tropical conditions.