NATTAPHON CHONGKASIKIT

THE IMPACT OF ADAPTIVE PERFORMANCE ON HOLSTEIN BREEDING IN NORTHERN THAILAND

GEORG – AUGUST – UNIVERSITY, GÖTTINGEN, GERMANY

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Nattaphon Chongkasikit
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Referee: Prof. Dr. H-J. Langholz

Co-Referee: Prof. Dr. Udo ter Meulen

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My mother and my aunt

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1. INTRODUCTION

Dairy production is going to play an important role in Thailand's agriculture, although the present dairy industry in Thailand is still fairly small but growing. Many milk factories were established in the recent years. An increasing number of farmers have changed from growing plant to dairy cattle raising, especially in the northern part of Thailand (Chiangmai, Chiangrai, Lamphun and Lampang Provinces), which was encouraged by the government extension policy since 1962. This development was backed up by the introduction of dairy cooperatives for managing the production, collection and marketing of the milk. The cooperatives are private and an increasing number of them have their own cooler tank for storing fresh milk. Since most of the dairy cattle raising areas are far away from the consumption centers the cooperatives also have to take care of the transportation of the milk and it's marketing strategy to the milk processing industry.

Most of the dairy farms in Northern Thailand are small farms with about 5-10 milking cows and a very limited area for raising cattle. Normally the farmers are raising their cows in their housing area with no or a small area for growing grass. The main feed resources are fresh cut grass from the road sides, rice straw and by products from vegetable cultures (baby corn, peanuts, soybeans) respectively from vegetable and fruit processing. The supply with ready mixed concentrates is well established and their application on farm level according to the performance status of the cows is common practice.

Most of dairy cattle in the northern part of Thailand are Holstein Friesian upgrades based on Thai native cattle and Brahman native cows. Other genetic sources e.g. Sahiwal and Jersey deriving from specific imports are of certain importance. The actual breeding work is more or less completely based on A.I. which is controlled and guaranteed by the official livestock promotion programs on a regional basis. Purebred Holstein Friesians are kept on government farms (Livestock Research and Breeding Development Centers, Department of Livestock Development) or in large scale private farms with larger herd sizes and modern technology, which serve as genetic basis for the upgrading process. The actual upgrading level range between 50 – 93.75 % Holstein Friesian, which causes a large variation in the phenotypic performance characteristics especially in milk yield.

The coincidence of high temperature with high humidity of the tropical climate of Thailand leads to reduced feed intake of the ruminants. This again results in low growth rate, low milk production and reduced fertility. Also the immune competence of the cattle especially of the lactating cows is severely affected leading to a high frequency of mastitis and reproductive disorders.

These constraints are increased by the reduced roughage quality caused by high fiber content and shortcomings in feeding and herd management. The establishment of adequate feed reserves for the dry season and of consistent feeding plans is still in its initial stage. The same holds for reproductive and breeding planning within farms and on the regional level. However there is a wide range to be observed between farms in the feeding and breeding efficiency with an increasing percentage of well managed dairy farms which efficiently employ services of the dairy cooperatives and of the A.I. organization for their farming strategy. It is the aim of this study to identify by an on farm survey the bottlenecks in Northern Thai dairy cattle breeding and define measures to overcome them. Special emphasis should be laid on the adaptive performance to the impaired climatic and feeding environment. The final aim is to work up the population genetic basis data for developing sustainable breeding plans for Northern Thai Holstein breeding.

2. REVIEW OF LITERATURE

2.1 Breeding History of Dairy Industries in Thailand

Thailand is the tropical country under the influence of monsoon climate. Most of the people in rural areas are farmers. They have a remarkable tradition in plant growing such as rice, sticky rice, sugar cane, corn and specific fruits. Raising of animals up to very recently was predominantly subsistence oriented based on native types of chicken, buffalo, cattle, duck, swine, and goat, depending on the differing demands in each area and the appropriation of land. In the north and northeast parts of the country e.g. there is a pronounced demand for beef from cattle and buffalos. In middle part, there is a dominating demand for pork and in south part for meat from goats and chicken because most of people in the south part are Muslims. Whilst for several plant products like rice and tapioca established markets have developed also for export purposes market oriented animal production has reached a significant impact not before the recent decades. This holds especially for poultry and swine production.

In the early 1950 many programs were started to induce Thai people to drink milk. The popularity of drinking milk as a beverage since then continued to rise providing a market for the dairy industry, which in the initial phase exclusively was supplied by imported or recombined dairy products. Dairy farming in Thailand itself began in 1956 when Food and Agriculture Organization of the United Nations (FAO) conducted a survey on animal husbandry practices in small farms. They recommended that improving native draft cattle by crossing them with dairy breeds would increase milk production significantly. Therefore the Department of Livestock Development. (DLD) have opened the first Artificial Insemination (AI) center in Chiangmai province in 1956 and started AI services with fresh semen from imported dairy sires and training programs in dairy farm management. Dairy farming became increasingly of interest for farmers. That was a turning point in establishing an own dairy farming industry.

In 1961 the Thai Danish dairy farm in Muag lek, Saraburi was established with the assistance from the government of Denmark. At the beginning, Red Danes (RDM) was the only dairy breed raised on this farm. Later in 1971 this farm was taken over by the Ministry of Agriculture and Cooperatives (MOAC) and converted into the Dairy Promotion Organization of Thailand (DPO) being responsible for all dairy breeding and production activities throughout the country . In 1999 DPO controlled 29 milk collection centers and 5 milk processing centers processing 250 tons of milk daily from 25,776 dairy cows. DPO also provides training on practical dairy management skills and AI services. The Thai German dairy project was started in 1965 with assistance from the German government in Chiangmai province. The dairy breeds introduced by this project were German Brown and German Friesian with an increasing impact of the Friesians over the years. Like for the Thai Danish dairy farm the dairy plant of this project was handed over to the DPO in the year 1977, whilst the breeding herd being improved by Canadian Holsteins in the later years remained under the control of the Department of Livestock Development (DLD) and serving as a breeding nucleus up to today.

Very recently a greater import of 1000 Holstein Friesian crossbreds (75% , 62.5%) by the DLD for extension purpose in the Chaiprakarn district, Chiangmai province has had a significant impact on promoting dairy production in the Northern part of Thailand.

Encouraged by these various official promotion schemes and additional private support especially in processing and marketing of milk a comprehensive dairy cattle population of ~150000 heads could be build up in a fairly short time all over the country. Ongoing marketing problems and short falling in feeding and breeding planning on many farms led a certain stagnation of the local dairy industry in the recent years with a stable number of dairy farms and a slightly increasing number of milking cows. Less successful dairy farmers changed back to plant growing or to other livestock branches. However in the Northern parts of Thailand there is still a certain growth of the dairy production to be observed obviously due to the more favorable production environment. In the three provinces Chiangmai, Chiangrai and Lamphun the dairy cattle population is up to 14000 heads and 7800 cows (table 1).

As known the impact of genetic improvement programs can be substantially increased by artificial insemination (A.I.). Genetic material of high quality can be propagated in a considerably shorter time using A.I. than using of natural service of bulls. The intensity of selection between sires can also be greatly increased through AI progeny testing programs organized on a sufficient large scale.

Table 1. Number of Dairy Cattle and Farms in Chiangmai, Chiangrai and Lamphun Province (Agriculture Statistics, 2001)

Provinces	Female Calves (Head)		Cows (Head)		Farmers
	New Born-1 year	1 year-1st pregnancy	Milking Cows	Dry Cows	
Chiangmai	2,057	2,400	4,868	1,122	750
Chiangrai	212	355	377	144	99
Lamphun	738	415	1,069	219	191

The Artificial Insemination Division (AI Division), the organization under DLD and responsible for biotechnological research, AI training, semen production, milk recording, progeny testing and sire evaluation was set up in 1956. At the beginning, AI services were undertaken by using fresh semen from proven dairy sires of several breeds such as Brown Swiss and Jersey which were imported from USA. In 1971 the Thai government has chosen only the Holstein Friesian breed to be used for further genetic improvement of the Thai dairy population. Since 1991 a regular sire evaluation was established based on BLUP procedures and performed by DPO. In 1961 AI in swine was taken up and in 1974, the program was expended to beef cattle. At present there are about 30 artificial insemination stations in operation.

2.2 Body Characteristics of Dairy Cattle

2.2.1 Body Size

Dairy cattle have large framed bone structures with a pronounced pelvis area and a reduced muscularity. Because the aim of dairy cattle breeding is to increase milk yield and also milk contents such as fat % and protein%, the body structure of dairy cattle turn out to be different from beef cattle and native cattle in Thailand. Within each dairy breed large cows give more milk, on the average, than small cows, but they also require more maintenance feed. There are research results that the additional costs for larger cows equalize the additional income derived from them (Wilcox *et al.*, 2001). In the case of two cows with equal production but different size, one actually would expect the smaller cow to be more profitable. However, there is research proof that milk yield in dairy cows can be increased significantly without increasing the size. Selection for increased body size could be successful, but the correlated response in milk yield though probably positive will be of negligible impact (Wilcox *et al.*, 2001).

For the size of dairy cows in Northern Thailand Aussawin *et al.*. (2002) reported that the height, heart girth and length of body were 125.55±0.13 cm, 179.95±0.26 and 74.22±0.14 respectively. In addition an effect of herd size on body size was observed, the average of body size in large herds being significantly higher than in small herds. Obviously the farms with larger dairy herds have a higher skill for raising and managing of dairy cattle.

2.2.2 Type Traits

Type traits are very important, because of their relationship with performance of dairy cattle. Such as herd life, the genetic correlations between type traits and herd life indicate the importance of conformation traits in selecting for improved herd life. The estimated genetic correlations for type traits can be used to set up an indirect functional herd life index. Liu *et al.* (2001) found that the genetic correlation between type traits and herd life were moderate and the genetic correlations between functional herd life were 0.20, 0.19, 0.23, 0.56, 0.49, 0.57 and 0.06 for frame capacity, rump, feet and legs, fore udder, rear udder, mammary system and dairy character respectively.

Dickinson, F.N. (2001) found that phenotypic and genetic correlations between milk yield and final score, stature, strength, dairy character, foot angle, rear legs(side view), pelvic angle, thurl width, fore udder attachment, rear udder height, rear udder width, udder depth, suspensory ligament and front teat placement were 0.29, 0.00, 0.11, -0.01, 0.12, 0.07, 0.50, 0.68, 0.00, -0.24, 0.02, 0.14, 0.04, 0.19, 0.10, -0.11, -0.09, -0.47, 0.12, -0.13, 0.16, 0.09, -0.27, -0.64, 0.14, 0.12, 0.02 and -0.12 respectively.

Ashwell *et al.* (1998a) reported about the quantitative trait loci (QTL) affecting conformational type traits using the granddaughter design and 16 microsatellite markers on 10 chromosomes. The most significant marker effect was BM203 (chromosome 27) for dairy form in a single grandsire family. A multivariate analysis for dairy form and milk yield was used and resulted in high significant effects, indicating that a segregating quantitative trait locus or loci affecting dairy form and milk yield could exist near BM203 on chromosome 27. Marker BM1258 (chromosome 23) had a significant effect on udder depth. A multivariate analysis on udder depth and somatic cell score was conducted for markers 513 and BM1258, and both markers showed significant effects on these traits, indicating that one or several quantitative trait loci affecting udder depth and mastitis might exist on chromosome 23. Marker BM4204 (chromosome 9) had a significant effect on foot angle and on the composite index of traits pertaining to feet and legs, indicating that one or several quantitative trait loci affecting traits pertaining to feet and legs might exist on chromosome 9. Selection on these markers could increase genetic progress within these families.

Quantitative trait loci affecting milk yield, milk composition, health, and type traits were studied by Ashwell *et al.*. (1998b) for seven large grandsire families of US Holstein using the granddaughter design. The families were genotyped at 20 microsatellite markers on 15 chromosomes, and the effects of the marker alleles were analyzed for 28 traits (21 type traits, 5 milk yield and composition traits, somatic cell score, and productive herd life). The result was that an increase in productive herd life is associated with an allele at marker BM719 on chromosome 16 in one grandsire family.

Dickinson, F.N. (2001) reported that the heritabilities of final type score, stature, chest and body (strength) , dairy character, foot angle, rear legs (side view), rear legs (rear view) pelvic angle (rump side view), rump width, fore udder attachment, rear udder height, rear udder width, udder depth, suspensory ligament and teat placement (rear view) were 0.30,0.40, 0.20, 0.20, 0.10, 0.15, 0.10, 0.20, 0.25, 0.20, 0.15, 0.15, 0.25 0.15 and 0.20, respectively.

Tempelman *et al.* (2001) reported that heritabilities of final score, general appearance, dairy character, capacity, rump, feet and legs, mammary system, fore udder and rear udder of dairy cattle were 0.15, 0.14, 0.21, 0.29, 0.22, 0.10, 0.14, 0.13 and 0.13 respectively.

The heritabilities of type traits to be used in the sire evaluation of Thailand are shown in table 2 (Genetic Evaluation, 2001). The type traits differ substantially in heritability. For example, udder depth has a significantly higher heritability than foot angle. As a result, for a given level of selection it would be greater response to selection for udder depth compared to foot angle.

Table 2. Heritabilities of Type Traits (Genetic evaluation, 2001)

Traits	h^2	Traits	h^2	Traits	h^2
Statue	0.42	Rear legs (Side)	0.21	Rear Udder Width	0.23
Strength	0.31	Rear legs (Rear)	0.11	Udder Cleft	0.24
Body Dept	0.37	Foot Angle	0.15	Udder depth	0.28
Dairy Form	0.29	Feet and Legs score	0.17	FrontTeat Placment	0.26
Rump Angle	0.33	Fore Udder Attachment	0.29	Teat Length	0.26
Thurl Width	0.26	Rear Udder Height	0.28	Final score	0.29

2.2.3 The Coat Color (% of white color)

The coat color might be of greater importance for dairy production in tropical environments. However in recent years, black and white Holstein-Friesians or their red and white genetic alternatives have become the preferred dairy breed worldwide, also in tropical zones (George, 1993).

In the past, in many countries besides Holstein other breeds with specific characteristics like Guernseys, Jerseys, Ayrshires and Brown Swiss were of significant importance.

There are, however, some biological differences between cows with differing colors leading to differences in enduring environmental stress from heat, humidity and solar radiation (Godfrey *et al.,* 1994a). Some research results indicate that there were physiological differences in adaptation and productivity, depending on the amount of black or white color. Godfrey *et al.*.(1994c) found that the percentage of black or white coat color in Holsteins influences milk production. Climatic stress especially from heat and solar radiation decreases milk production, changes milk composition and affects the reproductive performance.

Solar radiation is a significant factor because it increases body temperature directly. In addition Godfrey *et al.* (1994b) found an increased milk production of 4.5 pounds for each percent more of white coat color in Holstein cows. More white coat color also resulted in better reproductive efficiency under heat stress. White cows produce more milk than black cows, have a lower age at first conception, are fewer days open and have a shorter calving interval. Currently, most of the cattle in Northern Thailand are Holstein-Friesian upgrades and only a minority belongs to uniform colored brown cattle resulting from crossbreeding with Sahiwal or Brown Swiss, which might have some impact on the adaptive performance.

Recent research results on the color controller gene of cattle have been presented by Klungland *et al.*. (1995). They reported that the color of dairy cattle is controlled by 3 loci : EE, SS and S^{H}– as shown in table 3.

Table 3. Color Controller Genes in Dairy Cattle (Klungland *et al.*, 1995)

Dominant		**Recessive**	
Colors	**Genotype**	**Color**	**Genotype**
Black	E-	Red	ee
Uniform	S-	Spotted	ss
White Head	S^{H}–	Uniform	SS

The Holstein Friesian dairy breed has the genotype EEss and the Danish Red dairy breed (RDM) has the genotype eeSS. Crosses between HF and RDM become uniformly black. Some RDM have a different color pattern, tiger stripes, which is caused by an allele in the e locus which dominates over red color. In some British beef cattle breeds, for instance Hereford, white head color pattern occur, having dominant inheritance, it is inherited from a dominant allele in the same locus as spotted. It is known, that the gene for spotted is in chromosome 6.

2.3 Performances of Dairy Cattle

2.3.1 Fertility

Fertility performance is a very important trait for dairy production. It refers a successful farm management. The farms which obtain a high fertility level in their dairy herd will get much better revenue. Fertility is a quantitative trait (Royel *et al.*, 1999), therefore the variation observed (phenotypic) is comprised of both genetic and environmental variation. The coefficient of genetic variation present in many fertility traits is of similar magnitude to that present in production traits (Royel *et al.*, 1999b). This means there is potential for improvements in fertility genetically.

There are many measures to predict the fertility performance of dairy cattle such as days open, conception rate, services per conception and calving interval, etc. Normally, however, the heritability of fertility traits is low ($h^2<0.05$).

In recent studies, Pinit *et al.*. (2000a) reported that the days open, days dry, calving interval and services per conception of 500 Sahiwal x Friesian dairy cows under 100 small farms in Chaiprakarn district, Northern Thailand were 89.76±30.88 days, 87.96±28.19 days, 374.89±38.42 days and 1.71±0.58 services respectively. They also reported (Pinit *et al.*, 2000b) that the days dry, days open, calving interval, age at first calving and service per conception of 245 local crossbred dairy cows raised by 49 small farms were 65.24±22.83 days, 117.48±60.35 days, 403.57±67.82 days 34.55±3.30 months and 2.46±1.61 services, respectively.

Sornthep *et al.*.(1993) reported that the average of services per conception in Sahiwal x Friesian crossbreds raised in the middle part of Thailand in first and second lactation were 1.70 and 1.31 respectively and the calving interval between first and second lactation was 369.79 days.

Suwannee (1994) reported that the calving interval, service per conception and days open of Holstein Friesian crossbreds in Chachiangchao province, East of Bangkok were 429.62 days, 2.48 services and 143.77 days, respectively.

Ageeb *et al.* (2001) reported that the heritability (h^2) of lactation length, estimated by the paternal half-sib method to be 0.00. The repeatability was 0.07 for lactation length. Heritability and repeatability estimates for calving interval were 0.00 and 0.02 respectively.

There is a report from Buckley *et al.*. (2001) that the h^2 estimate for the interval between calving to 1st service was 0.06 and for period between start of breeding to 1st service was also 0.06. These estimates are very similar to those previously published (Veerkamp and Brotherstone, 1997).

Raheja *et al*.. (1989) reported that the heritabilities of calving interval , days between calving and first breeding, days open and number of inseminations per conception per cow were 0.1, 0.05, 0.03 and 0.03 respectively.

Wilcox *et al*.. (2001) reported that the heritability range of conception rate, reproductive efficiency and calving interval of Holstein Friesian cattle were 0.0-0.1, 0.0-0.1 and 0.0-0.2 respectively.

Mao (1984) reported that the range of heritabilities for days open, dry period, breeding problems, calving interval, services per conception, age at first calving and dystocia were 0.01-0.10, 0.15-0.35, 0.00-0.20, 0.00-0.10, 0.00-0.10, 0.15-0.70 and 0.03-0.15, respectively.

Thus fertility parameters in general show a low heritability, resulting in very limited chances for improving the fertility of the cow herd by within herd selection. This on the other hand show that various environmental effects or non additive genetic effects are affecting the fertility performance such as temperature, humidity, feed and farm management. For example, heritability estimates for dystocia (difficult calving) range from 0.03-0.15. This means 3 to 15% of the variation in dystocia scores is due to additive gene action and 85 to 97% of the variation in dystocia is due to environmental influences or non-additive gene action, because the animal performance is a combination of the genetic ability of the animal and the effects of the environment.

Nutrition is potentially the most critical factor affecting reproduction, especially in tropical dairy production systems. The effects of poor nutrition can affect different developmental stages of the cows. Underfeeding heifers e. g. will result in delayed puberty (Walker *et al.,* 2001). A high percentage of underfed heifers will not reach puberty. In addition, delayed skeletal maturity caused from underfeeding can result in decreased pelvic opening and subsequently in increased calving difficulties.

Regarding the direct environmental factors, the stressing climatic conditions of the tropics with high temperatures combined with high humidity can cause decreased reproductive performance. An increase of body temperature by 1.5-2°C can result in embryonic mortality and abortion (Walker *et al.,* 2001). Providing access to shade and fresh water can minimize the effects of heat stress. However an extreme cold on the other hand will result in increasing feed requirements. Each degree drop below the critical temperature in beef cows, resulted in a corresponding 1% increase in the required energy demand.

2.3.2 Productive Performances

In dairy cattle farming, the main components of productive performance are milk yield, fat yield, protein yield and milk contents, particularly fat % and protein %. The objectives of many breeding plans are directed towards increasing them. In developed countries for example Germany, U.S.A. and Canada, the genetic trends of productive performance are steadily increasing. Canada dairy commission (2001) reported that in 1999 dairy cows,one of the main sources of Thai Holstein breeding,in official milk recording produced an average of 8,738 kilograms of milk, which corresponds well to the milk yields obtained in other countries. This reflects an steady increase of 1574 kg milk since 1988 or of 143 kg per cow and year.

Syrstad (2001a) reported that in a single herd a genetic gain of 30 to 40 kg of milk per year can be achieved by selecting young bulls on the basis of their pedigree and cows on the basis of pedigree and first lactation performance. However for a herd of 500 cows, a scheme based on progeny testing of bulls was predicted to give lower genetic gain. Progeny testing schemes are competitive only in units of several thousand recorded cows.

However a certain improvement of milk yield can be done by isolated feed improvement. Wiess (2001) found that small grain forage harvested at the boot or milk stage will support 50 to 65 lbs of milk when fed in properly balanced diets. The diets based on small grain forage harvested at the milk stage requires more concentrate supplementation (energy).

For productive performance of dairy cattle in Thailand meanwhile several reports are available. Pinit *et al.* (2000) reported that average milk yield and lactation length of 500 imported Sahiwal x Friesian crossbreds in Northern Thailand were 3,273.13$\pm$1,202.04 kg and 281.07$\pm$30.47 days, respectively. Furthermore, the average milk yield and lactation length of 245 local Holstein dairy upgrades raised on 49 small farms were 3,263.85$\pm$960.72 kg and 339.67$\pm$75.34 days, respectively.

Sornthep *et al.* (1993) reported that the milk yield and lactation length of Sahiwal x Friesian crossbreds of Thailand in first and second lactation were 1223.20, 1429.40 kg and 193.20 and 173.66 days, respectively.

Chokchai dairy farm (1992) reported that milk yield and lactation length of Sahiwal crossbreds from New Zealand were 2,979.55 kg and 281.50 days, respectively.

Suwannee (1994) reported that milk yield, lactation length and days dry of Holstein Friesian upgrades in Chachiangchao province, east of Bangkok were 2,802.4 kg, 256.87 days and 194.67 days, respectively.

Sureerat *et al. (1*997) reported that milk yield and lactation length of 1,068 Sahiwal x Friesian crossbreds in 16 provinces of Thailand were 2.336 kg and 295 days, respectively.

From the reports above it turns out that the dairy cattle performance in the tropics of Thailand is still much behind the performance level of dairy cattle in temperate countries, which to a great deal most likely is caused by non-genetic rather than by genetic factors.

The heritability estimates for productive performance traits as a rule are distinctly higher than for fertility traits. Thus genetic progress which can be obtained from selection and breeding activities is much more pronounced. Many reports show a range of heritability estimates between 0.2-0.6 as detailed in the following selected examples.

Wilcox *et al.* (2001) reported that the range of heritability estimates for milk yield, milk fat yield, protein yield, total solids yield, milk fat percentage, protein percentage, persistency, peak milk yield, milking rate, gestation length, birth weight, mature weight, wither height, heat tolerance, life span, feed efficiency, mastitis resistance were 0.2-0.3, 0.2-0.3, 0.2-0.3, 0.2-0.3, 0.5-0.6, 0.5-0.6, 0.3-0.5, 0.2-0.4, 0.3-0.6, 0.3-0.5, 0.3-0.5, 0.4-0.6, 0.4-0.6, 0.0-0.2, 0.1-0.3, 0.3-0.4, 0.2-0.3, respectively.

Tempelman *et al.* (2001) reported heritabilities for milk yield and fat yield of dairy cattle of 0.4 and 0.32 respectively.

Ageeb *et al.* (2001) reported that the heritabilities estimated by the paternal halfsib method for daily milk yield and lactation length were 0.21 ±0.20 and 0.00, respectively and repeatabilities estimated by the between and within cows components of variance method were 0.22 and 0.07 for daily milk yield and lactation length respectively. Additional estimates on repeatability of milk yield and lactation length ,which more easily can be obtained for dairy populations in the tropics and which can be considered as the highest estimates for heritability are shown in Table 4.

Table 4 . Repeatability of Milk Yield and Lactation Length in Tropical Cattle

Breed and country	Repeatability		Source
	Milk yield	Lactation length	
Kenana, Sudan	0.43	0.19	Alim, 1960
Nganda, Uganda	0.73	0.42	Mahadevan & Marples, 1961
Hariana, India	0.39	0.28	Singh & Desai, 1961
Butana, Sudan	0.42	0.42	Alim, 1962
East African Zebu, Kenya	0.55	0.38	Galukande, Mahadevan & Black, 1962
Sahiwal crosses, Kenya	0.65	0.33	Mahadevan, Galukande & Black, 1962
Gaolao, India	0.12-0.44	0.20-0.35	Patil & Prasad, 1968, 1970
Gir, India	0.40	0.22	Shulkla & Prasad, 1970
Northern Sudan Zebu, Sudan	0.38	0.29	Osman & El Amin, 1971
Deshi, India	0.42	0.18	Moulick *et al.,* 1972
Kenana, Sudan	0.47	0.47	Wilson *et al.,* 1987
Mpwapwa, Tanzania	0.48	0.46	Kasonta, 1988
White Fulani, Nigeria	0.32	0.21	Mrode, 1988

Vaccaro *et al.* (2001) reported the phenotypic and genetic correlations between milk yield and days open to be 0.21 and 0.16. The phenotypic and genetic correlations between milk yield and calf weight were low but positive (0.11 and 0.16) and the phenotypic and genetic correlations between calf weight and days open were nearly zero. They suggested that although the phenotypic correlation between milk yield and days open was very weak in suckled cows the genetic correlation might increase with higher levels of milk yield (above 2700 kg) achieved without suckling.

The studies of Plante *et al.* (2001) on Holstein Friesian revealed the presence of QTL affecting milk, fat, and protein yield on chromosomes 20 and 26 and of QTL affecting fat and protein percentage on chromosome 3. Analyses within each sire family separately indicated the presence of segregating QTL in at least one family on 7 of the 10 chromosomes included.

Statistically significant estimates of QTL effects on breeding value ranged from 438 to 658 kg of milk, from 17.4 to 24.9 kg of fat, 13.0 to 17.0 kg of protein, 0.04 to 0.17 % fat and 0.07 to 0.10 % protein.

2.3.3 Adaptive Performances

The adaptation of dairy cattle to their production environment can become evident in many patterns depending on the environmental situation such as reduced production at high external temperatures or reduced fertility after feeding low quality diets etc. There are many reports on the effect of environmental factors on the performance of dairy cows, from which the following shall be emphasized.

Age at first calving,

Osei *et al.* (2001) reported that for Holstein Friesian crossbreds in Ghana a mean age at first calving of 34.4 months was obtained with a range of 30 to 36 months. This compares with 30.8 months obtained by Gyawu and Agyemang (1977) for the foundation stock imported in 1974. Comparable figures for Friesians in other tropical areas are 34.8 months in Iraq (Kassir, Juma and Al Jaff, 1969), 40 months in Sri Lanka (Mahadevan, 1956) and 40.4 months in Uganda (Trail and Marples, 1968). Gyawu and Agyemang (1977) reported that the average age at first calving of the contempory Holstein Friesian cattle in Canada and the Netherlands was 27.7 and 25 months respectively. These results indicate that the rearing environment for dairy heifers under tropical conditions turns out to be a specific problem and a key for substantial improvement of the subsequent dairy performance.

Calf birth weights,

Osei *et al.* (2001) reported a mean birth weight of Holstein Friesian crossbreds in Ghana of 30.4 kg, with a coefficient of variation (CV) of 21.1 percent. This value is distinctly lower than what is reported by Diggins, Bundy and Christenson (1984) for Friesian calves in the United States (40.8 kg). In general, the offspring of females in hot climates are lighter at birth than their counterparts in temperate climates (McDowell, 1972). The factors which are responsible for the lighter birth weights are divers and complex. One is weight of the dams, the major factor dictating birth weights of the offspring. Dams of comparable age are usually significantly lighter under tropical conditions than those under cold conditions. McDowell (1972) suggested that the tropical environment exerts some influence on physiological functions of the dam including endocrine responses for the fetal growth.

In addition, Osei *et al.* (2001) reported that the effects of lactation number, season of birth and sex of calf were not significant ($P<0.05$) on calf birth weights. There was a slight reduction in birth weight after the second lactation. Calves which were born in the rainy season were slightly lighter weighing 30.13 kg than those born in the dry season weighing 30.77 kg. These observations support the earlier findings of Kabuga and Alhassan (1981), who considered the effect of season on calf birth weights to be of insignificant importance.

Sex ratio,

Osei *et al.* (2001) found that the sex ratio of Holstein Friesian crossbreds in Ghana was approximately 30 males to 27 females at birth which is a ratio of 52.63 % male : 47.37 % female at birth, being not significantly different from the 50:50 ratio.

Calving interval,

Osei *et al.* (2001) reported that the mean of calving interval of Holstein Friesian crossbreds in Ghana was 16 months. Hernandez (1965) reported a mean calving interval of 15.4 months for Friesians in Venezuela; Kassir, Juma and Al Jaff (1969) of 15.6 months for Friesian cows in Iraq. The calving interval of Holstein Friesians under temperate conditions is distinctly lower averaging about 13 months for the US Holstein population but slightly increasing with increasing milk performance. The observed differences mainly result from a prolonged breeding period under tropical conditions.

Conception rate,

Osei *et al.* (2001) has studied the conception performance in the 39 Holstein Friesian crossbreds in Ghana and found that 16 cows (41 percent) were pregnant at first service, l3 cows (33 percent) at second service, 7 cows (17.9 percent) at third service and 3 cows (7.7 percent) after fourth services. Thus 74.3 percent were pregnant after two services and almost

92 percent after three. These results are higher than reported by Gyawu and Agyemang (1977). The number of services per conception averaged 1.97 and increased with the age of cows. Also under temperate conditions of New Jersey, USA Spalding, Everett and Foote (1975) found an increased number of services per conception for cows older than 5 years.

Gestation length,

Osei *et al.* (2001) reported that the gestation length of Holstein Friesian crossbreds in Ghana averaged 278.4 days with a coefficient of variation 3.18 percent, which was not significantly influenced by the calving season.

Milk yield,

As already lined out under chapter 2.3.2 the milk performance of Friesian upgrades under the tropical conditions of Thailand is significantly lower than of the Friesian cows in the countries of origin, which also can be considered as an adaptive response to the tropical heat stress and the shortcomings in feeding and management. Also the adaptive reactions in the studies cited above turn up in corresponding reduction of milk yield e.g. 2499 kg (305 d) for Friesian crossbred cows in the forest zone of Ghana (Osei *et al.*, 2001); 2483 kg (305 d) for the situation in Iraq (Kassir *et al.*, 1969) and 4041 kg (305 d) for the Holstein herd at Maracay, Venezuela (Martinez *et al.*, 1982).

Growth rate,

Osei *et al.* (2001) reported that the growth rate for Friesian calves in the humid forest zone of Ghana averaged 0.44 kg per day from birth to three months, 0.27 kg per day from three to six months and 0.23 kg per day from six to nine months resulting in an average weight of 116 kg at nine months.

Calf mortality,

Osei *et al.* (2001) reported that the mortality within 12 months after birth averaged 17.8 percent. Wilkins (1986) reported in his survey on productive and reproductive performance of cattle in the tropics an average calf mortality of 30.6 percent within the first 6 months, which in some cases could come up to 100 percent.

2.4 Body Condition Score (BCS)

Body condition scoring is an important tool to control dairy cattle feeding. Quite often dairy farmers fail to condition their cows accordingly to their lactation stage with a tendency of overconditioning in the dry stage . This again might result in metabolic disorders, calving problems, depressed production and reproduction performance.

Body condition is referring to the body fat reserves of cows. These reserves can be used by the cow in periods when the energy balance gets negative. In high producing cows, this normally happens during early lactation. But it may also happen when cows get sick or when feeding poor quality feeds. After a period of weight loss, cows should be fed more than their standard requirements to restore normal body condition. Normally body condition scores are assigned by checking fat deposition at the backbone, loin and rump areas. Because the pin bone, hip bone, the top of the backbone, and the ends of the short ribs have no muscle tissue these areas are only build up by skin and fat and thus indicate directly the degree of fat deposition (Rodenburg, 2001).

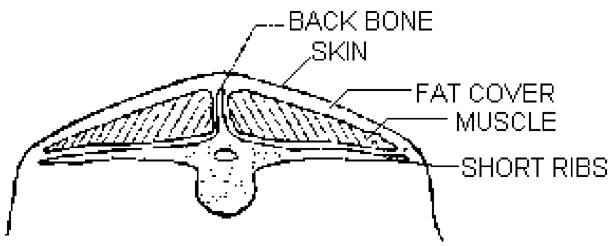

Figure 1. Locations to Assign Body Condition Score (Rodenburg, 2001)

As a rule a scoring system with a range of 1-5 scores is applied, 1 refers to a very thin cow with no fat reserves and to 5 to a severely over conditioned cow. Under the 1-5 scoring system a further differentiation might be indicated working in steps of 0,5 scores, especially for a more refined classification of the over conditioned cow classes.

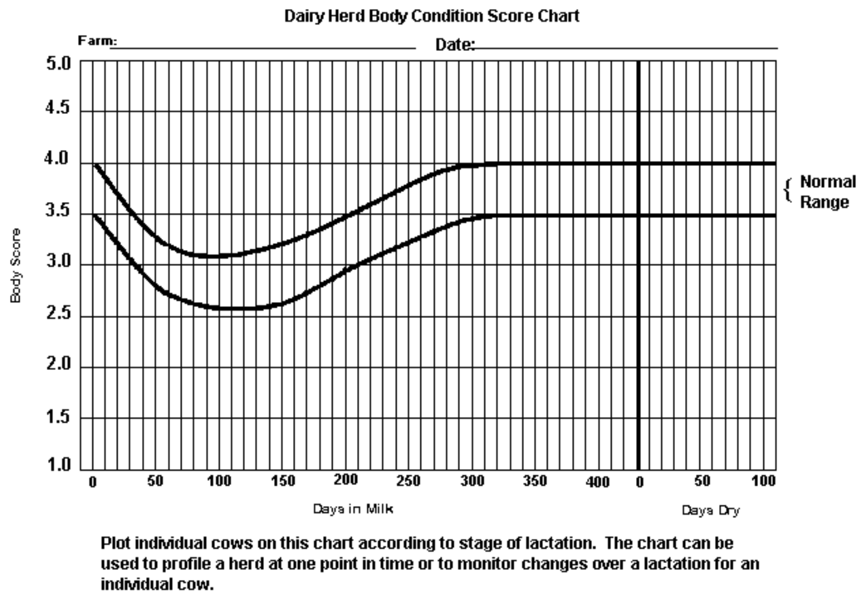

Figure 2. Dairy Herd Body Condition Score Chart for plotting Individual Cows according to their Stage of Lactation (Rodenburg, 2001)

Rodenburg (2001) reported that the ideal condition scores fall in the range of 3.5-4.0 at dry off and calving and 2.5-3.0 at peak lactation and no cows changing by more than 1 condition score class over any lactation period as indicated in figure 2.

Richard *et al.* (2001) reported that body condition score is a reliable indicator for the dairy feeding system. The body fat reserves can affect the milk production, reproductive efficiency and herd longevity. The fat cows or thin cows might have metabolic problems, lower milk yield, poor conception rates and dystocia (difficult calvings). A rapid change in body condition score in the early period of lactation may indicate problems in herd health or feeding strategy. Jeffrey (2001) suggested the following body condition scores for the different lactation stages and various heifer ages (table 5).

Table 5. Desired and Reasonable Body Condition Scores of Dairy Cattle at Critical Times (adapted from Jeffrey, 2001)

Time of scoring	Desired score	Range
Cows		
Calving	3.5	3.0-4.0
Peak Milk	2.0	1.5-2.0
Mid-lactation	2.5	2.0-2.5
Dry Off	3.5	3.0-3.5
Heifers		
6 Months	2.5	2.0-3.0
Breeding	2.5	2.0-3.0
Calving	3.5	3.0-4.0

Parker (2001) indicated the necessity for six scoring times during the year to evaluate the condition of cows as basis for an efficient feeding, breeding and health management in dairy herds. These are the middle of dry period, the time at calving, and at 45, 90, 180 and 270 days into lactation.

2.5 Interaction between Genotype and Environment

In dairy farming, differences between the production environments are significantly influencing the performance especially between temperate and tropical countries, which brings up the question of a possible genotype environment interaction between these two completely different production environments. There are two comprehensive reports on comparing the performance of Friesian cows in Morocco with the performance of their relatives in Europe. Bradly (1978) reported that dairy cows which were imported from European countries to Morocco needed some time to develop their full performance because of an obviously ongoing adaptation process to the new production environment. In addition, clear differences in the adaptive reaction between regions could be observed. Hajjani (1986) reported that the interaction between the European origin of the Friesian populations and the Moroccan environment were highly significant for milk content traits. However this interaction between European genotypes and Moroccan environment is only due to a scale effect and not due a changed ranking of the paternal halfsib families in Morocco. The genetic correlation between milk yield, fat yield and fat content of halfsib daughter groups of Dutch and German sires were positive and of Danish sires were negative. This situation does not necessarily imply a repeated sire evaluation for the Moroccan dairy production environment.

2.6 Genetic Evaluation

Genetic evaluation includes the estimation of genetic parameters such as variance components (additive genetic, environmental), heritability, phenotypic and genetic correlations, aiming at the estimation of breeding values of animals to be selected for breeding purpose respectively for predicting the genetic progress of complex selection schemes. The essential population parameters can be estimated from phenotypic observations of family members within populations. Generally, the phenotypic performance of a animal results from genetic and environmental effects as following (Mrode, 1996):

$$y_{ij} = \mu_I + g_j + e_{ij} \quad \text{……………….(1)}$$

when

y_{ij}	is	Record number i from animal number j
μ_I	is	Fix effect of environment such as birth year, birth season etc.
g_j	is	Effect of additive genetic effect, dominant effect and epistatic Effect (interaction between loci) of animal number i
e_{ij}	is	Random environmental effect

From equation (1) the general model (mixed linear model) or animal model (BLUP) to estimate the breeding value can be derived as follows:

$$y = Xb + Za + e \quad \text{………………….(2)}$$

when

y	is	vector n x 1 of observations (n = number of records)
b	is	vector p x 1 of fixed effect (p = number of groups of fixed effects)
a	is	vector q x 1 of random effect (q = number of groups of random effects)
e	is	vector n x 1 of random residual effect

X is n x p design matrix which relate records to fixed effects

Z is n x q design matrix which relate records to random effects

From equation (1) and (2) it gets evident that the most important thing is to identify random and fixed effects which significantly affect the observations. There exist numerous research results from different places with differing production environments to explain and identify the fixed and random effects valid for the different breeding populations, which have to be included in the model

2.7 Applied Breeding Planning

Skjervold and Langholz (1964) were the first to highlight that only an optimum constellation of all components of a breeding plan will lead to a maximized breeding progress. They identified a number of factors affecting the overall genetic gain of a breeding plan such as population size, testing capacity, heritability, selection intensity, inbreeding effect, etc. and considered the optimum size of progeny groups for sire evaluation and the optimum use of young versus proven A.I.bulls to be of dominating importance for the efficiency of A.I. breeding plans. Langholz (1973) showed that also the costs of the breeding activities, especially of the testing schemes have to be included into the optimization of the breeding plans and that both the genetic merits and the costs have to be discounted to the same point of time and beyond of this it has to be taken into account that genetic dairy merits in males cannot be exploited before one generation later indicating a greater impact of cow sires and cow dams on the genetic progress.

Such on progeny testing based A.I. breeding programs have in the recent decades been established in all greater dairy populations of the developed countries. The systematic use of embryo transfer and an increased use of younger sire dams with improved merit prediction changed the contribution of the different genetic pathways in favour of the pathway dam to sire. Beyond of this the increased importance of functional dairy traits including fertility require a substantial increase of the optimum progeny test group size because of the low heritability of these traits (Danner *et al.*, 2002) which for the main dairy traits with a heritability of ~ 0.25 has been at an optimum of ~ 60 daughters (Dekker *et al.,*1996). Even though an extensive use of young unproven bulls in many cases theoretically will yield a higher genetic progress, especially in smaller populations most applied breeding plans rely on a dominating use of proven bulls. One remarkable exception is the Finnish Ayrshire breeding plan heading for 40% insemiations with young A.I. bulls in order to guarantee a progeny testing of a sufficient number of dairy bulls within the own population with sufficient accuracy also for functional traits (FABA, 2003).

3. MATERIALS AND METHODS

3.1 Experimental Animals

The experimental animals for this study were 2,764 lactating dairy cows of Holstein Friesian upgrades up to 500 days in milk from 252 farms in Chiangmai, Chiangrai and Lamphun Province. These animals were raised in small farms (8.56 ± 3.24 cows per farm).

3.2 Methods (Data Collection)

3.2.1 Data of Farms

Farm data collection included number of cattle in each farm, farm size and feeds quality with the following grouping characteristics:

Number of cattle in each farm (farm type 1):

Group	Number of cows
1	≤ 5
2	6-10
3	11-20
4	≥ 21

Farm size (farm type 2):

Group	Farm size (Rai)
1	≤ 5
2	6-10
3	11-20
4	≥ 21

Feeds quality (farm type 3):

Group	Feeds quality
1	Grass and total mixed ration (TMR)
2	Grass and by products after harvesting
3	Grass and straw
4	Fermented straw and grass

3.2.2 Data of Cows

Data of cows included number of cows, number of bull, number of dam, age, first calving age, second calving age, %HF, % of white color ,body measurements (heart girth, height, length), body condition scores (1-5), days open, gestation length, services per conception, days of heat return after calving, calving interval, calving season and calving year. On a selected sample of 234 cows body weight was measured by an electronic balance and simultaneously the three body measurements as basis for estimating the body weight for the total sample of cows.

HF percentage and percentage of white color was grouped as follows:

%HF

Group	1	2	3	4	5
% HF	50-60	61-70	71-80	81-90	91-100

% of white color

Group	1	2	3	4	5	6	7	8	9	10
% of white color	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100

The calving seasons were rainy (June – Oct), summer (March – May) and winter (Nov – Febr).
The calving years were 1997, 1998, 1999, 2000 and 2001.

3.2.3 Body Condition Scoring

The cows were scored by 1-5 scores system as follows:

Condition Score 1, this cow is emaciated. The ends of the short ribs are sharp to the touch and together give a prominent shelf-like appearance to the loin. The individual vertebrae (spinal processes) of the backbone are prominent. The hook and pin bones are sharply defined. The thurl region and thighs are sunken and in-curving. The anal area has receded and the vulva appears prominent.

Condition Score 2,this cow is thin. The ends of the short ribs can be felt and the individual vertebrae are less visibly prominent. The short ribs do not form as obvious an overhang or shelf effect. The hook and pin bones are prominent but the depression of the thurl region. between them is less severe. The area around the anus is less sunken and the vulva less prominent.

Condition Score 3, a cow in average body condition. The short ribs can be felt by applying slight pressure. The overhanging shelflike appearance of these bones is gone. The backbone is a rounded ridge and hook and pin bones are round and smoothed over. The anal area is filled out but there is no evidence of fat deposit.

Condition Score 4, a cow in heavy condition. The individual short ribs can be felt only when firm pressure is applied. Together they are rounded over with no shelf effect. The ridge of the backbone is flattening over the loin and rump areas and rounded over the chine. The hook bones are smoothed over and the span between the hook bones over the backbone is flat. The area around the pin bones is beginning to show patches of fat deposit.

Condition Score 5, a fat cow. The bone structure of the topline, hook and pin bones and the short ribs is not visible. Fat deposits around the tailbone and over the ribs are obvious. The thighs curve out, the brisket and flanks are heavy and the chine very round.

3.2.4 Milk Sampling

Randomized 600 milk samples were collected from cows with known pedigree (target was 600 cows from 10 sires, or 60 cows per sire) for estimation of genetic parameters for milk contents (%protein, %fat, %lactose, %total solids, %solids not fat and somatic cells) and milk yield.

3.2.5 Working Period of Data Collection

January 2000 to January 2002.

3.2.6 Working Areas

Chiangmai, Chiangrai and Lamphun province, Northern Thailand.

3.3 Data Analysis

3.3.1 Analysis of Performance Data and their Variation

Performance data and their variation were characterized by the following statistical parameters: mean, standard deviation, standard error, variances and median, calculated by SAS for Windows Version 8.1 (SAS, 1999). The relationship between body condition score (BCS) and days after calving was calculated by quadratic and cubic regression.

3.3.2 Analysis of Systematic Effects on Performance

3.3.2.1 Productive Performance

For analyzing the effects of % HF and of % white color on milk yield, %protein, %fat, %lactose, total solids and solids not fat the GLM procedure of SAS was used. The model showed the following specification:

$$y_{ijk} = \mu + a_i + b_j + a_ib_j + e_{ijk}$$

where

y_{ijk}	is	milk yield, %protein, %fat, %lactose, total solids and solids not fat
μ	is	mean
a_i	is	effect of % HF (50-60, 61-70, 71-80, 81-90, 90-100)
b_j	is	effect of % white color (0-10, 11-20, 21-30, 31-40, 41-50, 51-60, 61-70, 71- 80, 81-90, 91-100)
a_ib_j	is	effect of interaction between % HF and % white color
e_{ijk}	is	residual error

For analyzing the effects of farm size, number of cows in each farm and feed quality on milk yield, %protein, %fat, %lactose, total solids and solids not fat the GLM procedure of SAS was used. The model showed the following specification:

$$y_{ijkl} = \mu + a_i + b_j + c_k + a_ib_j + a_ic_k + b_jc_k + a_ib_jc_k + e_{ijkl}$$

where

y_{ijkl}	is	milk yield, %protein, %fat, %lactose, total solids and solids not fat
μ	is	mean
a_i	is	effect of farm size (1-4 groups)
b_j	is	effect of number of cows in each farm (1-5 cows, 5-10 cows, 10-20 cows and more than 20 cows)
c_k	is	effect of feed quality (1-4 groups)
a_ib_j	is	effect of interaction between farm size and number of cows in each farm
a_ic_k	is	effect of interaction between farm size and feed quality
b_jc_k	is	effect of interaction between number of cows in each farm and feed quality.
$a_ib_jc_k$	is	effect of interaction between farm size, number of cows in each farm and feed quality
e_{ijkl}	is	residual error

For analyzing the effects of calving season and calving year on milk yield, %protein, %fat, %lactose, total solids and solids not fat the GLM procedure of SAS was used. The model showed the following specification:

$$y_{ijk} = \mu + a_i + b_j + a_ib_j + e_{ijk}$$

where

y_{ijk}	is	milk yield, %protein, %fat, %lactose, total solid and solid not fat
μ	is	mean
a_i	is	effect of calving season (rainy, summer and winter)
b_j	is	effect of calving years (1997, 1998, 1999, 2000 and 2001)
a_ib_j	is	effect of interaction between calving season and calving years
e_{ijk}	is	residual error

3.3.2.2 Reproductive Performance

For analyzing the effects of % HF and % of white color on days open, gestation length, service per conception, days of heat return after calving and calving interval the GLM procedure of SAS was used. The model showed the following specification:

$$y_{ijk} = \mu + a_i + b_j + a_ib_j + e_{ijk}$$

where

y_{ijk}	is	days open, gestation length, service per conception, days of heat return after calving, calving interval, first calving age and second calving age
μ	is	mean
a_i	is	effect of % HF(50-60, 61-70, 71-80, 81-90, 90-100)
b_j	is	effect of % white color (0-10, 11-20, 21-30, 31-40, 41-50, 51-60, 61-70, 71-80, 81-90, 91-100)
a_ib_j	is	effect of interaction between % HF and % white color
e_{ijk}	is	residual error

For analyzing the effects of farm size, number of cows in each farm and feed quality on days open, gestation length, service per conception, days of heat return after calving and calving interval the GLM procedure of SAS was used. The model showed the following specification:

$$y_{ijkl} = \mu + a_i + b_j + c_k + a_ib_j + a_ic_k + b_jc_k + a_ib_jc_k + e_{ijkl}$$

where

y_{ijkl}	is	days open, gestation length, service per conception, days of heat return after calving, calving interval, first calving age and second calving age
μ	is	mean
a_i	is	effect of farm size (1-4 groups)
b_j	is	effect of number of cows in each farm (1-5 cows, 5-10 cows, 10-20 cows and more than 20 cows)
c_k	is	effect of feed quality (1-4 groups)
a_ib_j	is	effect of interaction between farm size and number of cows in each farm
a_ic_k	is	effect of interaction between farm size and feed quality
b_jc_k	is	effect of interaction between number of cows in each farm and feed quality
$a_ib_jc_k$	is	effect of interaction between farm size, number of cows in each farm and feed quality
e_{ijkl}	is	residual error

For analyzing the effects of calving season and calving year on days open, gestation length, service per conception, days of heat return after calving and calving interval the GLM procedure of SAS was used. The model showed the following specification:

$$y_{ijk} = \mu + a_i + b_j + a_ib_j + e_{ijk}$$

where

y_{ijk}	is	days open, gestation length, service per conception, days of heat return after calving and calving interval
a_i	is	effect of calving seasons (rainy, summer and winter)
b_j	is	effect of calving years (1997, 1998, 1999, 2000 and 2001)
a_ib_j	is	effect of interaction between calving season and calving years
e_{ijk}	is	residual error

3.3.3 Conformation Traits

For analyzing the effects of age and % HF on size of cows (rear height, heart girth and length of body) the GLM procedure of SAS was used. The model showed the following specification:

$$y_{ijk} = \mu + a_i + b(x_j - \bar{x}) + e_{ijk}$$

where

y_{ijk}	is	size of cows (rear height, heart girth and body length)
μ	is	mean
a_i	is	effect of % HF (5 groups)
$b(x_j - \bar{x})$	is	age of cows as a covariate
e_{ij}	is	residual error

For analyzing the effect of % HF on % of white color the GLM procedure of SAS was used. The following model was used:

$$y_{ij} = \mu + a_i + e_{ij}$$

where

y_{ij}	is	% of white color
a_i	is	effect of % HF (50-60, 61-70, 71-80, 81-90, 90-100)
e_{ij}	is	residual error

The relationship between age, %HF and % of white color of cows was analyzed by curvilinear regression.

3.3.4 Analysis of the Effects of Sires and Raising Areas on Body Weight and Regression of Body Weight on Body Measurements

For analyzing the effects of sires and raising area on body weight GLM procedure of SAS was used. The model showed the following specification:

$$y_{ijkl} = \mu + a_i + c_j + a_i\, c_j + e_{ijkl}$$

where

y_{ijk}	is	weight of cows
μ	is	mean
a_i	is	effect of sires
c_j	is	effect of raising areas
$a_i\, c_j$	is	effect of interaction between sires and raising areas
e_{ij}	is	residual error

Regression coefficients of body weight on body measurements were estimated by SAS, using the following model:

Linear model

$$y = b0 + b1.x1$$

$$y = b0 + b1.x1 + b2.x2$$

$$y = b0 + b1.x1 + b2.x2 + b3.x3$$

where

y	is	body weight
bi	is	regression coefficients
x1	is	heart girth
x2	is	body length
x3	is	height

Curvilinear model (Quadratic equation)

$$y = b0 + b1.x^1 + b2.x^2$$

where

y	is	body weight
bi	is	regression coefficients
x	is	heart girth and body length

3.3.5 Analysis of Genetic Parameters

Data on % fat, % protein, % lactose, total solids, solids not fat and somatic cells of 391 daughters from 85 sires, data of milk yield at 100 days (M100D) and 305 days (M305D) of 2,764 daughters from 570 sires and data of first calving age, second calving age, days open, gestation length, service per conception, days of heat return and calving interval from 1,673 cows were used to estimate the heritabilities of production traits as shown in table 6. Phenotypic correlations were estimated by SAS procedures and the estimation of heritabilities and genetic correlations was based on the animal model (BLUP), using restricted maximum likelihood calculation method by VCE 4 (Groeneveld, 1998) applying the following model:

$$y_{ijklm} = \mu + Color_i + HF_j + HY_k + Season_l + Animal_m + b(X_{ijklm} - X) + Error_{ijklm}$$

where

y_{ijklm}	is	production traits
μ	is	means
$Color_i$	is	group of % of white color (0-10, 11-20, 21- 30, 31-40, 41-50, 51-60, 61-70, 71-80, 81-90, 91-100 %)
HF_j	is	group of % HF (50-60, 61-70, 71-80, 81-90, 90-100 %)
HY_k	is	Herd - Year (1997, 1998, 1999, 2000 and 2001)
$Season_l$	is	calving season (winter, summer and rainy)
$Animal_m$	is	animals
$b(X_{ijklm}-X)$	is	first calving age as covariate
$Error_{ijklm}$	is	residual effect

Table 6. Data Structure for Estimation of Variance Components and Heritabilities

TRAITS	**Number of sires**	**Number of daughters per sire**	**S.D**	**MAX**
Fat%	85	4.6	10.83	64
Protein%	85	4.6	10.83	64
Lactose	85	4.6	10.83	64
Total solids	85	4.6	10.83	64
Solids not fat	85	4.6	10.83	64
Somatic cells	85	4.6	10.83	64
Milk 100 d	570	4.19	15.18	189
Milk 305 d	570	4.19	15.18	189

The methods applied for predicting the genetic gain of alternative breeding scenarios and for estimating the net profit of alternative breeding plans are explained directly in connection with the model calculations under chapter 4.14 “Response to alternative breeding strategies”.

4. RESULTS

4.1 Actual Breeding Structure of Northern Thai Dairy Herd

Breeding structure of the Northern Thai dairy herd is fairly complex. Most of the semen comes from the artificial insemination stations, Department of Livestock Development (DLD). The semen production is done at regional A.I.-stations, which are distributed all over the country and keeping in average 4-5 bulls per station. After collection of the semen at the regional A.I. stations all semen doses will be sent to the central station in Pratumthani Province, where they will be controlled, registered and stored. The central station also is planning the redistribution of the semen regarding the periods, the scale and the region of use for breeding planning and for protection against inbreeding.

The redistribution of the semen goes through the livestock development offices in each province, from which the semen will sent again to the artificial insemination units on district level for using.

Between 1956 and 1975 there were a total of 70,236 dairy cows inseminated in Thailand, giving birth to 44,104 offspring. The conception rate at the first insemination was 32-33 % (Wongsongsara *et al.*, 1977). This conception rate was lower than in developed countries, averaging about 50-60 %. There are many reasons for the low conception rate in Thailand such as the culled female animals are not sent for slaughter but simply change ownership, the owners of the animals sometimes fail to inform the inseminator of returning a cow to estrus or of a parturition after insemination. Problems in communication and transportation result in inseminations too early or too late in the estrus period. Insufficiencies in nutrition, in the quality of the semen and problems with infectious diseases such as brucellosis and tuberculosis might have additional impact.

The actual number of artificial inseminations in 1999 of Chiangmai, Chiangrai and Lamphun Provinces are shown in table 7. Although the majority of farmers is using the semen from DLD, quite a number of interested farmers is importing semen directly from overseas especially from Australia, New Zealand, America and some European Countries for running their own breeding strategy and some farmers simply rely on natural breeding. This causes a heterogeneous starting condition for improvement of dairy cattle breeding in Thailand.

Table 7. Number of Artificial Inseminations in 1999, performed in Chiangmai, Chiangrai and Lamphun Provinces (Department of Livestock Development, 2001)

Province	No. of Inseminations	No. of Calvings
Chiangmai	6,269	3,246
Chiangrai	1,396	955
Lamphun	1,456	1,067
Total	9,121	5,268

4.2 Production Structure of Northern Thailand Dairy Industries

Production structure of the dairy industry in Northern Thailand is very diverse. The main dairy raising areas are concentrated in Chiangmai, Chiangrai and Lamphun Provinces as shown in figure 2. The organizational basis of the dairy industry are the dairy cooperatives, taking care of the quality control, the storing and the marketing of the fresh milk and in a number of cases offering additional services like milk production control, concentrate supply etc. Due to differing efficiency, time of operation and regional production structures the milk price paid to the farmers might vary. There are 8 dairy cooperatives operating in Chiangmai, Chiangrai and Lamphun Provinces running 16 milk collecting centers: Chiangmai cooperative, Maewang cooperative, Pateung cooperative, Maejo cooperative, Lamphun cooperative, Chaiprakarn cooperative, Chiangrai cooperative and Banta cooperative (Table 8).

5 of these 8 cooperatives are located in Chiangmai province: Chiangmai, Maewang, Pateung, Maejo and Chaiprakarn cooperatives.

Chiangmai cooperative is the largest and most important one. This cooperative is running 5 collection centers: Saraphae, Sankampang, Sanpatong, Huaychai and Sansai. Saraphae milk collecting center is serving as main office of the Chiangmai cooperative. There are 265 active members with 25,000 milk kg/day.

Maewang is a small and very young cooperative in Maewang district Chiangmai province with only 1 milk collecting center with 19 active members and 2,000 kg milk / day.

Pateung is a medium sized cooperative in Pateung village with 1 milk collecting center with 130 active members and 5,500 kg milk / day.

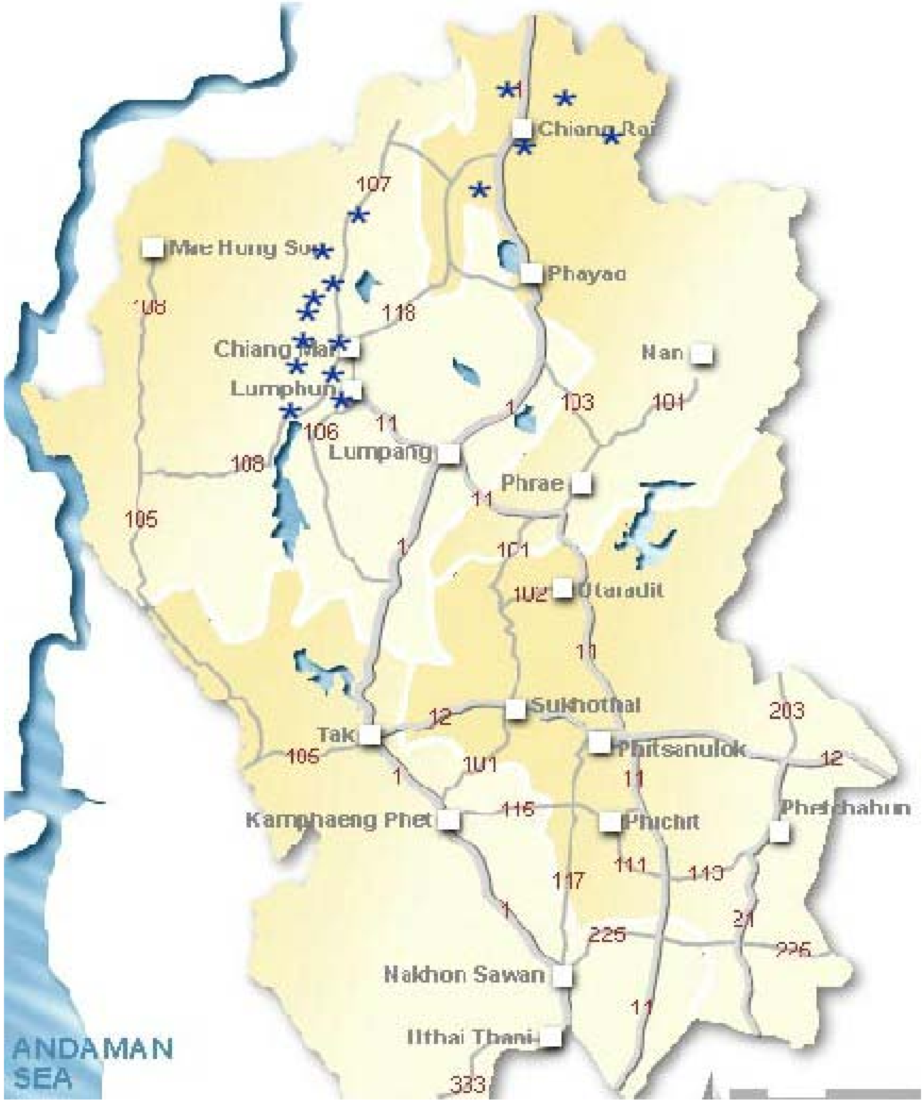

Figure 2. Map of Northern Thailand with the location of the 16 milk collection centers (*)

Maejo is the name of a district in Chiangmai province. There is 1 cooperative called Maejo cooperative with 1 milk collecting center. There are 94 active members with 6,000 kg of milk/day.

Finally in Chaiprakarn district Chiangmai province there is 1 cooperative called Chaiprakarn dairy cattle cooperative with 1 milk collecting center which takes care of their 130 farmers. This cooperative at the moment shows a very dynamic development with an increased milk production year by year. As special service this cooperative has introduced Total Mix Ration

(TMR) and centralized maize silage production for supporting their members. The fifth dairy cooperative in Chiangmai Province, the Fang cooperative just has been established for serving the dairy farmers in Fang district and 4 farmers from the northern part of the Chaiprakarn district. Since at the moment this cooperative does not have an own collection center the members send their milk to Chiangrai cooperative for producing pasteurized milk.

Table 8. Actual Structure of Dairy Cattle Population Connected to Milk Collecting Centers in Northern Thailand (Status December 2000)

Milk Collection Center	Organizational Structure (Cooperatives)	Member		Cattle Population				Daily milk Production Kg/day
		Total	Active	Total	Cows in Milk	Dry Cows	Pregn. Heifers	
San kampang	Chiangmai	-	160	-	1080	232	857	14500
Saraphae	Chiangmai	-	22	-	-	-	-	2200
Sanpatong	Chiangmai	-	36	604	460	-	-	3300
Huaychai	Chiangmai	-	23	-	225	48	71	2600
Sansai	Chiangmai	-	24	-	-	-	-	2400
Mae wang	Mae wang	37	19	-	-	-	-	2000
Pateung	Pateung	235	130	1296	530	158	160	5500
Maejo	Maejo	174	94	1209	451	152	102	6000
Lamphun	Lamphun	-	106	1000	350	65	100	4800
Ban hong	Lamphun	-	-	-	-	-	-	5000
Chaiprakan	Chaiprakan	570	130	-	1044	148	537	8300
Mae lao	Banta Dairy	-	37	337	143	53	34	1600
Banta	Banta Dairy	-	56	827	409	45	43	3500
Pan	Chiangrai Dairy	-	24	317	145	36	30	1400
Praya mangrei	Chiangrai Dairy	-	11	165	94	-	11	950
Wieng chiangrung	Chiangrai Dairy	-	11	165	70	3	4	700
Free Farmers	-	-	21	369	150	-	-	1200
Muang Chiangmai	-	21	3	-	52	20	14	700
TOTAL			**1010**	**9050**	**6250**	**1125**	**1675**	**66650**

Lamphun is a province located close to Chiangmai. There is 1 dairy cooperative with 2 milk collecting centers: Lamphun and Banhong milk collecting center. Under Lanphun milk collecting center, there are 106 active members with 4,800 kg of milk/day.

Chiangrai province is bordering north to Chiangmai province. There are 2 cooperatives: Chiangrai cooperative and Banta cooperative. The 3 milk collecting centers under the Chiangrai cooperative are Pan, Praya mangrai and Wieng chiangrung with 46 active members in total and 3,050 kg milk/day. The Banta cooperative is running 2 milk collecting centers: Banta and Maelao with 93 active members and 5,100 kg of milk/day.

4.3 Breeds of Dairy Cattle in Northern Thailand

Dairy cattle raising in northern Thailand started in1962 by importing dairy cattle from the other countries. In that early stage many kinds or cattle breeds were tried such as Sahiwal, Holstein Friesian, Brown Swiss, Jersey and their crossbreds with Thai native cattle.

Nowadays the Department of Livestock Development for dairy purposes exclusively is producing the semen from Holstein Friesian bulls with 75 % HF or more. So the dominating breed of dairy cattle are Holstein Friesian and their upgrades. Also those farmers ordering the semen for artificial insemination from the other countries by themselves are mostly using semen from Holstein Friesian. Thus nowadays more than 90 % of dairy cattle in Northern Thailand are upgrades of Holstein Friesian from Thai native cattle and only few purebreds of Holstein Friesian are kept.

There are at the moment 2 projects under way for further improvement of the dairy cattle. These are the master bull project and the Thai Friesian project. Both are running under the Department of Livestock Development. The master bull project is aiming at finding proven bulls by progeny testing procedures. In a first step the bull dams with a good record for milk yield will be selected and in a second step these will be bred by semen from selected imported sires. The male calves will be raised under performance testing procedures at a special station and at A.I stations respectively. The project covers all areas of Thailand.

The Thai Friesian project is a project devoted to found and improve a dairy cattle breeding base on Holstein Friesian which is appropriate to the dairy production environment of

Thailand. The testing area covers especially the production conditions of Northern Thailand. The center of this project is the National Dairy Research Institute, Sanpatong district, Chiangmai, which runs a purebred Holstein Friesian herd of 95 cows.

4.4 Actual Performance of Lactating Cows

4.4.1 Productive Performance

The productive performance is shown in table 9 and 10. The average milk yields adjusted for calving age at 100, 305 days and in total average in lactation number 1 and 2 were 1101.45 ± 12.50 and 3359.45 ± 38.14, 1439.44 ± 29.63 and 4390.29 ± 90.37 and 1267.89 ± 20.94 and 3867.07 ± 63.86 respectively.

Table 9. Average Milk Yield at 100, 305 d and Total Average

number of lactation	N	milk at 100 days kg	milk at 305 days kg
1	570	1101.45 ± 12.50	3359.45 ± 38.14
2	553	1439.44 ± 29.63	4390.29 ± 90.37
Total	1,123	1267.89 ± 20.94	3867.07 ± 63.86

The average milk contents fat%, protein%, lactose%, total solids, solids not fat and somatic cells were 3.81 ± 0.075, 3.22 ± 0.028, 4.66 ± 0.017, 15.51 ± 2.55, 8.54 ± 0.024 and 267.28 ± 32.85 respectively.

Table 10. Milk Contents of First Lactation Dairy Cows

N	Fat %	Protein %	Lactose%	Total Solids	Solids Not Fat	Somatic Cells (x100)
391	3.81±0.075	3.22±0.028	4.66±0.01	12.88±0.25	8.54±0.02	267.28±0.03

4.4.2 Reproductive Performance

The first calving age, second calving age, days open, gestation length, services per conception, days of heat return after calving and calving interval were 870.57 ± 3.81, 1319.45 ± 6.64, 129.5 ± 64.32, 281.1 ± 10.84, 2.81 ± 2.40, 109.92 ± 47.34 and 462.67 ± 91.65 respectively which is illustrated in table 11.

Table 11. Average Reproductive Performance

N	First calving age	Second calving age	Days open	Gestation length	Services per conception	Days of heat return	Calving interval
1,623	870.57 ± 3.81	1319.45 ± 6.64	129.5±64.32	281.1±10.84	2.81±2.40	109.92±47.34	462.67±91.65

4.5 Body Size

The rear height, heart girth and length of body of dairy cattle in the different age classes: less than 1 year, 1-2 year, 2-3 year and more than 3 years were 106.00 ± 2.17, 153.55 ± 4.77 and 61.10 ± 2.47, 121.90 ± 0.60, 166.90 ± 1.18 and 65.87 ± 0.55, 124.25 ± 0.30, 175.17 ± 0.66 and 70.62 ± 0.36 and 126.16 ± 0.13, 182.15 ± 0.30 and 75.60 ± 0.13 respectively which is shown in table 12. The estimated body weights for these age classes are added to the body measurements showing a slow body devopment of the dairy cows not reaching a sufficient developmental stage before 3 years of age.

Table 12. Average of Body Size of Dairy Cattle by Age Classes

Age Class (years)	Rear Height (cm)	Heart girth (cm)	Length of body (cm)	Estimated Body Weight (kg)
<1	106.00±2.17	153.55±4.77	61.00±2.47	198.72
1-2	121.90±0.60	166.90±1.18	65.87±0.55	287.72
2-3	124.25±0.30	175.17±0.66	70.62±0.36	317.98
>3	126.16±0.13	182.15±0.30	75.60±0.13	425.93

4.6 Variation of Coat Color (% of White Color) in the Population

The distribution of cows with different percentage of white color and the variation in each color group is shown in figure 3 and table 13 respectively. It indicates that most of cows in the population have a predominantly black coat. The number of cows in the color groups with more white coloring seem to amount to the inverse proportion of the percent of white color. Thus with increasing percentage of white color the cow number in the color groups is decreasing.

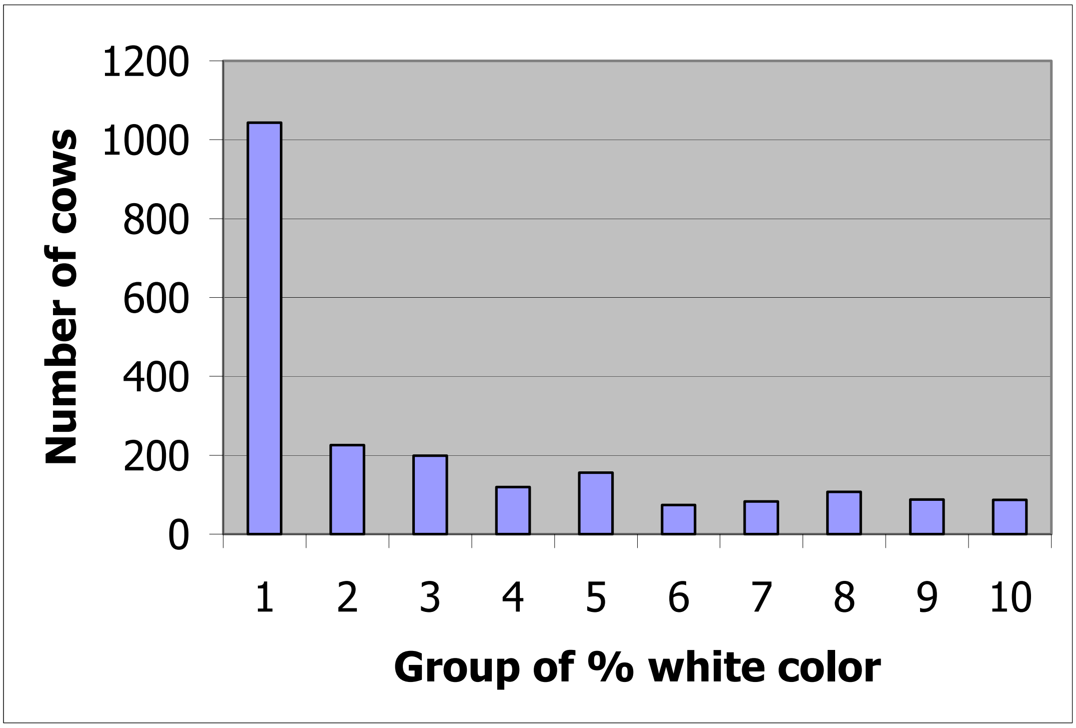

Figure 3. The Distribution of Coat Color in the Population

The variation of coat color in the population turned out to be high, ranging from 0 to100 percent white color in the coat. The average of percent of white coat color (mean), standard deviation, standard error of mean and variance were 27.01, 29.75, 0.65 and 885.11 respectively as shown in table 14.

Table 13. Number of Cows, Mean of White and Standard Deviation in Each Color Group

Group of White Color	Mean	N	Std. Deviation
1	3.14	1043	3.32
2	17.54	226	2.49
3	27.79	199	2.49
4	38.82	119	2.12
5	48.87	156	2.07
6	59.16	74	1.86
7	68.61	83	2.25
8	77.79	107	2.54
9	87.33	88	2.53
10	95.93	87	1.97

Table 14. Mean, S.D., S.E., Variance of Coat Color in Population

Mean	N	Minimum %	Maximum %	Std. Deviation	Variance	Std. Error
27.01	2,182	0.00	100.00	29.75	885.11	0.65

The results show a dominating frequency of black color in the population as indicated by a mean frequency of 27.01% white color (table 14) and a high variation of coat color in the population with a standard deviation as high as the mean white percentage. With regard to the color distribution a strong skewness of 0.97 towards the black color is to be observed with a positive median of 15% (Table 15). This indicates that 50% of cows in the population have less than 15% white color on their body surface.

Table 15. Skewness, Standard Error of Skewness and Median of Percent White Color in the Population

N	Skewness	Std. Error of Skewness	Median
2,182	0.97	0.053	15.00

4.7 Change in Body Condition Scores (BCS) after Calving

The observed overall mean and variation parameters for body condition scores of all cows scored after calving are given in table 16. Mean, S.D., S.E. and variance were 3.316, 0.776, 0.019 and 0.603 respectively. The great range of scoring time after calving of 1-500 days was subdivided into 10 groups as follows: 1-50 days = group1, 51-100 days = group2, 101-150 days = group3, 151-200 days = group4, 201-250 days = group5, 251-300 days = group6, 301-350 days = group7, 351-400 days = group8, 401-450 days = group9 and 451-500 days = group10. The variance of body scores was not high showing that the change in body condition during the milking period seems to be fairly low.

Table 16. Mean, S.D., S.E., and Variance of Body Condition Scores

N	Mean	Std. Deviation	Std. Error	Variance
1672	3.31639	0.77654	0.019	0.603

However with regard to the individual observations for a number of cows in certain periods extreme score values of 1 or 5 were observed. This was mainly affected by the overall on farm situation with evident feeding and management differences between farms. In some farms the farmers take extreme good take care of their cows and in others it is just the opposite. The means and confidence intervals (95%) of body condition scores in each time group after calving are shown in figure 4.

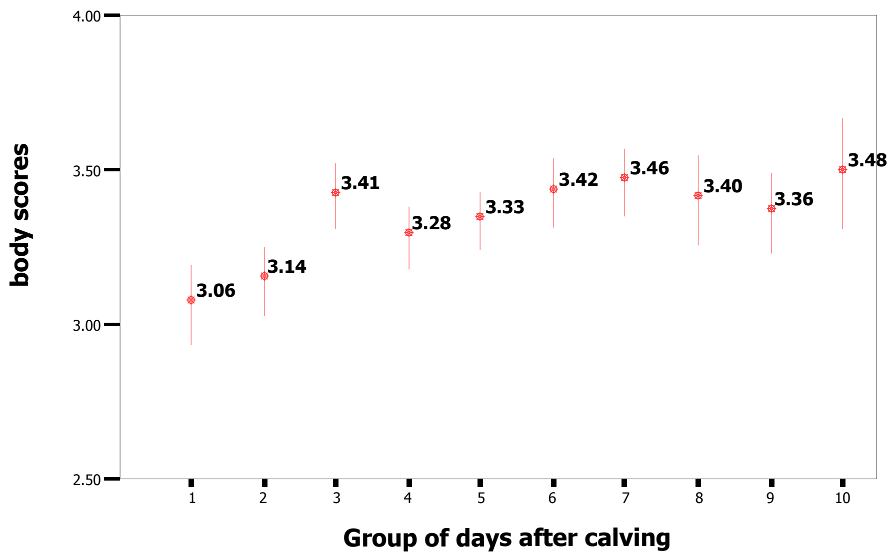

Figure 4. Means and Confidence Intervals (95%) of Body Condition Scores at different Time Periods after Calving

In table 17 the regression coefficients for the quadratic and cubic equations of body scores on days after calving are given. b0 are constant values, b1, b2, b3 are regression coefficients of the body scores on the days after calving. The values of b1 and b2 in quadratic equation were 0.0021 and -3.0×10^{-6} and the values of b1, b2 and b3 in cubic equation were 0.0025, -5.0×10^{-6} and 3.0×10^{-9}, respectively. These are nearly zero showing that the effect of the days after calving in this population on body condition scores is rather low.

However from both the regression equations and figure 5 a slight and steady increase in body condition of the cows after calving up to 3.43 scores at about 305 days after calving can be observed, followed by more or less stable condition thereafter. These results differ from the findings of Jeffrey (2001) and Rodenburg (2001) who reported that after calving caused by the high energy demand of the high yielding cows the body scores will slowly decrease in the early stages of lactation, then they would be slowly increasing again until about 260 days in milk and staying constant from that stage on.

Table 17. Regression Coefficients for Quadratic and Cubic Equations of Body Condition Scores on Days after Calving

Type	Rsq	b0	b1	b2	b3
Quadratic	0.021	3.0315	0.0021	-3.0×10^{-6}	-
Cubic	0.021	3.0143	0.0025	-5.0×10^{-6}	3.0×10^{-9}

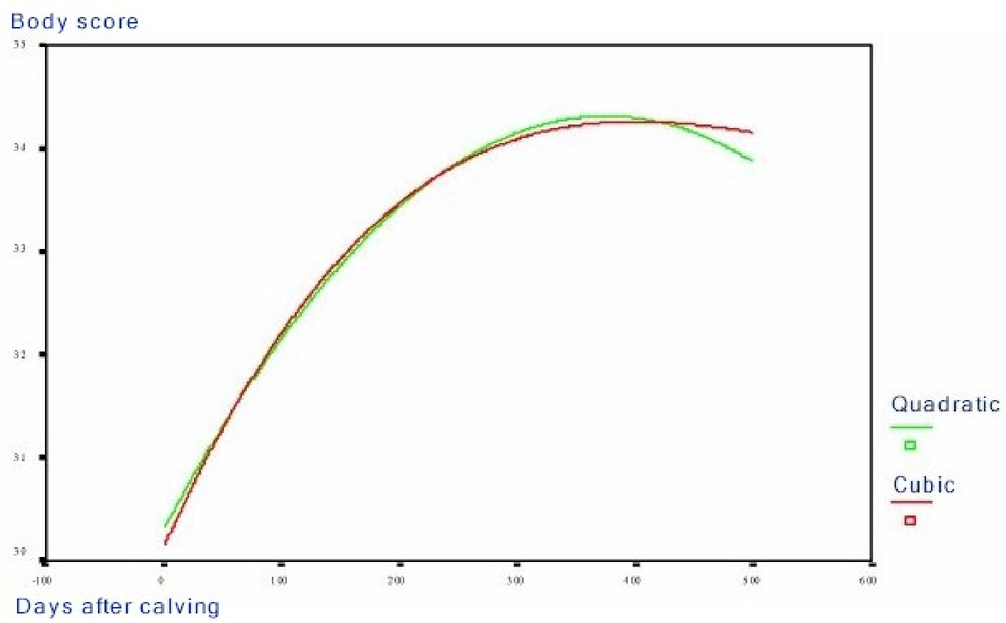

Figure 5. Quadratic and Cubic Regression Curves of Body Condition Scores on Days after Calving

4.8 Distribution of Holstein Friesian Upgrade Groups in the Population

The distribution of Holstein Friesian upgrade groups in the population is shown in figure 6. The mean and S.E. of %HF in population were 83.58% and 0.16 respectively. The minimum, maximum, S.D., median, and variance were 50.00, 100.00, 8.49, 84.37 and 72.71 respectively as shown in table 18.

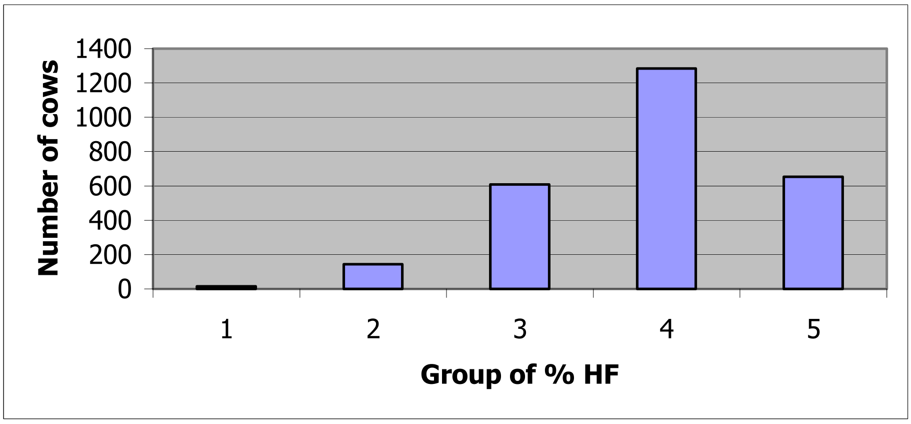

Figure 6. The Distribution of Cows on %HF Groups in the Population

Table 18. Statistical Parameters for the Distribution of Cows on %HF Groups in the Population

N	Mean	Minimum	Maximum	Std. Error	Median	Variance	Std. Deviation
2,705	83.58	50.00	100.00	0.16	84.37	72.17	8.49

The number and percentage of cows in each %HF group are shown in table 19 and in figure 6. The number and % of cows in the groups 1, 2, 3, 4 and 5 were 15 and 0.55, 144 and 5.3, 608 and 22.5, 1285 and 47.5, 653 and 24.1, respectively. These frequencies show that 50% of the cows in the population have an upgrade level of more than 84.37% HF.

Table 19. Frequency of Cows in Each Upgrade Group of Holstein Friesian

Percent of HF	Group of %HF	N	% of N
50 – 60	1	15	0.55
61 – 70	2	144	5.3
71 – 80	3	608	22.5
81 – 90	4	1285	47.5
91 – 100	5	653	24.1
	Total	2,705	100

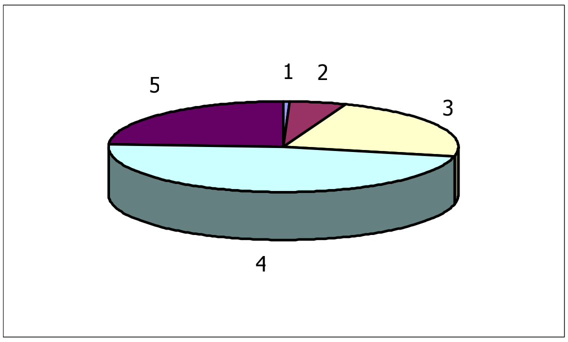

Figure 6. Percent of Cows in Each HF-Upgrade Group

4.9 Systematic Effects on the Performance of Lactating Cows

4.9.1 Productive Performances

4.9.1.1 The Effects of % HF and % of White Color on Milk Yield, %Protein, %Fat, %Lactose, Total Solids and Solids Not Fat

The effect of % HF and % of white color on milk yield, %protein and %fat were analyzed by a factorial model, the results of which are shown in table 20 and 21. There are no effects of % HF, % of white color and interaction between % HF and % of white color on milk yield at 100 days (M100D), milk yield at 305 days (M305D), % protein, % fat, % lactose, total solids and solids not fat.

Table 20 . Average of Production Performance by Groups of % HF

%HF	Traits						
	M100D	M305D	Protein %	Fat %	Lactose%	Total solids	Solids not fat
1	1154.87	3522.36	-	-	-	-	-
2	1215.83	3708.27	3.13	3.65	4.67	12.26	8.77
3	1195.79	3647.16	3.10	3.81	4.72	12.72	8.59
4	1182.89	3607.81	3.20	3.79	4.66	12.98	8.60
5	1209.03	3687.55	3.12	3.82	4.59	12.78	8.47

[a,b] Means within a column with different superscripts differ significantly ($P < 0.05$)

Table 21. Average of Production Performance by Group of Color

Color Group	Traits						
	M100D	**M305D**	**Protein %**	**Fat %**	**Lactose %**	**Total solids**	**Solids not fat**
1	1203.00	3669.15	3.21	3.88	4.64	12.08	8.55
2	1182.37	3606.23	3.13	3.70	4.66	12.74	8.55
3	1192.65	3637.57	3.13	3.64	4.67	13.71	8.61
4	1156.26	3526.58	3.19	3.94	4.63	12.90	8.56
5	1179.82	3598.45	3.10	3.62	4.62	12.57	8.41
6	1189.22	3627.12	2.94	3.59	4.63	12.98	8.27
7	1203.07	3669.38	3.01	3.90	4.59	13.57	8.30
8	1193.45	3640.03	3.16	3.81	4.72	12.97	8.86
9	1229.00	3748.46	3.13	3.73	4.76	12.44	8.74
10	1187.53	3621.98	3.04	3.68	4.70	11.35	8.44

^{a,b} Means within a column with different superscripts differ significantly ($P < 0.05$)

4.9.1.2 TheEffect of Farm Size, Number of Cows in Each Farm and Feed Quality on Milk Yield, % Protein, % Fat, % Lactose, Total Solids and Solids Not Fat

The effects of farm size, number of cows in each farm and feed quality on milk yield, %protein and %fat were analyzed by a factorial model, the results of which are shown in table 22, 23 and 24. The results indicate an influence of cow number in each farm (herd size) on milk yield at 100 days (M100D) and milk yield at 305 days (M305D). The smallest herd size group 1 (1-5 cows) had a significantly higher milk yield (P<0.05) than the other groups (2, 3, 4 and 5). However, there was no effect on %protein, %fat , % lactose, total solids and solids not fat.

Table 22. Average of Production Performance by Groups of Herd Size

Herd size	Traits						
	M100D	M305D	Protein %	Fat %	Lactose%	Total solids	Solids not fat
1	1227.32[a]	3743.31[a]	3.10	4.01	4.79	12.96	8.64
2	1206.08[b]	3678.53[b]	3.14	3.88	4.65	12.85	8.60
3	1190.78[b]	3631.87[b]	3.15	3.76	4.64	12.73	8.53
4	1185.75[b]	3616.63[b]	3.20	3.71	4.61	12.94	8.53

[a,b] Means within a column with different superscripts differ significantly (P < 0.05)

There were no effects of farm size, feed quality and their interaction on milk yield at 100 days (M100D), milk yield at 305 days (M305D), % protein, % fat, % lactose, total solids and solids not fat. However there is a slight advantage in milk yield for those farms to be observed using fermented straw in the diet.

Table 23. Average of Production Performance by Groups of Farm Size

Farm size	Traits						
	M100D	M305D	Protein %	Fat %	Lactose%	Total solids	Solids not fat
1	1188.19	3623.97	3.09	3.83	4.65	12.81	8.44
2	1191.47	3633.99	3.08	3.70	4.75	12.51	8.58
3	1198.21	3654.54	3.20	3.84	4.60	12.97	8.55
4	1185.21	3614.89	3.21	3.79	4.57	12.75	8.54

[a,b] Means within a column with different superscripts differ significantly (P < 0.05)

Table 24. Average of Production Performance by Groups of Feed Quality

Feed Quality	Traits						
	M100D	M305D	Protein %	Fat %	Lactose%	Total solids	Solids not fat
1	1186.00	3617.29	3.12	3.73	4.67	12.95	8.54
2	1198.63	3655.83	3.16	3.79	4.68	12.60	8.64
3	1204.74	3674.45	3.17	3.80	4.63	12.58	8.53
4	1223.33	3731.16	3.22	3.87	4.62	13.17	8.56

[a,b] Means within a column with different superscripts differ significantly (P<0.05)

4.9.1.3 The Effects of Calving Season and Calving Years on Milk Yield, % Protein, % Fat,% Lactose, Total Solids and Solids Not Fat

The effects of calving season and calving years on milk yield, %protein and %fat were analyzed by a factorial model, the results of which are shown in table 25 and 26. There are no significant effects of calving season and calving years on milk yield at 100 days (M100D), milk yield at 305 days (M305D), % protein, % fat, % lactose, total solids and solids not fat, even though there is a certain advantage in milk yield for the cows calving in summer to be seen and a steady increase in milk yield with the ongoing calving years.

Table 25. Average of Production Performance by Calving Season

Calving Season	Traits						
	M100D	**M305D**	**Protein %**	**Fat %**	**Lactose%**	**Total solids**	**Solids not fat**
Rainy	1181.69	3604.15	3.25	3.78	4.59	13.10	8.55
Summer	1206.89	3681.01	3.19	3.77	4.68	12.72	8.62
Winter	1171.67	3573.06	3.05	3.79	4.64	12.68	8.44

[a,b] Means within a column with different superscripts differ significantly (P <0.05)

Table 26. Average of Production Performance by Calving Year

Calving year	Traits						
	M100D	**M305D**	**Protein %**	**Fat %**	**Lactose %**	**Total solids**	**Solids not fat**
1997	967.79	2951.76	-	-	-	-	-
1998	1169.64	3567.40	-	-	-	-	-
1999	1178.37	3594.04	3.24	3.71	4.67	13.18	8.62
2000	1220.82	3723.51	3.23	3.80	4.59	12.99	8.58
2001	-	-	2.99	3.74	4.74	12.42	8.45

[a,b] Means within a column with different superscripts differ significantly (P < 0.05)

However, there is a clear interaction between calving season and calving years on milk yield at 100 days (M100D) and milk yield at 305 days (M305D) to be observed, which is shown in table 27. Climatic differences between years obviously can affect the milk yield such as in the summer season of 1997, where the milk yield was significantly lower than in the other seasons of that year as compared to the summer season of 1998, where the milk yield was significantly higher than in the rainy and winter season. However regarding the main effect of calving years and calving season these specific seasonal effects between years on milk yield obviously are compensated to a great deal.

Table 27. Average of Production Performance by Calving Year and Calving Season

calving year	calving season	M100D	M305D
1997	Rainy	1066.91^{b}	3254.07^{b}
	Summer	925.00^{b}	2821.25^{b}
	Winter	1015.00^{b}	3270.75^{b}
1998	Rainy	1200.64^{c}	3661.95^{c}
	Summer	1324.93^{d}	4041.03^{d}
	Winter	1090.32^{b}	3325.48^{b}
1999	Rainy	1182.26^{c}	3605.89^{c}
	Summer	1168.57^{c}	3564.15^{c}
	Winter	1184.18^{c}	3611.75^{c}
2000	Summer	1281.89^{d}	3909.77^{d}
	Winter	1169.36^{c}	3566.54^{c}

[a,b,c,d] Means within a column with different superscripts differ significantly (P < 0.05)

4.9.1 Reproductive Performance

4.9.2.1 The Effect of %HF and % of White Color on Days Open, Gestation Length, Service per Conception, Days of Heat Return, Calving Interval, First Calving Age and Second Calving Age

For the reproductive traits days open and gestation length no differences (p>0.05) between the different groups of % HF was observed (table 28). However % HF can affect those reproductive traits more linked to the conception performance, e.g. service per conception, days of heat return, calving interval, first calving age and second calving age. Cows in the groups of 50-60, 61-70 and 71-80 % HF show services per conception which are significantly (P<0.05) lower than for the groups 81-90 and 91-100 % HF. Cows in groups of 50-60, 71-80 and 81-90 % HF show days of heat return which are significantly (P<0.05) lower than for the groups 61-70 and 91-100 % HF. Cows in the groups of 50-60, 61-70, 71-80 and 91-100 % HF have calving intervals which are significantly (P<0.05) higher than for the group 81-90 % HF. Cows in the group of 50-60 % HF are significantly (P<0.05) older at first and second calving than cows of the groups 61-70, 71-80, 81-90 and 91-100 % HF as shown in table 28. Since the number of informations for the different reproductive traits vary to some extent, especially for the calving interval the trait averages are not fully compatible.

Table 28. Average of Reproductive Performance by Groups of %HF

% HF	Traits						
	Days open	Gestation length	Services per conception	Days of heat return	Calving interval	First calving age	Second calving age
50-60	136.43	279.64	1.23^{a}	109.43^{a}	447.76^{a}	1030.75^{a}	1639.50^{a}
61-70	153.23	278.33	1.43^{a}	155.50^{b}	425.33^{a}	964.58^{b}	1414.24^{b}
71-80	145.67	276.80	1.10^{a}	89.50^{a}	437.30^{a}	983.04^{b}	1442.34^{b}
81-90	138.94	277.33	2.23^{b}	83.50^{a}	383.01^{b}	952.00^{b}	1396.45^{b}
91-100	150.67	278.62	2.14^{b}	109.95^{b}	445.91^{a}	965.20^{b}	1355.99^{b}

^{a,b} Means within a column with different superscripts differ significantly (P < 0.05)

There were no difference (P>0.05) between groups of % of white color on days open, gestation length, services per conception, days of heat return after calving and calving interval. These results underline the missing effect of the coat color on fertility performance.

4.9.2.2 The Effects of Farm Size, Number of Cows in Each Farm (Herd Size) and Feed Quality on Days Open, Gestation Length, Services per Conception, Days of Heat Return after Calving, Calving Interval, First Calving Age and Second Calving Age

There were no effects from farm size, herd size and interaction between farm size and herd size on days open, gestation length, services per conception, days of heat return calving interval first calving age and second calving age (P>0.05) to be observed. However regarding the feed quality, there was an effect on days open, services per conception and calving interval. The feed quality in group 1 and 4 show days open and services per conception which are significantly (P<0.05) lower than in group 2 and 3. Cows in feed quality group 1 obtain a significantly (P<0.05) lower calving interval than cows of group 2 and 3 as shown in table 29.

Table 29. Average of Reproductive Performance by Feed Quality Groups

Feed quality	Traits						
	Days open	Gestation length	Services per conception	Days of heat return	Calving interval	First calving age	Second calving age
1	128.33[a]	279.31	1.23[a]	107.43	398.34[a]	970.75	1427.77
2	155.42[b]	276.64	2.31[b]	109.92	432.13[b]	978.11	1400.49
3	167.82[b]	280.01	2.22[b]	120.23	423.22[b]	935.59	1346.13
4	133.22[a]	278.43	1.47[a]	117.04	411.57[ab]	951.78	1369.79

[a,b] Means within a column with different superscripts differ significantly ($p < 0.05$)

4.9.2.3 The Effects of Calving Season and Calving Years on Days Open, Gestation Length, Services per Conception, Days of Heat Return after Calving and Calving Interval

There is a clear effect of calving season on days open, services per conception, days of heat return and calving interval. In the rainy season, days open and days of heat return were significantly higher (P<0.05) than in the winter and summer season. In winter, services per conception were significantly lower (P<0.05) than in the rainy and summer season; and in summer the calving interval is significantly higher (P<0.05) than in the rainy and winter season.

For the calving years no effects on days open, gestation length, days of heat return after calving and calving interval could be observed. However calving years can affect the services per conception. In 1997 e.g. services per conception were significantly higher than in 1998, 1999 and 2000 as shown in table 30.

Table 30. Average of Reproductive Performance by Calving Season and Calving Years

Calving season	Traits				
	Days open	Gestation length	Services per conception	Days of heat return	Calving interval
Rainy	218.00[a]	280.33	3.22[a]	148.67[a]	526.71[b]
Winter	118.78[b]	277.83	1.06[b]	107.13[b]	415.21[a]
Summer	133.50[b]	278.54	2.38[a]	92.50[b]	425.00[a]
Calving year					
1997	167.34	279.72	2.01[a]	109.43	453.50
1998	156.43	278.23	1.53[b]	107.23	429.58
1999	162.87	281.56	1.78[b]	116.20	410.15
2000	143.46	276.45	1.56[b]	122.00	422.06

[a,b] Means within a column with different superscripts differ significantly ($P < 0.05$)

4.10 Conformation Traits

4.10.1 The Effect of % HF on Size of Cows

The results from analyzing the effect of age on size of cows by regression method differ significantly ($p<0.05$) as illustrated in table 31. Cows of the 50-60 % HF group had rear height significantly ($P<0.05$) lower than the other groups. Also in heart girth the 50-60 % HF cows show significantly ($P<0.05$) lower measurements than cows of the other groups. No significant differences were observed between 61-70 % HF cows, 71-80 % HF cows and 91-100 % HF cows for height and heart girth. Only the heart girth of 81-90 % HF cows was significantly ($P<0.05$) reduced. Regarding body length the 50-60 % HF cows were not significantly different ($P>0.05$) from the cows of all other HF groups. However the 81-90 % HF cows were significantly shorter as than the other groups of higher upgrades as shown in table 32.

Table 31. Curvilinear Coefficients for the Regression of Size of Cows on Age

Traits	Model	Rsq	B0	B1	B2
Rear height	Quadratic*	0.02	120.74	0.00408	-6.89
Heart girth	Quadratic*	0.015	162.46	0.017	-0.000028
Body length	Cubic*	0.20	58.92	-0.000049	4.13×10^{-10}

* Significantly affected (P<0.05)

Table 32. Average Body Size by % of HF Groups

% of HF	Rear height (cm)	Heart girth (cm)	Body length (cm)	Weight (kg)
50-60	114.69^{a}	175.23^{c}	74.15^{ab}	397.12 ± 35.71
61-70	124.79^{b}	181.25^{ab}	75.42^{b}	427.37 ± 44.94
71-80	125.13^{b}	180.83^{ab}	74.61^{b}	423.40 ± 42.16
81-90	125.23^{b}	179.56^{a}	73.46^{a}	414.70 ± 41.92
91-100	125.89^{b}	183.85^{b}	74.67^{b}	420.37 ± 46.89

^{a,b,c} Means within a column with different superscripts differ significantly (P < 0.05)

4.10.2 The Effect of % HF on % of White Color

The average of % of white color of cows belonging to the different HF groups 50-60%, 61-70%, 71-80%, 81-90 and 91-100 % were 14.27, 14.92, 23.14, 26.89 and 36.56 respectively (Table 33). There are no significant (P>0.05) differences between the first two groups with the lowest HF percentage 50-60 % and 61-70 %HF cows. However the three HF groups with more than 70 % HF show a significant increase of white color for each upgrade group.

Table 33. Average of % of White Color by % of HF-Classes

% Holstein Friesian	**% of white color**
50-60	14.27[d]
61-70	14.92[d]
71-80	23.14[c]
81-90	26.89[b]
91-100	36.56[a]

[a,b,c,d] Means within a column with different superscripts differ significantly ($P < 0.05$)

In the regression analysis between % HF and % of white color, there are significant ($P<0.05$) interrelationships up to cubic equation to be observed as shown in table 34. From the regression equations it can be seen that the % of white color were direct proportional to % of HF.

Table 34. Regression Coefficient for % of White Color on % HF

Equation	**R^2**	**d.f.**	**b0**	**b1**	**b2**	**b3**
Linear*	0.048	2115	-36.71	0.77	-	-
Quadratic*	0.049	2114	35.15	-1.01	0.01	-
Cubic*	0.049	2114	13.03	-0.16	-	0.00005

* Significantly affected ($P<0.05$).

4.11 The Effect of Sires and Raising Areas on Body Weight and the Relationship between Body Weight and Body Measurements

The effect of sires and raising areas on body weight were analyzed by a complete factorial model for the selected sample of cows weighed directly by electronic balance. No significant effect of sires and no significant interaction between sires and raising area for the body weight of cows ($P>0.05$) was found which obviously is caused by the insufficient number of offspring per sire in this reduced data set. As shown below the analysis on the estimated weight based on the complete data set reveals distinct differences between sire progeny groups.

On the other hand the raising area did clearly affect the body weight. The body weight of cows which were raised in Chaiprakan district was significantly higher ($P<0.05$) than the body weight of cows which were raised in Maeon district .The average body weight and its standard deviation for each district is shown in table 35.

Table 35. Average Body Weight and Standard Deviation of Cows in 2 selected Districts

District	N	Body weight ± S.D.
Chaiprakan	162	415.45 ± 52.74[a]
Maeon	72	382.72 ± 51.19[b]

[a,b] Means within a column with different superscripts differ significantly ($P < 0.05$)

The regression of body weight on body size (heart girth, height and body length) was estimated by linear and curvilinear models. The regression coefficients and R^2 of each linear model are shown in table 36.

The linear regression equations for body weight on body measurements are:

$$y = -435.58 + 4.68a \ldots\ldots\ldots\ldots 1$$

$$y = -667.42 + 3.87a + 3.54b \ldots\ldots\ldots 2$$

$$y = -746.35 + 3.73a + 3.37b + 0.95c \ldots\ldots 3$$

where

y	is	Body weight
a	is	Heart girth
b	is	Body length
c	is	Height

Table 36 . Linear Coefficients for the Regression of Body Weight on Body Size Measurements

Model	**R^2**	**Constant**	**Regression Coefficients**		
			Heart girth	**Body length**	**Height**
Simple linear	0.591	-435.58	4.68	-	-
Multiple linear	0.751	-667.42	3.87	3.54	-
	0.719	-746.35	3.73	3.37	0.95

The regression coefficients and R^2 of the applied curvilinear models are shown in table 37. The curvilinear regression equations were confined to the regressions of body weight on heart girth and of body weight on body length as follows:

$$y = -1600.80 + 17.44a - 0.349a^2 \ldots\ldots\ldots\ldots\ldots 4$$

$$y = 134.42 - 0.87b + 0.32b^2 \ldots\ldots\ldots\ldots\ldots\ldots 5$$

where

y	is	Body weight
a	is	Heart girth
b	is	Body length

Table 37. Curvilinear Regression Coefficients between Body Weights and Body Sizes

Model	Variable	R^2	Constant.	Regression Coefficients	
				b1	**b2**
Quadratic	Heart girth	0.596	-1600.80	17.44	-0.349
Quadratic	Body length	0.393	134.42	-0.87	0.32

In table 38 the average estimated body weight for sire progeny groups with 20 and more offspring is listed as an example. The overall average weight amounts to 414.65 kg which is about ²/3 to ¾ of the weight of Friesian cows under field conditions in temperate zones. Between progeny groups the average estimated body weight range from 377.79 to 462.18 kg with a fairly stable standard deviation of ~ 39 kg. The observed differences between sire groups also indicate a clear genetic control of body weight, which is proven by the heritability estimate.

Table 38. Estimated Body Weight for Sire Progeny Groups with 20 Offspring and more

Sire	Number	Mean Weight	S.D.
68756	20	462.18	49.97
68661	25	450.55	35.46
DINKLE	32	443.45	37.86
EDIFICE	67	425.46	38.02
ALADIN	103	418.26	39.56
CRHF	40	417.29	31.22
TYRONE	102	414.56	40.84
71H01064	24	400.90	39.45
73H01529	59	400.82	37.93
A72	88	398.54	39.32
9H1619	28	393.68	38.50
71H01083	23	377.79	42.53
Total	611	414.65	39.07

Finally the relationship between body weight and milk and fertility performance is illustrated by the corresponding milk yield and calving interval of the different weight classes (table 39), showing a slight advantage in milk yield for average weight classes and in fertility for the heavier cows.

Table 39. Milk Yield and Calving Interval by Weight Classes

Weight Class kg	N	Milk Yield (305d) kg	Calving Interval d
325.0-350	63	3614.85	480.50
350.1-375	175	3551.14	450.97
375.1-400	206	3831.19	430.69
400.1-425	263	3627.29	450.30
425.1-450	214	3567.86	458.72
450.1-475	144	3653.68	450.52
475.1-500	76	3521.07	433.50
500.1-525	20	3469.48	437.01
>525.1	15	3131.60	433.56

4.12 Estimates of Genetic Parameters

4.12.1 Heritabilities of Productive Traits

The heritabilities of milk yield at 100 days (M100D), milk yield at 305 days (M305D), % protein, % fat, % lactose, total solids, solids not fat, weight and somatic cells were 0.378, 0.352, 0.342, 0.379, 0.238, 0.260, 0.133, 0.461 and 0.097 respectively as shown in table 40.

Table 40. Heritabilities, Additive Genetic Variances and Residual Variances of Productive Traits

	N	M100D	M305D	% protein	% fat	% lactose	Total solids	Solids not fat	Weight	Somatic cells
Heritabilities	391	0.378	0.352	0.342	0.379	0.238	0.260	0.133	0.461	0.097
Additive genetic variances	391	25707.82	250518.83	0.041	0.130	0.022	0.963	0.036	1121.15	107837.72
Residual variances	391	42302.29	461181.83	0.079	0.212	0.069	2.736	0.238	1310.64	745422.13

4.12.2 Heritabilities of Reproductive Traits

The heritabilities of first calving age, second calving age, days open, gestation length, services per conception, days of heat return, calving interval were 0.271, 0.196, 0.031, 0.371, 0.011, 0.032 and 0.023 respectively as shown in table 41.

Table 41. Heritabilities, Additive Genetic Variances and Residual Variances of Reproductive Traits

	N	First calving age	Second calving age	Days open	Gestation length	Services per conception	Days of heat return	Calving interval
Heritabilities	1,673	0.271	0.196	0.031	0.371	0.011	0.032	0.023
Additive genetic variances	1,673	5323.54	8765.18	67.97	18.82	0.018	39.87	255.57
Residual variances	1,673	14320.53	35955.14	2124.64	31.90	1.67	1206.22	9581.70

4.12.3 Phenotypic and Genetic Correlations

Phenotypic and genetic correlations are shown in table 42 and 43. The range of phenotypic correlations between % HF and milk contents is between -0.076-0.030, between % white color and milk contents between -0.122-0.049. The phenotypic correlations between first calving age and milk contents are ranging between -0.048-0.043, and between second calving age and milk contents between -0.142-0.079. The phenotypic and genetic correlations between milk contents themselves were somewhat firmer ranging between -0.091-0.286 and 0.008-0.283 respectively. This holds especially for the phenotypic and genetic correlations between the different fertility traits ranging between 0.054-0.858 and 0.007-0.613 respectively.

Table 42. Phenotypic Correlations (above Diagonal) and Genetic Correlations (below Diagonal) between Systematic Factors and Production Traits

	% HF	% of white color	First calving age	Second calving age	% Protein	% Lactose	% Fat	Total solids
%HF		0.218	-0.046	-0.087	-0.003	-0.076	0.030	0.008
% of white color	-		-0.040	-0.006	-0.122	0.049	-0.092	-0.049
First calving age	-	-		0.691	-0.008	-0.048	0.037	0.043
Second calving age	-	-	-		-0.142	0.079	-0.124	-0.116
% Protein	-	-	-	-		-0.020	0.109	0.286
% Lactose	-	-	-	-	0.054		0.097	-0.091
% Fat	-	-	-	-	0.008	0.011		-0.007
Total solids	-	-	-	-	0.175	0.283	0.267	

Table 43. Phenotypic Correlations (above Diagonal) and Genetic Correlation (below Diagonal) between Fertility Traits

	Service Period	Calving interval	number of A.I. services	Days open	M305D
Service period		0.174	0.159	0.358	0.020
Calving interval	0.523		0.107	0.672	0.069
Number of A.I. services	0.023	0.254		0.676	-0.044
Days open	0.102	0.613	0.287		-0.042
M305D	0.039	0.014	0.045	-0.029	

4.13 Breeding Plan for Sustainable Dairy Cattle Breeding

As shown by the results of this study many effects are affecting the adaptive performance of dairy cows. Cows with high and low % HF were low in fertility and with regard to the overall dairy performance and to the body development of the cows an optimum level of upgrading has to be considered around 71-90% HF. Besides the calving age the systematic effects of herd size, feeding basis and calving season have to be considered in the model for estimation of breeding values; the latter effect has to be adjusted within calving year to account for the significant interaction between calving seasons and calving years.

Since purebred HF and lower HF upgrade cows were less efficient in adaptation to the dairy production environment of Northern Thailand an own sustainable breeding and selection program will be appropriate in the long run based on the higher upgrades of up to 90% HF. However in the starting phase a linkage to the leading Holstein Friesian breeding schemes seems advisable to select top bull sires worldwide with special regard to fertility and lifetime performance. These should be bred with the best bull dams in Thailand and the elite sons resulting from such elite matings should be raised under growth control and afterwards subjected to a field progeny test for milk and fertility performance in order to identify the best crossbred bulls for extensive use in the population. In detail such a breeding program might be set up by the following steps:

1. Sort the best cows by their dairy performance, their conformation and pedigree in Northern Thailand to serve as bull dams.

2. Find and import the semen from best sires worldwide with special regard to fertility and lifetime performance to bred with the selected bull dams.

3. Performance testing of young bulls until 12-15 months (serviceable age). From the young bulls which passed the performance test a sufficient amount of semen (4,000-6,000 doses per young bull) has to be collected from which 500-1,000 doses have to be distributed as test semen to the participating farmers.

4. Progeny testing of their daughters with regard to milk performance, fertility and body development.

5. The sires of the best progeny are chosen for extensive use as proven bull.

6. A certain number of the male calves (brothers to the best daughter groups) are to be included into the performance test of young bulls.

The total procedure is illustrated in figure 7 with two different strategies in using the proven bulls. However the most important prerequisite is the reliability of the records on dairy performance, fertility and pedigree of the cows.

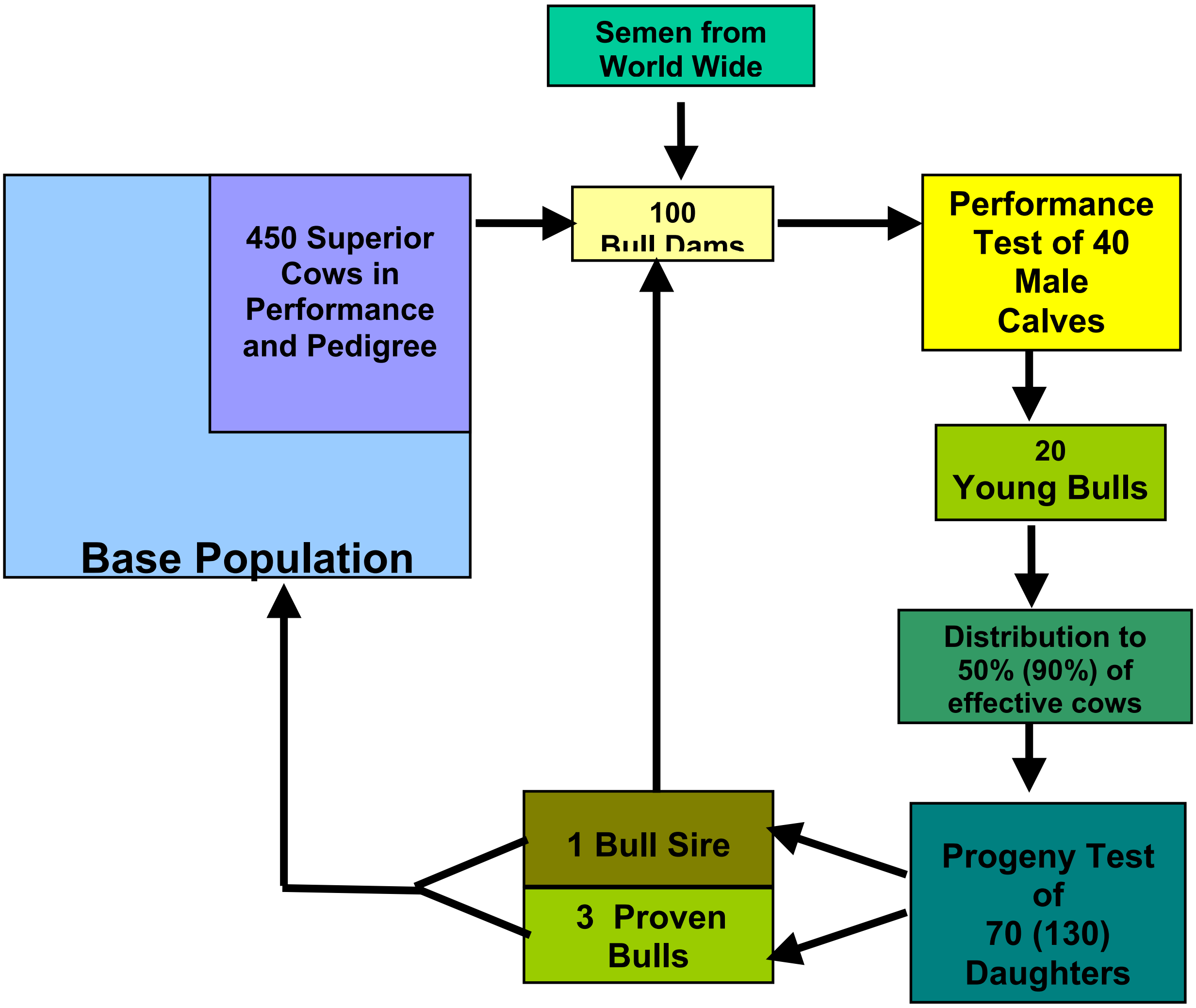

Figure 7. General Scheme for a Northern Thai Breeding Program with 2 Alternative Strategies in the Usage of Bulls (Proven Bull Program, Young Bull Program)

4.14 Response to alternative breeding strategies

4.14.1 Developing breeding scenarios

Utilizing the phenotypic values and genetic parameters (table 44) obtained in the first part of the current study, different breeding scenarios were developed. This was done in order to combine reproduction (adaptation) and production traits in the total merit index. The alternatives included selection based on M305D, and an addition based first on calving interval and second on calving interval and body weight. Traits in the selection criteria and in the aggregate genotype (H) are shown in table 45. Secondly, further versions of the alternatives with changes in the number of daughters per young sire were examined according to different scales of using young sires in the breeding program.

Table 44. Phenotypic and genetic correlations (above and below the diagonal respectively) and heritability values (along the diagonal) of the traits as utilised in the selection index

Trait	M305D	Calving interval	Body weight
M305D	**0.352**	0.069	0.020
Calving interval	0.014	**0.023**	0.035
Body weight	0.105	0.023	**0.461**

Table 45. Alternative Breeding Plans

Breeding plan	Selection criteria	Traits in aggregate genotype
A1	Milk yield (M305D)	Milk yield (M305D)
A2	Milk yield (M305D),Calving interval and Body weight	Milk yield (M305D)
B1	Milk yield (M305D),Calving interval	Milk yield (M305D),Calving interval
B2	Milk yield (M305D),Calving interval and Body weight	Milk yield (M305D),Calving interval
C1	Milk yield (M305D),Calving interval and Body weight	Milk yield (M305D),Calving interval and Body weight

The analysis was done in a half-sib family structure. In the young bull program, the average number of daughters per test bull is 130, while in the proven bull program the number of daughters per test bull is 70. The Northern Thai dairy population is characterized by a total number of 10000 heads of which 90 percent are to be considered as active breeding cows (inseminated and with dairy records). In the young bull program, 90 percent of the inseminations are done by test bulls (TB), while in the proven bull program the part of the test bulls decreased to 50 percent and 50 percent of inseminations remained for cow sires (CS). The parameters of the other parts of selection (BS= bull sire, BD = bull dam, CD = dam of cows) left to be constant for all scenarios in calculating selection response (see table 46).

Table 46. Parameters for calculating of selection response

	BS	BD	CS	CD	TB[1)]
i	2.063	2.063	1.4	0.35	0.8(0.374)
p (%)	5	5	20	80	50 (90)
L (years)	6	3.35	6	5.5	2.5

[1)] values in brackets for selection intensity (i) belong to the young bull program

The complete formula to calculate selection response in dairy cattle considering the percentage of inseminations with proven and young bulls goes back to Langholz and Skjervold (1964):

$$\Delta G = \frac{I_{BS} + k * I_{CS} + (1-k) * I_{TB} + I_{CD} + I_{BD}}{L_{BS} + k * L_{CS} + (1-k) * L_{TB} + L_{CD} + L_{BD}}$$

where:

k = is the percentage of cows in the population which is inseminated by proven bulls. This means k = 0.45 in the proven bull program and k = 0.09 in the young bull program in the scenarios mentioned above.

I = $i * r_{TI} * \sigma_a$

L = generation interval

The different values for correlation between index and aggregate genotype (accuracy = r_{TI}) depend on the numbers of traits which are considered in the index and aggregate genotype, the number of information sources and on the heritabilities of traits. Greater differences in accuracies are only expected for the cows depending on the status of the sire of the cow (proven bull or test bull). The accuracies for the different scenarios, calculated with selection index program, are shown in the results in table 47.

4.14.2 Selection index construction

In order to examine and determine the optimum strategy to be employed for optimum genetic progress, selection index theory was used. The breeding value of the aggregate genotype can be represented as:

$$H = w_i a_i + w_j a_j + w_k a_k$$

where:

H = aggregate genotype of cow

w_i, w_j, w_k = economic weight for each trait; milk yield, calving interval and body weight

a_i,a_j,a_k = breeding value for each trait; milk yield, calving interval and body weight

The selection index to predict H was then

$$I = b_i x_i + b_j x_j + b_k x_k$$

where:

I = selection index

b_i,b_j,b_k = selection index coefficient (b-values) or weights

x_i,x_j,x_k = observations on milk yield, calving interval and body weight as own performance of cows and relatives information.

The b-values were determined as:

$$b = P^{-1}Gw$$

were b is the vector of m selection index coefficients (b-values); P is a m*m-matrix of phenotypic variances and covariances among the observations in the index, G is a m*n-matrix of genetic covariances among the m observations in the index and the n traits in the aggregate genotype, and w is a column vector of economic weights of the n traits in the aggregate genotype.

4.14.3 Economic weights

The current payment system of the dairy cooperatives in Northern Thailand is based on milk yield and fat content with no consideration of protein. The payment system pay minimally for butter fat. The economic weight for milk yield was derived as first derivate of profit function. The profit function was developed from the economic data that were collected in the study as:

$$P = -m + y(s - a)$$

where P is the profit per cow as function of level of production y; m is the maintenance cost of cow; y is the lactation milk yield; s is the price per litre of milk; and a is the marginal cost of milk.

The economic weight of milk (w_m) was therefore, determined as:

$$w_m = \delta P / \delta y$$

The economic values of calving interval and body weight were calculated based on the relationship of these two traits and milk yield i.e. what is the cost of having longer than ideal (365 days) calving intervals on milk yield? The economic weight for body weight was calculated by the expected change in milk yield. The detail of these calculations are outlined in the appendix.

Applying the selection index procedure using SIP computer program (Wagenaar et al., 1995) the standard deviation of the index and the aggregate genotype, the correlation between the index and the aggregate genotype and the expected genetic gain in each trait was calculated and compared for different scenarios. The expected genetic gain was used to identify the optimal breeding strategy.

4.14.4 Response to selection

Phenotypic standard deviations of the traits as applied in the selection index and their economic weights as included in the aggregate genotype are shown in table 47.

Table 47. The economic weight of milk yield, calving interval and body weight

Traits	Phenotypic standard deviation	Economic weight
M305D	1257.59	4.78
Calving interval	98.28	-61.37
Body weight	51.47	0.808

Using the price function derivate approach, the economic weight for milk yield was 4.78 bath/kg. The economic weight for calving interval was calculated as – 61.37 bath/day while that for body weight was 0.808 bath/kg. The economic weights are certainly different from those calculated in the European production systems where there is a quota system for milk and fat, protein percentage in the milk plays an important role in the selection criteria and adaptation of the cattle is not a major problem.

Estimates of the response to selection per year and selection accuracy for cows in the proven bull program (P) and the young bull program (Y) based on one round of selection are given in table 48. The information sources for a cow's breeding value were traced back two generations in the pedigree. An average number of 100 daughters per sire of young bulls was supposed and for cows one own performance in first lactation.

Table 48. Accuracy (r_{IH}) and response to selection on the cow – sire path estimated for the proven bull program (P) and the young bull program (Y)

Plan	r_{IH}		Response for traits in aggregate genotype					
			M305D (kg/year)		Calving interval (days/year)		Body weight (kg/year)	
	P	Y	P	Y	P	Y	P	Y
A1	0.65	0.56	61.72	68.42	-	-	-	-
A2	0.65	0.56	61.84	68.73	-	-	-	-
B1	0.65	0.56	60.97	67.50	-0.12	-0.14	-	-
B2	0.65	0.56	60.97	67.50	-0.12	-0.14	-	-
C1	0.65	0.56	60.97	67.50	-0.14	-0.14	0.34	0.37

The correlation between selection index and aggregate genotype (r_{IH}) was calculated by:

$$r_{IH} = \sigma_I / \sigma_H = \sqrt{(b'Gw / w'Gw)}$$

where:

σ_I = standard deviation of selection index

σ_H = standard deviation of aggregate genotype.

The advantages of the young bull program in comparison with the proven bull program for all scenarios can be summarized as follows: plus 7 kg in milk yield per year, reduction of 0.2 days in calving interval per year and an increase of 0.3 kg in the weight of cows per year. The superiority in the young bull program results in the shorter generation interval (2,5 years for test bulls in contrast to 6 years for proven cow sires), which has greater impact than the increased accuracy of estimated breeding values in the proven bull program.

There was a minimal increase in the expected genetic gain in milk yield after introduction of calving interval in the selection index (scenario A2 in comparison with A1). Although the major source for the dairy farmers in Thailand is from the sale of milk, in trying to improve dairy production, most emphasis need only be placed on milk yield. The marginal reduction in the genetic gain for milk yield with the direct selection on calving interval in scenarios B1, B2, C1 is beneficial to the farmer in the long run. The reduced calving interval means within a productive life time, a cow would produce more calves than when the calving interval is long. This then would result in more replacing in the herd as well as more lactations per productive life time of a cow. This would off-set the loss that is envisaged in the reduction in milk yield per lactation which comes as a result of including calving interval in the selection criteria. This agrees with Meuwissen and Wooliams (1993) who indicated that as milk production increases, other traits become increasingly important, especially fertility traits. But nevertheless, the impact of body weight and calving interval on milk yield is very low, because phenotypic and genetic correlations between these traits are near zero. In the biological sense, the positive correlation on the low level between milk yield and calving interval has a negative impact since the aim is to increase milk yield and reduce calving interval in the process enhancing fertility. When the heritability value for calving interval was low (0.023) regardless of the number of daughters per sire, the improvement of calving interval was very low. Adding the body weight into the aggregate genotype don't change results in selection response for milk yield. This is mainly because of the low genetic correlation between milk yield and body weight ($r_g = 0.02$).

4.14.5 Net Profit of the alternative Breeding Plans

The economic evaluation of the two alterntive breeding plans (young bull program versus proven bull program) with their different selection scenarios is done by assessing the discounted value of the genetic response per year in the breeding traits reduced by the yearly costs of the breeding programme per cow according to the calculation procedure outlined by Langholz (1973):

$$Net\ \mathrm{Pr}\,ofit_{BP} = \sum \Delta G_i * a_i * v \frac{v^{y-1} - v^n}{1 - v} - \frac{K_F + K_v}{N}$$

Where

ΔG_i	is	Genetic gain of the breeding trait i
a_i	is	Economic weight of the breeding trait i
v	is	Discounting factor = 1/q = 1/1.07 (7% interest rate)
y	are	Number of years for realizing first genetic response
n	is	Total program period (30 years)
K_F	are	Fixed costs of the breeding plan
K_v	are	Variable costs of the breeding plan per year
N	are	Number of efficient breeding cows

Assuming an interest rate of 7% and a total program period of 30 years the discounted value of one year selection response in the young bull program is the 9.48-fold and in the proven bull program the 9.18-fold of the actual value of one year response. A rough estimate of the program costs amounts to 264,- Bath per cow and year as lined out in the appendix. The estmates on the achievable net profits of the two alternative breeding plans are given in table 49:

Table 49. Net Profit of alternative Breeding Plans (Bath/cow/year)

	P	**Y**
A1	2444	2856
A2	2449	2851
B1	2478	2877
B2	2478	2877
C1	2481	2880

P is Proven bull program
Y is Young bull program

Due to the low labour costs and pronounced selection response in milk the profibility of breeding programs in the dairy cows has to be considered quite substantial. As already lined out before the response in milk yield is dominating the selection scenarios leading to only small monetary advantages for including adaptive performance traits in the breeding plan.
Due to the shorter average generation interval in the young bull program the advantage of this program alternative becomes even more pronounced with regard to total economic merit.

5. DISCUSSION

5.1 Breeding and Production Structure of Northern Thai Dairy Production

The results show a complex structure of dairy cattle breeding and production in Northern Thailand. Most of the semen is produced within Thailand by artificial Insemination Stations, Department of Livestock Development (DLD). A certain amount of semen is regularly imported from overseas mainly from USA, Canada and Germany. This implies a wide range of bulls in use and leads to problems for implementing efficient breeding plans. An additional problem derives from the very variable quality of the insemination data recorded on farm. Although insemination cards are installed for each cow by the A.I. service and kept on farm the consistency of recording by the inseminators and the interest of the farmers in the data differ widely. Also the production structure is differing widely from farm to farm due to variable quality of feed reserves, variable herd sizes and management skill. In addition the competence of the dairy cooperatives acting as milk collection and marketing centers is quite different leading to quality differences in farm advise and economic efficiency.

5.2 Performances of Lactating Cows

Productive Performance

The overall milk yield amounts to 1158 resp. 3532 kg for 100 days resp. 305 days lactation with small differences between the 3 main regions included in this study. This is still less than half of performance obtained in developed countries like e.g. Canada (the main origin of the Holsteins in North Thailand) with an average 8,738 kg in 1999.

This low performance level most likely results from the climatic pressure and the shortcomings in feeding, herd management and breeding strategies. However there are clear indications for further improvement of the dairy performance in the future. The actual yearly increase in milk production in the period and region covered by this study is close up to 7 % per year which is quite noticeable as compared to ~ 2 % improvement in the developed countries. The main reason for this actual improvement is to be seen in feeding improvements (feeding planning, feed reserves) and in improved herd management. The ongoing progress in Thai dairy cattle farming gives also the explanation for lower yield level recorded in earlier studies from Chokchai dairy farm (1992), Suwanee (1994) and Sureerut, et al. (1997).

Similar performance already recorded by Sornthep, et al. in 1993 are obviously due to the advance dairy farming in the uplands North of Bangkok. The average Holstein percentage with slightly above 80 % seems to be close to the optimum, since there is no yield increase to be observed for upgrading levels above 70 % Holstein Friesian. Regarding herd sizes there is a slight advantage for very small herds. All other factors which might influence the production performance are of minor importance.

The performance level of first calving cows reaches only 77 % of older cows which is fairly low as compared with first calving cows under temperate conditions (87 %) and obviously due to insufficient feeding in the rearing phase.

Regarding the milk contents (% fat, % protein, % lactose, total solids and solids not fat) no distinct difference is to be observed whether between different dairy farming environments within Thailand nor in relation to developed countries.

Reproductive performance

The overall reproduction performance of the cows included in this study turns out to be fairly low. This holds especially for the calving interval with 463 days and for the insemination index with 2.81 services per conception leading to a prolonged service period with 130 days open. This fertility performance is distinctly lower than what is observed under temperate conditions with exception of the first calving age which is with 28.5 months quite similar. Also in comparison to earlier studies on Thai dairy cows by Pinit et al (2000a, 2000b), Suwanee (1994) and Sornthep et al. (1993) the observed fertility performance in tendency has got somewhat poorer. This might be caused by an increased upgrading with Holstein-Friesiain combination with a reduced first calving age. Above 80 % Holstein percentage fertility performance gradually gets poorer and up to a level of 90 % Holstein first calving age is reduced. This might on the other hand simply result from sampling differences. With 1623 cows the sample in this study is much more reliable than in most of the other studies and beyond of this there are distinct differences of the climatic impact on fertility between years and seasons to be expected. As to be explained more detailed below in this study there are significant differences to be observed not only between the calving years but even more distinct between the different seasons of the year. The climatic load on the fertility parameters is quite pronounced during the hot summer and the rainy season the latter in coincidence with increased frequencies of mastitis and foot rot.

Body size and body weight

The body size as characterized by rear height, heart girth and body length differ widely between farms, regions and age groups, which reflects the differences in the rearing and feeding environments. The variation coefficient for body weight e.g. ranges between 10 and 17 % between regions and age groups, which is about twice the weight variation to be observed in cows kept under temperate conditions. First calving cows from the region Chaiprakarn are 24 kg or 6 % heavier than first calving cows from Maeon region, which mainly is to be explained by greater insufficiencies in the roughage supply in that region.

With older cows this weight difference between these regions is reduced to about half that difference, the body weight variability however is increasing. Regarding the age effect the older cows (> 3years) show with 126.2 cm rear height, 182.2 cm heart girth and 76.6 cm body length a slight increased body size than the first calving cows with 125.5 cm rear height, 180.0 cm heart girth and 74.2 cm body length recorded by Aussawin et al. from the same sample. As compared to cows under temperate conditions the cows in Northern Thailand reach only about 90 % of the size and with an average of 415 kg about 70 % of the body weight, which has to be considered as one main reason for the reduced dairy performance under the tropical Northern Thai environment.

5.3 Population Characteristics

The population characteristics cover the structure of Holstein upgrading, the whiteness in coat colour and the body condition scoring after calving.

The structure of Holstein upgrading characterized by 5 classes in 10 % steps beginning at 50 % HF show a frequency of 0.6 %, 5.3 %, 22.5 %, 47.5 % and 24.1 %. Thus 70 % of the population reaches an upgrading level of above 80 % with a fairly consistent HF-level as indicated by a median of 84.4 at an overall mean of 83.4 % and a standard deviation of 8.5 %. Such a high and increasing upgrading level deserves increasing efforts to maintain sufficient sustainability in the overall dairy performance, especially with regard to fertility and stay-ability.

The degree of whiteness in the coat colour might effect the overall performance of dairy cows, assuming a higher absorption of solar radiation of the black skin areas, which leads to higher skin and body temperature and subsequently to decreased feed intake (Godfrey et al. 1994). In this context it is surprising that the Northern Thai Holsteins are fairly dark. The mean percentage of white colour in the coat reaches only 27.0 % with a pronounced skewness in the percentage of white colour. The median lies at 15.0 %, indicating that 50 % of the cows have less than 15 % white colour in their coat. The rest of the cow population show a more or less equal distribution on the colour classes up to 90-100 % whiteness, which is also indicated by the high standard deviation for the white colour percentage of 29.8 %.

From literature it was expected that the body condition of Friesian dairy cows is low after calving, slightly further decreasing during the early stages of lactation and increasing again during the middle stages of lactation up to 260 days pp, remaining constant after that (Jeffrey, 2001 ; Rodenburg, 2001). Contrary to this expectation in the present study body condition of the Thai dairy cows is continuously increasing from an average of 3.06 scores straight after calving and reaching a maximum of 3.43 scores at about 305 days after calving.

This reflects a fairly limited change in body condition during lactation with a very low regression coefficient of body scores on days after calving and with a small variation of the scores between cows in the same stage of lactation. Also extreme scoring values were very seldom if at all observed. This has obviously to be seen on the background of the low performance level of Thai dairy farming based on fibre rich feed sources.

5.3 Systematic Genetic Effects on the Performance of Lactating Cows

As systematic effects of genetic nature the HF-upgrading level and the degree of whiteness in the coat colour were included and their impact on the dairy and reproductive performance studied:

There was no effect of further Holstein upgrading to be observed beyond 60 % HF-percentage in the cows (class 2) neither for milk yield over 100 days respectively 305 days nor for the milk contents protein %, fat %, lactose %, total solids and solids non fat. Obviously the reduced energy intake caused by the high fibre content of the roughages in combination with the heat load of the tropical climate is cealing the production level per cow. With increasing level of upgrading also the adaptation competence against the environmental stress might be reduced and thus overlay the higher genetic merit for milk yield (Kassir et al., 1969; Martinez et al., 1982). These results are congruent with the findings that also the percentage of white colour in the coat has no effect on milk yield and milk contents even though the percentage of white colour is increasing with increasing HF-percentage from 14.3 % for class 1 (50-60 % HF) to 36.6 % for class 5 (90-100 % HF).

Contrary to the dairy performance there is a clear effect of the upgrading on reproduction performance to be seen. The insemination index gets significantly poorer when the upgrading exceeds 80 % HF and the calving interval is significantly increased above 81-90 %. Also the trend towards earlier maturity of HF-crossbreds is slightly reversed for the upgrading class with the highest HF%. Even though fertility traits generally show very low heritabilities (Ageeb et al., 2001; Buckley et al., 2001; Mao,1984; Raheja et al., 1989; Veerkamp and Brotherstone, 1997; Wilcox et al., 2001) the reduced fertility in the highest upgrading classes have to be considered as a clear genetic (breed) effect.

Thus it finally has to be concluded that for the actual situation in Northern Thai dairy cattle breeding a sustainable breeding strategy at an upgrading level of 75-85 % HF has to be highly recommended. Since definitely no effect of the degree of whiteness in the coat colour was found also not with regard to the reproduction parameters there is no indication for including the coat colour in the selection process of breeding dairy cows.

5.5 Systematic Environmental Effects on Performance of Lactating Cows

The systematic environmental effects analysed included parameters of the farm environment (farm size, herd size and feeding basis) and indicators of the overall climatic and production environment (calving year and calving season):

Regarding the influence of the farm environment on dairy performance of the cows only a slight but significant advantage of the small herds (1-5 cows) in the milk yield (+ 100 kg / 305 days yield) is to be observed, which most likely results from the very intensive care of the cows in these herds. Furthermore there is a similar even though not significant advantage in milk yield combined with an improved protein content (+ 0.05 to +0.10 %) for farms which feed treated straw. In all other situations there are no effects of the environmental farm parameters neither on milk yield nor on milk contents, indicating a dominating effect of the individual farming environments due to the differing management skills of the individual farmers.

This holds also for the influence of the farm environment parameters on the reproductive performance of the dairy cows with the exception of a more pronounced impact of the feeding basis. Farms with a more balanced energy supply e.g. farms relying on ready mixed feeds (type 1) respectively on treated straw as a main roughage component obtain a significant improved fertility performance as indicated by a reduced service period (~ -1 month), an improved insemination index (~ - 0.75 services / conception) and a reduced calving interval (~ - 3 weeks). This reflects the predominating role of further feeding improvements for the actual promotion strategies of the dairy industry.

Regarding the impact of the calving year a certain improvement of the milk yield and of the reproductive performance is to be observed over the period covered by this study (1997 – 2000), which might result mainly from general improvements in dairy farming rather than from climatic year effects. Surprisingly there is also no overall effect of the calving season on the dairy performance neither on milk yield nor on milk contents. However there is a clear and significant interaction between year and seasonal effects. In the years 1998 and 2000 the summer calving cows significantly exceeded the yield of the winter calving cows by 21 % and 10 % respectively, which most likely can be explained by the cooler and less stressing summer climate in these years. Quite clear and distinct are the seasonal effects on the reproductive performance showing significantly improved fertility for rebreeding winter calving cows and the poorest reproduction results for cows calving in the rainy season as indicated by an extreme prolonged service period (218 days) and an extreme insemination index (3.2 inseminations / conception). This implies the advantage of a certain seasonal breeding strategy favouring calving and rebreeding in the winter / summer season.

5.6 Effect of Body Size and Weight on Lactation Performance

Even though there are remarkable differences between regions, between farms within regions and also between progeny groups in body weight and body size measurements there is no clear relation of these body development parameters to the dairy production traits. There is only a slight positive intersire correlation between 305 days yield and body weight of r = 0.02 and a slight negative correlation between body weight and calving interval of r = - 0.03 to be observed. On the other hand there is a more clear correlation of the body condition scoring to body weight r = 0.2 but not to the size (height) r = - 0.09. This reflects the tendency that higher HF-upgrades get taller and show a poorer condition especially at younger ages.

Since a consistent body development is reflecting a more balanced adaptation to the specific constrains of the Northern Thai dairy farming environment a more pronounced effect of body development parameters is to be expected for lifetime performance which has to be followed up in further screening of the Northern Thai dairy data. Thus to ensure a sufficient body development in Northern Thai dairy cattle breeding a weight control at first calving should be generally included in selection decision for breeding cows. The practical weight control can be done by the three body measurements heart girth, body length and rear height. Ensuring a calculation of the regression function of the body weight on these three body measurements based on a sufficient large weighing sample a weight prediction with a high accuracy of $R^2 > 0.7$ can be obtained.

5.7 Genetic Parameters

The heritabilities of the production traits obtained from this study for the Northern Thai dairy cow population are at the upper range of what is recorded for dairy populations from temperate zones (Wilcox et al., 2001) and very congruent to genetic studies on dairy cow populations under tropical conditions (Ageeb et al., 2001). Special attention should however be drawn to the high additive genetic variation to be observed for all important dairy traits especially for the fat and protein content. The additive genetic coefficient for 305 days yield, fat % and protein % amounts to 13.7 %, 9.5 % and 6.4 % respectively, indicating pronounced selection prospects for consistent breeding activities within the Northern Thai dairy population.

Regarding the reproduction traits is was postulated that the high environmental pressure of Northern Thai dairy regions would result in greater differences between progeny groups of sires coming from different breeding origins. However the heritability estimates for essential reproduction parameters turn out to be as low as found in other studies and similar to the reports of Ageeb et al. (2001), Mao (1984), Raheja et al. (1989) and Wilcox et al. (2001). Despite the low heritabilities for the main reproduction traits there is still a certain scope for selection improvements indicated by an additive genetic variance of VA = 4 - 6 % provided that sufficient large progeny groups can be recruited to ensure sufficient reliable estimates of the breeding values, which not easily can be realized under the limited size of the Northern Thai dairy breed population. Thus improvement of the impaired fertility situation predominantly should be tackled by improving the feeding and reproduction management.

Due the limited sample size especially with respect to the number of progeny per sire the estimates on the genetic correlations between the performance parameters are fairly uncertain.

There are slight positive relations between the milk content components, especially between total solids with the percentage of protein, fat and lactose. The lower correlation level between the single components to some extent might reflect from genetic differences in the adaptation potential, resulting in a decrease of fat and protein percentage of less adapted cows. Regarding the reproductive traits there is a neutral relation to all dairy traits. Between the different fertility parameters there is a clear positive correlation between days open, number of services per conception and calving interval, which has mainly to be interpreted as autocorrelation of the same genetic phenomenon. Having very similar genetic structures as in other dairy populations one might use the genetic correlation estimates from larger samples of other genetic studies with smaller standard errors on the estimated correlation coefficients when formulating alternative sustainable breeding plans for Northern Thai dairy cows.

5.8 Sustainable Breeding Plans and Their Genetic Gain

Facing the performance decrease of high Holstein upgrades in fertility and adaptation and having significant selection prospects for improving dairy traits under the Northern Thai production conditions due to high additive genetic variability in these traits there is a strong indication for establishing a sustainable breeding strategy for the Northern Thai dairy population. Due to the limited population size of ~ 10000 active cows an open breeding plan should be preferred like it is applied in other small dairy breeding populations in tropical areas e.g. in Australia (Owens, -). This means that bull sires regularly are introduced from other breeding of Thailand and world wide, putting special selection emphasis on breeding merits in fertility performance. A limited number of sons of these imported bull sires then have to be tested and selected under Northern Thai conditions before extensive use. The core of the breeding concept should be a strict selection of bull dams on within dairy cooperative basis. The technical realisation of the breeding programme including all testing activities best would be in the hands of the dairy cooperatives organised as a joint venture.

From the alternative selection strategies analysed an index selection including protein and fat corrected milk yield, calving interval and first calving heifer weight as selection traits should be preferred aiming at maximizing genetic merit in milk yield and fertility in the aggregate genotype, since the meat production from the dairy herd has no essential impact on Thai dairy farming economy. Under idealised selection conditions the expected genetic gain of such a breeding plan would be +60 - 70 kg milk / per cow and year combined with a reduction of the calving interval of .12 - .14 days. This corresponds to 1.7 % and 0.03 % per year respectively and has to be considered as a quite remarkable prospect. Due to the limited population size an extensive use of young bulls should be favoured in the A.I. breeding plan with an increased net profit expectation of ~ 16% above a traditional A.I. breeding plan relying on maximum use of proven bulls. It still remains to be cleared to what extent this expected genetic progress can be realised under the structural conditions of Northern Thai dairy farming.

6. SUMMARY

The aim of this study was to investigate the actual production and breeding status of the Northern Thai dairy herd in order to identify the data basis for developing sustainable breeding concepts for Northern Thai Holstein breeding. For this purpose field data on dairy production, reproductive performance and breeding structure (percentage of Holstein upgrading) were collected from 2764 cows distributed on 252 farms in the provinces Chiangmai, Chiangrai and Lamphun / North Thailand. Additional data on body measurements (heart girth, body length, rear height), body weight, condition scores and degree of whiteness in the coat colour were collected to identify indicators for the adaptation performance.

The results can be summarized as follows:

With an average production of 3668 kg milk per lactation (305 days) the actual performance reaches only half the level of the Holstein performances in temperate zones indicating essential feeding and management reserves despite the depressing effect of the humid and hot tropical environment. The milk contents however are with an average of 3.85 % fat, 3.15 % protein and 4.67 % lactose up to a similar level.

The dairy performance of the heifers with an average first calving age of 28.5 months is 23.5 % lower than of cows in the second lactation which is much more distinct than in temperate zones and obviously resulting from nutritional deficiencies under rearing. The milk contents on the other hand are however not affected.

The overall fertility performance turns out to be fairly low as indicated by a prolonged calving interval of 463 days resulting from an increased A.I. index of 2.81 inseminations per conception and a service period of 130 days. There are however distinct differences between years and seasons within years, obtaining a significant better fertility in winter calving cows and the poorest results for cows calving in the rainy season.

The degree of Holstein upgrading reaches an optimum at 70 – 90 % HF. There is no further increase in milk yield beyond the upgrading class 60 - 70 % HF and there is a clear reduced fertility performance in the highest HF-upgrading class. Also the trend towards earlier maturity with increasing Holstein percentage is reversed in this class indicating increasing adaptation problems of high upgrades. Thus the actual average degree of upgrading at 83.4 %

has to be considered as optimum for the field farming conditions and no further upgrading can be recommended.

Increased Holstein upgrading in addition leads to an increased whiteness in the coat colour from 14.3 % to 36.6 % white colour for the HF-classes 50 –60 % to 90 –100 %. However there is no relation at all between the degree of whiteness and the dairy and reproductive performance of the cows which was supposed to result from a reduced heat stress of cows with a brighter coat indicating no necessity for colour selection.

With an average body weight of 415 kg the Holstein cows under the Northern Thai dairy farming conditions obtain only ~ 70 % of the weights of Holstein cows in temperate zones which explain a great deal of the reduced production level .Even though there are remarkable differences in body size and body weight between regions and farms there is nearly no positive effect of a better body development on the milk performance to be observed. This holds also for the condition scores which contrary to dairy farming in temperate zones show a gradual improvement of the body condition after calving up to an optimum 260 days post partum. Regarding the reproduction performance there is a tendency of better results with increased body weights.

From the systematic environmental factors analysed only a slight positive effect of small herd sizes on milk yield and of better farm feeding environments on the reproductive performance was observed. Also the overall effect of calving year and season on the dairy production was not very pronounced. There is however a significant interaction between years and season favouring the summer calving cows in some years with a milk yield increase of 10 – 21 %

The estimation of the genetic parameters is based on 2764, 1673 and 391 daughters for reproduction traits, milk yield and milk contents respectively. The number of sires range from 570 – 85, resulting in fairly small progeny group sizes of 4.2 – 4.6 in average. SAS procedures were applied to analyse the phenotypic variability, the estimation of heritabilities and genetic correlations were based on the animal model, employing restricted maximum likelihood calculation procedures (VCE 4, Groeneveld, 1998).

The heritability estimates for the dairy traits under Northern Thai dairy farming are at the upper range of what is recorded for temperate dairy production environments, the genetic variability however is much more distinct, especially for fat and protein percentage. This

opens substantial prospects for selective improvement of fat and protein yield in sustainable breeding approaches.

Contrary to an expected increased genetic variability of the reproductive performance resulting from differences in genetic adaptation potential heritability estimates on the fertility parameters are as low as recorded generally for dairy populations worldwide. The genetic correlation between fertility and milk yield turned out neutral, whilst the genetic relationship between the different reproduction traits service period, insemination index and calving interval are clearly positive (rg = 0.3 – 0.6), which indicate an autocorrelation of the same genetic phenomenon.

The consistent reduction in fertility and adaptive performance of the highest Holstein upgrading classes and the pronounced selection prospects for fat and protein yield has to be considered as a strong indication for establishing an independent sustainable Holstein breeding program for Northern Thailand. With respect to the limited population size an open breeding concept should be preferred, importing regularly bull sires with superior merits in fertility performance from other Holstein populations. An index selection including milk yield, calving interval and body weight is recommended aiming at maximizing the economic progress in dairy and reproductive performance and employing a strict selection among bull dams as key activity. Under ideal selection structures an optimum selection response of 1.7 % increased milk yield per cow and year combined with a reduction of calving interval by 0.03 % is predicted. Due to the small population size an extensive use of young bulls is superior to a maximized use of proven bulls in the A.I. breeding program by 16% in the net breeding profit. The realisable genetic improvement under the actual breeding structures of the Northern Thai dairy herd is still left to be quantified.

7. Zusammenfassung

Das übergeordnete Ziel der vorliegenden Untersuchung war eine Statusanalyse der Zucht- und Produktionsstrukturen in der Milchviehzucht Nordthailands als Basis für die Entwicklung eines eigenständigen Besamungszuchtprogramms für die nordthailändische Holsteinzucht. Hierzu wurden auf 252 Milchviehbetrieben in den Provinzen Chiangmai, Chiangrai und Lamphun Daten zur Milch- und Fruchtbarkeitsleistung sowie zur Zuchtstruktur (Holstein Friesian Genanteil) von bis zu 2764 Kühen erhoben. Zusätzlich wurden an gezielten Stichproben Informationen zur körperlichen Entwicklung (Brustumfang, Körperlänge, Kreuzbeinhöhe, Körpergewicht), zum Konditionszustand sowie zur Fellfarbe (Grad der Weißfärbung) als mögliche Indikatoren für die Adaptationsleistung erhoben.

Die Untersuchungsergebnisse lassen sich wie folgt zusammenfassen:

Mit einer durchschnittlichen 305 Tageleistung von 3668 kg erreicht die Milchleistung nur etwa die Hälfte des aktuellen Leistungsniveaus an gemäßigten Futterbaustandorten, was trotz der besonderen Belastungen am tropischen Standorten noch weitreichende Reserven im Fütterungs- und Herdenmanagement deutlich macht. Die Milchinhaltsstoffe bewegen sich mit Gehalten von 3.85% Fett, 3.15% Eiweiß und 4.67% Laktose auf vergleichbarem Niveau.

Die Michleistung der Färsen bleibt bei einem Erstkalbealter von 28.5 Monaten 23.5% unter dem Leistungsniveau der Zweitkalbskühe, was gegenüber den gemäßigten Milchvieh-standorten ein deutliches Zurückbleiben der Färsenleistungen kennzeichnet und mit besonderen Unzulänglichkeiten in der Färsenaufzucht in Verbindung zu bringen ist. Die Milchinhaltsstoffe sind bei den Färsenleistungen hingegen nicht beeinträchtigt.

Die Fruchtbarkeitsleistung liegt mit einer verlängerten Zwischenkalbezeit von 463 Tagen auf einem insgesamt niedrigem Niveau, was aus einem erhöhtem Besamungsindex von 2.81 Besamungen pro Trächtigkeit und verlängerten Besamungsperiode von 130 Tagen resultiert. Zwischen den Jahren und vor allem zwischen den Jahreszeiten bestehen jedoch deutliche Unterschiede mit der besten Fruchtbarkeitsleistung nach Winterkalbungen und sehr unbefriedigen Fruchtbarkeitsergebnissen bei Abkalbungen in der Regenzeit.

Der Grad der Verdrängungskreuzung mit Holstein Friesian erreicht ein Optimum bei 70-90% HF. Oberhalb der Kreuzungsstufe 60-70% HF sind keine weiteren Leistungssteigerungen zu

beobachten und in der höchsten Kreuzungsstufe > 90% HF fällt die Fruchtbarkeitsleistung klar zurück. Auch der Trend zur früheren Zuchtreife von Färsen mit steigenden HF-Genanteilen ist in der höchsten Kreuzungsstufe gebrochen, was insgesamt wachsende Anpassungsprobleme der Tiere in der höchsten Kreuzungsstufe deutlich macht. Mithin ist der aktuelle durchschnittliche Aufkreuzungsgrad von 83.4% als Optimum für die Milchviehzuchtpraxis anzusehen und darüber hinaus gehende Aufkreuzungen können nicht empfohlen werden.

Wachsende HF-Genanteile führen zu wachsenden Anteilen von weiß in der Fellfärbung mit einer Steigerung von 14.3% auf 36.6% weiß bei einer Steigerung der HF-Genanteile von 50-60% HF auf 90 - 100% HF. Es konnten jedoch keinerlei Beziehungen zwischen den Weißanteilen in der Fellfärbung und der Milch- und Fruchtbarkeitsleistung gefunden werden, die als Folge einer geringeren Strahlungsbelastung der Kühe mit der helleren Fellfärbung erwartet worden waren. Mithin gibt es keinen Anlass zur Berücksichtigung der Fellfarbe in der Zucht.

Mit einem durchschnittlichen Körpergewicht von 415 kg erreichen die Holstein Friesian Kühe in Nordthailand nur ~ 70% Körpergewichts von Holstein Kühen an gemäßigten Milchviehstandorten, was einen großen Teil der bestehenden Leistungsunterschiede erklären dürfte. Obwohl deutliche Unterschiede in der Körpergrösse und im Körpergewicht zwischen Regionen und zwischen Betrieben innerhalb Regionen zu beobachten sind, gibt es nur einen begrenzten positiven Effekt einer guten körperlichen Entwicklung auf die Leistung und dieses eher bei der Fruchtbarkeit. Gleiches gilt für den Konditionszustand, der im Unterschied zu den gemäßigten Milchviehstandorten sich von der Abkalbung an graduell verbessert bis zur Optimalkondition nach 260 Tagen post partum.

Von den untersuchten sytematischen Umweltfaktoren zeigen nur die kleine Herdengrösse einen positiven Einfluß auf die Milchleistung und die bessere Qualität der Futtergrundlage auf die Fruchtbarkeitsleistung. Wenn auch die Jahres- und Saisoneffekte über den gesamten Untersuchungszeitraum nicht sehr ausgeprägt sind, so gibt es jedoch signifikante Interaktionen zwischen Jahren und Jahreszeiten, wobei in einigen Jahren im Sommer abkalbende Kühe eine Leistungsüberlegenheit von 10-21% erreichen. Somit sind in der Zuchtwertschätzung saisonale Effekte innerhalb Jahren zu berücksichtigen.

Die Schätzung der Populationsparameter basieren auf Leistungsinformationen von 2764 Töchtern für die Fruchtbarkeitsparameter, von 1673 Töchtern für die Milchleistung und von 391 Töchtern für die Milchinhaltsstoffe. Die Zahl der Väter schwankt zwischen 570 und 85, woraus sich vergleichsweise kleine Nachkommengruppengrößen von 4.2 - 4.6 Töchtern ergeben. Das SAS Programmpaket wurde zur Analyse der phänotypischen Variabilität eingesetzt. Die Schätzung der Heritabilitäten und genetischen Korrelationen erfolgte auf der Basis des Tiermodells unter Anwendung der restriktiven Maximum Likelihood Methode nach Groeneveld (1998).

Die Heritabilitätsschätzwerte liegen für Milchleistungsmerkmale im oberen Bereich der Schätzwerte für Populationen an gemäßigten Milchviehstandorten. Die genetische Variabilität ist hingegen sehr viel ausgeprägter, vor allem für die Milchinhaltsstoffe, was besondere Erfolgsaussichten für ein eigenständiges Zuchtprogramm eröffnet.

Eine auf Grund genetischer Unterschiede in der Adaptationsleistung am tropischen Standort erwartete erhöhte genetische Variabilität der Fruchtbarkeitsmerkmale konnte nicht nachgewiesen werden. Die geschätzten Heritabilitäten liegen auf dem gleichen niedrigen Niveau wie sie weltweit für Milchviehpopulationen gefunden werden. Die genetische Beziehung zwischen der Milchleistung und Merkmalen der Fruchtbarkeitsleistung ist unbedeutend, während die genetische Korrelationen zwischen den Fruchtbarkeitsmerkmalen Besamungsperiode, Besamungsindex und Zwischenkalbezeit untereinander mit r_g = 0.3-0.6 deutlich positiv sind, was im wesentlichen einer Autokorrelation desselben biologischen Phänomens zuzuschreiben ist.

Die durchgängige Beeinträchtigung der Fruchtbarkeits- und Adaptationsleistung in der höchsten HF-Kreuzungsstufe und die besonders guten Erfolgsaussichten einer Selektion auf Milchmengenleistungen verlangen nach einer möglichst umgehenden Einführung eines eigenständigen Zuchtprogramms für die nordthailändische Holsteinzucht. Angesichts der noch begrenzten Populationsgröße empfiehlt sich ein offenes Zuchtprogramm mit regelmäßigem Import von Bullenvätern aus der weltweiten Holsteinzucht unter besonderer Beachtung der Fruchtbarkeits- und Lebensleistung. Weiter empfiehlt sich eine Indexselektion mit den Selektionsmerkmalen Milchleistung, Zwischenkalbezeit und Körpergewicht der Färsen ausgerichtet auf eine Optimierung des Zuchtfortschritts in der Milch und Fruchtbarkeitsleistung. Unter idealen Zuchtstrukturen wird auf Grund der ermittelten Populationsparameter ein jährlicher genetischer Fortschritt von 1.7% in der Milchleistung und von 0.03% in der Zwischenkalbezeit geschätzt, wobei eine umfassender Einsatz von Testbullen im Rahmen eines Jungbullenprogramms dem klassischen Konzept eines auf nachkommengeprüften Altbullen beruhenden Zuchtprogramms klar überlegen ist. Der konkrete Zuschnitt eines solchen Zuchtprogramms auf die nordthailändische Holsteinzucht und die sich daraus ableitenden Erfolgserwartungen sind noch zu klären.

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9. List of Abbreviations

AI	Artificial Insemination
BCS	Body Condition Scores
BLUP	Best Linear Unbiased Predictor
BV	Breeding Value
DLD	Department of Livestock Development
DPO	Dairy Promotion Organization of Thailand
EBV	Expected Breeding Value
FAO	Food and Agriculture Organization
Hb	Hemoglobin
HF	Holstein Friesian
M100D	Milk Yield at 100 Days
M305D	Milk Yield at 305 Days
MME	Mixed Model Equation
PTA	Predicted Transmitting Abilities
QTL	Quantitative Traits Loci
REL	Reliability
TA	Transmitting Abilities
TMR	Total Mixed Ration
SNF	Solid Not Fat

10. APPENDIX

10.1 Determination of Economic Weights using Profit Functions

10.1.1 Milk Yield (M305D)

Average production 3523.47 Kg/ year/ cows X 10 cows= 35234.7 kg / year

Price of milk = 11 Bath / Kg

Fix costs = 10,000 bath / year (150,000/ 15 years)

Average Cost of Milk

Feeds Concentrate = 5x6 bath / days = 30 = 30x365 = 10,950 bath / year

=10950X10 = 109500 /year

Grass = 5 x 365 x 10 = 18250 Bath /cow

water + electric + labor + drug = 2000 + 2400 + 26400 + 5000 = 35,800 bath/years

= 109500 + 18250 + 35800 = 163550 Bath / year

Average cost = 163550/35234.7 = **4.64** Bath

Profit per cow as a function of production level (y)

P = -10,000+y(11-4.64)

dP / dy = 6.36

then **VM = 6.36**

Marginal Cost of Milk

Price of milk = 11 Bath / Kg

Average production

In farm with 3523.47 kg/cow

feeds Concentrate = 5x6 bath / days = 30 = 30x365 = 10,950 bath / years

=10950X10 = 109500 /years

Roughage = 5 x 365 x 10 = 18250 Bath

water + electric + labor + drug = 2000 + 2400 + 26400 + 5000 = 35,800 bath/years

Total 109500 + 18250 + 35800 = 163550 Bath / year

In farm with 3850 kg/cow

feeds Concentrate = 5.67x6 bath / days = 34.02 = 34.02x365 = 12417.3 bath / years

=12417.3X10 = 124173 /years

Roughage = 6x 365 x 10 = 21900 Bath

water + electric + labor + drug = 2000 + 2400 + 26400 + 7000 = 37,800 bath/years

Total 124173 + 21900 + 37800 = 183873 Bath / year

= 183873 – 163550 = 20323 = 2032.3/ cows

= 2032.3/(3850-3523.47) = **6.22**

Marginal profit per cow as a function of production level (y)

P = -10,000+y(11-6.22)

dP / dy = 4.78

then **VM = 4.78**

10.1.2 Economic Weight for Calving Interval

Average of milk production =3523.47 kg / year

Calving interval = 462.67 days

Milk yield 3 year(1095 days) = (1095/462.67)3523.47= 8338.98 kg

If calving interval = 365 days then milk yield = (1095/365)3523.47= 10570.41 kg

Milk yield were increase = 10570.41-8338.98 = 2231.43 kg

In {1095x(365-462.67)}/462.67 = -231.16

= 2231.43/-231.16= -9.65 kg /days

value = 9.65 x 6.36 = -61.37 (if calving interval increase then milk yield were decrease)

= -61.37

10.1.3 Economic Weight for Weight

Regression coefficient between m305d and milk yield = 0.127

That is if weight increases by 1 kg the m305d will increase = 0.127 Kg

Value = 0.127x6.36= **0.808** (if body weight increases then milk yield will increase)

10.1.4 Determination of (Kv+KF)/N

Fix costs

300000 for performance test station

300000 for computer system

= 600000/9000 = 67 bath/cow

= 67/5 = 13.4 bath/cow/year

Variable costs

Labor costs =22 Milk controller x 6000 x 12 = 1584000

Feed cost = 6 x 5 = 30 Bath/test bull/day x 400 d x 20 test bulls = 2400000

Costs for program management, 3 officers x 12000 x 12 = 432000

= (1584000 +240000 + 432000)/9000 = 250.7

Total = 13.4 + 250.6 = **264.-** bath/cow/year

CURICULUM VITAE

Name	Nattaphon CHONGKASIKIT
Date of Birth	17 July 1973
Place of Birth	Uthaithani, THAILAND
Nationality	Thai
Civil Status	Single
Religion	Buddhism
Address	0ffice: Department of Animal Science, Faculty of Agriculture, Chiangmai University, Chiangmai, Thailand. 50200. Residence: 244/71 Lanna pinnery Village, Hangdong Distric Chiangmai Province, Thailand.

Education	1979-1985	Anuban Uthaithani Primary School
	1985-1988	Uthaiwittayakom Lower Secondary School
	1988-1991	Uthaiwittayakom Upper Secondary School
	1991-1995	Changmai University, Chiangmai, Thailand (B.Sc.Agriculture)
	1995-1998	Chiangmai University, Chiangmai, Thailand (M.Sc.Agriculture)
	2000-present	Institute of Animal Breeding and Animal Genetics Georg-August University, Goettingen, Germany
Professional career	1998-present	Lecturer in Department of Animal Science, Faculty of Agriculture, Chiangmai University.