The Genetics of Reproductive and Productive Performance of Holstein-Friesian Cattle in Khartoum State, Sudan

By

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Abstract

This study was conducted to estimate the effect of some environmental and genetic parameters on reproductive and productive performance of pure Holstein-Friesian cattle at Dairy-Land farm (Azaheir) in Khartoum, State Sudan.

The study included 736 Holstein-Friesian cows from 43sires covering the first five lactations during the period from 1984 to 2004 were used in the study.

The reproductive characteristics examined were: age at first calving, number of services per conception and calving interval. The productive characteristics examined were: total milk yield and lactation length.

The data were subjected to statistical analysis using Harvey's Least Squares and maximum likelihood analysis.

The results showed that the least squares means for age at first calving, number of services per conception, calving interval, total milk yield and lactation length were 29.90±0.72 months, 2.77±0.12, 521.10±18.78days, 3762.29±156.47Kg, and 279.99±1.90 days, respectively.

The analysis of variance revealed that the sires of cows birth did not significantly ($p>0.05$) influence the calving interval and lactation length but, they had a highly significant ($p<0.01$) effect on age at first calving, number of services per conception and lactation yield.

The year-season of calving did not significantly affect ($p>0.05$) calving interval, lactation yield and lactation length. However, it had a highly significant ($p<0.01$) effect on age at first calving. The parity number did not have a significant ($p<0.05$) effect on number of services per conception, calving interval, lactation yield and lactation length. Analysis the linear regression showed a highly significant ($p<0.01$) effect on lactation yield and lactation length but had a significant affect ($p<0.05$) on calving interval.

Genetic, phenotypic and environmental correlations were estimated by paternal half-sib analysis of covariance (Becker, 1975). And the Heritabilities were estimated by paternal half-sib analysis as described by (Falconer, 1996). The estimates were (0.151 ± 0.042), (0.062 ± 0.019), (0.002 ± 0.014), (0.110 ± 0.029), (0.011 ± 0.11) for age at first calving, number of services per conception calving interval, total milk yield and lactation length, respectively.

ملخص الأطروحة

أجريت هذه الدراسة علي بعض العوامل البيئية والوراثية المؤثرة علي الصفات الإنتاجية والتناسلية لأبقار الفريزيان والمحفوظة في مزرعة الديريلاند(أزاهير) بولاية الخرطوم في السودان.

غطت الدراسة 736 من أبقار الفريزيان وقد تم تحليل سجلات التربية خلال الخمسة مواسم الإنتاجية الأولى في الفترة من 1984 – 2004م والصفات التناسلية التي تمت دراستها هي : متوسط العمر عند أول ولادة ، متوسط عدد التلقيحات المخصبة ومتوسط طول الفترة بين الولادتين والصفات الإنتاجية التي تمت دراستها هي : متوسط إنتاج اللبن في الموسم ومتوسط فترة الحلب. وقد تم تحليل سجلات التربية باستخدام برنامج هارفي (Harrvey,1990) وقد أوضحت الدراسة أن متوسط العمر عند أول ولادة ، متوسط التلقيحات المخصبة ، متوسط طول الفترة بين الولادتين ، متوسط إنتاج اللبن في الموسم ومتوسط طول فترة الحلب هي 29.90±0.72 أشهر2.77±0.12، 521.10 ± 18.7 يوم ، 3762.29 ± 156.4 كجم و 279.99 ± 1.90 يوم علي التوالي .

وجد أن تأثير أبا الأبقار غير معنوي (P>0.05) على متوسط الفترة بين الولادتين ومتوسط فترة الحاب ، لكنه عالي التأثير المعنوي (P<0.01) علي متوسط إنتاج اللبن، العمر عند أول ولادة وعدد التلقيحات المخصبة.

كما وجد أن سنة الولادة غير معنوي (P>0.05) التأثير علي متوسط الفترة بين الولادتين ،متوسط إنتاج اللبن ومتوسط طول فترة الحاب لكنها عالية التأثير المعنوي (P<0.01) علي متوسط العمر عند أول ولادة. بينما كان ترتيب موسم الحليب عديم التأثير المعنوي (P>0.05) علي متوسط عدد التلقيحات المخصبة ،متوسط طول الفترة بين الولادتين ، متوسط إنتاج الحليب ومتوسط طول فترة الحليب.

كما وضحت الدراسة أن الانحراف الخطي عالي التأثير المعنوي (P<0.01) علي متوسط إنتاج اللبن خلال الموسم ومتوسط طول فترة الحاب لكنه مؤثر معنويا (p>0.05) متوسط طول الفترة بين الولادتين.

من ناحية أخري اشتملت الدراسة علي تقدير المكافئات الوراثية بطريقة Paternal half-sib analysis (Falconer, 1996) وقد كانت تقدير المكافئات الوراثية كالآتي : 0.042±0.151 ، 0.014±0.002 ، 0.019±0.62 ، 0.110±0.029 و0.011±0.011 للعمر عند أول ولادة ، طول الفترة بين الولادتين ، عدد التلقيحات المخصبة ، إنتاج الحليب خلال

الموسم وطول فترة الحليب علي التوالي وذلك حسب تقدير الارتباطات الوراثية، البيئية و المظهرية بطريقة تحليل التباين المشترك (أنصاف الأشقاء) (Falconer, 1996).

Chapter One

Introduction

In Sudan there are many cattle breed types and strains. Each strain or type is adapted to certain climatic and feed conditions. Tropical environmental factors and other constraints have limited animals reproductive and productive performance. Despite the huge cattle numbers in Sudan, milk production is low due to low genetic potential of the indigenous cattle breeds, poor management and low feeding standards. Jasiorowski *et al*. (1987).For that reason, breed crossing and grading up of local breeds with European breeds of high productivity or directly importing breeds to increase milk and milk products has become very popular.

The productive and reproductive traits of Holstein- Friesian cattle are high in their original homeland. Heifers mature and come in milk between 24-30 months. Annual production of the breed is approximately 4000 Kg milk per 305day lactation, (Blakley and Bade,1976). But, in tropical and subtropical countries this is different.

In 1984, Arab Sudanese Dairy Company (Dairy land) was established as a commercial unit for milk and dairy products. The production in the farm started with a herd of Holstein-Friesian. The animals were imported from Holland as 4-6 months in calf heifers. The farm is located at about 30 km south of Khartoum.

The objective of this research was to study the performance of those imported pure Friesian cattle with regard to

1- Production of milk.
2- Reproductive performance.

The study utilized data from records of 736 Holstein-Friesian heifers and 41 sires kept in the aforementioned farm between the years 1984-2004. The productive, reproductive and heritability estimates were obtained by paternal half-sib procedure (Falconer, 1996). The data was analyzed using Harvey's (1990) least squares program.

Chapter Two
Literature Review

2.1 Reproductive Traits:

2.1.1 Age at first calving:

The term defines the period of time that elapses from the date of birth of the animal to the first calving. It is considered as one of the most important economic factors that determine a cow's future productive and reproductive performance.

Estimates of age at first calving obtained from Holstein populations in temperate countries were often different from those obtained in tropical and subtropical countries. In temperate regions Friesians attain puberty earlier than in the tropics (8-11 months compared to about 20 months in tropics) and their age at first calving is between 20-26 months in the tropics (Zaied, 1995). Bayoumi and Khalifa (1966) found that the age of animals was an important physiological factor affecting the yield and composition of milk. Godora *et al.* (1990) investigated the genetic and non-genetic factors affecting milk production in temperate Holstein-Friesian, Brown Swiss and Jersey X Zebu (Haryana) crossbreds. They obtained an overall mean for age at first calving as 31.4±0.23 months, whereas genetic group, and period of calving had a significant ($p<0.05$ and $p<0.01$) effect on the trait. The season of calving, however, had no significant ($p> 0.05$) effect on age at first calving.

In the tropics and subtropics, Abu Baker *et al*. (1986) reported that age at first calving averaged 36.6 months in a set of 53470 records of Holstein cows in Columbia. Mbap and Ngere (1989) found the mean age at first calving of Friesian cows in Nigeria as 37.9 and 29.4 months for imported and locally born heifers. Gyawu *et al*. (1990) studied the performance of Holsteins in Ghana and found that their age at first calving averaged 30.4± 0.5 months. Hough *et al*. (1990) analyzed 27465 records and found that age at first calving was 33.0 months in Western Australia. Juma and Altkriti (1991) analyzed 273 records and found that the age at first calving was 28.14 ± 0.2 months for Holstein-Frisian cattle in Iraq.

Osei *et al*. (1990) studied the performance records of 27 Holstein-Frisian heifers born in Ghana and found that age at first calving averaged 34.14±1.27 months for Holstein heifers. Abuzaid (1999) reported that the average age at first calving of imported and locally born Frisians in Sudan was 24.5±1.5 and 26.1±3.2months, respectively. Elkhalil (2001) analyzed 839 records from 462 Libyan Frisian cows and found that age at first calving was 36.57±8.80 months with 24.06% coefficient of variation. Also she found that both sire and calving year-season had highly significant ($p<0.001$) effects on age at first calving. Neiva et al. (1993) reported that Holstein heifers born in Brazil calve for the first time at 32.15±0.40 months. Nbah *et al*. (1992) studied the performance of dairy cattle in Cameroon and found that age at first calving of Holstein cows averaged 26.6±6.5 months. Morsy *et al*. (1990) studied some production characteristics of Friesian cattle and reported that 33.9 months was the age at first calving of Friesian heifers. Jardon (1992) who studied

Holstein heifers in Mexico reported that age at first calving was 26.8±3.5 months.

Thus, it can be summarized that Frisians cattle born in the tropics have shown late age of first calving. Most of the estimates ranged between 24 and 36 months of age.

Table: 2.1 Age at first calving for one herds:

No of Cows	Herds	Mean± S.E	Author
223	Dairy Land Co	29.76±0.40	Abdelgader (2004)
155	Dairy Land Co	26.70±0.60	Mahmoud (1998)

S.E. = Standard error

2.1.2 Number of services per conception (NSPC):

Number of services per conception is one of the measurements of reproductive efficiency. It is the number of services required for a female to conceive. It is calculated as a measure of a females breeding efficiency (Sastery and Thomas, 1976).

It expresses the fertility level of dairy herds. It is simple and easy to calculate and understand and it is a good measure of reproductive status but still it usually does not indicate reasons why heifers and cows fail to conceive. The term was defined by Esslemont *et al*. (1985) as the total number of services given to a group of cows over a defined period divided by number of cows. Thus, services to culled cows should be included. Younis *et al*. (1976) reported mean NSPC of Friesian cattle under Kuwait conditions was 2.23±0.28. They also reported that the source of animal importation and year variation had a significant ($p<0.01$) effect on NSPC, months of calving did not affect the trait.

In the tropical and subtropical countries, Bradely (1979) in Mexico recorded 2.1 as the NSPC of Friesian cattle. Also, in Mexico Gabellofairs and Ruizdias (1980) observed that 2.11± 0.29 services were required for conception of Holstein-Friesian. Aquilar and Hinojosa (1981) reported NSPC of 2.5 for the same breed in Mexico. Costa *et al*. (1982) reported that NSPC for Holstein-Friesian was 1.52±0.04 in Brazil. Mangurkar *et al*. (1986) recorded 2.99 inseminations per conception for purebred Holstein-Friesians in India. They also found that the effect of parity and period of the year was significant. In Indonesia, Alamsyah (1987) reported that 2.55 services were required for conception of Holstein cattle.

The performance of Holstein-Friesian cows in Ghana was studied by Gyawu *et al.* (1990). They stated that NSPC was 3.0±0.3. Also in Ghana Osei *et al*. (1990) reported the number of inseminations required for conception of Friesian cattle was 1.97, and they stated that the number improved with the age of cow. Juma *et al*. (1988) studied factors affecting number of services per conception in the pure bred Friesian and their grades in two farms in Iraq They found that the trait was not significantly affected by sire, farm and parity. However, it was influenced by the level of milk production ($p<0.01$) and season ($p<0.05$) being lowest during spring and highest during summer. Thus services per conception ranged between" 2-3.

Table 2.2: Number of services per conception for different herds:

Item	No of Cows	Herd	Mean ± S.E	Author
Overall mean	671	Dairy land	2.35± 0.11	Abdelgader (2004)
Parities				
First parity	671	Dairy land	2.08± 0.11	Abdelgader (2004)
Second parity	671	Dairy land	2.06±0.11	Abdelgader (2004)
Third parity	671	Dairy land	2.41± 0.12	Abdelgader (2004)
Fourth parity	671	Dairy land	2.84± 0.19	Abdelgader (2004)
Overall mean	155	Dairy land	1.50± 0.29	Mahmoud (1998)

2.1.3. Calving interval:

This is the period between two consecutive calvings. It is also one of the productive parameters since it is the sum of lactation length and the dry period. A regular calving at a year interval is known to be economical in terms of production and breeding efficiency. Calving interval is one of the important parameters in relation to the breeding efficiency of dairy cattle. The standard calving interval for Holstein-Friesian is between 356-380days (Abdelaziz, 1995).

Most breeders try to increase the lifetime reproductive efficiency of the cow by having a calf every year. In temperate regions, calving interval usually ranges between 12 and 13months. This had been reported by several researchers (Spike and Mcedows, 1973).

Many researchers reported similar results for Friesian cattle performance in temperate regions. Dong and Van Vleck (1989) estimated the calving interval from 2456 and 2006 data sets of Holstein in USA and reported a mean calving interval of 382.4(12.7 months) and 387.2 days (12.9 months) for the first and second data sets, respectively.

In the tropics and sub tropics, many authors confirm that the calving interval is not less than 14 months (Spike and Mcedows, 1973). Ahmed *et al*. (1996) obtained a mean first calving interval for Sudanese indigenous breed X European breeds of 481.82 days, which was significantly ($P<0.05$) affected by year-season. Map and Ngere (1989) reported a mean calving interval for Friesian cows in Nigeria as 364 days and only year of calving had a significant ($P<0.05$) effect on the trait, whereas neither season nor parity number had an effect on calving interval.

Abubaker *et al*. (1986) studied 31777 Holstein records in Columbia and reported that the mean calving interval was 421 days (14 months). Also Abubaker *et al*. (1987) reported that mean calving interval was 416±123 days or 13 months for Holstein in Mexico. Morsy *et al*. (1990) reported that the mean calving intervals were 17.4 and 13.6 months for Frisian cattle in Libya. Salhab *et al*. (1997) reported that calving interval averaged 425.77±1.89 days (14.2 months) for Frisian cattle in Libya, and they found that the parity and calving year but not calving season significantly ($p<0.01$) affected calving interval. The regression of calving interval and its components on actual milk yield was significant ($p<0.01$).

Abuziad (1999) reported that the mean calving interval of imported and locally born Friesian cows in Sudan were 479±129 days (16.0 months) and 477.10±152.4 days (15.9 months), respectively. Tahir(1985) studied the performance of Friesian cattle in Iraq and reported that the mean calving interval was 442.47±5.25days(14.1months). He indicated that calving interval was not affected significantly by the sire of cows.

Thus, it can be seen that mean calving interval reported in literature ranged between 13 and 16 months on average.

Table 2.3: Calving interval for one herds:

Parities	No of cows	Herds	Mean±S.E	Author
Overall means	705	Dairy land	433.18±6.70	Abdelgader (2004)
First parity	705	Dairy land	422.89±6.70	Abdelgader (2004)
Second parity	705	Dairy land	430.53±8.32	Abdelgader (2004)
Third parity	705	Dairy land	445.97±9.67	Abdelgader (2004)

2.2. Productive traits:

2.2.1 Milk yield:

Milk production is the most economically important character in dairy cattle. Many researchers investigated performance of the indigenous dairy in the Sudan (Abuzaid, 1999, Mahmoud, 1998 and Abdelgader, 2004). Crossbreeding of native breeds to European breeds is the most important tool in the hands of animal breeders to enhance milk production potentiality of our indigenous breeds.

According to Ibrahim (1983) the first lactation yield for 62.5% foreign blood was found to be 2598.3 Kg and the average milk yield for the cross of 25%, 37.5%, 50% and 75% foreign blood were 2292, 2324, 2347, and 2457 Kg, respectively. Fawi (1994) reported that the average total milk yield was found to be 2882.2, 2910.7, 3292.9 and 3097.3 Kg for the early summer, late summer, early winter, late winter, respectively for cross-bred cows at University of Khartoum Farm. Yeoticcar and Despande (1990) where showed that the lactation yield of crossbred cows was 2159.6± 10.32 Kg.

Dhangar, *et al.* (1992) where reported that lactation milk yield averaged 2630 ± 4.03 Kg with a CV% of 22.6%. They also noted that parity number had a significant effect on milk yield. Chopra (1990) reported that first lactation milk yield of half-bred cows of Hariana crossbreds with Holstein-Friesian, Brown Swiss and Jersey were 2647, 2187.7 and 1968.8 Kg, respectively.

In the Sudan Ibrahim (1983) reported that the average lactation yields of first three lactations of Friesian cattle in Dairy-land farm were

3892.8, 3337.14 and 3866.19 Kg, respectively. Are there pure Friesians the author also stated that the milk yield tends to decrease from first to third lactation and attributed this decrease to management. Habeeballa (1996) reported 12.86 Kg as daily yield for Friesian cattle. Mohamoud (1998) reported that the 84 day milk yield for Friesian cattle was found to be 811.3±5.9 Kg and the average daily milk yield was 8.4±0.2 Kg. In Iraq, Elbarbary *et al*. (1983) found that the average milk yield of Holstein Friesian was 3745.0±4.0 Kg. He also reported that lactation length and dry period had a highly significant effect on milk yield. In Brazil, Costa *et al*.(1982) showed that the mean milk yield of Holstein Friesian cows for 305 days was 3935.9±32 Kg. He also indicated that the trait was affected by year and season of calving. In comparison, Ribas (1984) reported 5085.65± 32.8 Kg as average milk yield per lactation for Friesian cattle. In Brazil, Neiva *et al*.(1993) reported that lactation yield average 5137.95±63.6 and 6147.3±64.5 Kg for Brown Swiss and Holstein-Firesian cows, respectively. The author also stated that parity number and year of calving had significant effects on milk yield, but season of calving did not affect milk yield. In Nigeria Mbap and Ngere (1989) examined the productivity of Friesian cattle and found that the overall milk yield and milk yield per day were 3893 and 9.9 Kg, respectively. Thy also reported that the effect of parity number on lactation yield and yield per day was significant but the effect of season of calving on both traits was not significant. In Venezuela, Torres and Gonzalez (1992) reported that milk yield was found to be 3278.0±795.0, 2855.5±813.0 and 2250.9±814.0Kg Holstein, Brown Swiss and Brahman cows, respectively. They also reported that milk yield was not affected by season of calving.

In India Juneja, Sastry and Yadav (1992) reported that the mean lactation milk yield for Jersey and Holstein Friesians were 2408.0±655.0Kg and 3592.0±102.0Kg, respectively.

This can be summarized that Friesian cattle born in the tropics in the total milk ranged between 2300-6150Kg.

Table 2.4: Total milk for one herds:

Item	No of cows	Herds	Means± S.E	Author
Overall mean	967	Dairy Land Co	3475.53± 78.89	Abdelgader (2004)
Parities				
First parity	967	Dairy Land Co	3186.69± 93.58	Abdelgader (2004)
Second parity	967	Dairy Land Co	3496.30± 93.58	Abdelgader (2004)
Third parity	967	Dairy Land Co	3577.38± 96.79	Abdelgader (2004)
Forth parity	967	Dairy Land Co	3641.73±114.65	Abdelgader (2004)
Overall mean	155	Dairy Land Co	1976.9±08.70	Mahmoud (1998)

2.2.2. Lactation length:

Lactation length is defined as the period between two consecutive calvings during which cows are capable of producing milk or lactating.

In Sudan, Mohamoud (1998) reported that the mean lactation length for Friesian cattle was 241±0.5 days. In Venezuela Torres and Gonzalez (1992) reported that lactation length was found to be 363.7±66.9 days for Holstein. The authors also reported that this trait was not affected by season of calving but by methods of milking in the presence or absence of their calves. Taneja *et al*. (1982) noted that first lactation length for pure-bred Holstein- Friesian in India was 279±81.8 days. Murdia *et al.* (1992) showed that the lactation length for Holstein heifers was 300 days. They also found that season of calving had significantly affected lactation length. In Brazil, Ribas *et al*. (1987) reported that the lactation length of Holstein Friesian cows imported from Canada was 316.3±5.5 days and the lactation length was significantly affected by region and season of calving but not by lactation number. Ribas *et al*. (1984) studied the lactation length in dairy type Holstein-Friesian and found the mean to be 306.5±1.8 days. The authors stated that season of calving had a significant effect on lactation length. Ibrahim (1983) noted that average lactation lengths of Friesian cattle in Dairy Land Farm in the first three lactations were 297.8, 266.8 and 240.3 days, respectively. El-barbary *et al*. (1983) examined the economic characteristics of Friesian cattle. They found that lactation length was 316.9 days.

In Mexico, Becerril et al. (1983) reported that the lactation length for Friesians was 296.0±8.0days. Oldenporek (1979) studied records of

Holstein Friesian in the Netherlands and reported that lactation length averaged 346 days. Ortizmartinez (1979) in Mexico reported that lactation length averaged 339 days for Holstein Friesian while Abubakar *et al*. (1987) reported that the mean days in milk were 268 days for Holsteins in Mexico. Also, they reported (1986) that the mean days in milk were 267 days for Holstein in Columbia. Romero *et al*. (1992) reported that lactation length averaged 288.4 days, and that season of calving had a significant effect on lactation length for Holstein cows in Venezuela. Neiva *et al*. (1993) reported that Holstein cows in Brazil had an average lactation length of 304.0±1.93 days and that it was significantly affected by year of calving. Davinder and Jai (1983) found that lactation length averaged 319.99 days for Holstein Friesian in India. Mbap and Ngere (1989) found that the mean lactation length was 292 days for Friesian cows in Nigeria and that the lactation period was significantly affected by year of calving ($P<0.01$) and parity ($P<0.05$). Zaied (1995) indicated that lactation length averaged 320 days for Friesian in Iraq, 380 days for Friesian in Tunisia, 300 days for Friesian in Egypt and 332 and359 days for homebred and imported Friesian cattle in Libya. Ahmed *et al*. (1996) reported that lactation duration was 323.9±3.3, 315.2±2.8, 293.0±2.5 and 372.6±4.5, 350.6±2.4, 359.6±3.1 days consecutively for the first three lactations for imported and locally born Holstein Friesian cows in Libya. Boujenane and Badry (1981) studied Holstein- Friesian records in Morocco and found that mean lactation duration was 338± 80.9 day with a coefficient of variation of 24%. Abuzaid (1999) studied lactation length for imported and locally born Friesian in Sudan and reported the average lactation length to be

375.7±103.8 and 366.8±79.6 days, respectively. It can be seen that there is a wide range of lactation length (from 270 to 370 days). This could be due to different managerial practices.

Table 2.4: Lactation length for one herds:

Item	No of cows	Herds	Mean±S.E	Author
Overall mean	705	Dairy land	294.11±3.62	Abdelgader (2004)
Parities				
First parity	705	Dairy land	298.51±4.68	Abdelgader (2004)
Second parity	705	Dairy land	298.48±4.71	Abdelgader (2004)
Third parity	705	Dairy land	293.12±4.87	Abdelgader (2004)
Forth parity	705	Dairy land	286.32±6.23	Abdelgader (2004)

2.3 Genetic Parameters:

2.3.1 Heritabilities:

The heritability in its narrow sense is defined as the proportion of the total phenotypic variance attributed to the additive genetic variance. A high heritability shows that a substantial proportion of the phenotypic variance is due to additive genetic variation. Non-additive genetic factors make a large contribution to the phenotype, when the heritability is low. The heritability is a measure of the phenotypic differences between parents that can be passed on to their offspring. For the same character, heritability is not constant and may show some variation, depending on the herd in which it is measured.

The most important function of the heritability in the genetic study of metric characters is its predictive value. Selective breeding is one of the most important tools of improvements available to the dairy cattle breeder. The heritability of the character determines the potential for its improvement that can be attained by selective breeding. The potential to improve economic traits through selection is largely a function of how heritable a character is, and how much variation is exhibited by the trait. This further emphasizes the need to estimate the genetic parameters such as the heritability and relationships between traits as this will be essential for predicting the response to selection. In general, heritability estimates vary a great deal. When heritability is low, the trait is greatly influenced by environmental conditions. But when heritability is high the trait would be highly heritable under the prevailing conditions and its improvement becomes faster. Generally, productive traits are moderately heritable compared to reproductive traits which generally have low heritabilities.

This is probably a result of additive genetic variance being depleted by continued natural and artificial selection.

2.3.1.1 Heritabilities of Reproductive Traits:

2.3.1.1.1 Heritabilities of Age at First Calving:

In temperate regions many authors have reported heritabilities of age at first calving in Holsteins. Silva (1978) reported from data collected over 52 year on Holstein-Friesian cattle in USA that the heritability of age at first calving was 0.16. In Canada Moore *et al*. (1990) reported that for Holstein cows in their first lactation heritability estimates of 0.09 and 0.039 were obtained when using single and multi-trait analysis, the single traits analysis was based on 53174 observations in which the correlations between traits were ignored. Dizdarevic (1990) reported that the heritability of age at first calving was 0.17±0.10 among Holsteins in Bosnia.

In tropical and sub tropical countries. Abdelgader (2004) reported that the heritability of age at first calving was 0.10±0.10 for Holstein-Frisian in Sudan. Taneja (1978) reported heritability estimate of 0.21± 0.09 and 0.23±0.12 for 24-30/64 and 36-63/64 Holstein crossbred grades in India. Davinder and Jai (1983) reported that heritability estimate of age at first calving obtained from 119 records of Holstein-Friesians in India was 0.03±0.08. Singh *et al*. (1992) reported that the heritability of age at first calving was 0.54±0.38 for crossbreds of Holstein x Sahiwal cows in India. Khattab and Sultan (1992) reported that heritability of age at first calving was 0.39 from 1317 lactation records of Friesian cattle in Egypt. Also Khattab and Sultan (1993) reported a heritability estimate of 0.59±0.14 from records of 767 Friesian cows in Egypt. Kassab (1995) reported that the heritability of age at first calving was 0.36±0.6 for 587 Friesian cows records in Egypt. El-Khalil (2001) reported that the heritability of age at first calving was 0.41±0.08 for a Holstein-Friesian herd in Libya.

2.3.1.1.2 Heritability of Number of Services per Conception:

By using paternal half-sib method, Juma *et al.* (1988) in Iraq analyzed data that included 449 records on 207 offspring from 19 sires of purebred Friesians and their progeny. They estimated the heritability of number of services per conception as 0.04±0.01. Abdelgader (2004) reported that the heritability of number of services per conception was 0.51±0.37 for Holstein-Friesian in Sudan.

2.3.1.1.3 Heritability of Calving Interval:

In the temperate regions, different estimates of heritability of calving interval among Friesians have been reported. Campitelli *et al.* (1976) reported from data on 650 Friesian cows that the heritability of calving interval was 0.12. Silva (1978) studied Holstein-Friesian, Guernsey and Jersey cows at 7 farms in Florida and reported that the pooled estimate of heritability of calving interval was 0.05. Dong *et al.* (1989) analyzed four data sets each one including about 3000 Holstein cows and reported that the heritability of calving interval was 0.15.

In the tropics, and subtropics, there are different estimates of heritability of calving interval among Friesians. Abdelgader (2004) reported that the heritability of calving interval was 0.05±0.05 for Holstein-Frisian in Sudan. Davinder and Jai (1983) analyzed 119 records of Holstein-Friesian cattle and reported that the heritability of calving interval was 0.16±0.09. El-Amin *et al.* (1986) reported that the heritability of calving interval was 0.01 for Holstein crossbreds in Sudan. Tahir and Maarof (1990) reported that the heritability of calving interval was 0.04±0.36 for Holsteins in Iraq. Ageeb and Hillers (1993) reported from study of crossbreeding Sudanese cattle with British Friesian, that the heritability of calving interval was 0.29±0.35. Kassab (1995) reported that the heritability of calving interval was 0.02±0.005 for 587 Friesian cow records in Egypt. Afifi *et al*. (1998) reported that the heritability of calving interval was 0.11±0.09 for a Friesian herd in Egypt. EL-Khalil (2001) reported that the heritability of calving interval was 0.02±0.02 for a Holstein-Friesian herd in Libya.

2.3.1.2 Heritabilities of Productive Traits:

2.3.1.2.1 Heritability of Milk Yield:

In temperate regions, Pander *et al.* (1992) analyzed data on 47,736 heifers using the maximum likelihood method and found that the heritability was 0.49 for lactation yield in UK. Jamrozik and Schaeffer (1997) reported that the heritability of 305 days lactation yield was 0.32 for lactation yield in Canada. Dermatawewa and Berger (1998) reported that the heritability of milk yield was 0.20 from 122,715 lactation records of Holstein cows in the USA.

In the tropics and subtropics, Abdelgader (2004) reported that the heritability estimate of lactation yield was 0.13±0.04 for Holstein-Friesian in Sudan. Abubakar (1986) reported a heritability estimate of 0.07 for milk yield from 31,777 records of Holsteins in Columbia. Also he reported a heritability estimate of 0.34 from 53,470 first lactation records of Holstein in Mexico. Queiroz *et al*. (1992) analyzed 1710 milk records of Holstein cows in Brazil and reported that the heritability estimate of milk yield was .027. Tahir and Maarof (1990) reported that the heritability estimates for 60, 90, 120 and 305 day yields, were

0.00±0.10, 0.01±0.16, 0.12±0.16 and 0.25±0.22, respectively for Friesian cattle in Iraq. Khattab and Sultan (1993) reported that heritability among Friesian cattle in Egypt estimated by half-sib analysis using records of first lactation data was 0.19±0.10 for milk yield in the first two months of lactation and 0.43±0.12 for 305 day lactation yield and 0.31±0.11 for total milk yield. Ashmawi and Khalil (1993) analyzed 10,431 first lactation records for Holstein-Friesian cows in Egypt, and reported that the heritability of milk yield was 0.25. Rege and Jeo (1991) analyzed 31,661 lactation records of Friesian cows in Kenya and found the heritability of milk yield was 0.324. Kassab and Salem (2000) studied 4200 records from 1019 Friesian cows in Egypt and reported that the heritability for 90, 180 and 305 days milk yield was 0.22, 0.29 and 0.25, respectively. Ageeb and Hillers (2000) analyzed records of a Holstein herd in Sudan and they found that the heritabilities of milk yield in heifers and cows was 0.05±0.24. Atil and Khattab (2000) analyzed 1931 first lactation records for Holstein-Friesian cows in Egypt and reported that the heritabilities of 90 and 305 day milk yield were 0.39±0.08, 0.27±0.07, respectively. El-Khalil (2001) reported that the heritability of milk yield was 0.08±0.03 for 839 Friesian cow records in Libya.

2.3.1.2.2 Heritabilties of Lactation Length:

Mosi (1988) analyzed data on Friesian cows in UK and reported that the heritability estimates of lactation length were 0.06 to 0.08. Kattab and Sultan (1992) reported that the heritability of lactation length was 0.08±0.9 among Friesian in Egypt. Al-Ani and Al-Rawi (1996) analyzed 605 records of Friesian cows and reported a heritability ranging from 0.02 to 0.06 for lactation period estimated by paternal half-sib intraclass correlations in Iraq. Davinder and Jai (1983) found that the heritability of lactation length was 0.47±0.11 for Holstein-Friesian in India. Sang *et al*. (1986) reported for Holstein cattle in Korea a heritability estimate of lactation length of 0.104±0.042. Aubakar *et al*. (1986) reported that the heritability of lactation length was 0.06 from a study of 31777 records of Holsteins in Columbia. Kassab (1995) reported that the heritability of lactation length was 0.50±0.04 for 587 Friesian cows' records in Egypt. Afifi *et al*. (1998) analyzed records of a Friesian herd in Egypt. The heritability estimates of lactation length in the first, second and third lactation were 0.16±0.07, 0.19±0.1 and 0.10±0.12, respectively. Atil and Khattab.(2000) analyzed 1931 first lactation records for Holstein-Friesian cows in Egypt and reported the heritability of lactation length was 0.14±0.05. El-Khalil (2001) reported that the heritability of lactation length was 0.04±0.02 for 839 Friesian cows in Libya Abdelgader (2004) reported that the heritability estimate of lactation length was 0.17±0.06 for Holstein-Frisian in Sudan.

2.3.2: Correlations:

Generally, the correlation coefficient is a measure of the variation in trait (y) that is attributable to a linear relationship with trait (x) (Cameroon, 1997).

The genetic correlation is the correlation of breeding values while the environmental correlation is the correlation of environmental deviations together with non-additive genetic deviations. The association between the two characters that can be directly observed is the correlation of phenotypic values (The phenotypic correlation) (Falconer.1986).

Correlated characters (Either positively or negatively is of interest for three chief reasons:

1. In connection with the genetic causes of correlations through the pleiotropic action of genes.
2. In connection with the changes brought about by selection: It is important to know if the improvement of one character will cause simultaneous changes in other characters.
3. In connection with natural selection (The relationship between a metric character and fitness, (Falconer, 1986)

2.3.2.1 Phenotypic correlation:

McDowel *et al*. (1976) analyzed 17255 lactation records of Holstein-Friesian in Mexico and reported that the phenotypic correlations between milk yield, lactation length and calving interval were 0.58 and 0.12 respectively. The phenotypic correlation between lactation length and calving interval was 0.11.Dong and Van Vlek (1989) in USA analyzed two data sets of first lactation records and reported that the phenotypic correlations between milk yield and calving interval were 0.23 for Holstein cows. Abubaker *et al.* (1986) analyzed 31777 records of Holstein in Columbia and reported that phenotypic correlation between milk yield and lactation length and age at first calving were 0.72 and -0.04. The phenotypic correlation between lactation length and age at first calving was -0.06. Davinder and Jai (1983) studied 119 Holstein-Friesian cows in India and reported that the phenotypic correlation between lactation length on one hand and age at first calving and calving interval on other were 0.15±0.4 and 0.68±0.1, respectively. In Sudan Ibrahim (1989) conducted a study on Holstein-Friesian records. He found that phenotypic correlations between age at first calving and the yield of first three lactations were 0.038, 0.105 and -0.286. He stated that the results were found to be statistically significant except for third lactation yield. He found that the phenotypic correlations of age at first calving with the length of three lactation length were -0.0169, 0.076 and 0.065 respectively and they were statistically significant. Nartey (1990) in Ghana analyzed data of Friesian cows, and found that total milk yield was positively and highly phenotypically correlated with lactation length 0.71. In Pakistan Mohiuddin *et al*. (1992) reported that the phenotypic correlation between first lactation 305-days milk yield and age at first calving was 0.09, which was significant. The phenotypic correlation between first lactation 305-days milk yield and first lactation length and first calving interval were 0.47 and 0.24 and were significant ($p<0.01$). Kassab and Salem (2000) studied 4200 records from 1019 cows in Egypt

. They found that the phenotypic correlations among milk yield traits were positive and highly significant. El-Khalil (2001) reported that the phenotypic correlation ranged between 0.02 for age at first calving and calving interval to 0.86 for calving interval and lactation length.

In India Davinder and Jai (1983) analyzed data of Friesian cattle and found that the genetic correlation between age at first calving and calving interval, first lactation yield and lactation length were 0.34±0.86, 0.29±0.60 and 0.30±0.58 respectively. They also stated that the genetic correlations of calving interval with first lactation yield and lactation length were 0.19±0.59 and 0.30±0.54, respectively. They found that the first lactation was generally correlated with lactation length 0.56±0.34. Abubaker *et al.* (1987) studied 53470 first lactation records in Mexico and reported that the genetic correlation of milk yield with lactation length was 0.84, between milk yield and age at first calving was 0.10. They found a negative genetic correlation between age at first calving and lactation length. Mohiuddin *et al*. (1992) in Pakistan reported that the genetic correlation between first lactation 305-days milk yield and age at first calving was high 0.44 and significant ($p<0.01$). The genetic correlations between first lactation 305-days milk yield and first lactation length and first calving interval were significant ($p<0.01$) and amounted to 0.06±0.20. Khattab and Sultan (1992) studied 1317 Friesian records in Egypt and reported that the genetic correlation between milk yield and lactation length was positive 0.66±0.03 and highly significant. Al Salman and Yousif (1994) analyzed 732 records of Holstein-Friesian in Iraq and they found that genetic correlations among production traits ranged from 0.676 to 0.986. Al Ani and Al-Rawi (1996) in Iraq reported for 605 records of Friesian, Iraq x Friesian cows that genetic correlation between total milk yield and lactation length was high and significant ($p<0.01$). Afifi *et al*. (1998) analyzed records of a Friesian herd in Egypt. They found a positive estimate of genetic correlation between milk yield and calving interval. Kassab and Salem (2000) studied 4200 records from 1019 cows in Egypt. They found the genetic correlations among all productive traits were positive and highly significant. ElKhalil (2001) reported that the genetic correlations ranged between 0.08±0.40 for lactation length in Libya.

Chapter Three
Material and Methods

3.1 Introduction:

This study utilized data collected from 1310 records of Holstein-Friesian cows raised under an intensive management system. Those heifers were born in Sudan during the period 1984-2001 and gave their first calf in the period 1986-2001. The cows were divided in groups according to the season of birth.

The farm location is about 30 Km south of Khartoum. The site lies within the semi-desert ecological zone. Climatological normals of the area for the period 1998-2004 are show in the table (3.1).

Table 3.1: Climatological Normal of the Study Area:

Element	Mean Temperature °C		Relative	Total Rainfall
Month	Max	Min	Humidity %	(Mm)
January	30.97	15.69	25.71	T R
February	33.91	18.16	20.71	T R
March	36.64	20.19	15.14	T R
April	41.13	24.53	14.29	T R
May	42.43	27.69	19.29	03.36
June	41.77	27.93	24.86	06.64
July	39.01	26.41	42.00	14.40
August	37.04	25.26	53.86	46.90
September	38.84	26.29	48.43	24.84
October	37.86	25.91	32.43	12.56
November	36.43	22.26	25.57	00.00
December	27.70	17.77	30.86	00.00
Total				108.37

Note: Max =Maximum — Ministry of aviation (2004)

Min = Minimum — T R = Trace

As can be seen from the table the maximum temperature ranged from 27.70̊C to 42.43˚C in December and May and the minimum temperature ranged from 17.77˚C to 27.93˚C in December and June respectively. The rainfall ranged from 00.0 Mm to46.90 from November, December and August and relative humidity was 14.29% to 48.43% from may to October respectively..

The period of study covered wet and dry summer as well as winter.

3.2 Management system:

3.2.1 Housing:

Animals were kept in open sheds, which were oriented north-south and constructed with iron bars with cement fouler.

3.2.2 Animals:

The animals in the farm were divided into young calves, heifers, milking herd dry herd cows in late pregnancy and stud bulls. The calves were individually penned during the suckling period. After weaning they were grouped according to sex and age and housed separately from their dams.

The most common breeding practice was Artificial Insemination (AI). Heifers were usually inseminated at 10-18 months of age / or 250-300 Kg body weight. They were monitored for signs of estrus twice a day in the morning and evening. Rectal palpation was done to confirm pregnancy. Newly born calves were removed from their dams soon after birth. The calves were allowed to suckle their mothers for the first three days to make use of the colostrums. From day 7-14 they were bucket fed on whole milk twice a day and there after up to weaning, they were fed a molasses at a rate of 10% of their body weight (2.5Kg/day).

3.2.3 Milking:

The cows were machine milked twice a day at 4 am and 4 pm. Weekly, monthly and annual milk were recorded.

3.2.4 Health:

Routine vaccination of animals against diseases such as: Rinder-pest, Anthrax, Contagious Bovine, Pleuro-pneumonia Hemorrhagic Septicemia and Brucellosis are carried out.

3.3 Statistical Analyses of the Data

The data had been analyzed using four statistical models according Harvey (1990) models used were as follows:

3.3.1 Model (1):

With regard to age at first calving only the effect of year season of the heifer's birth and sire were included as follows:

$Y_{ij} = \mu + A_i + S_j + E_{ij}$

Where:

Y_{ij} = the $_{ij}$th observation on the trait in question.

μ = the overall mean.

A_i= the $_i$th year-season of heifers birth effect (i= 1-9).

S_j = the $_j$th sire effect (j= 38).

E_{ij} = the residual error.

3.3.2 Model (2):

This model was used to analyze number of services per conception:

$Y_{jk} = \mu + S_j + H_k + E_{jk}$

Where:

Y_{jk} = the $_{jk}$th observation on the trait in question.

μ = the overall mean.

S_j =effect of $_j$th sire (j= 42).

H_k = Effect of $_k$th parity number (k=1-5).

E_{jk} = the residual error.

3.3.3: Model 3

The following model was used to analyze calving interval and dry period:

$Y_{ijk} = \mu + A_i + S_i + H_k + bF + E_{ijk}$

Y_{ijk}= the ij_{kth} observation on the trait in question.

μ = the overall mean.

A_i = effect of $_{ith}$ year-season of calving (I =1-9).

S_j = effect of $_{jth}$ sire (j= 1-33).

H_k =effect of $_{kth}$ parity number (k= 1-5).

F =the deviation of lactation length from its mean.

b = linear regression of the trait in question on lactation length.

E_{ijk} = the residual error

3.3.4 Model. 4:

This model used to analyze milk yield per lactation and lactation length:

$Y_{ijk} = \mu + A_i + S_j + H_k + b_{1F}\ b_2F2 + E_{ijk}$

Where:

Y_{ijk} = the ij_{kth} observation on the trait in question.

μ= the overall mean.

A_i = effect of $_{ith}$ year-season of calving (I =1-9).

S_j = effect of $_{jth}$ sire (j = 38).

H_k =the $_{kth}$ parity number effect (k =1-5).

F= the deviation of lactation length from its mean.

b_1= linear regression of the trait in question on daily milk yield.

b_2 = quadratic regression the trait in question on daily milk yield.

Eijk = the residual error.

3.3.5 Heritability estimates:

The productive and reproductive estimates were obtained by paternal half-sib procedure (Falconer, 1996).

4.2.2 Genetic, Phenotypic and Environmental correlations:

The genetic, phenotypic and environmental correlations among the studied traits were estimated by paternal half-sib analysis of variance and covariance (Falconer, 1990). Data were analyzed using Harvey's computer program.

Chapter Four
Results

4.1 Factors affecting reproductive and productive traits:

The least-squares means, standard errors and the mean squares from the analysis of variance were estimated using mixed model least-square and maximum likelihood analyses.

The least square means for ages at first calving are shown in Table (4.1). The result showed that the overall mean of age at first calving was 29.90±0.72months.And the coefficient of variation (C.V%) was (18.04%).

The analysis of variance for age at first calving is presented in Table (4.2). This analysis showed that the sire of cow had a highly significant ($p<0.01$) effect on the age at which she first calved. Also, the year-season of cow calving had highly significant ($p<0.01$) influence on age at first calving.

Table 4.1: Least squares and standard errors of age at first calving over periods and year-season:

Items	NO. OBS.	(L.S.M ±S.E) days
Overall mean	570	29.90± 0.72
Calving year-season		
Winter 1986 –1988	108	35.23 ±1.22
Dry summer 1986 –1988	067	35.67± 1.29
Wet summer 1986 –1988	079	34.54± 1.25
Winter 1989 –1993	088	30.93± 1.12
Dry summer 1989 –1993	067	29.09± 1.21
Wet summer 1989 –1993	092	30.50± 1.16
Winter 1994 –2001	017	23.43± 2.04
Dry summer 1994 –2001	021	23.54± 2.02
Wet summer 1994 – 2001	031	26.15±1.96
Coefficient of variation		18.04%

L.S.M =Least-squares mean S.E = Standard error

NO. OBS. = Number of observations

Table 4.2: Analysis of variance for effects of sire and year-season on Age at first calving:

Source	D.F	Sum of Squares	Mean squares	F	Prob
Between sires	37	3613.76	97.67	3.358**	0.0000
Between year season of birth	8	1820.36	227.55	7.823**	0.0000
Remainder	524	15240.53	29.08		
Total	569				

**= High significant

The least squares means for number of services per conception (NSPC) are shown in Table (4.3). The results showed that the overall mean of NSPC was 2.77±0.12 with a coefficient of variation C.V 56.62% it was rather high. This might be a reflection of the large variations between bulls or cows.

The analysis of variance for number of services per conception is shown in Table (4.4). This analysis revealed that the sire of the cow had a highly significant ($p<0.01$)effect on the number of service per conception. Parity number of the cow did not significantly ($p>0.05$) affect the number of services per conception.

Table 4.3: Least squares means (L.S.M) and standard errors (S.E) of number of services per conception (NSPC) across parities:

Items	NO. OBS.	L.S.M ± S.E
Overall mean	1310	2.77±0.12
Parity		
First parity	376	2.85± 0.14
Second parity	390	2.75±0 .13
Third parity	288	2.85± 0.14
Forth parity	171	2.68±0.16
Fifth parity	085	2.73± 0.20
Coefficient of variation		56.62%

Table 4.4: Analysis of variance of the effects of sires and parities on number of services per conception (NSPC):

Source	D.F.	Sum of Squares	Mean squares	F	Prob
Between sires	41	300.81	7.34	2.98**	0.0000
Between parities	4	5.27	1.32	0.54ns	0.7102
Remainder	1264	3112.74	2.46		
Total	1309				

n.s= Not significant

The least squares means of calving interval are shown in Table (4.5). The results showed that overall mean of calving interval was 521.10±18.78days. The coefficient of variation (C.V%) was (39.60%) .reflecting that there was no important variation between years-seasons. Also the variation between parities was not significant.

The mean squares from analysis of variance for calving interval are shown in Table (4.6). The results showed that the sire of the cow, the year-season, the parity number of the cow and the quadratic regression on lactation length had no significant ($p>0.05$) effect on calving interval.

The regression on lactation length had a significant ($p>0.01$) effect on calving interval.

The least squares means of milk yield is shown in Table (4.7). The results showed that the overall mean for milk yield was 3762.29± 156.47Kg. The coefficient of variation C.V% was 27.93%. It can be seen that there was no significant variations between years-seasons of calving or between parities.

The mean squares from the analysis of variance of lactation yield are shown in Table (4.8). The results showed that the sire of the cow and linear regression on lactation length had a highly significant ($p>0.01$) effect on lactation yield. But parity number of the cow, year-season of calving and quadratic regression did not significantly ($p>0.05$) affect milk yield.

The least squares analysis of lactation length is shown in Table (4.9). The results showed that the overall mean of lactation length was 279.99± 1.90 days. The coefficient of variation (C.V%) was very low (12.17%).

The mean squares from the analysis of variance of lactation length are shown in Table (4.10). The results showed that the sire of the cow, parity number and year-season of lactation did not significantly affect lactation length ($p>0.05$).

The linear regression on lactation length had a highly significant ($p<0.01$) effect on the lactation yield.

Table 4.5: Least-squares means (L.S.M) and standard errors (S.E) of calving interval:

Items	NO. OBS.	(L.S.M. ± S.E.) days
Overall mean	658	521.10±18.78
Calving year season		
Winter 1988 – 1992	108	504.28±36.39
Dry summer 1988 – 1992	051	475.23±45.71
Wet summer 1988 – 1992	095	461.49±38.04
Winter 1993 –1997	105	536.80±27.73
Dry summer 1993 –1997	052	495.16±34.98
Wet summer 1993 –1997	124	548.76±27.06
Winter 1998 –2004	036	561.05±47.06
Dry summer 1998 –2004	047	601.35±42.09
Wet summer 1998 –2004	040	505.73±46.68
Parities		
First parity	278	526.23±22.37
Second parity	195	522.40±18.96
Third parity	119	556.69±23.48
Forth parity	058	477.53±30.90
Fifth parity	008	522.62±76.72
Linear regression on lactation length		1.40±0.4.45day
Quadratic regression on lactation length		0.01±0.01day
Coefficient of variation		39.60%

Table 4.6: Analysis of variance of calving interval:

Source	**D.F**	**Sum of Squares**	**Mean squares**	**F**	**Prob**
Between sires	32	1406585.35	43955.79	1.032n.s	0.4200
Calving year-season	8	492548.91	61568.61	1.446n.s	0.1741
Between parities	4	240359.44	60089.86	1.411n.s	0.2286
Linear regression on lactation length	1	413597.80	413597.80	9.715*	0.0019
Quadratic regression on lactation length	1	90538.47	90538.47	2.127n.s	0.1453
Remainder	611	26013312.238696	42574.98		
Total	657				

*= Significant ($p<0.05$)

Table 4.7: Least-squares means and standard errors of total milk yield:

Items	NO. OBS.	(L.S.M. ± S.E.) Kg
Overall mean	1087	3762.29 ±156.47
Calving year season		
Winter 1988 – 1992	166	3908.80 ±201.34
Dry summer 1988 – 1992	110	3838.98 ±219.53
Wet summer 1988 – 1992	152	3921.60 ±202.69
Winter 1993 – 1997	179	3954.93 ±174.12
Dry summer 1993 – 1997	085	3580.42 ±192.71
Wet summer 1993 – 1997	190	3645.13 ±172.90
Winter 1998– 2004	067	3742.24±229.56
Dry summer 1998– 2004	060	3563.35 ±225.77
Wet summer 1998– 2004	078	3705.16±226.59
Parities		
First parity	415	3669.03±171.36
Second parity	313	3826.24 ±163.58
Third parity	197	3907.12 ±171.91
Forth parity	115	3858.68 ±184.66
Fifth parity	047	3550.37±219.61
Linear regression on lactation length		18.80±1.54
Quadratic regression on lactation length		0.013±0.02
Coefficient of variation		27.93%

Table 4.8: Analysis of variance of lactation yield (kgs).

Source	D.F	Sum of Squares	Mean squares	F	Prob
Between sires	38	173012104.11	4552950.11	4.12 **	0.0000
Year-seasons	8	14188332.98	1773541.62	1.61n.s	0.1187
Parity	4	8495437.28	2123859.32	1.923n.s	0.1044
Linear regression on Lactation length	1	164125737.65	164125737.65	148.62 **	0.0000
Quadratic regression on Lactation length	1	390613.34	390613.34	0.35n.s	0.5521
Remainder	1034	1141847851.30	1104301.60		
Total	1085				

Table 4.7: Least- squares means and standard errors of Lactation length:

Items	NO. OBS.	(L.S.M ± S.E) Days
Overall mean	1087	279.99± 1.90
Calving year season		
Winter 1988 - 1992	166	278.73±4.57
Dry summer 1988 - 1992	110	277.45±5.34
Wet summer 1988 - 1992	152	283.29±4.59
Winter 1993 - 1997	179	279.12±3.12
Dry summer 1993 - 1997	085	288.00±4.06
Wet summer 1993 - 1997	190	284.93±3.01
Winter 1998 - 2004	067	274.46±5.77
Dry summer 1998 - 2004	060	277.95±5.63
Wet summer 1998 - 2004	078	276.01±5.65
Parities		
First parity	415	284.44±2.99
Second parity	313	279.55±2.48
Third parity	197	280.62±2.95
Forth parity	115	276.70±3.66
Fifth parity	047	278.65±5.37
Linear regression on daily milk yield		1.69±0.27Kg
Coefficient of variation		12.17%

Table 4.10: Analysis of variance of lactation length (days):

Source	D.F	Sum of Squares	Mean squares	F	Prob
Between sires	38	56344.23	1482.74	1.277n.s	0.1235
Year-season	8	13284.29	1660.54	1.430n.s	0.1795
Parity	4	4305.00	1076.25	0.927n.s	0.4475
Linear regression on daily milk	1	44055.17	44055.17	37.939**	0.0000
Remainder	1035	1201855.31	1161.21		
Total	1086				

4.2 Genetic Parameters:

4.2.1 Heritability estimates:

The heritability estimates of reproductive and productive traits are presented in Table (4.11). The results show that the heritability of reproductive traits ranged between 0.062±0.019 for number of services per conception to 0.002±0.014 for calving interval. With regard to productive traits heritability estimates ranged between 0.055±0.032 for milk yield to 0.011±0.011 for lactation length.

All these estimates were obtained by paternal half-sib procedure (Falconer, 1996).

4.2.2 Genetic, Phenotypic and Environmental correlations:

The genetic, phenotypic and environmental correlations among the studied traits were estimated by paternal half-sib analysis of variance (Falconer, 1990). Data were analyzed using Harvey's computer program.

The result show that the genetic correlations ranged between 2.45±29.14 between lactation length and calving interval to-9.03±110.72 from calving interval and number of service per conception. However, phenotypic correlations ranged between 0.562 from lactation length and milk yield to -0.037 from total milk yield and number of services per conception with regard to environmental correlations ranged between 0.527 from milk yield and lactation length to -0.055 from number of services per conception and milk yield.

Table 4.11: Heritabilities of reproductive and productive traits:

Traits	Estimates
Age at first calving	0.151 ±0.042
Calving interval	0.002 ±0.014
Number of services per conception	0.062 ±0.019
Milk yield	0.110 ±0.029
Lactation length	0.011 ±0.011

Table 4.12:Genetic correlations among various traits in Holstein-Friesian cattle

Traits	Age at first calving	Number of services per conception	Calving interval	Total milk yield	Lactation length
Age at first calving	-	-	-0.64±0.98	0.48±032	0.50±068
Number of services per conception	-	-	-9.03±110.72	0.48±0.88	0.39±0.83
Calving interval	-	-	-	-0.97±11.74	2.45±29.14
Total milk yield	-	-	-	-	0.88±0.11
Lactation length	-	-	-	-	-

Table 4.13:Phenotypic and Environmental correlations among various traits in Holstein-Friesian cattle*

Traits	Age at first calving	Number of services per conception	Calving interval	Total milk yield	Lactation length
Age at first calving		-	0.059	0.097	-0.008
Number of services per conception	-		0.355	-0.037	0.045
Calving interval	0.102	0.378		0.052	0.153
Total milk yield	0.020	-0.055	0.065		0.562
Lactation length	-0.047	0.037	0.139	0.527	

*Above diagonal are phenotypic correlations estimates, below diagonal are environmental correlations estimates.

Chapter Five

Discussion

The sale of milk is the primary income source for dairy farmers. Productive and reproductive inefficient animals can inhibit the profits realized from the sale of milk.

The main traits related to productive and reproductive performance studied in this research are age at first calving, calving interval, and number of services per conception, total milk yield and lactation length.

Age at first calving is one of the most economically important traits in terms of the length of productive life of the cow. In this study, overall mean age at first calving was 29.90±0.72months with a coefficient of variation 18.04 % (Table 4.1).

The result is comparable with the result reported by Abdelgader (2004) for Holstein-Friesian in Sudan and Mbap and Ngere (1989) for Holstein- Friesian in Nigeria. A lower estimate of age at first calving for Holstein- Friesian was reported by Zaied (1991) (20-26months). A higher estimate was reported by Juma and Al Ani (1991) for Holstein- Friesian in Iraq, Jardon (1992) for Holstein- Friesian in Mexico, Mahmoud (1998) for Holstein-Friesian in Sudan, Nbah *et al* (1992) for Holstein-Friesian in Cameron and Abuzaid (1999) for Holstein-Friesian in Sudan. However, the present result is less than the age reported by Niva *et al* (1993) for Holstein-Friesian in Brazil, Elkhalil (2001) for Holstein-Friesian in Libya and Abubker *et al*. (1986) for Holstein-Friesian in Columbia.

The late age at first calving in this study can be attributed not only to the rate of growth but also to the effect of environmental conditions and the management system such as the level of nutrition and disease.

The results showed that sire and calving year-season had a highly significant ($p>0.05$) effect on age at first calving (Table 4.2). The results were in disagreement with those obtained by Godora *et al* (1990) for Holstein-Friesian in temperate regions and similar to the results reported by Elkhalil (2001) for Holstein-Friesian in Libya.

The overall mean number of services per conception in the present study was 2.77±0.12 with a coefficient of variation of 56.62% (Table 4.3). This result was less than that reported by Gyawu *et al*. (1990) for Holstein-Friesian in Ghana and Manquker *et al*.(1986) for Holstein-Friesian in India. However, the mean number of services per conception obtained in this study was higher than that reported by Alamsyah (19987) for Holstein-Friesian in Indonesia, Younis *et al*. (1976) for Holstein-Friesian in Kuwait, Ruizdias (1980) for Holstein-Friesian in Mexico, Bradly (1979) for Holstein-Friesian in Mexico and Osei *et al* (1991) for Holstein-Friesian in Ghana.

The analysis of variance of the results showed that the parity number did not significantly ($p>0.05$) affect the number of services per conception, but sire of cows had highly significantly ($p<0.01$) affected the number of services per conception, (Table 4.4). This result was contradictory to that reported by Younis *et al*. (1976) for Holstein-Friesian in Kuwait and in agreement with the findings of Juma *et al*. (1988) for Holstein-Friesian in Iraq for parity number. However, its in disagreement with their results regarding the effect of sire of cows in number of service per conception . The result indicates that the trait is considerably affected by management system, environmental conditions, and disease among the cows.

Calving interval is one of the important traits in relation to the breeding efficiency of dairy cattle. The standard calving interval for Holstein-Friesian is between 356-380days (Abdelaziz, 1995).

The overall mean calving interval in the present study was 521.10±18.78 days with a coefficient of variation 39.60% (Table4.5). This is a very high estimate indicating the presence of problems in the management system, environmental factors and disease.

This is comparable with the results reported by Morsy *et al*. (1990) for Holstein-Friesian in Libya. However, it was higher than those obtained by Abdelgader(2004) and Abuziad (1999)for Holstein-Friesian in Sudan, Salhab *et al*. (1997) for Holstein-Friesian in Libya, Abubaker *et al*. (1986) for Holstein-Friesian in Columbia, Dong and Van Vleck (1989) and Mbap and Ngere (1989) for Holstein-Friesian in Nigeria. These results indicate that the trait is considerably affected by the management level in this farm; environment and disease played a considerable role too.

The variations in calving interval between Friesian populations in different countries are probably due to different managerial practices, environmental factors, disease, variation systems concerning the service time and inadequate nutrition.

Analysis of variance of the results (Table4.6) showed that the sire of cows, year-season, parity number and quadratic regression on calving interval did not significantly ($p>0.05$) affect. This result is in agreement with the findings obtained by Mbap and Ngere (1989) for Holstein-Friesian in Nigeria. However, the linear regression on milk yield highly significantly ($p<0.01$) affected the calving interval. This finding disagrees with the result obtained by Salhab *et al.* (1997) who found that the parity number and calving year significantly (p>0.01) affected calving interval. In addition the result showed a longer calving interval that generally reported for Holstein-Friesian in the tropics.

Milk yield is the most important productive trait. In this study, overall mean milk yield per lactation was found to be 3762.29±156.47Kg (Table4.7) with a coefficient of variation amounting to 27.93%. This is higher than the value commonly reported for the coefficient of variation of milk yield (14-20). The higher value in the present study is probably due to the variation in lactation length and other genetic and environmental factors. However, the high coefficient of variation might be a good indicator of the possibility of genetic improvement of the trait. This result is comparable with the results reported by Elbarbary *et al*.(1983) for Holstein-Friesian in Iraq. The results were higher than those reported by Abdelgader (2004) for Holstein-Friesian in Sudan, Torres and Gonzalez (1992) for Holstein-Friesian in Vennezuela, Mahmoud (1998) for Holstein-Friesian in Sudan and Dhangar *et al*. (1992) for Holstein-Friesian in the tropics. However, they are lower values reported by Costa *et al* (1982) for Holstein-Friesian in Brazil, and Mbap and Ngere (1989) for Holstein-Friesian in Nigeria

The analysis of variance of milk yield showed a highly significant (p<0.01) effect of sires and linear regression of lactation length on milk yield. But the, year-season, parity number and quadratic regression did not significantly (p>0.05) affect milk yield (Table4.8). This finding disagrees with the results obtained by Costa *et al*. (1982) for Holstein-Friesian in Brazil. However, there are some disagreement with results reported by Mbap and Ngere (1989) for Holstein-Friesian in Nigeria, and Torres and Gonzalez (1992) who reported that milk yield was not significantly affected by season of calving.

On the other hand the results reported that the effect of parity number caused an increase in milk yield which reached a show maximum milk yield in third parity. The increase in milk yield shown in this study might be due to the increase in body weight and development of the udder.

The overall mean of lactation length was found to be 279.99±1.90days which is close to the optimal lactation length (305days) with a coefficient of variation amounting to 12.17% (Table 4.9). This finding agrees with the results obtained by Taneja *et al*. (1992) for Holstein-Friesian in India. A higher estimate was found by Ibrahim (1983) for Holstein-Friesian in Sudan and Mahmoud (1998) for Holstein-Friesian in Sudan. Lower estimate for lactation length had been reported by Mbap and Ngere (1989) for Friesian in Nigeria, Becerril *et al.* (1983) for Holstein-Friesian in Mexico, Ribas *et al*. (1984)in Canada and Torres and Ganzalez (1992) for Holstein-Friesian in Venezuela.

The analysis of variance showed that the sire of the cows, parity number and year-season did not significantly ($p>0.05$) affect lactation length (Table 4.10). However, the linear regression on daily milk highly significantly ($p<0.01$) affected lactation length. This finding was in agreement with the results obtained by Mbap and Ngere(1989) for Holstein-Friesian in Nigeria and Nevia et al. (1993) for Holstein-Friesian in Brazil. The coefficient of variation in this study was lower than that reported by Boujenane *et al.* (1981) for Holstein-Friesian in Morocco.

5.2 Genetic parameters:

The dairy cattle improvement is dependent on increasing the frequency of genes which have favorable effects on dairy traits. It is important to determine the extent to which improvement in productivity results from variation in genetic constitution, which offers preliminary indications as to how easily a trait may respond to selection.

The heritability of age at first calving in this study was found to be 0.151±0.042. The estimate had a rather large standard error. This finding agrees with the result obtained obtained by Silva (1987)in USA. Lower estimates were obtained by Dizdarevic (1990) for Holstein- Friesian in Bosnia, Davinder and Jai (1983) for Holstein- Friesian in India, Khattab and Sultan (1992)in Egypt, Kassab (1995) for Holstein- Friesian in Egypt and Elkhlil (2001) for Holstein- Friesian in Libya. However, this result is higher than that reported by Moore *et al*. (1990) in Canada for first lactations and Addelgader (2004) for Holstein- Friesian in Sudan.

The heritability of number of services per conception in this study was 0.062±0.019. This estimate has a reasonable standard error. It is lower than that obtained by Abdelgader (2004) for Holstein- Friesian in Sudan. However, it is higher than that reported by Juma *et al*. (1988) for Holstein- Friesian in Iraq.

The heritability of calving interval in this study was 0.002±0.014. This estimate has a high standard error. It is lower than those obtained by Campitelli *et al*.(1976) for Holstein- Friesian, Silva (1978) for Holstein- Friesian, Abdelgader (2004) for Holstein- Friesian, Davinder and Jai (1983) for Holstein- Friesian and El-Amin *et al.* (1989) for Holstein- Friesian in Sudan.

In general, the heritability estimate of reproductive traits is found to be very low in this study. The estimates of heritability of age at first calving, numbers of services per conception and calving interval were particularly low which indicates that most of the variation in these traits is due to environmental causes and the improvement of these reproductive traits lies in better feeding and management. Another explanation is due to the small number of the animals involved in the analysis.

In this study the heritability of milk yield per lactation and lactation length was found to be 0.110±0.029 (Table 4.11). This estimate is rather high when compared with the values for habitability of milk yield reported by Queirozetal (1992) for Holstein- Friesian in Brazil and Abubaker *et al* (1986) for Holstein- Friesian in Columbia. But it was agreement with that reported by Abdelgader (2004) for Holstein- Friesian in Sudan and Elkhalil (2001) for Holstein- Friesian in Lybia. These low estimates are probably due to the fact that the sample of cows is rather small in this study and was highly selected. The heritability estimate of milk yield in this study indicates that the variation in milk production is due mainly to environmental factors.

The heritability of lactation length in this study was 0.011±0.011. (Table 4.11). This estimate is rather small when compared with the generally accepted value for the heritability of lactation length as reported by Khattab and Sultan (1992) for Holstein- Friesian in Egypt, Al-Ani and Al-Rawi(1996) for Holstein- Friesian in Iraq, Song *et al*. (1986) for Holstein- Friesian in Korea and Abdelgader (2004) for Holstein- Friesian in Sudan.

Table 4.12 showed that the genetic correlation between age at first calving and calving interval was negative. However, the correlation between age at first calving and total milk yield was positive and moderately. Also the correlation between age at first calving and lactation length was positive and moderately.

The genetic correlation expresses the extent to which the genetic improvement realized in one trait will be reflected in other traits.

The results in table (4.12) showed that age at first calving was positively genetically correlated with both total milk yield and lactation length. Positive genetic correlations of age at first calving with the other traits were also reported by Davinder and Jai (1983) for Holstein-Friesian in India, Abubaker *et al.(*1987) for Holstein-Friesian in Mexico and Mohiuddin *et al.*(1992) for Holstein-Friesian in Pakistan. The results also showed that the number of services per conception was positively genetically correlated with both total milk yield and lactation length. Consequently there was a positive genetic correlations between calving interval and lactation length. These findings are in line with those reported by Davinder and Jai(1983) for Holstein-Friesian in India and Elkalil (2001) for Holstein-Friesian in Libya. Total milk yield was positively genetically correlated with lactation length This finding are in agreement with that reported by Davinder and Jai(1983) for Holstein-Friesian in India, Abubaker *et al.* (1987) for Holstein-Friesian in Mexico and Mohiuddin *et al.* (1992) for Holstein-Friesian in Pakistan. Therefore, any effort to improving these traits would be by improving the management practices.

The results in table (4.13) showed that age at first calving had a positive phenotypic correlation with both calving interval and total milk yield. These findings are in agreement with those reported by Ibrahim (1983) for Holstein-Friesian in Sudan. However, they disagree with those reported by Abubaker *et al.* (1987) for Holstein-Friesian in Mexico and Davinder and Jai(1983) for Holstein-Friesian in India. The number of services per conception had a positive phenotypic correlations with both calving interval and lactation length. These findings are in line with those reported by Elkalil (2001) for Holstein-Friesian in Libya. The result also showed that calving interval was positively phenotypically correlated with both total milk yield and lactation length. However, total milk yield was positively phenotypically correlated with lactation length. These findings are in agreement with that reported by McDowell *et al*. (1976) for Holstein-Friesian in Mexico, Dong and Vanvleck (1989) for Holstein-Friesian and Abubaker *et al*. (1986) for Holstein-Friesian in Columbia.

Regarding environmental correlations, among some studied traits, the results showed that there were positive correlations between age at first calving on one hand and both calving interval and total milk yield on the other hand. Age at first calving had a negative environmental correlation with lactation length. Also the results showed that the number of services per conception had a positive environmental correlation with calving interval and lactation length, but negative correlation with total milk yield. Also there was a positive correlation between calving interval in one hand and both total milk yield and lactation length in other hand . In addition there was a positive environmental correlation between total milk yield and lactation length.

Conclusions

The environment of Sudan has a profound influence on the expression of an animal's genetic potential for production. The objective of this study was to evaluate the reproductive and productive performance of a Holstein-Friesian herd under Sudan condition.

The data obtained from were records of a Holstein-Friesian herd in the Azaheir Farm covering the period from 1984 to 2004. The studied reproductive traits were Age at first calving, Number of service per conception and calving interval. Age at first calving (29.90±0.72months) was significantly ($p<0.01$) affected by year-season and sire. Number of service per conception (2.77±0.12) were significantly ($p<0.01$) affected by sire of cows. Calving interval (521.10±18.78) was significantly ($p<0.05$) affected by linear regression on lactation length. The productive traits were lactation length and milk yield. Lactation length (279.99±1.90) was significantly ($p<0.01$) affected by linear regression on daily milk yield Moreover, Milk yield (3962.29±156.47) was significantly ($p<0.01$) affected by sire of cows and linear regression on lactation length.

The heritability of reproductive traits studied were 0.151±0.042, 0.062±0.019, 0.002±0.014, 0.110±0.029, and 0.011±0.011 days for age at first calving, number of services per conception, calving interval, total milk yield and lactation length, respectively.

The genetic correlations ranged between –9.03 for number of service per conception and calving interval to 2.45±29.14.

In general, the difference in the performance of Holstein-Friesian cows in their home-land and in Sudan can be attributed to the different climatic conditions and interaction between the animal and the environment. However, general problems in this herd were faced in adequate quantity and quality of fodder and concentrates, poor management systems and disease.

The conclusion which can be drawn from this study is that the Holstein-Friesian cows in this Farm were of moderate productivity compared to the performance of the same breed in the other tropical areas. However, conclusions drawn from this study are not encouraging.

More studies are required to evaluate property the performance of Friesian and other breeds before decisions can be taken on imports of foreign breeds at the commercial level,

Recommendations

1- Holstein-Friesian require special care and good management practices. If such management is provided Holstein-Friesian can play an important role in the improvement of dairy production in the Sudan.

2- Raising pure Holstein-Friesian cattle under Sudan conditions is an expensive venture and requires a great deal of care and attention. Experience in the Sudan has shown that the best approach to the problem is to raise selected good local breeds and perhaps grade them up by crossing. Using crossbreed cattle rather than pure Holstein-Friesian (50% crosses) have shown great promise with regard to productivity.

Chapter Sixth

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Appendix

The least square means of age at first calving over periods and year-seasons are shown in figure (4.1). The results showed that there are high variations between year-season from 35.67months in 1986-1988 to 23.43 months in 1994-2001. The least squares means of number of services per conception over parity number are shown in figure (4.2). The results showed that the overall mean of number of services per conception reflect no variation in number of service per conception between parities. The least squares means of calving interval in different periods and year-seasons are shown in figure (4.3). The least squares means of calving interval in different parities are shown in figures(4.4).

The least square means of milk yield across periods and year-seasons are shown in figure (4.5). The least squares means of milk yield in different parities are shown in figures(4.6). The results showed that parities did not significantly affect milk yield. The least squares means analysis of lactation length over period and year-season are shown in figure (4.7). The least squares means of lactation length over parity number are shown in figure (4.8).

Figure4.1: Least squares mean of age at first calving over periods and year-season:

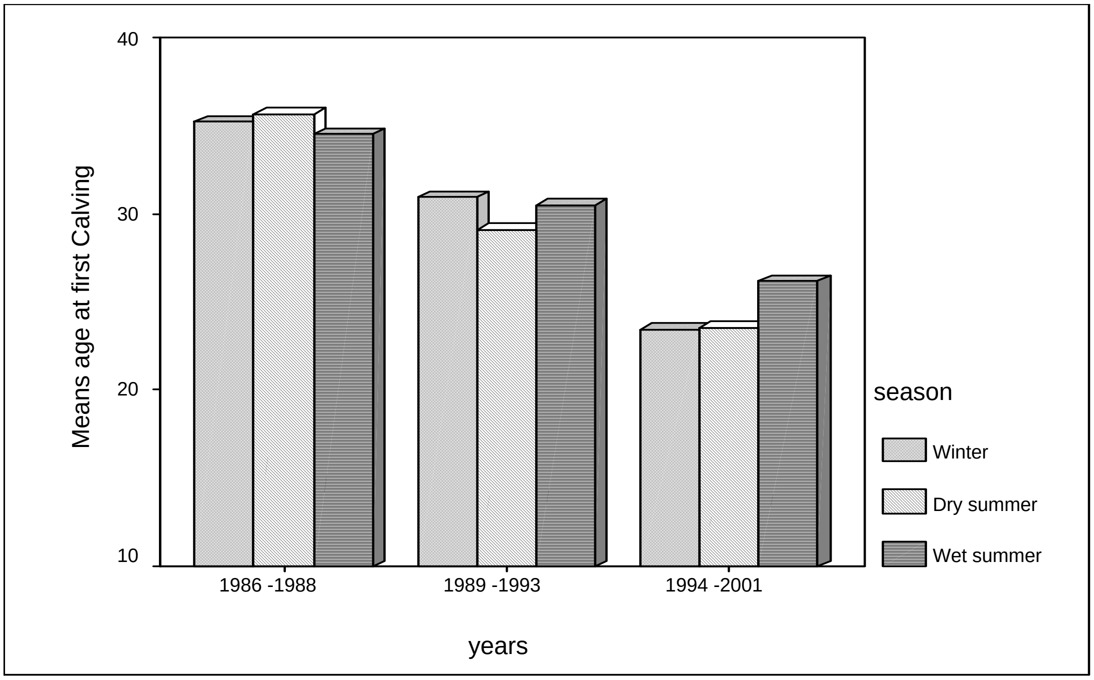

Figure4.2: Least squares mean of number of services per conception over parity number:

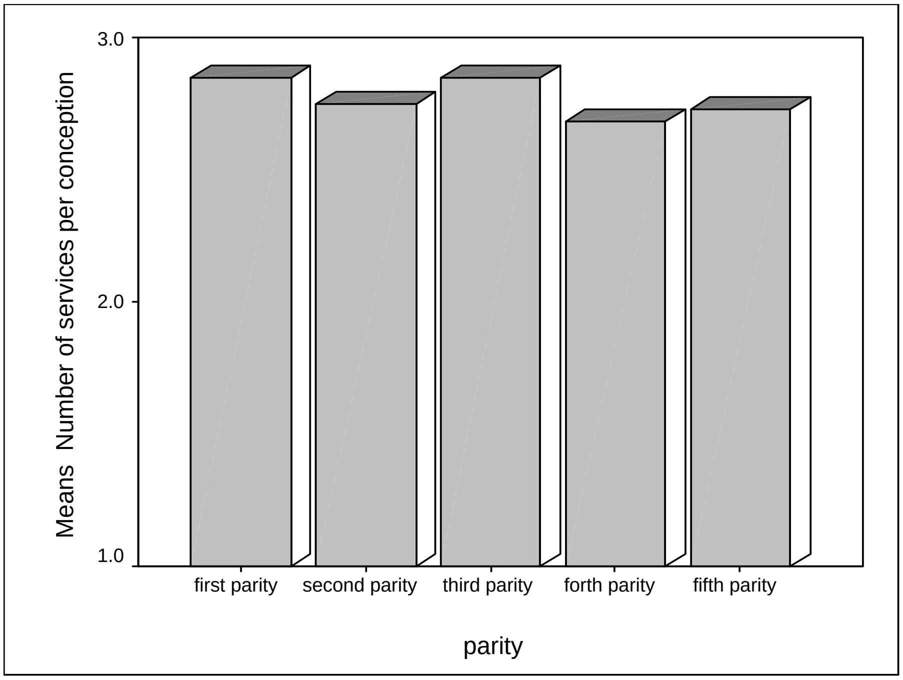

Figure4.3: Least-squares means of calving interval over periods and year-season.

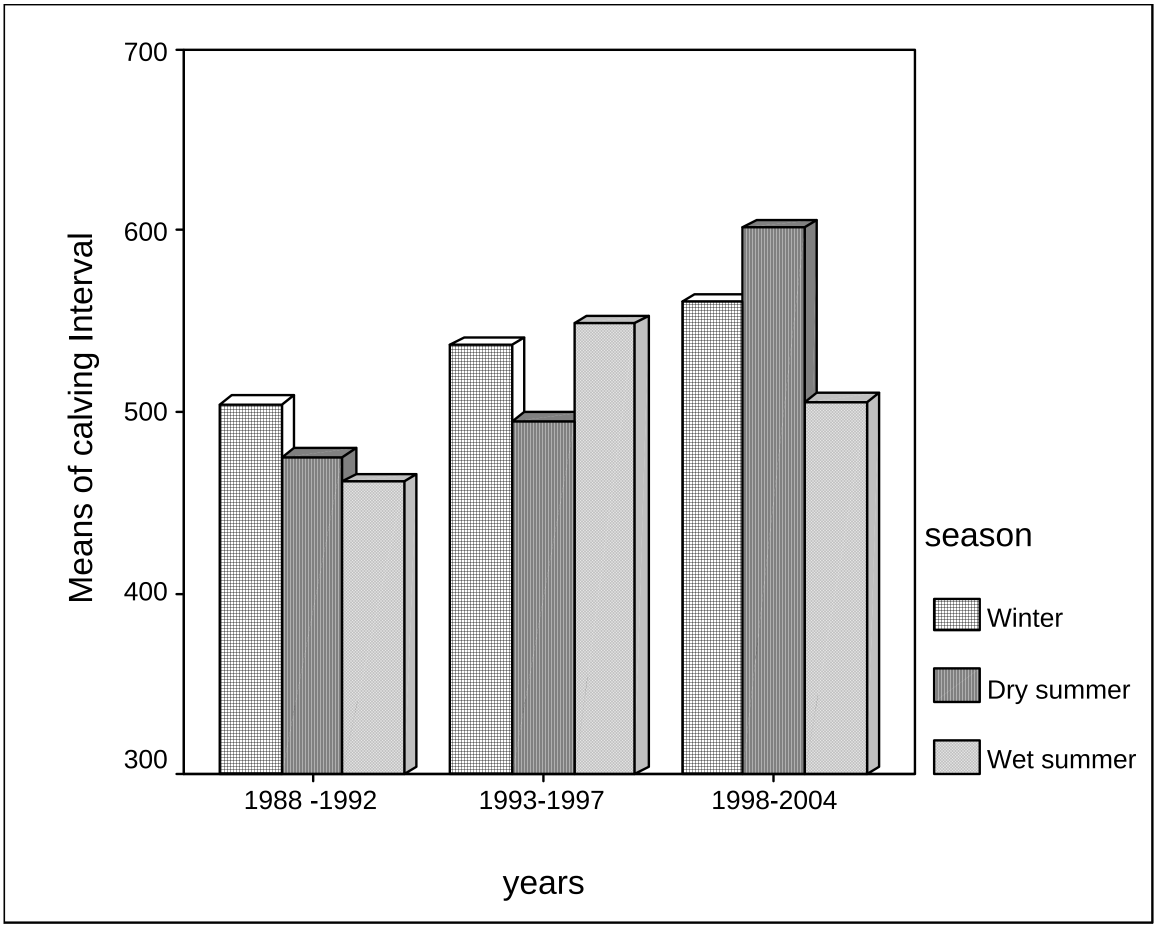
700
600
500
400
300
Means of calving Interval
1988 -1992
1993-1997
1998-2004
years
season
Winter
Dry summer
Wet summer

Figure4.4: Least-squares means of calving interval over parity number.

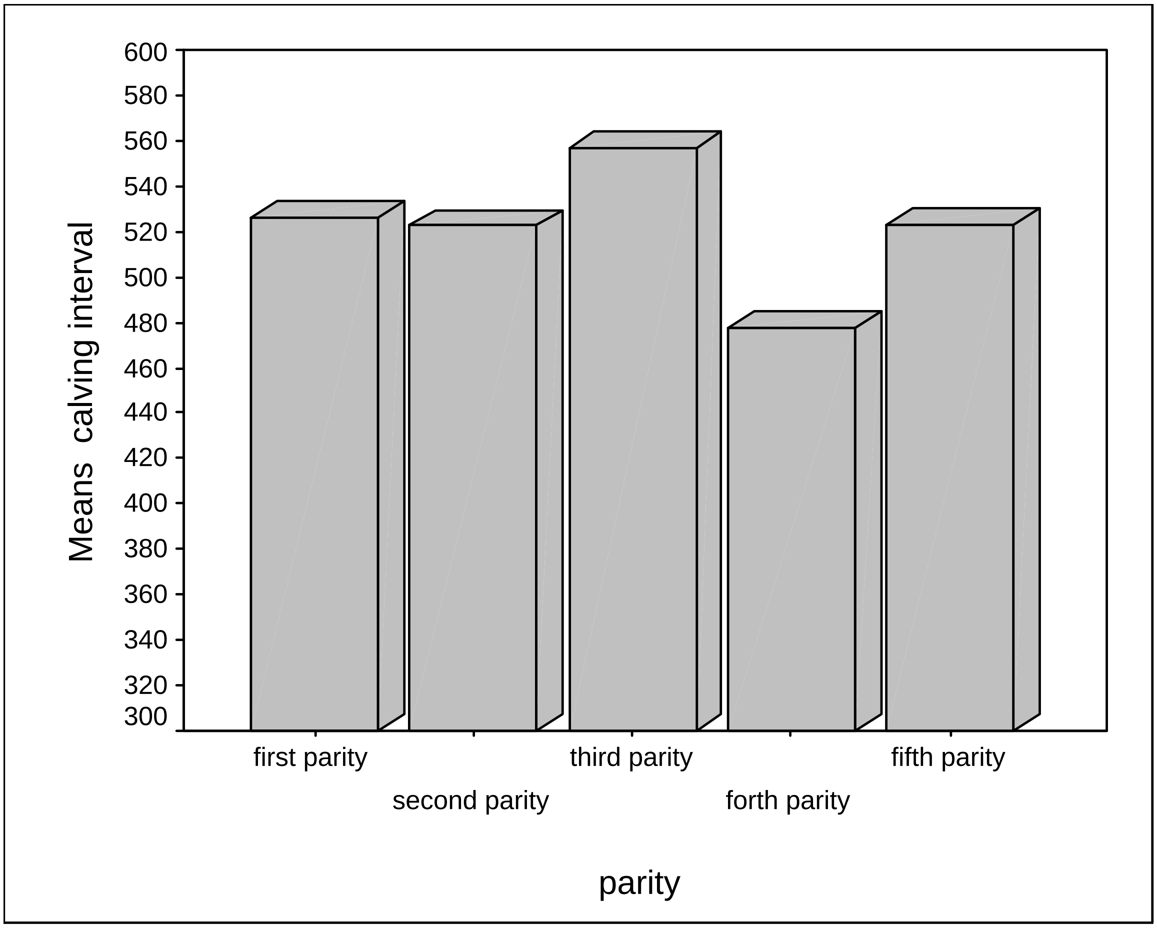

Figure4.5: Least-squares means of total milk yield over period and year-season:

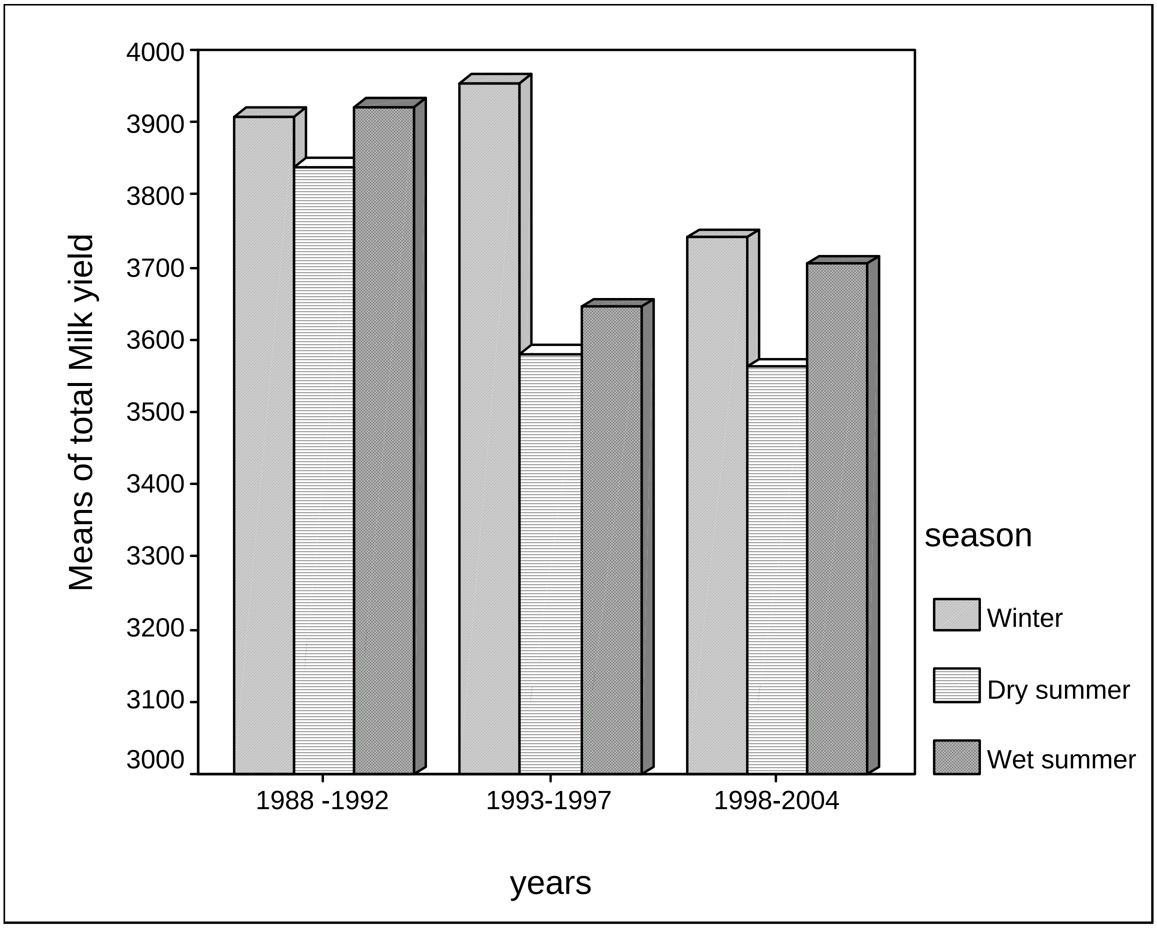

Figure4.6: Least squares means of total milk yield over parity number:

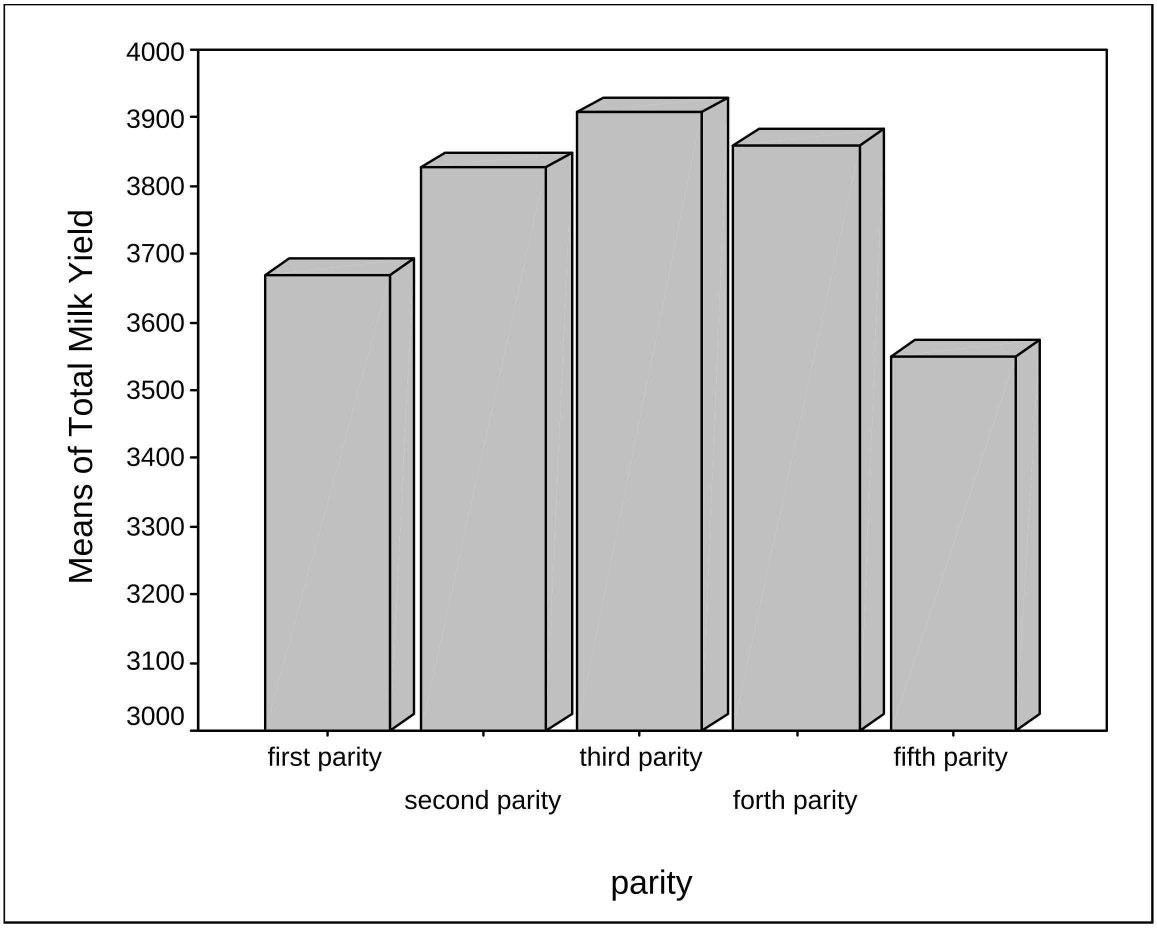

Figure4.7: Least-squares means of lactation length over periods and year-season:

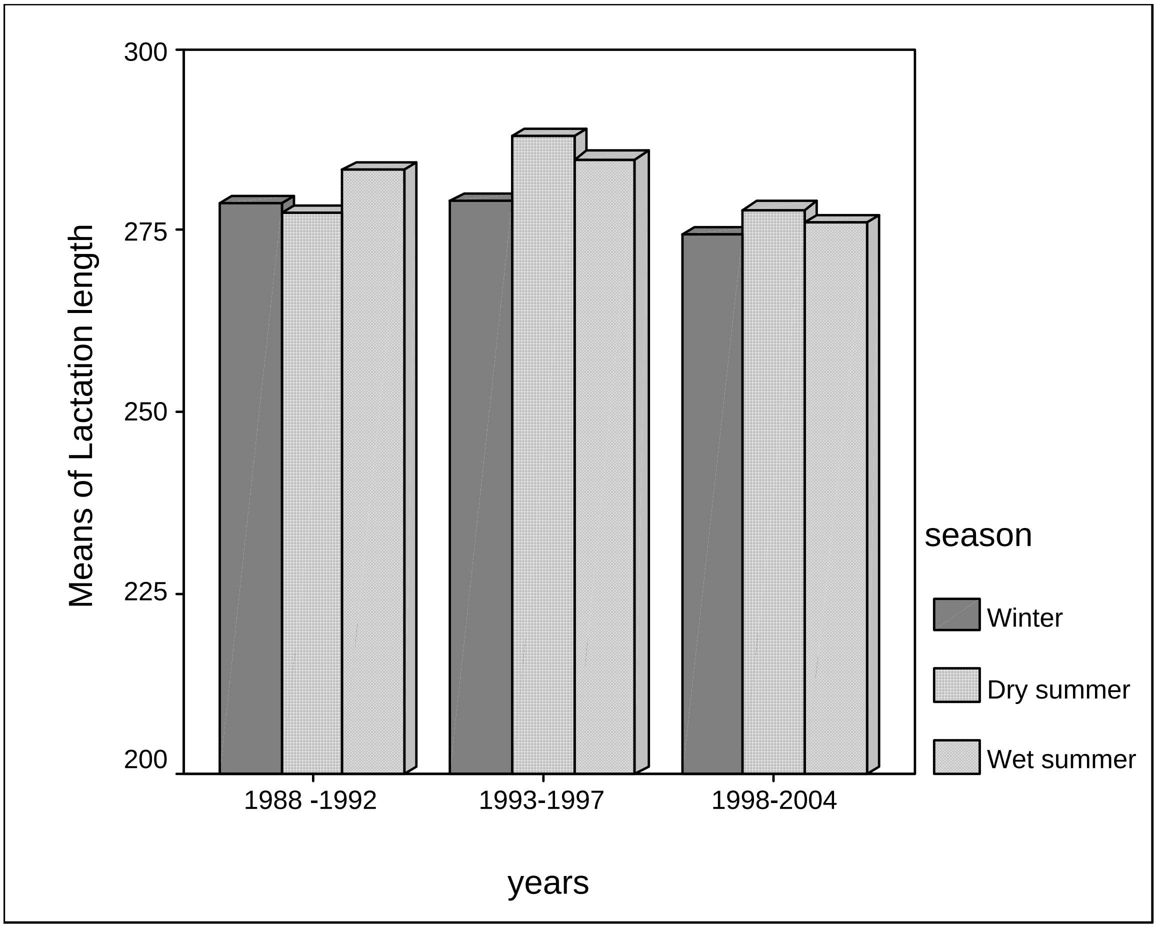

Figure4.8: Least squares means of lactation length over parity number: