RANKING OF ECUADORIAN SIRES BY BEST LINEAR UNBIASED PREDICTION

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ABSTRACT

RANKING OF ECUADORIAN SIRES BY
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By

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First and second lactation records from 785 Ecuadorian Holsteins distributed in four altitude areas, three "year" groups and six "season" groups were analyzed with the objective of ranking sires.

BLUP approach was used to rank sires from three models and computer programs from Genstat were used to assist the analysis.

Results show that sires did not rank the same in first and second lactation records. R^2 statistics were obtained for each model; the highest value, 0.50, was obtained with a model (iii) which includes herd, year group, season group, and sire as sources of variation in first lactation milk yield.

To compare ranking of sires from different models and lactations, Spearman's correlation was made. The highest correlation value, 0.98, was yielded between model (ii) which includes area, and model (iii) which includes herd; and between milk and fat yield.

Although smallest σe^2 was obtained in second lactation records, because a sire must be progeny tested early in life to obtain faster genetic improvement, ranking of sires using first lactation records in a model which includes herd, year, season, and sire is recommended in Ecuador.

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PREAMBLE

This work was initiated under the guidance of Dr. Ivan Mao, in the genetics section of the Department of Dairy Science. The 58,455 records of milk production used in this study were provided by Dr. Charles Wilcox, University of Florida.

The objective of the study was to learn to use dairy records to make certain management decisions and to gain experience using the computer. During the last half of my research Dr. Mao left for a sabbatical. After six months under the supervision of Dr. T. Ferris, my program was transferred to Dr. R.M. Cook. This thesis was completed under his guidance. Dr. William Magee and Dr. K.A. Wilson, in the Institute of International Agriculture also served as advisors, for which I am very grateful.

To my father for his thought.

To my mother for her faith.

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CHAPTER I

INTRODUCTION

Dairying is one of the top enterprises in Ecuador's agricultural industry. Dairy farms in Ecuador are found mainly in the Andean region from 2,250 to 3,400 meters above sea level. Plenty of sunshine, rainfall distributed throughout the year, moderate temperatures ranging from 10 to 17°C, and vigorous grass growth in this region create ideal conditions for milk production.

The predominant breed of dairy cattle is Holstein-Freisian. Registered animals have been imported since the beginning of this century and native cattle have been upgraded for several generations through artificial insemination, principally using U.S.A. proved sires.

Dairy scientists have been working to increase milk production through genetic progress and enhanced environmental conditions. Research on genetic and environmental factors affecting milk production, genetic and environmental trends, correction factors, and production parameters have been done. New methods, techniques and improved management systems have been tested and adopted when convenient.

The selection of genetically superior parents has a great influence upon the improvement of succeeding generations. This study evaluated sires in Ecuador using the BLUP approach method of sire evaluation.

The information obtained should aid sire selection and genetic improvement of the dairy cattle population in this area of the world.

CHAPTER II

LITERATURE REVIEW

II.1 Sire Evaluation

Background and historical development of sire evaluation

The rate and success of genetic progress is dependent upon the selection of sires whose daughters will produce milk at a more profitable level than their dams. About 90% of the pressure to improve potential in the North American population is on the sires (McDaniel, 1974). Because of the essential role that sires play in genetic improvement of dairy cattle, researchers have sought more effective methods of sire evaluation. Estimates of the genetic worth of bulls have been produced through the consideration of factors chosen to make these estimates as representative as possible of the genetic transmitting ability of the sires (Norman, 1974). With emphasis on certain traits such as milk production, many factors must be considered in order to optimize our results.

II.1.1 Factors Considered in Sire Evaluation

II.1.1.1 Environmental variations

Johanson (1960) working with progeny testing methods, found that for an accurate evaluation of sires it is necessary to eliminate the effects of systematic environmental factors that are affecting milk production. The method used in this process is to compare the production of the bull's daughters.

Keown (1974) writes that environmental variation has existed and probably still exists. He found that highest yields were obtained in January-February and were lowest for July-August calvings.

McDowell et al. (1976) working with Mexican data found that the effects of the year, the season, and the age of the cows were important influences on milk yield. The variation in milk yield accounted for by four climatic variables plus feed and body weight ranged from 11 to 62%, the larger variation being for cows calving in July and August and the smaller for those calving in spring and fall. Climatic conditions appeared to have the greatest influence in the first 60 days of lactation.

Roman (1970) using Ecuadorian data, pointed out that seasonal effects were not important sources of variation affecting milk and fat yield as is sometimes the case in temperate zones; the variability due to season of freshening was less than 1% of total variance in registered or grade cows. Season classification was January to March, April to June, July to September and October to December.

A general conclusion from experiments on the effect of climatic stress is that the best yields and efficiency of performance could be obtained under stable environmental conditions with temperatures in the comfort between regions in the Predicted Differences (P.D.) of bulls. The mean of herdmate sires' P.D. should be approximately equivalent to the average genetic transmitting ability value of the bulls used in the area previous to the period studied. He indicates that when using AI in the same breed for several years, the variation in production within a farm is from environmental conditions. The changes in production that are reflected in the herd averages are caused by environmental factors, management, sanitation practices, and nutrition.

Roman (1970) analyzing Ecuadorian data, found that farms within area accounted for 26.3% and 37.5% of variability in milk yield, and 5.90% and 15.65% for fat yield, in registered and grade cows respectively.

II.1.1.2 Environmental correlations

Several authors (Bereskin and Freeman, 1965; McDaniel, 1974; McDaniel and Plowman, 1961; Thompson and Freeman, 1970; and Arora and Freeman, 1971) have reported small environmental correlations in different populations ranking from near 0 to 0.14. These authors agree that there are a number of possible causes of environmental correlations. Among these are:

a. Failure to remove all herd effects, herd year effects, year-season effects, or herd-year-season interaction effects.

b. Paternal half-sisters may be managed and fed more alike than other cows in the same herd-year-season.

Large numbers of progeny would tend to eliminate environmental biases if a bull's progeny were compared to a random sample of cows. There are high correlations between herdmates' sires in repeated samples. Environmental biases would probably be small if there were no correlations between a bull's breeding value and that of the sires of his progeny's herdmates. Evidence suggests a strongly positive association.

IV.1.1.3 Seasonal effects

Even though many sources of variation have been considered in sire evaluation including herds, regions, production level, lactation length, days open, genotype by environmental interactions and others, one of the more important factors which ought to be considered is the seasonal effect on milk yield. In Michigan, Wunder and McGilliard (1971) found differences in milk yield between seasons of calving and age of animals.

IV.1.1.4 Genetic trends

Changes with time are due to both genetic and environmental factors and trends in a population or in individual herds are difficult to disentangle. Warwick (1979) found genetic trends are of interest when comparing sires used in different periods of time. Van Vleck (1961) noted that genetic trends and overlapping generations create difficulties in comparisons between younger and older sires. Differential use of sires by dairymen has caused the progeny of some bulls to be compared with herdmates that are better genetically than herdmates of other bulls. There are positive genetic trends in Artificial Insemination (AI) sires indicated by both milk and fat yields in dairy cattle (Everett, 1976).

The annual changes in management and genetics showed that in recent years there were more improved genetic evaluation procedures. With continued economic restrictions on feed input, breeding is expected to continue as an important factor for improved yields (Powell, 1979).

Lush and Shrode (1950) studying selection or culling, genetic or environmental time trends and repeatability, pointed out that positive genetic trends could be confused with age, and to determine the size of these biases, additional information regarding the amount and kind of selection practices is needed. Positive genetic trends make herdmate comparisons for young bulls, relative to older bulls, lower than they really are (McDaniel, 1973). Genetic trends are generally obtained by comparing overall production with environmental estimations of milk or fat yield (Burnside, 1967).

Mao (1971) using age-month adjusted records, pointed out that time trends may be the result of genetic homogeneity and/or environmental heterogeneity. Genetic trends have little importance in evaluation of contemporary sires. If sires used in widely different time periods are to be compared, trends in genetic merit must be considered.

Least squares procedures and family relationships have been used used to estimate genetic trends (Van Vleck and Henderson, 1961; Smith, 1962).

Rodriguez (1974) has detected in an Ecuadorian Holstein population a positive genetic trend in yields and negative environmental and phenotypic trends in yields.

In Mexico, positive genetic trends for sires from the USA, Mexico and Canada were found by McDowell et al. (1976). Adkinson (1972), using Ecuadorian data, dated from 1964 to 1968, found that genetic trends for yields were positive and curvilinear, appearing to plateau around 1960. Trends were linear and positive for fat percent and accounted to 0.024±0.004% per year; he found that environmental trends were negative and curvilinear for milk and fat yields, negative but linear for fat percent and negative environmental trends which might appear unusual but have been reported previously.

II.1.1.5 Age correction factors

Age of calving is one of the main factors affecting milk and fat yield in dairy cattle. Comparisons between cows frequently include animals of different ages, and since cows generally produce less when young and during old age, it is necessary to standardize records with age correction factors developed for that purpose (Lush and Shrode, 1950; Mao, 1974).

The age distribution of both daughters and herdmates may differ among sires. It is generally assumed that application of age correction factors will remove some biases; however, other effects are confounded with age such as herd-year, cow selection, breed and geographical region; therefore, age adjustments ought to be made either jointly with the adjustment for these combined effects or free from them (Mao, 1974).

There is some controversy regarding benefits of using cows of all ages in sire evaluation. Sire sampling is by necessity concerned with first lactation daughters (Powell, 1972).

Changes in lactation yield with season of calving and age were found by Wunder and McGilliard (1971). Mao (1973), working with first and second lactations, found differences in lactation yield at calving ages between 31-37 months. The same author (1974) recommends age month adjustment factors for accurate comparisons of cow's productivity.

A method known as Gross Comparison was developed by Gowen (1920,1924). It establishes a comparison of milk production averages of different age groups. Sanders (1928) in an attempt to diminish the biases of this Gross Comparison Method, weighed each consecutive pair of records between the same group of cows, thus creating the Paired Comparison Method.

Later, Beardsley (1952) used a maximum likelihood (ML) procedure to create an age correction factor considering herd and age effects. Lush and Shrode (1950), Searle and Henderson (1959), and Mahadevan (1951) discussed weaknesses and biases of these methods.

Miller and Henderson (1968), working with age correction factors pointed out that ML estimates may or may not be biased depending on the aptness, appropriateness and completeness of the model. Roman (1970), found in Ecuadorian Holsteins that within herd variability in milk yield and fat yield was due to age variations. He reported that seasonal effects were not an important source of variation in milk and fat yields. Age correction factors developed by Rodriguez (1974) in an Ecuadorian Holstein-Friesian population, were found to be very similar to those developed in the temperate zones of the United States of America.

II.1.1.6 Pedigree

A sire's proof is more reliable when pedigree is included. It is a record of the animals from which a given individual is descended. It includes identification of ancestors, collateral relatives and information on their performance or progeny records (Warwick, 1979).

Normally, a pedigree index is done using a multiple regression approach. In general, the contribution of information on a relative toward estimated pedigree index for the bull in question is a function of three factors.

a. Relationship of the relative to the individual;

b. Relationship of the relative to the other relatives used in the evaluation; and

c. Accuracy of the breeding value estimate on the relative (Butcher, 1967).

A pedigree index is useful as a relative estimate of a bull's breeding value. Combining information on sire, maternal grand sire, and dam's early lactation by current pedigree indexing procedures is effective for screening prospects for a young sire sampling program (Butcher, 1973).

Van Vleck and Carter (1972), working with Holstein bulls, concluded that pedigree indexes were an effective method of selecting young sires and Casell et al. (1976) added to the evidence of benefits from careful pedigree selection for production traits in bulls used under limited and multi-herd conditions.

Butcher (1976) pointed out that high pedigree index bulls have a much higher probability of achieving a high P.D. proof.

The maximum rate of genetic improvement in yield traits in a closed dairy cattle population is obtained when an appropriate proportion of the mating is to young bulls selected on pedigree (Butcher 1976; Specht, 1960).

II.1.1.7 Repeatability

The regression of future performance on past performance is called repeatability. It is really a confidence factor that depends on:

a. How many daughters are available;

b. How many herds they are in; and,

c. How they are distributed among herds.

Repeatability is a factor which ranges from 0 to 99% depending upon the amount of daughter information and distribution of daughters over herds. The repeatability is higher when more daughters are randomly distributed over more herds.

The higher the percent repeatability, the more accurate the P.D. value and the narrower the confidence range in the P.D. milk (McDaniel, 1974; Mao, 1980).

II.1.1.8 Sire groups

Ideally, groups should be defined alike so there is maximum genetic similarity within sizable groups and in such a way that the means of groups represent genetic differences. Possible bases for grouping are year of birth, year of first daughter freshening, year within stud or pedigree estimate (Powell and Freeman, 1974; McDowell et al., 1976).

Grouping by geographical area is beneficial because the genetic value of a bull could be affected by the geographical area in which their daughters are milked; herds, regions or areas with higher selection differentials on bulls have the most under-rated bulls (McDaniel, 1974; Tomaszewsky, 1973; Henderson, 1974).

When we group sires, genetic trends are accounted for if the estimates of merit for sires of herdmates are unbiased and properly applied. Working with a mixed model without groups accounts for the merit of sires of herdmates, but the estimates of merit for all sires are biased by regression to an inappropriate mean.

Grouping is an arbitrary process. The purpose of grouping sires in a model is to recognize that sires are not all random samples from a static population. Grouping is an attempt to identify and take into account the non-random source of the sire sampling. Grouping sires by pedigree could be more effective in removing the environmental variation than grouping by stud-year as is done by the Northeast Artificial Insemination Sire Comparison Program (NEAISC), if there are differences in quality of bulls purchased each year by individual studs (Norman, 1974).

Pedigree grouping would encourage the sampling of sires with outstanding pedigrees because the estimate of an individual sire is influenced to a large extent by the group mean, particularly when evaluated on a limited number of daughters (Norman, 1974).

II.1.2 Methods of Sire Evaluation

The goal of breeders is to obtain genetic estimates of bulls which account for independent non-genetic factors. Those estimates are as representative as possible of the genetic transmitting ability of sires (Normal, 1974).

Sire evaluation methods have been developed from genetic theory and usually include simplifying assumptions. While the approximate validity of the assumptions used is subject to experimental verification, the inability to measure true genetic value complicates empirical comparisons among methods (Jamison, 1977).

Over time, many procedures have been developed. In general, any procedure generates estimation of some sort and only the differences among breeding values are meaningful (Van Vleck, 1976).

II.1.2.1 Daughter Average

The Daughter Average is the simplest method of sire evaluation (the average production of the daughters of a bull computed to the average production of daughters of other bulls). It once had as its prerequisite the following: The compared bulls must come from the same population and there must be genetic equality among mates of the bulls (Van Vleck, 1976).

II.1.2.2 Daughter-Dam Comparison

The Daughter-Dam Comparison method (trying to measure the effect of a bull by comparing dam with daughter), was suppose to account for differences in mates but actually may have been more useful in adjusting for herd level. One of the biases of this method is that it puts too much weight on dam average so one of the weakest links is the change in herd-year-season effects from dam to daughter (Van Vleck, 1976).

II.1.2.3 Herdmate Comparison (HMC)

The Herdmate Comparison method, developed by C.R. Henderson and A. Robertson in 1950 is the well known fixed model which was computed using Least Squares (LS).

Y = X +   + E

Where: "Y" is an observation vector (records);

"X" is known matrix;

" " is an unknown fixed vector; and

"E" is a more observable random vector with a mean, a vector of zeros and a variance-covariance matrix (Henderson, 1974).

It does contain a herd-year-season effect. This method uses a difference between a sample of the transmitting ability of a bull and the average transmitting ability of sires of the daughter's herdmates plus the difference between her dam's transmitting ability and the average transmitting ability of dams of her herdmate. Several assumptions underlie this method. For example, the sires of herdmates of daughters of bulls are equal in average transmitting ability and in the genetic base of the group to which the sire belongs. Other assumptions cannot be supported. These include.

1. Bulls' daughters do not receive preferential treatment relative to herdmates;
2. Each bull is mated to a representative sample of the population for the traits evaluated in the progeny;
3. All sires with tested daughters from a breed are a random sample from a single population; and,
4. The distribution of sires across the herds is random.

The Predicted Difference (P.D.) will drop each year, on the average, by an amount equal to one-half of the yearly genetic improvement in the dairy cow population. This is the reason why the P.D. for older bulls appears somewhat more favorable compared to the P.D. for younger bulls than it actually is (Van Vleck, 1976; McDaniel, 1974).

The P.D. is defined as the expected deviation in milk or fat of a bull's progeny from their herdmates in a breed-average herd. It compares a bull's daughter to the progeny of other bulls that calved in the same herd at the same time, taking into account season and age at calving and length of lactation. Besides having higher milk yields, it has also been shown that the daughters of high P.D. sires:

1. Have more income over feed cost per lactation;
2. Have greater feed efficiency;
3. Voluntarily consume more forage when it is offered free choice; and,
4. Have longer productive lives than daughters or low P.D. sires.

The USDA sire summary, utilizing herdmate comparisons, is accurate enough to be considered an effective tool for genetic improvement and it is widely used in dairy cattle (McDaniel, 1974).

Norman et al. (1972) have shown that the deviation of a progeny from herdmates depends on the genetic ability of the sires of herdmates. As the genetic value of the herdmates increased, so did daughter average yield, but daughter deviation from herdmate average decreased.

There are several reasons why the herdmate comparison is inadequate. Sires of herdmates from progeny of specific sires will differ in genetic merit because sire proofs tend to decline in successive generations. This can produce wide discrepancies in merit of sires of herdmates among sires being tested (Powell, 1974).

The same author points out that the classic method of sire evaluation by herdmate comparison does not account for the merit of sires of herdmates.

P.D. is affected by daughters' distribution across herds because of the sires' repeatability is used to regress the daughter-herdmate deviation toward the population mean (Norman, 1974).

The P.D. method places great reliance on accurate age factors since young cows are compared with herdmates of all ages and old cows are compared with herdmates of all ages (Everett and Henderson, 1972).

II.1.2.4 <u>USDA-DHIA modified contemporary comparison (MCC)</u>

This method was implemented in 1974 to replace the HMC in order to overcome the invalidity of some assumptions (USDA Report, 1976). For the MCC, the contemporary average encompasses records initiated during a five month interval. It includes animals which calve two months before the individual daughters calve, the month the daughters calved and two months after the daughters calved. In order that the contemporary comparison be effective the sire's daughters and contemporaries must be provided the same opportunity (Warwick, 1979).

The MCC utilizes two contemporary groupings:

1. First lactations (MC1); and,
2. Second and later lactations (MCL).

First lactation daughters are compared to MC1 and second and later lactations to MCL. The results of the MCL are expressed as a Predicted Difference (P.D.) which is an estimate of the expected average of many future daughters of the sire.

The major improvement in the MCC is the adoption of a genetic base from which all P.D.s are expressed to minimize the impact of genetic trends in the comparison of bulls over time when the MCC was implemented in 1974. The genetic base was related to the average calving date of the records used in the fall 1974 USDA Sire Summaries. This base can be changed in accord with the average genetic change that has taken place in the breed (USDA Report, 1976).

II.1.2.5 Cumulative Difference

The Cumulative Difference (CD) is another important method developed by Bar-Anan and Sacks (1974). It offers a prediction of breeding values of sires when data are available only on progeny. The usual approach is essentially a two-way classification model in which unbiased estimates of progeny means are obtained and then breeding values of sires are found by weighting these estimates by their heritabilities. The evaluation becomes available over a period of time and the information of estimation is valid during that time (Thompson, 1976).

Bar-Anan (1974) points out that although a daughter record appears in only one period of time, sire tests in different periods are not independent since there is a covariance between the records of a bull's daughter in different periods.

II.1.2.6 Sire evaluation by linear models

Mixed linear model methods for sire evaluation have been developed by Henderson and they provide a powerful tool for use under a wide variety of situations (Warwick, 1979). The general form of the mixed model equation is:

$$Y = x\,\beta + Zs + e$$

Where: Y is a vector of observations;

β is a vector of unknown fixed effects;

s is a vector of unknown random effects;

e is a random residual effect;

x, z are design matrices; and,

$E(e) = 0$, var $(e) = r^2_e$, $E(e) = 0$, var $(e) = r^2$.

This method, originally called Maximum Likelihood (ML), has been used in breeding research for more than 25 years (Shaeffer, 1976).

The Northeast Artificial Insemination Sire Comparison (NEAISC) is a mixed linear model method developed by Henderson at Cornell University. It uses records from two year old freshening cows as a genetic base and has several advantages.

1. The bulls are evaluated according to the levels of competition
2. It eliminates problems of differential culling among sires
3. The age correction factors problem is reduced
4. It eliminates the biases caused by genetic trends
5. It uses sire groups (Everett and Henderson, 1972; Everett and Quaas, 1979; Everett, 1974).

On November 15, 1966, Dr. C. Henderson introduced another method of sire evaluation based on statistical concepts which are referred to as the BLUP techniques. It was developed for working with selection indexes and linear model techniques to deal with a large set of data with unequal subclass numbers. This new method accounts for unknown and environmental trends, herd, season, age effects and differential culling of daughters. This method has no statistical limitations except computer storage and ability to handle large matrix operations for a specified model and all the related assumptions and restrictions (Mao, 1980; Shaeffer, 1975).

A simple modification of the regular least squares leads to a BLUP solution. To the evaluation problems in situations of unequal numbers $R = I$, G^{-1} is simply added. When the sires are unrelated and herds are fixed, this means adding r_e^2/r_s^2 to the diagonal of the sire equations; this ratio in heritability terms becomes $(4 - h^2)/h^2$, (Van Vleck, 1976).

If $R \neq I$ some modifications are required. The equations in this case are solved by the Gauss-Siedel iterative method.

As with any statistical procedure, the validity of its properties depends on the development of a correct model to describe the data. If the data is appropriate then the model as noted by Henderson (1975), Van Vleck (1976), Mao (1979, 1980), Vinson (1979), Casell (1979), and Shaeffer (1975) has the following characteristics.

1. Can be used in a wide variety of situations
2. The evaluation obtained is unbiased and has the smallest possible variance of prediction errors
3. Combines unequal numbers of daughters unevenly distributed in a population of herds in an optimal way

4. The correlation between predicted and true variance is minimum.

5. If the data are true values and have a multi-variance normal distribution the probability of correcting and ranking pairs of true values is minimum.

6. The maximization of genetic progress through truncation selection.

7. Maximization of the probability of selecting the better of two bulls.

8. Pairs of sires which do not have direct comparison may have indirect comparisons with common sires.

9. Maximization of the correlations between predicted and predictor.

10. Can use pedigree information and other factors, making this method a super machine that is very flexible and eliminates bias from genetic trend.

11. Considers pure genetic makeup between sires by comparing daughters of different sires directly or indirectly.

12. Probability or confidence statements about genetic values can be made from the predicted true values and variance errors of prediction which come out directly in the Arithmetic of Predications.

13. Sire solutions within group sum to zero.

Some mathematical disadvantages of BLUP include the following.

1. Only linear functions of observations are used in common with nearly every other procedure.

2. Although unbiasedness is a desirable characteristic, certain biased procedures may have a smaller squared prediction error, but there is no way to tell if the biased procedure results in more or less prediction errors than BLUP;

3. The correct ratio of variances of random effects (sires) is assumed known for predicting genetic values; it depends on heritability which is often known within reasonable limits.

4. If an equation is needed for every level or every factor in the model in animal breeding, problems could result in thousands of equations and unknown quantities to be estimated or predicted.

5. Records must be standardized or adjusted by age to avoid biases produced by unbalanced data.

6. Efficient absorption and sorting procedures are necessary in solving BLUP equations (Van Vleck, 1976; Mao, 1980; Ufford, 1977; Shaeffer, 1975).

BLUP approach has been used in many ways. For example, it could be used in estimation of genetic trends (Miller, 1970; Lentz et al., 1969; Everett, 1972; Henderson, 1973) with categorical data (Conolly, 1981) and, of course in sire evaluation for production and type characteristics (Walter and Mao, 1981).

It is not known at the present time what are the more appropriate computing strategies and procedures (Henderson, 1974; Ufford, 1977).

Evaluation by BLUP methodology require the solution of a large set of linear equations. It requires knowledge of LS methods and computing strategies as the well-known absorption technique (Ufford, 1977). Computing alogrithms for several models are available for sire evaluation by BLUP (Henderson, 1966). The procedures for solving equations are very flexible but could become complex according to the number of variables present in the model (Mao, 1980).

It is a necessary mathematical procedure to reduce the number of equations to a manageable limit and still obtain the same solution as if all the equations were solved (Shaeffer, 1975; Ufford, 1977).

To obtain solutions some restrictions must be imposed. Any two nonestimatable restrictions will result in solutions which will estimate the same estimatable functions. Solutions to the random effects will always be the same, but solutions to the fixed effects will depend on the restrictions used. The expected values of the solutions will, however, indicate what functions of the fixed effects can be estimated. The expected values of the solutions can be obtained by multiplying the generalized inverse of the BLUP by the original least square equations and solutions can be obtained for multiplying the inverse times the totals on the right hand side (Van Vleck, 1976; Mao, 1980; Shaeffer, 1975).

II.1.3 First Lactation Records and Sire Evaluations

First lactations of dairy cows are of special importance to sire selection as the most frequent lactation. They are 24 to 28% of all lactations (Powell, 1972). Powell (1972) suggest that the first lactations should be the most meaningful because previous production selection and cumulative disorders are not attributable to a cow's merit. Dairy cattle breeders have pondered whether information from first lactation production is accurate enough as a predictor of performance in later lactations. This would allow sire evaluation to be based only on first lactations (Tomaszewsky, 1974).

Butcher (1968) pointed out that there are several possible explanations for lower utility of later lactations of the cow:

a. Preferential treatment relative to herdmates

b. Lower heritability of later records

c. Small genetic correlations between lactations

d. Effective repeatability of less than 0.5

Every attempt should be made to compare equivalent lactation records; otherwise serious problems may result. If a cow that has a first lactation record is compared with another cow that does not, a serious bias is introduced. This is due to a first lactation record being compared with a selected set of later records (Keown, 1976).

II.1.4 Later Lactation Records and Sire Evaluations

Second selection tests are not only important for asserting sire lactation number interactions but also for increasing the accuracy of the estimated breeding values. By combining first and second lactations in progeny test proof, repeatability is increased and a yield increase per cow year in daughters of proven bulls is obtained (Bar-Anan, 1975).

Casell and McDaniel (1980) working with first and all lactations in sire evaluations concluded that:

1. Proofs for milk based on later lactation records exceeded proofs based in first records.

2. Sire differences in differences between later and first proofs were noted.

3. Correlations between first and later lactation proofs were low enough to produce some misranking of sires for later lactation progeny tests.

4. Increased culling on first lactation performance resulted in increased differences between first proof and later proofs.

Comparing a sire's daughter to other cows in the herd, calving in the same period has become accepted in evaluating bulls. Some sire summaries have compared first lactation daughters to first lactation contemporaries. The present USDA-DHIA (United States

Department of Agriculture-Dairy Herd Improvement Association) sire summary compares progeny of all ages to herdmates of all ages (Norman, 1974).

The belief that sires differ in the rate that their daughters mature seems to be a major reason why some people prefer the use of all lactation records. Differing rates of maturity may be accounting for a sire by age interaction. That is, two sires may transmit the same merit for a first lactation period but yet differ in merit for a second lactation period (Ufford, 1977).

Nicholson et al. (1974) evaluating sire by age interactions using only first, only second, only third, only fourth lactation records having adjusted records for selection and using BLUP procedures, found that a few bulls did differ significantly in their evaluation from one lactation to the next. They concluded that the first lactation proofs were an accurate predictor of later lactation proofs. If the time arrives that sire by age interaction should be considered, each lactation could be treated as a separate trait correlated with other lactations being necessary to weigh each lactation according to its economical importance (Ufford, 1977).

The residual error of an individual sire seems to be of special importance for evaluating breeding programs which use regression parameters for sire evaluation. This is because the animal breeder wants to know what range in the indirectly estimated daughter performance he may expect from using an individual bull (Bar-Anan, 1974).

In a herdmate sire evaluation, Tomaszewsky et al. (1975)

concluded that bulls ranked similar for first or second evalutions.

The use of later records in a sire summary is based upon the assumption that the same genes are influencing both first and later lactations. If this assumption is not justified, it may be that more emphasis should be placed in later lactations (Wickham, 1976).

Research done by Shaeffer (1975) and Wickham (1977) support the statement that later lactations are influenced by a different set of genes. Therefore, there should be two sire summaries: one based on first lactation information and the other one based on later information records.

Norman (1974) reports that the accuracy of sire summaries are affected by the number of cows to which each daughter is compared and the genetic correlations between yield in various lactations. The use of multiple records will result in a substantial increase in the time required for computing sire summaries. A thorough analysis of sire evaluation should consider the following points:

1. The reduction in sampling variance from adding daughter and additional herdmates in comparison.

2. The estimates from the literature of genetic correlations between first and later lactation records.

3. The value of additional accuracy compared to the cost of acquiring such information.

When comparing selected later records with first lactation records, a problem arises: if all records are used, some adjustment must be made for cows with later lactation records that do not have first lactation information. If the records are adjusted properly, the addition of these records in BLUP methods will help estimates of sires (Keown, 1976; Norman, 1976).

The merit of incorporating all lactation records can be considered in terms of prediction error variance and bias. Since the first lactation records are a subject of all lactation records of prediction, error variances will be smaller when all records are used. Unfortunately, biases are difficult to evaluate (Ufford, 1977). Use of multiple records appears to be more acceptable to the dairy industry.

CHAPTER III

MATERIALS AND METHODS

III.1 Materials

III.1.1 Source of Data

III.1.1.1 Origin

The data set analyzed in this study was obtained from the official milk testing program of Ecuador through the University of Florida. The original data set contained 58,455 records from 1948 to 1967. Each record contains the following coded information: farm, breed, cow, sire, dam, birth date (month and year), freshening date (month and year), age in months, condition affecting records (CAR), lactation length, times milked per day, area, cow's classification (pure breed or grade), milk production in pounds, classification by type of body conformation and lactation number.

The statistical package for social sciences (SPSS) was used to obtain some statistics, frequency tables and milk yield, fat percentage and fat yield means; tables III.1 to III.11 summarize the results.

III.1.2 Screening of Data

Fortran programs were written to read, clean, and edit the data. During this process records were deleted for the following reasons:

- Missing information on some variables: farm, cow, sire identification, date of birth, date of freshening, age, conditions affecting the record, incomplete lactation or lactation number.
- No information of milk yield, fat percentage, and fat yield.
- Sires having less than two daughters.
- For parity, cows older than 48 months of age at first parturition.

The final data set contained information from 101 sires, 785 cows with both first and second lactation records in 30 herds, four geographical areas, three year groups, six season groups. Each record was standardized to a mature equivalent age using values developed with the original population and a maximum likelihood model which includes farm, cow, freshening date, linear, quadratic, and cubic length of record; and linear, quadratic, and cubic cow's age as source of variation (Rodriguez, 1974).

III.1.3 Sire Groups

The grouping criteria used for the different statistical models were: area, herd within area, five year group, and two month season.

III.2 Methods

To rank the sires the BLUP approach was used and the general statistical program (Genstat) was used to obtain solutions.

TABLE III.1 Age of cows in years, number of observations, absolute relative and cumulative frequency for the original data set

Age (year)	Absolute frequency	Relative frequency (PCT)	Cumulative frequency (PCT)
1	12	0.02	0.02
2	497	0.85	0.87
3	7965	13.62	14.49
4	8114	13.88	28.35
5	6902	11.80	40.16
6	5864	10.03	50.19
7	4606	7.87	58.07
8	3559	6.08	64.16
9	2623	4.48	68.65
10	1977	3.38	72.03
11	1287	2.20	74.23
12	778	1.33	75.56
13	1713	2.93	78.49
SUBTOTAL	45,893		
MISSING	12,562	21.49	99.98
TOTAL	58,455		

TABLE III.2 Birth date of cows by year, absolute, relative and cumulative frequency

Birth date (year)	Absolute frequency	Relative frequency (PCT)	Cumulative frequency (PCT)
1	1,245	2.12	2.12
2	11,329	2.27	4.40
3	1,418	2.42	6.82
4	1,147	2.96	8.79
5	1,647	2.81	11.60
6	2,316	3.96	15.57
7	2,438	4.17	19.74
8	2,870	4.90	24.65
9	2,984	5.10	29.75
10	3,333	5.70	35.45
11	3,068	5.24	40.70
12	2,786	4.76	45.47
13	2,640	4.51	49.98
14	2,203	3.76	53.75
15	1,516	2.59	56.35
16	1,138	1.94	58.29
17	863	1.47	59.77
18	592	1.01	60.78
19	99	0.16	60.95
20	2	0.03	60.95
SUBTOTAL	35,623		
MISSING	22,821	39.04	
TOTAL	58,455		100.00

TABLE III.3 Birth date of cows by month, absolute, relative and cumulative frequency

Birth date (month)	Absolute frequency	Relative frequency (PCT)	Cumulative frequency (PCT)
1	3,345	5.72	5.72
2	3,238	5.53	11.26
3	3,150	5.38	16.65
4	3,160	5.40	22.05
5	3,463	5.92	33.82
6	3,463	5.92	33.82
7	3,164	5.41	39.24
8	3,296	5.63	44.88
9	3,234	5.53	50.41
10	3,224	5.53	55.94
11	3,032	5.18	61.13
12	3,248	5.55	66.68
SUBTOTAL	38,973		
MISSING	19,482	33.32	
TOTAL	58,455		100.00

TABLE III.4 Freshening date by year, absolute, relative and cumulative frequency

Freshening date (year)	Absolute frequency	Relative frequency (PCT)	Cumulative frequency (PCT)
1	79	8.13	0.13
2	178	0.30	0.43
3	790	1.35	1.79
4	1,396	2.38	4.17
5	1,207	2.06	6.24
6	1,158	1.98	8.22
7	1,299	2.22	10.44
8	1,479	2.53	12.97
9	1,957	3.34	16.32
10	2,531	4.32	20.65
11	3,263	5.58	26.23
12	3,767	6.43	32.67
13	3,290	5.62	38.30
14	3,725	6.37	44.67
15	4,639	7.93	52.61
16	5,141	8.79	61.40
17	4,728	8.08	69.70
18	4,510	7.71	77.20
19	4,063	6.95	84.16
20	1,771	3.02	87.19
SUBTOTAL	50,971		
MISSING	7,484	12.80	
TOTAL	58,455		99.99

TABLE III.5 Freshening date by month, absolute, relative and cumulative frequency

Freshening date (month)	Absolute frequency	Relative frequency (PCT)	Cumulative frequency (PCT)
1	4,288	7.33	7.33
2	4,018	6.87	14.20
3	4,210	7.20	21.41
4	4,325	7.39	28.81
5	4,620	7.90	36.71
6	4,450	7.61	44.32
7	4,434	7.58	51.91
8	4,343	7.42	59.34
9	4,276	7.31	66.65
10	4,173	7.13	73.79
11	4,336	7.41	81.21
12	4,487	7.67	88.88
SUBTOTAL	51,960		
MISSING	6,495	11.11	
TOTAL	68,455		100.00

TABLE III.6 Lactation length in months, number of observations, absolute, relative and cumulative frequency

Lactation length (month)	Absolute frequency	Relative frequency (PCT)	Cumulative frequency (PCT)
1	88	0.15	0.15
2	431	0.73	0.88
3	568	0.97	1.85
4	612	1.04	2.90
5	721	1.23	4.13
6	1,012	1.73	5.87
7	1,737	2.97	8.84
8	2,694	4.60	13.45
9	4,731	8.09	21.54
10	45,834	78.40	99.95
SUBTOTAL	58,428		
MISSING	27	0.04	
TOTAL	58,455		100.00

TABLE III.7 Condition of cows affecting record, absolute, relative and cumulative frequency

Code	Absolute frequency	Relative frequency (PCT)	Cumulative frequency (PCT)
0 (Normal)	35,146	60.12	60.12
1 (Sold)	4,258	7.28	67.40
2 (Mastitis)	164	0.28	67.68
3 (Inf. Disease)	39	0.06	67.75
4 (Died)	1,224	2.09	69.85
5 (Ill)	638	1.09	70.94
6 (Incomplete record)	16,621	28.43	99.37
7 (Abort)	178	0.30	99.68
8 (Transport)	186	0.31	99.99
SUBTOTAL	58.454		
MISSING	1	0.00	
TOTAL	58,455		100.00

TABLE III.8 Description of geographical region

Code	Altitude (mts)*	Temperature (°C)**	Rainfall (mm annual)	Relative humidity
1	2600 - 3400	10 - 14	750 - 1250	83 - 88
2	2250 - 2700	14 - 17	840 - 1100	73 - 82
3	2700 - 3100	11 - 13	800 - 1700	77 - 80
4	2500 - 2900	12 - 13	504 - 1400	75 - 90

*Meters above sea level.
**Celsius degrees.

TABLE III.8.1 Distribution of cows by region, absolute, relative and cumulative frequency

Code	Absolute frequency	Relative frequency (PCT)	Cumulative frequency (PCT)
1	10,913	18.66	18.66
2	5,743	9.82	28.49
3	20.761	35.51	64.00
4	20,911	35.77	99.98
SUBTOTAL	58,328		
MISSING	127	0.21	
TOTAL	58.455		100.00

TABLE III.9 Type of cows, absolute, relative and cumulative frequency

Code	Absolute frequency	Relative frequency (PCT)	Cumulative frequency (PCT)
1 (Pure)	8,458	14.46	14.46
2 (Grade)	42,350	72.44	86.91
SUBTOTAL	50,808		
MISSING	7.647	13.08	
TOTAL	58.455		100.00

TABLE III.10 Body conformation, absolute, relative and cumulative frequency

Code	Absolute frequency	Relative frequency (PCT)	Cumulative frequency (PCT)
0 (No classification)	53,784	92.00	92.00
1 (Poor)	4	0.00	92.01
2 (Regular)	605	1.03	93.05
3 (Good)	2,045	3.49	96.54
4 (More than good)	1,591	2.72	99.27
5 (Very good)	382	0.65	99.92
6 (Excellent)	44	0.07	
TOTAL	58.455		100.00

TABLE III.11 Lactation number, absolute, relative and cumulative frequency

Lactation number	Absolute frequency	Relative frequency (PCT)	Cumulative frequency (PCT)
1	19,137	32.73	32.73
2	11,521	19.70	52.44
3	6,931	11.85	64.30
4	2,812	4.81	69.11
5	1,189	2.03	71.14
6	528	0.90	72.05
7	157	0.26	72.32
8	25	0.04	72.36
SUBTOTAL	42,290		
MISSING	16,175	27.65	
TOTAL	58,455		100.00

TABLE III.12 Distribution of cows by region, absolute, relative and cumulative frequency for the edited data set

Area altitude	Code	Absolute frequency	Relative frequency (PCT)	Cumulative frequency (PCT)
2600-3100*	1	130	16.6	16.6
2250-2700*	2	7	.9	17.5
2700-3100*	3	295	37.6	55.0
2500-2900*	4	353	45.0	100.0
TOTAL		785	100.0	

*Meters above sea level.

TABLE III.13. Freshening year group at first lactation, absolute, relative and cumulative frequency

Year Group	Code	Absolute frequency	Relative frequency (PCT)	Cumulative frequency (PCT)
First*	1	60	7.6	7.6
Second**	2	335	42.7	50.3
Third***	3	390	49.7	100.0
TOTAL		785	100.0	

*1953-1957
**1958-1962
***1963-1967

TABLE III.14 Freshening month group at first lactation, absolute, relative and cumulative frequency

Month Group	Code	Absolute frequency	Relative frequency (PCT)	Cumulative frequency (PCT)
Jan.-Feb.	1	110	14.0	14.0
Mar.-Apr.	2	133	16.9	31.0
May-June	3	142	18.1	49.0
July-Aug.	4	133	16.9	66.0
Sept.-Oct.	5	119	15.2	81.0
Nov.-Dec.	6	148	18.9	100.0
TOTAL		785	100.0	

TABLE III.15 Freshening year group at second lactation, absolute, relative and cumulative frequency

Year Group	Code	Absolute frequency	Relative frequency (PCT)	Cumulative frequency (PCT)
First*	1	24	3.1	3.1
Second**	2	228	29.0	32.1
Third***	3	533	67.9	100.0
TOTAL		785	100.0	

*1953-1957
**1958-1962
***1963-1967

TABLE III.16 Freshening month group at second lactation, absolute, relative and cumulative frequency

Month Group	Code	Absolute frequency	Relative frequency (PCT)	Cumulative frequency (PCT)
Jan.-Feb.	1	121	15.4	15.4
Mar.-Apr.	2	128	16.3	31.7
May-June	3	129	16.4	48.2
July-Aug.	4	132	16.8	65.0
Sept.-Oct.	5	124	15.8	80.8
Nov.-Dec.	6	151	19.2	100.0
TOTAL		785	100.0	

TABLE III.17 Farm distribution, absolute, relative and cumulative frequency

Farm	Absolute frequency	Relative frequency (PCT)	Cumulative frequency (PCT)
3	25	3.2	3.2
18	12	1.5	4.7
19	22	2.8	7.5
20	30	3.8	11.3
21	13	1.7	13.0
22	28	3.6	16.6
63	7	.9	17.5
101	37	4.7	22.2
104	65	8.3	30.4
107	31	3.9	34.4
108	11	1.4	35.8
116	13	1.7	37.5
119	1	.1	37.6
120	27	3.4	41.0
121	68	8.7	49.7
126	23	2.9	52.6
134	17	2.2	45.8
136	2	.3	55.0
151	35	4.5	59.5
153	64	8.2	67.6
154	48	6.1	73.8
155	74	9.4	83.2
158	3	.4	83.6
159	4	.5	84.1
162	3	.4	84.5
168	43	5.5	89.9
170	45	5.7	95.7
172	11	1.4	97.1
174	15	1.9	99.0
175	8	1.0	100.0
TOTAL	785	100.0	

TABLE III.18 Sire distribution, absolute, relative and cumulative frequency

Sire I.D.	Absolute frequency	Relative frequency (PCT)	Cumulative frequency (PCT)
24	7	.9	.9
26	8	1.0	1.9
52	4	.5	2.4
54	5	.6	3.1
206	3	.4	3.4
232	3	.4	3.8
251	9	1.1	5.0
252	4	.5	5.5
269	8	1.0	6.5
299	12	1.5	8.0
378	5	.6	8.7
380	3	.4	9.0
431	9	1.1	10.2
432	8	1.0	11.2
440	5	.6	11.8
445	3	.4	12.2
447	4	.5	12.7
448	9	1.1	13.9
450	12	1.5	15.4
481	5	.6	16.1
504	4	.5	16.6
536	7	.9	17.5
546	2	.3	17.7
548	12	1.5	19.2
588	9	1.1	20.4
604	4	.5	20.9
609	3	.4	21.3
612	6	.8	22.0
641	17	2.2	24.2
678	2	.3	24.5
690	14	1.8	26.2
697	3	.4	26.6
744	2	.3	26.9
862	3	.4	27.3
866	8	1.0	28.3
888	6	1.0	29.9
938	2	.3	29.3
944	6	.8	30.1
949	3	.4	30.4
952	5	.6	31.1
1069	2	.3	31.3
1094	7	.9	32.2
1146	25	3.2	35.4
1172	2	.3	35.7

TABLE III.18 (continued)

Sire I.D.	Absolute frequency	Relative frequency (PCT)	Cumulative frequency (PCT)
1239	5	.6	36.3
1259	7	.9	37.2
1284	5	.6	37.8
1321	14	1.8	39.6
1322	7	.9	40.5
1360	8	1.0	41.5
1408	4	.5	42.0
1409	2	.3	42.3
1479	7	.9	43.2
1494	21	2.7	45.9
1519	22	2.8	48.7
1520	41	5.2	53.9
1523	24	3.1	56.9
1538	5	.6	57.6
1562	2	.3	57.8
1582	18	2.3	60.1
1587	13	1.7	61.8
1597	10	1.3	63.1
1662	2	.3	63.3
1783	2	.3	63.6
1801	4	.5	64.1
1870	16	2.0	66.1
1871	12	1.5	67.6
1881	4	.5	68.2
1969	4	.5	68.7
1993	38	4.8	73.5
2001	5	.6	74.1
2091	31	3.9	79.4
2092	37	4.7	84.1
2144	2	.3	84.3
2276	2	.3	84.6
2289	6	.8	85.4
2313	3	.4	85.7
2346	4	.5	86.2
2372	3	.4	86.6
2665	4	.5	87.1
2749	7	.9	88.0
2994	2	.3	88.3
153006	2	.3	88.5
153012	3	.4	88.9
153013	2	.3	89.2
153016	2	.3	89.4
153018	2	.3	89.7

TABLE III.18 (continued)

Sire I.D.	Absolute frequency	Relative frequency (PCT)	Cumulative frequency (PCT)
153073	14	1.8	91.5
153101	4	.5	92.0
153141	15	1.9	93.9
153152	3	.4	94.3
153194	3	.4	94.6
153251	2	.3	94.9
153252	9	1.1	96.1
153283	2	.3	96.3
153311	5	.6	96.9
153312	7	.9	97.8
153314	3	.4	98.2
153316	12	1.5	99.7
153344	2	.3	100.0
TOTAL	785	100.0	

III.2.1 Models Used

Three mixed models were used in this study. The elements of Model (i) were fixed factors area, year group, season groups, and its random portion sire. This model was used to test two way interactions.

$$\text{(i)}\quad Y_{ijklm} = M + \alpha_i + \beta_j + \partial_k + D_l + (\alpha\beta)_{ij} + (\alpha\partial)_{ik} + (\beta\partial)_{jk} + \varepsilon_{(ijklm)}$$

Where the subscripts:

i indicates the area (i = 1, 2, 3, 4)

j indicates the year group (J = 1, 2, 3)

k indicates the season group (k = 1, 2, 3, 4, 5, 6)

l indicates the sire (l = 1,...101)

m indicates the observation record within the th sire, kth season, jth year, and ith area or herd.

and

M is a common effect for all Y

α is a fixed area effect

β is a fixed year group effect

∂ is a fixed season group effect

D is a random sire effect

$(\alpha\beta)$ is a fixed area-year group interaction

$(\alpha\partial)$ is a fixed area-season group interaction

$(\beta\partial)$ is a fixed year group-season group interaction

is a residual error

The elements of Model (ii) were fixed factors area, year group, season group, and the random factor sire.

(ii) $Y_{ijklm} = M + \alpha_i + \beta_j + \partial_k + D_l + \varepsilon_{(ijklm)}$

Where the subscripts:

i indicates the area (i = 1, 2, 3, 4)

j indicates the year group (j = 1, 2, 3)

k indicates the season group (k = 1, 2, 3, 4, 5, 6)

l indicates the sire (l = 1,...101)

m indicates the observation record within the th sire, kth season, jth year, and ith area or herd.

and

M is a common effect for all Y

α is a fixed area effect

β is a fixed year group effect

∂ is a fixed season group effect

D is a random sire effect

ε is a residual error

In order to obtain more accurate sire estimates model (iii) in which herd is used instead of the fixed factor area was applied.

(iii) $Y_{ijklm} = M + \alpha_i + \beta_j + \partial_k + D_l + \varepsilon_{(ijklm)}$

Where the subscripts:

i indicates herd (i = 1...30)

j indicates the year group (j = 1, 2, 3)

k indicates the season group (k = 1, 2, 3, 4, 5, 6)

l indicates the sire (l = 1,...101)

m indicates the observation record within the lth sire, kth season, jth year, and ith area or herd

and

M is a common effect for all Y

α is a fixed herd effect

β is a fixed year group effect

∂ is a fixed season group effect

D is a random sire effect

ε is a residual error

With models ii and iii first and second lactation records were analyzed separately and factor estimates, percentages of the variance and BLUP estimates of sires were obtained using the following equation:

$$\begin{bmatrix} X'X & X'Z \\ Z'X & Z'Z + G^{-1} \end{bmatrix} \begin{bmatrix} \beta \\ U \end{bmatrix} = \begin{bmatrix} X'Y \\ Z'Y \end{bmatrix}$$

Where Y is the vector of observed records

B is the vector of unknown fixed effects for area, year, season is a random effect

X & Z are design matrices describing the contribution of fixed (X) and random (Z) effects to the records and,

G^{-1} identity matrix in which the variance ratio $\sigma e^2/\sigma s^2$ was added to the sire portion of the diagonal (submatrix Z' Z).

Adkinson (1974) using Ecuadorian data obtained values of heritability of 0.32±0.02, 0.48±0.03, and 0.68±0.03 for milk yield, fat yield and fat percentage, respectively. These values were used to calculate the Scalars: 11.500 for milk yield, 7.3333 for fat yield and 4.8824 for fat percentage, which were added to the $\underset{\sim}{Z}' \underset{\sim}{Z}$ submatrix according with the analyzed Y.

CHAPTER IV

RESULTS AND DISCUSSION

IV.1 Records Management

The analyzed data set tell us about management conditions on dairy farms in Ecuador during the study period. Frequency distributions for each one of the variables present in the records were obtained. A discussion of these follows.

IV.1.1 Age

The cow's age varies form one to thirteen years. Twenty two % of the records had no age information. Sixty-four % of the cow's were under 7 years and 36% were more than 7 years old (Table III.1). Age is important in relation to genetic progress, generation interval and profitability obtained from an animal. Age at first freshening was 35.47 months and 67 months at second freshening. Roman (1970) found an age average of 3.22 months in registered and 33.66 months in grade cows at first freshening and 47.83 and 48.85 months for registered and grade cows, respectively, at second freshening. Longevity is possitively correlated with production traits to select sires in Ecuador.

IV.1.2 Date of Birth

In the study period, 39% of the records had no year of birth information and 33% were incomplete with regard to month of birth (Tables III.2 and III.3). The difference of 6% between these two parameters suggest inaccurate record keeping at the farm. These factors are of primary importance to standardize milk production to mature equivalent.

IV.1.3 Freshening Date

In the data set shown in Tables III.4 and III.5, 13% of the records of year of freshening and 11% of the records of month of freshening were missing. Again the lost information is important in genetic type of work. Errors are always additive.

IV.1.4 Lactation Lenth

For lactation by month (Table III.6) 27 records were missing and 78% of the records had complete lactations. The incomplete lactation records increased from 0.2% in the first to 9% at the 9th month. Four % of the lactations were finished before the 3rd month period in which the lactation peak is achieved (Ferris, 1982). Other causes such as environmental, genetic, management or combinations of these could be the cause of incomplete lactations.

IV.1.5 Condition Affecting the Record (CAR)

One out of 58,455 records were missing in this variable (Table III.7). Sixty % of the records were normal lactations, 28% were incomplete lactations and 2% were reported from milking cows with mastitis or that had aborted.

IV.1.6 Area

The analyzed data set is coming from the Andean Zone where dairy operations are principally located in valleys within the different basins formed by the west and east mountain chains and their numerous connections between them. Four areas have been identified (Table III.8); their altitude goes from 2,500 to 3,400 meters above sea level; the weather is sui generis. The average temperature is between 10 to 14°C normally, but there are rare days with 1°C or highs of 29°C. Rainfall goes from 750 to 1,400 mm per year. It is not possible to define seasons as in the temperate areas of the world. However, two seasonal periods, wet and dry, are easily determined. Relative humidity varies from 73 to 90% the year around. Areas coded as 3 and 4 had the heavier cow density with 36% of the population (Table III.8.1).

IV.1.7 Type of Animal and Body Conformation

The data set was made up of two types of animals: grade cows which formed the larger group with 73%, and pure registered cows with 14%. Thirteen % of the records were missing (Table III.9). Ninety two % of the records had no type classification. This high percentage indicates the number of grade cows. Eight % were classified as regular, good, more than good or excellent (Table III.10). Body conformation is negatively correlated with production traits (Everett, 1977). Therefore, in Ecuador more emphasis must be given to age in sire selection.

IV.1.8 Lactation Number

Records up to eight lactations (Table III.11) have been recorded. Thirty three % corresponded to first, 20% to second, 12% to third lactation and the last 7% to lactations from the fourth to the eighth. Twenty eight % of the records were missing.

IV.1.9 Milk Production

Actual 2X, 305 days of milk and fat yields and fat percentages were obtained from 8,168 records which constituted 43% of the total first lactations, and from 6,770 records which constituted 58% of the total second lactations (Table IV.1). Production was 6,835 lb of milk with 3.44 fat % and 234 lb of fat in the first lactation; and 7,785 lb of milk with 3.41 fat % and 266 lb of fat in the second lactation. These values are lower than those found by Adkinson (1972) working with Ecuadorian data.

After standardization to M.E. the number of records was reduced (Table IV.2) to 4,932 records of first lactation and to 5,119 records of second lactation; the yields were 8,212 lb of milk, 3.35 fat % and 276 lb of fat in the first lactation and 8,654 lb of milk with 3.37 fat % and 291 lb of fat in the second lactation.

IV.2 Statistical Models

From the 58,455 records only 1,848 records had complete and valuable information corresponding to 5% of the first and 8% of the second lactations. From these a total of 1,570 records from both first and second lactations were selected for analysis. The absolute, relative and cumulative frequencies from each one of the chosen variables for the statistical models used are shown in Tables III.12 through III.18. Table IV.3 shows R^2 values resulting from fitting different models and "Y" variables in first and second lactations.

Model (i) was used to determine the effect of fixed factors and its interactions. Both Models (ii) and (iii) were used to rank sires having as fixed and random factors area, year, season, and sire or herd, year, season, and sire, respectively. These models were used because a confounding effect obtained with a model which included both area and herd effects. Herd effect was nested within area effect making unfeasible herd absorption. Analysis of variance for each one of the models is listed in Tables IV.4 to IV.8.

IV.2.1 Examination of Factor Effects

IV.2.1.1 Area

Area was found as a highly significant factor (P<0.01) using Fisher's test in models (i) and (ii) for milk yield, fat % and fat yield in both first and second lactation records (Tables IV.4 and IV.5).

IV.2.1.3 Year Group

Year group was highly significant (P <0.01) for milk yield, fat % and fat yield in first lactation records (Table IV.5) and for milk yield and fat yield in second lactation records using model (ii) (Table IV.6). Fat % using model (iii) (Table IV.8) as well as fat yield was significant (P<0.05) (Table IV.8). Similar results were obtained by Roman (1970), Adkinson (1972) and Rodriguez (1974).

IV.2.1.4 Season Group

Season-group was not a significant factor in any model for milk yield, fat % or fat yield. Roman (1970) found

TABLE IV. 1 Milk and fat yield, in pounds and fat percentage (actual records)

	Mean ($\bar{x}$)	Std. Error	Std. Dev.	Range
First Lactation (8168 Records)				
Milk yield (lb)	6835.45	1.90	172.35	1383
Fat (%)	34.45	0.03	2.66	53
Fat yield (lb)	234.11	0.62	56.23	727
Second Lactation (6770 Records)				
Milk yield (lb)	7785.24	2.28	188.14	1377
Fat (%)	34.16	0.03	2.69	51
Fat yield (lb)	266.56	0.74	61.00	760

TABLE IV.2 Milk and fat yield, in pounds and fat percentage (mature equivalent records)

	Mean ($\bar{x}$)	Std. Error	Std. Dev.	Range
First Lactation (4932 Records)				
Milk yield (lb)	8211.84	29.44	2068.07	15609.05
Fat (%)	3.35	0.00	0.31	5.16
Fat yield (lb)	275.85	0.94	66.36	894.08
Second Lactation (5119 Records)				
Milk yield (lb)	8654.17	28.53	2041.53	14047.70
Fat (%)	3.37	0.00	0.27	5.05
Fat yield (lb)	291.22	0.90	64.90	728.46

TABLE IV.3 R^2 statistics for the different models and "Y" variables in first and second lactations

	First Lactation			Second Lactation		
	Milk Yield	Fat %	Fat Yield	Milk Yield	Fat %	Fat Yield
Model i	0.3199					
Model ii	0.2935	0.1688	0.3080	0.2822	0.1279	0.2910
Model iii	0.4989	0.2123	0.4946	0.4824	0.1672	0.4762

TABLE IV.4 Summary of analysis of variance in first lactation region model (i)

Source of variance	df	Mean Square	F Test*
Area	3	1.284 E8	43.34 (1)
Year	2	3.215 E7	10.85 (1)
Season	5	2.648 E6	0.89
Sire	101	3.668 E6	1.24 (2)
Area-year	4	5.761 E6	1.96 (2)
Area-season	13	2.095 E6	0.71
Year-season	10	2.436 E6	0.82
Error	646	2.962 E6	
Total	784		

*Fisher's variance ratio.
(1) P<0.001.
(2) P<0.10.

TABLE IV.5 Summary of analysis of variance in first lactation region model (iii)

Source of variance	df	Mean Squares*		
		Milk Yield	Fat %	Fat Yield
Area	3	1.284 E8 (1)	0.55724 (1)	108303 (1)
Year	2	3.215 E7 (1)	0.35379 (1)	42684 (1)
Season	5	2.648 E6	0.04646	3366
Sire	101	3.668 E6 (1)	0.02213	5066 (1)
Error	673	2.976 E6	0.03981	3134
Total	784			

*Fisher's variance ration; test of significance.
(1) P<0.001.

TABLE IV.6 Summary of analysis of variance in second lactation region model (ii)

Source of	df	Mean Squares*		
		Milk Yield	Fat %	Fat Yield
Area	3	1.381 E8 (1)	0.48136	116437 (1)
Year	2	3.292 E7 (1)	0.04700	38424 (1)
Season	5	4.005 E6	0.00914	3184
Sire	101	3.935 E6	0.04496	6192 (1)
Error	673	3.394 E6	0.03165	3499
Total	784			

*Fisher's variance ratio; test of significance.
(1) P<0.001.

TABLE IV.7 Summary of analysis of variance in first lactation herd model (iii)

Source of variation	df	Mean Squares* Milk Yield	Fat %	Fat Yield
Herd	29	4.536 E7(1)	0.13946(1)	45888(1)
Year	2	2.248 E6	0.41402	8651
Season	5	2.016 E6	0.04475	2258
Sire	101	1.156 E6	0.02458	1526
Error	647	8.947 E5	0.03171	1506
Total	784			

*Fisher's variance ratio, test of significance.
(1) P<0.001.

TABLE IV.8 Summary of analysis of variance in second lactation herd model (iii)

Source of	df	Mean Squares* Milk Yield	Fat %	Fat Yield
Herd	29	4.962 E7(1)	0.11271(1)	49533(1)
Year	2	2.309 E6	0.08346(1)	3663(2)
Season	5	1.794 E6	0.04611	2493
Sire	101	1.566 E6	0.03122	2018
Error	647	8.368 E5	0.02765	1265
Total	784			

*Fisher's variance ratio; test of significance.
(1) P< 0.001.
(2) P< 0.05.

highly significant effects for fat % and fat yield using three month season groups. However, for sire ranking purposes under Ecuadorian conditions (rainy and dry seasons) the season-group effect sill remains to be demonstrated.

IV.2.1.5 Interactions

Effects of the two way interactions area-year, area-season and year-season were tested in model (i) (Table IV.4). They were not significant (P<0.10) and consequently they were eliminated from further analysis.

IV.2.1.6 Sire

Sire effects were found highly significant (P <0.001) in model (ii) for milk and fat yield in first lactation heifers and for fat yield in second lactation cows (Tables IV.5 and IV.6). Also, sire effects were significant (P <0.10) in model (i) (Table IV.4) but not significant for any variable in model (iii) in both first and second lactation records (Tables IV.7 and IV.8). These values agree with Roman (1970).

IV.3 Sire's Rank

Rank of sires using models (ii) and (iii) were obtained. Top and bottom sires were the same for first and second lactations in each model for milk and fat yields. For fat % the best and the worst sires were different in both lactations and models.

The range in model (ii) was higher for the analyzed production traits than in model (iii) (Table IV.9).

The sire's rank obtained in models (ii) and (iii) for milk yield were compared to the rank for the other traits in first and second lactations using Spearman's correlation of ranks (Table IV.10).

Higher correlations ($P<0.0001$) were obtained in model (iii) between lactations one and two. For lactation two model (ii) and for lactations one and two model (iii), the correlations were significant.

The rank of BLUP estimates in 305 day first and second lactations for milk yield, fat %, and fat yield in both models are summarized in Tables IV.11 to IV.16.

Herd model produced a higher R^2 in both lactation records for all production traits. Smaller error variance (σe2) was obtained using this model. Then, a more accurate estimate of sire effects could be obtained. The use of both area and herd models could be recommended in Ecuador. A computer run including herd in the model after deletion of all negative sire estimates obtained using model (ii) will produce a more confident estimation of sires.

TABLE IV.9 Range of BLUP estimates and its standard error in models (ii) and (iii) for milk yield, fat %, and fat yield in both first and second lactations

		Model (ii)			Model (iii)		
		Sire	Estimate	Std. Error	Sire	Estimate	Std. Error
	MY	1523	1700.53	303.76	153194	620.93	392.73
		944	-777.75	415.89	949	-589.06	394.50
L1	F%	251	0.13	0.61	251	0.12	0.06
		269	- 0.15	0.06	153344	- 0.13	0.08
	FY	1523	69.52	10.77	153194	29.47	15.38
		944	- 35.75	15.52	949	- 28.88	15.51
	MY	1523	1348.38	327.93	153194	860.28	442.54
		944	-894.10	444.76	604	-596.16	409.25
L2	F%	1881	0.13	0.08	678	0.12	0.09
		153344	- 0.12	0.08	1519	- 0.14	0.05
	FY	1523	52.81	11.41	153194	37.51	16.33
		944	- 41.97	16.44	604	- 27.48	15.63

TABLE IV.10 Sperman's rank correlation for models (ii) and (iii). All traits and lactations

			Area					Herd					
			Lactation 1			Lactation 2		Lactation 1			Lactation 2		
			MY	FZ	FY	MY	FZ	FY	MY	FZ	FY	MY	FZ	FY
		MY		0.75	0.50	0.50	1.00	0.50	0.50	0.75	0.50	0.50	0.96	0.50
	L1	FZ			0.75	0.75	0.75	0.74	0.74	0.94	0.74	0.75	0.72	0.75
AREA		FY				0.97	0.50	0.91	0.92	0.66	0.94	0.96	0.47	0.95
		MY					0.50	0.94	0.96	0.67	0.97	0.99	0.48	0.98
	L2	FZ						0.50	0.50	0.75	0.50	0.50	0.96	0.50
		FY							0.90	0.66	0.92	0.94	0.44	0.96
		MY								0.62	0.93	0.95	0.47	0.94
	L1	FZ									0.67	0.67	0.69	0.67
		FY										0.97	0.48	0.96
HERD		MY											0.48	0.98
	L2	FZ												0.48
		FY												

TABLE IV.11 Rank of sires - lactation 1 - milk yield

	Model Area (ii)			Model Herd (iii)		
Rank	Sire I.D.	Estimate	Std. Error	Sire I.D.	Estimate	Std. Error
1	1523	1700.53	306.75	153194	620.93	392.73
2	2072	1034.74	379.48	2091	497.39	282.55
3	612	926.39	415.77	2072	450.78	360.99
4	1960	899.04	440.64	1538	434.72	380.62
5	2373	875.12	454.55	431	398.33	348.71
6	2091	865.72	281.92	2373	388.80	394.51
7	1538	813.27	427.42	1969	382.76	413.76
8	153252	596.95	387.19	1520	341.00	240.83
9	153194	568.12	455.41	1519	335.66	275.15
10	1993	558.71	269.76	450	332.32	317.56
11	1360	531.97	396.41	1494	291.93	306.58
12	269	426.08	396.53	52	270.93	380.35
13	450	389.43	363.12	1360	259.07	355.34
14	2001	375.16	428.19	1662	231.83	405.41
15	2092	358.75	268.61	1409	213.20	404.79
16	1801	334.02	439.81	153006	204.03	404.84
17	448	318.44	389.60	604	188.84	379.74
18	888	300.35	416.75	153252	185.99	341.50
19	1409	254.81	470.71	1881	172.53	379.92
20	1479	241.82	407.52	1284	158.08	371.90
21	153006	227.94	470.53	2749	141.08	366.16
22	604	199.04	440.60	1523	140.08	319.48
23	1519	196.26	309.86	448	139.92	364.50
24	1662	183.66	470.49	1479	129.94	371.03
25	52	182.35	440.67	269	128.06	355.35
26	1881	160.16	441.25	612	113.43	369.58
27	24	151.24	414.07	1993	113.11	303.06
28	744	126.26	470.72	1562	109.63	404.61
29	481	124.65	426.89	1408	105.46	379.82
30	432	119.96	395.13	445	100.18	393.67
31	54	118.00	433.09	432	98.88	341.76
32	2665	122.84	441.50	504	98.00	400.77
33	153012	109.04	454.59	153314	83.86	392.42
34	153152	99.10	454.41	481	79.77	371.94
35	447	92.88	442.04	1582	77.48	306.94
36	153101	82.96	441.39	1801	77.18	379.41
37	431	81.59	394.87	678	77.02	406.17
38	2144	67.97	470.47	447	69.04	380.39
39	678	49.08	470.36	153012	68.67	391.52
40	1520	43.66	257.77	153141	62.17	303.33
41	1587	41.93	358.95	1871	59.92	340.85
42	1562	11.56	470.25	2276	59.40	405.61
43	153283	1.26	470.37	866	36.57	346.13
44	546	-1.67	470.32	1783	29.41	406.14
45	1408	-1.75	440.10	299	28.11	323.33

TABLE IV.11 (continued)

Rank	Model Area (ii) Sire I.D.	Estimate	Std. Error	Model Herd (iii) Sire I.D.	Estimate	Std. Error
46	1322	-11.22	405.39	944	28.00	398.28
47	2276	-34.86	470.74	153101	15.36	388.31
48	2994	-35.33	470.60	54	-5.34	374.55
49	1172	-48.29	470.73	2665	-9.46	381.82
50	153013	-54.70	470.35	1069	-11.33	409.53
51	866	-56.93	398.69	153152	-18.82	393.77
52	153314	-76.80	455.31	153344	-21.37	406.37
53	1284	-79.45	428.95	24	-28.63	359.86
54	949	-83.95	454.25	697	-33.15	393.00
55	938	-94.22	470.70	153312	-38.70	354.10
56	5360	-95.51	406.32	1322	-41.41	350.69
57	445	-95.93	454.15	380	-51.32	395.20
58	153344	-103.67	471.49	153311	-54.97	449.78
59	153251	-125.61	470.47	744	-56.96	406.25
60	1783	-128.16	470.75	2346	-58.88	381.54
61	1239	-128.39	426.82	440	-59.55	368.99
62	1259	-136.45	405.04	252	-65.52	379.54
63	1069	-150.66	470.36	153013	-67.70	405.08
64	2749	-161.67	405.48	588	-78.95	338.17
65	862	-164.16	455.39	546	-84.30	410.54
66	206	-164.87	454.61	2289	-84.38	372.14
67	380	-165.04	456.73	2313	-87.44	393.12
68	609	-173.57	454.82	153316	-90.25	325.11
69	440	-175.14	427.23	1092	-93.05	354.07
70	1871	-181.37	364.45	1259	-97.21	352.13
71	697	-184.51	454.97	2092	-105.17	280.18
72	1494	-196.36	319.26	153073	-109.26	335.92
73	251	-215.24	390.94	641	-111.51	303.56
74	690	-228.26	357.26	2144	-120.05	406.17
75	588	-232.81	385.87	2994	-125.55	439.21
76	1321	-234.77	349.38	251	-128.11	338.95
77	153016	-239.76	470.65	938	-138.08	407.13
78	952	-242.71	427.29	206	-139.60	394.81
79	2313	-268.01	455.32	1870	-147.11	327.76
80	153073	-282.43	349.77	1597	-148.99	336.51
81	26	-289.91	403.41	1321	-150.53	305.78
82	252	-299.67	439.84	952	-158.26	368.09
83	299	-300.52	361.94	2001	-170.15	374.31
84	641	-341.61	334.35	888	-170.88	375.59
85	153018	-379.27	470.60	690	-175.29	311.61
86	2346	-384.14	440.74	153282	-202.01	407.00
87	1093	-388.67	406.18	547	-213.51	315.20
88	153141	-395.48	342.73	609	-240.47	406.34
89	2289	-401.50	416.40	1587	-241.92	376.45

TABLE IV.11 (continued)

	Model Area (ii)			Model Herd (iii)		
Rank	Sire I.D.	Estimate	Std. Error	Sire I.D.	Estimate	Std. Error
90	1582	-422.15	330.72	232	-255.21	396.32
91	153311	-436.56	427.76	1146	-261.42	292.57
92	1870	-438.47	340.42	1172	-283.40	406.64
93	232	-444.57	457.43	153016	-292.04	404.73
94	1597	-488.63	378.46	153251	-313.65	406.17
95	153312	-503.66	404.70	862	-320.44	393.18
96	504	-507.38	440.71	536	-361.70	361.23
97	378	-586.77	428.31	26	-379.66	349.85
98	547	-652.13	361.97	153018	-380.11	405.62
99	153316	-713.03	363.81	378	-495.41	372.07
100	1146	-746.74	308.45	1239	-507.74	376.12
101	944	-777.75	415.89	949	-589.06	394.50

TABLE IV.12 Rank of sires - lactation 1 - fat %

	Model Area (ii)			Model Herd (iii)		
Rank	Sire I.D.	Estimate	Std. Error	Sire I.D.	Estimate	Std. Error
1	251	.12	.06	251	.11	.06
2	153251	.12	.08	153251	.11	.08
3	1582	.11	.04	2994	.11	.09
4	547	.09	.05	1582	.09	.05
5	1146	.09	.04	1523	.09	.05
6	24	.08	.06	547	.08	.05
7	588	.08	.06	206	.07	.07
8	206	.08	.07	1146	.07	.05
9	1520	.08	.03	1538	.07	.07
10	2994	.06	.08	862	.07	.07
11	153316	.06	.05	448	.07	.07
12	2665	.06	.07	588	.06	.06
13	1094	.06	.06	2665	.06	.07
14	1587	.06	.05	445	.06	.07
15	1322	.05	.06	2001	.06	.07
16	153006	.05	.08	2289	.06	.07
17	1259	.05	.06	153073	.06	.06
18	1538	.05	.07	24	.04	.06
19	862	.05	.07	1520	.04	.04
20	54	.05	.07	481	.04	.07
21	448	.05	.06	1094	.03	.06
22	2001	.04	.07	1993	.03	.05
23	153312	.04	.06	153066	.03	.08
24	26	.04	.06	1259	.03	.06
25	609	.04	.07	1969	.03	.08
26	2289	.04	.06	1322	.03	.06
27	697	.04	.07	2072	.02	.07
28	445	.03	.07	1587	.02	.07
29	481	.03	.07	609	.02	.08
30	153311	.02	.07	678	.02	.08
31	1523	.02	.04	54	.02	.07
32	440	.02	.07	1360	.02	.06
33	2144	.02	.08	153018	.02	.08
34	1562	.02	.08	153316	.01	.05
35	153018	.02	.08	1562	.01	.08
36	1881	.02	.07	440	.01	.07
37	153016	.01	.08	536	.01	.06
38	392	.01	.07	2144	.01	.08
39	252	.01	.07	252	.01	.07
40	153194	.01	.07	1881	.01	.07
41	1662	.00	.08	2373	.01	.07
42	447	.00	.07	26	.00	.06
43	432	.00	.06	2091	.00	.05
44	2072	.00	.05	697	.00	.07
45	604	.00	.07	153194	.00	.07

TABLE IV.12 (continued)

	Model Area (ii)			Model Herd (iii)		
Rank	Sire I.D.	Estimate	Std. Error	Sire I.D.	Estimate	Std. Error
46	378	.00	.07	153312	.00	.06
47	52	.00	.07	52	.00	.07
48	1969	-.00	.07	153016	.00	.08
49	153073	-.00	.05	1662	.00	.08
50	153012	-.00	.07	378	.00	.07
51	1783	-.00	.08	952	-.00	.07
52	678	-.00	.08	604	-.00	.07
53	641	-.00	.04	938	-.00	.08
54	1321	-.00	.05	2749	-.00	.07
55	1597	-.01	.05	447	-.00	.07
56	938	-.01	.08	153283	-.01	.08
57	1993	-.01	.03	432	-.01	.06
58	1408	-.01	.07	612	-.01	.07
59	2313	-.01	.07	153252	-.01	.06
60	2373	-.01	.07	153152	-.01	.07
61	1284	-.01	.07	641	-.01	.05
62	1519	-.02	.04	153311	-.01	.05
63	1360	-.02	.06	949	-.02	.07
64	536	-.02	.06	944	-.02	.08
65	153252	-.02	.06	380	-.02	.07
66	153283	-.02	.08	888	-.02	.07
67	690	-.02	.05	1408	-.02	.07
68	2749	-.03	.06	153101	-.02	.08
69	944	-.03	.06	232	-.02	.08
70	153141	-.03	.05	690	-.02	.05
71	2091	-.03	.04	2313	-.02	.07
72	1069	-.03	.06	153012	-.02	.07
73	232	-.03	.07	1597	-.02	.06
74	153101	-.03	.07	1479	-.02	.07
75	153152	-.03	.07	153314	-.02	.07
76	2276	-.04	.08	153141	-.02	.05
77	153314	-.04	.07	546	-.03	.08
78	1479	-.04	.06	1783	-.03	.08
79	1494	-.04	.04	2092	-.03	.05
80	1409	-.04	.08	1870	-.03	.06
81	888	-.04	.06	1284	-.03	.07
82	1870	-.04	.05	1871	-.03	.06
83	5040	-.04	.07	504	-.03	.08
84	1801	-.05	.07	1069	-.04	.08
85	2346	-.05	.07	1519	-.04	.04
86	380	-.05	.07	1801	-.04	.07
87	949	-.05	.07	1321	-.05	.05
88	153013	-.05	.08	1409	-.05	.08
89	612	-.05	.06	1172	-.05	.08
90	744	-.05	.08	431	-.06	.06

TABLE IV.12 (continued)

	Model Area (ii)			Model Herd (iii)		
Rank	Sire I.D.	Estimate	Std. Error	Sire I.D.	Estimate	Std. Error
91	1172	-.05	.08	744	-.06	.08
92	546	-.06	.08	1239	-.06	.07
93	431	-.06	.06	299	-.06	.05
94	1871	-.06	.05	2276	-.06	.08
95	450	-.07	.05	1494	-.07	.05
96	2092	-.07	.03	153013	-.07	.08
97	299	-.07	.05	2346	-.08	.07
98	866	-.07	.06	866	-.09	.06
99	1239	-.08	.07	269	-.11	.06
100	153344	-.14	.08	450	-.11	.05
101	269	-.15	.06	153344	-.12	.08

TABLE IV.13 Rank of sires - lactation 1 - fat yield

	Model Area (ii)			Model Herd (iii)		
Rank	Sire I.D.	Estimate	Std. Error	Sire I.D.	Estimate	Std. Error
1	1523	69.52	10.77	153194	29.46	15.38
2	2072	44.22	13.83	1538	26.83	14.82
3	2373	42.40	17.49	2072	21.91	13.88
4	1538	42.25	16.09	2091	20.90	10.40
5	1969	40.51	17.76	2373	20.12	15.51
6	612	40.06	15.51	1969	20.07	16.58
7	2091	33.36	9.78	1520	18.37	8.56
8	153194	28.50	17.54	1360	13.47	13.59
9	2001	21.23	16.12	153006	13.15	16.06
10	153252	20.97	14.17	52	12.96	14.71
11	1993	20.26	9.40	1523	12.09	11.90
12	1360	19.75	14.59	1582	12.04	11.42
13	448	17.60	14.28	1993	11.29	11.36
14	153006	15.50	18.37	448	10.88	14.02
15	24	12.48	15.45	431	10.37	13.20
16	450	11.14	13.08	1662	10.07	16.10
17	1801	11.08	16.71	1519	8.80	9.88
18	2092	10.52	9.30	604	8.17	14.67
19	2665	10.26	16.80	1562	7.96	16.04
20	1520	9.94	8.89	445	7.89	15.45
21	888	9.32	15.57	1881	7.86	14.69
22	54	9.30	16.39	1494	7.32	11.41
23	604	9.17	16.75	1409	6.07	16.05
24	1409	9.03	18.38	450	5.93	11.68
25	52	8.93	16.76	1284	5.54	14.27
26	1662	8.15	18.37	481	5.45	14.27
27	1479	7.88	15.12	612	5.26	14.23
28	1587	7.87	12.94	2665	4.97	14.79
29	1881	7.35	16.79	678	4.96	16.15
30	481	6.66	16.05	2745	4.59	14.11
31	2144	6.08	18.37	153252	4.42	12.83
32	269	5.19	14.60	1408	2.85	14.68
33	1322	5.09	15.00	1479	3.23	14.34
34	153012	4.87	17.49	447	2.82	14.72
35	447	4.81	16.83	504	2.62	15.94
36	1519	4.58	10.87	24	2.44	13.69
37	432	4.28	14.52	153315	2.29	15.36
38	1562	2.73	18.35	251	2.24	12.65
39	153251	2.68	18.37	432	2.15	12.78
40	744	2.61	18.38	1322	1.99	13.21
41	678	2.40	18.36	153012	1.65	15.31
42	2994	2.20	18.38	54	1.63	14.43
43	153101	1.81	16.80	588	1.55	12.61
44	153152	1.49	17.49	944	1.02	15.80
45	1408	-.60	16.73	153141	.98	11.05

TABLE IV.13 (continued)

Rank	Model Area (ii)			Model Herd (iii)		
	Sire I.D.	Estimate	Std. Error	Sire I.D.	Estimate	Std. Error
46	251	-.66	14.33	1871	.20	12.93
47	153282	-1.35	18.36	1783	.15	16.13
48	546	-1.83	18.36	2994	.01	18.16
49	445	-2.64	17.47	153073	-.12	12.65
50	1259	-3.21	14.99	2276	-.35	16.10
51	2276	-3.27	18.38	440	-.54	14.12
52	588	-3.38	14.09	1801	-.75	14.67
53	206	-3.57	17.49	697	-.91	15.39
54	431	-4.14	14.54	153312	-.91	13.40
55	862	-4.15	17.54	153101	-1.04	15.20
56	938	-4.56	18.38	2289	-1.32	14.39
57	1284	-4.92	16.16	1094	-1.36	13.38
58	153013	-5.35	18.36	153311	-1.47	18.93
59	440	-5.63	16.07	153152	-1.55	15.48
60	1582	-5.72	11.75	269	-2.03	13.59
61	949	-5.95	17.48	252	-2.30	14.67
62	609	-6.02	17.51	153316	-2.44	12.06
63	1783	-6.04	18.38	547	-2.55	11.57
64	697	-6.13	17.52	299	-2.61	11.94
65	153314	-6.20	17.53	206	-2.80	15.49
66	1172	-6.40	18.38	1069	-2.91	16.33
67	866	-7.23	14.70	1259	-3.09	13.28
68	1321	-8.08	12.49	866	-3.55	13.00
69	536	-8.20	15.06	2001	-3.61	14.42
70	1069	-8.74	18.36	1146	-3.74	10.83
71	2749	-8.95	15.02	380	-3.88	15.52
72	1494	-9.41	11.30	2144	-4.03	16.14
73	153073	-9.70	12.51	546	-4.17	16.40
74	1871	-10.45	13.16	2313	-4.59	15.43
75	153016	-10.49	18.38	2092	-5.18	10.30
76	26	-10.75	14.92	2346	-5.60	14.79
77	380	-10.76	17.62	641	-5.73	11.20
78	2313	-12.03	17.54	938	-6.64	16.21
79	1239	-12.10	16.05	153013	-7.21	16.07
80	153344	-12.56	18.43	744	-7.26	16.14
81	1094	-13.25	15.05	153344	-7.39	16.15
82	252	-13.55	16.71	153251	-7.42	16.14
83	641	-14.34	11.87	1321	-7.79	11.15
84	2289	-15.70	15.55	1597	-8.33	12.67
85	952	-16.36	16.07	1587	-9.69	14.58
86	299	-16.66	13.02	1870	-9.20	12.39
87	153311	-17.05	16.10	888	-.953	14.58
88	153018	-17.78	18.37	862	-9.74	15.40
89	153141	-18.05	12.20	153282	-10.20	16.21
90	2346	-18.89	16.76	609	-11.35	16.15

TABLE IV.13 (continued)

Rank	Model Area (ii)			Model Herd (iii)		
	Sire I.D.	Estimate	Std. Error	Sire I.D.	Estimate	Std. Error
91	153312	-19.44	14.97	232	-13.23	15.60
92	1870	-19.94	12.15	952	-13.62	14.07
93	547	-20.37	13.03	153016	-13.85	16.05
94	1597	-21.28	13.78	536	-14.62	13.87
95	1146	-21.46	10.86	26	-16.62	13.18
96	690	-21.81	12.85	153018	-17.91	16.10
97	232	-23.31	17.66	1172	-18.12	16.17
98	153316	-25.80	13.12	690	-18.56	11.42
99	378	-26.45	16.13	378	-22.43	14.28
100	504	-26.50	16.76	1239	-27.25	14.56
101	944	-35.75	15.52	949	-28.88	15.51

TABLE IV.14 Rank of sires - lactation 2 - milk yield

Rank	Model Area (ii)			Model Herd (iii)		
	Sire I.D.	Estimate	Std. Error	Sire I.D.	Estimate	Std. Error
1	1523	1348.38	327.92	153194	860.28	422.54
2	2072	959.17	404.41	450	497.13	343.37
3	153194	773.81	485.92	1360	367.68	382.14
4	2092	771.35	284.95	481	357.33	400.18
5	1538	746.64	456.49	2092	303.31	301.26
6	450	708.57	388.67	1969	284.79	445.11
7	1360	681.62	422.31	1538	276.05	409.77
8	612	668.85	443.86	588	273.07	363.89
9	2373	622.99	485.16	1146	268.68	314.46
10	1969	616.59	470.29	1479	266.70	399.62
11	153252	576.22	413.20	1409	254.83	435.82
12	2091	554.60	299.91	1094	254.15	381.63
13	1993	510.97	287.61	2072	251.21	387.35
14	269	499.59	424.31	1519	249.76	295.38
15	481	399.51	455.60	1322	249.33	377.66
16	1322	382.64	432.60	866	243.02	372.18
17	2001	370.27	456.45	2276	232.66	436.73
18	1479	358.13	435.21	1284	228.35	400.17
19	1409	337.57	502.59	2373	203.11	424.68
20	744	318.29	502.20	2091	185.26	303.72
21	888	301.32	443.75	2313	178.30	422.36
22	1519	255.55	330.57	546	172.36	441.99
23	432	253.38	422.30	432	151.85	368.59
24	448	249.93	416.65	447	150.94	408.45
25	1801	229.14	470.08	641	148.29	328.01
26	153006	217.36	502.80	153006	147.31	435.98
27	447	199.31	470.20	269	129.83	383.55
28	1587	195.94	381.67	440	128.31	396.44
29	536	191.76	433.88	153344	101.12	440.28
30	1172	189.01	502.46	1520	96.72	260.69
31	1239	177.87	455.51	445	93.57	423.76
32	546	158.39	501.95	153101	90.70	417.89
33	153101	157.59	471.06	448	90.37	392.02
34	866	146.49	425.24	1523	84.33	343.10
35	2665	146.42	471.31	678	78.43	437.42
36	588	144.09	411.31	944	77.35	428.92
37	2276	136.62	502.78	1662	72.99	436.40
38	949	135.51	485.12	744	66.45	437.19
39	2994	124.98	502.48	153316	60.97	351.13
40	153251	114.23	502.20	1408	53.28	409.24
41	938	88.40	502.50	153252	49.35	367.42
42	153012	73.95	484.91	938	42.25	438.24
43	1284	70.73	457.86	697	37.28	423.60
44	862	48.22	486.80	52	31.03	408.80
45	26	26.31	431.27	2665	24.10	410.86

TABLE IV.14 (continued)

Rank	Model Area (ii) Sire I.D.	Estimate	Std. Error	Model Herd (iii) Sire I.D.	Estimate	Std. Error
46	54	12.03	472.48	1801	15.61	408.71
47	67	11.14	502.34	2994	13.65	472.89
48	440	9.23	455.35	153312	10.15	381.59
49	2313	6.29	485.18	299	6.84	346.10
50	251	2.36	418.00	612	.53	397.74
51	1662	-5.51	502.20	2749	-1.45	394.08
52	2144	-7.24	502.20	251	-2.96	365.97
53	52	-14.96	469.76	504	-6.59	431.43
54	153344	-19.09	505.79	1562	-6.69	435.51
55	1094	-22.98	433.93	1993	-15.02	327.53
56	24	-33.13	458.18	153012	-31.83	421.23
57	153283	-37.10	502.18	54	-41.57	409.80
58	1321	-47.75	375.19	232	-42.18	424.54
59	1520	-49.41	277.96	2289	-46.38	400.57
60	641	-56.74	357.92	153073	-50.23	361.79
61	1408	-67.75	470.14	431	-50.63	370.72
62	153152	-71.20	485.29	380	-54.57	424.30
63	1562	-73.13	502.04	153314	-55.58	422.20
64	690	-77.93	380.33	1582	-57.62	329.31
65	697	-129.95	485.99	1783	-68.98	437.04
66	445	-130.04	484.65	206	-87.07	425.75
67	1146	-138.59	329.04	1494	-88.49	328.64
68	206	-142.73	486.34	26	-96.41	376.62
69	609	-149.71	485.27	1172	-96.78	437.77
70	153013	-160.08	502.08	1587	-105.90	405.03
71	153018	-196.19	502.58	2001	-107.24	402.43
72	153016	-216.44	502.38	2346	-122.74	410.63
73	380	-226.88	485.72	24	-126.42	397.84
74	299	-227.13	385.77	69	-128.68	334.28
75	1881	-230.62	471.20	536	-137.31	389.26
76	232	-246.21	485.72	153251	-137.60	437.19
77	153314	-246.24	485.29	153311	-137.71	483.56
78	1783	-248.45	502.45	1321	-154.40	330.14
79	153073	-343.72	375.93	862	-160.76	423.79
80	2346	-349.52	470.77	153141	-161.70	324.93
81	153312	-395.59	432.71	609	-189.04	437.35
82	431	-416.11	415.33	1881	-202.17	409.21
83	153311	-417.60	456.33	153152	-206.42	423.93
84	1259	-435.41	432.67	153018	-207.97	436.75
85	1069	-448.09	502.20	1239	-218.34	404.52
86	153141	-465.54	365.23	153013	-222.84	436.25
87	952	-468.21	456.02	1871	-225.11	366.94
88	252	-473.39	469.88	1870	-232.30	352.38
89	153316	-475.47	389.64	1069	-251.67	441.03
90	378	-541.75	457.35	888	-255.66	403.74

TABLE IV.14 (continued)

Rank	Model Area (ii)			Model Herd (iii)		
	Sire I.D.	Estimate	Std. Error	Sire I.D.	Estimate	Std. Error
91	1494	-548.31	340.11	2144	-259.08	437.19
92	1582	-567.02	352.33	949	-265.29	424.68
93	2289	-609.10	444.06	153283	-265.93	438.12
94	2749	-621.86	432.80	252	-270.20	408.81
95	604	-633.87	471.05	153016	-302.54	435.64
96	547	-670.25	386.04	547	-352.69	339.06
97	504	-713.09	470.02	1259	-387.97	379.26
98	1597	-811.91	404.47	378	-391.31	400.45
99	1871	-817.80	388.75	1597	-439.10	363.26
100	187	-878.37	363.48	952	-446.07	396.16
101	944	-894.10	444.76	604	-596.16	409.24

TABLE IV.15 Rank of sires - lactation 2 - fat %

	Model Area (ii)			Model Herd (iii)		
Rank	Sire I.D.	Estimate	Std. Error	Sire I.D.	Estimate	Std. Error
1	1881	.13	.07	678	.12	.08
2	1322	.12	.06	1881	.12	.07
3	206	.10	.08	1322	.10	.06
4	153018	.10	.08	1408	.08	.07
5	678	.09	.08	206	.08	.08
6	1408	.08	.07	153018	.08	.08
7	2665	.08	.07	888	.07	.07
8	4400	.07	.07	2665	.07	.07
9	2001	.07	.07	862	.07	.08
10	888	.07	.06	2001	.06	.07
11	547	.06	.05	536	.06	.07
12	862	.05	.08	440	.06	.07
13	153316	.04	.05	1146	.05	.05
14	153012	.04	.07	153311	.04	.10
15	5400	.04	.07	540	.04	.07
16	1146	.04	.04	547	.04	.05
17	2520	.04	.07	2749	.04	.07
18	5880	.04	.06	269	.04	.07
19	153251	.04	.08	641	.04	.05
20	2749	.03	.06	1523	.04	.05
21	2320	.03	.07	612	.04	.07
22	2289	.03	.06	153012	.03	.07
23	153311	.03	.07	2289	.03	.07
24	1582	.03	.04	2994	.03	.10
25	1562	.03	.08	153251	.03	.08
26	1783	.03	.08	153316	.03	.06
27	153314	.02	.07	252	.02	.07
28	378	.02	.07	1582	.02	.05
29	690	.02	.05	1969	.02	.08
30	1969	.02	.07	24	.02	.07
31	481	.02	.07	938	.02	.08
32	536	.02	.06	1562	.02	.08
33	24	.02	.07	232	.02	.08
34	697	.02	.08	1479	.01	.07
35	2276	.02	.08	153006	.01	.08
36	1321	.02	.05	944	.01	.08
37	2994	.01	.08	588	.01	.06
38	153006	.01	.08	1783	.01	.08
39	641	.01	.05	153314	.01	.08
40	432	.01	.06	690	.01	.05
41	153312	.01	.06	697	.00	.08
42	604	.01	.07	2276	.00	.08
43	520	.01	.07	378	.00	.07
44	1520	.01	.03	432	.00	.06
45	609	.01	.07	1801	.00	.07

TABLE IV.15 (continued)

Rank	Model Area (ii) Sire I.D.	Estimate	Std. Error	Model Herd (iii) Sire I.D.	Estimate	Std. Error
46	380	.00	.07	604	.00	.07
47	612	.00	.06	1172	.00	.08
48	1587	.00	.05	4481	.00	.07
49	1259	.00	.06	153312	.00	.06
50	744	.00	.08	1538	.00	.07
51	251	.00	.06	153073	.00	.06
52	938	.00	.08	481	-.00	.07
53	1538	.00	.07	1321	-.00	.05
54	1801	.00	.07	2373	-.00	.08
55	1172	-.00	.07	1259	-.00	.06
56	2346	-.00	.07	1259	-.00	.06
57	2144	-.00	.08	1239	-.00	.07
58	269	-.00	.06	2346	-.00	.07
59	1094	-.00	.06	2144	-.01	.08
60	1523	-.00	.04	609	-.01	.08
61	1069	-.00	.08	520	-.01	.07
62	153016	-.00	.08	380	-.01	.08
63	1409	-.01	.08	153282	-.01	.08
64	2313	-.01	.07	504	-.01	.08
65	153283	-.01	.08	1871	-.01	.06
66	1239	-.01	.07	2313	-.01	.08
67	1479	-.02	.06	1587	-.01	.07
68	153194	-.02	.08	153016	-.01	.08
69	431	-.02	.06	251	-.01	.06
70	866	-.02	.06	1409	-.01	.08
71	153141	-.02	.05	1662	-.02	.08
72	2373	-.02	.07	1094	-.02	.06
73	1662	-.02	.08	1520	-.02	.04
74	1494	-.02	.04	153152	-.02	.08
75	447	-.03	.07	2092	-.02	.05
76	260	-.03	.06	1069	-.02	.08
77	1871	-.03	.05	1993	-.02	.05
78	153013	-.03	.08	1494	-.03	.05
79	944	-.03	.06	26	-.03	.06
80	153152	-.04	.07	431	-.03	.06
81	1284	-.04	.07	153194	-.03	.08
82	448	-.04	.06	546	-.03	.08
83	153073	-.04	.05	2091	-.03	.05
84	450	-.04	.05	447	-.04	.07
85	952	-.04	.07	153013	-.04	.08
86	1597	-.05	.05	949	-.05	.08
87	187	-.06	.05	445	-.05	.08
88	546	-.06	.08	866	-.05	.06
89	504	-.06	.07	153141	-.05	.05
90	153252	-.07	.06	187	-.05	.06

TABLE IV.15 (continued)

Rank	Model Area (ii)			Model Herd (iii)		
	Sire I.D.	Estimate	Std. Error	Sire I.D.	Estimate	Std. Error
91	2092	-.07	.03	1360	-.05	.06
92	1993	-.07	.03	450	-.05	.05
93	949	-.07	.07	1284	-.05	.07
94	299	-.07	.05	153252	-.06	.06
95	2091	-.07	.04	1597	-.06	.06
96	2072	-.08	.05	952	-.06	.07
97	455	-.09	.07	153101	-.08	.07
98	1360	-.09	.06	2072	-.08	.07
99	1519	-.10	.04	299	-.12	.05
100	153101	-.11	.07	153344	-.12	.08
101	153344	-.11	.08	1519	-.13	.04

TABLE IV.16 Rank of sires - lactation 2 - fat yield

Rank	Model Area (ii)			Model Herd (iii)		
	Sire I.D.	Estimate	Std. Error	Sire I.D.	Estimate	Std. Error
1	1523	52.85	11.40	153194	37.51	16.33
2	153194	34.50	18.52	1322	18.49	14.05
3	1538	32.75	17.01	481	16.76	15.15
4	612	32.16	16.39	1969	15.73	17.60
5	2072	31.38	14.58	450	15.67	12.48
6	1969	30.30	17.70	588	14.18	13.40
7	2373	27.99	18.48	1479	13.31	15.25
8	1322	25.82	15.85	1538	13.22	15.76
9	450	25.49	13.87	678	12.94	17.17
10	2001	24.28	17.00	1360	11.86	14.43
11	2092	24.16	9.76	440	11.04	14.97
12	1360	21.10	15.38	1146	10.99	11.49
13	481	20.94	16.96	1409	10.48	17.06
14	888	19.43	16.39	2092	9.67	10.93
15	153252	18.26	14.97	2373	9.09	16.48
16	269	17.20	15.48	1094	9.00	14.24
17	2091	17.05	10.31	153006	8.48	17.07
18	744	15.94	19.41	641	8.34	11.96
19	1409	14.87	19.43	1284	7.75	15.16
20	1479	13.48	15.98	2313	7.60	16.35
21	2665	12.30	17.75	2276	7.59	17.12
22	432	12.14	15.36	1408	7.53	15.62
23	1993	12.10	9.91	1523	6.97	12.62
24	153006	12.03	19.44	432	6.73	13.61
25	1172	11.38	19.42	269	6.66	14.49
26	588	10.93	14.86	2665	6.46	15.71
27	1801	10.67	17.69	866	6.25	13.79
28	536	9.53	15.92	546	6.16	17.43
29	153251	9.44	19.41	2091	5.52	11.03
30	1587	9.30	13.60	153316	5.13	12.87
31	678	8.59	19.41	944	5.11	16.80
32	2994	8.10	19.42	938	4.23	17.23
33	447	6.75	17.69	2072	3.92	14.69
34	153012	6.46	18.46	380	3.91	16.43
35	440	6.44	16.94	2994	3.85	19.30
36	448	5.85	15.12	612	3.85	15.12
37	862	4.74	18.57	448	3.84	14.88
38	939	4.65	19.42	447	3.71	15.58
39	866	4.17	15.51	744	3.19	17.15
40	546	4.12	19.39	1662	2.83	9.15
41	1239	3.82	16.95	1520	2.14	15.00
42	540	3.73	17.86	2749	1.99	15.60
43	2276	3.59	19.44	52	1.83	16.39
44	24	3.31	17.15	697	1.82	16.39
45	1519	2.50	11.48	1582	1.36	12.08

TABLE IV.16 (continued)

Rank	Model Area (ii)			Model Herd (iii)		
	Sire I.D.	Estimate	Std. Error	Sire I.D.	Estimate	Std. Error
46	1408	1.87	17.69	2001	1.07	15.30
47	949	1.65	18.48	54	1.05	15.70
48	1284	1.55	17.08	1562	.98	17.05
49	52	1.42	17.67	445	.86	16.42
50	251	.53	15.17	153012	.62	16.26
51	153101	.45	17.74	153312	.47	14.27
52	1520	.29	9.51	1801	.41	15.60
53	690	-.23	13.53	153101	.18	16.15
54	2144	-.28	19.41	536	.02	14.75
55	2313	-.30	18.48	232	-.23	16.47
56	1321	-.94	13.29	1519	-.54	10.47
57	1662	-1.11	19.41	206	-.69	16.51
58	26	-1.23	15.80	24	-.86	15.09
59	1562	-1.58	19.40	2289	-.86	15.30
60	1094	-1.80	15.91	153073	-1.12	13.45
61	206	-1.81	18.54	251	-1.15	13.50
62	641	-1.99	12.59	1993	-1.19	12.13
63	380	-2.82	18.51	504	-1.41	16.94
64	153283	-3.17	19.41	153314	-1.77	16.31
65	153018	-4.30	19.43	1783	-2.13	17.13
66	1881	-4.57	17.75	1172	-2.25	17.18
67	697	-5.30	18.52	888	-2.97	15.47
68	1146	-5.85	11.47	153252	-3.08	13.62
69	153152	-6.68	18.49	690	-3.28	12.08
70	609	-6.71	18.49	153251	-3.31	17.15
71	153344	-9.16	19.62	862	-3.72	16.40
72	153013	-9.43	19.40	153344	-3.73	17.33
73	153314	-9.56	18.48	1881	-4.04	15.62
74	232	-9.84	18.51	431	-4.74	13.81
75	1783	-9.95	19.42	153311	-5.05	20.08
76	153016	-10.74	19.41	1494	-5.29	12.05
77	445	-11.94	18.45	153018	-5.99	17.12
78	299	-14.69	13.73	2346	-6.21	15.71
79	153316	-14.91	13.92	1587	-6.24	15.49
80	153073	-15.17	13.34	26	-6.76	14.01
81	153312	-15.77	15.86	1321	-6.83	11.89
82	153311	-16.24	17.00	299	-7.87	12.60
83	2346	-16.40	17.73	609	-10.19	17.16
84	1582	-18.06	12.38	153141	-10.81	11.67
85	1259	-18.52	15.85	153152	-10.92	16.45
86	431	-20.05	15.06	1239	-11.81	15.45
87	252	-20.48	17.68	1871	-11.86	13.75
88	153141	-20.66	12.87	252	-12.25	15.60
89	1069	-21.84	19.41	547	-12.42	12.29
90	952	-22.22	16.98	2144	-13.03	17.15

TABLE IV.16 (continued)

Rank	Model Area (ii)			Model Herd (iii)		
	Sire I.D.	Estimate	Std. Error	Sire I.D.	Estimate	Std. Error
91	1494	-22.76	11.90	153013	-13.31	17.09
92	2749	-23.66	15.87	1069	-13.36	17.37
93	547	-24.13	13.75	153283	-13.55	17.22
94	378	-24.20	17.05	1870	-14.24	13.14
95	2289	-24.27	16.40	153016	-15.54	17.05
96	604	-28.50	17.74	949	-16.45	16.48
97	871	-35.50	13.89	1259	-17.50	14.12
98	504	-37.47	17.69	378	-18.96	15.17
99	1870	-37.62	12.84	952	-22.86	14.95
100	1597	-37.99	14.58	1597	-22.95	13.51
101	944	-41.97	16.44	604	-27.48	15.62

CHAPTER V

SUMMARY AND CONCLUSIONS

Ranking of Ecuadorian sires from the official milk testing program was conducted in both first and second lactation records using BLUP approach in three statistical models and computer programs from Genstat.

The highest R^2 (0.50) was obtained for first lactation records with a model which includes herd, year group, season group, and sire as sources of variation.

The smallest error variance ($\sigma^2 e$) was obtained with the same model but with second lactation records.

Using Spearman's correlation to compare ranking of sires the highest value 0.98 was obtained between models (ii) and (iii) and milk and fat yield.

Results of analysis of variance and significance tests show that the fixed factors of area, herd, and year group were highly significant ($P<0.001$) in all models. Season group and the two way interactions area-year, area-season, and year-season were not significant ($P<0.05$) in any model for sire ranking purposes.

Ranking of sires using first lactation records in a model which includes herd, year, season, and sire as sources of variation is recommended for the Ecuadorian conditions.

An efficient system for keeping and managing dairy records is necessary in Ecuador. From 58,455 analyzed dairy lactation records only 3.16% were complete and 84.95% of those were used for sire ranking purposes. Milk yield, fat percentage, and fat yield (ME, 2X) was 8211.84 lb, 3.35, 275.85 lb respectively for the first lactation and 8,654.17 lb, 3.37 and 291.22 lb for the second lactation.

Extension work on dairy farms in Ecuador is required. Government, universities, and research institutions should work together to generate more accurate information.

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