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Optimization of Dairy Cattle Breeding Strategy in Israel and in the United States

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GENERAL ABSTRACT

Research was carried out on national dairy cattle milk records and insemination reports focussing on genetic and environmental effects on dystocia, calf viability, reproduction and type traits and their interrelationship with yields, and yield persistency within and across lactations

Three experiments were carried out for (i) progeny testing top proven sires from five Holstein-Friesian national strains in high yielding dairy herds, (ii) comparing yields, health and production economy of cows produced from high versus average Holstein sires, and (iii) investigating the interrelationship between genetic and endo-environmental associations in laboratory rats.

Highest daily yields were achieved when calving intervals of primi- and multiparous cows were 12 and 11 months respectively, and one month longer when following lactation yields were considered. The genetic association between nulliparous fertility and primiparous yields was positive, however variable between cow fertility and yields. Herd yields and conception rates were positively associated, but high yields prior to insemination affected conception rate negatively.

Dystocia is unrelated to production and slightly antagonistic to type scores. Genetic effects on dystocia and calf mortality were highly correlated and the effect of the calf masks the maternal effect. Sire evaluation by multi-trait methods, taking into account dystocia, and calf mortality in calvings of heifer and cow mates and daughters, was suggested.

Breeding for production aggrevated health problems, but lifetime profit increased markedly with increased yields. Genetic and phenotypic variation across years decreased in Israeli dairy herds for first, but not for second and third lactations. Findings implied the need for second lactation progeny tests for final sire selection.

GENERAL INTRODUCTION

The purpose of our study was to investigate methods and means for comprehensive improvement of dairy cows. The research design and approach were set up jointly by the ISU and ARO groups. However, each group worked independently on the basis of its national data banks for milk records and insemination reports.

Besides the analyses of data sets , three investigations were carried out:

i) In Israel an experiment was started to compare daughters of Holstein Friesian bulls from 5 countries shown to have highest yields in the FAO trial in Poland. The purpose of this experiment was to investigate possible genetic variation in productivity and health among top representatives of these strains.

ii) In the ISU dairy herd, two Holstein sub-strains were developed, one producing high and the other moderate milk yields. The fertility and health performance of these strains were investigated and analyzed from an economic viewpoint.

iii) At the ARO four sub-strains of Rattus Norvegicus were developed for investigating the role of genetic by endo-environmental interactions on genetic correlation parameter estimates.

It had been planned that the senior ISU investigator would visit ARO to draft an integrated final report. As this plan was not realized, the final scientific report is presented in sections. The ISU part is presented first and it contains the introductory discussion of the issues investigated.

A continuous list of references was prepared containing publications under the project and relevant literature. The list was arranged in three parts: a. ISU publications; b. ARO publications; c. relevant bibliography.

D1. SCIENTIFIC REPORT (ISU)

A B S T R A C T

Recent work with the genetic aspects of dystocia, reproduction, and its association with production and calf livability are presented and the literature is reviewed. Measures of reproduction and production are presented. Direct genetic and maternal effects, sire evaluation by births from heifers and older cows, and correlations with production and type are discussed for dystocia. Heritabilities of measures of reproduction were low. Fertility and production were antagonistic in cows, but complementary between heifer breedings and production in first lactation. Previous and current reproductive performance, including days dry, have major effects on present production. Increased production is associated with increased health problems, but lifetime profit increases markedly with increased production. There were differences among sires for calf mortality up to 48 h after birth, but heritabilities were low. Livability and dystocia are closely correlated genetically. Sire evaluation should ideally use multiple-trait methods. Linear scoring of conformation results in higher heritabilities of the traits, and offers possibilities for gaining new knowledge relating conformation to economy of production.

INTRODUCTION

Selection for milk production in the United States has been effective with consistent genetic gain in the last few years (97). Major research efforts have developed the methods of sire selection and evaluation currently practised for production. In contrast, there has been comparatively little genetic research in the United States on the reproductive complex, cow health related to production, and linear type until fairly recently. Sires have been evaluated and selected for reproductive traits in addition to production and other traits of economic importance in the northern European countries and Israel. In the United States, selection has been poorly organized for daughter reproduction though sires have been culled for low fertility. Sires have been evaluated for conformation, or type, of their daughters, but scoring has been relative to a preconceived ideal.

Reproductive problems account for 16% of all disposals of Holsteins in the United States (84, 107), 27% in Israeli Holsteins (66), and rank second to production as a reason for disposal. Pelissier (87) discussed costs of low fertility and estimated the total costs of low fertility from milk losses, calf losses, replacement costs, veterinary services and medication, and additional breeding costs to be $116.25 per cow in 1981. This accumulates to 1,266 billion dollars for the U.S. dairy industry per year.

The reproductive complex considered here includes the events leading to conception, through birth and immediate postnatal survival; dystocia is a part of this complex. The extent of dystocia in Holsteins can be estimated from data collected through the National Association of Animal Breeders (NAAB) sire evaluation program. From 471,484 birth reports from dams of all ages scores and percentage of observations in each class were: 1, no problem, 80%; 2, slight problem, 7%; 3, needed assistance, 8%; 4, considerable force, 3%; and 5, extreme difficulty, 2%. For first calvers, 14% were scores 3, 6% scored 4, and 5% scored 5. McDaniel (83) estimated the minimum costs per birth assisted in heifers was $50-$60.

Calf mortality from the NAAB sire evaluation data (12) was 6.65% for all Holstein calves up to 48 h after birth. Mortality of male calves was

7.63% and for females, 5.65% for all parities of dams. Calf mortality in births from first-parity dams was 10.5%, for second parities was 5.5%, and for third and greater parities was 5.7%.

Genetic aspects of the reproductive complex will be considered for dystocia, measures of fertility and their association with production, and calf mortality. Associations among these and other traits will be considered. Genetic and environmental parameters for linear type were estimated and differences in health from progeny of high and average sires are reported.

ESTIMATION OF ANNUAL GENETIC TREND IN THE REGISTERED HOLSTEIN POPULATION

Lee (11) estimated the genetic trend and selection practised in the registered Holstein population. The data were: 1) pedigrees of 440,702 males and 526,956 females (1 10% sample) born between 1960 and 1979, with Predicted Differences (PD's) and cow indexes (CI) expressed relative to the 1974 constant base. There was essentially no trend in either the male or female population between 1960 and 1968. Genetic change dramatically increased between 1969 and 1979. The average trend was 67.5±1.4 kg in milk and 2.0±.06 kg in fat with a slight reduction of -.0064±.0004 in fat percent. It seems likely that dairymen accepting PD's and CI's was a major reason for the genetic gain in the latter time period. A time lag existed between the observed gain in sires and the gain in dams. Genetic merit of the parents of AI bulls was clearly superior to that of non-AI bulls.

Studs continually raised selection standards for young sires (11). Average PDM of sires of progeny-tested bulls born in 1960 was -101.2 kg and average Cow Index Milk (CIM) of dams of the same progeny-test bulls was 70.8 kg. In 1979, the estimated transmitting abilities (ETA) for milk of sires and dams averaged 662.3 and 535.7 kg, respectively.

The effectiveness of using pedigree information to predict son's PD's was examined (11). ETA's of sires', dams', and maternal grandsires' (MGS's) and maternal granddams' (MGD's) were used singly and in combination in prediction equations which also contained birth year of the offspring as a fixed effect. The prediction equation containing sire PDM, dam CIM, and MGS PDM was relatively accurate for predicting son's PDM. Adding MGD CIM was of little or no value. In this set of data which covered a long period of time, PDM's of sons were predicted with approximately equal accuracy whether sire PDM or dam CIM or sire PDM and MGS PDM were used. In contrast, when predicting son PD%, the R^2 for the prediction equation containing sire Predicted Difference Fat % (PDF%) and MGS PDF% was considerably smaller than the R^2 for the equation including sire PDF% and dam CIF%.

DYSTOCIA

Dystocia will be considered a direct genetic effect as opposed to a maternal effect, unless otherwise noted.

Early studies of dystocia in the United States were with beef cattle and often involved crossbreeding (54,58,76,57,99). The first large study with dairy cattle in the United States was started in 1972 jointly with Midwest Breeders Coop. and later, Select Sires, Inc., contributed data. This work was published by Pollak and Freeman (95). This preliminary work was expanded to data collection by member organizations of NAAB and accepted as a national NAAB-sponsored program in 1976. Holstein sires in artificial insemination (AI) service have been evaluated for dystocia since 1977 as described by Berger and Freeman (55). Work in the United States on sire evaluation for dystocia has been by Cady (59), Teixeira (105), Mee (81) and Quass and Van Vleck (98). Philipsson (88,89,90,91,92,93) worked extensively with calving difficulty in Sweden. A comprehensive summary of work relating to calving problems and early calf visibility (71) was published that includes much European research.

Factors affecting calving difficulty

Herds, years, and season of birth affect birth difficulty in dairy cattle and should be considered in sire evaluation. Subjective evaluations of birth difficulty will vary among herd owners in the scores assigned to differing degrees of birth difficulty. Absorbing herd-year-season subclasses adjusts for average differences and interactions among these effects but does not take out inconsistencies of scoring within these subclasses. Births from all ages of dam have higher scores in winter than do births in the summer (95). Heifer births also are scored higher in winter in Israel (53) and in Sweden (89). It is not known if this is a true seasonal effect but could be influenced by increased exercise in the summer or closer observation by owners in the winter.

Sex of calf has a large effect on difficulty scores, amounting to about a .32 unit difference when birth difficulty is scored on a 1 to 5. Male calves are born with the most difficulty. Age of the dam giving birth has a major effect on birth difficulty. In the recent NAAB data, differences between first and third and greater parities is about .7 with scoring 1 to 5. Pollak and Freeman (95) showed a significant but small interaction of age of dam by sex of calf for calving difficulty. Males always had a higher incidence of dystocia across ages of dam but less in older cows.

Size of calf also has a major effect on dystocia (95) when size of calf was scored subjectively into five classes. Sex of calf remained a significant effect with calf size in the model (95), which indicates differences due to sex other than size. Size of calf also could be used as a measure of calving difficulty for sire evaluation. Seventy-six sires with an average of 130 progeny rank differently ($r = .74$) when evaluated for dystocia and calf size (94) where both traits were scored subjectively 1 to 5. Perhaps direct evaluations for calving difficulty are more accurate than indirect evaluations by calf size.

Direct-maternal effects

Heritabilities for calving difficulty are low whether measured as a trait of the calf (direct effect) or as a trait of the dam (maternal effect). Almost all estimates of heritabilities of calving difficulty as a maternal trait are lower than estimates for the direct effect. Heritability estimates also are higher for direct effects measured on heifers than on older cows. Most estimates for direct effect are less than .10 in heifers and smaller in cows. Cady's (59) estimates were higher.

To estimate direct-maternal relations in first parities, 19,237 birth reports were available from 5,409 herd-year-seasons, and for later parities 69,458 birth reports in 11,280 herd-year-seasons were available from 323 sires (18). The mixed-model multiple-trait procedure to estimate the relationship between direct and maternal effects used the same set of sires, with each bull represented as both a sire and a maternal grandsire. Heritabilities as a maternal effect were .03 for heifers and .01 for cows. Genetic correlations between direct and maternal effects were -.38 for heifers and -.25 for cows. These were slightly larger than the -.19 estimated by Philipsson (90) from heifer data.

These results (93,90) indicate genetic antagonism between direct and maternal effects, implying relatively small fetus-maternal incompatability. If selection was applied and effective in improving dystocia as a direct effect, such selection conceivably could become counterproductive or at least not effective in total because of the antagonistic direct-maternal relation. Freeman et al. (3) examined the expected response from selection for both direct and maternal effects, the effect of restricting maternal change to zero, and the effect of selecting for only direct effects. The conclusions were: 1) direct effects are more important than maternal effects for dystocia in Holsteins; 2) selection for only reduced dystocia by using progeny from all parities with equal economic weights for direct and maternal effects, would be expected to result in about 80% of the gain from selection for change of the direct component; and 3) current selection in the U.S. artificial insemination industry, which applies minimal selection for dystocia, is not likely to produce significant change of birth difficulty as a maternal trait.

Calving difficulties of heifers and older cows have been considered separate traits for sire evaluation and selection in Europe and Israel. Thompson et al. (18) estimated a genetic correlation of .84 between dystocia measured separately for heifers and cows. They used a mixed-model multiple-trait procedure with birth reports from 29,099 heifers, 114,386 cows from 650 sires in 14,170 herd-year-seasons. Selection of sires based on combined first- and later-parity births was always more efficient than selection on births from either first or later parities. This result (18) allows for a normal ratio of first to later parities, differences in direct and maternal heritabilities, and genetic correlation of .84.

Relationship of dystocia transmitting ability with type and production transmitting ability

Sires were evaluated for dystocia in the NAAB program (55). Transmitting abilities for production were PD milk, fat, fat percentage, and dollars from the USDA sire evaluation 1 July 1978. Transmitting abilities for type were PD type (PDT) and Total Performance Index (TPI) from 1 January 1979 Holstein-Friesian sire evaluation. Best Linear Unbiased Predictors (BLUP)(67) were computed for each trait in the Mating Appraisal for Profit (MAP) data of Midwest Breeders Coop. Thompson et al. (106) described these data and correlated predictions of transmitting ability among these traits. Genetic correlations between dystocia and each measure of PD for production ranged from -.04 to .03 for 423 active AI sires or for a larger sample of 1,315 sires rank correlations ranged from -.04 to .06. There is little relation between transmitting abilities for production and dystocia.

Transmitting abilities of dystocia were negatively correlated with PDT and TPI (106). Genetic correlations ranged from -.23 to -.29 and rank correlations from -.14 to -.08. Scale had the largest negative genetic correlation -.30, and rank correlation -.20 with dystocia in the MAP data. Selection for PDT would be expected to have a slight correlated response increasing dystocia, probably by increasing scale.

Sire evaluation for dystocia

Best Linear Unbiased Predictions (BLUP) for all Holstein sires in AI have been obtained by NAAB for dystocia since 1977 as in (55). Evaluations were within studs through 1979 because there were not sufficient ties across studs. Examination of the data in 1979 showed that all sires within each stud were tied to each other and that all studs had ties among their sires. Ties were progeny within herd-year-seasons. Ties through the relationship matrix from sire and maternal grandsire pedigree information supplenent these data ties.

Categorical data present problems in analyses, and dystocia has been scored in categories although the underlying scale of liability of dystocia is probably continuous. Sires are evaluated by a mixed model (55) that provided BLUP of a sire's transmitting ability for ease of calving. Primary variables that affect ease of birth of a sire's progeny are adjusted in the analysis to avoid these variables causing biases in estimates of sire's transmitting ability. Variables accounted for are herd-year-season of birth, sex of calf, and age of dam. Also, there is more variation of birth difficulty of first-calf heifers than older cows, which is accounted for in the analysis. Three items of information from the analysis (55) are presented on each sire. They are: 1) Effective number of progeny, which is the diagonal of the sire equations in the BLUP analysis after herd-year-seasons are absorbed and before the ratio of the error to sire variance is added to the diagonal; 2) probability that a sire's transmitting ability is above the population mean of the sires evaluated, which assumes normality of sire transmitting abilities; and 3) expected percentage of birth difficulties of first calf heifers. The latter is computed as the expected regression of percentage 4 and 5 dystocia scoresoof first-calf heifers on each sire's transmitting ability. The regression coefficient is computed from previous years' data.

It conceptually could be more desirable if the expected difficult births in first calf heifers could be obtained directly from the sire evaluation procedure. The procedure of Quaas and Van Vleck (98) obtains BLUP of the category frequencies for future progeny. If economic values can be assigned to each category, their procedure predicts future value of progeny. This can be a large number of economic values (59), that are not known in practical sire evaluation. Mee (81) developed an analysis that considers ordered categorical responses as for dystocia scores. This procedure uses more information because it uses the ordered categories. It (81) is computationally more tedious than that of (55). Mee (81), however, found little difference in the rank of sires by his procedure from the other two (55,98). Gianola (64) considered alternatives for analyzing threshold data. This paper reviewed past methods and characterized options for animal breeding applications. None of these procedures accounts for potential bias from selection. The latter may not be large for dystocia in dairy cattle because little selection is applied to AI sires for dystocia.

REPRODUCTION

Much literature exists on fertility and its relation to production in dairy cattle. Only some of the literature that seems useful to potential sire evaluation will be discussed. Many management and some genetic aspects of reproduction, and its relation to production, are covered in Proceedings of the National Invitational Dairy Cattle Reproduction Workshop, 13-15 April 1982 by the Extension Committee on Policy, SEA-USDA. Much of the genetic literature was reviewed by Hansen (7,8,9,10). Two major questions are at issue. One is selection for reproductive performance, with consideration of appropriate measures of reproduction; the other is the yield-fertility relationship for currently established measures of yield.

Measures of fertility

Maijala (12) reviewed a number of studies up to 1957. Weighted averages were .077 for repeatability and .032 for heritability of number of services and .123 for repeatability and .033 for heritability of calving interval. Everett et al. (63) found heritability of about .05 for many measures of fertility. Miller et al. (85) reported heritabilities of .04 for calving interval and herdlife. Schaeffer and Henderson (102) estimated heritabilities for days open in first, second, and third lactations of .02, .04, .00, respectively. Kragelund et al. (74) found a heritability of .06 for days open in Israeli Friesians. Although heritability was small, he (74) suggested that it still might be possible at least to prevent deterioration of fertility. Bar-Anan et al. (50) estimated heritability of nonreturn rate .01 and conception rate .035.

Recent work in this area (7,56) used data from different regions of the United States to look at fertility, yield, and their relationship in Holsteins. Berger et al. (56), using a large data set from California, found heritabilities of .04 for days to first breeding, .04 for days to last breeding, .02 for days open, and .01 for number of services per conception in first lactations. Hansen (9) estimated heritabilities of many measures of fertility in a large sample of New York data. His estimates were all ≤.04. He considered days open restricted to 150 days and without restriction. Heritability estimates were higher when the variable was restricted, which presumably eliminates the effect of preferential treatment given to particular cows allowing them more opportunity to conceive. Restricting number of breedings to three and service period to 91 days produced similar results. Repeatability estimates (8) were all <.158 and generally <.10. Days open and service period had the largest repeatabilities, and days open and days to first breeding had the highest heritabilities, approximately .03. Measures associated with fertility that had the highest heritabilities were age at first breeding, .06, and age at successful breeding, .16, for breedings of virgin heifers. These may be measures more of maturity than true reproductive measures.

Heritabilities of reproductive traits are low, generally ≤.05 as estimated from paternal half sisters. This implies that gains from mass selection would be minimal; however, selection of sires for daughter fertility could be effective. Reasonably large daughter groups would be needed, but use of a relationship matrix adds accuracy to selection when sires have small daughter groups and when a large data base is available. Selecting sires of sons in addition to selecting individual sires could make gains in fertility, though a reduction in yield could be expected as will be discussed later (10).

<u>Relationship of yield and fertility</u>

Genetic evidence on the yield-fertility relation comes from two sources, data from producers and designed experiments.

Laben et al. (75) found that California herds, 130,022 records from Holsteins in 201 herds, with higher Dairy Herd Improvement yields had distinctly shorter intervals to first postpartum breeding and fewer days open. Evidence was of an overall small, but significant, antagonistic association between yield and fertility after adjustment for herd-year-seasons and parities. The increase in days to first breeding, days to last breeding, days open, and number of breedings associated with a 100 kg increase in 180-day fat corrected milk (FCM) averaged .27, .80, .61, and .014, respectively. This work (75) indicates that high yield and(or) associated stress have a small but real depressing effect on fertility; however, records of high producing herds show this antagonism can be overcome by good management.

Berger et al. (56) used the same data (75) to investigate genetic aspects of yield and fertility. As Laben et al. (75) did, FCM was used to better indicate stress of production than either milk or milk fat alone. With 72,187 records in 201 herds, genetic correlations between measures of reproductive performance and 60-, 180-, and 305-day FCM were positive, indicating that genetically higher-producing cows bred later, took longer to conceive, and required more services per conception. Genetic correlations in first lactation were highest between measures of reproductive performance and 305-day FCM (.48 to .62) and decreased for 180- and 60-day (.36 to .47) yields. The latter being unaffected by pregnancy.

Because of the potential significance of the yield-fertility relationship, Hansen (8,9,10) used independent data (provided by R. Everett, Cornell University, and J. Keown, Eastern Artificial Insemination Coop., Inc.) from the northeastern U.S. to determine if results of (56) could be corroborated. Genetic correlations were positive, or antagonistic, between measures of yield and fertility in cows. The antagonism was greater in first, less in second parity, and less yet in third parity. Correlations in third parity of most measures of fertility and yield were smaller or not significantly different from zero, by using approximate standard errors. Others using large data bases (63,65,74) found a genetic antagonism between yield and fertility, but this was not so in all studies.

Data were available for fertility of virgin heifers (10). Genetic correlations among measures of fertility from virgin heifers and measures of their production in first lactation were negative, indicating a complementary relationship. Although these correlations were consistent in sign, most were not larger than their approximate standard errors. These results agree with those in the summary of Maijala (79) and with Metz and Politiek (82) but not with those of Janson (72).

Experimental evidence on genetic association of yield and fertility is available from four designed experiments in the North Central Regional Dairy Cattle Breeding Project, NC-2. Herds at Iowa State University (104), University of Minnesota (65), and the University of Wisconsin (78), were selected for milk production by using sires rated high for PDM. Comparison groups at different amounts of production were contemporary. One USDA herd at Beltsville, MD, had one comparison group selected for milk and one selected on additional traits intended to reflect net merit (100). Correlated response of fertility were not significantly different between groups within any of the four herds; however, in more recent progeny groups (2) fertility declined as production increased. Designed experiments can be controlled more carefully to study the stated objectives but cannot generate the volume of data available from producers' herds. It is possible that better reproductive management, including veterinary care, was maintained in these herds than in producer herds, so reproductive differences, as correlated responses, may not have been observed for this reason. Also, not over about 16% of the genetic variance of fertility is associated with yield, so lack of detection of significant differences between groups in fertility is not surprising.

Hansen (10) used index theory to quantitate expected response to selection for yield only, fertility only, restricting change in fertility to zero and with a range of economic weights on yield and fertility. If selection produced a 60 kg response in yield (305-day FCM) per year, the expected results of alternative selection can be summarized as: 1) Selection for only yield would be expected to reduce heifer service period 1 day and increase days open in first parity 1.5 days; 2) selection for only days open in first parity gave an expected response per year of -11 kg yield, .3 days in heifer service period, and -.6 days open in first parity; 3) restricting change in days open to zero in first parity resulted in an expected reduction of 22 kg for yield and a loss of .6 days for heifers' service period compared to selection for only yield; 4) relatively large economic weights on fertility were needed to get much response in first parity fertility; and 5) gains of cow fertility tended to be offset by losses of heifer fertility. Estimates for heifer service period (first breeding to conception) were when service period was restricted to 91 days and days open limited to 150.

Production is affected by pregnancy status. Days open is used commonly as a measure of pregnancy status. Many authors have studied effects of days open on milk and milk fat production. Oltenacu et al. (86) investigated the influence of days open in cows divided into high and low production classes based on early lactation production. The association between days open and cumulative yield was less for cows within a production class than across cows, with early lactation ignored. They (86) concluded that correction of 305-day yield should be to a standard number of days open and should be additive. Bar-Anan and Soller (52) recommended that early production be considered in adjusting for days open.

Thompson et al. (20) developed factors to adjust milk and milk fat records for days open and gave literature citations on the subject. They (20) showed that mature equivalent yields for the first three parities were lower for fewer days open and higher in later lactation than days-open-adjusted yields. Effects of days open on production were reduced by including summit production (average of two highest of first three test days) in models; however, adjustments of records by factors from models including summit production were not satisfactory for records ≥180 days open. Yields adjusted for days open were most predictive among three measures (305-day mature equivalent (ME) adjusted for days open, annualized yield, and 305-day ME-FCM records) of total cumulative yields at 26, 39, and 52 mo. Rank correlations among sire transmitting abilities were >.86. Records should be adjusted for days open for sire and cow evaluation. Even though the gains may not be large, small increases of accuracy can be justified for genetic evaluations.

Funk (5) reviewed the literature on the effects of days open and days dry on lactation production. Previous work considered these effects lactation by lactation; however, Funk (5) determined the effects of previous days open, days dry between lactations, and present days open for the first three lactations. These effects were fit simultaneously using a mixed linear model. The estimates he obtained were Best Linear Unbiased Estimates. Fitting previous reproductive performance simultaneously had not been done before and the results differ from fitting these effects by lactation. Measures of yield were FCM milk, and milk fat all adjusted to a 305-day, mature equivalent basis. Data were 84,356 first parity, 140,233 first and second parity, and 174,251 first, second and third parity records.

As present days open increased from 20 to 300 days open, lactation yields for FCM, milk and milk fat increased approximately 1,250, 1,350 and 45 kg. As previous days open increased from 20 to 300 days open, lactation yields for FCM, milk and milk fat increased approximately 625, 650 and 25 kg. Cows dry 60 to 69 days gave the most milk the following lactation. Cows dry 40 days or less produced much less the next lactation. All three measures of yield responded similarly to the effects of previous days open, previous days dry and present days open.

Multiparity analyses were conducted using a model where later parity records could be compared with more unselected first parity records. Adding additional parity information using this model made little difference in how cows responded to previous days dry and previous and present days open.

Heritability estimates for previous days dry were approximately 6%. Days dry were largely determined by environmental influences. Since heritability estimates for previous and present days open are also quite small, adjusting lactation yield records for previous days dry and previous and present days open is warranted.

Multiplicative adjustment factors were developed for FCM, milk and milk fat. Adjustment factors could have a large impact on genetic cow evaluations which currently do not adjust for the largely environmental effects of days open and days dry.

Male fertility is also a part of the reproductive complex. This is a problem that includes differences of ability of bulls to produce offspring, and relationships of sires' fertility to their sons and daughters. Saacke (101) gave a general description of measures of semen viability, conditions that affect semen viability, and types of abnormal sperm with discussion of how these relate to fertility. Laboratory (101) evaluation of semen is useful for predicting sire fertility. The goal is to predict fertility before semen is shipped from the laboratory, but the goal has not been reached. He (101) suggests that if emphasis is to be placed on reproductive efficiency, progress will be most efficient by culling bulls, not ejaculates within bulls.

Coulter and Foote (61) reviewed information on testicular measurements as indicators of reproductive performance and their relationship to productive traits. Heritability estimates were .67 for scrotal circumference and .34 for testicular consistency. Correlations with several measures of seminal characteristics, other than those related to volume and sperm numbers, were high. Further, the correlation between tonometer readings and fertility, as measured by 60- to 90-day nonreturns, to service were .67.

Although substantial information is available on semen characteristics and their relationship to sire fertility there seems to be very little work on the relationship of a sire's fertility to the fertility of his sons or daughters. This type of information is needed to understand adequately the reproductive complex.

LIVABILITY

Little attention has been given to genetic differences of calf livability in the United States. This discussion will relate to perinatal mortality of Holsteins.

Most of the effects associated with variation of dystocia also affect calf livability. Livability, as discussed here, concerns those factors closely associated with birth. Prominent among these are herd-year-season, sex of calf, age of dam, size of calf, gestation length, and multiple births (46,53,60,77,88,89,90,105).

Heritability of stillbirth rate generally has been $\leq .05$ as a trait of the sire. Heritabilities of stillbirth as a maternal trait have been mostly lower than as trait of the sire (direct effect). Lindstrom and Vilva (77), studying Ayrshire data, reported a tendency for heritability of stillbirths to be higher for cows as dams (.082 and .049) than for heifers as dams (.027 and .029), bulls regarded as sires and maternal grandsires, respectively.

Martinez (12,14,15,16) used data from the NAAB dystocia project. A total of 136,775 records were available with complete information on herd code, date of birth, gestation length, calf livability score, dystocia score, sex of calf, calf size, age of dam, and sire of calf. Calf livability was scored as dead at birth and died by 48 h. Using calves dead at birth and all deathers by 48 h, and normalizing these same classifications of mortality, he (15) found heritabilities generally ≤.015. When these heritability estimates were adjusted for discontinuity, they were ≤.061. Even though heritabilities were low, sires with over 400 offspring varied from 3.1 to 12.1% mortality of their offspring; one sire with 98 offspring had 1% mortality, and another sire with 81 progeny had 16% mortality of his progeny.

Martinez (14) found a quadratic relationship between livability and gestation length. This relationship differed for heifers and cows. For heifers, the optimum survival was for gestation lengths 3 to 4 days below the mean gestation length of 278.8 days for heifers; mortality increased rapidly for gestation lengths greater than the mean for heifers. For cows, the optimum survival was for gestation lengths 1 to 4 days above the mean of 279.7 days for cows; mortality was much greater for births less than the mean gestation lengths for cows.

With use of multiple-trait mixed-model methods, genetic correlation between livability of progeny of heifers and of cows was estimated as .32 (14), not a strong genetic relation between expressions of the same trait in cows and heifers. Relations between direct and maternal effects on calf livability were analyzed separately for first and later parities. Genetic correlations were -.52 for both heifers and cows, showing a distinct antagonism. The genetic correlation between calf livability and calving difficulty, with use of all parities, was .66. Heritabilities from multiple-trait methods were .01 for calf livability and .041 for calving difficulty. Martinez (15) considered the expected correlated response of calf livability to direct selection for dystocia. With equal selection intensities for the two traits, genetic correlation = .66, dam heritability for dystocia = .04, and heritability of livability = .01, the expected correlated response was 41% greater than direct selection for livability in Holsteins. Such results, however, need to be viewed with caution because small changes in parameter estimates cause substantial differences of expected correlated responses, and accurate prediction of correlation responses has been difficult in laboratory experiments.

DIFFERENCES IN HEALTH COSTS AND INCOME OVER FEED AND HEALTH COSTS IN PROGENY OF SIRES SELECTED FOR HIGH AND AVERAGE MILK PRODUCTION

An experiment producing progeny from Holstein sires selected only for high and average milk now has fourth generation progeny milking. Realized gain is about 1.3 times expected with progeny groups now separated by over 3,000 lbs of milk. Records of all incidences of health problems have been recorded to determine the correlated responses in differences in health between the progeny groups.

Daughters of high sires incurred higher lifetime health costs in all categories (2). They had 9% more respiratory costs, 6% more digestive costs, 49% more skin and skeletal costs. They also had, probably as a result of added stress due to increased milk production, 36% more mammary costs and 42% more discarded milk. They required, however, only 9% more feed costs. Overall, progeny of high sires made 18% more lifetime profit (income over feed and health costs) had 19% more profit per day of herd life, indicating superior efficiency.

On a lactation basis, milk production and profit peaked in fourth lactation (2). Lifetime profit logically continued to increase as lactations progressed. The number of reproductive exams and breeding also substantially increased in later lactations.

The daughters of high sires produced 12.5% more milk per lactation and netted 15.5% more profit (2). Although the number of reproductive exams and breedings differed little between daughters of high and average sires over the whole experiment, the daughters of high sires in later generations continued to require more breedings as milk production increased. This experiment produced more production than expected, had higher health costs for daughters of high sires, and had more profit from daughters of high than average sires.

LINEAR APPRAISAL OF CONFORMATION IN HOLSTEIN CATTLE

All artificial insemination organizations and Breed Associations in the U.S. are scoring 14 conformation traits on a linear scale of 50 points. Disposition of the cow and milk out data are available from part of the data (19). An appropriate model (19) to describe the traits included evaluators, herds within evaluators, parity of cow, interaction of evaluator by parity, sire, and linear and quadratic effects of days in milk. Heritabilities of linearly scored traits were generally higher than traits scored relative to preconceived ideal (19). No ideal is perceived with linear scoring, rather traits are scored from one extreme to the other. Genetic correlations among traits were the same sign and generally higher than phenotypic correlations (19,21). All correlations among udder traits were high. Genetic correlations indicated that selection for dairy character (angular frame) also would result in taller animals, stronger in udder traits, narrower and slightly sloping in rump and more crooked legs viewed from the side.

Linear scoring offers the potential to determine which attributes, if any, contribute to increased herd life. Alternatively, changes in conformation could allow less udder problems or change other attributes that allow more profitable production. Enough time has not yet elapsed to make these determinations.

DISCUSSION

Dystocia, the yield-fertility relationship, livability, and some related aspects have been considered. Perhaps measures of more specific physiological functions could be useful for reducing fertility problems by selection. Examples could be accurate recording of cystic ovaries and monitoring the progesterone in milk as possible measures of reproductive performance to be used alone or with other measures of fertility. Such data are difficult to collect in large numbers.

The cause of the antagonistic genetic correlation between yield and fertility can be discussed in several contexts. Normally, genetic correlations are considered to be caused by pleiotropy or linkage. The linkage groups would be expected to be broken up by crossing over after time unless strong selection kept them intact. Pleitropy does cause genetic correlations. Bar-Anan (51) has proposed an intuitive argument, which he termed "endo-environmental effect", that he considers to be a cause of genetic correlations, but not necessarily the sole cause. For the antagonistic yield-fertility relationship, he suggests that the estimated negative association is a direct function of the endo-environmental effect. He suggests that adjusting feeding to the requirements of higher producers may provide equal opportunity for reproduction and avoid the antagonistic relationship.

The work of Hansen et al. (10) and Berger et al. (56) suggests a favorable relation between genetic potential and fertility of heifers that becomes antagonistic when these heifers calve and are subjected to the stress of production. This could strengthen the hypothesis of Bar-Anan (51), but Laben (75) showed that the underlying antagonism exists at herd yields of more than 9,000 kg milk. Such relationships as found by Hansen (10) also could be explained by true pleiotropy but with different genes producing the pleiotropy at different times in the animal's life. This reversal of the genetic correlation could be termed interaction of genotype x environment. Little seems to be gained until such hypotheses can be tested. Perhaps additional knowledge will allow development of management techniques to overcome this problem.

A practical consideration for potential genetic improvement of fertility is accurate and uniform recording to fertility data. Whether for sire fertility or daughter fertility, more accurate and uniform data are needed on a national basis. Organizations for AI vary in the information available and collected. Some measures such as calving interval (except for the last), perhaps days open, and number of services are available through DHI programs. These may vary among processing centers as to the specific data used and kept; however, DHI programs certainly have the potential for recording such data.

The objective of a generally healthy cow that maximizes production and minimizes costs seems intuitively appealing. Although information is not available to select for minimizing health costs there is information

(2) that suggests greater health cost accompanying increased production. There is a reasonable body of information related to fertility. At least three broad questions should be considered before selection is practised. First, is the biology of the complex of reproductive traits reasonably well understood. This also includes ability to measure the traits, their genetic and environmental variances and covariances, potential interactions, and any attributes that allow management adjustments that might make selection unnecessary. Second, what are the economic values of the traits considered jointly. Are the economic values of near universal application, or do they differ markedly among producers. For example, getting cows to conceive is more nearly a problem experienced in common by dairy producers than is dystocia. Some breeds and herds within breeds experience little dystocia. If economic values differ substantially, this implies different selection goals. The latter is easier to accommodate on a herd than on a national basis, but different selection goals can be incorporated in sire selection. The more difficult problem is likely to be clearly defining goals. Indeed, determining selection goals is one of the most difficult, if not the most difficult, task of animal breeders. This is accentuated because of the lag between when selection is applied and when animals with the desired characteristics are produced for breeding. Third, is the analysis used to identify superior parents for breeding.

Funk's (5) work indicates that adjusting for previous and present reproductive performance, including days dry, could commonly result in adjustment of ±1,200 kg on a 9,000 kg record. These adjustments should be done in sire and cow evaluation. Such adjustments could substantially improve the selection of bull mothers. Also, adjustments found by Funk (5) could possibly reduce the antagonism between yield and fertility. This will be investigated.

Sires could be evaluated for traits measuring reproductive fitness. It is doubtful that any single trait can measure all aspects of fertility. Stayability or some measure of how long cows remain in herds is an overall index of cow usefulness, but this has many components such as production, fertility, dystocia, diseases, etc., including the dairy producers personal preferences. In the absence of a single measure of fertility, economic values of components of the reproductive complex are needed.

Given that the biology of the traits is reasonably well understood and economic weights of the traits are known, a multiple-trait mixed-model analysis seems appropriate. A multiple-trait mixed-model analysis for individual animals was described by Henderson and Quaas (69). Henderson (68) described a general analysis for sire evaluation using multiple traits including a relationship matrix. Both genetic and environmental correlations should be included, and were in his general description, but environmental correlations between traits were not used in his example. Multiple-trait analysis could be computationally expensive but could add precision to selection.

Martinez (15) solved for BLUP of sires separately with a mixed-model for livability, separately for dystocia, and then used a mixed-model multiple-trait procedure for the two traits. Rank and product-moment correlations were higher between solutions for sire transmitting abilities when the multiple-trait analysis was used. Multiple trait techniques incorporate both direct and indirect prediction using correlations between traits. This just illustrates differences in sire evaluation techniques. If selection is for many traits, including production, type, reproduction, etc., all traits under selection ideally should be included in a multiple-trait mixed-model analysis such as described by Henderson (68). Our current state of knowledge was not progressed far enough to allow this.

Scoring conformation on a linear basis from one extreme to the other may allow determining which, if any, conformation traits contribute to increased herd life and economy of production. The latter could be either in ease of milking from cows with, e.g., better udders, less mastitis, etc. Whether we are able to determine optimum conformation using linear scoring will be the subject of future research.

D2. SCIENTIFIC REPORT (ARO)

ABSTRACT

Yield during lactation was affected by lactation number, herd and within herd cow yield and pregnancy from its first month. However, highest mean daily yields were achieved quite uniformly, when calving intervals were 12 and 11 months for primi-and multiparous cows, respectively, and one month longer when following yield was taken into account.

Conception rates of nulli-, primi- and multiparous cows were 64.3, 41.9 and 39.6%, respectively, the difference in conception rates between August and December inseminations for parous cow was 22.4%. Conception rate tended to be associated positively with genetic and herd milk yield levels, however negatively with daily yield prior to insemination. Yield persistency within lactation of progeny groups was associated positively with their conception rate.

Both genetic and phenotypic variations of first lactation yield have decreased in the course of eight years, but not of second lactation progeny tests. Progeny testing for yield development across lactations was suggested.

The estimated genetic correlations between the sire and maternal grandsire effects for heifer calving difficulty and calf mortality were above .5 indicating; (i) the overriding effect of the calf on births and (ii) that sire selection will affect positively calvings of both mates and daughters.

An experiment was started to compare daughters of top proven bulls from the five highest producing national Holstein-Friesian strains. The ranking of the strains for calving difficulty and calf mortality from low to high proportions was: New Zealand, Israel, U.S., Canada and Sweden.

INTRODUCTION

The research focussed on improving the overall productivity of dairy cows in Israel. The major issues investigated were: calving performance, calf viability, peak yields, yield persistency within and across lactations, female fertility, incidence of mastitis, type traits and within herd stayability.

Research was oriented to estimate environmental and genetic effects on these characters and the iterrelated effects of yield on fertility and of fertility on yield. The hypothesis that genetic correlation estimates, such as between milk yields and cow fertility, may be functions of endo-environmental effects was tested by an experiment with laboratory rats.

Further objectives were to set the optimum time for breeding cows and to predict yields in the remainder of the lactation by accounting for the quadratic effects of days in milk and days pregnant.

An investigation was started to explore the tentative contribution of crossing sub-strains of the Holstein-Friesian breed to national improvement programs.

1. Effects during lactation on daily milk yields.

The effects of the calving month, months in milk and months pregnant on monthly milk records of Israeli-Holstein dairy cows in 1st and 2nd lactations were studied by means of 717,966 monthly records in 76,788 lactations, which were followed by calving (28,29).

The objectives of the investigation were to estimate the interrelationships among the effects of peak yields, days from calving and days pregnant on yields at various production levels of herds and cows within herds. In a previous study

Bar-Anan and Soller (52) had found that the optimum time for heifers to conceive in high- and low-yielding herds was between 100 to 120 and 70 to 100 days open, respectively, and 70 to 80 and 40 to 50 days-open for cows.

In the present study the major factor affecting yields was the number of months post partum : The monthly proportional decline in yields from the 1st to the 10th lactation month, independent of the effect of pregnancy, was .17 and .46 in heifers and cows, respectively. Peak yields were achieved later in high than in low-yielding herds, but the rates of yield decline from the 2nd to the 10th month were similar. Within herds, the proportional monthly decline from the 2nd to the 10th months of lactation of high and low peak yield were .035 and .022 respectively for heifers, and .063 and .052 respectively for cows.

Effect of pregnancy on milk yields was observed from the 1st month after conception, but the effect was small. The findings support previous evidence (62). The effects of seven months of pregnancy on test-day yields were 3 to 4 kg milk, independent of the yield level of the cow. Pregnancy had similar effects on high- and low-producing heifers and cows.It was suggested that the cows in a herd should generally be bred at approximately the same time postpartum, and that heifers should be bred later than cows.

2. Parameters of yield characters.

The effects of age , month of calving, days open (DO) on milk yields, and the variance components of herds and sires were analyzed by means of 209,863 lactation records in Israeli dairy herds (22,23,30). There was a strong and positive association between 305 day yields and days open. In the range of 45-203 days open, 305 day milk yield records of heifers and cows increased by 16.9% and 15.2%, respectively. In Israel, lactation records are annualized for economic and genetic decisions, where annualized lactation yield (AY)= 365 x lactation yield/days between calvings. The effect of delaying calving age by 10 months increased AY by 10.5,7.3,6.0 and 2.6% for 1st, 2nd, 3rd and 4th lactations, respectively. An interaction between calving age and lactation number was found. Old primiparous and young multiparous cows, yielded less than predicted by the quadratic regression of yield on age over all lactations. Heifers calving in November and July, and cows calving in December and July produced highest and lowest yields, respectively. The range was 4.4% for heifers and 6.8% for cows.

In the range of 45-200 DO, AY of heifers increased by 4.2%, and AY of cows decreased in the 2nd, 3rd and 4th lactation by 3.3, 4.2 and 5.3%, respectively(26).

It was concluded that under environmental conditions prevalent in Israel, production may be increased by clustering calvings in the autumn and by increasing the number of days open for primiparous cows and decreasing the length of the open period for multiparous cows.

h2 estimates for peak yields, 305 day yields, annualized yields, yield persistency and days open were .24, .24, .23, .14 and .05 respectively, for primiparous cows, and .11, .20, .19, .17 and .05 for multiparas. Thus, heritability of peak yields was more than twice as high for primi- than for multiparous cows. Heritability for 305 day yields and days open were similar to means of published data (80).

Sire, herd and residual components of variance in heifer yields remained stable for a period of eight years, but decreased in relation to the mean. The findings imply that for genetic evaluations across years, quantitative production measures may provide more accurate predictions over years than percentages or SD units.

3. Factors affecting conception rate

The effects of parity, month of insemination, days from calving, calving performance, inseminator, herd, sire and mating sire on conception rate were tested by means of >250,000 inseminations in 200 Kibbutz herds in the years 1980/1 (35,40,44). Pregnancy was determined by veterinary palpitation, or when absent by subsequent parturition. Conception rates (CR) of nulli-, primi- and multiparous cows were 64.3,41.9 and 39.6%, respectively. CR was above the mean from February to July for heifers, and from December to May for cows, the highest CR were in March and January for heifers and cows, respectively. The lowest CR were in August and October for heifers and cows, respectively. It was suggested that CR of heifers might have been affected by increase or decrease in daylight, while CR of cows had been affected adversely by the Israeli summer climate in regions at or below sea level. The range between the least squares means for the months of highest and lowest CR was 6% CR in heifers and 22.4% in cows. Apparently, the interaction of lactation and summer climatic conditions results in substantial reduction of fertility.

CR of cows inseminated prior to 60 days post partum was 3.9% lower than those inseminated 60-90 days post-partum. Retained placenta and difficult calving reduced CR by 3.6 and 4.45 %, respectively. Least square means for CR of 1st, 2nd and 3rd inseminations of heifers were 66%, 62% and 60% respectively.

The SD among least squares effects of cows' CR for herds, inseminators, sires and service sires were each slightly below 4%. The SD among service sires for CR when measured by arithmetic means and was two and a half times larger than by least squares effects implying that sires were used nonrandomly. The correlations between CR of heifers and cows between effects of inseminator, mating sire, herd and sire were .64, .54, .17 and .27, respectively. The low correlations between heifers and cows for herd and sire effects, suggest that both herd management and the genetic mechanism for fertility may differ for cows and heifers. Hansen et al (9) have reported similar findings. However, Jansen (72) reported that heifer and cow fertilities were closely related. Heritability of sire effect for cow conception rate was small (.016), and similar to previous findings. However, the SD of sire Predicted Difference (PD) was 6% of the mean observed conception rate, which is about twice as large as the SD among sire PD for milk yield in comparison with its means (36).

Significant improvement may be achieved in fertility by selection of service sires, sires, and inseminators provided that the evaluations are based on large numbers of observations. However, the major increase of conception rate may be expected from reducing adverse effects of summer conditions on reproductive performance.

4. Associations between conception rates and production characters.

The effects of daily milk yields prior and during the month of insemination on conception rate (CR) were studied by means of 67,245 inseminations and adjacent milk records (24,37). The regression of CR on daily Kg fat-corrected milk prior to insemination (MPI) was -.26 and -.20 for primi- and multiparous cows respectively. There was no correlation between CR and decline in yield during the insemination month, but there was a correlation between CR and absolute milk yield change (AYC) (either increase or decrease). The regression of CR on AYC, independent of MPI was -.44, -.2, and -.46, for 1st ,2nd and 3rd lactations, respectively. In contrast, mean herd MPI and mean herd CR were correlated positively in 1st and 3rd lactations: .2 and .14 respectively. Heritability estimates were .026, .018, and .004 for 1st, 2nd and 3rd lactation CR and the correlations between Predicted Differences for fat-corrected annualized milk and for CR were .03, .23 and .3, respectively.

These findings did not support reported genetic antagonism estimates between yield and fertility measures (10,56). However, Hansen et al. (9) have reported a favourable genetic correlation between fertility of nulliparous heifers and milk yield of primiparous ones, but an unfavourable genetic correlation between fertility and yields within first lactations. The findings may imply a positive genetic relationship which may become reversed due to the endo-environmental effect of high yield on reproductivity. Laben et al. (75) have suggested that high yielding herds overcome the depressing effect of yield on reproduction by feeding regime.

It was concluded that individual high daily yield prior to insemination or a rapid increase or decrease in yield during the month of insemination affects CR adversely within herds. However genetic or management factors may improve both yield and conception rate.

The genetic correlations across all lactations between CR and annualized yields (AY), yield persistency, and culling rate were .08, .42 and -.53, respectively. AY was also associated positively with yield persistency and negatively with culling rates. It was suggested that selection for yield persistency may improve overall merit.

5. Collateral investigations with laboratory rats.

The role of physiological effects in genetic associations was investigated in experiments with laboratory rats (Rattus Norvegicus) (43).

Four strains were developed; for high and low milk yields, measured by litter weight gain up to 14 days; and for early and late sexual maturity, scored by age at vaginal opening. After 10 generations of selection the litters of the high yield strain were 25% heavier than of the low yield strain (standardized number of offspring), and the early maturing strain attained puberty 10 days earlier than the late one.

A genetic association between age at puberty (AAP) and milk yields (MY) was realized by selection for each trait; the high yield strain matured seven days earlier than the low yield strain, and symetrically, the early maturing strain progeny were heavier by 8% than the late maturing progeny when mated at the same age. When both strains were bred at puberty, 30 and 40 days for early and late maturing strains, respectively there were no differences in their milk yield. However, the genetic association with milk yield/dam-weight was highly significant. Moreover, the early strain when bred at puberty (30 days) produced heavier litters in the second lactation than either the late maturing strain or the early maturing strain when bred late.

Intensive management was simulated by mating lactating dams immediately post partum (73). During pregnancy, milk yields were low and there was no difference in milk yields between the early and late maturing strains.

Apparently, the genetic association between AAP and MY per dam weight was stable. However, moderate stress due to early matings tended to increase the phenotypic differences in 2nd lactations and severe stress due to early pregnancy post partum produced an opposite effect.

The findings seem relevant for explaining variation in genetic correlation estimates between milk yields and female fertility in cattle. This variation may be due to endo-environmental effects.

6. <u>Effects of days open current and following lactation yields</u>.

Lactation yields in Israel are estimated per day between calvings and annualized. Annualized yield (AY) is an economic estimate of production per fixed period of time. For genetic evaluations , AY may have to be adjusted according to days open (DO). For economic decisions when to breed cows postpartum , the effects of DO on annualized current and following lactation yields have to be considered. The effects may vary according to lactation number and postpartum peak yield. It was the purpose of this investigation to estimate effects of DO on current lactations for developing DO adjustment factors for AY, and on combined current and following lactations for mangement decisions. The effects were studied by means of 120,243 first to third lactations of Israeli Holsteins (45).

99% of maximum economically fat-corrected milk (ECM) yields in current lactations were obtained when heifers and cows conceived between 75-150 and 46-90 days, respectively. Days open for maximum current yields were 111 and 67 for heifers and cows, respectively, and about one week earlier for high producers. The findings imply that additive DO adjustment factors would be more adequate than multiplicative ones and that there should be separate factors for multiparous cows according to post partum peak levels. The findings are in concert with those by Oltenacu et al.(86) and opposed to suggestions by other authors (20,47,103). When ECM yields in the current and following lactation were combined with the economic value of the calf (52), 99% of maximum economic returns were achieved when heifers and cows had 80-154 and 64-133 DO, respectively. Thus, by including the following lactation yield the optimum number of DO for cows was changed. Curves were fitted by days open classes for estimating economic returns from fat-corrected milk yields in current and following lactations and from the calf crop. The number of days open in current lactations which resulted in maximum returns from current and following lactations were for heifers with high, medium and low current daily peak yield, 126, 119 and 107 days open, respectively, and 116, 100 and 86 days open in cow lactations.

The results for the low peak classes may have been biased by selection. For animals of the medium and high peak yield classes the number of days open for highest economic returns was greater by 20 days for heifers than for cows. For both heifers and cows, the number of days open for highest returns was 13 days less for high than for the medium peak classes.

Possibly the most significant finding was the adverse effect of early breeding. Heifers and cows which conceived between 46-60 days post partum yielded over the current and following lactation 521 and 238 less annualized kg fat-corrected milk than when conceiving between 91 to 105 days post partum. It was concluded that primiparous heifers should be mated not earlier than 90 days post partum while cows should be mated to conceive as closely as possible to 90 days post partum.

7. <u>Factors for predicting annualized yield and mean daily yield up to 217 days pregnant.</u>

Yields in Israeli dairy herds are estimated by annualizing production between calvings. For management, culling, and progeny testing dairy sires, factors for extending incomplete to annualized lactation yields are required. Furthermore, dairymen are interested in the yield from the last recording day up to day dry for culling decisions.

As partial lactations are of different lengths, the main factor affecting predicted yield in the remaining part of the lactation will be the number of milking days left. For this reason, remaining production was estimated as a function of farm type (Kibbutz or Moshav), season of lactation, last test day production, days pregnant, and days in milk, all multiplied by days remaining in the lactation; estimated as day 217 of pregnancy. Thus a mean dry period of 60 days was assumed.

105,372 completed lactations of first through third parity cows were used in the analyses (38). Each lactation provided several partial records by computing the milk, fat, and ECM yields obtained from each test day to the exit day, starting with the second test through the last test prior to 184 days pregnant. In this manner, 363,654 heifer and 384,250 cow "partial" records were obtained with the remaining yield known.

It was found that remaining yield was best estimated as a quadratic function of last test day yield, days in milk, and days pregnant, with calving season and farm type (Kibbutz or Moshav) included in the model as class effects, with all effects multiplied by days remaining. Heifers and cows were analyzed separately for milk, fat, and ECM. All effects included in the model were significant at .001 for most of the analyses. The coefficients of determination were all above .98, but this includes the explanitory powers of the mean and days remaining. A function was also derived to predict days to pregnancy as an inverse function of days in milk for partial records terminating prior to pregancy.

In preliminary studies, the dependent variable was taken as remaining daily yield. In this case, R2 values for ECM were .56 and .64 for heifers and cows respectively. Inclusion of interactions among the effects listed above increased R2 values only marginally.

The estimation functions were then used to predict total lactation yield for each group of partial records terminated in each month in milk separately. For cows not yet pregnant, date of pregnancy was predicted using the function of days in milk described above. Coefficients of determination for records terminated in the second and sixth months in milk were .64 and .89, respectively for both heifers and cows. In all cases, biases of prediction computed separately for each month in milk were all less than 60 kg.

8. Associations between type and production traits.

Primipara daughter groups were evaluated for type traits at an early lactation stage and genetic correlations were estimated between dairy character, body and udder conformation with annualized fat corrected milk yields (33,34). Each of the primipara type traits was negatively associated with yield persistency in both first and second lactations, although there were positive correlations between yield and type and between yield and persistency. The multiple correlation among the six type traits and yield persistency in the first and second lactations were .18 and .15, respectively. Four of 12 correlations were significant between type traits and persistency in first and second lactation and all 12 were negative and unfavourabe. Apparently the superior type cows at an early lactation stage were less capable of keeping milk production at a high level. The findings support the contention of Hickman (70) that physiological bases for early and late lactation yields are different.

There were no significant correlations between type traits and primipara culling rate, but genetic correlations between primiparous heifers' dairy character and rear udder conformation, with second lactation culling rates were .41 and .42, respectively.

In a further study (39), significant correlations were found between paternal granddams and grandaughters for size, body and rear udder conformation .

9. Genetic variation and associations among single lactations.

80,000 first to fourth lactation records were analyzed for genotype x environment interaction, where the genotype was defined as the overall milk yield producing ability and the environments were : level of milk yield of the herd; herd types - kibbutz or moshav; years of production and number of lactation of the cow (41) . The interaction between yield producing ability of sires and number of lactation was highly significant. The findings corroborate earlier documentation of different genetic patterns for yield developments across lactations.(48). Powell et al (1981) have reported that first lactations had the lowest predictive value for future performance of a sire (96). It was suggested that the maturing rhythm of a sire might be regarded as a dynamic expression of the genetic makeup controlling lactation development (41).

In a further study, associations among predicted differences (PD) for single lactation progeny tests of Israeli Holstein sires were investigated (31,32,36). Genetic correlations between PD for first and second, first and third, and second and third lactations were .82,.62 and .94 and for PD percent fat .94 for the three associations.

Regressions of PD milk of sons on sires for first, second and third lactation records were .32, .42, .56 , and intraclass correlations between half brothers were .09, .28, .25 . Thus PD for second and third lactations were near the theoretical expectation of .5 and .25 for regressions of sons on sires and intra-class correlations among half-brothers, but lower for first lactations.

The standard deviations (SD) among PD of sires were 224, 254 and 234 kg milk for 1st, 2nd and 3rd lactations, which were 3.14, 3.3 and 2.9% of the respective lactation means. The SD among sires of sons and among means of son groups were relatively small for 1st lactation kg milk.

The SD of sire evaluations from daughters in first lactations were virtually the same as eight years ago (48) although the increase in milk yields was approximatly 20%. In an independent study it was shown that variance components between sires of first lactations did not increase during eight years (30) in accord with phenotypic yield increase. It appears that expressing breeding values in relation to phenotypic means may undervalue sires that were proven in high yielding populations or periods.

Regressions of later lactation on first lactation Predicted Difference (PD) were less than unity. These findings confirm results in previous investigations (48,96,108). It follows that pooling age adjusted primiparous records across lactations with multiparous records will increase instead of regress primiparous records. When sires are tested on first lactation, age adjustments will have only a scale effect, but pooling over lactations will overweight the first lactation records because of disregarding the interaction component of sire by number of lactation. Comparing sires with first lactations only, to sires with adult lactations may overrate the precocious animal, the overrating will be diluted with additional later records, but not removed.

It appears that selection on the sire-to-sire path with respect to first lactation PD has reduced the variance among son groups. However, sire-to-sire selection had only slightly affected sire variances in second to third lactations. The evidence that variances between sire families were smaller for first than for adult lactations supports the hypothesis that part of the genes involved in milk production affect primi- and multi-parous cows differently.

Taking into account second and third lactations for the sire-to-sire path may be feasible without increasing generation interval; bull-dams may be bred after 1st lactation tests, sons will be selected and reared when the 2nd lactation test becomes available, and the final decision on the use of a young bull for testing will coincide with 3rd lactation tests.

Follow-up single or multiparous lactation progeny tests also seem warranted for the sire-to-cow path (48).

10. Sire and maternal grandsire effects on incidence of calving difficulty and calf mortality.

The effects of the sire and the maternal grandsire of the calf on incidence of calving difficulty (DIFF) and calf mortality (MORT) were studied by means of progeny tests of >.6 repeatability for calvings of heifer mates (HM), heifer daughters (HD), cow mates (CM) and cow daughters (CD) in Israeli dairy herds (25).

The SD among predicted differences (PD) for DIFF of HM, HD, CM and CD were 3.0, 2.1, 1.1 and .9, respectively. The corresponding values for MORT were 2.4, 2.1, 1.0 and .9. The coefficients of variation were similar for all effects. The estimated genetic correlation (r_g) between DIFF and MORT approached unity in calvings in both HM and HD. r_g between calvings of heifers and cows on DIFF and MORT were .9 and .7 for the sire effect, and .5 and .4 for the grandsire effect. r_g between calvings of HM and HD (sire and maternal grandsire effects) were .6 for both DIFF and MORT, however not significant between calvings of CM and CD.

The positive correlation between calvings of HM and HD were in concert with those reported for MORT in heifer calvings of Finnish Ayrshire (77). However, when the grandsire effect on the calf was dissociated from the sire effect on the ability of the cow to calve (maternal effect), negative correlations were reported for both DIFF (19,90) and MORT (14,15)

The evidence denotes that the calf effect masks the maternal effect and that all eight calving characters (DIFF and MORT in calvings of HM, HD, CM and CD) could be combined for predicting the sire effect on DIFF and MORT. The distribution of sires with large heifer mate and daughter groups was kurtotic, suggesting that only a few genes may be involved in controlling the calf effect.

11. The proven bull comparison

An experiment was started to explore the possible contribution of combinations of national strains in improving overall performance of dairy cows in high yielding and intensively managed herds. Five strains were chosen on the basis of the results from the Holstein-Friesian strain comparison in Poland (49). In the F.A.O experiment in Poland 10 national strains were represented by semen of young sires; the daughters of sires from U.S., Canada, Israel, New Zealand and Sweden produced above average heifer milk yields under extensive conditions. These strains were chosen for the Israeli experiment; each strain was represented by 5-6 sires which were among the highest proven bulls of their strain for daughter milk yields at the time when sires for the experiment were selected.

Approximately 10,000 doses of semen were obtained, 400 from each bull, and in addition 200 for each of two U.S. half-brothers. 9,411 inseminations of 5,735 nulliparous heifers were carried out between June 1981 and August 1982 in 110 high yielding Israeli kibbutz herds. An equal number of inseminations from each bull were carried out on each farm. Israeli bulls in the experiment were given special identification numbers in order to separate the offspring belonging to the experiment from the remainder.

Mean conception percentages for semen from the U.S., Canada, Israel, New Zealand and Sweden were : 62.2, 57.6, 64.9,61.9 and 59.2, respectively. Semen was packed either in mini-straws, midi-straws or pellets and the experience of the inseminators with the various forms of semen may have affected conception rates. 4,864 calvings were reported and among them 2,169 viable heifer calves. In the analysis of calving performance, the effect of the strain of the mating sires, the sex of the calf, the herd, season, and the sire of the dam were included in the model. The mean for calving difficulty and calf mortality were 13.2% and 11.0%, respectively. The least square means of bull calves were higher than for heifer calves by 10.4% and 7.4%, for calving difficulty and calf mortality, respectively. The least square effects in comparison to the mean of the experiment, of sires from the U.S., Canada, Israel, New Zealand and Sweden were 2.1, 1.9, -1.0, -2.7 and 5.1 for percentage of calving difficulty and 1.3, 2.2, -1.1, -1.0 and 3.8 for percentage of perinatal calf mortality,respectively.

Heifer daughters which were produced in the course of the experiment started to calve in spring 1984.

DISCUSSION

The big difference in Israel between conception rates of heifers and cows, and between summer and winter conception rates for cows but not for nulliparous heifers, suggest stress effects of lactating on conception in the Israeli summer climate. The herd yield level tended to be positively associated with cow fertility, implying that management for high yields succeeded in maintaining high cow fertility. In Israeli dairy herds the genetic correlation between fertility and milk yield of primiparous heifers tended towards positive, but the correlation between daily milk yield prior to insemination and conception rate was negative. It was postulated that high and low producing cows in the same herd provided different endo-environments for conceiving.

The hypothesis of endo-environmental role in genetic correlation estimates has been tested by an experiment with laboratory rats. The genetic correlation between maturing age and milk yields were negative at constant age but when nulliparous early maturing females were mated at first estrus, or when primiparous females of either strain were mated immediately post partum no correlations were evident. It was suggested that there exists a genetic association between maturing age and milk yields, which under endo-environmental stress of pregnancy at an early age or during lactation will be suppressed.

It was concluded that dairymen could continue to breed for high milk yields disregarding negative association estimates with fertility, but that both the herd and the cows within the herd have to be managed according to yield level.

In breeding cows for economically optimum production the effects of calving age, calving season and days open have to be considered. Postponing calvings in the autumn will increase production due to age and season effects, while in the spring the effects of age and season will tend to cancel each other. Number of days open significantly affected milk yields in the current and following lactations. Highest economic returns from milk yields and calf production may be achieved by calving intervals of about 13 and 12 months for heifers and cows, respectively. To achieve maximum return, high yielding cows should be bred slightly earlier than moderate or low yielding cows. The loss due to early breeding of cows was greater than the loss due to delayed insemination. This effect was even more pronounced for heifers. The findings and suggestions are at variance with the common belief among dairymen that heifers should be bred early post partum and high yielding cows relatively late.

The conclusions were supported by findings for the effects of number of days in milk and days pregnant on daily milk yields. The decline in milk yields of high yielding cows was relatively fast, but the effects of pregnancy were similar for high and low peak yielding cows; Thus it is not pregnancy but peak yield which affect the slope for yield decline.

Annualizing yields turns the biological span between calvings into a fixed time span for economic evaluations. The bias incurred by days open on annualized yield estimates is smaller than the bias in 305 day yields, especially for lactations with short number of days open. Adjusting annualized yields for days open will only marginally improve the prediction of yields in the following lactation. Yield predictions for the remainder of the lactation up to 217 days pregnant which take into account the quadratic effects of days in milk and pregnant, are economically useful for culling decisions among lactating cows and can be annualized and integrated into a progeny testing system based on annualized yields.

The genetic correlation between conception rate and annualized milk yields was near zero, but between yield persistency and either annualized yield or conception rate significantly positive. The findings suggest that common factors, such as appetite, may be involved in keeping milk and fertility from declining. The yield persistent cow may not score high for type, although the negative correlations between postpartum type and yield persistency is at present not understood or solidly based. The findings indicate that heifers with poor dairy character or rear udders will survive first lactations, but are likely to be culled during their second lactation.

It appears that the genetic variation for first lactation yields of the sires eligible for producing sons in Israeli dairy herds had become narrowed at the time of our investigation. On the other hand, there was no such reduction among sire families for second and third lactation yields. The findings suggest progeny testing for single lactation yields in order to establish the yield development pattern for dairy sires. Selection on second lactation yields for the sire-to-sire path may become an efficient tool for further genetic improvement.

Calving performance and perinatal calf viablity were mainly effects of the calf. This can be deduced from the highly positive correlation between the Predicted Differences for the effects of the sire and the maternal grandsire for calving difficulty and calf mortality. When the effect of the maternal grandsire on the calf was dissociated form its effect on the dam of the calf (maternal effect), the maternal effect was small and negatively correlated with the calf effect. The evidence implies that the effect of the calf overrides the calving ability of the cow. It was suggested that calving performance could be improved by the use of a selection index which takes into account sire effects on calving difficulty and calf mortality in calvings of heifer and cow mates and daughters.

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E. DESCRIPTION AND RESULTS OF COOPERATION

Dr. Bar-Anan visited ISU in the first and third years of the project. During the first visit, procedures were jointly designed and in the third year, results were evaluated.

Dr. Jeff Berger spent a month in Israel discussing programming approaches to the objectives of the project. He presented a workshop on mixed model animal prediction methods and studied dairy breeding and production conditions in Israel.

The cooperation resulted in a better understanding of ideas and methodologies in each other's country and perhaps the greatest benefit has been that some of these ideas are already incorporated in improvement procedures.

F. BENEFIT TO AGRICULTURE

1. Increased accuracy in phenotypic and genetic evaluations.

Procedures of adjusting yields for effects of age and month of calving and for days open were improved and new procedures for predicting yields of lactating cows up to day dry and for accounting for previous days open were developed. New procedures for cow selection and sire progeny testing have been incorporated in the national Israeli dairy cattle improvement scheme and were adopted by some US A.I. studs for bull-dam selection.

2. Optimum time for breeding cows post partum.

Findings indicated optimum times for breeding cows post partum in consideration of current and following lactations, number of lactation and time of the year. The findings were opposed to the belief upheld by many dairy farmers that heifers should be bred early post partum and high yielding cows late, and thus are expected to improve economic management.

3. Breeding for reduction of incidence of dystocia and calf mortality

Research by both groups on the genetic background for dystocia and perinatal calf mortality implied that the sire effect on its calf masks its effect on the maternal ability of his daughters, resulting in a positive relationship between the effects as sire and as maternal grandsire.

Parameters for multi-trait analyses combining data on dystocia and calf mortality in calvings of heifer and cow mates and daughters have been estimated and made available for index selection.

4. Production - reproduction relationship.

Research brought forward that the basic genetic relationship between production and reproduction tends to be positive, but high yields prior to insemination produce an adverse endo-environment for reproduction. Management has succeeded in coping with this effect for herds, but not within herds. The findings suggest cow management according to production within herds. The positive genetic association among yield, yield persistency and cow fertility suggest paying attention to persistency as a selection criterion.

5. Yield development across lactations.

The findings of diminishing genetic variation in first lactation yields and of diminishing increase from first to later lactations imply the need for single lactation progeny tests and multi-trait sire evaluations. Application will result in more high producing adult cows.

6. Relationship of yield and health

Increased production increased health problems, but also net merit. Application of the net merit function developed by ISU may increase net return from selection.

7. Broadening the genetic base of Israeli Holsteins.

The proven bull experiment has aggregated in Israeli dairy herds genes of some of the top proven bulls world-wide of the Holstein-Friesian breed . The project has broadened the genetic base for selection and will disclose possible genetic variation between strains.

G. LIST OF PUBLICATIONS UNDER I-3-79

See pages 46-49