PROVED SIRES AND PARTIALLY PROVED DAMS IN BREEDING DAIRY CATTLE FOR PRODUCTION

A. C. DAHLBERG
ABSTRACT

The breeding program in the development of the Experiment Station Jersey herd may be divided into two periods. Commencing with two foundation cows in 1900, a uniform policy was followed until 1921. Bull calves were selected from good dairy cows in the herds of successful breeders of dairy cattle. These bulls were used until 4 or 5 years of age, when they were slaughtered. Herd production per year varied from 300 to 325 pounds of butter fat. Since 1921, bull calves have been selected from excellent herds with special attention to the progeny of their immediate ancestors. Those sires that proved good, together with their daughters, have been used for breeding thruout their life time. Under this breeding program herd production has increased to an average of 423 pounds of butter fat for the past 3 years.

It was learned that the progeny of one cow were poor producers for three generations and this poor stock was eliminated. The four daughters and five grand-daughters of another cow produced much above herd average and their blood lines have been intensified in the herd. Some progress has been made by selection of dams for breeding purposes.

Consideration has also been given to the selection of bull calves by pedigree and to the proper evaluation of a proved sire in a given herd.
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INTRODUCTION

Increased production of milk and butter fat per cow must always be one of the goals of dairy farmers and breeders of dairy cattle. If total milk and butter fat production must be lowered to meet market demands, it is better to decrease the cow population thru removal of the lowest producers or diseased animals, thus increasing production per cow, rather than to decrease production per cow and maintain the same number of cows. To economize and reduce production to market requirements, factories endeavor to reduce the number of operating machines rather than to run all machines at part capacity. Labor costs increase with the number of cows rather than with production per cow, while the amount of feed per unit of product increases with decreased production. These fundamentals of production costs and profits clearly emphasize that it is always advantageous to breed dairy cattle for increased production per cow even in times when total production is being decreased.

Progress in developing superior production in breeds of dairy cattle has been slow. Production has increased thru better methods of feeding and management. It has been shown that many dairy herds have made no progress in developing increased production thru inheritance; and, tho one might question that no progress has been made in breeding, there can be no doubt that progress in breeding dairy cattle to increase milk and butter fat production has been exceedingly slow.

It is the purpose of this publication to show how progress has been made in increasing production of the Experiment Station herd thru careful breeding methods and to consider these experiences and other observations from the viewpoint of the dairy farmer and the breeder of dairy cattle. No endeavor will be made to review the numerous publications on the subject of breeding dairy cattle for milk production.
INCREASED PRODUCTION BY BREEDING

In the fall of 1921 the writer, to familiarize himself with the history of the Station herd, compiled production records to show the progress in breeding to increase production and to study various blood lines. Only the records of those cows whose names appeared in the pedigree of cows in the herd in 1921 were included in these data. It is doubtful if any selection of consequence in the females was practiced, so that these records are representative of the whole herd rather than being above the herd average as one might anticipate. Each lactation period included the total time that the cow milked after each calving, except that no periods were extended over 12 months and no lactation periods of less than 9 months were included. The records were entered for the year in which they ended and to simplify presentation all production records were expressed in butter fat. The average butter fat content of the milk varied from 5.4 to 5.8 per cent on a yearly basis.

Ample evidence is available to show that milk production and percentage of butter fat in milk are inherited separately, that is, a given sire may not affect at all or may decrease or increase milk production irrespective of changes in the percentage of butter fat. If total butter fat production is increased, the product of the weight of milk multiplied by percentage of butter fat has been increased, but either the weight of milk or the test may not have increased, while one or the other may actually have decreased.

These herd production records given in Table 1 strikingly illustrate that from the beginning of the Jersey herd at the Experiment Station in 1900 thru 1921 no improvement was made in the yearly production per cow. It is true that from 1914 to 1918, inclusive, there appeared to be a definite increase of 30 to 40 pounds of butter fat per cow per year. Analysis of the records show, however, that this increase was due to the fact that older cows were being milked for longer lactation periods during this interval. Expressed in another way, the milking herd was young while it was being expanded in numbers prior to 1914. In 1906 to 1908, inclusive, the herd averaged 340 pounds of butter fat per cow per lactation period, while in 1919 to 1921, inclusive, it averaged 344 pounds.

The production records per cow per lactation period since 1921 are also given in Table 1. These records show that the butter fat production per cow was increased above 400 pounds in 1923 and,
except for 1926, has remained above that figure since that time. This increase in production amounts to about 30 per cent which means that with the herd of 26 cows producing at the present level, 7 could be killed or sold without reducing the amount of milk below that given by 26 cows in 1919 to 1921.

That this increased production has been very substantial is emphasized by the fact that the average production for all heifers born since 1925 is greater than the best record of any heifer born prior to 1921. The records made by all the heifers in the ancestry of the cows in the herd in 1921 and of all heifers in the herd thereafter thru 1929 are given in Table 2. These records are for 10-month lactation periods. They show that production did not

**Table 1.—Yearly Average Butterfat Production of Experiment Station Jersey Herd Based Upon Lactation Periods of 10 to 12 Months.**

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of Cows</th>
<th>Butterfat, Pounds</th>
<th>Year</th>
<th>No. of Cows</th>
<th>Butterfat, Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1906</td>
<td>4</td>
<td>341</td>
<td>1922</td>
<td>23</td>
<td>353</td>
</tr>
<tr>
<td>1907</td>
<td>5</td>
<td>334</td>
<td>1923</td>
<td>14</td>
<td>407</td>
</tr>
<tr>
<td>1908</td>
<td>6</td>
<td>345</td>
<td>1924</td>
<td>17</td>
<td>427</td>
</tr>
<tr>
<td>1909</td>
<td></td>
<td></td>
<td>1925</td>
<td>22</td>
<td>452</td>
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<tr>
<td>1910</td>
<td>5</td>
<td>351</td>
<td>1926</td>
<td>18</td>
<td>397</td>
</tr>
<tr>
<td>1911</td>
<td>6</td>
<td>372</td>
<td>1927</td>
<td>24</td>
<td>405</td>
</tr>
<tr>
<td>1912</td>
<td>10</td>
<td>375</td>
<td>1928</td>
<td>23</td>
<td>425</td>
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<tr>
<td>1913</td>
<td>10</td>
<td>362</td>
<td>1929</td>
<td>21</td>
<td>422</td>
</tr>
<tr>
<td>1914</td>
<td>14</td>
<td>389</td>
<td>1930</td>
<td>21</td>
<td>405</td>
</tr>
<tr>
<td>1915</td>
<td>20</td>
<td>387</td>
<td>1931</td>
<td>23</td>
<td>473</td>
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<tr>
<td>1916</td>
<td>12</td>
<td>396</td>
<td>1932</td>
<td>16</td>
<td>463</td>
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<tr>
<td>1917</td>
<td>15</td>
<td>388</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1918</td>
<td>15</td>
<td>388</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1919</td>
<td>17</td>
<td>340</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1920</td>
<td>20</td>
<td>356</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1921</td>
<td>22</td>
<td>337</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 2.—Summary of Production Records Made in 10 Months at 2 Years of Age for All Cows in the Station Herd January 1, 1922, and Their Ancestors, and of All Cows Raised Thereafter.**

<table>
<thead>
<tr>
<th>Year of Birth, 5-year period</th>
<th>Number of Cows</th>
<th>Fat Production, Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1900–1904</td>
<td>5</td>
<td>276</td>
</tr>
<tr>
<td>1905–1909</td>
<td>7</td>
<td>312</td>
</tr>
<tr>
<td>1910–1914</td>
<td>11</td>
<td>278</td>
</tr>
<tr>
<td>1915–1919</td>
<td>12</td>
<td>260</td>
</tr>
<tr>
<td>1920–1924</td>
<td>25</td>
<td>324</td>
</tr>
<tr>
<td>1925–1929</td>
<td>19</td>
<td>370</td>
</tr>
</tbody>
</table>
increase with heifers born from 1900 to 1919, inclusive, but thereafter production increased quite markedly. These data are particularly comparable for heifers are least prone to udder trouble and are least apt to show effects of differences in feeding and management. All heifers were milked twice daily, but some of the older cows in the herd have been milked and fed three times daily since 1922.

**BREEDING PRACTICES, 1900 TO 1921**

The breeding practices followed in the Station herd prior to 1922 illustrate methods which were formerly considered to be the best and which even today would do much toward improving production on most dairy farms. From a strictly practical standpoint for the average dairy farmer these early methods are still satisfactory, but they are antiquated for those breeders of dairy cattle who wish to secure superior production for the breed. The records from 1900 to 1921, inclusive, show that an average herd production of about 350 pounds of butter fat per cow per lactation period (contained in 6,474 pounds of Jersey milk or 10,294 pounds of Holstein milk) might well be expected from these practices.

The present Experiment Station herd of Jerseys was founded with the purchase of Millie Darling 87835, a bred 8-year-old cow, in 1900, and a bred heifer, Dotshome Carey 176896, the following year. Another bred cow, Mabel of Springbrook 112904, was purchased in 1900, but all of her progeny were lost from the herd. The heifer calf Princess Aurora 178233 was born at the Station in 1902 from the cow Aurora of the Station 2nd 178232 so that other registered Jerseys were here in 1900. However, early barn records were lost in a fire and no progeny of these cows are in the ancestry of the animals now in the herd. The two foundation cows were probably good average Jerseys, but it is certain that they were not highly selected breeding stock. Their photographs (Fig. 1) show them to be large rough, rugged animals.

After 20 years a herd is largely the product of the sires used in that time and has little resemblance to the foundation females. Considerable care was always given to the selection of bull calves to develop as herd sires.

Men are largely responsible for the development of dairy cattle, so it is proper that bull calves were purchased for the Experiment Station from men who had made a reputation for their skill in
Fig. 1.—The two foundation cows from which all cows in the station herd are descendents.

*Above*, Dotshome Carey 176896; *below*, Millie Darling. 87835.
developing an outstanding herd. These men have been of much assistance in selecting the bull calves. Generally, these calves were selected from one of the good dairy cows in each herd as judged by her production records, type, and pedigree. It is self evident that the sire of the bull calf ought to be good enough if the whole herd was satisfactory on an average. That pedigrees were studied to aid in the selection of bull calves it is superfluous to state, but information on desirable points to observe in a pedigree were not always understood or available.

The daughters of all the sires who appear in all ancestors of cows in the herd in 1921 were studied in that year. All butter fat records of these daughters, made on two milkings per day, were averaged for 10-month periods as 2-year olds. Heifer records were used as they are obtained first and are most comparable. Since 1921, the records of all daughters of sires have been compiled as completed. These data are given in Table 3.

Of special interest to breeders of dairy cattle is the fact that prior to 1921 the daughters of only two bulls produced more than 300 pounds of fat in 10 months as 2-year olds. Only six daughters of these two best bulls appear in the ancestry of the present herd. On the other hand, 15 daughters of the two poorest bulls were used for breeding purposes to develop (or undevelop?) the herd. That "like begets like but with variation" was apparently forgotten, for the least that could have been done in developing a herd was to keep the daughters of the cows which were the best producers. Another fundamental error in developing the herd was the policy of killing all bulls at 4 or 5 years of age before their value was determined.

Most breeders of dairy cattle try to develop their herds along the lines previously followed in the Station herd, namely, (1) select bull calves from dams of good conformation, with good records, bred in fine herds; (2) buy a bull calf every second or third year and kill him at 4 or 5 years of age; and (3) practice no selection of females within the herd for breeding purposes. Under these conditions the Station herd produced about 350 pounds of butter fat per lactation period which must be near the average of the better herds of the breed and which must indicate approximately the results that the better dairymen might expect to secure. Making allowances for extra long lactation periods, dry periods, etc., this would mean an average herd production on a calendar year basis for all cows that
have ever freshened of 300 to 325 pounds of butter fat. The average dairyman may still follow these breeding practices with gratifying results, particularly if low producers are removed from the herd.

**Table. 3—Summary of Production Records As Pounds of Butterfat Produced in 10 Months at 2 Years of Age of the Daughters of All Sires Whose Blood Lines Are in the Herd or Its Ancestry.**

<table>
<thead>
<tr>
<th>Name of Sire</th>
<th>Year of Birth</th>
<th>Number Daughters</th>
<th>Fat Production, Pounds</th>
<th>Increase or Decrease Over Dams, Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundation Stock*</td>
<td></td>
<td>4</td>
<td>270</td>
<td></td>
</tr>
<tr>
<td>King St. Lambert Fancy 64050</td>
<td>1901</td>
<td>3</td>
<td>323</td>
<td>+72</td>
</tr>
<tr>
<td>Blue Belle Prince 70075</td>
<td>1904</td>
<td>9</td>
<td>271</td>
<td>-10</td>
</tr>
<tr>
<td>Oxford Lad St. Lambert King 82209</td>
<td>1908</td>
<td>3</td>
<td>311</td>
<td>+39</td>
</tr>
<tr>
<td>Jewel’s Gold Fern 103652</td>
<td>1910</td>
<td>4</td>
<td>286</td>
<td>-7</td>
</tr>
<tr>
<td>William Rufus of Bleak House 3rd 112452</td>
<td>1913</td>
<td>7</td>
<td>256</td>
<td>-52</td>
</tr>
<tr>
<td>Millie’s Fern Experiment 138782</td>
<td>1916</td>
<td>8</td>
<td>268</td>
<td>-13</td>
</tr>
<tr>
<td>Jacoba’s Farm Boy 169934</td>
<td>1918</td>
<td>16</td>
<td>326</td>
<td>+54</td>
</tr>
<tr>
<td>Excelsior Owl Interest 192214</td>
<td>1921</td>
<td>9</td>
<td>279</td>
<td>-3</td>
</tr>
<tr>
<td>Owirest 211961</td>
<td>1922</td>
<td>15</td>
<td>377</td>
<td>-9</td>
</tr>
<tr>
<td>Superb Owirest 234550</td>
<td>1923</td>
<td>8</td>
<td>362</td>
<td>-27</td>
</tr>
</tbody>
</table>

* Four sires are represented in this average, namely, D. Leo Mahkenac 46695, Prince of Astoria 50016, Czar of River Meadow 51936, and Golden Gem Roter 64080.

**PARTIALLY PROVED DAMS**

The information considered thus far is of general application to all dairymen. To increase production of purebred cattle above the average of the breed is a problem of real difficulty and in its solution very few persons have been successful. More complete knowledge of purebred cattle as secured thru production and type records, particularly as fostered thru the breed associations and herd improvement associations, make it possible to breed dairy cattle more constructively.

Too much attention cannot be given to the use of proved sires whose daughters are outstanding producers, but too little attention is often given to partially proved dams. The influence of the sires in a herd is much greater than that of the dams due to the greater number of their progeny, but the dairy cattle breeder has a large number of dams to select from and only a few sires.

Now and then a cow shows marked prepotency for high or low production which seems to be almost unaffected by the inheritance of the sire. An outstanding example of a dominant variation for low production was the family of “Queens” in the herd of 1921. Carey
Fairy Queen was the mother of five heifers. Two of these made State championship records for butter fat, two produced an average of 543 pounds fat in 12 months, and the fifth daughter was Golden Fern's C. F. Queen that gave only 218 pounds of fat as a 2-year old. Golden Fern's C. F. Queen was the mother of Carey's Bleak House Queen, who gave only 168 pounds fat as a 2-year old, and the daughter of Carey's Bleak House Queen, Experiment Bleak House Queen, produced 213 pounds of fat. For three generations this strain averaged less than 200 pounds of butter fat in 10 months as heifers, in spite of the fact that all the daughters of the three sires involved that were raised in the herd had an average production of 271 pounds.

When it was discovered in 1922 that these cows had so adversely affected production, the two cows then in the herd, together with their two heifer calves, were sold. In this manner this low-producing strain was forever eliminated from the herd.

Careful attention has been given in recent years to the reproducing ability of the cows, for in the herd of 26 cows there is considerable opportunity for selection even tho progress is made slowly. Geneticists and others have very much belittled selection thru dams probably because so much more rapid and certain results can be secured thru the use of proved sires. No opportunity for improvement should be overlooked. Definite progress in improvement in the Station herd has been made thru selection of dams for breeding purposes, in spite of many contentions to the effect that progress is not made in this way.

Exceptions are said to prove the rule so the exceptional inheritance of the cow Jacoba Princess 574662 is an object lesson. The record of 378 pounds of fat in 10 months was made as a 2-year-old and her next year's record was 491 pounds of butter fat in 10 months. She was the mother of four daughters by two sires that produced an average of 429 pounds of butter fat in 10 months as 2-year-olds. Two of her daughters are shown in Fig. 2. Her first five granddaughters gave an average of 374 pounds which included one low record of 290 pounds that is now being greatly increased as a 3-year-old. The records of these four daughters and five granddaughters are above the average of all heifers in the Station herd and of all 2-year-old daughters of the sires of these heifers. These nine daughters and granddaughters are now in a herd of 26 cows so that about one-third of the herd is her progeny. Furthermore, five
Fig. 2.—Two Daughters of the Cow Jacoba Princess 574662, Taken as 2-Year Olds.

Above, Owlrest's Alice 807492 which had just begun a record of 514.6 pounds of fat in 10 months; below, Superb Owlrest's Patricia which freshened 2 weeks later and produced 483.9 pounds of fat in 10 months. It is interesting to note the improvement in dairy type of these two heifers as compared with the foundation cows.
other granddaughters are now present in the calf herd so that the influence of this cow will be present for years to come.

Selection of cows of recognized inheritance for dams of future herd sires is a feasible and practical proposition which will be discussed later as an aid in breeding sires with greater probability of proving satisfactory.

PROVED SIRES

The Station herd, like those of the majority of dairy cattle breeders, has been one in which the value of sires has been proved rather than one in which proved sires have been regularly used. There is little value in proving that a sire gets high producing daughters unless the sire is used after his value has been established.

In recent years every endeavor has been made to intensify in the herd the blood lines of those sires whose daughters have been the best producers. To accomplish this, the 10-month records of all daughters were compared with the records of their dams at 2 years of age. Entries of the daughters and dams were made promptly as the 2-year-old records of the daughters were completed so that the value of the sire could be visualized as soon as possible.

As previously mentioned, this comparison was rather discouraging when first made in 1921. There had been only two bulls whose progeny, which had been or were milking in the barn, showed increased production of daughters above that of their dams. As the heifers freshened which were sired by Jacoba’s Farm Boy or Excelsior Owl Interest, the two bulls then in the herd, they were carefully watched, for it was hoped that either or both sires would get increased production.

The value of Jacoba’s Farm Boy was soon evident for his daughters, as 2-year-olds, were better milkers than their dams. As a consequence this bull was used until 5 years old and 16 of the 26 cows in the barn were his daughters. Furthermore, the female calves of his daughters were generally saved for replacements in the herd.

What should be done with a proved sire of this merit? Obviously, he should not be slaughtered. This bull was sold to a breeder of purebred Jerseys, thereby giving him the opportunity of using a sire who would produce daughters that would probably not be disappointing. This breeder kept Jacoba’s Farm Boy until he was 8 years old when he sold him to another breeder who kept him until 11 years
of age when he was slaughtered as no one was found who wished to own this old bull. The use of this bull throughout most of his life made it possible for two breeders of Jersey cattle to secure a bull of known prepotency for a total of 6 years.

The daughters of the next herd sire, Excelsior Owl Interest, presented an interesting problem in breeding and some question might be raised regarding his value. The daughters of Excelsior produced 297 pounds of fat in 10 months as 2-year-olds which compared unfavorably with the 326-pound average of the previous bull. Furthermore, Excelsior’s daughters were extremely variable, some failing to qualify for Register of Merit while one won a silver medal for production. On account of this variability and the fact that his daughters were lowering the herd production, the bull was slaughtered at 5 years of age. An inheritance peculiarity of this sire is that his daughters showed only 3 pounds decrease as compared with their dams, as the dams were below the average of the daughters of Jacoba’s Farm Boy. By chance the dam and daughter comparison showed that Excelsior was maintaining production, but their production was below the herd average. Further developments showed the wisdom of slaughtering Excelsior and, at the present time, progeny thru only two of his daughters are in the herd so his blood lines have been almost eliminated.

The next two sires, Owlrst and Superb Owlrst (Fig. 3), have been outstanding, together with Jacoba’s Farm Boy, in raising herd production. Their daughters produced as 2-year-olds in 10 months 377 and 362 pounds of fat, respectively (Table 3). These averages are the highest ever secured in the Station herd and their daughters have been uniformly good. As a consequence of their recognized values, their daughters have been saved until, at the present time, every cow in the barn is a daughter of one of these sires.

To intensify their blood lines still further, the granddaughters of each bull are being mated to their grandfather. This practice, which is experimental and is not being recommended at this time, makes it possible to keep a proved sire in a herd throughout his active life. It should reduce variations in breeding from the use of unproved sires, and it should reduce the number of sires needed by a breeder. It is estimated that a new bull every 5 years should be ample, providing each new bull proves to be a good sire. Greater care can be used in selection and higher prices can be paid without increasing yearly costs.
Fig. 3.—Two Proved Sires Now in Use in the Station Herd.

Above, Owlrest, 211961; below, Superb Owlrest, 234550. The 15 daughters of Owlrest have won four silver medals and averaged 575 pounds of butter fat. The pedigree of Superb Owlrest with the records of his daughters is given on page 27.
Reference to Table 3 shows that on the basis of the customary comparison of the records of daughters with those of their dams, Owlrest and Superb Owlrest both decreased production. On the other hand, their daughters are the largest producers ever present in the Station herd. This apparent inconsistency is due to the selection of the highest producing cows for breeding purposes. The writer believes that the production of the daughters of these two bulls is a better index of their breeding value than the comparison of the records of the dams and daughters due to selection of dams. Such a conclusion must be justified as herd production has increased or it must be concluded that progress was made thru selection of dams in spite of the use of inferior sires. The latter assumption is hardly tenable, even tho some improvement has been made by selection of dams, as the inheritance of the dams would need to be assumed to be materially above that of the bulls used in the herd thruout the past 21 years and of the foundation stock. This problem will be discussed under the topic of bull indexes.

SIRE INDEXES

In recent years students of dairy cattle breeding from the viewpoint of genetics have endeavored to develop a method of calculating an exact numerical value for the total weight of butter fat or for the total weight of milk or for the butter fat percentage which would indicate the breeding value of the sire. Such a sire or bull index will be of great value in promoting the advancement of dairy cattle breeding. Herd testing, advanced registry, herd sire testing, etc., as now carried on thru the various breed associations are furnishing data which, if intelligently applied, ought to show results within the next decade or two in better purebred cattle. The use of this newer knowledge of cattle production records is already of inestimable value in planning the breeding program for the Experiment Station herd.

For the purpose of comparing records, it is necessary to adjust them to an equitable basis. Two adjustments are accepted by the American Jersey Cattle Club, namely, age and length of the lactation periods. The records are all expressed on the basis of a 12-month lactation period for a mature cow. A 10-month record is converted to 12 months by multiplying by 1.15. The age factors as given by Copeland for the American Jersey Cattle Club are given in Table 4. These factors are not identical for all breed associations. It is
impossible to adjust records satisfactorily to care for differences due to variations in herd management, except that an adjustment might also be made for the number of milkings per day.

The 2-year old records made on two milkings per day of all the female ancestors of the present Station herd have been computed to a mature basis and presented in Table 5. The records of their dams have been computed to a mature basis also. As shown in Table 3, the number of daughters of the first, third, and fourth bulls are too few for reliable data, but the daughters of all other bulls number seven or more so that the figures are reasonably accu-

![Graph](image)

**Fig. 4.—The Average Variation in Pounds of Butter Fat of Each Group of Daughters of a Sire from the Average Yield of All of His Tested Daughters.**

rate, especially as all records were made in the same herd. The number of daughters generally conceded as necessary to prove a sire varies from 5 to 10 and the American Jersey Cattle Club has adopted 10. In this connection the data of Copeland,¹ presented in Fig. 4,

¹*Jersey Bulletin, Jan. 6, 1932.*
Table 4.—Factors for Converting Production Records to a Mature 12 Month Basis, American Jersey Cattle Club.

<table>
<thead>
<tr>
<th>Age</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 2 years</td>
<td>1.45</td>
</tr>
<tr>
<td>2 to 2½</td>
<td>1.36</td>
</tr>
<tr>
<td>2½ to 3</td>
<td>1.28</td>
</tr>
<tr>
<td>3 to 3½</td>
<td>1.20</td>
</tr>
<tr>
<td>3½ to 4</td>
<td>1.14</td>
</tr>
<tr>
<td>4 to 4½</td>
<td>1.08</td>
</tr>
<tr>
<td>4½ to 5</td>
<td>1.04</td>
</tr>
<tr>
<td>5 to 6</td>
<td>1.02</td>
</tr>
<tr>
<td>6 to 10</td>
<td>1.00</td>
</tr>
<tr>
<td>10 to 12</td>
<td>1.02</td>
</tr>
<tr>
<td>12 years and over</td>
<td>1.05</td>
</tr>
<tr>
<td>305-day factor</td>
<td>1.15</td>
</tr>
</tbody>
</table>

were especially applicable and easy to interpret, as the accuracy of any given number of daughters in determining the average record of a larger number of daughters of a sire can be read from the graph.

The sire index based upon equal inheritance from the dams and the sire, or some slight modification, is now generally used in determining a sire’s index. The increase or decrease of the production of the daughters above or below the production of the dams is added to or subtracted from the daughters’ records. The formula is

\[
\text{Sire index} = \text{Daughter} + (\text{Daughter} - \text{Dam})
\]

The bull indexes given in column 4 of Table 5 were calculated by means of this formula. These data show that since 1921, except for Jacoba’s Farm Boy, the four bulls used in the herd decreased the production of the daughters as compared with the dams, but the production of both the daughters and the dams and of the entire herd increased during this period. Furthermore, the sire indexes, based upon equal parents, show a decrease in production by the last three sires but herd production was increasing. Apparently, there were some factors involved that were overlooked for production could not be increased by sires which decreased production.

Selection of the highest producing females for breeding has been very evident during the past 10 years as shown by the fact that the dams used in determining the index of the last two sires had average records of 600 pounds of butter fat on a mature basis. Did these cows transmit this high production to their daughters? If so, from
<table>
<thead>
<tr>
<th>Name of sire</th>
<th>Butterfat production, pounds</th>
<th>Sire index based on sires', daughters', and dams' production</th>
<th>Calculated inheritance of dams</th>
<th>Sire index based on sires', daughters', and dams' inheritance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daughters</td>
<td>Dams</td>
<td>Change</td>
<td></td>
</tr>
<tr>
<td>Foundation stock*</td>
<td>423</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>King St. Lambert Fancy 64050</td>
<td>505</td>
<td>392</td>
<td>+113</td>
<td>618</td>
</tr>
<tr>
<td>Blue Belle Prince 70075.</td>
<td>424</td>
<td>439</td>
<td>-15</td>
<td>409</td>
</tr>
<tr>
<td>Oxford Lad St. Lambert King 82209</td>
<td>486</td>
<td>425</td>
<td>+61</td>
<td>547</td>
</tr>
<tr>
<td>Jewel's Gold Fern 103652</td>
<td>447</td>
<td>458</td>
<td>-11</td>
<td>436</td>
</tr>
<tr>
<td>William Rufus of Bleak House 3rd 112452</td>
<td>400</td>
<td>481</td>
<td>-81</td>
<td>319</td>
</tr>
<tr>
<td>Millie's Fern Experiment 138782</td>
<td>419</td>
<td>439</td>
<td>-20</td>
<td>399</td>
</tr>
<tr>
<td>Jacoba's Farm Boy 169934</td>
<td>510</td>
<td>425</td>
<td>+85</td>
<td>595</td>
</tr>
<tr>
<td>Excelsior Owl Interest 192214</td>
<td>464</td>
<td>485</td>
<td>-21</td>
<td>443</td>
</tr>
<tr>
<td>Owlrest 211961</td>
<td>579</td>
<td>593</td>
<td>-14</td>
<td>565</td>
</tr>
<tr>
<td>Superb Owlrest 234550.</td>
<td>567</td>
<td>608</td>
<td>-41</td>
<td>526</td>
</tr>
</tbody>
</table>

* Four sires are represented in this average, namely, D. Leo Mahkenac 46695, Prince of Astoria 50016, Czar of River Meadow 51936, and Golden Gem Rieter 64080.

† Equal parent index.

what source did they inherit such breeding? It is most probable that these cows represented the best of the offspring of lower average inheritance and that their inheritance for production was below their records and nearer to that of their paternal half-sisters and close relatives on the dams’ side. The exception to this statement is the offspring of the cow Jacoba’s Princess to which attention has already been given, but it is doubtful indeed that selection of cows for breeding within one herd could completely offset the effect of the sires. The history of production in breed associations clearly shows that very limited progress in breeding has been made by selection of cows for breeding purposes on the basis of their production records so that the importance of the dams’ records have been overemphasized.

To give the sires credit for the increased production in the herd requires some alteration in the details of calculating sire indexes.
Copeland\textsuperscript{2} has been shown that in the Register of Merit for Jersey cattle an increase of 100 pounds in the records of dams means an increase of 32 pounds in the records of daughters, a ratio of 3:1. He also showed that all Register of Merit records on a mature 12-month basis averaged 549 pounds of butter fat and that the production of the dams and their daughters agreed at this figure. Such an average is too high for the breed as it represents the best records of the best cows in the best herds. Bull indexes ought to apply chiefly to the best stock of the breed, but the breed average for Register of Merit herds must be lower than the average of the individual cows in Register of Merit. As the daughters of all bulls and foundation stock, shown in Table 5, produced an average of 491 pounds of fat, it is evident that 500 pounds would represent a fair average for the Experiment Station herd. This figure is 10 percent less than the selected best lactations which appear in the Register of Merit. Accepting 500 pounds as the average inheritance of the dams for the Experiment Station herd or for the average for the best herds of the breed, then the inheritance of an individual dam or group of dams will be one-third the increase or decrease from the average plus the average. This may be calculated from the equation,

\[
\text{Inheritance of dam} = 500 + \frac{\text{Dam} - 500}{3}.
\]

The formula for calculating sire index, based upon equal inheritance from each parent, would be as follows:

Sire index = Daughter + (Daughter − Inheritance of dam).

By the use of these two formulae the inheritance of the dams and the sire indexes of the last two columns in Table 5 have been calculated.

This adjusted sire index has two important effects upon the index based upon the average production of the dams and of the sire’s daughters. When the production of the dams is below average (500 pounds fat), the “inheritance of dam” is higher than the production, thus tending to lower the bull index. For very high producing dams their inheritance is below their records and the adjusted bull index is increased. This compensated sire index gives values for the Experiment Station herd which are in better agreement with

changes in herd production, that is, the herd production was increased by the bulls with the best sire index, and *vice versa.*

Attention has been drawn by Lush* to the sire index of H. W. Norton, Jr., which uses an "expectancy of daughters" based upon the dams' records. Lush has calculated an equation for the data of Norton which is very similar to that just given, except that the "breed average" is inserted instead of a definite figure. The identical relationship in the trends of the records of dams and their daughters for both the Jersey and Holstein breeds indicates the general significance of the equation for calculating the "inheritance of dam" or the "expectancy of daughters," and the real problem involved in the calculation is the accuracy of the base figure accepted as the "breed average." That 500 pounds of butter fat has been suggested does not mean that figure is exact or that it should be constant for all conditions. In the future the Experiment Station herd will probably be milked three times daily so the figure should then be increased to about 600 pounds to be best for the herd in question. It is problematical if any "breed average" would be fair for all conditions, but an inheritance of dams calculated from it would be as reliable under the worst conditions in calculating a sire index as the records of highly selected dams even tho many geneticists seem to disagree with this statement. Norton's data* for Holsteins on three milkings per day show that the records of the dams and the daughters agree at 660 pounds of butter fat, an amount about 60 pounds in excess of that which might be fairly applied in the present study if all records were calculated to three milkings per day.

From the standpoint of the mathematically inclined geneticist, objections may be made to any sire index. It is probably true that all such indexes are subject to inaccuracies and should be used as approximations. Certain it is, that the records of selected dams are not a correct index of their inheritance so that the sire index based upon records of the sire's daughters and the dams' records may be somewhat in error even tho this index is so often recommended. This index would be reasonably correct if breeders tested heifers from all cows, whether good or poor producers. The index based upon the records of daughters of the sire and the calculated inheritance of the dams tends to mini-

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*Unpublished manuscript.
mize the effect of variable production of dams and would be less accurate only when there is no selection of dams and the dams were much above or below the breed average. Most constructive breeders practice some selection of cows for breeding or of their daughters for testing so that this proposed index may be of much value. In any event a breeder of dairy cattle must observe trends in herd production, the records of all the daughters of sires, and sire indexes to properly evaluate a sire.

PEDIGREE ANALYSIS IN SELECTING BULL CALVES

The most certain manner of securing herd sires of outstanding quality is to buy sires which some one else has proved to be valuable. The supply of such sires is limited and expensive and most breeders must try young sires to discover the good ones by the records of their daughters.

To make the most rapid progress, it is necessary to select bull calves with some assurance of success in maintaining or increasing high herd production. Even tho the breeding program is correct, variations of such magnitude will occur that progress cannot be made with certainty, but the chances of lowered production may be reduced while chances for high production are increased. The principle that can be used to best advantage is expressed in the ancient axiom "Like begets like but with variation."

The pedigree of the young bull calf that is to be raised for a future herd sire for a herd of outstanding production should show the following characteristics. First, the sire of the calf should be a proved sire, the majority of whose daughters should be tested for production and should show an average noticeably in excess of the average of the herd in which he will be used. For the Experiment Station herd or any herd of high production for the breed, his daughters should exceed 600 pounds of butter fat, the production used by the American Jersey Cattle Club to designate a "Superior Sire." It is doubtful if the use of the usual sire index would be of much greater value than daughter production and it is more difficult to secure. The sire index is of most value when the inheritance of the sire varies widely from that of the cows to which he is mated. Such a sire of the selected bull calf indicates proper inheritance from the sire. Obviously, the inheritance from the sire may be much lower than that just stated and still be very satisfactory for the average herd.
The inheritance which the bull calf receives from the dam is not so easily considered as past experience shows that her record alone, altho helpful, ought not be emphasized too much. The dam’s record should exceed 600 pounds of butter fat. Of greater importance, however, is the reproduction records of the dam if she is old enough to have several tested daughters. Since this is generally not the situation, the breeding records of her sire and dam are of major significance. The maternal grandsire of the bull calf should be a proved sire equal in value to the bull calf’s sire. Only one line of the pedigree is not accounted for, namely, the maternal granddam. She would be an old cow and she should have given over 600 pounds of fat and should be the mother of at least three, and preferably four, daughters which have averaged over 600 pounds of fat. It is known that four daughters do not properly prove an animal, but Copeland has shown (Fig. 1) that the records of the first four daughters of a bull come within an average of 60 pounds of showing the records of all of his daughters. Hence, the maternal granddam is practically a proved dam within this limit on the basis of four daughters.

Recently, Copeland⁵ has presented data which clearly illustrate the value of various records in predicting the probable or anticipated worth of a bull calf. The striking correlation of the records of the sires’ daughters to the records of the sons’ daughters would be expected and is shown in Fig. 5. The relationship of the production records of the dams of the sires to the records of the sires’ daughters was slight. On the other hand, when the sire’s dam had three or more tested daughters, there was a significantly good correlation between the records of the dam’s daughters and of her sons’ daughters. Copeland also found a significant relationship between the records of the daughters of the paternal and maternal grandsires and the records of the grandsons’ daughters. These correlations, which Copeland and others have found to be true, must be correct and should serve as the basis of constructive breeding. The pedigree analysis of future herd sires as given by Copeland and in this bulletin are essentially identical.

The author believes that no one seriously questions that sires whose daughters are excellent probably will continue to get excellent daughters and that this same proposition applies to dams, but with less accuracy due to fewer daughters. If such is the case, improved

production can be secured by the more general application of this type of knowledge which has been recently made available to breeders thru their respective breed associations and herd improvement associations.

The pedigree of the youngest herd sire at the Experiment Station, Interested Rosy's Baron, 339247, is presented to illustrate the possibility of selecting a bull calf with promising prospects based upon these points of self-evident value in pedigree study. The daughters of the sire of this bull calf have produced an average of 661 pounds of butter fat and it was known that there has been little selection in their testing. Nothing was known regarding the daughters of the dam of this bull calf as she was a young cow. She made the excellent record of 619 pounds of fat as a 2-year-old. Her inheritance was fairly well known, however, by the proved ability of her sire and dam. The daughters of the sire of the dam
of the bull calf produced an average of 608 pounds of fat and there was only limited selection. The dam of the mother of the bull calf was the dam of four cows that averaged 709 pounds of fat. The record of the maternal granddam is not particularly high which may be partly due to freshening at 1 year and 4 months of age. By averaging the records of the progeny of the bull calf's maternal grandparents, the inheritance of the bull calf's dam was figured to 659 pounds of fat. By averaging this figure with the records of the daughters of the sire, the inheritance of the bull calf was found to be 660 pounds of butter fat based upon the records of the progeny of his immediate ancestors. In a herd where management practices were similar to those in the herd of the bull calf's immediate ancestry (cows being fed and milked three times daily and there being a limited amount of culling of daughters), this calculated inheritance should be approximately correct.

Information in the pedigree of the proved sire Owlrest is scarcely sufficient to justify a pedigree analysis, but the data for Superb Owlrest are worthy of study. His pedigree is presented herewith with the thought of anticipating the production records of his daughters. When Superb Owlrest was purchased as a calf, the records of one of his full sisters and of the daughters of his full brother were unknown, but all other data were known or were partially available. The progeny record of the sire of Superb Owlrest was 683 pounds of fat for 82 daughters and there could have been only limited selection. The daughters of the maternal grandsire may have been highly selected as only one-third were tested, while the records of only two daughters (one made a world's record) of the maternal granddam were available. Obviously, the calculated inheritance of 739 pounds of fat for the mother of Superb Owlrest may be too high. The inheritance of Superb Owlrest was found to be 711 pounds of fat, as calculated from the pedigree. His two full sisters produced 772 pounds of fat, and his dam was the mother of two other cows which met with misfortune, but they probably were not equal to the two tested sisters. Most of these records were made on three feedings and milkings per day, whereas seven of the eight records of the daughters of Superb Owlrest were made on two milkings per day. If a correction of 20 per cent were made to adjust three milkings per day to two milkings per day, the inherited production of Superb Owlrest would be 593 pounds of fat. This inherited pro-
duction compares very favorably with the best records of his daughters (no selection) of 593.8 pounds of fat. The 18 daughters of the full brother of Superb Owlrest produced 607.1 pounds of fat on two milkings per day. A pedigree analysis of Superb Owlrest clearly indicates the approximate production of his daughters from high-producing dams.

In considering these pedigrees and the recommended production records of progeny of animals in the pedigree of a bull calf with best prospects of developing into an outstanding sire, it should be borne in mind that the number of bull calves of such breeding is very limited and that the number of herds requiring such highly bred bull calves is also limited. Sufficiently high production may be secured for good dairy herds by the older methods of selection. These high standards are suggested for the best herds of purebred dairy cattle from whose breeding the average production of purebred cattle will be improved.

Under any given market situation the sales value of dairy cattle depends upon production and type. The beautiful cow or bull which shows good type will sell for a higher price than one of less beauty but of equal production ability. A prospective buyer always wishes to select stock partially on the basis of appearance and it is sometimes difficult to interest him in the details of production records even tho he expects to use the cattle for production only. Breeding dairy cattle for type and beauty should not be overlooked, but it must be of secondary importance as the principal value of dairy cattle lies in milk production.

DISCUSSION AND CONCLUSIONS

The complete production and breeding records of the present Experiment Station Jersey herd are available from the beginning of the herd in 1900, altho registered Jerseys whose blood lines are not in the present herd were owned by the Station prior to that date. These records show the progress and changes in policies in dairy cattle breeding during the last third of a century.

For nearly a quarter of a century, 1900–1921, a uniform breeding policy was followed which was then considered the best practice but which is now somewhat behind more modern developments in breeding for maximum herd production. A bull calf was purchased every second or third year from a man who had been successful in breeding a good herd. The dam of the bull calf was a
Interested Rosy’s Baron 339247
Inherited production 660 # fat

Faucic Maid’s You’ll Do
225661
Silver medal
21 daughters average 661.5 # fat, 11,711 # milk, 5.65%

Maiden’s Masterman
207557
Silver medal

Maiden of 3 cows that average 571 # fat
Record of 623 # fat as 5 yr. old
Dam of winner of Parish Show

You’ll Do’s Faucic Maid
498556

Faucic’s Milkmaid 306564
Dam on 3 cows averaging 652 # fat
Excellent type show cow

Imported Oxford You’ll Do 111860
Gold and silver medal
84 daughters average 532.1 # fat, 10,263 # milk, 5.19%

Sayda’s Heir 3rd 74817
62 daughters average 544.9 # fat, 9,573 # milk, 5.69%

Jap Sada’s Baron
142559
Silver medal
27 daughters average 608.6 # fat, 10,552 # milk, 5.77%

Jap Sada’s Baroness 321895
14,438 # milk, 866 # fat, 6%, 4 year old

Baroness Rosy
780530
Silver medal record of 10,850 # milk, 619.6 # fat, 5.71% at age 2 yr. — 6 mo.
Inherited production 659 # fat

Interested Meridale Rosy
380805
Dam of 4 cows averaging 709 # fat, 12,700 # milk, 5.39%
Record of 317 # fat at 1 yr. — 4 mos. 393 # fat at 2 yr. — 8 mos.

Interested Prince 2nd
31 daughters average 547.1 # fat, 9,587 # milk, 5.71%

Masterman of Oakland 198269
39 daughters average 541.4 # fat, 9586 # milk, 5.65%

Sweet Maiden P. S. 1782
Famous Island Show cow

All records on basis of mature cows for 12 months unless otherwise stated. All records taken from Register of Merit or Tested Sires of American Jersey Cattle Club.

Jap’s Sayda Rose
310309
Gold medal — 737 # fat
Spermfield Owl’s Progress 163331

Silver and Gold medal
His 82 tested daughters average 683.7 # fat, 12,366 # milk, 5.53% 
Inherited production 711 # fat (3 milkings per day)

Superb Owirest 234550

The records of his 8 daughters average 593.8 # fat, 10,750 # milk, 5.52% (2 milkings per day) 
Inherited production 711 # fat (3 milkings per day)

Oxford Lad Progress 92916

15 daughters average 562 # fat, 10,587 # milk, 5.31%

Spermfield Owl’s Temisia 215982
875 # fat 
Dam of 4 medal sons and 1 medal daughter

Magvarland’s Temisia 134762
638 # fat

Interested Prince 58224

First prize at Pan-American Exposition—46 daughters average 537 # fat

Sibley’s Interested Owl 134969

Silver medal
11 daughters average 700 # fat, 12,846 # milk, 5.45%

Spermfield Owl’s Temisia 215982
875 # fat 
Dam of 4 medal sons and 1 medal daughter

Interested Marcella B 390013

Silver medal — 621.1 # fat, 10,727 # milk, 5.79% in 10 mo., age 3 yr-3 mo. 
Dam of 2 cows averaging 779 # fat, 12,980 # milk, 6.00%

Imported Financial Baron 139449
Silver medal bull whose 5 daughters average 771 # fat. Son of Golden Perin’s Noble.

Interested Golden Celia 313032
379 # fat as 2 yr. old 
Daughter of Interested Prince

Model’s Oxford Lad 66518
A show bull whose 11 tested daughters average 443 # fat. Son of Oxford Lad

Spermfield Owl Belle 194051
636 # fat as a mature cow
Dam of cow making 596 # fat, 2 yr old

Spermfield Owl 57088
Gold medal bull whose 49 daughters average 570.8 # fat

All records on basis of mature cows for 12 months unless otherwise stated. All records taken from Register of Merit or Tested Sires of American Jersey Cattle Club.
good dairy cow which the owner knew to be a good milker or which actually had a bonafide record of production. The bull was slaughtered at 4 or 5 years of age. There was no endeavor to select the cows in the herd for rearing heifers as they were all considered to be so closely related as to make selection futile. Under such a breeding program the 10 to 12 months' records of all cows varied from 337 to 396 pounds of butter fat, the approximate equivalent of 300 to 325 pounds of fat as a herd average on a calendar year basis, a very creditable record. It would be expected, therefore, that the average good dairyman might readily develop a herd of equally good production by these methods which are so easily followed. The real disappointment of this breeding program to the student and breeder of dairy cattle is the fact that no increase in the production of the herd was made during 21 years, a large portion of a man's productive life. As knowledge of the feeding and management of dairy cattle actually advanced during this period, there is indirect evidence that the inheritance of the herd for milk production may have retrograded slightly.

In this early period the daughters of the foundation stock and of six sires were in the Station herd. Of these sires two gave daughters above the average of the herd, but their inheritance was soon lost as these sires were slaughtered while young and only three daughters of each were used for breeding purposes. During this time the progeny of one cow appeared to be uniformly low producers even thru the third generation. These observations emphasize the value of the present educational teachings to keep proved sires of superior merit thru their productive life time. They also indicate that there is opportunity to increase production by careful observation of the offspring of the cows, for altho the number of heifers that may be secured from a cow is very limited, the number of cows that may be used for selection is very large.

Since 1921 the Station herd production has been increased about 30 per cent. The average production for lactation periods of 10 to 12 months, chiefly 10 months, is from 397 to 473 pounds of butter fat and the average yearly herd test for the last three years is 423 pounds of fat. This increase has been made by the selection of dams for breeding purposes, more advanced methods of selecting bull calves for future herd sires, and the use of the best herd sires after their value was known. Some of the increased production has also been due to improved feeding and management practices.
Thru selection of dams progress has been made in two ways. All progeny of one low-producing strain were slaughtered. All progeny of one high-producing strain have been saved in the herd. The low-producing strain that was eliminated from the herd for three generations produced less than 200 pounds of butter fat in 10 months as 2-year-olds, while the four daughters and five granddaughters of the cow which founded a high-producing strain whose blood lines have been intensified in the herd gave an average of 398 pounds of butter fat. Obviously, progress in breeding can be made thru the dams.

Of the four sires whose daughters have been in the herd since 1921, one failed to produce daughters that were satisfactory producers on an average. This sire was slaughtered and heifer calves from his daughters were not raised in the herd. The other three sires proved to be very good. One was sold for use in another herd and was later transferred to a third herd. The other two proved sires are still in the Station herd at 10 and 11 years of age. Thru proper handling and old age they have become very docile. The use of these proved sires has made it possible to know the probable production of heifers with considerable certainty.

To evaluate a sire with producing daughters properly, required a knowledge of several factors. First, consideration was given to the average production of all his daughters. When the sire's daughters produced more than the average of the entire herd, progress was being made either thru the sire or thru the dams. Altho it was generally true that herd production increased and a sire was of real value when his daughters produced more than his dams, yet in recent years two sires were shown to decrease production of the daughters as compared with their selected dams, while herd production increased and cows were not removed from the herd as low producers. In careful evaluation of sires the production of the daughters, their dams, and of herd production ought to be considered. A sire index can be only approximate so that the record of all the daughters with some indication of the extent of selection appears to give ample information for constructive breeding in a given herd. The sire index is of special value in considering the probable result of transferring a proved sire from one herd to another.

This study of the Station herd, together with much published data from innumerable sources, clearly indicates that bull calves should be selected by more attention to progeny of their ancestors. By careful study, a bull calf could be located or bred which has a
sire and a maternal grandsire whose daughters were outstanding producers and whose maternal granddam was the mother of three or four cows all of which made outstanding records. Such a bull calf from a dam with a high record and whose sire and dam are themselves of excellent type and who come from stock of good type would be most apt to be a valuable sire. The amount of selection in the daughters whose records are in the pedigree, the conditions under which the records were made, and natural variations in the results of breeding will always introduce plenty of hazards.

The application of the usual sire index to the results secured in the Experiment Station herd showed some minor irregularities. A formula was developed for calculating a sire index which used a calculated inheritance for the dams and the records of the daughters. These adjusted indexes appeared to be more consistent with the observed facts than those obtained by the equal parent index. As sire indexes are fundamentally more accurate for evaluating sires than production of daughters alone, every effort should be made to increase their accuracy and extend their use.