A GENETIC STUDY OF THE AYRSHIRE BREED OF CATTLE.

by

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Introduction.

Numerous writers have found the origin of the Ayrshire breed of cattle an intriguing study, and although many have tried to throw light on the subject, the historic origin of the progenitors of the breed is still somewhat obscure.

Considering that the Ayrshire is one of the most recent of dairy breeds, this lack of authentic records is rather surprising. Speir (11) states that "Careful scrutiny of every available source of information for 300 years back, clearly indicates that, in the district of Cunningham in Ayrshire, which is held to be the district in which the breed originated, no breed existed in any way resembling the present Ayrshire". Douglas (3) in his "Origin of the Ayrshire Breed" refers to the Kylo, the common indigenous cow of Scotland at the formative period of the breed, as being the probable foundation stock. He describes the Kylo as a very small, fine-horned cow, prevailing dark in colour. Quoting Aiton's description of the cattle of Ayrshire before the introduction of the Ayrshire breed, Douglas confirms his own opinion, "The cows of Cunningham are generally black with some white on the face, belly, neck or tail". Douglas, however, stresses the fact that although the prevailing colour was black other colours were also encountered. Quoting Lawrence, he states
"The Kylo is black, brindle, dun brown or red".

The first improvement of the Ayrshire breed dates from the year 1750, when the Earl of Marchmont introduced new stock into the county from his estates in Berwickshire. Unfortunately, on this point we again find differences of opinion among various writers.

Farrell (4) states: "On competent authority the Earl of Marchmont had brought from his estates in Berwickshire a bull and several cows, which he had some time previously procured from the Bishop of Durham, of the Teeswater breed, then known by the name of the Dutch or Holstein breed. These cattle were light brown spotted with white. They were introduced in Kyle, a district of Ayrshire, by Bruce Campbell, his lordship's factor, and, rapidly getting into repute, their progeny gradually spread into the adjoining districts. A bull from this stock was bought by a Mr. John Hamilton who raised a numerous herd by crossing with native cattle."

Speir (11), however, proves that the introduction must have taken place at least 10 years earlier, and he quotes Mr. Robertson, factor to the Earl of Eglinton in 1811, to the effect that Mr. Bruce Campbell died in 1740. Further, he states that Mr. Robertson had distinctly proved that this particular introduction must have occurred between 1734 and 1740.

"About the same time", states Farrell (4), "Mr. John Dunlop of Dunlop House, in Cunningham district, purchased several stranger animals from which the
Cunningham cattle of the present day are descended." Douglas (3) states that "whereas the cattle brought in by the Earl of Marchmont were from the North of England and are described as either Teeswater or other English breed, those introduced by Mr. Dunlop are said to be Dutch or English". Farrell and Douglas appear to ascribe different meanings to "Teeswater breed". Farrell (4) states "the Teeswater were known by the name of the Dutch or Holstein breed", whereas Douglas (3) differentiates between Teeswater and Dutch breeds.

The next definite date of the introduction of new blood is 1769, and all writers agree that John Orr of Barrowfield introduced new stock, and that his example was copied by several other dairy farmers, although no mention is made of their names.

From 1769 onwards there is no reliable information on the further introduction of fresh blood, save the oft-debated question of Highland stock. Douglas, dealing with this question, refers to the herd of Mr. Theophilus Paton of Swinlees and states "that there is no doubt that the basis of this famous herd was a cross between an Ayrshire bull and a West Highland heifer. This herd was noted for the size of body, volume of udder, neatness and perpendicularity of a large corky teat, and brown colour."

During the intervening years, until the Ayrshire Herd Book was established in 1877, the Ayrshire breed made great strides and achieved great popularity as a
dairy breed, and spread rapidly throughout the south-west counties of Scotland. During this period also great advances were made in the practice of agriculture. Better systems of farming resulted in a higher plane of nutrition which in turn demanded a higher level of milk production, and under such evolutionary conditions the Ayrshire breed developed rapidly.

Another great influence on the breed which did much to develop as well as to popularise it, was the Kilmarnock Farmers' Club which was instituted in 1793. The objects of the Club were inter alia stated to be the improvement of Agriculture, and of the breed of Black Cattle in Ayrshire. This incidentally supports Douglas's view that the original cattle of the district were black, and that the native cows were graded up by stock introduced from time to time.

The first show of cattle was held in 1806 but was confined to Club members only until 1828 when it was extended to include farmers of the adjoining districts of Cunningham and Kyle. Notes on the Ayrshire breed, published in 1920 (9), state that on this occasion it is noteworthy that the prize for the best bull went to Mr. Theophilus Paton of Swinlees, perhaps the most prominent breeder of his day, and to whose herd many of the Ayrshires of the present day can be traced.

In 1811 the word "black" was omitted from the show announcement, a fact which appears to indicate the increasing numbers of brown, or brown and white animals.
The Highland and Agricultural Society first awarded premiums for Ayrshires in 1814, but these were confined to stock from Kyle, the central district of Ayrshire. This was, in 1821, extended to include both Cunningham and Kyle, and was further extended in 1822 to embrace the three divisions of Ayrshire, viz. Cunningham, Kyle and Carrick. In 1825 the Highland Show was held at Glasgow, and the Ayrshire entries included animals from the counties of Ayr, Renfrew, Lanark and Stirling.

In 1825 the Ayrshire Agricultural Association was formed but did not hold their first show until 1836. The show, which was held at Kilmarnock, seems to have been confined to the county of Ayr, but it was held at different towns until 1852, when it was decided that in future it should be held at Ayr.

From this data until the inauguration of the Ayrshire Cattle Herd Book Society in 1877 there is little of significance to record regarding the historical development of the breed. The first volume of the Herd Book was published in 1878. From this date records of the breed were available for an intensive investigation which is detailed later in this study.

The writer has already mentioned the part played by local and centralised shows in the evolution of the breed, in that they formed an incentive to breed for type and uniformity, and aided in popularising the breed. From one point of view, however, these shows exerted a retarding influence upon the development of
a good milking type in the breed, owing to the fact that, through over-emphasis on 'show' points, the potential productivity of the cattle did not receive proper consideration. This effect unfortunately brought the breed into disrepute; so much so, that progressive breeders for milk production, even at the present time, have to oppose this 'show' type in order to maintain the high qualities of Ayrshires as a dairy breed.

MacNeilage (6) gives a graphic description of the cleavage which took place in the breed: "The difficulty which at once confronts the historian of any department of the Ayrshire breed is the well-known division of the breed into milk stock and yeld stock. This division has become so marked as to necessitate the appointment in most cases of two classes of judges, and the extreme men in both sections will hardly admit that an avowed patron of the section to which they do not happen to belong can possibly know anything about the section on which they bestow their attention."

The main difference between the two types of Ayrshire cattle lies in the conformation of the udder and teats, this being of primary importance to any dairy cow - no matter to what breed she belongs. The promoters of the 'vessel' type were in favour of a tight, flat vessel with small hard corky teats - a combination which is wholly inconsistent with utility. As the vessel-bred type were show favourites at this time, the so-called 'yeld' section could only show
their stock before the vessel developed if they hoped to be in the prize list at all. The result was that in this section of the breed due to her mammary development no animal was ever exhibited after she had a calf.

Speir (11) writes that this state of affairs existed as early as 1850 and quotes the following report on the Highland Show held in Glasgow in that year: "It is feared that the Ayrshire milking stock of late years has been bred to too light weights - a delicate appearance and a well-set udder being the points most aimed at".

In the Transactions of the Highland and Agricultural Society 1907, no fewer than thirty gentlemen of leading note remitted a memorandum to a Committee of the Board of Directors on this subject, in which they stated "We view with apprehension the basis upon which the Awards to that Class of Stock have been given for several years. In our opinion the bulk of the Show-yard judges do not select as Prize Winners such specimens of the breed as the average farmer considers profitable cattle for the production of milk, butter or cheese. Farmers in the South-West of Scotland make their living principally from dairying and any departure from the type of cow which has been proved to be the most profitable dairy animal is sooner or later to have a very detrimental effect on farming."

This menace to the successful development of the
breed as a first-rate milking type became so serious that, in 1921, in addition to the show held by the Ayrshire Agricultural Association, at which the vessel-bred type held sway, the Ayrshire Herd Book Society held another termed the Ayr New Show. The chief aims of this show were to give due recognition to mammary development, and to actual, as well as potential, milk yields.

For this purpose a revised system of judging was formulated, points being allocated as under:

- **Form, Symmetry, and Constitution** 30 points
- **Mammary Development, to include teats, shape of udder, milk veins, etc.** 35 points
- **Authenticated Milk Yield in the case of a Cow** 35 points
- **Authenticated Milking Pedigree in the case of Bulls and Heifers** 35 points

In allocating the points for Authenticated Milk Yield and Authenticated Milking Pedigree a minimum and maximum yield was fixed. The minimum for a heifer was to be the equivalent of 500 gallons and for a cow 650 gallons. The maximum for a heifer was the equivalent of 850 gallons and for a cow 1,000 gallons - all at 3.8 per cent. butter fat. All yields had to be taken and kept under the scheme, and in conformity with the Rules and Regulations of the Scottish Milk Records Association, and the said yields had to be certified by the Secretary of this Association.
Fifty-two weeks was taken as the normal period between calvings, and yields of lactations beyond the normal were reduced in inverse proportion to the length of the lactation as compared with the normal, calculating to the nearest full week. Opening date of calving and date of next calving had in every case to be specified.

This show was extremely beneficial, since it provided a strong incentive to breeders of the milk class of stock to breed and show the milk strain of Ayrshires. In order to illustrate the valuable work of this show in increasing the milking propensities of the breed, an examination has been made of the show catalogues of 1921 and 1927. The points awarded for authenticated milk records of the 78 animals entered in 1921 and of the 76 animals entered in the final year of the show in 1927 were collected and tabulated.

Table I gives the comparison of the points awarded for milk yield in the first and last years of the show and indicates the improvement that took place in the breed during that period. This improvement may have been due to improved breeding aided by the better method of judging or may have resulted from the fact that there had been presented an opportunity of showing cows which would never have been shown under the old conditions.
TABLE I.

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of Animals exhibited</th>
<th>% under 30 points</th>
<th>% over 30 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1921</td>
<td>78</td>
<td>57.7</td>
<td>42.3</td>
</tr>
<tr>
<td>1927</td>
<td>76</td>
<td>7.9</td>
<td>92.1</td>
</tr>
</tbody>
</table>

The show, however, had the desired effect of bringing to notice animals of the right type so that the value of their progeny could be appreciated.

The influence of milk recording on the Ayrshire breed will be dealt with later in this study, but as far as the showing of Ayrshires in milk is concerned, it is unfortunate that the New Show was suspended after 1927.

It will be seen therefore from the foregoing historical survey that the Ayrshire cattle of the present day possess a somewhat mixed ancestry, and that existing types have a relatively brief history of pure breeding. Moreover the genetic construction of the breed is further complicated by a cleavage in the methods of individual breeders into two groups - those who breed for "vessel type" (with tight, flat vessels, and small corky perpendicularly-hung teats), and those who concentrate on "milking type", irrespective of the minutiae of udder conformation. The Ayrshire breed constitutes, therefore, for the geneticist, an unusually interesting study, combining a relatively recent history of pure breeding with a
present-day cleavage in breed types.

**Objects.**

The objects of the present study were as follows:

(1) To study the construction of the Ayrshire breed, and the part contributed thereto by inbreeding. Homozygosity is the result of inbreeding, and, as it is possible to determine the amount of inbreeding that has taken place in a breed, a measure of the homozygosity can be obtained. Moreover, an investigation along these lines also provides an opportunity to study whether certain blood lines have played an important part in the construction of the breed, and to determine what special methods of breeding, if any, were practised by former breeders. It is also possible to compare the homozygosity of the breed with that of other breeds.

(2) To determine whether any relation exists between inbreeding and productivity. It has been the opinion of the majority of breeders that inbreeding has a detrimental effect on high milk production. This study has therefore been extended to include the intensity of inbreeding in certain groups of high and average milk yielders of the Ayrshire breed, in order to compare these with the average for the breed as a whole.

**Material.**

The material for this study was procured from
the following sources:

(1) The Ayrshire Herd Book Society's recorded pedigrees, the first volume of which was issued in 1878.

(2) The Annual Reports of the Scottish Milk Records Association for 1923 and 1928.

Methods.

The period over which authentic pedigrees were kept was taken as that period covered by the Ayrshire Herd Book Society's published volumes, namely from 1878 to 1927. Difficulties were encountered in the endeavour to procure a representative sample of the populations. Methods used by workers in studying other breeds were found to be unsuitable when applied to the Ayrshire breed. Calder (1), in his study of the Clydesdale breed, took the first animal on the top of every fifth page of every fifth volume, while McPhee and Wright (7), in studying the Shorthorn breed, took every animal whether male or female at the top of the page at regular intervals of so many pages and volumes. In the Ayrshire volumes, however, especially in the early editions, the number of animals entered on any one page varied from two to six, while later volumes had as many as eleven on one page.

It was decided, therefore, to take a set number of cows and bulls out of every fifth volume, and this number was evenly distributed throughout the volume. The number taken was 75 cows and 75 bulls.

In examining the pedigrees of the breed population
both the Long and the "Approximate (or 'Short') Method of Calculating Coefficients of Inbreeding" (13) evolved by Wright and McPhee were employed. In the Approximate method the sire and dam of the animal in question are recorded, and a random line of ancestry is obtained by letting the sequence of sires and dams which is to be traced back in the herd book be heads and tails respectively in a coin-tossing experiment.

The coefficient takes the values of 50 per cent. and 0 per cent., neglecting the effect of an inbred common ancestor. Wright (12) also gives a method of estimating this effect. It was found, however, that in this study there were no inbred common ancestors, so that this part of the equation was omitted. As Wright pointed out, this method of determination means practically nothing so far as the individual is concerned, but by determining the proportion of ties in a sufficiently large random sample of a family or breed, a measure of the average degree of inbreeding of that family or breed can be obtained to as high a degree of accuracy as desired. Lush (5), in making some empirical tests of the reliability of this method, found that it was as accurate as its probable errors indicated.

In the Long Method the coefficient of inbreeding is obtained by a summation of the coefficients for every tie by which the parents are connected, each line tracing back from the sire to a common ancestor and thence forward to the dam, passing through no
individual more than once. The same ancestor may, of course, be involved in more than one line. If the contribution of any one tie between the parents in a pedigree is $F$ and if $fa$ is the coefficient of inbreeding of the common ancestor forming the tie, and $n$ and $n_1$ the number of generations which separate the common ancestor from the sire and dam respectively, then

$$F = \left(\frac{1}{2}\right)^{n+n_1+1}(1 + fa).$$

In the present study pedigrees of 1,200 animals were examined, using the Approximate Method. In applying the Long Method to these animals their pedigrees were extended to the sixth generation and individual coefficients of inbreeding were calculated. By this means it has been possible to compare the results obtained by the two methods and to make a study of the different blood lines and systems of mating. Six generation pedigrees of average and high milk yielders were also drawn up in order that any relationship between systems of mating and yield of milk might be revealed.

In addition, six generation pedigrees were drawn up in respect of representative samples of "milk" and "vessel bred" herds. The application of the Long Method to the pedigrees of all the above mentioned animals involved the tabulation of 126 ancestors in respect of each animal. There being 2,169 animals the total number of ancestors so tabulated was in the region of 273,294.
Results.

Inbreeding in the Breed.

Average coefficients of inbreeding of animals in the breed at different periods are shown in Table II. For purposes of comparison the figures obtained by the two methods are shown side by side.

Only in respect of the years 1912, 1922 and 1927 is the difference between the two figures significant. In the present investigation the results obtained from the two methods thus correspond fairly closely. In the pedigrees of animals in the earlier periods it is invariably found that the female lines run out more quickly than those of the males. This is a serious disadvantage in the employment of the short method, as it means that 25-35 per cent. of the female pedigree is missing. The fact that in spite of this disadvantage the short method gives higher coefficients of inbreeding than does the long method restricted to six generations shows that inbreeding is taking place to the early ancestors of the breed. But from the fact that in this study the ties obtained by the short method trace to a great variety of common ancestors, few of which appear more than once or twice, indicates that this inbreeding is not deliberate on the part of breeders from 1912 onwards, and that it is rather incidental.

In other breed studies the inbreeding to remote ancestors has taken place to a few well recognised
TABLE II.

Average Coefficients of Inbreeding during period 1892-1927.

Comparison of Results obtained by Two Methods.

<table>
<thead>
<tr>
<th>Year</th>
<th>Long Method</th>
<th></th>
<th></th>
<th></th>
<th>Short Method</th>
<th></th>
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<th></th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bulls</td>
<td>Cows</td>
<td>Breed</td>
<td>Bulls</td>
<td>Cows</td>
<td>Breed</td>
<td>Breed</td>
<td>Breed</td>
<td></td>
</tr>
<tr>
<td>1892</td>
<td>1.01</td>
<td>1.70</td>
<td>1.36 ± .27</td>
<td>1.33</td>
<td>4.00</td>
<td>2.66 ± .92</td>
<td>1.30 ± .96</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1897</td>
<td>1.41</td>
<td>1.07</td>
<td>1.23 ± .24</td>
<td>1.33</td>
<td>1.33</td>
<td>1.33 ± .65</td>
<td>0.10 ± .69</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1902</td>
<td>1.15</td>
<td>1.61</td>
<td>1.38 ± .20</td>
<td>2.00</td>
<td>3.33</td>
<td>2.66 ± .92</td>
<td>1.28 ± .94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1907</td>
<td>1.20</td>
<td>1.37</td>
<td>1.28 ± .21</td>
<td>2.00</td>
<td>4.00</td>
<td>2.00 ± .80</td>
<td>0.72 ± .83</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1912</td>
<td>1.97</td>
<td>1.21</td>
<td>1.60 ± .23</td>
<td>4.00</td>
<td>4.66</td>
<td>4.33 ± 1.14</td>
<td>2.73 ± 1.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1917</td>
<td>1.50</td>
<td>1.15</td>
<td>1.32 ± .22</td>
<td>4.66</td>
<td>2.66</td>
<td>3.66 ± 1.05</td>
<td>2.34 ± 1.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1922</td>
<td>1.17</td>
<td>0.59</td>
<td>0.88 ± .17</td>
<td>6.66</td>
<td>5.33</td>
<td>6.00 ± 1.32</td>
<td>5.12 ± 1.34</td>
<td></td>
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</tr>
<tr>
<td>1927</td>
<td>1.02</td>
<td>2.18</td>
<td>1.59 ± .30</td>
<td>4.00</td>
<td>4.66</td>
<td>4.33 ± 1.14</td>
<td>2.74 ± 1.18</td>
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</tr>
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</table>

* No inbreeding was noted during the period 1877-1892.
animals. McPhee and Wright (8), in the Shorthorn, stresses this in respect of the Favourite and Comet strains, and latterly of Champion of England. Calder (1) shows it in the Clydesdale for Darnley and Prince of Wales, and the same holds in the study of Rambouillet sheep by Dickson and Lush (2) where the pedigrees trace to specially selected foundation stock.

As one of the purposes of a study of this nature is to discover the blood lines favoured by the breeders of a particular period it is therefore obvious that the higher coefficient obtained by the short method in this study of the Ayrshire breed may be misleading. Accordingly, with a view to studying the trends in the development of the Ayrshire breed, for the present study special emphasis has been laid on the long method restricted to six generations.

From an examination of the figures thus obtained it would appear that there has been no change in the degree of inbreeding since 1892. To this there is one important exception. The average coefficient of inbreeding for 1922 (0.88 ± .17) differs significantly from the averages for 1912 and 1927 (1.60 ± .23 and 1.59 ± .30) the difference being respectively .72 ± .29 and .71 ± .34. A further check sample was taken in respect of 1922. The average coefficient of inbreeding found was .74 ± .11. This figure was significantly lower than the corresponding figures for 1892, 1902, 1907, 1912, 1917 and 1927, the respective differences being .62 ± .29, .64 ± .23, .54 ± .24,
.86 ± .25, .58 ± .25 and .85 ± .32.

This significant fall in the coefficient of inbreeding in respect of 1922 was due in part to the rapid extension of the dairy industry during the war period. It must be remembered too that in the herd book volumes for 1917, 1918 and 1919 the number of entries was small - totalling 773 cows and 3,246 bulls. In the single volume for 1920 the corresponding totals were 11,224 and 1,201. Volumes for the years immediately following 1920 contained animals calved during the war years. During the years 1917, 1918 and 1919 there had been in force a system of produce registration. According to the terms of this scheme on and after 1st July 1915 the produce (male or female) of cows entered or to be entered in the Herd Book either with a number or in the Appendix had to be entered within six months of date of birth of such produce. As will be shown later a difference in inbreeding exists between animals of the vessel-bred type and those of the milk bred strain, the latter type having a lower average coefficient of inbreeding. In the period immediately after the war considerable difficulty was experienced by the Society in persuading the breeders of vessel bred cattle to enter all progeny in the Herd Book. This was in part due to an increase in entry fee. Despite financial penalties for late entry they continued to enter only those animals which they intended to show. This disparity between the number of animals born and the number of
animals entered of the vessel bred type was most acute at this period and directly affected entries in the 1922 herd book. The vessel bred animals as a group have definitely a much higher coefficient of inbreeding than the milk stock, which can be appreciated from an examination of Table X, but that its effect was so great as to be reflected in the average coefficient of inbreeding of the breed is very remarkable.

In order to assess the contribution to inbreeding of the breed made by different animals a complete analysis of the inbreeding coefficients of each animal was carried out. The number of ties to each animal was noted. These are shown in Table III where figures for bulls and cows in the sample of the breed are given separately. Bulls with less than five ties are omitted.

A summary of the total number of ties attributable to these animals is given in Table IV. From this table it is seen that the bulls which had the widest influence upon the breed were Hover-a-Blink, White Prince and Craigs of Kyle.

The period of time elapsing between the date of birth and the period in which inbreeding first occurs in respect of each bull is shown in Table V. From these figures the average time elapsing is seen to be in the region of 25 years. In the Clydesdale breed Calder (1) gave this figure as 20 years.

An indication of the part played by the different herds in the genetic composition of the breed may be obtained by summating the total number of ties attri-
TABLE III.

<table>
<thead>
<tr>
<th>Date</th>
<th>Animals to which there is inbreeding</th>
<th>No. of ties noted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Bulls</td>
</tr>
<tr>
<td>1892</td>
<td>Burnhouses (8)</td>
<td>6</td>
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<tr>
<td>1897</td>
<td>Burnhouses (8)</td>
<td>10</td>
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<td></td>
<td>Burnhouses White Prince (63)</td>
<td>12</td>
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<td>1902</td>
<td>Burnhouses White Prince (63)</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Drumjoan Hover-a-Blink (892)</td>
<td>16</td>
</tr>
<tr>
<td>1907</td>
<td>Burnhouses White Prince (63)</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Drumjoan Hover-a-Blink (892)</td>
<td>12</td>
</tr>
<tr>
<td>1912</td>
<td>Drumjoan Hover-a-Blink (892)</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Drumjoan Craigs of Kyle (1793)</td>
<td>15</td>
</tr>
<tr>
<td>1917</td>
<td>Drumjoan Craigs of Kyle (1793)</td>
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<tr>
<td></td>
<td>Drumjoan Cock-a-Bendie (1204)</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Whitehill Peter (1397)</td>
<td>-</td>
</tr>
<tr>
<td>1922</td>
<td>Lessnessock Marshal Oyama (5841)</td>
<td>8</td>
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<tr>
<td></td>
<td>Hillhouse Not Likely (4469)</td>
<td>6</td>
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<td></td>
<td>Balmangan Johnny Cope (4087)</td>
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<td></td>
<td>Bargenoch Durward Lely (5559)</td>
<td>-</td>
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<tr>
<td>1927</td>
<td>Lessnessock Marshal Oyama (5841)</td>
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<td></td>
<td>Whitehill Envy Me (7027)</td>
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<td></td>
<td>Monkland Zomosal (5887)</td>
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<tr>
<td>Name of Bull</td>
<td>Total No. of Ties Attributable</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------</td>
<td>--------------------------------</td>
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</tr>
<tr>
<td>Burnhouses White Prince (63)</td>
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</tr>
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<td>Drumjoan Hover-a-Blink (892)</td>
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<td>Cows 38</td>
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<td>Drumjoan Craigs of Kyle (1793)</td>
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<td>Cows 25</td>
</tr>
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butable to animals within these herds. This has been done in respect of the pedigrees of all bulls in Table VI, cows in Table VII and the breed in Table VIII. It will be seen that, in the main, inbreeding contributions of the various herds has been wider in extent amongst bulls than amongst cows. This is particularly true of the Drumjoan herd. So far as extent of influence upon the breed as a whole is concerned this is easily the most important herd. The greatest contribution is made by Hover-a-Blink and this bull's son Cock-a-Bendie.

**Herds Contribution to Breed History.**

A survey of the intensity of inbreeding attributable to the different herds was then carried out. The figures in Table IX illustrate in an interesting manner the rise and decline in the popularity of various herds within the Ayrshire breed. The first three herds, Burnhouses, Drumlanrig and Drumjoan, each show an increase in the number of ties up to the fourth or fifth five-year period, followed by a gradual decrease in this figure. In respect of all three herds there is a constant fall in the average intensity of inbreeding from the first period studied to the last. Of these herds Burnhouses and Drumjoan were of the milk type, while Drumlanrig belonged to the vessel type.

The number of ties is an index to the popularity of any herd at any particular time. The herd of Lessnessock, in which this figure is on the increase, is
### TABLE VI.

**Bulls.**

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**Relevant Notes:**
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- **Tetheries**
- **Craigrees**
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**Intensity of inbreeding in the Breed.**

**Contribution of Various Herds.**

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<tr>
<td>Auchenbrain</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>1.95</td>
<td>2</td>
<td>0.39</td>
</tr>
<tr>
<td>Cavens</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bargenoch</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hillhouse</td>
<td>1</td>
<td>1.56</td>
<td>1</td>
<td>1.56</td>
<td>1</td>
<td>12.50</td>
<td>1</td>
<td>3.13</td>
</tr>
</tbody>
</table>

No. of Av. = Number of Averages; Ties Coeff. = Ties Coefficient
gaining in popularity at the present time. In the figures for this herd there is a drop during the period which may have been associated with the temporary cessation in the holding of annual sales. The owner of this herd purchases for export many of the leading sires of the breed.

The herds of Auchenbrain and Bargenoch are rising in favour as judged by prices and showyard records. The number of ties in respect of these herds is also on the increase.

Carston herd is exceptional in so far as the number of ties is small although the average coefficient of inbreeding is relatively large. The influence of this herd - of the bessel bred type - is confined to a limited portion of the breed, as a whole due to the fact that vessel breeding is on the wane, although isolated groups of keen supporters still exist.

Although not included in the table under consideration, it is of interest to remark upon the peculiar nature of one herd. The herd of Bargower is the outcome of successful 'nicking' between the vessel bred and milk types. The resulting cattle are of heavy type, and it will be of interest to ascertain the accuracy of breed enthusiasts' belief that coarseness in conformation is incompatible with milk production.

**Breed Types.**

Reference has already been made to the existence of two strains within the Ayrshire breed - the vessel
bred and the milk type. Twelve herds were selected, six of each type. All herd book entries of these herds made in 1921, 1924 and 1927 were noted and their pedigrees were tabulated to six generations. Three three-yearly intervals were chosen rather than three successive years in order to avoid the repetitive influence of any single bull used in the herd. Bulls used for a longer period than three years, with records of their daughters available, would be deliberately retained.

The results are summarised in Table X.

### TABLE X.

<table>
<thead>
<tr>
<th>Year</th>
<th>Vessel Bred Stock</th>
<th>Milk Stock</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1921</td>
<td>5.73 ± .37</td>
<td>1.07 ± .16</td>
<td>4.66 ± .63</td>
</tr>
<tr>
<td>1924</td>
<td>2.84 ± .67</td>
<td>.92 ± .19</td>
<td>1.92 ± .70</td>
</tr>
<tr>
<td>1927</td>
<td>6.35 ± .61</td>
<td>1.96 ± .30</td>
<td>4.39 ± .68</td>
</tr>
</tbody>
</table>

It will be seen that in each of the three years considered there was a significant difference in the average coefficient of inbreeding - the vessel bred stock being the more highly inbred.

In order to ascertain whether there existed any relationship between milk production and inbreeding, an examination was made of certain groups of cows at different levels of production. Annual reports for
1923 and 1928 of the Scottish Milk Records Association were the source from which data were secured. The sampling was done in the following manner. A group of high yielding cows was obtained by taking the first animal with a yield of 1,000 gallons or over on each page of the 1923 volume. Since milk records under 2,800 gallons as cows and 2,240 gallons as heifers, both at 1 per cent. butter fat, are not published, it was impossible to obtain a sample of low yielders. Accordingly, a sample of average yielders was taken by noting the first animal producing less than 800 gallons on every third page of the same volume. A further sample of high yielders was taken in a similar fashion from the 1928 volume. It should be noted that animals appearing in the Milk Records volumes for 1923 and 1928 correspond to the herd book entries of 1917 and 1922. The existence of a marked decrease in inbreeding in the breed between 1917 and 1922, as has already been shown in Table II, caused the milk records of 1923 and 1928 to be of special interest. Coefficients of inbreeding are given in Table XI.

<table>
<thead>
<tr>
<th>Year</th>
<th>Breed Average Coeff.</th>
<th>Cow Coeff.</th>
<th>High Milk Yielders 1000 galls. and over</th>
<th>Low Milk Yielders 800 galls. and under</th>
</tr>
</thead>
<tbody>
<tr>
<td>1917</td>
<td>1.32</td>
<td>1.15</td>
<td>0.4579</td>
<td>0.5042</td>
</tr>
<tr>
<td>1922</td>
<td>0.88</td>
<td>0.59</td>
<td>1.1466</td>
<td></td>
</tr>
</tbody>
</table>
No difference in this respect was found to exist between high and average milk yielders corresponding to Herd Book entries of 1917, although both were slightly lower than the average of cows in the breed for the same year. In the 1922 groups it was found that the average coefficient of inbreeding of the high milk yielders was greater than that of the cows and of the breed. McPhee and Wright (8), in a study of the British Dairy Shorthorn, found that there was no substantial difference in the high yielders as against the breed average.

While, in this study, the differences are not significant and too much attention should not be paid to these figures, they might be interpreted as in some way confirming what is known of the history of the breed. From 1910 to 1920 there was an increasing tendency to emphasise the value of milk records, and the high yielding cows of that period would be of various bloodlines and of little or no deliberate selection in their pedigrees for high yield; many of them would have short pedigrees. It became clear on studying the pedigrees of the high yielders that about two-thirds of the pedigrees by the long method traced to non-pedigreed animals in the second and third generations on the dam's side of the pedigree. From 1920 onwards deliberate selection of breeding stock for high yield has been taking place. The figures in this table support the general observation of the development of the breed.
An examination was then made of the animals and herds contributing to the inbreeding in these groups. A comparison of the influence of the different herds in this connection is shown in Table XII. Of these the Drumjoan herd has the widest influence. The percentage number of ties attributable to this herd in the high yielding group of 1923 is the same as the percentage for the corresponding year in the breed (Table IX). In the group of animals yielding under 800 gallons the percentage of ties attributable to Drumjoan is less than half of the corresponding breed figure. The figure in respect of the high milk yielders of 1928 is higher than the corresponding figure for the breed. In all three groups the figure for the Bargenoch herd is lower than that in the breed. This is also true of figures for the Lessnessock herd in respect of the high yielding group of 1928. In figures for the breed for 1917 Lessnessock played no part, but is represented in both groups for 1923. Figures for the Hillhouse herd in all three groups are lower than in the breed. With regard to the Auchenbrain herd, figures for high yielders in 1923 and 1928 are lower than the corresponding breed figures. The average yield group has a figure similar to that for the breed.

As an indication of the dominant part played by the Drumjoan herd, and in particular by the bull Hover-a-Blink, in the breeding of these special groups, the pedigrees have been extended of all animals to which inbreeding has been traced. The Drumjoan herd made
**TABLE XII.**

**Milk Producing Groups.**

**Herds Contribution to Inbreeding.**

<table>
<thead>
<tr>
<th></th>
<th>1923.</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>166 Animals 1000 galls.</td>
<td>166 Animals 800 galls.</td>
<td>102 Animals 1000 galls.</td>
</tr>
<tr>
<td></td>
<td>and over</td>
<td>and under</td>
<td>and over</td>
</tr>
<tr>
<td></td>
<td>Total Ties</td>
<td>% Ties</td>
<td>Total Coeff.</td>
</tr>
<tr>
<td>Wyndholm</td>
<td>6</td>
<td>6.37</td>
<td>6.34</td>
</tr>
<tr>
<td>Morton Mains</td>
<td>1</td>
<td>5.58</td>
<td>4.68</td>
</tr>
<tr>
<td>Auchenbrain</td>
<td>12</td>
<td>4.78</td>
<td>2.67</td>
</tr>
<tr>
<td>Drumlanrig</td>
<td>11</td>
<td>4.38</td>
<td>0.97</td>
</tr>
<tr>
<td>Holehouse</td>
<td>9</td>
<td>3.58</td>
<td>2.54</td>
</tr>
<tr>
<td>Netherhall</td>
<td>8</td>
<td>3.19</td>
<td>1.90</td>
</tr>
<tr>
<td>Orchardton</td>
<td>6</td>
<td>2.39</td>
<td>4.00</td>
</tr>
<tr>
<td>Carston</td>
<td>6</td>
<td>2.39</td>
<td>1.22</td>
</tr>
<tr>
<td>Bogwood</td>
<td>6</td>
<td>1.19</td>
<td>0.34</td>
</tr>
<tr>
<td>Southwick</td>
<td>3</td>
<td>1.19</td>
<td>0.34</td>
</tr>
<tr>
<td>Carsegowan</td>
<td>2</td>
<td>0.79</td>
<td>0.88</td>
</tr>
<tr>
<td>Lessnessock</td>
<td>2</td>
<td>0.79</td>
<td>0.82</td>
</tr>
</tbody>
</table>
use of three prefixes - Drumjoan 1883-1893, Wyndholm 1893-1904, and Morton Mains from 1904 onwards. All animals related to Hover-a-Blink have been listed together with a note of the number of ties attributable and the summation of their coefficients. These are shown in Diagrams 1, 2 and 3. These results are also summarised in Table XIII, in which the three Drumjoan prefixes have been grouped together.

**General Summary.**

**Origin of the Breed.**

In the present study an examination has been made of the history of the Ayrshire breed of cattle. With regard to the foundation of the breed it would appear that in its early days it was made up of native cattle and that these were improved in the eighteenth century by the introduction of imported stock. It is difficult to ascertain the exact nature of these imported animals but reference is made to the Teeswater breed as a possible source of introduction. Light brown in colour with white markings, these cattle were also referred to by some writers as being of the Dutch or Holstein breed. That West Highland blood was also introduced about the beginning of the nineteenth century seems to be generally accepted.
ANIMALS TO WHICH INBREEDING WAS TRACED AND WHICH ARE RELATED TO HOVER-A-BLINK THROUGH SIRE'S PEDIGREE.

HOVER-A-BLINK
OF DRUMJOAN 2690
(3) (.1462)

Hover of Kirkchrist 2697
(1) (.39)
Sir Thomas of Auchenbrain 9760
(5) (.0975)

Famous Design of Wyndholm 3118
(1) (.3469)

Gigantic Stunner of Wyndholm 3972
(2) (.3295)

Carsegoran John Brown 5070
(3) (.3988)

Auchenbrain Hope Again 5150
(2) (.0975)

General MacDonald of Hillhouse 4609
(6) (.0654)

Lassemasock Marshal Ogana 5041
(10) (.15449)

Netherton Prince Birnbecko 8849
(1) (.7800)

Finlayston James Likely 6461
(5) (.7900)

Monskland Remossal 5887
(3) (.3412)

Lessemasock Good Gift 7368
(2) (.11700)

Whitehill Envy No 7037
(4) (.54675)

Fryenshead Sir William 9913
(1) (.7900)

Brae Rising Star 8187
(7) (.1055)

Drunken Sir Robert 7805
(1) (.78)

Finlayston Spicy 31379
(1) (.62500)

Netherton Raines PLACE
President 8808
(1) (.5185)

Feisty End of Monkland 10246
(3) (.38277)

Total Number of Ties for Group of Animals 1000 gallons or over for 1928
204
Total % of Ties traced to Animals related to Hover-a-Blink
49.84
Total Inbreeding Coefficient for Group of Animals 1000 gallons or over for 1928
101.16
Total % Inbreeding Coefficient of Animals related to Hover-a-Blink
64.36%
ANIMALS TO WHICH INBREEDING WAS TRACED AND WHICH ARE RELATED TO HOVER-A-BLINK THROUGH SIRE'S PEDIGREE.

HOVER-A-BLINK OF DRUMJOAN 882
(22) : (1.56)

Cock o' the Walk of Drum Joan 1917
(2) : (1.1462)

Buntie 3rd of Auchenbrain 9479
(1) : (.0487)

Total Number of Ties for Group of Animals 1000 gallons or over for 1923 : 251
Total % of Ties traced to Animals related to Hover-a-Blink : 39.5%
Total Inbreeding Coefficient for Group of Animals 1000 gallons or over for 1923 : 101.136
Total % Inbreeding Coefficient of Animals related to Hover-a-Blink : 96.07%
DIAGRAM 3

ANIMALS TO WHICH INBREEDING WAS TRACED AND WHICH ARE RELATED TO HOVER-A-BLINK THROUGH HIRE'S PEDIGREE.

HOVER-A-BLINK
OF DRUMJOAN 892
(8) : (.7798)

Hover's Heir of Southwick 2690
(1) : (.0975)

App. Vol. 19
2890

Desdico of Overton 4004
(3) : (.3924)

App. Vol. 22
3118

Gigantic Stunner of Wyndholm 3872
(1) : (.0975)

Not Likely of Hillhouse 4469
(7) : (2.3400)

Carsegowan John Brown 5070
Hood 6657
5531

Motherhall Robin

Lessnessock Marshal
Craigm 8841
(5) : (1.3875)
6486

Auchenbrain Crusader
6807
(4) : (4.1900)

Lessnessock Gay Scott 7367
(1) : (3.1556)

Total Number of Ties for Group of Animals under 800 gallons for 1923 : 232

Total % of Ties traced to Animals related to Hover-a-Blink : 41.39%

Total Inbreeding Coefficient for Group of Animals under 800 gallons for 1923 : .88.69

Total % Inbreeding Coefficient of Animals related to Hover-a-Blink : 37.35%
<table>
<thead>
<tr>
<th>Year</th>
<th>Animals of 1000 gallons or over</th>
<th>Total Number of Ties for the Group</th>
<th>% Ties traced to Animals related to Hover-a-Blink</th>
<th>Total Coefficient for Group</th>
<th>% Coefficient traced to Animals related to Hover-a-Blink</th>
</tr>
</thead>
<tbody>
<tr>
<td>1928</td>
<td>102</td>
<td>204</td>
<td>49.0</td>
<td>101.16</td>
<td>64.36</td>
</tr>
<tr>
<td>1923</td>
<td>166</td>
<td>251</td>
<td>39.5</td>
<td>101.136</td>
<td>26.07</td>
</tr>
</tbody>
</table>

Animals of 800 gallons or under

1923 166 232 45.19 88.69 38.35
Influence of Shows.

It is true of many breeds, and particularly true of the Ayrshire, that breed development has been profoundly influenced by conditions of shows at which animals of the breed have been exhibited. It has been shown in the present study that, although early shows were beneficial, there was subsequently an undesirably strong concentration upon certain show points – a concentration which actually caused a cleavage of type within the breed. That milk producing potentialities as indicated by conformation together with actual milk records were more important than conformation alone was recognised by the Herd Book Society. In their first Show – Ayr New Show – held in 1921 due weight was given to milking performance in the allocation of points in judging. During its seven years' existence this show produced good results as is indicated by the rise in the general standard of milk production amongst the animals exhibited. Such a combination of conformation and performance in showyard standards has affected the entire breed.

Inbreeding.

In dairy breeds it is possible directly to assess the value of bulls on the basis of the average of their daughters' milk production and to assess the value of cows, using the average of their actual milk yields. For this reason it is to be expected that recourse need not be had to inbreeding to such an extent in
dairy as in beef breeds. This is true of the Ayrshire breed, and has already been demonstrated in the Beef and Dairy Shorthorns by McPhee and Wright ([7] and [8]). In respect of the Shorthorn breed, the coefficient of inbreeding was as high as 25 per cent., as compared with figures around 2 per cent. for the Ayrshire breed. No sex differences in respect of degree of inbreeding was found in the Ayrshire breed during the period covered by this study. Smith ([10], in a study of the Jersey breed, made a similar observation. Homozygosity is readily attainable by inbreeding, but it is equally possible to accomplish this by selection and but little inbreeding. This seems to be the method which has been applied in the evolution of the milk type in the Ayrshire breed. The Ayrshire as a breed are noted for their uniformity as regards milk production in comparison with other breeds of dairy cattle. This means that a certain degree of homozygosity has been achieved in this respect, and certainly far more than inbreeding can account for. The practical implication is that, with a productive character amenable to measurement, a reasonable degree of homozygosity can be obtained by selection only, i.e. by the mating of desired types to each other. Calder (1) has shown that similar methods were employed by the breeders of Clydesdale horses. Both in the Clydesdale breed of horses and in the Ayrshire breed of cattle, the existence of predominating blood lines has increased the rapidity with which homozygosity has been attained.
The genetic composition of the Ayrshire differs remarkably from the genetic composition of the Shorthorn breed in one respect. In the Ayrshire, families of cattle are purely local in nature - completely unlike the widespread Duchess family in the Shorthorn. The place which the bull Hover-a-Blink occupies in Ayrshire breed history is similar to that occupied by Favourite 252 in the Shorthorn breed. Hover-a-Blink has exerted a powerful influence upon the Ayrshire breed, being responsible through related animals for nearly a third of the total inbreeding noted. An examination has been made of the contribution of herds and of animals in the herd to the inbreeding in the breed.

The degree of inbreeding in respect of vessel type animals was found to be significantly higher than that of the milk type.

In the Ayrshire breed, therefore, it was anticipated that bulls might show a higher degree of inbreeding in view of the selection of show strains. That this was not found to be the case suggests that the influence of the vessel bred type has not been so widespread as is generally believed.

Productivity.

There appears to be no relationship between inbreeding and productivity in the groups concerned. From the fact that the group of 800 gallons and under are no more inbred than the high milk yielding cows
it can be stated that such inbreeding as has occurred has not shown any positive evidence that inbreeding has been detrimental.

There are two influences, however, which vitiate any definite conclusions being arrived at on this problem. First, the 800 gallon group must be taken as an average milk producing group and not as low milk yielders, the records of such a group are not published and are therefore not available for study. Secondly, it may be that breeders of milk stock have tried to imitate the methods of the breeders of the vessel strain and have failed to obtain the desired results, in which case no records can be secured. While the vessel bred animals have a definitely higher coefficient of inbreeding they are not primarily bred for milk. It is a known fact that their period of lactation is shortened in order to conserve udder confirmation, consequently animals of this type do not appear in the milk recorded groups, and direct comparison is impossible.

The Drumjoan herd played a large part in the inbreeding of the high yielding group. That the bull Hover-a-Blink played an important part in this respect has also been demonstrated.

Conclusions.

1. Breed evolution was influenced by the introduction
of imported stocks.

2. Shows have affected the development of the breed—beneficially and adversely, according to the standards set by the judges.

3. Homozygosity in the breed has been attained by selection, with but little recourse to inbreeding. This does not apply to the vessel bred type.

4. No sex difference in respect of inbreeding has been noted.

5. No relationship has been demonstrated between inbreeding and productivity. There is also no conclusive evidence that inbreeding has had a detrimental effect on high milk production.

6. One herd—Drumjoan—and one sire—Drumjoan Hover-a-Blink—have had an outstanding influence on the breed, but this influence came through the fact that he sired bulls of good conformation. Such inbreeding as took place to him was largely incidental because he had so many sons of good show type.

7. The level of inbreeding amongst vessel bred type is significantly higher than that of the milk type.
REFERENCES.


