AN ANALYSIS OF THE 1948 JERSEY HEIFER REGISTRATION DATA TO PROVIDE INFORMATION CONCERNING SOME FEATURES OF NEW ZEALAND PEDIGREE JERSEY CATTLE.

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INTRODUCTION.

At present there is a lack of information concerning the breeding methods practised by owners of pedigree dairy cattle in New Zealand. This deficiency is a serious handicap in attacking some of the major problems facing the dairy industry in this country. Since the emergence of the Dairy Board in 1936 as the main national force concerned with herd improvement a great deal has been achieved in the field of dairy cattle improvement and the evolution of a sire survey applicable to conditions obtaining in New Zealand is one of the major achievements of the Dairy Board. But many aspects of the pedigree industry which provides the majority of sires used in the Dominion remain to be elucidated. For example, the present scarcity of proven sires, and the more or less stationary level of production of commercial herds are some of the problems which have direct bearing on the pedigree section of the dairy industry. These facts alone illustrate the importance of the study of current breeding methods and of the pedigree system as it exists in New Zealand.

Many investigations relating to dairy cattle breeding have been carried out overseas. Although many of the problems studied are encountered in New Zealand, the Dominion's typical grassland farming and the seasonal dairying associated with it limit the usefulness of such investigations. With more information becoming available breed societies are beginning to adjust themselves to a new phase of cattle breeding. The increasing emphasis on production as an aid to selection, and the acceptance of artificial insemination are two phases in which a change of attitude is desirable. The rapid growth of pedigree herds, the more frequent appearance of performance details in pedigrees and the increasing number of pedigree animals mated artificially each year illustrate this gradual change.

There are certain factors, however, which can affect the rate at which these changes take place. Some, such as the attitude of the breeders themselves cannot be measured. Others lend themselves to study and at a time such as this when dairy cattle breeding in New Zealand is at the crossroads, an analysis of these factors is appropriate and of interest to all those concerned with dairy cattle improvement in New Zealand.

SOURCE OF DATA.

Data used in this study have been obtained from the 1948 herd book of the New Zealand Jersey Cattle Breeders' Association. The New Zealand Dairy Board in the course of sire survey investigations carried out the preliminary work which consisted of transferring the details of parentage of each heifer registered in the 1948 herd book on to separate Powers Samas cards. The information on these cards after checking was then tabulated on the Powers Samas machine. By these means the herd book data was rearranged so that all sires with daughters registered in the 1948 herd book were listed according to their registration numbers together with all their daughters registered in the herd book under consideration. A replica of one of the 485 pages supplied by the New Zealand Dairy Board is shown (p.3). From these data and from appropriate volumes of the Jersey herd books information has been extracted in a manner described in the following sections.

TREATMENT OF DATA.

The list of sires and their progeny registered in the 1948 herd book was supplemented by details of dates of birth and a code number indicating the herd in which each animal was bred. This information was extracted from the appropriate herd books. When sampling methods have been employed the technique has been described in the appropriate section of the thesis.

To test the significance of the result Pearson's Chi-square test has been employed using the 5% and the 1% levels in the table compiled by Snedecor (Snedecor p.190). The first of these values is designated as significant, while the second or any value less than 1% is highly significant. For ease of comparison the results of the statistical analysis are tabulated in the appropriate section.

REGISTRATION NUMBER OF HEIFER.	REGISTRATION NUMBER OF SIRE.
255274	84601
262761	84915
248212	84933
248232	84933
248382	85108
258056	85108
258057	85108
258058	85108
258059	85108
250909	85365
249613	85956
249614	85956
249618	85956
249619	85956
249623	
257296	86098
257319	86098
250080	86533
250344	86641
250345	86641
250346	86641
250347	86641
250348	86641
250349	86641
250350	86641
250351	86641
250352	86641
250353	86641
250354	86641
250355	86641

THE AGE DISTRIBUTION OF SIRES OF JERSEY HEIFERS REGISTERED IN THE 1948 JERSEY HERD BOOK.

With the notable exception of Donald's work (1947) few studies on the age distribution of dairy cattle provide information directly concerned with problems of selective breeding. The majority draw attention to the presumed advantage associated with longer herd life, though Rendel and Robertson (1950) have thrown considerable doubt on the assumption that longevity is necessarily an important aspect in higher economic returns. Another shortcoming with many age-distribution studies is that they relate solely to the female section of the cattle population and neglect the all-important potential information which may be derived from a knowledge of the age-distribution of sires in use in a particular population. Under New Zealand conditions preliminary progeny test information cannot generally be available until a sire is approximately 5 years of age. Sires less than 5 years of age can only be assessed on their pedigree and appearance and the appearance of their daughters. This is a less reliable estimate of breeding worth than that based on a progeny test. It is important then, to know what steps are being taken within the pedigree section of the dairy industry to ensure that where possible preference is given to bulls which have demonstrated their ability to leave high producing daughters. Such information cannot be accurately obtained but an estimate of it may be derived from an analysis of the age-distribution of sires used to beget registered heifer calves. A similar analysis has been conducted by the New Zealand Dairy Board (1940-41) in a sample of recorded herds in this country. It was found that of the pedigree sires in these herds, the majority of which consisted of grade cattle, 11.4 per cent of the bulls in use were yearling, 23.6 per cent 2 year olds and 18.5 per cent were over the age at which progeny test details could have been available in the season in which they were used. This information while valuable is not necessarily applicable to the pedigree section of the industry, and consequently has limited use. For this reason the age-distribution of the sires used in pedigree herds has been studied.

Two methods of approach havebeen used. The first consisted in determining the age-distribution of sires of the heifers of registered offspring sired. The second consisted

Fig. 1. The distribution of sire-daughter intervals irrespective of years but with the same number of months e.g. 2 years 2 months, 3 years 2 months, 4 years 2 months etc. in one category, 2 years 3 months, 3 years 3 months, etc. in the next category and so on.

in measuring the average sire-daughter interval within each paternal half-sib group weighting each interval according to the number of daughters involved.

(A) The Age of Bulls used in New Zealand Pedigree Jersey Herds to sire Registered Heifers.

Under New Zealand conditions the majority of dairy cattle are born between July and September inclusive. For this reason parent-offspring intervals fall into fairly distinct age-classes. However, in a study of this nature, arbitrary limits to the age classes have to be made and sire-daughter interval classes have been decided upon only after considering their distribution. A sample consisting of 1450 sire-daughter intervals was studied, the sample consisting of the three heifer calves appearing at the top of each sheet on the New Zealand Dairy Board data already described (see p.3). The data was then distributed so that all sire-daughter intervals irrespective of years but with the same number of months were grouped together, e.g. 3 years 2 months, 4 years 2 months, 5 years 2 months etc. in one class; 3 years 3 months, 4 years 3 months, 5 years 3 months etc. in the next class and so on. This distribution, shown in Fig.1, indicates that the most satisfactory arbitrary division could be made where the sire-daughter interval is x years and 5 or 6 months. The latter was chosen because of the fewer observations and sire-daughter interval classes of - 1.6 (up to 1 year 6 months), 1.7 - 2.6 (1 year 7 months to 2 years 6 months) etc. have been adopted. From the same data the average sire-daughter interval has been calculated to determine whether sires in the respective classes could, with justification, be referred to as yearlings, 2 year olds, 3 year olds, etc. The averages are shown in Table I and justify the use of the general term in the discussion to follow.

TABLE I. The average sire-daughter interval within arbitrary classes.

Class (years and months)	Number	Average sire-daughter interval (years).
1.7 - 2.6	410	2.02
2.7 - 3.6	294	2.99
3.7 - 4.6	257	3.97
4.7 - 5.6	170	4.95
5.7 and over	319	(7.61)
Total	1,450	4.11

The average sire-daughter interval for the 1450 observations was 4.11 years, a slightly lower estimate than that of 4.28 years obtained by Stewart (1951) using the same method but with a smaller sample of 415 observations.

In the 1948 Jersey Herd Book 3970 sires were represented by registered female progeny. The sires had varying numbers of registered daughters (see p. 3), but it is of interest to determine the age distribution of the sires actually in use. To obtain the age of the sire at the birth of its offspring involved averaging the sire-daughter intervals within each of the 3970 progeny groups. This was necessary because in some cases breeders entered two years' registrations in one season. The results are shown in Table II, and the outstanding feature is that approximately one third of the sires used in the pedigree industry were 2 years of age when their registered daughters were born, i.e. one-third of the bulls used were "yearling" bulls or, more accurately, about 15 months of age at mating. Preliminary progeny test information could have been available when the registered daughters of 20% of the sires used were conceived, i.e. the sires were 5 ormore years of age at mating.

TABLE II. Distribution of bulls according to their age at the birth of daughters registered in the 1948 Jersey Herd Book.

Age of sire at daughter's birth (yrs. mths.)	Number of sires	% of total sires of registered heifers	Cum. %	
- 1.6	23	0.58	0.58	
1.7 - 2.6	1253	31.56	32.14	
2.7 - 3.6	848	21.36	53.50	
3.7 - 4.6	614	15.47	68.97	
4.7 - 5.6	420	10.58	79.55	
5.7 - 6.6	257	6.47	86.02	
6.7 - 7.6	219	5.52	91.54	
7.7 - 8.6	147	3.70	95.24	
8.7 - 9.6	96	2.42	97.66	
9.7 -10.6	49	1.23	98.89	20.4
10.7 -11.6	20	0.50	99.39	
11.7 -12.6	16	0.40	99.79	
12.7 -over	8	0.21	100.00	
Total	3970	100.00		

Examination of the table suggests that the decrease in the number of bulls in consecutive age classes is not influenced

by culling at any particular stage as for example if bulls were progeny tested and the unsatisfactory animals disposed of when test details became available. The most reasonable conclusion that one can make is that sires are selected on pedigree and their performance in the majority of cases is of little consequence in their use subsequent to purchase.

It is notable too, that the distribution shown in Table II differs markedly from that published by the New Zealand Dairy Board for sires in use in a sample of recorded herds during the 1940-41 season. The preponderance of "yearling" bulls (approximately 32%) in use in the pedigree section of the industry is in marked contrast to the Dairy Board figures which shows that only 11.4% of the bulls used in their sample were "yearlings". Differences in the percentages of bulls over the age at which progeny test details could have been available at mating are less marked, however; from the New Zealand Dairy Board sample 18% compared with 20% in the pedigree section. The difference in the proportion of "yearling" bulls usedin the two samples may be explained in part by the increasing pedigree cattle population but this would not be expected to have such a marked effect on the Ø bull population. One must conclude that prior to 1948 breeders were not unduly concerned with progeny test information based on production records of daughters of the bulls they were using. Stewart (1951) has suggested that the large proportion of yearling and two year old bulls may be due in part to the large number of small pedigree herds in New Zealand, and accentuated by breeders preferring unused yearling bulls with promising pedigree to similar bulls which had already had one or two year's service in other breeder's herds. There is an additional temptation to dispose of young bulls after their use as yearlings because as two-year olds such pedigree animals usually command higher prices than if retained and sold as "aged" bulls.

(B) <u>The Sire Progeny Interval in New Zealand Pedigree Jersey Cattle</u>.

Progeny test information is seldom available under New Zealand conditions before a sire is 4 years 10 months of age. Since seasonal dairying is practised by the vast majority of breeders it is unusualto find a progeny-tested bull in use before it is 5 years 3 months of age. Consequently for progeny test information to have been used the sire-daughter

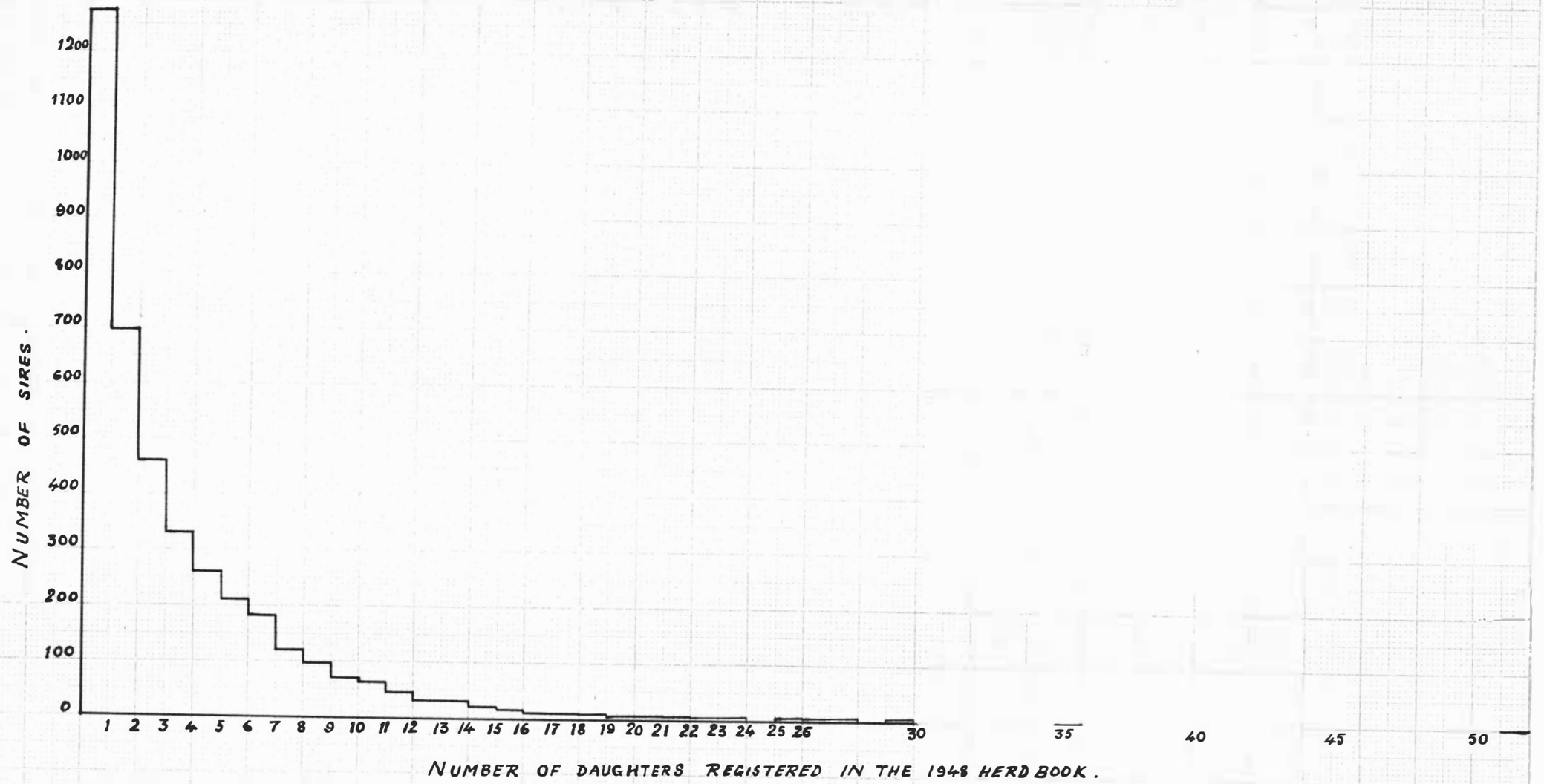

Fig 2. Distribution of bulls according to number of daughters registered in the 1948 herd book.

interval must be at least six years. In the preceeding section the numbers of bulls in the different age classes which have sired heifers registered in the 1948 herd book have been shown. No allowance was made, however, for differences in the extent to which bulls of different ages may have been used. More precise information may be derived from the data by weighting the bulls age according tothe number of registered heifers each sired. That large differences in the extent to which bulls are used to sire registered heifers do exist may be seen in Table III and Fig. 2 in which the 3970 bulls with daughters entered in the 1948 herd book have been distributed according to the number of daughters registered in that year.

TABLE III. Distribution of bulls according to numbers of daughters registered in the 1948 herd book.

No. of heifers per bull.	No. of bulls.	Total nos. heifers	%age of all heifers registered.	Cu. % ages.	%age of all bulls siring reg. heifers.	Cu.%
1	1272	1272	8.04	8.04	32.04	32.04
2	696	1392	8.80	16.84	17.53	49.57
3	459	1377	8.70	25.54	11.56	61.13
4	331	1324	8.37	33.91	8.34	69.47
5	262	1310	8.28	42.19	6.60	76.07
6	211	1266	8.00	50.19	5.31	81.38
7	182	1274	8.05	58.24	4.58	85.96
8	120	960	6.07	64.31	3.02	88.98
9	97	873	5.52	69.83	2.44	91.42
10	70	700	4.43	74.26	1.76	93.18
11	66	726	4.59	78.85	1.66	94.84
12	44	528	3.34	82.19	1.11	95.95
13	30	390	2.47	84.66	0.76	96.71
14	32	448	2.83	87.49	0.81	97.52
15	21	315	1.99	89.48	0.53	98.05
16	17	372	2.35	91.83	0.43	98.48
17	9	153	0.97	92.80	0.23	98.71
18	11	198	1.25	94.05	0.26	98.97
19	9	171	1.08	95.13	0.23	99.20
20	6	120	0.76	95.89	0.15	99.35
21	4	84	0.53	96.42	0.10	99.45
22	5	110	0.69	97.11	0.13	99.58
23	3	69	0.44	97.55	0.08	99.66
24	2	48	0.30	97.85	0.05	99.71
25	0	0	0.00	97.85	0.00	99.71
26	2	52	0.33	98.18	0.05	99.76
27	1	27	0.17	98.35	0.03	99.79
28	4	112	0.71	99.06	0.10	99.89
29	0	0	0.00	99.06	0.00	99.89
30	2	60	0.38	99.44	0.05	99.94
36	1	36	0.23	99.67	0.03	99.97
52	1	52	0.33	100.00	0.03	100.00
Total	3970	15,819	100.00	100.00	100.00	100.00

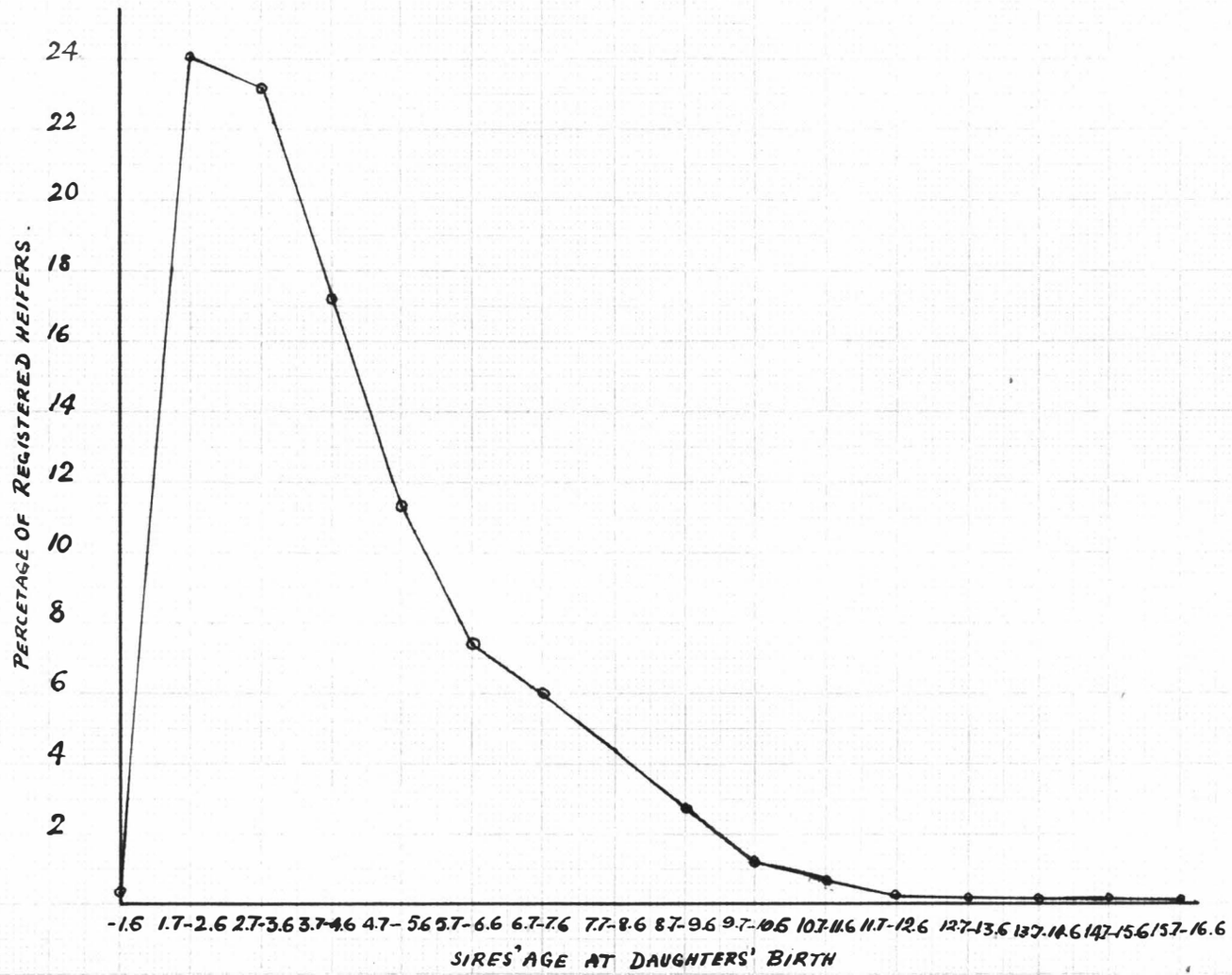

Fig.3 The distribution of 15,819 heifers registered in 1948 according to the age of their sires (at the birth of the heifers).

Seventy per cent of the bulls sired less than five daughters and only nine per cent sired ten or more daughters the minimum number required by the New Zealand Dairy Board for an official sire survey.

The 15,819 heifers registered belong to 3,970 separate paternal half-sib groups of varying size. These have been distributed in Table IV according to the average age of the sire at the birth of his progeny registered in 1948 and weighted according to the size of the half-sib group. The findings are also presented in Fig. 3.

TABLE IV. Distribution of all progeny groups according to the average age of the sire to show the relative importance of each age class.

Age of sire at daughter's birth (yrs. mths.)	Number of progeny groups.	Heifers registered.			
		Number	%age of total.	Cum. %	
- 1.6	23	25	0.16	0.16	
1.7 - 2.6	1253	3828	24.20	24.36	
2.7 - 3.6	848	3580	22.63	46.99	
3.7 - 4.6	614	2786	17.61	64.60	
4.7 - 5.6	420	1876	11.86	76.46	
5.7 - 6.6	257	1193	7.54	84.00	
6.7 - 7.6	219	1005	6.35	90.35	
7.7 - 8.6	147	714	4.51	94.86	
8.7 - 9.6	96	425	2.69	97.55	
9.7 -10.6	49	211	1.33	98.88	23.54
10.7 -11.6	20	91	0.58	99.46	
11.7 -12.6	16	67	0.42	99.88	
12.7 -over	8	18	0.12	100.00	
Total	3970	15,819	100.00		

The table shows that 23.54 of the heifers registered in 1948 could have been sired by bulls for which progeny-test details were known when their daughters were conceived, approximately a quarter of the heifers born were by "yearling" bulls (at the time of conception). These findings though reflecting more favourably on breeders as a whole than those of the previous section, do not suggest, however, any marked appreciation of selective breeding based on progeny testing of the bulls used. A comparison of Tables II and IV indicates that in general older

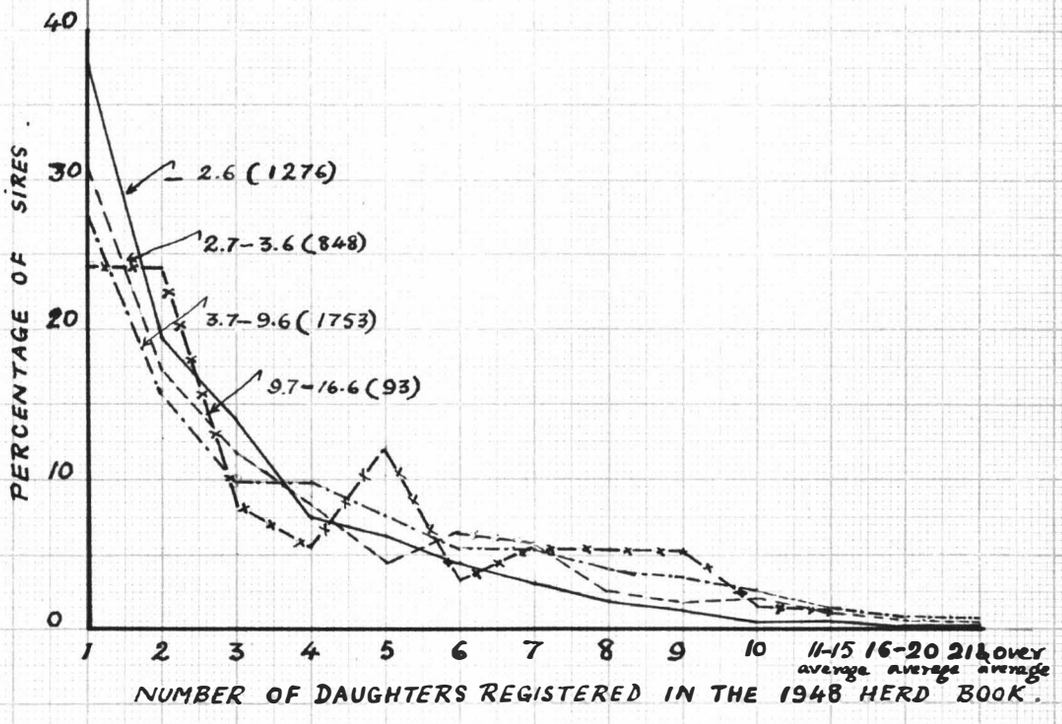

Fig. 4 The percentage distribution of bulls of various ages according to the number of daughters registered in the 1948 Herd Book.

bulls are used slightly more extensively than younger bulls to sire registered heifers and that this is the reason for the slightly better but still far from satisfactory picture. Approximately 20% of the sires of registered heifers were six or more years of age at the conception of their daughters and these bulls sired 24% of all registered heifers.

(C) Annual Heifer Registration per Sire in relation to the Sire's age.

In the previous section it was tentatively suggested that older bulls were used more extensively than young bulls to sire registered heifer calves. The use to which bulls of various ages are put is important in a selective breeding programme. Ideally where attempts are made to prove young sires and simultaneously exploit progeny tested sires, every endeavour should be made to obtain progeny test samples from the first year's matings of a particular bull, to use him lightly if at all during the subsequent interval which must elapse before progeny test details become available and then, if results are satisfactory, to use him as widely as herd size will permit. For this reason if progeny testing was favoured by pedigree breeders as a means of identifying animals of superior breeding worth one would expect yearlings and 2 year olds to be used fairly extensively and for the subsequent two or three age classes to show a marked reduction in the number of registered heifers sired by them. Then of these bulls, one would expect those proven of satisfactory merit to sire large numbers of registered daughters.

In Table V and Fig. 4 3970 sires with daughters registered in the 1948 herd book have been distributed according to age at birth of registered daughters and to number of registered daughters. To facilitate comparison between the different age classes percentage distributions and cumulative totals are shown. The results of the statistical examination of the data are also included. It is clear that yearling bulls do sire fewer registered daughters than bulls which were two or more years of age at mating. This difference is due in part to the relatively large percentage (37.9%) of yearling bulls which sire only one registered heifer and in part to the small percentage of yearling bulls which sire six or more registered heifers. This latter aspect is probably a reflection of the general reluctance among farmers to mate yearling bulls with many animals rather than discrimination against the daughters of young sires.

TABLE V The percentage distribution of Jersey pedigree sires according to age at birth of registered daughters and number of heifer calves registered in the 1948 herd book.

Age of sires at birth of daughters (No. of sires)	Percentage of Sires within each class													Average
	Number of registered daughters													
	1	2	3	4	5	6	7	8	9	10	11-15	16-20	21 & over	Registered daughters per bull
up to 2.6 (1276)	37.9 37.9	19.7 57.6	14.1 71.7	7.4 79.1	6.3 85.4	4.7 90.1	3.3 93.4	1.9 95.3	1.3 96.6	0.6 97.2	2.5 99.7	0.2 99.8	0.08 100	3.1
2.7 - 3.6 (848)	31.1 31.1	17.2 48.3	11.7 60.0	8.1 68.1	4.6 72.7	6.3 79.0	5.8 84.8	2.9 87.7	1.7 89.4	2.0 91.4	5.7 97.1	2.0 99.1	0.9 100	4.2
3.7 - 4.6 (614)	25.6 25.6	17.1 42.7	9.0 51.7	10.9 62.6	7.0 69.6	5.5 75.1	5.0 80.1	5.0 85.1	3.1 88.2	2.8 91.0	6.0 97.0	1.6 98.6	1.4 100	4.5
4.7 - 5.6 (420)	27.6 27.6	16.2 40.9	10.7 50.5	11.2 59.9	7.9 68.8	4.7 74.6	4.7 80.8	2.6 85.1	1.7 89.9	1.7 93.3	8.1 96.8	2.4 98.7	0.5 100	4.5
5.7 - 6.6 (257)	29.2 29.2	11.7 40.9	9.7 50.6	9.3 59.9	8.9 68.8	5.8 74.6	6.2 80.8	4.3 85.1	4.3 89.9	3.9 93.3	3.5 96.8	1.9 98.7	1.3 100	4.7
6.7 - 7.6 (219)	25.6 25.6	16.0 41.6	13.2 54.8	5.5 60.3	7.7 68.0	7.7 75.7	5.0 80.7	2.7 83.4	5.9 89.3	2.3 91.6	6.8 98.4	1.0 99.4	0.5 100	4.5
7.7 - 8.6 (147)	29.3 29.3	16.3 45.6	8.2 53.8	8.2 62.0	8.2 70.2	3.4 73.6	3.4 77.0	6.8 83.8	2.0 85.8	3.4 89.2	8.2 97.4	1.3 98.7	1.3 100	4.5
8.7 - 9.6 (96)	33.3 33.3	13.5 46.8	8.3 55.1	8.3 63.4	6.3 69.7	1.0 70.7	9.4 80.1	6.3 86.4	4.2 90.6	2.1 92.7	3.1 95.8	4.2 100		4.4
9.7 & over (93)	23.7 23.7	23.7 47.4	8.6 56.0	5.4 61.4	11.8 73.2	3.2 76.4	5.4 81.8	5.4 87.2	5.4 92.6	1.0 93.6	6.4 100			4.2
Total	32.04 32.04	17.53 49.57	11.56 61.13	8.34 69.47	6.60 76.07	5.31 81.38	4.58 85.96	3.02 88.98	2.44 91.42	1.76 93.18	4.87 98.05	1.30 99.35	0.65 100	4.0

Results of Statistical Analysis

Class	2.7 - 3.6	3.7 - 4.6	4.7 - 5.6	5.7 - 6.6	6.7 - 7.6	7.7 - 8.6	8.7 - 9.6	9.7 & over
1.7 - 2.6	S	H.S	S	H.S	H.S	H.S	S	H.S
2.7 - 3.6		S	•	•	•	•	•	•
3.7 - 4.6			•	•	•	•	•	•
4.7 - 5.6				•	•	•	•	•
5.7 - 6.6					•	•	•	•
6.7 - 7.6						•	•	•
6.7 - 7.6							•	•
7.7 - 8.6								•
8.7 - 9.6								•
[illegible]								

There was no statistically significant difference in the extent to which sires between the ages of 2 years 7 months and 9 years 6 months were used with the one exception shown in Table V. The significant difference between bulls 2 years old and 3 years old at mating appears to depend upon the large percentage (31.1%) of 3 year old bulls which sires only one registered heifer. The reasons for this difference are not clear.

A further interesting feature of Table V is the decrease in the maximum size of progeny-groups after the bulls have reached a certain age. There were no bulls which were approximately 8 years of age when mated leaving more than 20 registered daughters, and among bulls a year older the largest progeny group was 15 daughters. These findings probably reflect the decline in bull fertility associated with advancing age.

The information printed in Table V has been summarised in Table VI. The number of sires over 12 years at the birth of their progeny is so small that reliable information cannot be obtained.

TABLE VI. The distribution of sires of heifers registered in the 1948 herd book according to age to show the average number of heifers registered by sires of each age class.

Class	No. of bulls	No. of heifers registered.	Heifers registered/bull.	
up to 2.6	1276	3853	3.1	
2.7 - 3.6	848	3580	4.2	
3.7 - 4.6	614	2786	4.5	
4.7 - 5.6	420	1876	4.5	
5.7 - 6.6	257	1193	4.7	
6.7 - 7.6	219	1005	4.5	
7.7 - 8.6	147	714	4.5	" 4.5
8.7 - 9.6	96	425	4.5	
9.7 -10.6	49	211	4.3	
10.7 -11.6	20	91	4.6	
11.7 - 12.6	16	67	4.1	
12.7 -over	8	18	2.3	
Total	3,970	15,819	3.98	

" Mean heifer registration/bull for bulls of ages 3 years to 12 years inclusive.

It is of interest to note, however, that the oldest bull used was 15 years 3 months at the conception of his daughters

(3 in number) and the youngest only 7 months old. In the 1948 herd book individual bulls sired four registered heifers. Yearling bulls on the average sired 3.1 registered heifers each the comparable figure for bulls 2 years of age and over being 4.5 registered heifers.

Where, as is common in New Zealand, grade animals, as well as pedigrees are maintained in the same herd, the situation may not be as disturbing as would appear from these findings. However, since the ratio of pedigree to grade cattle within herds under Official Pedigree Test is approximately 1.5 : 1.0 (Herd Recording Council Minutes, 1951), in the majority of cases individual breeders are probably in little better position than these findings suggest. Not only do they dissipate their opportunities for proving sires by using the majority of them too sparingly as young bulls, but among sires for which progeny test data should be available there is no apparent attempt to exploit the information as reflected by an increase in the size of the progeny groups.

(D) The Origin of Sires in Relation to Annual Heifer Registrations.

Changes of ownership probably improve a sire's expectation of life, not so much because the change may correct nutritional deficiencies but because it is likely that a purchased sire will find itself in a herd in which the standards of performance are not so high as in the herd in which it was bred. Not only are purchased sires probably older than home-bred but since the vast majority of bulls are used in New Zealand when the information concerning them is restricted to pedigree details (Stewart 1951) it is likely that purchased sires will be used more extensively than home-bred. Thus the differential use of sires of varying ages already noted may depend largely upon the origin of the sire rather than upon its age as such.

From the data supplied by the New Zealand Dairy Board (see p.3) a random selection of 954 sires consisting of the first and last bulls on each page of the tabulated material (see p.3) was made. Since the sires were listed according to their registration numbers the sample was representative of the various age groups and as it consisted of approximately 24% of all sires of registered heifers in that particular year, it may be regarded as adequate.

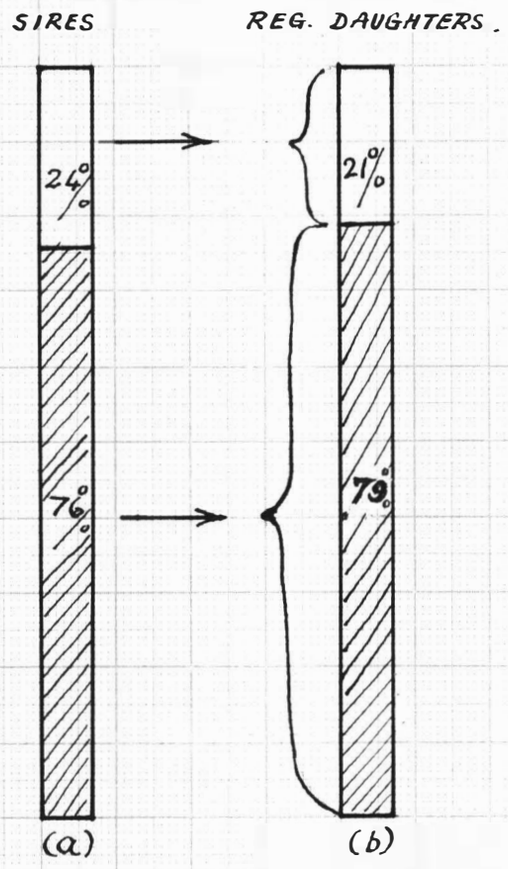

Fig:5 Showing (a) the proportion of home-bred and purchased bulls in a sample of 954 sires of heifers registered in the 1948 Herd Book, and (b) the proportion of their daughters which were sired by home-bred or purchased sires.

In Fig. 5a the 954 sires have been classified according to whether they were home-bred or purchased. It may be seen that 24% of all the sires in the sample were used in the herd in which they were bred, the remaining 76% being purchased from other pedigree herds. The proportion of home-bred or purchased sires does not, however, measure accurately the relative importance of each class of bull. A better estimate is shown in Fig. 5b in which the 4695 registered daughters of these 954 sires have been grouped according to theorigin of their sires (home-bred or purchased). 79% of these heifers were by sires not bred in the herd in which they were used.

Figs. 5a and 5b indicate first the minority of home-bred bulls and the daughters of home-bred bulls and secondly that home-bred bulls are used less extensively to sire registered daughters than those of purchased origin. 24% of the sires in the sample were bred in the herd in which they were used and sired only 21% of all the registered heifers in the sample in that particular year. To determine whether this could be related to some feature of the breeding method adopted by pedigree breeders both home-bred and purchased bulls have been separately distributed according to age at birth of their daughters in Table VII.

TABLE VII. Distribution of home-bred and purchased sires according to age showing average number of daughters sired by bulls of each age class.

Age of sire at daughter's birth. (yrs.mths.)	Home-bred sires.				Purchased Sires.			
	No.	%	Registered daughters.	Ave-rage.	No.	%	Registered daughters.	Ave-rage
1.7 - 2.6	114	49.1	358	3.1	164	22.7	585	3.6
2.7 - 3.6	44	19.0	200	4.5	164	22.7	1030	6.3
3.7 - 4.6	23	10.0	138	6.0	129	17.9	751	5.8
4.7 - 5.6	22	9.5	172	7.8	92	12.7	504	5.5
5.7 - 6.6	9	3.9	51	5.7	55	7.6	290	5.3
6.7 - 7.6	10	4.3	49	4.9	47	6.5	295	6.3
7.7 - 8.6	5	2.1	9	1.8	32	4.4	123	3.8
8.7 - 9.6	3	1.3	8	2.7	19	2.6	62	3.3
9.7 - over	2	0.9	8	4.0	20	2.8	62	3.1
Total	232	100.0	993	4.28	722	100.0	3702	5.13

Results of Statistical Analysis.

Between averages of purchased and home-bred bulls aged.....	1.7 - 2.6	.
" " " "	2.7 - 3.6	S
" " " "	3.7 - 4.6	.
" " " "	4.7 - 5.6	S
" " " "		

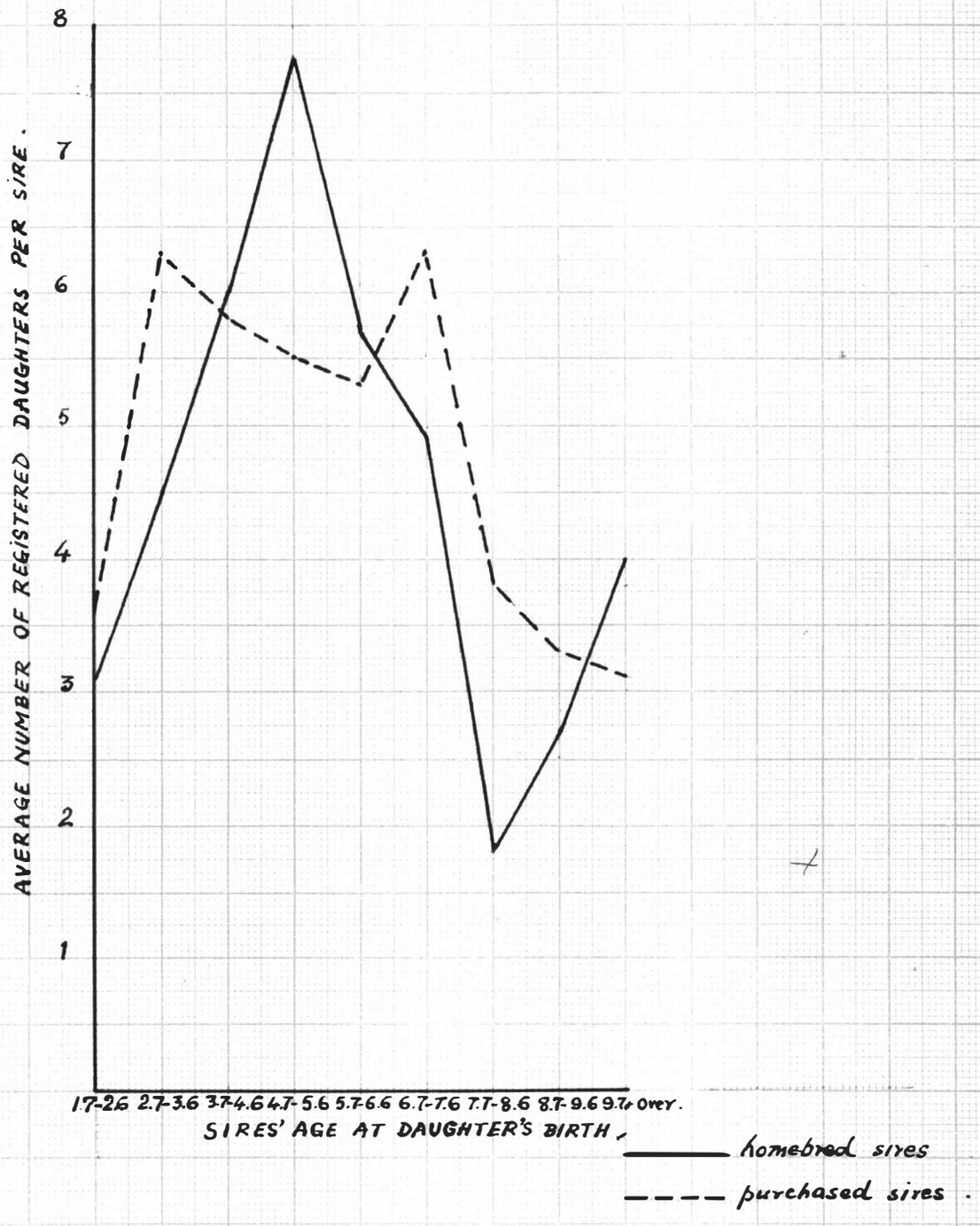

Fig. 6. Showing average number of registered daughters sired by a sample of purchased and home-bred bulls of various age classes.

The total and average number of heifers sired by bulls of each age class are shown together with the results of the statistical analysis conducted. Clearly the average bull, whether purchased or home-bred, sires too few registered daughters to permit adequate progeny testing in a single year. This is particularly so with home-bred bulls, especially yearling animals which on the average sired only 3.1 daughters in 1948 compared with 4.28 and 5.13 registered daughters for all home-bred and purchased bulls respectively. The small number of registered daughters sired by young home-bred bulls is probably due in part to their being run with small groups of yearling heifers owned by breeders with small herds. It is not likely that breeders would purchase young sires for the sole purpose of getting their yearling heifers in calf. One would expect that if a young bull had been purchased he would be highly regarded and more use made of his services than home-bred bulls of a similar age.

The average number of registered daughters sired by bulls of each age class is also shown in Fig.6. On the average purchased sires are used more extensively than home-bred sires though it is interesting to note (see Table VII) that once a home-bred bull is saved for another mating season in the herd in which it is bred, then it is likely to be used more extensively than purchased sires of similar age. This may be a reflection of the relatively few large herds which are to some degree closed. In such herds the higher number of registered heifers per sire may represent an attempt to exploit information obtained from earlier matings. However, the data are limited for the home-bfed sires, and such conclusions that have ben advanced must be regarded as tentative.

It was thought that the use of the averages shown in Table VII might not reveal the true position and consequently distributions are shown in Tables VIII and IX in which purchased and home-bred bulls havebeen distributed according to age and the number of daughters registered in the 1948 herd book. In Table VIII the difference between the number of daughters sired by purchased bulls aged 3.7 - 4.6 and bulls aged 1.7 - 2.6 at the birth of their progeny differed significantly.

TABLE VIII. Distribution of 722 Jersey pedigree bulls of purchased origin according to age and number of daughters registered in the 1948 herd book.

Age of sire at daughter's birth. Yrs.mths.	Percentage of sires within each age class. Number of registered daughters.										Total.
	1	2	3	4	5	6	7	8	9	10	
1.7 - 2.6	23.8	14.0	15.2	9.2	11.0	9.8	6.7	3.0	2.4	4.9	164
2.7 - 3.6	23.8	16.5	6.7	2.4	5.5	7.9	7.9	4.3	1.2	23.8	164
3.7 - 4.6	22.5	12.4	5.4	10.1	7.8	6.2	7.8	6.2	2.3	19.4	129
4.7 - 5.6	16.3	16.3	14.1	12.0	6.5	3.3	6.5	1.1	4.4	19.6	92
5.7 - 6.6	30.9	9.1	7.3	3.6	3.6	7.3	5.5	5.5	7.3	20.0	55
6.7 - 7.6	17.0	8.5	14.9	6.4	10.6	2.1	4.2	8.5	4.3	23.4	47
7.7 and over	25.4	8.5	8.5	8.5	11.3	2.8	7.0	4.2	5.6	18.3	71
Percentage	22.9	13.3	10.1	7.5	8.0	6.5	6.9	4.3	3.2	17.3	722

Results of Statistical Analysis

Age class	2.7-3.6	3.7-4.6	4.7-5.6	5.7-6.6	6.7-7.6	7.7-over
1.7-2.6	.	H.S.	.	.	.	.
2.7-3.6		.	.	.	.	.
3.7-4.6			.	.	.	.
4.7-5.6				.	.	.
5.7-6.6					.	.
6.7-7.6						.

TABLE IX. Distribution of 232 Jersey pedigree bulls of home-bred origin according to age and number of daughters registered in the 1948 herd book.

Age of sire at daughter's birth. Yrs.mths.	Percentage of sires within each age class. Number of registered daughters.										Total
	1	2	3	4	5	6	7	8	9	10	
1.7 - 2.6	31.6	16.7	17.5	8.8	5.3	7.9	3.5	5.3	0.9	2.6	114
2.7 - 3.6	27.3	11.4	13.6	11.4	2.3	11.4	2.3	6.8	-	13.6	44
3.7 - 4.6	8.7	8.7	13.0	26.0	13.0	4.4	4.4	-	4.3	17.4	23
4.7 - 5.6	13.6	9.1	9.1	4.5	4.5	9.1	9.1	4.5	-	36.4	22
5.7 and over	17.2	20.7	6.9	13.8	3.4	13.8	6.9	-	10.3	6.9	29
Percentage	25.0	14.7	14.2	11.2	5.1	9.1	4.3	4.3	2.2	9.9	232

Results of Statistical Analysis

Age class	2.7 - 3.6	3.7 - over
1.7 - 2.6	.	S
2.7 - 3.6		.

Failure of the remaining differences between the number of registered daughters sired by young and old bulls to attain significance was probably due to the small number of observations. It is of interest to note that with the exception of yearling purchased bulls approximately 20% of purchased bulls sired each year sufficient registered daughters for an adequate progeny test (at least 10 daughters). In Table IX, however, a very different position obtains in which a much smaller percentage (10%) of the home-bred bulls sired 10 registered daughters annually. Of the 114 home-bred bulls used, only 3 (2.6%) sired more than 10 daughters registered in 1948. Owing to the small number of home-bred sires it was necessary to group the sires over the age of 3 years 7 months before the data were tested for statistical significance. Two-year old bulls (when mated) were found to sire fewer daughters than sires in the remaining age classes of home-bred bulls. The data in Tables VIII and IX were then compared and it was found that purchased 2 year old bulls (at mating) sired significantly more daughters than home-bred sires ($P=0.02$) of similar age. This is probably due to the greater likelihood of home-bred bulls being

used sparingly in their second season in the herd in which they were bred whereas many of the purchased bulls of this age class would be in their first season's use.

There are two outstanding features in the material which is presented. The first the high proportion of heifers registered in 1948 by purchased sires thus indicating that relatively few herds are likely to be developing distinct strains within the breed. The second is the difference in the extent to which home-bred and purchased sires are used. In Tables VIII and IX it can be seen that only 23 or 10% of the home-bred sires have more than 10 daughters per annum whereas amongst purchased sires 127 or 17.30% have more than 10 daughters each year. More important still is the fact that in the group of sires only 9 (4%) of the home-bred bulls used as yearling or 2 year olds sired 10 or more daughters registered in 1948. In the purchased groups 47 (7%) leave sufficient daughters for a possible early progeny test.

With this general emphasis on the purchased sires clearly established within the pedigree section of the breed both in respect of numbers and extent of use, it is of interest to determine which are the most important bull breeding pedigree herds. This investigation has been made in a later section (see p.27).

(E) The Dispersion of Progeny Groups.

Reference has already been made to the relatively few bulls siring sufficient registered daughters in 1948 to permit their being adequately progeny tested (see p. 9). It is appreciated that many of the bulls considered may have sired grade animals in addition to their registered daughters and that the situation is probably not as discouraging as would at first appear. There is, however, another aspect of this problem of obtaining sufficient daughters for an adequate progeny test which merits attention, namely, the dispersion of individual bull's daughters in different herds. If the progeny is dispersed, not only is the collection of performance date made difficult, but the interpretation of the resultant progeny test requires considerable care. In view of the relatively high proportion (39%, Stewart 1952) of dams of registered heifers which were not bred in the herd in which their daughters were born it was considered that pr ogeny dispersal might be of some importance in New Zealand.

The Dairy Board's data (see p.3) supplemented with code numbers indicating the herds in which heifer calves and their sires were born were used for this study. The 3970 sires of heifers registered in 1948 were then grouped according to their age at the birth of their daughters and then each group distributed according to the number of herds in which their registered daughters were born. The findings are shown in Table X and it may be seen that the daughters of 80% of all the sires represented in the 1948 herd book were born in one herd while the registered daughters of the remaining 20% were born in two or more herds. With the exception of 23 sires less than 1 year 6 months of age at thebirth of their registered daughters there did not appear to be marked differences in dispersion between the remaining sires grouped according to age. Nevertheless the data were examined statistically to determine whether there were significant differences between the progeny dispersion of sires of different ages.

All the daughters of the 23 bulls less than 1 year 6 months at the birth of their daughters were born in one herd and it is probable that these matings were accidental. For the purposes of statistical analysis these 23 bulls were grouped with the next age class, but despite this the registered daughters of bulls aged 2 years 6 months or less (at birth of progeny) were significantly more dispersed than those of sires aged 2 years 7 months to 3 years 6 months. This was probably due to the widespread practice of mating yearling bulls and yearling heifers together before those heifers surplus to herd replacement requirements were sold and, as a result of this, the daughters of yearling bulls are more likely to be dispersed in different herds than the daughters of older bulls. Since Stewart (1952) states that approximately 60% of the registered daughters of 2 year old heifers are by "yearling" bulls (at mating) this would appear a reasonable contention. The failure of the remaining differences between the youngest age groups andthe older groups to attain significance is probably due to the inadequate numbers in the latter. The consistently significant differences between the progeny dispersion of sires aged 5.7 - 6.6 at the birth of their daughters is puzzling. The differences do not seem to be associated with any particular practice and it must be tentatively concluded that the result is due to chance. The last note-worthy feature of Table X is that the high percentage of sires aged 7.7 years and over which have progeny dispersed in 7 or more herds. This is largely due to the use of 5 proven sires at the Ruakura Bull Centre for artificial insemination.

TABLE X. Percentage distribution of 3970 sires according to age (at birth of their daughters) and the number of herds in which their daughters, registered in the 1948 herd book, were born.

Age of sires at birth of their daughters.	Percentage of sires							Number of sires.
	No. of herds in which registered daughters of 3970 sires were born.							
	1	2	3	4	5	6	7	
- 1.6	100							23
1.7 - 2.6	77.3	12.1	6.1	3.4	0.8	0.2	0.2	1253
2.7 - 3.6	81.5	10.8	4.5	1.1	0.7	0.7	0.7	848
3.7 - 4.6	77.0	13.7	5.4	2.0	1.1	0.3	0.5	614
4.7 - 5.6	80.2	12.1	3.8	2.1	0.5	0.5	0.7	420
5.7 - 6.6	88.7	7.0	1.6	0.4	0.8	0.8	0.8	257
6.7 - 7.6	79.9	12.8	3.2	0.9	1.4	0.9	0.9	219
7.7 - over	81.5	9.7	3.9	0.9	0.9	0.6	2.4	336
Total sires	3170	458	187	78	33	18	26	3970
% of sires	79.8	11.5	4.7	1.96	0.8	0.5	0.7	

Results of Statistical Analysis.

Age of sires at birth of daughters.	2.7-3.6	3.7-4.6	4.7-5.6	5.7-6.6	6.7-7.6	7.7-over
- 2.6	S	.	.	S	.	.
2.7 - 3.6		.	.	S	S	.
3.7 - 4.6			.	S	.	.
4.7 - 5.6				S	.	
5.7 - 6.6					.	.
6.7 - 7.6						.

The fact that the registered female progeny of 80% of the sires with daughters registered in 1948 were born in one herd would not give rise to misgivings were it not that 91% of all bulls sired less than 10 registered daughters, the minimum number for an official sire survey in New Zealand. This is particularly disquieting when it is remembered that the progeny of yearling bulls are most likely to be dispersed and that these young bulls sire fewer registered daughters than older bulls. Opportunity for obtaining information

concerning a bull's breeding worth at an early age is therefore reduced in New Zealand not only by small crops of registered daughters sired when bulls are yearlings, but also by increased chances of dispersion of their registered female progeny.

HERD SIZE IN THE NEW ZEALAND PEDIGREE JERSEY CATTLE INDUSTRY.

The pedigree cattle of New Zealand are grouped into herds of varying size each herd being to some extent an isolated sub-group of the pedigree cattle population. Though the hereditary material within each herd is subject to the effect of selection and addition from other herds, sampling accidents can cause marked fluctuations in gene frequencies. Fisher(1930) has pointed out that these random fluctuations vary inversely as the number of breeding animals weighted according to their reproductive importance. Hazel (1943) stated that few herds are sufficiently large to provide information which will reduce these sampling errors to small proportions. These fluctuations are of first importance in selective breeding, and since they are so affected this aspect of the New Zealand pedigree jersey cattle industry should be widely appreciated.

Herd size is also of considerable importance in the application of a constructive breeding plan. First it determines to a large measure the rate at which offspring may be produced to enable sires to be progeny tested. This rate does not necessarily increase with herd size since some breeders prefer to limit the number of services which a sire is allowed to perform in any one year. But in large herds young bulls have scope for moderately extensive use as yearlings and two year old animals may then be retired until production records of their daughters become available.

Further, in small herds where some attempt to progeny test has been made, it is difficult to cull all the daughters of an unsatisfactory sire. Similar difficulties apply in large herds but they are more easily dealt with when a number

of sires have been used and the progeny of one is to be eliminated. An additional disadvantage of small herd size is that in small herds, if a sire has been proven and found satisfactory, then his use is limited by the presence in the herd of his progeny test sample which comprises a considerable proportion of the entire herd; the majority of breeders avoid mating sires with their daughters and consequently the full exploitation of the sire which has been proved at some inconvenience is impossible in that herd. This is largely responsible for the large turn-over in herd sires (Ward 1940) and since many breeders appear to prefer bulls which have not been used in other pedigree herds (Stewart 1951), the result is that a large number of yearling bulls with little information concerning them other than pedigree are used in the pedigree industry (see pp 6). The result of such widespread use of yearling bulls, few of which are selected with high genotypic accuracy, and the provision of their male offspring to the commercial farmer is no doubt partly responsible for the almost stationary level of production reported in the annual reports of the New Zealand Dairy Board. Donald (1945) has shown that in Great Britain small herds are usually short-lived. It is not known whether the same applies to New Zealand, but if such is the case these small herds can do little more than multiply existing stocks rather than select for improved gene combinations resulting in increased production.

An additional and important implication of small herd size has recently become apparent in New Zealand. This relates to the expenses connected with the recording of small herds. The overhead cost of recording are not greatly diminished by increasing herd size, and consequently the price of testing individual animals in small herds is higher than in large herds. In many cases this has resulted in breeders with small herds not recording their cattle.

Estimates of the size of the pedigree units in New Zealand are difficult to make. In the first place, a large proportion of pedigree cattle are in herds in which commercial cattle are also kept. Secondly, the New Zealand Dairy Board which has provided so much valuable statistical information has access only to data concerning recorded herds. A proportion of the pedigree cattle are not tested and these are probably collected in small groups. Despite the fact that they are not recorded, the progeny of these animals may be registered, and be used in both pedigree and commercial herds. Even if information concerning herd size was available it would not necessarily give

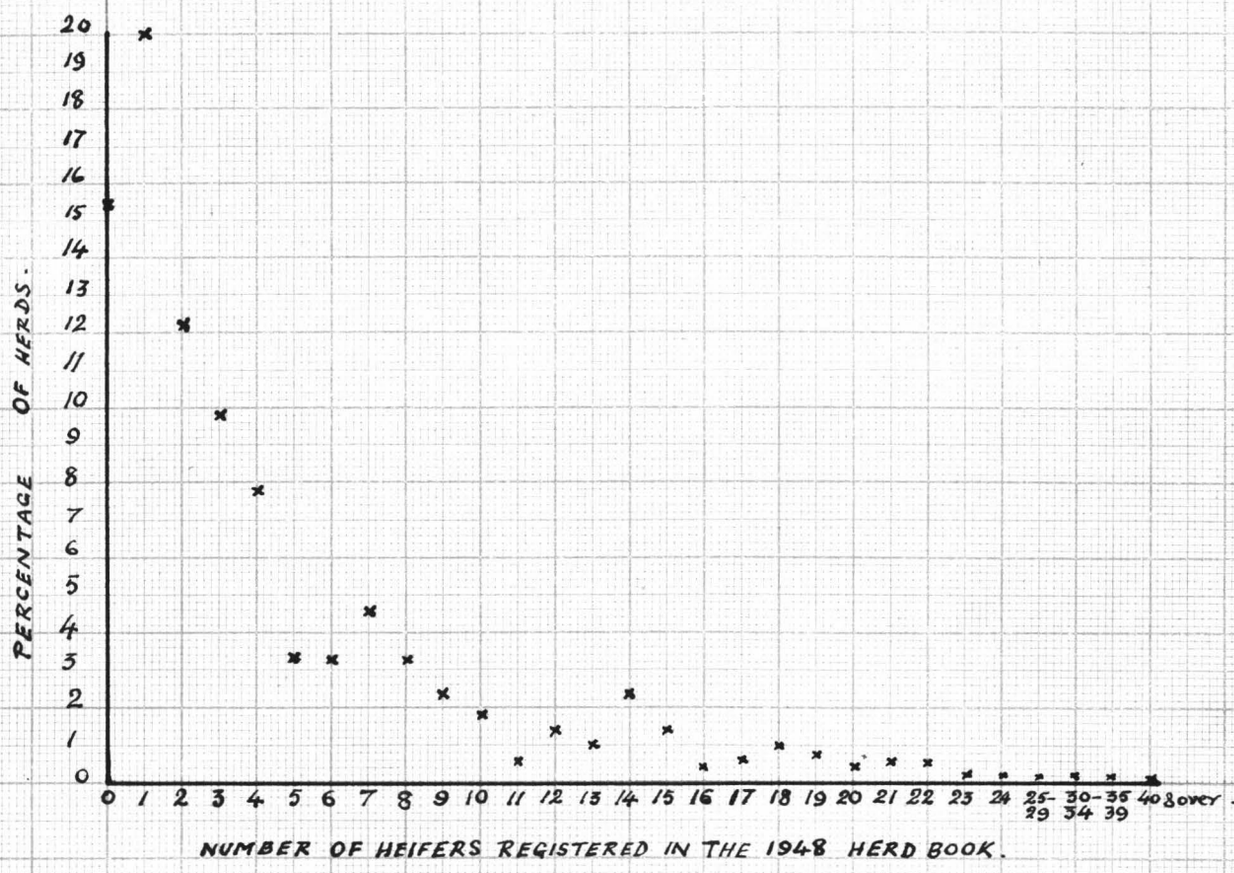

Fig. 7. Distribution of a sample of Jersey pedigree herds according to the number of heifers registered in the 1948 Herd Book.

an accurate picture of the true situation, since the considerations mentioned above apply to the effective breeding units rather than all members of the herd. The term herd size should really indicate the number of breeding animals weighted according to their reproductive importance. One way of measuring the size of the effective breeding units is to consider the registrations from individual breeders. Vagaries of sex-ratios, varying severity of selection between herds, differential wastage rates etc. must lead to unavoidable inaccuracies, but the number of heifers registered by each breeder should indicate the chief features of the size distribution of pedigree breeding units. There is a good reason to believe that in view of rate of expansion of pedigree population all or nearly all heifers born alive of pedigree parents are registered, consequently a fairly reliable picture should be available.

Data have been drawn from the 1948 Jersey herd book consisting of 584 breeders whose names commenced with letters A, B, C and E, and who between them registered approximately 20% of the total heifer registration entered in that particular year. Table XI and Fig.7 show the distribution of these breeders according to the number of heifers registered in 1948.

TABLE XI. The distribution of a sample Jersey breeder according to the number of heifers registered in the 1948 herd book.

No. of females registered in 1948.	Breeders		Total♀♀ registered	
	Number	% age	Number	% age
0 - 4	383	65.6	614	19.3
5 - 9	101	17.3	695	21.9
10 -14	44	7.5	536	16.9
15 -19	26	4.5	435	13.7
20 -24	14	2.4	302	9.5
25 -29	3	0.5	81	2.6
30 -34	7	1.2	223	7.0
35 -39	3	0.5	111	3.5
40 -over	3	0.5	178	5.6
Total	584		3,175	

Of the breeders who registered at least one animal (male or female) 15% did not register a heifer calf and a further 50% registered four or less heifer calves. Thus two-thirds of the breeders represented in the sample registered fewer than five heifers each in 1948. They were, however,

responsible for almost 20% of the heifers registered in that year. Approximately 83% of the breeders in the sample studied registered less than 10 heifers in the year studied, less than that required for the official sire survey of one bull. The number of heifers registered by these breeders with small pedigree herds represented more than 40% of the total. However, these results should be interpreted with care, since there is no indication of the number of grade animals which was maintained along with each small pedigree group and in the larger pedigree groups, no data have been presented upon the number of bulls used to sire registered heifer calves. It has been shown (p 13) that the average number of registered heifers per sire is 3.98 and this suggests that the situation is far from satisfactory even in herds from which a large number of heifers are registered each year. Though the majority of breeders registered less than 5 heifers in 1948, there were some herds registering more than 40 heifers. The 5% of the breeders who register more than 20 heifers per year would with few exceptions be the only ones possessing adequate material from which to arrive at a reliable estimation of the breeding worth of the sires they use. For this reason, there seems little justification at present in regarding individual herds as such as the significant units in breed improvement.

Mention has been made of the limitation imposed by herd size in the use of sires. From the data used above an analysis has been made of the extent to which sires were used in effective breeding units of varying size. Again conclusions must be tentative in the absence of the information concerning the number of grade cattle kept in by these pedigree breeders. Information collected by the New Zealand Dairy Board (1951) indicated that at the commencement of the 1951-52 season in the 699 herds in which pedigree cows were tested the average herd size was 51 animals of which 32 were pedigree and 19 grade. One would expect an average of approximately 10 heifers to be registered from these recorded herds. In the herd book sample discussed above an average of 5.8 heifers were registered per breeder. Clearly the two samples are not comparable, and it would be reasonable to infer that since small herds are less likely to be recorded, that the herd book sample would be drawn from herds in which there were proportionately less grade animals than the New Zealand Dairy Board sample. It is reasonable to assume, therefore, that small pedigree units are maintained in herds in which grade cattle are even less important relatively than when large pedigree units are concerned. Data relating to

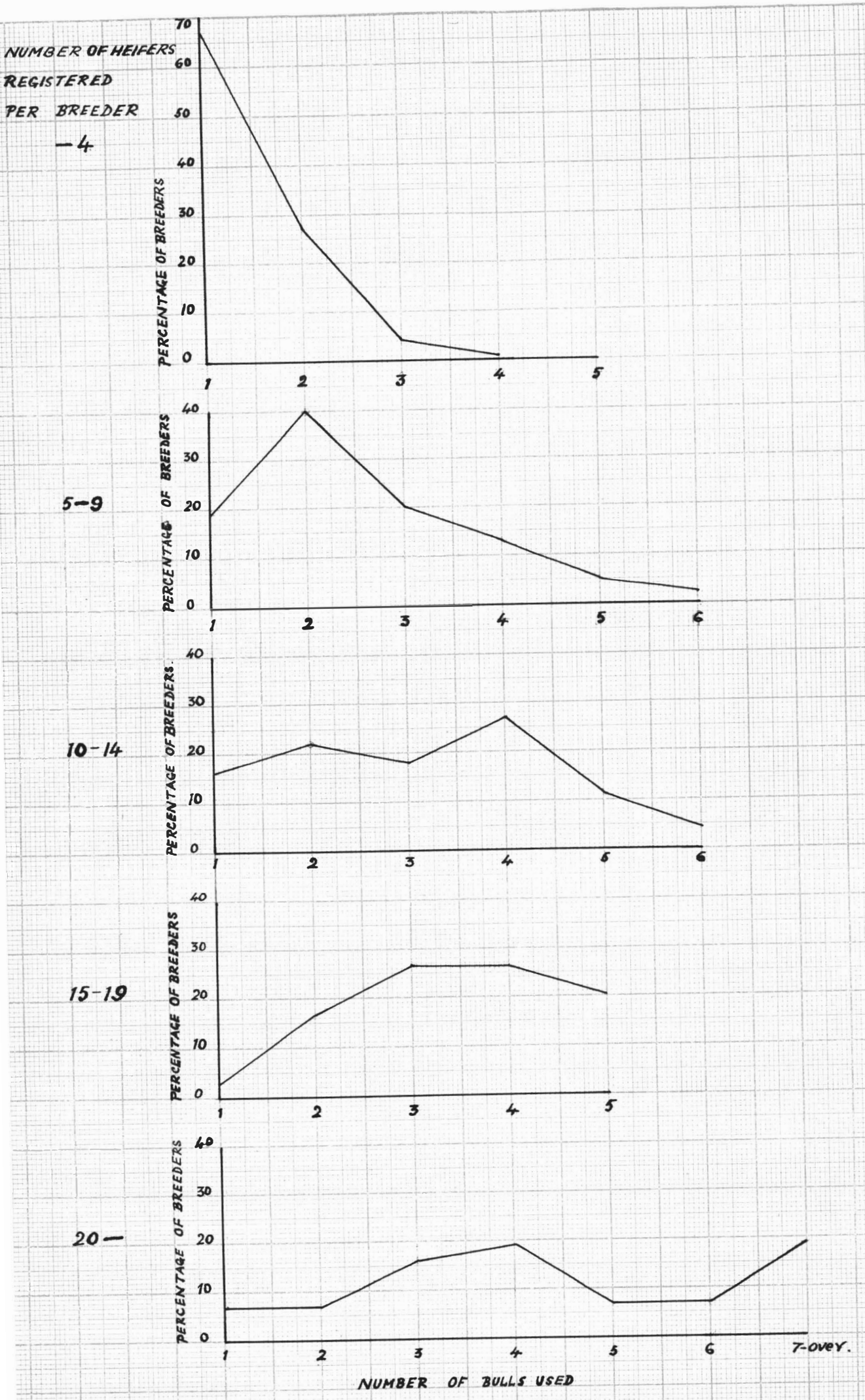

Fig 8. Distribution of a sample of breeders according to the number of bulls used to sire heifer calves registered in the 1948 herd book.

the use of sires which had registered offspring in 1948 will, therefore, give a reasonably accurate picture of what occurs in the pedigree section of the dairy cattle population.

In Table XII breeders have been grouped according to the number of heifers registered in 1948 and for each category the number of heifers registered per sire is shown.

TABLE XII. Breeders distributed according to the number of heifer calves registered to show the average number of heifers registered per sire.

No. of heifer registrations per breeder.	Total no. of bulls used.	Total no. of heifers registered.	No. of heifers registered/bull used.
- 4	409	614	1.50
5 - 9	249	695	2.79
10 -14	126	536	4.25
15 -19	90	435	4.83
20 -	169	895	5.29

Results of Statistical Analysis.

No. of heifers registered per breeder.	5 - 9	10 - 14	15 - 19	20 & ove
1 - 4	H.S	H.S.	H.S.	H.S.
5 - 9		H.S.	H.S.	H.S.
10 -14			H.S.	H.S.
15 -19				H.S.
20 &over				

H.S. - P .01

Breeders who did not register any heifer calves have been omitted, but despite this, the bulls used by breeders registering less than five heifers in 1948 sired an average of only 1.5 registered daughters in that year. The situation improves as the number of heifer registrations per breeder increases, but even when 20 or more heifers were registered by individual breeders in the 1948 herd book the sires averaged only 5.29 registered daughters each. The difference between the various classes are highly significant (P. less than .01) showing that herd size as indicated by the annual heifer registration is an extremely important factor in the extent to which sires are used. The data is also presented in Fig.8 and it is clear that the number of sires used in pedigree units of different size does not increase as rapidly as one might

expect. Some breeders registering less than 5 heifers per year used 4 sires while of those registering 20 or more per year the greatest number of sires used in any particular herd was 7. It is difficult to explain this extravagance in sires; in some instances it may have been due to a large number of grade animals present in the herd, although this is unlikely to provide the complete answer. It seems more probable that with the existing methods of sire-selection breeders are loathe to commit themselves too deeply to individual sires.

These findings while purely tentative in nature suggest that the present size of the pedigree units in New Zealand with its consequent misuse of sires offers little hope for genetic improvement of the pedigree population unless breeding plans to embrace the whole breed are initiated. Either smaller breeders should become "multipliers" for the larger herds under the control of breeders who appreciate and take advantage of the facility offered by the more extensive scope for selective breeding, or, smaller breeders should restrict their choice of sires to progeny-tested bulls maintainced at Artificial Insemination Centres.

THE RELATIVE IMPORTANCE OF PEDIGREE HERDS.

Annual pedigree bull sales are a prominent feature of the New Zealand dairy industry. In addition many pedigree bulls are bought and sold privately, the number transferred in New Zealand each year being more than 8,000 in the Jersey breed alone. Purchasers of pedigree sires are breeders of both pedigree and grade cattle and to those interested in the structure of the Jersey breed this traffic in sires between pedigree breeders is of first importance.

It indicates that some of the pedigree breeders are not self-sufficient in respect of sires and it may well be that certain herds exert an influence on the breed as a whole out of all proportion to their size and duration. This would be possible if some herds supplied bulls predominently to other pedigree herds which in turn supplied bulls to breeders of grade cattle. On the other hand the considerable traffic in sires may represent an interchange of bulls between pedigree breeders resulting in a frequent levelling out process of the

hereditary material within the pedigree section of the breed as a whole. If such is the case, few herds would likely be isolated from one another in the genetic sense and the existence of the families or strains characterised as a whole by certain levels of performance would appear unlikely. This in turn would emphasise the need for co-ordination of the numerous individual breeding efforts at present largely dissipated.

Since the vast majority of male calves born in grade herds are slaughtered within a few days of birth and since there are no official grading schemes in this country it follows that bulls bred in grade herds are of little interest in so far as future generation of pedigree stock are concerned. On the other hand sires which are used in pedigree herds have considerable opportunity to make their presence felt since their progeny in turn may be used in pedigree herds.

There are various ways of obtaining a picture of the herds which are of importance in the Jersey breed as a whole. Those which supply the greatest number of sires used in all pedigree herds are of obvious immediate importance. In New Zealand it is the common practice for each breeder to register a herd prefix. In the 1948 herd book there were approximately 4,000 registered prefixes (though only 2,600 breeders registered cattle in that particular year) in addition to which there was a comparatively small number of breeders with unregistered herd prefixes. It is almost universal practice for animals to include the herd prefix as their first name, consequently it was a simple though laborious task to distribute all bulls used to sire heifers registered in 1948 according to the herd prefix of their sires. The analysis was simplified by the way in which the material supplied by the New Zealand Dairy Board was tabulated. In all there were 3,970 sires of registered heifers in the 1948 herd book, and these have been grouped according to the herd in which they were bred (as indicated by a common herd prefix).

Table XIII shows the relative importance of the herds as judged by the number of sires represented by heifers registered in the 1948 herd book. In view of the age distribution of sires used in the pedigree herds (Table II) one would expect the herds supplying bulls to pedigree herds to be represented in any one year by two or three times their annual supply of bulls to the pedigree industry. It is surprising, therefore, to find that only one herd is represented by more than 50 sires amongst the parents of the heifers registered in the 1948 herd book, and that only 23 herds each provided more than 20 sires of the total of

3,970 bulls in effective use. It is equally surprising that only 1291 herds of a total of 2,606 herds from which stock were registered supplied bulls for use in the pedigree industry, and that the vast majority (1089) supply less than 5 sires of

TABLE XIII. Herds supplying sires of heifer calves registered in the 1948 herd book distributed according to the number of sires with registered daughters.

No. of sires in use.	Herds in which sires bred			Total sires		
	No.	Name (Number of bulls in brackets).		No.	%	Cum.%
50 -	1	O.K. (51)		51	1.28	1.28
40 - 49	2	Erinview (41)	Abberville (40	81	2.04	3.32
30 - 39	6	Oaklea (38)	Waipiko (33)			
		Cloverfield (37)	Oddicombe (32)			
		Maori (36)	Allandale (32)	208	5.24	8.56
20 - 29	14	Pinewoods (29)	Marshlands (22)			
		Jersey Glen (27)	Croydon (22)			
		Beaulieu (27)	Heatherlea (21)			
		Ngahiwi (26)	Reshure (21)			
		Green Meadows (26)	Greencroft (20)			
		Tolgarth (24)	Broken Hill(20)			
		Elmsford (23)	Beechlands (20)	328	8.26	16.82
15 - 19	18	Rata Glen (19)	Glan Dwr (17)			
		Raeburn (19)	Faundale (17)			
		Lilyoak (19)	Tokorangi (16)			
		Windermere (18)	Roseneath (16)			
		Pinecrest (18)	Pakowhai (16)			
		Forest Home (18)	Glenmore (16)			
		Trelan (17)	Tekara (15)			
		Fairy Meadows (17)	Ridgeway (15)			
		Glamorgan (17)	Premier (15)	305	7.68	24.50
10 - 14	35			404	10.18	34.68
5 - 9	126			786	19.80	54.48
1 - 4	1089			1807	45.52	100.00
Total	1291			3970	100.00	

registered heifers. These individually unimportant herds were responsible, however, for the sires of almost half (45.5%) of the heifers registered in the 1948 herd book. Many of the sires bred in these apparently unimportant herds may have been used in the herds in which they were bred for reasons of economy. Other herds may be included in the list of bull breeding herds because the owners retained yearling home-bred bulls to mate with yearling heifers more for the reason of getting the yearlings in calf than to provide herd replacements. The calves born of such matings would be eligible for registration, and since the breed was expanding rapidly and prices for registered stock were high during the period subsequent to 1943

it is probable that many daughters of 2 year old parents would be registered despite the original intentions of the breeders.

The names of 41 more important herds as judged by the criterion of the number of sires used in pedigree herds have been included in Table XIII. Together these herds represent 0.15% of the 2605 breeders registering animals in the 1948 herd book but they supplied almost 25% of the bulls used to sire heifers registered in that year.

The number of bulls of common herd origin in use throughout the pedigree industry gives, however, only an approximate indication of the relative importance of different herds. A more accurate assessment can be obtained by weighting each sire according to the number of daughters registered in the 1948 Jersey herd book. The data already described has been arranged in Table XIV to show the relative importance of herds as measured by the number of registered heifers sired by bulls bred in particular herds. Table XIV shows that four herds (0.31%) each supplied sires of 250 or more heifers registered in 1948 and these 1054 heifers comprised 6.66% of the 15,819 heifers registered in that year. Of the herds supplying bulls used in pedigree herds 4.7% supplied the sires of approximately 40% of the heifers registered in 1948. Comparison between Table XIII and Table XIV shows that the relative importance of the named herds judged by either criterion is approximately the same. All except one of the 41 herds named in Table XIII are among the 61 named in Table XIV and the relative positions of herds in the two tables do not differ greatly. The latter table, however, is a more useful indication of the relative importance of the various herds since it takes into account the extent to which sires were used.

The names of the important herds have been included in Tables XIII and XIV, since they are of general interest to those concerned with the structure of the jersey breed and should a similar study be conducted at some future date, it will be interesting to note the changes in their relative importance and to diagnose the reasons for such changes.

The above estimates of the relative importance of the various herds do not give as informative a picture as could be desired since certain herds may owe their eminence to their supplying sires to some large pedigree herd which in turn supplied sires only to grade herds. Others may appear important due to their owners using bulls of their own breeding extensively to sire registered stock, but only supplying bulls to grade herds.

An attempt to find out more about the structure of the breed in its dependence upon the leading herds were therefore made.

TABLE XIV. Herds supplying sires of heifer calves registered in the 1948 Jersey Herd Book distributed according to the number of registered daughters by sires with common herd prefixes.

Category.	Herds in which sires bred.				Heifer registrations.		
	No.	% of total	Cum.%	Name	No.	% of total	Cum. %
250-	4	0.31	0.31	Abbeville (274) O.K. (271) Erinview (259) Cloverfield (250)	1054	6.66	6.66
225-249	1	0.08	0.39	Oaklea (232)	232	1.47	8.13
200-224	1	0.08	0.47	Maori (203	203	1.28	9.41
175-199	1	0.08	0.55	Beaulieu (179)	179	1.13	10.54
150-174	4	0.31	0.86	Green Meadows (173) Oddicombe (166) Allandale (159) Jersey Glen (153)	651	4.12	14.66
125-149	4	0.31	1.17	Pinewoods (132) Ngahiwi (130) Glam Dwr (129) Waipiko (125)	516	3.26	17.92
100-124	6	0.46	1.63	Lilyoak (121) Marshlands (115) Takeke (113) Reshure (110) Croydon (109) Greencroft (101)	669	4.23	22.15
75- 99	12	0.93	2.56	Glenmore (99) Tokorangi (99) Beechlands (96) Fairy Meadows (94) Heatherlea (93) Rata Glen (91) Raeburn (89) Elmsford (86) Glamorgan (85) Pinecrest (85) Tekara (77) Broken Hill (75)	1069	6.76	28.91
50 - 74	28	2.17	4.73	Waikari (73) Tuiglen (69) Snow View (68) Ivanhoe (67) Pakowhai (67) Trelan (67) Faundale (65) Mount View (65) Landsdrone (64) Rainbow (64) Springdale (64) Ridgway (63) Mapple (61) Forest Home (60) Middlemore (60			

				Heatherleigh (60 Windermere (59) Craig Knoll (57) Manakoa (57) Roseneath (56) Centennial (55) Brokendell (54) Penrose (53) Tolgarth (53) Jersey Nook (52) Pai Rata (52) Brookside (50) Peveril (50)	1631	10.31	39.22
25- 49	81	6.27	11.00	(2817)	2817	17.81	57.03
1- 24	1149	89.00	100.00	(6798)	6798	42.97	100.00
Total	1291	100.00			15819	100.00	

In the 1948 Jersey herd book 2605 breeders registered stock. These breeders obtained their sires from 1291 herds (see Tables XIII and XIV) of which 336 herds were defunct. Consequently 1650 breeders registering stock in 1948 did not supply bulls used in pedigree herds (see Fig.9) Of the remaining 955 herds (those supplying bulls used in pedigree herds) the sires from 276 were used to sire registered heifers only in the herds in which they were bred. Since these herds do breed sires of registered heifers but do not supply sires to other pedigree breeders they have been classified separately (see Fig.9). The 955 herds breeding sires of registered heifers obtained their sires from 521 herds of which 131 were defunct. The herds not surviving this tabulation include the 276 herds already mentioned and the 289 herds which supply sires only to the 1650 herds already mentioned and to grade herds form these 289 herds along with 205 defunct herds form the next strata.

This process of tabulating herds which supplied sires to the next lower stratum and ascertaining where they in turn obtained their sires was repeated until there were only minor changes in the herds represented. Bulls may have been used in the herds in which they were bred but, subsequent to the identification of the 276 herds the sires from which were used only in thepedigree herds in which they were bred, home-bred sires have not been taken into consideration when classifying the herds. Thus there may be herds which only use home-bred bulls but their importance will depend upon the stratum in which the herds to which they supply bulls are to be found.

The final stage was reached when 112 herds remained of which 93 registered cattle in the 1948 herd book, the majority of the remaining 19 being defunct. These findings are shown

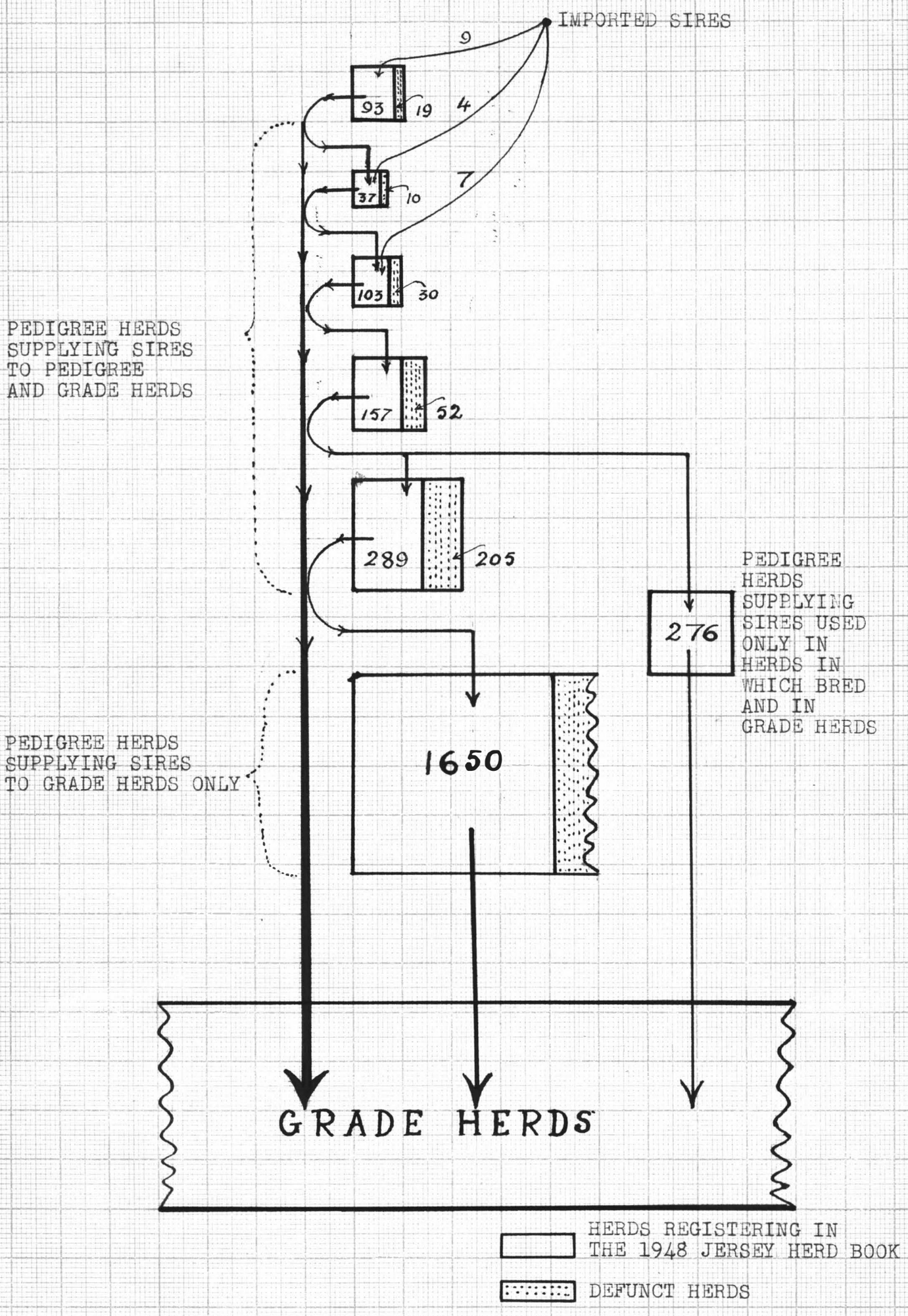

FIG. 9 THE 2605 PEDIGREE HERDS FROM WHICH HEIFERS WERE REGISTERED IN THE 1948 JERSEY HERD BOOK ACCORDING TO THEIR IMPORTANCE AS BULL-BREEDING HERDS AND ARRANGED TO SHOW THE STRATIFICATION WITHIN THE JERSEY BREED.

diagramatically in Fig.9 and the stratified nature of the Jersey breed is apparent. The 112 herds may be regarded as the top level herds in the Jersey breed since these herds supply sires to each other and to herds in any of the other strata. Sires used in the 93 existing herds were home-bred, purchased from herds in the top strata or obtained to a limited extent from overseas. There were 20 imported sires with registered daughters in the 1948 herd book. Nine of these were used in the top strata and the remainder in the intermediate strata.

Since the data related to registrations for only one herd book year it is not suggested that the above findings apply rigidly in each year. A number of the herds included in the top stratum supplied relatively few sires used in pedigree herds and it is unlikely that these herds would consistently supply sires to the top-level herds. There were, however, 79 herds which supplied more than 5 bulls which sired registered daughters in herds in various strata. These 79 herds have been distributed in Table XV according to the number of sires supplied to pedigree breeds. The majority of herds which were included in Tables XIII and XIV appear also in Table XV. All the sires supplied by the herds listed in Table XV could obviously not be used in the top stratum of breed. This indicates that the strata are by no means as distinct in the genetic sense as the information presented in Fig.9 suggests. Many of the herds in the lower and intermediate strata use sires bred in the same herds which supply bulls to herds in the top stratum. It is not known whether from the same herds, the owners of herds in the lower strata choose sires of inferior breeding worth to those selected by the owners of herds in the upper strata. If such is the case then the strata may be genetically isolated to some degree. On the other hand if emphasis is placed on selection criteria other than those directly related to butterfat production then the greater part of the breed may be relatively homogeneous so far as the genes associated with milk and butterfat production are concerned.

There is some evidence, however, that within the top stratum there are some herds which are genetically isolated from the remainder. Again the information consisting of one year's registrations is unsatisfactory but some of these top-level herds did, in the year under consideration, use only home-bred sires. This in itself does not mean that these herds are genetically different from the remainder but it could be so.

TABLE XV. Top-stratum pedigree herds supplying more than 5 bulls distributed according to the number of sires with registered daughters.

Category	No.	Names of herds in which sires bred.	
50 -	1	O.K. (51)	
40 - 49	2	Erinview (41)	Abbeville (40)
30 - 39	6	Oaklea (38)	Waipiko (33)
		Cloverfields (37)	Oddicombe (32)
		Maori (36)	Allandale (32)
20 - 29	14	Pinewoods (29)	Marshlands (22)
		Jersey Glen (27)	Croydon (22)
		Beaulieu (27)	Heatherlea (21)
		Ngahiwi (26)	Reshure (21)
		Green Meadows (26)	Greencroft (20)
		Tolgarth (24)	Beechlands (20)
		Elmsford (23)	Broken Hill (20)
15 - 19	12	Rata Glen (19)	Glan Dwr (17)
		Raeburn (19)	Faundale (16)
		Windermere (18)	Tokorangi (16)
		Forest Home (18)	Glenmore (16)
		Fairy Meadows (17)	Pakowhai (16)
		Glamorgan (17)	Ridgway (15)
10 - 14	16	Peveril (14)	Wattle Brae (11)
		Rainbow (14)	Waikari (11)
		Landsdowne (13)	Pukeroa (11)
		Takeke (13)	Penrose (11)
		Pai Rata (12)	Iris (11)
		Snow View (12)	Glenora (11)
		Tuhitarata (12)	Craigknoll (10)
		Mapple (11)	Davaar (10)
5 - 9	28	Ypress (9)	Willersden (7)
		Ivanhoe (9)	Finvoy (7)
		Kiteroa (9)	Muritai '6)
		Dunlavin (9)	Pampapuria (6)
		Tararua (9)	Silverlea (6)
		Abberley (8)	Pacific (6)
		Ashvale (8)	Allington (5)
		Belford (8)	Hampton (5)
		Brookdale (8)	Hetana (5)
		Crystal Spring (8)	Littlebourne (5)
		H.O. (8)	Meridale (5)
		Beacon Hill (7)	Tintern (5)
		Lancewood (7)	Bush Park (5)
		Neatherleigh (7)	Mount Meadows (5)

In Table XVI the 67 top stratum herds shown in Table XV to have supplied 7 or more bulls to sire registered heifer calves in 1948 have been distributed according to the percentage of home-bred bulls. The total number of heifers registered from each herd is shown in brackets and it is clear that there is no uniform practice in respect of whether home-bred or purchased sires are used. A more detailed study of some of these herds was made. Since the study is concerned in the possible genetic isolation of some of the more important herds, registration details of 32 herds shown in Table XVI from which

more than 40% of the heifers registered were by home-bred bulls were examined in some detail. Heifers registered annually from each of these 32 herds during the nine years period 1940-48 were grouped according to whether they were by home-bred or purchased sires. The annual figures together with the totals for the nine years studied are shown in Table XVII the herds being listed according to the percentage of the total heifers by home-bred bulls. Clearly, during the period studied, some herds, notably the Maori, Heatherlea and Pakowhai studs, havebeen closed to a considerable degree and for this reason may possess appreciably different genetic material from each other and the remainder of the herds in the top stratum of the breed. This is particularly likely in the case of the Maori herd since the purchased sires used were imported animals. Among the 32 herds examined no other herd relied solely upon home-bred and imported bulls for herd sires.

However, as a result of their success as bull breeders, all these herds are constantly losing their genetic isolation and any genetic superiority they may have. There is a need for continued genetic improvement in these top herds and whether this can be accomplished by the application of breeding practice used in the past or whether a new approach will have to be made to the problem is a matter for speculation.

TABLE XVI. Distribution of the top-pedigree herds supplying 7 or more sires of heifer calves registered in the 1948 herd book according to the percentage of registered heifers by home-bred sires.

% age of registered heifers by home-bred sires.	Name (Total heifers registered in brackets)	
100	Maori (40) Landsdowne (15) Pai Rata (9) O.K. (8)	Forest Home (5) Faundale (8) Waipiko (3)
80 - 99	Neatherleigh (27) Pakowhai (22) Lancewood (14)	Heatherlea (11) Ypress (10)
60 - 79	Erinview (70) Broken Hill (34) Craigknoll (27) Glenara (26) Tuhitarara (21)	Rata Glen (15) Penrose (14) Glamorgan (13) Fairy Meadows (10)
40 - 59	Reshure (56) Jersey Glen (48) Tolgarth (27) Croydon (22) Mount Meadows (17) Beacon Hill (15)	Waikari (12) Peveril (9) Iris (7) Belford (5) Tokorangi (2)
20 - 39	Elmsford (54) Pinewoods (46) Beaulieu (33) Brookdale (31) Windermere (25)	Oaklea (22) Ivanhoe (20) Marshlands (19) Wattle Brae (12) Crystal Spring (10)
1 - 19	Ridgway (65) Beechlands (51) Mapple (38) Oddicombe (29) Allandale (27)	Kiteroa (23) Dunlavin (22) Greencroft (18) Abbeville (14)
0	Willersden (18) Takeke (18) Cloverfields (15) Ngahiwi (14)	Abberley (11) Snow View (10) Raeburn (7) Finvoy (7)
Herds not registering in 1948	Green Meadows Glenmore Rainbow H.O.	Glen Dwr Davaar Ashvale Tararua

TABLE XVII 32 top-stratum pedigree herds distributed according to the percentage of heifer registration by home-bred sires for the 9 year period 1940-8.

Names of Herds	1948		1947		1946		1945		1944		1943		1942		1941		1940		Total for the period 1940-1948			% ♀♀
	* P.	** H.B	P.	H.B	P.	H.B.	P.	H.B	P.	H.B	P.	H.B	P.	H.B	P.	H.B	P.	H.B	P.	H.B	Total	Reg. by H.B. Bulls
Maori	-	40	-	39	-	48	-	33	-	33	4	37	8	38	37	38	1	-	50	306	356	86
Heatherlea	1	10	6	16	-	16	-	15	-	16	1	15	3	6	9	1	5	4	25	99	124	80
Pakowhai	3	19	14	4	7	7	6	13	5	8	-	19	-	21	-	12	4	13	39	116	155	75
Jersey Glen	25	23			11	16	16	25	3	20	2	12	-	1	5	21	5	15	67	133	200	67
Ypress	1	9	4	7	3	25	-	18	10	3	6	9	4	6	4	4	10	1	42	82	124	66
Belford	3	2	3	3			4	3	4	6	-	8	-	1	-	3	-	-	14	26	40	65
O.K.	-	8	2	5	1	6	-	3	4	1	20	45	30	56	-	-	38	34	95	158	253	62
Penrose	4	10	-	20	8	7	5	5	18	2	9	7	5	15	-	18	5	3	54	87	141	62
Faundale	-	8	-	12	-	20	9	5	3	7	14	6	4	-	11	7	7	10	48	75	123	61
Resbure	29	27	20	29	-	-	22	57	-	-	14	11	-	-	17	13	12	35	114	172	286	60
Tokorangi	1	1	1	-	2	-	8	-	-	6	-	6	-	4	5	2	-	4	17	23	40	58
Peveril	4	5	15	5	4	9	2	7	5	4	-	15	6	6	21	11	-	-	57	62	119	52
Rata Glen	5	10	2	9	-	12	3	10	18	7	6	4	9	5	9	2	4	-	56	59	115	51
Landsdowne	-	15	2	7	8	9	7	-	2	1	10	-	2	-	9	7	-	-	40	39	79	49
Craig Knoll	7	20	7	23	9	10	1	4	3	2	13	8	14	13	17	7	18	-	89	87	176	49
Pai Rata	-	9	6	4	7	6	5	5	5	7	6	4	5	6	9	1	5	0	48	42	90	47
Erin view	28	42	-	-	19	10	29	9	30	2	6	21	14	19	25	23	-	-	151	126	277	45
Waipiko	-	3	13	7	5	8	6	10	10	5	13	4	21	3	9	14	13	17	90	71	161	44
Glamorgan	3	10	7	11	13	12	9	8	20	-	15	5	13	10	9	11	10	5	99	72	171	42
Waikari	5	7	-	1	16	15	9	12	12	18	17	23	-	-	37	20	22	-	130	80	210	38
Tolgarth	13	14	26	6	9	16	26	24	9	3	23	9	22	11	35	7	16	9	179	99	278	36
Glenara	8	18	24	5	22	5	9	17	19	6	20	2	11	6	17	7	10	11	140	77	217	35
Neatherleigh	4	23	1	1	22	22	6	2	21	4	1	-	9	-	25	2	10	-	99	54	153	35
Forest Home	-	5	-	1	2	9	15	9	-	-	24	-	8	-	1	-	-	-	50	24	74	32
Lancewood	2	12	-	-	16	1	9	11	2	4	10	4	14	1	9	-	9	-	71	33	104	32
Beacon Hill	7	8	16	2	19	-	18	1	7	6	3	6	2	9	8	3	10	1	90	36	126	29
Broken Hill	8	26	27	-	19	6	23	8	19	6	25	2	14	1	18	7	20	-	173	56	229	24
Mount Meadows	8	9	10	3	12	7	13	-	10	1	13	1	11	-	13	-	4	7	94	28	122	23
Tuhitarata	8	13	9	4	9	8	7	3	7	1	8	-	19	4	22	-	17	-	106	33	139	23
Croydon	13	9	11	5	21	-	9	5	9	5	19	13	14	-	19	1	12	-	127	28	155	18
Fairy Meadows	3	7	18	-	10	10	8	5	18	-	10	-	12	-	8	-	19	1	106	23	129	18
Iris	4	3	9	-	15	-	7	-	5	-	3	-	6	-	4	-	4	-	57	3	60	5

* P - by purchased sires
** H.B - by Home-Bred sires

SUMMARY.

From a study of the 1948 heifer registrations the following results were obtained:-

1. The average sire-daughter interval for a sample of 1450 observations was 4.11 years.

2. Approximately one-third of sires of heifers registered in 1948 were 2 years of age at the birth of their daughters or 15 months of age when they were mated. Only 20% of the 3970 sires represented in the 1948 herd book were 6 or more years of age at thebirth of their daughters and these bulls sired 24% of all the heifers registered in 1948. Over 47% of heifer registrations in that year were by sires 2 years or less when they were mated in the previous season.

3. The average size of the progeny-groups for all the sires represented in the 1948 herd book is 3.98 registered heifers. A vast majority (91%) of sires have less than 10 registered daughters, the minimum number for an official sire survey in New Zealand. There is a decrease in the size of the progeny-groups after the bulls have reached a certain age and these may reflect the decline in bull fertility with advancing age. The oldest bull used was 15 years 3 months of age at the conception of his daughters while the youngest was only 7 months old.

4. That the majority of pedigree breeders in New Zealand do not attempt to progeny-test their sires is clear from the examination of the data showing the extent to which bulls of different age classes are used to sire registered heifers. There was statistically no significant difference in the extent to which sires between the ages of 2 years 7 months and 9 years 6 months were used. The significant differences between sires 1 year old when mated and the rest of the age classes were due tothe large proportion of yearlings siring one registered daughter only. There was no evidence of fairly extensive use of yearling bulls followed by a reduction in their use until progeny-test details became available.

5. From the 1948 heifer registration data the origin of the sample of 954 (24%) sires represented in that herd book year was determined. The results ofthe analysis indicated that there is a preponderance of sires of purchased origin in the pedigree industry. Of the 954 sires studied 76% were purchased while the remainder were home-bred sires. The importance of purchased sires is also indicated from the percentage of heifer registrations by purchased sires.

Bulls of purchased origin sire 79% of the registered heifer calves in the sample.

6. Purchased sires were used more extensively than home-breds. Only a small proportion of home-bred bulls sired more than 10 daughters which was probably due to small herd size. It was interesting to find that once a home-bred bull was saved for another mating season it was likely to be used more extensively. Purchased bulls 2 years of age (when mated) sired significantly higher numbers of daughters than home-bred bulls of similar age. This was due to home-bred bulls being used sparingly in the herd in which they were bred, while many of the purchased bulls of this age class would be in their first season's use and thus have considerable scope for mating. The average number of daughters for yearlings, two year olds etc. appear to differ, but the sample was inadequate to establish the significance which one would expect.

7. The daughters of 80% of the 3970 sires represented in the 1948 herd book were born in a single herd while the remainder were born in two or more herds. The daughters of younger bulls appeared more dispersed than those of older bulls. This was particularly important with bulls 2 years and 6 months of age or less (at the birth of their daughters). In the case of very young bulls (less than 1 year 6 months) there was no dispersion as the matings were probably accidental. Daughters of bulls of the next age class (1.7 - 2.6) were more dispersed because of the widespread practice of mating yearling bulls with yearling heifers many of which were surplus to herd replacement requirements and sold.

8. The considerable traffic in sires as indicated by annual transfers as well as by the proportion of purchased sires represented in the 1948 herd book illustrates the importance of pedigree herds from which such sires originate. From the 1948 Jersey registration data such herds have been located.

There were 2605 pedigree herds registering stock in 1948 and out of these only 1291 herds supplied sires of heifers registered in that year. The relative importance of these 1291 herds has been studied from two standpoints of view, viz., number of bulls originating from these herds and the number of registered heifer calves sired by bulls bred in these herds. The names of important herds have been shown in TablesXIIIand XIV. Judged by either criterion there is

little difference in the relative position of the herds indicated in Tables XIIIand XIV. There was only one herd which supplied more than 50 sires of registered heifers while a vast majority (1089) supply less than 5 sires. These individually unimportant herds were responsible for 45.5% of the heifer registration in 1948.

9. The Jersey breed is divided into several strata, and the extent of stratification is shown in Fig.9. From the top strata sires are sold to middle and lower strata and to grade herds. There were 112 herds in the upper strata of the breed and out of this 19 were defunct. These top strata herds supply sires to each other and to herds of any other strata. There were 276 herds which used bulls entirely in their own herds and also supplied sires to grade herds.

10. There were 20 imported sires with registered daughters in the 1948 herd book. Of these 9 were used in the top-most strata while the remainder were used in lower strata.

11. A detailed study of heifer registration data of 32 herds for a nine-year period (1940-48) indicated that there were very few herds in the upper strata which might be regarded as genetically isolated from the remainder of the breed. Only three herds (Maori, Heatherlea and Pakowhai) showed evidence of being closed to a considerable degree. This is particularly true of the Maori herd in which the only purchased sires used in the period studied were imported animals. This herd would appear to possess distinct genetic material. Since the upper strata of the breed are losing their genetic isolation and superiority by the sale of bulls to other strata of the breed. The need for genetic improvement in these herds is obvious since the remainder are gradually being graded up to their genetic level.

CONCLUSIONS.

Schemes for dairy herd improvement in New Zealand are retarded by a lack of information concerning breeding methods adopted by owners of pedigree dairy cattle from whom the majority of sires used in the Dominion are purchased. A pedigree industry divided into more or less isolated units in the hands of individual breeders with different mating policies and selection criteria does not lend itself to easy analysis. From a list of the 1948 Jersey heifer registrations arranged in paternal half-sib groups some analyses have been made in an attempt to measure the adequacy of present practices.

Since the formation of the Jersey Cattle Breeders' Association in 1902 the main function of the Society has been registration of births to ensure accurate identification of individual animals. The official attitude of the Society as judged by their herd books and breed literature has not changed greatly during the intervening period. There has been a growing response to herd recording and in recent years increasing though small numbers of artificially bred cattle have been accepted for entrance into the herd book. However, artificial insemination has not received enthusiastic support from pedigree breeders due to its clashing with their traditional methods of animal breeding and also to their preferring sires of their own choice to those selected by committees acting for A.I. Centres.

The breed consists mainly of small and short-lived herds (Stewart 1952). The short-lived herds do not continue line-breeding for its effects to be recognised. Besides there is no unanimity among farmers on the use of the terms line-breeding or family breeding and until these are more clearly defined the confusion which exists at present will continue. The more widespread use and understanding of the co-efficients of relationship and inbreeding is desirable.

The findings of this thesis relating to herd size although tentative in nature do suggests that a vast majority of pedigree breeders are handicapped in pursuing animal breeding plans based on sound concepts. Their obvious difficulties include small half-sib groups and enforced out-crossing to avoid the risk of inbreeding. The majority of heifer registrations in 1948 come from individually unimportant herds which probably merely multiply the number of pedigree animals. The widespread use of A.I. or smaller breeders co-operating in their breeding plans seems to be the only solution to the problem.

The New Zealand Dairy Board in its herd improvement plans has advocated the use of proven sires. But the proven sire movement in New Zealand is not gaining ground as fast as it should mainly because of the paucity of proven sires. The reasons for the scarcity of proven sires may be found in some of the findings of this thesis. The average sire-daughter interval at the birth of the progeny is 4.11 years, and approximately one-third of the sires of registered heifer calves were only 15 months of age when their daughters were conceived. This indicates that to the majority of breeders performance details of theirsires are of minor importance, and that sires are selected either on pedigree or appearance or both. The majority of sires are no longer used in the pedigree opoulation when details concerning their breeding worth are available. The prospect of wide-spread progeny test is marred by small progeny number (see p.10) resulting mostly from small herd size (see p.25), the dispersal of sires' daughters in different herds (see p.20) and the small number of sires used by individual breeders (see p.26). The sires represented in the 1948 herd book averaged 3.98 registered daughters per sire, and there were very few sires which had more than 10 daughters. In the absence of data concerning grade daughters of pedigree sires, such a figure must be used with care. Nevertheless it does indicate the extravagance in the use of sires in the pedigree industry. These findings are cause for concern. There is need for more co-operation between breeders and in this sphere, breed societies should play a vital role. Failure of the breed societies to meet the increasing demand by the farmer for superior animals backed by performance may in future lead to a change in the present structure of the dairy industry.

Annual bull transfers and the proportion of purchased sires (76%) used in the pedigree industry indicate that the majority of pedigree breeders are placing reliance on the suppliers of their sires for herd improvement. This naturally brings into prominence the sources of su ch sires. In the 1948 herd book year there were 2605 breeders registering stock, but out of these only 112 could be regarded as more or less self-sufficient herds as far as the improvement of the breed is concerned. The breed is divided into several strata, and these 112 herds are in the uppermost strata of the breed. Even in this uppermost strata of the breed there were only 3 herds which could be regarded as genetically isolated from the remainder of the breed. As a result of sale of bulls to the middle and lower strata of the breed, these herds are constantly

losing their genetic isolation and whatever genetic superiority they might have. Therefore, there is a need of genetic improvement of these herds which exercise so much influence on the breed as a whole.

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