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"FACTORS AFFECTING THE RATE OF HERD IMPROVEMENT
IN NEW ZEALAND 1920-1942."

by

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Since 1901 the average production of all cows in milk and dry has increased by approximately 100 lbs. of fat and of this improvement some 70 lbs. has occurred since 1919-20. It was not till 1916 that numbers of cows in milk as distinct from total dairy cows were collected. The improvement in production per cow in milk has been approximately 61 lbs. and the data since 1919-20 are shown in this table together with the curve of cow numbers.

YEAR	Number of Cows in Milk		Average Yield of Butterfat per Cow in Milk.		
	Total	Increase (+) or Decrease (-) over previous season	Actual Yield (lbs.)	"Smoothed" Yield (lbs.)	Av. Improvement per Cow per Year.
1918-19	732,253	+ 21,692	169.9	180	
1919-20	782,757	+ 50,504	173.5	184	
1920-21	890,220	+107,463	174.1	188	
1921-22	1,015,325	+125,105	195.9	192	
1922-23	1,124,671	+109,346	200.5	196	
1923-24	1,184,977	+ 60,306	192.8	200	
INCREASE	Total 452,724	Av. + 90,545	22.9	20	4.0
1924-25	1,195,567	+ 10,590	201.6	204	
1925-26	1,181,441	- 14,126	198.0	206	
1926-27	1,181,545	+ 104	218.9	212	
1927-28	1,242,729	+ 61,184	212.6	216	
1928-29	1,291,204	+ 48,575	223.9	220	
INCREASE	Total 106,227	Av. + 21,245	31.1	20	4.0
1929-30	1,388,872	+ 97,668	226.1	223	
1930-31	1,499,532	+110,660	214.7	226	
1931-32	1,582,664	+ 83,132	214.7	228	
1932-33	1,723,913	+141,249	230.3	230	
1933-34	1,816,402	+ 92,489	234.9	232	
INCREASE	Total 525,198	Av. +105,040	11.0	12	2.4
1934-35	1,827,962	+ 11,560	224.3	234	
1935-36	1,823,358	- 4,604	233.2	235	
1936-37	1,805,405	- 17,953	245.9	236	
1937-38	1,763,775	- 41,630	238.3	237	
1938-39	1,744,478	- 19,297	215.9	238	
DECREASE	Total -71,924	Av. - 14,385	+19.0	6	1.2
1939-40	1,739,874	- 4,604	238.5	239	
1940-41	1,779,603	+ 39,729	252.2	240	
1941-42	1,777,239	- 2,364	237.8	240.5	
1942-43	-	-	230.0	241	
INCREASE	Total	Av.	14.1	3	0.75

The conclusion is inescapable that the rate of herd improvement has been slowing down rather than accelerating as might have been hoped in view of the rise of herd testing etc. Improvement in the ten years following 1920 was more than twice as rapid as in the period 1930-40 and per cow production is now almost stationary.

Factors Responsible for Improvement

Dairyfarmers have based their methods of increasing production per cow on:-

- (a) Provision of herd replacements by selection of daughters from their higher producing dams.
- (b) The use of pedigree herd sires, preferably from dams with butterfat backing above the average of the herd the bull is purchased to head.
- (c) The testing of herds in order to identify high and low producers and to enable:-
 - (i) elimination of low producers, as soon as better stock is available to replace them.
 - (ii) rearing of replacement heifers from the higher producing cows.
 - (iii) latterly as a means of providing necessary data for sire surveys.
- (d) Better feeding by improved pasture management, saving of hay and silage, topdressing, etc.

Now it is necessary, if possible, to assess the part each of these methods has played in obtaining the observed improvement of approximately 61 lbs. per cow since 1919-20.

Selection: The benefit derived by selecting daughters from high producing dams is likely to be small for three main reasons :-

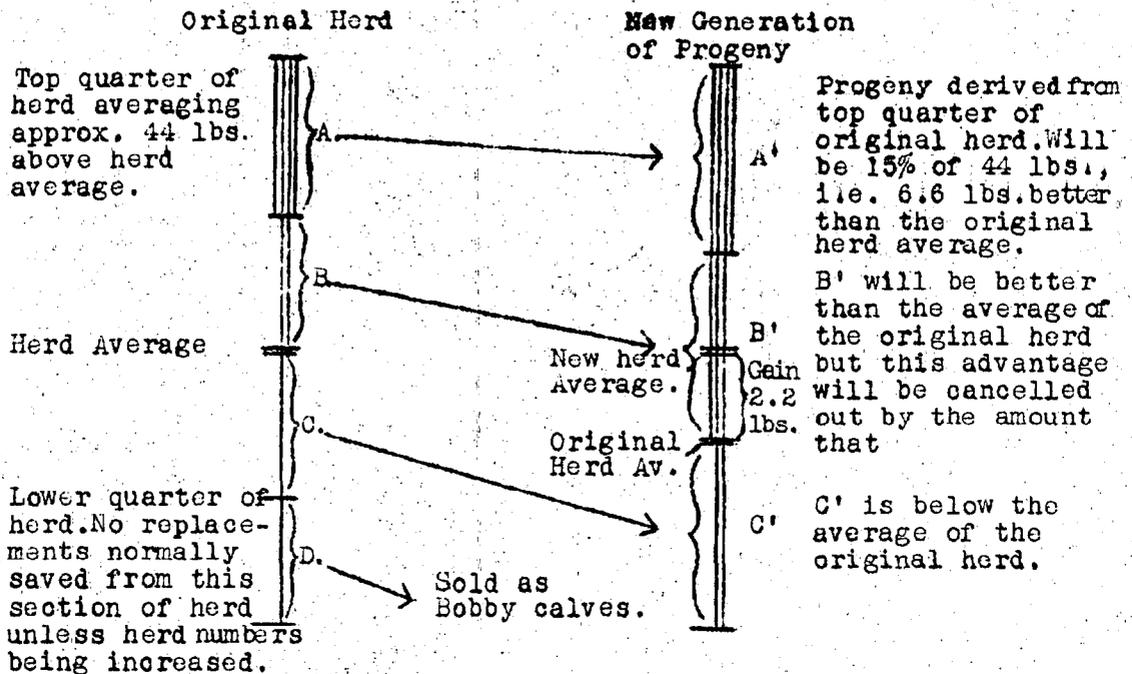
- (a) On the average, daughters from high producing dams will be better than daughters from low producing dams by an amount equal to 15% of the difference between the dams; e.g., two groups of daughters by the same bull - half from dams averaging 200 lbs. fat and half from dams averaging 300 lbs. fat - might be expected to differ by 15% of 100 lbs., i.e. 15 lbs. butterfat.
- (b) Improvement along these lines would be possible though slow were it not that herd wastage from disease etc. renders it virtually impossible to save calves only from dams producing above the average of the herd. Ward presents a summary of calving data on page 27 of the 1941-42 Report of the Herd Recording Department of the N.Z. Dairy Board, and the average of 1940-41 and 1941-42 seasons' data is shown below for an average herd of 100 cows.

NUMBER OF CALVES AVAILABLE
IN AVERAGE HERD OF 100 COWS

Cows and 2 year-old heifers overwintered	100.0
No. not in calf (4.2%)	4.2
No. aborting (4.9%)	4.9
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No. of cows and heifers calving normally	90.9
No. having heifer calves (47.4% of 90.9)	43.1
Dead or died at birth or later (7% of 43.1)	3.0
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Live Heifer Calves	40.1
Sold as "Bobby" calves (19.5% of 40.1)	8.0
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No. of calves available for rearing	32.1
Sold for dairying (10% of 32.1)	3.2
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Heifer calves reared by owner	28.9
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In the herds from which the above data are drawn there are therefore approximately 32 calves available for rearing and of these the owner rears 29 per 100 cows in milk. In order to maintain herd numbers stationary, approximately 17 2-year-olds must be brought into a herd of 100 cows each year. The available data indicate that losses between one month of age and two years are approximately 10% and a further 5% prove not in calf so that a minimum of approximately 20 calves are necessary to provide 17 replacements per 100 cows in milk, and the opinion is generally held that 24 is a safer number on which to base estimates. The owners included in Ward's sample are apparently intending to increase herd numbers or are raising additional numbers for sale.

Considering those periods in which herd numbers have been relatively constant it appears that approximately 24 out of the 32 available calves need to be reared in order to maintain herd numbers. Now, of the 32 calves available it may be assumed that half, i.e. 16, will be from cows producing above the herd average, while 8 will be from cows producing below the herd average. Under these conditions what improvement can we hope for in tested herds where the high and low producers can be identified. The position in such a herd is shown diagrammatically below:



The lower two-thirds (B' C') of the new generation will show no increase in average production but the upper one-third will show an average improvement of 6.6 lbs. over the original herd average. When averaged over the whole of the new generation this amounts to an improvement of 2.2 lbs. over all cows per generation. Allowing an average annual replacement rate of 20% this is equivalent to $2.2 \div 5 = 0.44$ lbs. per cow per year.

The total improvement possible by selection since 1920 if herd numbers had been stable would therefore have been approximately 11 lbs. per cow (i.e. 0.44×25) but this presupposes that all farmers have tested continuously and have been able to identify the high and low producers in their herds. In fact only some 15-16% of cows have been under test since 1923-24 and allowing for change in testing members some 30% of all cows have been tested once or more so that the possible gain in production due to selection of daughters from the best cows is unlikely to have been more than $3\frac{1}{2}$ lbs. since 1920.

- (c) Since 1920, however, there have been two periods (1920-24 and 1930-34) totalling ten years when expansion of herd numbers has been very rapid, the average increase being equal to 7-9% per annum. During these periods practically all available heifer calves must have been reared and no selection of above average progeny was possible. The gain from selection since 1920 has probably therefore been of the order of 2 lbs. per cow.

Elimination of Low Producers: Ward's herd wastage data shows that an average of 5.4% of cows have been culled for low production in tested herds and on the assumption that these represent the lowest producers such culling would serve to raise average production of the herd by approximately 4 lbs. fat per cow. In a herd of 100 cows averaging 250 lbs. fat, the lowest 5% of the herd would average approximately 180 lbs. per cow, i.e. 2 x S.D. below the mean. The remainder of the herd would therefore average :-

$$\frac{250 \times 100 - 180 \times 5.4}{94.6} = 254 \text{ lbs.}$$

However, only 15% of cows are annually under test so that the average improvement over all cows will be only 15% of 4 lbs. or a trifle over half a pound (0.6 lbs.) per year. If this rate had operated since 1922-23 the Dominion average would have been raised by 12 lbs. in the following 20 years.

It cannot be assumed, however, that this increase of 4 lbs. per cow can be maintained each year even in tested herds. For this to be possible it would be necessary for the 5% of low producers culled to be replaced by animals having a higher production. From the arguments advanced in the preceding section and from the fact that the average herd sire in the industry is not leaving daughters higher producing than their dams, any such assumption cannot be maintained. It is probable also that in periods of rapid expansion of herd numbers culling for low production has been considerably below the 5% level.

It is therefore estimated that the maximum improvement which can be credited to the elimination of low producers is about 8 lbs. per cow for the twenty year period and probably the major part of this improvement occurred prior to 1930.

Use of a Pedigree Herd Sire: There has been a steady increase in the proportion of pedigree sires in use in the industry and in tested herds 71% of the bulls in use are now pedigrees. The position as shown by official statistics from 1918-1928 are shown below with Ward's figures for 1940-41 for comparison.

PROPORTION OF ALL Sires IN USE
WHICH ARE REGISTERED PEDIGREES.

<u>Pedigree Sires</u>	<u>1918</u>	<u>1921</u>	<u>1924</u>	<u>1928</u>	<u>Tested Herds.</u>
	%	%	%	%	<u>1940-41</u>
Jersey	26.1	28.8	25.5	35.2	70.8
Friesian	16.3	22.0	24.1	29.8	80.7
Ayrshire	23.2	26.2	32.7	35.2	82.1
*Shorthorn	6.3	10.1	12.6	17.7	58.7

*Official statistics did not differentiate between "beef" and "dairy" shorthorn bulls so that the figures for Shorthorns should be accepted with reserve.

Since Ward's figures refer to tested herds they almost certainly overstate the Dominion figure. An estimate of the proportion of all Jersey sires in use in the Dominion which are registered purebreds indicates that the figure is probably about 60%. In 1940-41 there were 57,600 dairy bulls in the Dominion of which 78%, i.e. 45,000, are Jersey. Ward's figures (p. 27 1940-41) indicate that the average life of a herd sire is about 4.23 years so that approximately 10,610 young Jersey bulls must be needed each year for replacements. But in 1942 only 5,883 Jersey bulls were registered or sufficient to provide 58% of the necessary Jersey replacements.

There is little doubt that the use of pedigree sires led to improvement in production in the early stages, but Ward's sire survey data indicates that this is no longer the case and that the average sire in use today is able only to maintain production. There is no apparent method by which the effect of "grading up" can be estimated though the larger part of what is commonly ascribed to this cause is included below under "Change in Breed Composition".

Change in Breed Composition of Herds: An important factor in improved production per cow often overlooked, or confused with "selection" or "grading up" by the use of a pedigree herd sire, has been the rapid change in the breed composition of the herds in the Dominion. Statistics on the breeds of cattle in dairy herds were collected at regular intervals up to 1928 and these are shown below together with the estimated position in 1940.

PROPORTIONS OF THE MAIN BREEDS IN THE DAIRY
HERDS OF THE DOMINION

	<u>1920</u>	<u>1930</u>	<u>1940</u>
Shorthorn	58	20	8
Jersey	27.5	66	75
Friesian	11.5	11	11
Ayrshire	3	3	6
	<u>100.0</u>	<u>100</u>	<u>100</u>

The significance of the swing from Shorthorns to Jerseys has in the past been overlooked but G.H.T. results show that on the average Jerseys out-yield Shorthorns by approximately 15%, so that the rapid alteration in breed composition accounted for 12½ lbs. of the observed increase in per cow production in the period 1920-30, and 3.6 lbs. in the period 1930-40, or a total of 16 lbs. equal to 26% of the total improvement over this period.

Improved Feeding: Under the system of grassland farming adopted in New Zealand no direct measure of the plane of nutrition of dairy cows is available, but some indication of the position may be obtained by considering the area of hay and silage saved (including lucerne) and the area of grassland topdressed. These figures are given in the table below.

Year	<u>Area Cut for Hay and Silage</u>		<u>Area of Grassland Topdressed</u>	
	Thous. Acres	Acres per 1000 cows in milk	Thous. Acres	Acres per 1000 cows in milk
1919-20	117	149)		
1920-21	162	182)		
1921-22	187	184) 165		
1922-23	176	156)		
1923-24	189	159)		
1924-25	230	193)		
1925-26	225	190)	(1,260)	(107) }
1926-27	289	244) 225	1,521	129 } 144
1927-28	280	225)	1,952	157 }
1928-29	351	272)	2,385	185 }
1929-30	413	297)	2,651	191)
1930-31	442	295)	2,871	192)
1931-32	465	294) 298	2,454	155 } 161
1932-33	562	326)	2,458	143 }
1933-34	506	279)	2,249	124 }
1934-35	524	287)	2,684	147)
1935-36	577	317)	2,882	158 }
1936-37	543	301) 299	3,326	185 } 188
1937-38	483	274)	3,874	220 }
1938-39	555	318)	4,017	230 }
1939-40	594	342)	4,187	241)
1940-41	576	324) 326	4,649	261 } 246
1941-42	555	312)	4,212	237 }
1942-43				

The above statistics refer to the whole Dominion and necessarily include hay and silage saved for other stock or sheep country topdressed. The major part of the hay and silage saved or area topdressed is, however, associated with dairying as shown in the table below where area cut for hay and silage, area topdressed and number of cows in milk in each land district is expressed as a percentage of the Dominion total in the 1940-41 season. As might be expected, North Auckland apparently makes less and the South Island more than average provision of hay and silage for winter feeding, while in the Hawkes Bay-Gisborne area and the South Island some grassland not used for dairying is topdressed.

AREA CUT FOR HAY AND SILAGE (INCLUDING LUCERNE),
AREA TOPDRESSED AND NUMBER OF COWS IN MILK BY
LAND DISTRICTS AS PERCENTAGE OF DOMINION TOTAL

<u>Land District</u>	<u>Area cut for hay and silage</u> %	<u>Area Topdressed</u> %	<u>No. of Cows in Milk</u> %
North Auckland	12.19	15.56	21.0
Auckland	35.5	30.79	34.15
Gisborne-Hawkes Bay	6.47	10.75	5.88
Taranaki	14.25	9.46	13.0
Wellington	11.07	15.12	13.24
North Island	79.48	81.6	87.27
South Island	20.52	18.4	12.73
DOMINION TOTAL	100.0	100.0	100.0

The total area of hay and silage saved showed a continuous and rapid increase up to 1933 but has since remained practically stationary apart from seasonal variations, but when considered in terms of provision per 1000 cows in milk the influence of rapid expansion of herd numbers becomes apparent. The area saved per 1000 cows rose slightly over the period 1920-24 but showed a rapid increase in the succeeding five years, since when it has been almost stationary. It is probable that over the period under review, particularly 1920-30, there has been an increase in per acre yields of hay and silage but the available statistics are based on estimates on which great reliance cannot be placed.

Data on area topdressed were not collected until 1926. A rapid increase occurred up till 1930 followed by an equally rapid fall during the "depression". The area topdressed commenced to increase again in 1934 and approximately doubled by 1940. The fall in area topdressed due to rationing has as yet been small compared with the fall which occurred during the "depression".

During the period 1920-30 the area of hay and silage saved per cow in milk approximately doubled, but in the period 1930-40 it increased by only 15%. Area topdressed per cow in milk increased by 78% in the four years 1926-30, but by only 26% in the ten years 1930-40. This slowing down in the rate of improvement of provision of feed is paralleled by the slower rate of improvement in per cow production.

One effect of improved pasture management and the extension of topdressing, saving of more winter feed etc., has been to permit earlier calving of cows and longer autumn production. This increase in the average length of lactation has increased average production since there is very close correspondence between days in milk for all tested cows and average production. In the North Island average length of lactation increased rapidly after the 1927-28 season, reaching a peak in the "depression" years and then falling again to 1938-39 with some recovery in the following three years of war. The average lactation appears to be approximately 15-20 days shorter in the South Island.

The increase in average yield of fat per day of all tested cows in the North Island has shown a small and steady increase since the 1922-23 season when the straight line trend was approximately 0.98 lbs. per day to 1.03 lbs. in 1941-42 or an increase of 0.05 lbs. per day in twenty years. It must be emphasised that these figures regarding length of lactation refer only to tested cows.

While "persistency" or length of lactation is doubtless subject to hereditary influences, the increases shown above are thought to have been due almost entirely to improved management and feeding since such rapid variations are unlikely to have been due to breeding except to the extent that breed change may have influenced the position. The introduction of the marked calf scheme and the desire to get cows to qualify was probably partly responsible for the rapid increase about 1928-29, and lower prices during the "depression" doubtless induced every effort to keep cows in milk for as long as possible.

Summarising therefore, the various factors responsible for the observed increase in per cow production since 1920 may be tabulated as follows :-

	<u>Estimated Share of Improvement.</u>	<u>Percentage of Total</u>
Selection of daughters from highest producing dams	2 lbs.	3.3
Elimination of low producers	8 "	13.1
Change in breed composition)		
Grading up through use of pedigree sires)	16 "	26.2
Improvements in plane of nutrition of stock including increase in length of lactation	35 "	57.4
	<u>61 lbs.</u>	<u>100.0</u>

It must be emphasised that throughout this discussion we have been dealing with the average herd in the Dominion. There have obviously been many individual herds where the improvement in per cow production has been greater than the average shown or the causes of improvement differently distributed due to greater than average improvements in feeding, to lower incidence of disease, to a fortunate run of bulls who have left high producing progeny, to absence of breed change or to the benefits derived from continuous testing. These differences, important as they have doubtless been in individual herds do not invalidate the general conclusions drawn.

Importance of Herd Sire.

The above analysis has attempted to define the factors responsible for herd improvement since 1919-20 and in our opinion clearly indicates that conscious breeding and selection, as distinct from breed change, have played a minor part in the improvement achieved. The analysis serves to emphasise the paramount importance of the herd sire in securing further improvement in the producing ability of our dairy stock for the following reasons:-

1. In order to secure an improvement in average producing ability (as distinct from actual production which is of course partly determined by plane of nutrition as well as the inherent capacity of the animal as a producer) it is necessary that the 17-20% of animals culled each year for disease, low production, or other causes, should be replaced by animals of higher producing capacity.
2. The improvement on the basis of selection of daughters from the highest producing cows is very slow due to:
 - (a) Regression of daughters towards the mean - on the average only 15% of the dam's advantage is passed on to the progeny.
 - (b) Heavy culling for disease necessitates saving approximately one third of replacements from cows below the herd average.
 - (c) Not more than 30% of cows have ever been tested and therefore two-thirds of farmers do not know which are their highest producing dams.
 - (d) Rapid expansion of herd numbers has further limited the scope for selection.

3. Farmers are therefore forced to rely on the herd sire as the chief means of ensuring that herd replacements will be of superior producing ability to the culls they replace. If sires capable of leaving progeny of producing ability better than their dams are not available in sufficient numbers, then average producing ability will remain stationary apart from the very small improvement possible through selection on the female side.

Average production may however still be increased by better feeding in those herds where the plane of nutrition is below the optimum. Plane of nutrition and not breeding is probably the limiting factor to production in herds producing less than 240 lbs. of fat per annum; i.e., half the herds in the Dominion, and their production can probably be most easily and rapidly increased by better feeding.

DISCUSSION.

Dr. Filmer: Said that one of the major factors in increasing production appeared to have been the change from Shorthorns to Jerseys, and asked what was the mechanism by which this change was effected and if it could be used to further increase production?

Reply: The change to Jerseys presumably raised the average level of production because the breed average of pedigree Jerseys was above that of Shorthorns. We have now lifted our "grades" to the level of our pedigree Jerseys, and judging from Ward's sire surveys the grade herds in which bulls have been surveyed now approximate the same level of producing ability as the pedigree herds from which sires are drawn. Consequently the rate of improvement in average production is now almost stationary and further improvement in producing ability of grade herds is dependent on improvement in the producing ability of our pedigree herds. Alternatively, an increase in the proportion of pedigree cattle would permit us to select bulls more rigidly from only the higher producing dams.

Mr Ward: Raised the question of the degree to which selection of bulls would be possible in the future, considering the fact that there could have been little or no selection of bulls during the period of changeover from a predominantly Shorthorn to a predominantly Jersey cow population. With the population remaining reasonably static, as at present, would it be possible to exercise greater selection of herd sires?

Reply: At the present time approximately two Jersey bulls are registered for every three heifers as compared with a ratio of 1 to 4 in U.S.A. With natural service there is little hope of more rigid selection unless the numbers of pedigree cows are increased considerably though some improvement might be effected by co-operative bull clubs which would avoid danger of inbreeding in small herds and extend the useful life of bulls. The more hopeful method of securing improvement appears, however, to be along the lines of selecting the best bulls on a basis of the progeny test by sire survey and making widespread use of the best sires by artificial insemination.

Mr Ballinger: Asked how many cows received an optimum plane of nutrition and how much greater improvement it was estimated could be made by improving the feeding of dairy cattle?