

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

SELECTION
IN
DAIRY CATTLE
IN
NEW ZEALAND

A
Dissertation
by

"BREW"

H. Gilman

1st November, 1939.

MASSEY UNIVERSITY



1061111835

DEFINITION.

"Selection takes place whenever some kinds of individuals are caused or permitted to produce and rear more offspring than other kinds do. Under some circumstances selection may quickly cause large and permanent changes in the population. Under other circumstances it may cause marked changes, but the moment selection is relaxed, the population returns to its original condition. Under still other circumstances, selection may be virtually powerless to produce any change unless it is combined with some mating system like inbreeding."

J.L. Lush.

SELECTION IN DAIRY CATTLE IN NEW ZEALAND.

CONTENTS.

A. INTRODUCTORY:

The importance of Selection in New Zealand Dairy Cattle Breeding	1
---	---

B. THE DEVELOPMENT OF NEW ZEALAND DAIRY CATTLE BREEDING .. 7

I. The Multiplication of Cattle Numbers 8

a. The Period of Local Trade 9

(i) 1814-1851 - The Introduction of Cattle ...	9
(ii) 1852-1881 - The Phase of Early Expansion	13

b. The Period of Export Trade 18

(i) 1881-1895 - The Phase of Adjustment ..	18
(ii) 1896-1913 - The Phase of Steady Expansion	23
(iii) 1914-1919 - The Phase of War-Time Expansion	35
(iv) 1920-1934 - The Phase of "Intense" Expansion	39
(v) 1934 - - The Phase of Consolidation ...	49

c. Selection and Development 62

(i) Development	62
(ii) The influence of Herd Testing	79

II. The Registered Purebred Stock 89

a. General 89

b. Origins and Development of the Breeds 92

1. The Shorthorn ..	95
2. The Ayrshire ...	100
3. The Jersey ...	105
4. The Friesian ...	109
5. The Red Poll ...	113

c. The Development of the Breeds in New Zealand 117

1. The Shorthorn ..	117
2. The Milking Shorthorn.	120
3. The Ayrshire ...	125
4. The Jersey ...	128
5. The Friesian ...	133
6. The Red Poll ...	136

d. Functions of the Breed Associations 141

e. The Institution of C.O.R. Testing 145

f. Government Official Herd Test 148

III. ORGANISATION OF THE GENERAL DAIRY CATTLE POPULATION.

a. The Importance of Commercial Herds 150

b. The Role of the Registered Purebred Sire ... 155

c. The Rise of the Jersey 161

C. THE ROLE OF SELECTION IN DAIRY CATTLE IMPROVEMENT ... 175

D.

SELECTION IN DAIRY CATTLE IN NEW ZEALAND

A - INTRODUCTORY:

The Importance of Selection in Dairy Cattle Breeding in New Zealand.

Selection is not, in itself, generally believed to be a creative process. Ideally, it is a means by which the good, bad and indifferent elements comprising a given population are identified and classified. As such, selection is necessarily fundamental to any breeding system, whether the aim is consistent improvement or merely the maintenance of advances already achieved. Without some differentiation of the material, no firm basis can be established upon which to carry out further work.

The fact that in dairy cattle breeding in particular, it is seldom possible, where characteristics of economic importance are concerned, to conduct an intimate inquiry into the different genetic elements comprising the given subject with any degree of certainty, should not be permitted to detract from the value of preliminary selection as a foundation for more comprehensive determination of worth. With such "aids to selection" as progeny tests, production records, pedigree estimates and type valuations, a fairly accurate estimate of hereditary constitution can frequently be arrived at in so far as it affects the functions of economic value. The mode of operation of inheritance is now known in considerable detail and the breeders pursuing a broad programme of improvement may "act as if he knew the genes themselves" and make selections accordingly.

In making use of selection it is tacitly understood that some degree of improvement in the average productivity of the given population is sought, i.e., that in the consistent choice of superior individuals as breeding stock, succeeding generations should show progressive improvement in the characteristics upon which the selection of their parents was based.

The antithesis of selection, culling, implies that inferior individuals in each generation will not be represented by their offspring in the succeeding generation. In practice in New Zealand, the positive aspect of dairy cattle breeding (i.e., breeding only from superior individuals) has tended somewhat to yield in importance to the negative aspect of improvement (i.e. not breeding from very inferior individuals). Border-line stock has tended to be retained from the practical necessity of maintaining replacement rates due to disease incidence, and also from a lack of adequate information on such points as production transmitting ability, individual performance, "constitution", and breeding capacity. Moreover, during several phases in the development of dairy cattle breeding in New Zealand, selection has been forced to give way to the sheer multiplication of stock numbers. Signs are not wanting, however, that, in an endeavour to deal with current problems through reduction in producing costs, increasing attention is likely to be paid to a rationalisation and improvement in breeding methods.

Some measure of the importance of selection to the breeding of dairy cattle in New Zealand is to be found in an examination of :

- (i). The natural advantages of New Zealand as a dairying country.
- (ii) The elimination of distance as a factor in the international trade in dairy products.
- (iii) The growth of the dairy industry in New Zealand.
- (iv) Local and overseas evidence of the value of individual selection.

The natural advantages of moderate temperatures, well distributed rainfall and easy topography with which certain large areas of land in New Zealand are favoured, provide an optimum environment for the breeding of high producing strains

of dairy stock and of pasture and crop plants. Under such equable climatic conditions there has been no necessity for the housing and artificial feeding of stock adopted in other less favoured countries, and a vast pastoral industry unexcelled by any other in the world, has been developed. Pasture has been shown to be the cheapest and most nutritious of all feeds for dairy cows and in New Zealand where pasture has a growing period of between ten and twelve months, the application of scientific methods of pasture management has brought per-acre production to a point far in excess of that reached in any other country. In order to derive maximum economic advantage of these conditions of a superior environment, consistent improvement in the quality of the breeding stock enjoying it, has been essential. Current developments, indicating a trend towards the still more efficient utilisation of feed grown, emphasise the value and importance of selection in still further increasing per-cow-production and in still further reducing per-acre production costs.

The elimination of distance as a factor in the international trade in dairy products not only made the growth of the New Zealand dairy industry possible, but naturally brought New Zealand's products into intimate and active competition with those of once distant countries. New Zealand dairy produce came to play a prominent and important part in the world's markets and New Zealand dairy cattle came to be pitted against that of older established dairying countries. Close attention to quality and uniformity in the produce has enabled New Zealand products, despite the longer distance carried, to meet Danish butter and Canadian cheese on an almost equal footing on the world's markets. The competition so engendered has focussed attention upon the necessity for a high level of efficiency in feed conversion amongst the milking stock in the Dominion. If the higher transport costs from New Zealand to the common market are to be offset, the unexcelled natural conditions obtaining in New Zealand must be utilised to maximum

economic advantage. The importance of selection in sorting out strains of dairy stock that combine high production with low maintenance costs, must receive even greater emphasis in a future that seems unlikely to be a repetition of the rising prices and ever expanding markets which were dominant features of the early development of the export industry.

Basic factors in the growth of the dairy industry from its condition of subsistence farming prior to 1882 to its present status of a great export enterprise, have been the great suitability to dairying of large areas of the Dominion, commercial success in the application of mechanical refrigeration to ocean transport, and an expanding demand for dairy produce in the United Kingdom market. Under the main influence of these primary considerations, but affected also by many other factors contributing towards or consequent upon expansion of the industry on an export basis, the number of dairy cows increased nine and a half times from a total of 206,906 at their first enumeration in 1891 to a total of 1,935,524 for the season 1936-37. Over the same period, the annual factory output of butter increased by twenty-four times from 16,310,000 lbs in 1891 to 397,900,000 lbs in 1936-37; and that of cheese by twenty-nine times from 6,976,000 lbs in 1891 to 205,200,000 lbs in 1936-37. These figures serve to emphasise the phenomenal growth and present vastness of the New Zealand dairy industry. Basically, much of this absolute increase in production has been attained through great increases in the numbers of milking cattle and by the use of improved methods in stock feeding and management; but the factor of selection in the breeding of improved stock has also contributed in substantial measure to the raising of per-cow production. Nevertheless, according to an estimate made by the Department of Agriculture in 1934, approximately 50 per cent of the cows in the Dominion fall below the figure for average butterfat production per cow, and the volume output of this group is but 40 per cent of the Dominion gross production. It is apparent therefore that much yet may be accomplished in raising the general level of per-cow production, and^a national average of 300 lbs butterfat per

cow should be readily attainable. Selection, through a systematic breeding towards strains of dairy stock showing inherent capacity for the economical conversion of feed into butterfat, is a sine qua non of such a project.

Evidence available both locally and overseas emphasises the value of individual selection in bringing about specific changes in some desired direction within a given population. Certain dairy herds in the Dominion have been bred to a high average level of productivity with the aid of consistent individual selection, and the seasonal returns from Group Herd Testing show greater average butterfat production records per cow than those of the total national dairy cow population where the degree of individual selection practised is, in general, of a lower order. In certain overseas countries, individual selection for butterfat and milk yields on the basis of progeny performance records has successfully raised average production per cow to a high level. Denmark, New Zealand's most formidable competitor on the butter market of the United Kingdom provides probably the most notable example of the success attainable by such a policy, for returns from Danish cow-testing organisations, representing 45 per cent of the total cow population, have averaged in excess of 300 pounds of butterfat per cow for several years.

The classical experimental studies of Raymond Pearl (on high egg production in poultry) and of W.E. Castle (on the hooded pattern in the coat of the rat) have shown the extent of change possible in certain characters by the consistent use of individual selection. The work of Pearl in particular, has provided striking evidence of the high value of individual selection based on genotype, in breeding for improved productivity, as compared with the very limited success possible with mass selection based on phenotype. Jones summarised the position as follows : "The genotype conception focuses attention on the individual organism and the single factor as the basis for selection. Mass selection

can never be as effective as individual selection, because many forms having the same degree of development behave quite differently in transmission. It follows that visible characters are not reliable guides by which to ascertain the actual germinal composition of a plant or animal. This can only be accurately known by the progeny performance record."

In New Zealand, where mass selection based mainly on phenotypical considerations has for several reasons been standard practice for many years, there are indications in the fact that little or no progress has been made in further increasing average per cow production for some seven seasons, that there exists an immediate urgent need for the much wider use of methods of individual selection based on the results of complete progeny testing accompanied by efficient stock feeding and farm management, if the dairy industry of the Dominion is to reduce production costs sufficiently to be able successfully to withstand increasing competition at relatively low prices on the world markets for dairy produce.

_____ : _____
 :

B.: THE DEVELOPMENT OF DAIRY CATTLE BREEDING
 IN NEW ZEALAND

The growth of the dairy cattle population in New Zealand has not taken place as a process of consistent expansion over a period of years, nor have methods of selecting breeding stock remained unchanged by time and circumstances. In point of fact, the development of dairy cattle breeding, in its changes of rate of multiplication in cattle numbers and in its wide variations in the intensity of selection practised from time to time, reflects the impact of all those factors, economic, scientific and political, which in their combined effects have moulded the dairy industry to the form which it preserves today. Since the dairy cow is the focal point of the industry, trends which have occurred in the development of dairy cattle breeding since cattle were first introduced into the Colony, both reflect and also are reflected by influences affecting all or many other sections of the dairying system. An account of the growth of the dairy cattle population is therefore to a large extent an outline of the development of the dairy industry itself. For the purposes of the ensuing argument, however, the broad history of dairying in New Zealand is made subservient to the more present concern of trends of development in the breeding of dairy stock.

— : —
: —

SECTION I. THE MULTIPLICATION OF CATTLE NUMBERS.

On a broad general basis of classification of events, the period 1814-1939 naturally divides itself about the year 1882 when, with the application of mechanical refrigeration to ocean transport, the development of ^alarge export trade in dairy produce was made possible. Within each of these two main divisions, further differentiation into appropriate groups is made wherever special conditions operating at the time have brought about significant changes in the rate of multiplication of the dairy cattle population.

Throughout the period the principal studies are the natural multiplication of stock, stock importations and developments in selective breeding; but each of these and their inter-related factors are traced against a moving background - the growth of the dairy industry as a whole.

————— : —————
 :

a. THE PERIOD OF LOCAL TRADE.

The vast organisation of the dairy industry as it exists today has been determined by the growth of the export trade, but no survey of cattle breeding can be complete without a consideration of the formative period of the industry when the foundations of our present-day herds were being laid down.

(1) 1814-1851 - The Introduction of Cattle.

The Rev. Samuel Marsden is credited with introducing the first cattle into New Zealand when he landed a bull and two cows at the Bay of Islands in December 1814. These were selected from the Crown Herd of New South Wales. Marsden, it is to be noted had a very lively appreciation of the potential value and importance of the dairy cow to the struggling population of missionaries and whalers, for he is recorded as having stated : "My wish was that the missionaries in time should be supplied with milk, butter, cheese and animal food, which would in a great measure render them independent of the natives for support." Although he later sent further consignments of cattle from Australia, Marsden evidently had some difficulty in persuading the missionaries to share his views, for little care was bestowed upon the stock. Nevertheless, by January 1823, the cattle had reached a total of over fifty head, and the foundation stone was laid of an industry as yet unrealised.

Described as "the first settler", Mr. John Bell in March 1833 brought ten head of cattle from Sydney to Mana Island with the avowed purpose of supplying milk and beef to the whaling trade which was by this time firmly established on the more southern shores of New Zealand.

By 1839, the European population had swelled to a total of about one thousand whalers, sealers, traders, missionaries, adventurers and settlers. In this year, a shipment of young bulls and heifers was sent to Kapiti Island by Messrs. Cooper and Holt, Sydney.

The first cattle came to the South Island in November 1839 when fifty head were landed at Akaroa by Mr. W.B. Rhodes. These

cattle are of particular interest being described as "nearly pure Durham" and were purchased at £16 per head from the Hunter River District in New South Wales.

Mr. John Jones interested himself in land settlement about 1839-40 and is known to have brought cattle from Sydney both to Waikouaiti and also to Otago where he was later concerned in providing Dunedin's "great food supply".

With the beginnings of organised colonisation in 1840, settlements became established at Port Nicholson, New Plymouth, Wanganui, Nelson, Canterbury and Otago, and Australia continued to be the principal source supplying the Colony's increasing demands for stock. Letters from Port Nicholson, Nelson and New Plymouth between 1840-1842 (quoted by Philpott) contain descriptions of the numbers, condition and prices of cattle and emphasise the transport difficulties of the time. Petre * referring to the importation of cattle from New South Wales and Tasmania says that in "1841 milch cows were sufficiently numerous in Port Nicholson to afford milk and butter for constant sale". Also in 1841, William Wakefield *, writing from Wellington, states : "The importation of cattle from New South Wales supplies us with the means of increasing the best breeds".

Immigrant ships began to arrive in considerable numbers from the forties onwards and many of them carried milch cows for the purpose of providing milk for the passengers on the journey from England. Stock such as this must have been greatly valued by the struggling settlements for evidence is not lacking that already the colonists appreciated the importance of dairy stock to their continued well-being. That the dairy cattle population should have increased at this time as rapidly as it undoubtedly did is a tribute to the capacity of the dairy cow as a provider of some of the necessities of existence (milk, butter, cheese, meat) in a land to which the comforts of civilisation were as yet unknown. It is more astonishing, in view of the immense difficulties of transport and intercommunication between the scattered settlements, that the rapid multiplication of the dairy stock should have occurred over so wide an area.

* Philpott

But this was a phase characterised by a close relation between cattle numbers and total European population. In the earliest years of the Colony, dairy stock had been introduced as a necessity for providing fresh milk, dairy products and beef to missionaries and the whaling trade. In the subsistence pastoral farming that followed the gradual diffusion of settlers over the less inaccessible parts of the country, wool growing was expected to provide the ultimate monetary returns, but for the personal needs of existence, literally to keep the settler and his family alive, reliance was placed upon the dairy cow. This modest aspect in the development of New Zealand dairying illustrates the value of milk and its products to man, and emphasises the importance of milk independently of the exploitation of the dairy cow for large scale commercial purposes. No doubt it was the aim of these early stock-owners to multiply their animals as soon as might be, both in order to satisfy the immediate wants of a growing population, and at the same time to insure themselves against possible scarcity of items so important to their existence. To what extent these early settlers realised the importance of the dairy cow is shown in a particularly interesting way, in the organisation of a "co-operative cow company" which was formed at Howick in 1843 for the humble purpose of purchasing a cow for each of its members.

"The transplanted British farmers still looked for any amount of substance and beef in their dairy cows"; Moreover, the Shorthorn at this time had risen to a position of pre-eminent importance in Great Britain and its dual-purpose qualities and docility and adaptability were evidently well recognised; it is not therefore surprising that the colony's early cattle population should have consisted almost entirely of stock containing preponderant amounts of Shorthorn "blood". A proportion of these cattle was from the "Potter McQueen" strain of Australian Shorthorns and many of them, too, were purebreds. Since the Coates Shorthorn Herd Book had been established in 1811, it is not unreasonable to assume that some at least of these early cattle in the Colony were, if not themselves registered, at any rate related to registered pure-

bred stock. Philpott states: "the first cows, mainly Short-horns and Durhams, with a decided leaning to beef rather than butterfat, were scarcely the ideal foundation for the development of a dairying industry"; but it should be emphasised that this was a period indeed at which specialised dairy cattle were relatively undeveloped and that the cattle brought to the Colony at this time would represent a fair sample of the average milking stock available in the Old Country and Australia. The primary need of the pioneering population for milk and its products may quite reasonably be held to have influenced the choice of cattle destined for New Zealand, in the direction of dairying capacity.

Mention should be made of the arrival of the first Ayrshire cattle in the Colony in the year 1848. These were presumably the bull "Rob Poy" and several cows (A.D.B. Smith) consigned to Otago's first Presbyterian Minister, Dr. Burns.

Finally, it may be said of this phase in development that at first the factors of "strain" and "purebreeding" were of far less importance to the scattered European population, than the fact that the cows would produce milk. These people were concerned more with average ability than with individual excellence. Under such conditions, selection amongst the breeding stock was

less of a necessity than the multiplication of the existing numbers of stock without delay: in order to avoid chances of scarcity in the available milk supply probably all heifer calves would be reared; and many steers would be raised for supplying beef to the growing population. It was an era of subsistence farming, a time of intimate relation between producer and consumer, when the necessity to provide food for the family or for the settlement was the first consideration of the stock-owner; a humble beginning for the unrealised vast export dairy industry that was to come.

(11) 1852-1881 - The Phase of Early Expansion

The thirty years of experimentation in export trade and of expansion in local trade which preceded the commercial success of mechanical refrigeration in 1882, constitute a chapter in development that is largely dominated by the sudden increases which occurred in the white population. Over the whole period, in response in turn to the advance of settlement, the gold discoveries, and assisted immigration, the European population increased by nearly 1800 per cent, and cattle numbers consequentially rose by over 1900 per cent.

<u>GROWTH OF POPULATIONS.</u>					
<u>Year</u>	<u>Human Population</u>		<u>Cattle Population</u>		<u>Ratio of Cattle/persons</u>
	<u>Persons</u>	<u>Index Nos.</u>	<u>Number</u>	<u>Index Nos.</u>	
1851	26,700	100	34,787	100	1.30
1861	99,000	371	193,285	556	1.95
1871	267,000	1000	436,592	1255	1.64
1881	501,000	1876	698,637	2008	1.40

From the table, three stages of growth, each limited to almost a decade, are clearly distinguishable. Diagram shows that, while total cattle numbers moved generally in sympathy with those of the European Population, within each ten year period considerable variation took place in the respective rates of increase.

1. During the fifties, colonists were arriving in a steady stream, the area of land under cultivation advanced from about 15,000 acres in 1853 to 200,000 acres in 1861, and total cattle numbers had increased by 450 per cent in 1861. It was a time of steady progress in agriculture and self-sufficient pastoral farming continued to absorb the bulk of the population; the occupation of fresh territory occurred more on the open native grasslands of the South Island than on the less readily utilisable country of the North Island. The farm

dairies began to find a larger local market for liquid milk, butter and cheese, and increasing numbers of young stock were reared. But the scattered nature of the settlements, the immense difficulties of internal transport, together with the inferior quality and poor keeping capacity of much of the produce of the time, militated against the growth of an extensive dairying system based solely on supplying the local market.

Nevertheless, high local prices for produce, through the influence of the Australian gold-rush boom, stimulated the breeding of dairy stock to a degree much above the capacity of the local population alone to absorb the products at a payable price. Graph shows the very much higher rate of increase of the cattle population as compared with that of the European population for the ten year period.

Attracted by the boom prices and augmented population of the Australian gold-rush era, attempts were made throughout the fifties to establish an export trade connection in dairy produce. Although steam transport was established between Australia and New Zealand by 1857, the length of the journey, poor facilities for storing the extremely perishable products of the time, as well as the widely fluctuating prices of the market, made the success of such enterprises often extremely hazardous. The actual amounts of butter and cheese exported varied greatly throughout the fifties, 1853, 1859 and 1860 being the years of greatest activity. But the highest quantity in any one year was 1,926 cwt (exported in 1859) and there seemed little sound foundation upon which to base an extensive dairy cattle breeding industry. The restricted local market for produce and the over-large cattle population made prospects for dairying expansion at the close of the fifties appear extremely problematical.

11. Between 1857 and 1867, gold was discovered in Nelson,

Otago, Westland and Auckland Provinces and the situation in regard to dairy production became completely changed. With the influx of the gold-seekers and the capital they brought with them, all branches of the agricultural and pastoral industries flourished. "There was (now) a payable market within the

country for everything that could be raised". Commodities were in short supply and prices rose. Settlement was encouraged and the area of land in cultivation increased sixfold to 1,200,000 acres in 1871.

The total number of persons in the Colony grew by 170 per cent from 99,000 in 1861 to 267,000 in 1871. The cattle population, also, was more than doubled in the period, though the rate of increase (127 per cent) was relatively much lower than that of the white population (graph). But in absolute numbers, total cattle still far outweighed the white population in spite of the spectacular additions to the latter in the early years of the boom; (in the one year 1863, 35,000 new immigrants entered the country). Moreover, much of the activity of the decade took place in the back country particularly of the South Island and the older centres of settlement with their dairying systems firmly established, were at first not greatly affected by the inrush of population. Later, however, as the gold fever declined and many of the immigrants turned to settlement, cattle numbers increased rapidly and again at a greater rate than that of the European population.

In addition to its importance as a period of sheer growth, the decade of the sixties is notable as a time when, in an effort to increase production, dairymen were paying attention to the breeding of more specialised dairy stock. The Shorthorn continued for many years to be the most numerous represented breed of stock in the Colony but further importations of Ayrshires were made and in 1862 the first Jerseys came to New Zealand. A notable Jersey of some few years later was the cow "Orange Rose", who, landed in New Zealand, was requisitioned for the return journey of the same vessel in order to provide fresh milk en voyage for the Governor's son who was being sent to England for health reasons. "Orange Rose" returned to New Zealand again in the same ship, and, at a time when milch cows were frequently carried on the immigrant ships for the convenience of passengers, was noteworthy in her achievement. It is hardly necessary to emphasise that only cows outstanding in milking and constitutional qualities would be selected in England for what was in those days a long and arduous journey.

Agricultural shows, which had operated with considerable success during the fifties, continued to stimulate interest in dairy stock and in exhibits of their farm-made produce. The first herd books in the Colony were compiled during the sixties by Sir George Whitmore, Hawkes Bay, and three volumes were issued between 1862 and 1870.

Towards the end of the sixties, when, with the decline of the gold boom, numbers of the gold-seekers left the country, fresh attempts were made to export surplus dairy produce to Australia. Record quantities of over 5,000 cwts. were exported in 1869, 1870, 1871, but exports again declined with the further expansion of the local market in the next few years.

111. "In 1870, Sir Julius Vogel initiated a borrowing policy to subsidise immigration and carry out extensive public works - a young country with a population of 300,000 borrowed ten million pounds in ten years. The result was reckless private speculation and a serious boom in land". Moreover, world prices which had been rising steadily since the early 'fifties, continued to do so until the early 'seventies when a decline set in, but a decline that remained concealed for some time under cover of the inflation that took place in the Colony. The boom reached its peak in 1878 and with 1879 came a long period of profound financial depression.

The Vogel policy in operation saw significant changes within New Zealand. Millions were borrowed, hundreds of miles of railways and roads were constructed, immigrants were imported by the State or poured in of their own accord, and all phases of primary industry were greatly stimulated. The great bulk of activity took place in the South Island where, under the jurisdiction of the powerful southern provinces, the great wheat farms and wool farms of the period were developed. The greater proportion of the Colony's population continued to be located in the South Island but as land aggregation became intensified in Canterbury and Otago, numbers of settlers came North and development began anew in the North Island.

Throughout the decade, the white population and the numbers of total cattle very considerably increased but again there was a decided lag of the rate of increase of the cattle (60 per cent) behind that of the white population (88 per cent) (Graph No.) Of the several factors concerned, probably most important was that the many discouragements experienced in the various attempts to establish an export trade with Australia, together with developments in the extent and value of the internal market, tended towards a consolidation of the industry on the basis of local trade. For the farm dairies there was now a much larger, more profitable and less inaccessible market for their produce within the country. Exports of dairy produce were small and consisted mainly of cheese; but record totals of 5,000 cwt. of butter and the same amount of cheese were exported in the one year 1877 after which the trade again diminished.

It was again a period of experimentation and 1871 saw the establishment of New Zealand's first dairy factory. This venture was located first at Springfield and later at Highcliff, Otago Peninsula, and, operating co-operatively, sold cheese on the Dunedin market when prices were satisfactory and exported to Australia when local rates declined.

The decade, then, may be characterised as a period of experimentation and development in many fields. The rapid growth and apparent permanency of growth of the white population were respectively cause and consequence of increased productive activity. In absolute numbers, the European population increased by 234,000 between 1871 and 1881, and cattle numbers rose by 262,045 over the same period. The area of land in cultivation was more than quadrupled (from 1,200,000 acres to 5,200,000 acres). The opening of the first dairy factory (1871) and the State encouragement of the export trade by means of a bonus (1881) were signs that interest in dairying as a cohesive organisation was being aroused.

:
 :

b. THE PERIOD OF EXPORT TRADE.

"The whole history of New Zealand has been shaped by its isolation, its forests and its mountains. Its present organisation, a decentralised rural democracy dependent in an uncommon degree upon an external market at the other side of the world, is equally determined by its geographical resources and isolation."

Condcliffe.

Refrigeration supplied the initial stimulus to expansion by opening up an apparently limitless world market in which exportable surpluses of produce could profitably be sold; but the advance in dairying was facilitated and accelerated by the reorganisation of the industry on an export basis and (later) by the influence of steadily rising prices for butter and cheese. The rapid development of the factory system, of mechanical aids to working efficiency on the farm and in the factory, of better storage and transport facilities, and of improved methods of farm and stock management, together with a wide extension in the area of land under cultivation, constitute some of the more important factors which have contributed to expansion and been concerned in the huge and extraordinarily rapid increase of the dairy cattle population. The impact of these factors upon the cattle-rearing industry, and their importance in bringing about a high rate of natural multiplication in stock numbers, are briefly reviewed.

(1) 1882-1895 - The Phase of Adjustment.

On the 15th February 1882, the "Dunedin" a sailing vessel of 1200 tons, left Port Chalmers with the first cargo of frozen produce for the English market. After a passage of ninety-eight days, the ship reached London and the butter, though described as of inferior quality, realised 11½d per pound. The shipment established the fact that an export trade in butter was not only possible but likely to be profitable as well. On such premises capital expenditure for the purpose of developing an export industry was well justified.

The effects of refrigeration, however, did not immediately become apparent in the Colony for the world-wide depression of the decade was accentuated in New Zealand by difficulties following

the collapse of the land-boom in 1879, so that it was not until the 'mid-nineties that a measure of prosperity came to the struggling dairy industry. The 'eighties and early 'nineties are therefore notable chiefly as a period of instability, the industry gradually adjusting itself to new conditions. But the foundations of the modern export industry were nevertheless soundly laid during these formative years, and the process was probably the more thorough (as Philpott suggests) on account of the depressed conditions prevailing and the difficulties which had to be contended with.

The rate of increase in the total cattle population over the period reflects the uncertainties of the time.

<u>INCREASE OF POPULATIONS.</u>					
<u>Year</u>	<u>White Population</u>		<u>Cattle Population</u>		<u>Dairy Cows</u>
	<u>Persons</u>	<u>Index Nos.</u>	<u>Number</u>	<u>Index Nos.</u>	
1881	500,914	100	698,637	100	
1886	589,386	118	853,358	122	
1891	634,058	127	831,831	119	206,906
1896	714,162	142	1,047,901	150	276,200

For the first time in the history of the Colony, cattle numbers showed an appreciable decline. The years 1886-1891 were, in fact, among the darkest in the period. Prices for produce fluctuated considerably from year to year, both on the external market and in local trade, and the organisation of the industry, still very much in the experimental stage, did not lend itself to collective action on the part of the producers. Financial difficulties confronted many of the dairy factories so that in numerous cases, co-operative control of processing gave way to private interests. Moreover, dairying was still regarded as the "ugly duckling" of the export trade, for the trade in wool and in frozen meat was by now the dominant export industry.

The 'eighties saw a steady trend of settlement in favour of the North Island. Since 1858, the greater proportion of the Colonial population had been located in the South Island and under the influence of this weight of numbers, as well as its naturally greater

accessibility, the South Island at this time was in a far more fully developed condition than the North. With the cessation of the Maori Wars in 1870 however, and as a result of land aggregation and depressed prices for the pastoral produce of the South Island,^a growing proportion of the steadily increasing population was to be found in the North Island.

DISTRIBUTION OF WHITE POPULATION 1881-1896 (percentages).		
<u>Year</u>	<u>North Island</u>	<u>South Island</u>
1881	39.5	60.5
1886	43.3	56.7
1891	45.0	55.0
1896	48.5	51.5

The growth of settlement in the North Island was predominantly on dairying lines, for, apart from extensive forest-clearing activities in the vicinity of the old Wakefield settlements and at other accessible coastal districts, the great part of the Island was heavily bushed. With the clearing and burning of the forest lands, it was found that under the conditions of plentiful rainfall, the sowing of English grasses produced rich lush pastures among the stumps, and favoured cattle rearing rather than wool-growing. Moreover, these bush settlers were small farmers who depended upon their own family labour for practically all farm duties. Before factories became numerous, these settlers made butter and cheese in their crude farm dairies, depending for their returns on a casual barter trade with shop-keepers in the nearest settlement.

While the first few dairy factories were established in the South Island, the system now began to spread to the North; in 1883 nine new factories were built and seven of these were in the North Island. In spite of serious financial difficulties towards the close of the 'eighties as well as unsatisfactory transport conditions, the number of processing establishments steadily grew, and their output, though fluctuating considerably from year to year,

rapidly increased over the period also.

<u>FACTORIES AND OUTPUT</u>			
<u>Season</u>	<u>No. of Establishments</u>	<u>Butter (cwt)</u>	<u>Cheese (cwt.)</u>
1884-85	36	2.5	16.5
1889-90	74	17.6	39.2
1894-95	176	101.2	86.5

For the season 1894-95, the distribution of factories gives some indication of the rapid development of dairying in the North Island when, with the close of the period, a measure of security had come to the industry through the influence of rising prices, improved organisation and transport facilities and the advance of settlement.

<u>DISTRIBUTION OF FACTORIES AND OUTPUT</u> <u>1894-95</u>			
<u>District</u>	<u>No. of Establishments</u>	<u>Butter (cwt.)</u>	<u>Cheese (cwt.)</u>
Auckland	21	14.8	5.1
Taranaki	53	57.3	24.7
Hawkes Bay	8	1.5	2.3
Wellington	18	16.1	6.4
Marlborough	2	1.99	0.5
Nelson	10		
Westland	-	-	-
Canterbury	14	10.8	5.2
Otago	44	5.6	42.2
	170	101.2	86.5

The table is interesting in showing not only the importance of Taranaki already as a dairying district (producing nearly half the total factory production of butter and the second largest quantity of cheese) but also some considerable degree of regional specialisation in butter and cheese production as between Auckland and Otago respectively.

Fluctuations in total cattle numbers over the period have already been noted. The prospects of expansion disclosed by the initial success of refrigerated transport in 1882 gave a much needed stimulus to cattle-rearing and stock numbers increased by 22 per cent, in the five years 1881-85. Difficulties in transport, in farm and factory finance and in profitably exporting the produce then caused a slackening in the rate of increase, and cattle numbers in fact declined between 1886 and 1891. Brighter prospects on the external market, state assistance and greater cohesion in the internal organisation of the industry as well as scientific advances in production and processing then caused an increase in the cattle population of approximately 26 per cent between 1891 and 1896. A most important feature of this latter development was the advance in dairy cow numbers, now separately enumerated for the first time: the increase was approximately 33 per cent, for the five year period. That milking stock should have been separately so enumerated is perhaps the most significant indication of the emergence of dairying as a factor of growing importance in the Colonial economy.

Some extracts from the Annual Reports of the Department of Agriculture serve to emphasise that there was now in the Colony a growing appreciation for the breeding of specialised dairy stock, as distinct from mere multiplication of cattle numbers (i.e. "individual yields" as opposed to "bulk herd production").

1893. Referring to some recent importations of stock from Scotland and Victoria, the Report states: "The infusion of so much valuable blood into our herds will go a long way towards raising the general character of the cattle stock of the Colony. Now that dairying has become firmly established and the demand for dairy cows likely to increase, an endeavour should be made to establish a breed with good milking properties."

1894. "The rapid development of dairying has quite revolutionised cattle breeding, and instead of the calves being indiscriminately killed when dropped, they now pay well to rear".

..... "The growing importance of the dairy industry has led to more care being exercised in the breeding of cattle suitable for the pur-

pose and, as a result, the breed of cattle, as also their milking capabilities, will be very much improved".

1894. Report of C.R. Valentine, Chief Dairy Export, on "Selection of Dairy Stock" "it will perhaps be well to mention that more attention will have to be given to the selection and care of our dairy stock. The time has come when the producers must get the highest possible return from their cows; and, although feed or keep may be looked upon as a small item of cost, it must be remembered that it takes nearly as much to keep a bad milker as a good one. There are undoubtedly as good breeding stock in the Colony as it is necessary to have, but, unfortunately, there is a general want of proper attention to this point in many districts".

1895: ".....The farmer has endeavoured to secure only good milkers by the simple plan of breeding only from those cows which gave the largest quantity of milk, or better still, the greatest weight of milk. This method of breeding answered its purpose very well in this country till the season before last, when some of our factories adopted the system of paying for the milk according to its quality. This new system of payment came as a hardship on every farmer, and especially on those of them who were unfortunate enough to have just started dairyfarming and had bought all those cows the old dairy farmers had weeded out as inferior. The only remedy for the farmers who have suffered in this way is to go in for Babcock testers, so that they can test the quality of milk from each cow and at the same time weigh it, and keep a proper record of the results. There is no doubt that this system of payment will bring a revolution into several herds of dairy cattle; but that is just what is wanted. The sooner the farmer gets to know the full value of his herd, the sooner he will be able to take the necessary steps to improve it.

"The keeping of records is of the greatest value to the farmer, for without records it is impossible to adopt any new system of dairy farming or to improve on the old one

"As regards breeding, it is not sufficient to select a really good cow. It is still more important to have a really good bull....."

1896. "In the Auckland District there are 5,783 bulls or nearly one-third of the whole number in the Colony, and the most extraordinary thing is that/^{of}this large number, 3503 should be crosses, or in other words, of a nondescript breed. Such a large number of sires with no pretension to breeding within such a small area, cannot but have a detrimental effect on the general quality of the stock. I have no doubt that out of this large number there are many sires well fitted to throw useful stock, either for milking or fattening, but if such a system is continued, the progeny is certain to show signs of deterioration."

The cattle population was of course augmented throughout the period by arrivals of stock from (mainly) the United Kingdom and Australia. Many of these were carried for the convenience of supplying fresh milk to passengers on the long journey, but, particularly towards the close of the period, dairy cattle were brought into the Colony not so much/~~for~~ the sake of their immediate products, as for their value as breeding stock. The Babcock test for milk-fat (invented in 1890) began to be used first in the 1893-94 season, and payment for milk being made thereafter on a butter-fat content basis, the attention of dairy farmers became focussed for the first time upon the need to select their breeding stock on milk quality. The cattle population continued to consist very largely of Shorthorns, with Ayrshires (very much less in numbers) as the next prominent breed; but the first Friesian cattle (one bull and seven cows) had been landed at Lyttelton by Mr. John Grigg in 1883; and a number of further important consignments of Jerseys had been brought into the Colony. Increasing use tended to be made of sires of these specialised dairy breeds, crossing them with the Shorthorn and crossbred cows forming the main bulk of the population. Such development as did take place along these lines was more apparent in the more specialised and progressive dairying of the North Island "bush districts" than in the general dairying areas of the more conservative South where the Ayrshire and Shorthorn remained the prominent breeds and cheese the main ultimate product.

In summing up the general effects of this "adjustment

phase" in development it can be said that the period 1881-1895 marked the transition of dairying from an unorganised state of subsistence farming almost completely dependent upon the local market, into the beginnings of a composite industrial system organised on an export basis. The cattle population, stimulated by the impetus of refrigeration, at first increased rapidly but a decline subsequently set in, due less to the depressed prices prevailing than to difficulties in the internal organisation of the industry. Later, as experience brought about a greater degree of cohesion, active Governmental assistance and encouragement restored confidence in the industry; more factories were established, scientific advances in factory and farm technique were more widely utilised, transport problems were somewhat diminished; and, as in most periods of low prices, gross output was greatly increased. Cattle numbers had continued to show a generally close adherence to the number of persons, but the significant increase of 26 per cent over the last five years of the period (i.e. double the 13 per cent increase of the European population) seemed to indicate that the long period of cramping dependence upon a restricted local market was at an end.

(11) 1896-1913 The Phase of Steady Expansion

This period has been named a phase of "steady expansion but the description should be treated as relative only to late periods of spectacular progress, for in itself and compared with earlier periods of expansion it was a time of phenomenally rapid growth. During the 'eighties and early 'nineties, the possibilities of refrigeration having been proved, initial difficulties in organising the industry on an export basis were gradually being overcome, a large increase in the numbers of dairy stock took place, dairy factories were erected in large numbers, and boundaries of occupation and cultivation were pushed further afield, and a steady swing of population towards the North Island had commenced. These developments occurred for the most part under conditions of severe economic distress, the phase being characterised by an almost continuous fall in the general world price-level. Though many difficulties had yet to be faced, nevertheless the stage was set for expansion in dairying.

and rising prices for produce from 1896 onwards supplied the stimulus. "Too little prominence has been given in New Zealand to the importance of the part played by rising prices at a time when new industries, dairying and meat, were struggling for existence. Particularly in the case of dairying has the price factor been neglected. The more apparent influences of factory development, mechanical aids and transport have received a full enough recognition. But it was undoubtedly a matter of great importance that these advances should have been reinforced by a world-wide recovery in prices. The rate at which the new pastoral industries grew was not possible in an unfavourable price situation....."

This was essentially a phase of farming on the extensive system and, although the area of land in cultivation increased by over 50 per cent from 10.7 million acres in 1896 to 16.9 million acres in 1916, the greatest advances in production were made through extending the occupied area which reached its apparent economic maximum (43 million acres) in 1918. Intensive farming as we know it today is a post-war development and, in fact, the top-dressing of pastures with artificial fertilisers was scarcely used at this time. Only in Taranaki, where, as development proceeded, the virgin fertility of the soil was becoming depleted, was the practice at all common. Grass was the mainstay of the dairy stock, but considerable amounts of supplementary feeds (mainly swedes, turnips, rape) were grown.

The great bulk of development during this period took place in the North Island. The commencement of the swing of population to the North has already been noted; by 1900, the dominance of the South had passed and from then until the present day the North Island has contained an increasing proportion of the white population. This drift of the people is largely to be associated with the growth of specialised dairying under the highly favourable North Island conditions of rainfall and temperature.

Land settlement was accelerated by the State encouragement of farming through special legislation. Government measures aiming at a progressive land-settlement policy had been instituted in the early 'nineties; their full effects became apparent as soon as prices for produce began to rise after 1896; Public

Works policies in the 'seventies and 'eighties had provided railways, roads and bridges (though mainly in the South Island); the Seddon-Ballance land-settlement legislation of 1892 encouraged men of small capital to take-up land; the State Advances to Settlers Act (1894) in providing finance to farmers (and others) on generous terms, was an extremely important factor in the rapid deforestation and settlement of the North Island. In the wake of settlement came improved internal transport facilities and the erection of more and more processing establishments, organised for the most part now by co-operative effort.

Expansion in dairying proceeded first in the vicinity of the Wakefield settlements at Wellington, New Plymouth and Auckland. With the proving of the export trade, these areas became the centres of North Island development, and the Taranaki and Wellington-West Coast districts assumed the immediate lead. Prior to 1905-06, prices for butter rose more rapidly than those for cheese, and buttermaking preponderated in Taranaki, but thereafter, with the rising prices for cheese, Taranaki factories concentrated largely on cheese - making and the Province has continued to hold the lead in cheese production. Following the growth of dairying in the Taranaki and Wellington districts, transport conditions were greatly improving and this factor in itself favoured the development of cheese production. The great Auckland expansion had indeed begun but the undeveloped state of the Province with its lack of good roads and long distances between farm and factory militated against immediate expansion on a scale comparable with that which took place at this time in the more closely settled Taranaki.

Separators had been introduced to the Colony in 1883, but, for nearly thirty years longer, it was standard practice to deliver whole milk to butter factories as well as to cheese-factories. Home separation actually was initiated in New Zealand by a proprietary firm in Wellington in 1897 and the Hokianga dairy factory in 1908-09 was the first to derive the whole of its supply from farm-separated cream. The opposition to widespread home-separation was based on the difficulty of making high quality butter from the inferior farm-separated cream; but the solution of the problem of "fishy-flavour"

in butter in 1913, by means of the partial neutralisation of cream acidity, removed these objections and home-separation became the common practice for butter-factory suppliers. The effective range of such factories was therefore immensely widened, and the great expansion of the Waikato followed in due course.

From about 1906 onwards, too, milking machines were increasing in numbers and efficiency. Whereas the dairying system had been built up on a basis of small herds, milked usually by the settler and his family with the minimum of outside help, larger herds now became possible, and total dairy cows greatly increased in consequence. Moreover, as later in the period, more and more former farm-workers took up land on their own account, a shortage of farm labour developed, and this in turn encouraged extension in the use of the milking-machines.

State instructional and inspectional services (supplied mainly through the Dairy Division of the Department of Agriculture) were now becoming well-organised and a high standard of quality and uniformity in export dairy produce was gradually being attained.

The railway from Wellington to New Plymouth and the completion of the Main Trunk route in 1908 greatly assisted rapid development both in opening up new land and in providing speedy refrigerated transport for farm produce between the factories and the seaboard.

The most striking feature of the multiplication of cattle numbers during the period under review is their achievement now of complete independence of the human population.

INCREASES IN POPULATIONS (in thousands)						
Year	Persons		Cattle		Dairy Cows	
	No.	Index	No.	Index	No.	Index
1896	714	100	1048	100	276	100
1901	788	110	1257	120	372	135
1906	909	127	1811	173	518	188
1911	1025	144	-	-	634	230
1912	1053	147	2020	193	656	238
1913	1085	152	-	-	678	246

The number of white persons in the colony still showed a very considerable increase but at a diminishing rate, whereas cattle numbers (and very particularly, dairy cows) were advancing at a rapidly increasing rate; between 1896 and 1912-13, the increase in the white population (52 per cent) was only half that of the total cattle numbers, and little more than one-third that of the increase in dairy cows. These trends significantly indicate the growing reliance of New Zealand dairying upon external markets.

During the early years of the period, conditions of uncertainty within the young industry were reflected in a tendency towards instability, noticeable more particularly in the numbers of total cattle than of dairy cows. This can be associated with the early difficulties of the growth of dairying in the North Island and the absence of a settled policy amongst stock-raisers on the question of breeding beef and/or dairy stock. Fluctuations in price conditions between beef, butter and cheese considerably influenced the position also.

Between 1902 and 1907, the considerable progress of dairying development in Taranaki together with rapidly rising prices (more pronounced for cheese than for butter) assisted in bringing about a more steady and speedy increase in cattle numbers, dairy cows increasing at a smoother and faster rate than total cattle.

The seasons 1907-08 and 1908-09 are noticeable, however, for an appreciable slackening in the rate of progress brought about by a considerable actual decline in the total cattle population and a less pronounced but very important decrease in dairy cows.

The season 1907-08 was undoubtedly an exceptionally unfavourable one (a severe winter, wet cold spring, summer drought) and, equally undoubtedly, this fact did assist in the reduction of cattle numbers; but other factors within the cattle-rearing industry itself were of primary importance. It is apparent from Graph that the slackening in the rate of increase of total cattle began at least as early as the 1904-05 season, and it is indeed amongst the replacement stock that the largest decreases are to be found (Table).

CLASS	Population in 1905-06	Increase or Decrease over Previous Year.				Popula- tion in 1908-09
		05-06	06-07	07-08	08-09	
Bulls	27,992	incr.	incr	decr.	slight incr.	30,170
Cows - dairy	498,241	incr.	incr	decr	decr	536,629
Cows -breeding	170,037	incr.	decr.	slight incr.	decr	172,016
Heifers over 2 yrs - dairy	51,875	incr.	incr.	decr.	decr	54,988
Heifers over 2 yrs - breeding	48,211	incr.	incr.	incr.	decr	57,420
Cows and heifers for fattening	63,496	incr	incr.	incr.	incr	116,109
Heifers under 2 yrs)	614,406	decr.	decr.	decr.	decr	492,226
Steers " " "						
Steers over 2 yrs	262,592	incr	incr.	incr.	decr	313,768
TOTALS	1,736,850	incr.	incr.	decr.	decr.	1,773,326

It must be remembered of course, that, while herds of single-purpose dairy cows were by no means uncommon, yet the great bulk of cattle in the Colony up to this time was preponderantly "beefy" in type and Shorthorn in origin. It was standard practice therefore in dairying to rear large numbers of young stock, for steers, heifers, and culled cows could usually be profitably disposed of as stores for

fattening purposes. With, however, high prices for milk and pig products, it became much more profitable for dairy-farmers to keep a minimum number of young stock for replacement needs, while selling as many calves, young cattle and aged cows as possible for slaughter as "boned beef" in which a substantial trade had recently been developed with the English market. In these circumstances, the total cattle population considerably receded from its previous "peak" numbers and the policy of slaughtering calves at birth was carried to such lengths as effectively to reduce the milking population in the two seasons 1907-08 and 1908-09. This phase was not however without a permanently advantageous effect upon the dairy cattle breeding industry. The bulk of the milking stock was still of beef origin, but such a wholesale reduction in national herd size meant that "beefy" cows were culled first, and, further that a very much greater degree of care was exercised in the selection of those few calves it was proposed to rear. Milking capacity was further emphasised when, later in the period, the "boned beef" trade having encountered serious marketing difficulties in England, heifer calves were selected mainly with respect to milk production in their dams.

Moreover, as Buchanan points out : "Apart from the competition of chilled beef from Argentina, which did not in fact begin to be serious till almost the end of the period, the general disadvantage of marketing a commodity which suffers so relatively heavily under freezing had already been recognised, and the appropriate pastures were being utilised for dairy rather than beef cattle". The accent from this time onwards throughout the development of dairy cattle breeding in the Dominion, has been more and more upon the value of specialised dairy stock: following the recession in numbers during 1907-09 dairy cows increased independently of, and at a considerably more rapid rate than the total cattle population as a whole. It may be said that this brief phase of retrenchment marked the beginning of the modern emphasis upon the dairy cow per se.

Exports of dairy produce for the period showed a fivefold increase for butter and an eightfold increase in cheese.

EXPORTS OF DAIRY PRODUCE				
Year	(000 cwts).			
	Butter Quantity	Index	Cheese Quantity	Index.
1896	71	100	71	100
1901	202	285	104	146
1906	320	451	131	185
1911	302	425	439	618
1912	378	532	577	801
1913	372	524	612	862

The great bulk of the increase in the butter export occurred during the first ten years of the period while movement in the export of cheese did not become spectacular until the last eight years of the period. The (relatively) highly developed state of the Taranaki district with its network of improved communications and numerous dairy factories, together with the opposition to farm-separation, and the important factor of better prices for cheese than for butter, contributed to this significant change in the character of the export trade.

The main point is that bulk exports of butter and cheese combined increased by well over 523 per cent between 1896 and 1913; the white population increasing considerably throughout, the gross output of butter and cheese together advanced by 570 per cent over the same period. This greater bulk output of produce was achieved through closer settlement (a greater number of dairy farms), extended area of dairying land, larger herds (as the milking-machine became more common), and, ultimately, through a very largely increased dairy cow population.

The expansion of the time was therefore extensive rather than intensive; but, nevertheless, output per cow showed an important increase during the latter part of the period.

**ESTIMATED AVERAGE BUTTERFAT PER COW
(IN MILK AND DRY), 1900-1914.**

<u>Season</u>	<u>Production per Cow</u>	
1900-1	123.17	} <u>Average:</u> 126.21bs
1901-2	127.20	
1902-3	123.48	
1903-4	130.34	
1904-5	127.83	
1905-6	124.74	
1906-7	124.79	
1907-8	127.66	
1908-9	139.25	} <u>Average:</u> 145.7 lbs
1909-10	148.45	
1910-11	139.46	
1911-12	140.10	
1912-13	150.78	
1913-14	156.52	

It is apparent that in the eight years up to and including the season 1907-8, output per cow remained practically stationary; for the following six years it showed a significant and progressive increase, amounting (as an average) to practically 20 lbs butterfat.) Some of the more important factors contributing towards this condition have been already considered :

1. A reduction in the actual numbers of beef-type animals used as milking stock.
2. A more careful selection of replacement stock.
3. With the very much lessened emphasis upon beef-production, attention to specialised dairy stock, and the emergence of dairying as a specialised farming system in itself.

In consequence of this gradual change in dairy farming policy, three further factors came to be of importance:

1. Better feeding and management of dairy stock.
2. Herd-testing and herd-building.
3. Stock importations and the formation of breed associations.

These points will be fully treated at a later stage in this work but it may be said here that it was during the pre-War phase that these characteristics of modern dairying practice had their beginnings.

Before 1907-08, when large numbers of cattle were raised as stores in dairying areas, the feeding and management of dairy cattle was, generally speaking, inadequate for the needs of maximum production. The winter feeding of dairy cows and the care of growing stock, despite frequent emphasis on the point by Agricultural Instructors and progressive dairymen, was neglected on many farms. With the increasing use of more specialised dairy cattle, however, towards the end of the period the general standard of feeding and management, in the important dairying districts at least, showed a gradual improvement. This was doubtless an important factor also in the increase in per cow production of the late pre-war years.

Undoubtedly for many years progressive dairymen had been accustomed, to a greater or lesser extent, to cull their milking herds on the basis of "estimated" or "observed" amount of milk yield of individual cows and, since payment was made at first upon weight of milk, to breed their future milking stock as far as possible from cows believed to be giving the greatest quantity. Such methods could be accurate, even on a basis of relative milk yields, only within wide limits. With the adoption of Babcock testing and the payment for milk according to quality as well as quantity, the emphasis in breeding was transferred to butterfat production. The first cow-testing experiments in the Colony had been carried out in the Waikato as early as 1896, but, while systematic herd testing was inaugurated at Weraroa State Farm in 1904-5 and later privately in the Manawatu (1905-6) and at Warea (1906-7), it was not until the 21st August 1910 that the Dairy Division organised the Dalefield cow-testing association, Wairarapa. A total of 815 cows was so tested in the first season but the idea spread rapidly to Taranaki, Waikato, North Auckland, Otago and Canterbury, so that 25,000 cows were under test in the 1913-14 season. The value

of this early herd-testing lay not only in its immediate benefits to farmers actively participating but was due also to the educational influence of the movement upon dairy farming economy generally. Through herd testing, then, emphasis was laid upon the importance of scientific breeding and culling, as well as improved feeding and management in balanced and progressive dairying practice.

The formation during this period of associations to govern the registrations and general welfare of the four principal breeds of dairy cattle is witness also to the increasing importance being attached to specialised dairy stock. The New Zealand Jersey Cattle Breeders' Association (1902) issued its first herd-book in 1903; the New Zealand Ayrshire Cattle breeders' Association (1909) in 1910; the New Zealand Holstein-Friesian Association (1910) in 1911; the New Zealand Milking Shorthorn Association (1913) in 1915; the New Zealand Shorthorn Cattle Breeders' Association was formed in 1914 but Shorthorn herd books had been published more or less continuously since the Whitmore Herd Book of 1866; moreover purebred Ayrshire, Jersey and Dutch Friesian cattle had previously been registered in the New Zealand Herd Book of which Volume I was issued in 1886 by the Canterbury Agricultural and Pastoral Association. The first Red Poll cattle came to the Colony in 1898. The period was characterised throughout by extensive importations of blood stock, particularly of the dairy breeds, from England, Scotland, Jersey Island, the United States, Canada and Australia. The Department of Agriculture was active in stressing the importance of purebred sires from a good milking strain as being the most rapid method of improving the productivity of grade stock. Certificate-of-record/^{testing} of selected individual registered purebred cows was inaugurated in 1912 by the Dairy Division in co-operation with the Jersey and Holstein-Friesian Associations. Known for many years as "Semi-Official" testing, the system assisted greatly in emphasising the need for recorded butterfat production figures in pedigree dairy cattle breeding. Apart from maintaining tested herds of Shorthorn and Dutch Friesian cattle at some of the Experimental Farms for the purpose of supplying reliable sires to the industry, the Department in 1904 imported from Ireland eight head of Dexter-

Kerry cattle. This interesting development failed however to appeal to dairymen and the herd was dispersed in 1916. It is clear that with the emphasis upon specialised dairy stock and with the advocacy of the use of purebred sires in grade herds, the industry generally greatly benefited from the formation of the breed societies and the consequent stimulus to the importation of superior stock, and that a new attitude towards dairy cattle breeding had developed.

In recapitulating the general nature of the multiplication of stock numbers in the period 1896-1913 it is evident that the "phase of steady expansion" saw a number of significant and far-reaching changes in the dairy industry. Continuously rising prices for butter and cheese accelerated development throughout; the North Island dairying districts began their rise to prominence in the order - Taranaki, Wellington, Waikato, North Auckland, Bay of Plenty - under the influence of a population drift from the South Island; scientific advances in the organisation of the industry - in production, processing, grading and marketing - facilitated expansion; improved communications and internal transport facilities assisted in the development of formerly isolated areas of land; state assistance speeded up the rate of land settlement and encouraged closer settlement; the total cattle and dairy cow populations increased by 93 per cent, and 138 per cent respectively; most important of all, a significant change in the nature of the cattle industry was reflected in the gradual emergence towards the end of the period of specialised dairy farming as an important branch of the pastoral industry.

(iii) 1914-1919 - The Phase of War-Time Expansion.

The active war years cover the five seasons 1914-15 to 1918-19 and mark in reality a continuance of the "phase of steady expansion" as modified by the all-pervading influences of the time. In time of war, an enhanced value attaches to immediately utilisable primary products, both for army food purposes and for beleaguered populations. Hence, following the easing of initial doubts regarding the safety of transport to the United Kingdom, it became apparent that for the duration of the war at least, an era of unparalleled high prices for produce lay ahead of the New Zealand primary industries.

The manner in which high prices (and other factors) affected the rate of increase of the cattle and dairy cow populations is evident from the following table.

<u>INCREASE OF POPULATIONS 1914-1919</u>						
<u>Year</u>	<u>Persons</u> <u>(000)</u>	<u>Index</u>	<u>Total cattle</u> <u>(000)</u>	<u>Index</u>	<u>Dairy Cows</u> <u>(000)</u>	<u>Index</u>
1912	1053		2020		656	
1913	1085		-		678	
1914	1096		-		701	
1915	1103	100	2320*	100	725	100
1916	1101		2417		750	
1917	1098		2575		777	
1918	1108		2869		793	
1919	1117	107	3035	131	826	114
* Estimate						

The rapid increase in dairy cows which might reasonably have been expected to occur under the abnormally favourable price conditions for export butter and cheese, did not in fact eventuate; dairy cow numbers, actually, rose at the same smooth steady rate already noted as characteristic of the latter years of the pre-War phase. Total cattle, on the other hand, increased by more than 700,000 head over the five seasons; though the increase showed considerable fluctuation, the average rate was more than double that of the dairy cow population. In view of the favourable conditions for rapid expansion in dairy cow numbers shown in the latter pre-war years, this anomaly is of particular interest. An explanation may be sought in (i) the white population figures over the war years, and (ii) the export figures for certain commodities over the same period.

Vicissitudes of the War were responsible for the fluctuations in the rate of increase of the white population, for more than 10 per cent (over 110,000 persons) of the 1914 population left New Zealand for service overseas. The consequence was that all phases of industry were disrupted by an acute labour shortage, and dairying, with its high labour requirements, suffered particularly severely. The

The milking -machine, while growing steadily in importance, had not yet progressed in numbers and efficiency adequately to deal with the position and dairymen were working short-handed. Nevertheless, largely as a result of war conditions, the number of machines in use amounted to 7,500 plants in the 1918-19 season, nearly 50 per cent of the dairy cow population being milked by this means. Labour shortage, then, was of prime importance in restricting dairying to a condition of relatively slow progress.

From the export figures for butter, cheese, and frozen beef an explanation is apparent for the great increase noted in the total cattle population.

SELECTED EXPORTS, 1914-1919
(000 cwt's).

<u>Year</u>	<u>Butter</u>	<u>Cheese</u>	<u>Frozen Beef</u>
1914	395	782	326
1915	417	792	716
1916	398	863	750
1917	356	772	1009
1918	316	985	883
1919	430	991	805

Exports of butter remained practically stationary throughout; cheese continued to dominate the export market in dairy produce, but increased by only 27 per cent between 1914 and 1919. But, the exports of frozen beef which, owing partly to serious competition from the South American chilled product and partly to the rapid development of dairying, had shown a declining tendency since 1911, rose under the stress of war conditions to a total for 1917 of more than one million hundred-weights, a figure that remains a record.

It may be emphasised that, in a period of war, beef and to a lesser extent cheese are of considerably greater importance to an army than butter. Moreover, the position was exaggerated, by the shortage of competent workers in the Dominion, through a lesser labour demand in beef production as compared with that in milk production.

The labour shortage also gave a great impetus to the spread of the practice of home separation, once the problem of "fishy"

flavour in butter had been solved. The figures available extend only to 1915-16 but considerable progress is seen to have been made during the five year period.

SPREAD OF HOME SEPARATION

<u>No. of Separators</u>	<u>1910-11</u>	<u>1915-16</u>
At home	2418	11079
At butterfactories	850	770
<u>Butterfat separated:</u>		
At home	5.6 m. lbs	24.5 m. lbs
At butterfactories	44.1 m. lbs	29.7 m. lbs

It can be assumed that by the end of the War, home separation was becoming a dominant feature on farms supplying butterfactories: in the season 1918-19 there were 24,736 separators on farms, nearly 71 per cent of the total suppliers to factories being so equipped. Although the production of butter did not become of overwhelming importance until several years after the conclusion of the war, the movement towards home separation is to be associated largely with the rise to prominence during the latter war years of the Auckland dairying districts where, owing to transport conditions, butter was a more appropriate product than cheese.

During the War years a show extension occurred in the area of land in cultivation from 16.2 million acres (1911) to 17.6 million acres in 1919; but there was a definitely less thorough working of the cultivated area brought about through the depleted labour force. The area of land in occupation reached in 1918 a total of 43 million acres, the apparent economic maximum.

High and rising prices for produce during the War phase brought about conditions of great prosperity within the Dominion but rising prices also brought in their train rising costs of production and rising costs of living. Moreover, since "land is simply an agent of production and its true value at any moment is the capitalised value of its net productivity", rising prices for produce were capitalised into rising prices for land and the post-

war land boom had its beginnings during these prosperous latter years of the war.

(iv) 1919-1934 - The Phase of "intense " Expansion.

The phase of "intense" expansion may be summed up as a period of phenomenal advances in all sections of the dairying organisation advances which were facilitated and accelerated by a rapid and wide-spread change from methods of farming on the extensive system to a new dairying economy based on a progressive intensification in methods of land utilisation.

Huge increases occurred in all departments of the industry. From the season 1919-20 to that of 1933-34, the number of dairy cows was more than doubled and the total cattle population increased by 40 per cent; butterfat production increased threefold, butter output by 450 per cent, and cheese output by 70 per cent; the numbers of dairy-factory suppliers and of farm-separators were more than doubled; the number of milking plants and the number of cows machine-milked both increased threefold. Yet the area of land in sown grasses increased by only 6 per cent, and the area in field crops declined by 11 per cent. Clearly the production from grasslands was hugely intensified.

The effects of the Great War upon the dairy industry, including not only the benefits of greatly increased prices and an apparently unlimited demand for produce but also the disadvantages of highly inflated production costs, depleted labour force and difficulties of overseas transport and shipping space, did not all immediately disappear with the cessation of hostilities. On the contrary, while problems in regard to labour supply and transport facilities were largely solved, the havoc wrought by soaring produce prices upon land values and production costs has remained to the present time.

In the early post-War period of inflation with colossal prices for primary produce, particularly for butter, and a state land settlement policy for returned soldiers, there was furious speculation in land, on the (false) assumption that prices for dairy produce, having followed an ever-rising scale for more than twenty years, would

continue to rise. With the economic depression of 1921-22, it became plain that only increased production and reduced costs would restore a measure of order to the industry. Intensification of production was begun originally as a movement to offset War influences; with the recovery of prices it became an end in itself and a vital factor in the development of dairying as a major industrial enterprise. "A new era of land utilisation set in, and dairy-farm management changed rapidly from extensive grass utilisation, supplemented with root crops, to intensive pasture utilisation through the use of artificial fertilisers as a top-dressing, subdivision of paddocks, and the conservation of surplus grass in the form of hay and silage". Not only was carrying capacity greatly increased but, particularly in the Auckland Province where rainfall and topography were suitable, the application of cheap fertilisers and the adoption of advanced methods of pasture management made possible a large extension in the area of cultivated land upon which dairying could now profitably be practised. Though the great expansion in butter production which began with the season 1919-1920 is partly to be associated with a swing-over to butter production on the part of many cheese factories in Taranaki, in response to differential price movements more in favour of butter than of cheese, it was more directly due to the rapid rise to importance of these Auckland dairying districts where, owing to the relatively poor transport conditions and long distances to be traversed, butter became a more appropriate product than cheese. As a result of these forces, the factory production of butter, after a long period of stagnation, exceeded that of cheese in the season 1922-1923 and with but minor fluctuations has increasingly greatly overshadowed cheese production ever since.

The period from the close of the short first post-war depression (1921-22) to the beginning of the long second post-war depression (1931-1935) was a time of considerable prosperity for dairy farmers: although prices showed an erratic but persistent decline over the whole period, production so hugely advanced that farm income showed a progressive increase also

It was under these conditions that the profoundly significant trend of "intense expansion" took place. In response to a new and important emphasis upon the feeding and management of dairy stock, a high degree of intensification in pasture management was developed. This took the form of "improved pasture associations and the use of proved strains of grasses and clovers", closer subdivision of farms, greater attention to pasture cultivation, rationalised rotational grazing, and conservation of surplus pasture growth. These management factors, combined with the discriminate use of artificial fertilisers, enabled farmers to bring their good pasture-land to a higher state of efficiency, and to bring portions or the whole of previously undeveloped areas of their farms into a state of improved productivity".

A further significant feature of the movement towards greater dependence upon grasslands and greatly intensified production therefrom was the suddenness with which it occurred. Although there was increasingly abundant evidence both before and during the war that grasslands could be made to play a much more prominent and important part than hitherto in the feeding and management of dairy stock, it was the severe price-recession of the early 'twenties, which, in emphasising the unwieldy nature of production costs, accelerated the development of greater efficiency in dairy-farm management. Moreover the movement, while it applied more to the naturally more suitable dairying areas of the North than to the less favourably situated dairying districts of the South Island, occurred nevertheless on a very wide scale and speedily became characteristic of the national dairying economy.

The multiplication of dairy cattle numbers under the stimulus of these new forces in development, took place with phenomenal rapidity, but it is evident that the rate of increase was by no means uniform throughout the period under review.

INCREASES IN POPULATIONS

(thousands)

<u>Year</u>	<u>Persons</u>		<u>Total Cattle</u>		<u>Dairy Cows</u>	
	No.	Index	No.	Index	No.	Index
1919-20	1208	100	3102	100	893	100
1920-21	1240	103	3139	101	1005	113
1921-22	1265	105	3323	107	1137	127
1922-23	1289	107	3481	112	1249	140
1923-24	1316	109	3563	115	1313	147
1924-25	1346	111	3504	113	1323	148
1925-26	1365	113	3452	111	1304	146
1926-27	1385	115	3258	105	1303	146
1927-28	1400	116	3274	106	1352	151
1928-29	1417	117	3446	111	1371	154
1929-30	1436	119	3770	122	1441	161
1930-31	1450	120	4081	132	1602	179
1931-32	1460	121	4072	131	1702	191
1932-33	1470	122	4192	135	1846	207
1933-34	1479	123	4301	139	1933	216

It is apparent from this table and from Graph that progress occurred in three well-defined phases. In the first, ending with the season 1923-24, the dairy cow population increased by nearly 50 per cent in five years. Huge annual increments of from 64,000 cows (1923-24) to 132,000 cows (in 1921-22) were added to the total herds, the total net actual gain being more than 400,000 head, one of the most rapid advances in the history of the industry. The development was so rapid, however, that replacement stock was not available in sufficient numbers to meet the sudden heavy demand, and expansion was attained more through retention in the herds of aged cows and low producers that normally would have been culled, rather than by the addition of young dairy stock. It is also very probable that in some herds beef cows were diverted to dairy purposes. Butterfat production was increased by 70 per cent in the five-year period but the average productive merit of the cattle cannot be said to have increased correspondingly, except in so far as the improved feeding conditions consequent

upon more efficient farm practice assisted in raising per cow butter-fat production.

This expansion was initially dictated by economic forces: first, in the endeavour to take maximum advantage of the Imperial Government's offer to purchase the 1920-21 butter output of the Dominion at a record price (280 shillings per hundredweight); secondly, in the expectation by farmers that similarly high prices for produce would be likely to prevail for some lengthy period; thirdly, with the collapse of prices in the season 1921-22, in desperate attempts to reduce costs by increasing gross production. It became very evident as a result of this price recession that the economic position of the industry was unsound. The long period of rising prices had operated in the capitalisation of farm lands at values greatly in excess of their existing earning capacity so that when prices fell measures were sought that would increase farming efficiency and reduce the disharmony between costs and returns. The trend towards intensification of production from grasslands was thus initiated, and other developments indicative of a gradual reaction against traditional policies of laissez-faire, came into being - notably, the introduction of Group Herd Testing (1922) and the establishment of the Dairy Produce Export Control Board (1923).

During the second phase, embracing the seasons 1924-25, to 1929-30, dairy cow numbers showed a declining tendency for the initial three years but, slowly gaining momentum, the upward movement recommenced in 1927-28. The stationary period from 1924 to 1927 was a time of stock-taking and consolidation in the industry, reflecting the spectacular but unsound expansion of the early years of the decade. More young stock was gradually becoming available for replacement purposes in dairy herds, and it was now possible to dispose of the large numbers of aged, low-producing and beef-type cows the retention of which in the total milking stocks of the Dominion had contributed largely to the stability of the industry during the critical period of its changeover to more rationalised production methods. But such stock remained a potentially heavy liability so that a period of severe culling ensued and, although total dairy cow numbers remained

relatively constant, the composition of the national herds was considerably altered. At the same time the value of herd-testing was becoming more widely recognised, principles in the utilisation of artificial fertilisers for increasing production from grass lands were being more carefully followed and farming efficiency generally was greatly advanced, with the result that average per cow butterfat production showed a further substantial improvement.

The resumption of the upward trend in dairy cow numbers began in the 1927-28 season as a resultant of the naturally enhanced carrying capacity of dairying lands consequent upon greater amounts of more nutritive feed becoming available as efficiency in the growth and utilisation of high producing pastures was improved. There was a need for greater numbers of stock merely to take advantage of the greatly improved feed position. In addition, the 'twenties were, generally speaking, a phase of very buoyant though erratic returns to producers, and prices, though showing a slight declining tendency on the average, were nevertheless sufficiently high to provide, in conjunction with increased output, a greatly augmented farm income. Land values therefore again rose in sympathy and a further aim of the stocking position was a conscious endeavour on the part of farmers to improve net returns by a reduction in unit costs through increased gross production. The latter objective became the guiding force in expansion when the season 1929-30 closed with an average factory pay-out of 16.3 pence per pound of butterfat, heralding a long period of severe financial stringency in other industries as well as in dairying.

In general, the phase of development in 1924 to 1930 was a time of great prosperity in dairying, and important advances in all phases of production were attained. The total dairy cow population increased by only 9 per cent but the gross output of butterfat rose by 30 per cent to a (then) record total of 314 million pounds in 1929-30. Average butterfat production per cow increased by 20 per cent from 182 pounds in 1924-25 to 218 pounds in 1929-30. This was no doubt due to improvements in breeding as well as in feeding, for the Group Herd Testing movement.

greatly extended its scope and influence during this period, and the record total of cows tested in 1930 (20 per cent) has not since been exceeded. At the same time the total area of grassland top-dressed was practically doubled, and greatly increased acreages were cut for hay and silage.

During the third phase, the upward trend of the dairy cow population which had steadily been gaining in momentum since the 1927-28 season attained record proportions, involving the addition of a total of approximately 500,000 cows to the national dairy herds in the space of the four seasons 1930-31 to 1933-34. The movement directly reflected the improvements achieved in farming efficiency during the preceding decade but was precipitated by the drastic fall in prices for primary produce as a result of the world-wide financial crisis. Whereas in the eleven seasons from 1920 to 1930 dairy cow numbers rose by 550,000 largely in response to increased efficiency in farm practice, in the four seasons 1930 to 1934 they increased by a further 500,000 as a result of economic conditions. The volume output of butterfat greatly increased also but not sufficiently to balance the catastrophic fall in prices, with the consequence that gross farming income was greatly reduced, and the economic stability of the industry gravely threatened.

The following table of index numbers for prices, dairy cows and total butterfat produced illustrates the general position. (Average of the seasons 1923-24 to 1926-27 inclusive, equals 100).

<u>Season</u>	<u>Average Pay-out</u>	<u>Dairy Cows</u>	<u>Total Fat</u>
1927-28	109	103	110
1928-29	120	105	120
1929-30	98	110	130
1930-31	70	122	134
1931-32	67	130	141
1932-33	54	141	165
1933-34	55	147	177

The unprecedented collapse in export values for butter and cheese was the culminating point in the period of economic instability which had obtained in the world markets since the close of

the War. The British Market, which remained until recently the only free market in the world, became overwhelmed with supplies of surplus produce, particularly butter, from European countries pursuing policies of national self-sufficiency through import tariffs and quotas and export subsidies, and from overseas countries such as Australia and New Zealand where expansion in production was a natural phase of development. Prices for butter and cheese on the British market slumped in consequence.

Prices for meat and wool had fallen even before the severe decline in dairy produce values and many sheep-farmers either enlarged existing dairy herds or established new ones, and farmers with even two or three cows normally used solely for supplying household needs, began sending cream to butter-factories. The number of suppliers to dairy factories increased by nearly 30 per cent between 1929 and 1934. Moreover, when such herds on mixed farms were established or enlarged, it was usually by the addition of beef-type or inferior dairy-type animals. It is estimated that "possibly some 50,000 beef cows were utilised as dairy cows at some time during the depression years". Thus, although the true dairy farms in the Dominion did achieve phenomenal advances in butterfat output and in carrying capacity, it was also considerably due to increased dairying on mixed farm holdings that the national milking cow population and the Dominion production of butterfat were so greatly increased at this time.

On the true dairy farms, herd size was considerably enlarged but again young dairy stock was not available in sufficient numbers to meet the abnormal demand. The practice of deferred culling was again resorted to, and "it is estimated that roughly 200,000 dairy cows were represented by the aggregate of deferred culling during the five years 1929-1933". Old cows and inferior milking animals were retained in the herds in the absence of sufficient numbers of young stock, but as the need for expansion continued, larger numbers of replacement heifers were reared.

Every effort was made to stimulate production and to reduce costs. The factory production of butter increased by 40 per cent and of cheese by 20 per cent in the five seasons from 1929 to 1934.

Dairy cow numbers advanced 35 per cent. The number of milking machines in use increased by 23 per cent and the percentage of cows milked by machinery rose from 71 per cent in 1929-30 to 74 per cent in 1933-34. Government subsidies available in respect to herd-testing and fertilisers for top-dressing were not able to prevent a decline in the proportion of cows tested and a sharp reduction in the area of grassland top-dressed owing to the severe shrinkage in farming income. The average butterfat production estimated for all cows remained practically stationary throughout.

In the endeavour to exploit all possible avenues of production, slaughterings of bobby calves rose considerably and surplus dairy by-products began to be more widely used in pig-production.

Moreover, with the diversion of increasing proportions of the gross output of milk to butter manufacture, larger volumes of skim-milk became available on farms, and from 1929-30 onwards greatly increased numbers of pigs were raised and breeding-sows advanced by 60 per cent in the five seasons.

As a result of the declining prices for primary produce, Government assistance to the farming industries was made available, with the object of increasing net returns to producers. The Mortgagors and Tenants Relief Act (1931, etc.), the National Expenditure Adjustment Act (1932) and the Rural Mortgagors Final Adjustment Act (1934-35) made provision for reductions in salaries and wages, declared a mortgage moratorium, effected reductions in interest rates and introduced a system of conversion of mortgages under a Court of Review. While these various measures were designed to effect cost reductions to farmers, attempts were made to increase returns by depreciating exchange on sterling 10 per cent in 1930-32 and 25 per cent in 1933. Subsidies on artificial fertilisers and on freight rates, exemption of farm requisites from sales tax and assistance from unemployment funds were also made available.

Prices continued to decline and for the seasons 1932-33 and 1933-34, the average pay-out per pound of butterfat for all dairy factories was approximately 9 pence, at which figure the disproportion between costs and returns was such that the industry as a whole found itself unable to meet commitments. The grave menace

to national economic stability of an insolvent dairy industry led to the appointment by the Government of a Royal Commission which commenced its duties on the 9th May 1934. The commission, in its report, presented in October 1934, concluded that the condition of the industry was such that "unless early and effective measures (were) taken, the result (would) be a general breakdown of the financial relations of mortgagors and mortgagees in the Dominion and consequently it (would) become difficult, probably impossible for New Zealand to meet in full its overseas interest charges". As a result of its full investigations into all phases of dairying, the Commission recommended that the industry should be reconstructed through an immediate rationalisation of the mortgage system; the provision at low interest rates of credit for improving quality of produce and efficiency in production and manufacture; a comprehensive attack on animal disease; the reorganisation of farm and factory instruction, research work and herd testing on a sound basis; cost reductions by improved marketing methods. As a result of the Commission's recommendations, an Executive Commission of Agriculture was established to deal with the wider aspects of farm production and marketing and to co-ordinate the activities of the various Produce Boards, the Dairy Board was reconstituted with wider powers, and a Mortgage Corporation (now the State Advances Corporation) was founded to provide long-term credit and further mortgage relief.

The most striking features of the phase of intense expansion in the development of dairy cattle breeding in New Zealand are, first, the phenomenal rate of increase in numbers of dairy cows during the period, second the rapidity with which a high state of efficiency in intensive grassland farming was developed, and, third, the extreme importance of the influence of price-level upon the economic stability of the industry.

Economic stimuli in the form of fluctuating prices for produce have been guiding forces in the development of the industry during this period and others. It was primarily the record price for butter in the immediate post-war years that precipitated the rapid multiplication of dairy cow numbers and equally well was it the collapse of prices in the 1921-22 season that accelerated the

increase and facilitated the rapid evolution of a system of intensive farming on a grasslands basis. The continued buoyancy of produce prices encouraged further improvements in farming efficiency and it became essential to milk greater numbers of stock in order to derive the maximum economic advantage of the superior husbandry conditions now available. Progressive advances were made in both mass output and efficiency of organisation and scientific assistance became available to production and manufacture through state extension services.

It was a phase of almost continuous annual increases in gross income from dairying, despite a slight tendency towards declining unit prices, but production costs (and particularly land selling values) rose correspondingly. When, therefore, export values fell catastrophically in the early 'thirties, the intractability of farm costs led to a state of extreme economic distress in dairying and in the other primary industries also. Measures taken in attempts to alleviate these conditions included in the first place a natural movement on the part of farmers to reduce unit costs by increasing gross production. Heavy annual additions to the national dairy cow population followed accordingly. It became clear, however, that, despite legislative measures aiming directly and indirectly at cost recution, further action would be necessary if interest charges on inflated land values were required to be met in full. As a result of representations to the Government, a Royal Commission was appointed to inquire into conditions in the dairy industry. Many of the recommendations of the Commission were given immediate statutory authority and at the close of this period of unparalleled expansion, a thorough reorganisation of the industry along constructive lines seemed assured.

(v) 1934 - THE PHASE OF CONSOLIDATION.

This period, a time of consolidation in the dairy industry, is a direct resultant and inevitable consequence of the spectacular advances of the preceding expansionist phase. Five production seasons have now passed, embracing the aftermath of and recovery from financial depression including, for the past three seasons, an era of rising returns to producers under a State-administered system

of produce- purchase at fixed prices. The average seasonal dairy factory payout per pound of butterfat supplied has been, for the period under review, approximately 20 per cent higher than that for the preceding five-year period. Despite substantial reductions in dairy cow numbers since the 1934-35 season and in gross output of butterfat for the past two seasons, the gross income from dairying has exceeded pre-depression levels. Increased farming efficiency developed during the years of economic distress has been partially consolidated, becoming an essential feature of the national dairy economy. But the position has been arrived at where advancement has occurred so rapidly in some other departments of the industrial organisation that progress towards efficiency in farm production generally has been relatively slow.

In the train of rising prices for dairy produce, but accentuated by conditions of buoyant prosperity in the country generally, costs of production have pursued an upward trend and the problem of cost reduction has again become a universal objective. The necessity to reduce costs to a minimum compatible with high production has given a fresh impetus to the attainment of farming efficiency and increasing reliance has been placed upon pastures as the main or sole feed for dairy stock. A properly balanced grass-farming economy which will provide ample supplies of nutritious feed at all times of the year has yet to be perfected, however, in many instances. Notwithstanding the fact that many dairy cows are not fed to the limit of their hereditary needs for production, there is some evidence that considerable attention requires to be devoted to breeding as well as to feeding and management if complete farming efficiency is to be achieved, and production costs reduced by the method of increasing farm output.

Developments towards increased general farming efficiency during the period of intense expansion have been consolidated during the years under review, and, far from heralding a decline in the importance of dairying rather have precipitated a new era which may well lead to a thorough reorganisation and eventual complete rationalisation of all phases of dairy-farming production.

Dairy cow numbers reached a peak in the season 1934-35, totalling 1,952,094 head, from which figure they have since decreased by almost 100,000 to a total of 1,853,713 at 31st January 1939. It is very probable, however, that the recession in true milking stock is more apparent than real, that such reduction as has occurred is merely temporary and a natural resultant of forced expansion during the years of financial depression, and that the greater proportion of the decline is represented by retrenchment in dairying on sheep and mixed farms.

On true dairy farms, many herds had been enlarged, during the depression period, by a process of retaining aged cows and low producers until such time as sufficient young stock became available to meet replacement needs. Expansion however steadily continued and slaughterings of bobby calves were greatly increased also as a means of providing additional income, so that it was not possible in many cases to desist from the policy of deferred culling until prices for produce should have improved. However, when prices finally did begin to rise, culling remained relatively restricted because the supply of young dairy stock was not only inadequate to meet the abnormally high replacement requirements of the greatly increased population, but also was being utilised to an appreciable extent in the provision of young animals of the heavier breeds for the rapidly advancing chilled beef trade. Herds therefore declined in size. Often, too, where dairy-farmers in suitable districts had embarked upon fat lamb raising as an adjunct to dairying during the depression, herds were reduced on account of difficulties in securing suitable replacement stock or because of labour troubles, and sheep husbandry was constituted a larger part of the farm enterprise. It is probable also that with the recent revival of prices, some dairymen have now ventured to make permanent reductions in herd size with the object of paying more attention to the feed requirements of individual high producing cows. Unquestionably, many farms were considerably overstocked in depression years and it is very likely that reduction in herd size by judicious culling has been reflected in higher herd average production and maintenance of total output of butterfat.

With the improvement in prices for meat and wool, many dairy herds established or enlarged on sheep and mixed sheep and dairy farms for the purpose of augmenting farm income during the depression years, have been either dispersed or substantially reduced. An estimated total of 50,000 beef cows was temporarily impressed for dairy purposes on such farms and the greater part of these has now reverted to beef production in consequence of the rapidly increasing importance of the chilled beef trade. Difficulties in securing adequate supplies of suitable labour and the disinclination of many sheep-owners for the routine of dairy farm work have no doubt also contributed to the position.

It can reasonably be said of the decrease in the dairy cow population that it has occurred less on the permanently dairy farms than on holdings where dairying was temporarily adopted as a means of offsetting depressed prices for other produce. The result is an actual net gain to the industry rather than an indication that dairying is on the decline. Herds of indifferent milking stock on mixed farms have largely been eliminated from the industry, and the recession in cow numbers on dairy farms is symptomatic of a pronounced movement designed to consolidate advances achieved during the depression period and to increase efficiency in production generally.

The following table, covering the last ten production seasons illustrates essential differences between the five-year period of phenomenal expansion under the stimulus of sharply falling prices, and the last five seasons of consolidation under a steadily rising price-level.

SEASON	DAIRY COWS		BUTTERFAT OUTPUT		DAIRYING INCOME		
	No. (000)	Index	M. lbs	Index	Lbs.m.	Index	%*
1929-30	1440	100	314	100	24.4	100	43
1930-31	1602	111	322	103	17.9	73	42
1931-32	1702	118	340	108	17.4	71	45
1932-33	1846	128	397	127	16.5	68	44
1933-34	1933	134	427	136	17.8	73	37
1934-35	1952	136	410	131	18.3	75	40
1935-36	1952	136	425	135	23.9	98	41
1936-37	1936	135	442	141	27.5	113	39
1937-38	1873	130	420	134	28.9	118	43
1938-39	1854	129	376	120	-	-	-

Gross dairying income as percentage of the Gross Farming Income. Returns from pig-production are not included in Dairying Income.

Despite the reduction of 5 per cent in dairy cow numbers over the past five years, the population for last season (1938-39) was still 30 per cent higher than that at the commencement of the depression. And, although total butterfat production for last season showed a decline of 15 per cent from the peak figure of 442 million pounds in 1936-37, it yet represented an increase of 20 per cent on the pre-depression return of 314 million pounds in 1930. Moreover, the wide margin in the bulk output of butterfat between the seasons 1936-37 and 1938-39 was due more to differences in climatic conditions affecting the feed position than to difference in the number of cows milked. The gross income from dairying for last season is likely to exceed that of the year 1929-30, although, in view of the lesser butterfat production and only slightly increased pay-out, it may not represent any increase on the figure for 1937-38.

The phenomenal slump in average butterfat production per cow from the record level of 229 pounds in 1936-37 to 203 pounds in 1938-39 provides a very striking indication of the extreme susceptibility of New Zealand dairy production to climatic conditions. An increasing reliance upon production from grasslands has been a feature of dairying in the Dominion for a period of some twenty years, but the trend has been greatly accelerated since 1930 in a national endeavour to minimise production costs. Thus, the area of land devoted to root crops has steadily decreased, that planted in green fodder crops has remained stationary in recent years, while the acreage of grasses, clovers and lucerne cut for haying or ensilage has increased by about 35 per cent, though showing considerable seasonal variation. The results of such a season as the last (1938-39) clearly indicate, however, that although much has been achieved in increasing grass-farming efficiency, a much more adequate provision of supplementary feeds must be made for the needs of milking stock if dairy production is to be sheltered to the maximum possible extent from effects of abnormally unfavourable climatic conditions. The unusually favourable summer and autumn period of 1936-37 was mainly responsible for the high production of that season, indicating that the average dairy cow in the Dominion is not normally fed to the ^{economic} limit of her inherent production capacity. The main time of serious feed shortage is now the late summer-early autumn period, for in the effort to re-

duce production costs, the growth of special green fodder crops for summer feeding on dairy farms has been largely abandoned. Unfortunately it has not generally been part of this policy of almost complete dependence upon grasslands, to make special provision of high-class silages to supplement the normally low quality and frequently inadequate quantity of pasture feed available to heavily milking cows from mid-summer onwards. Indeed, a most disturbing feature of the feed position is the fact that the area of grasses and clovers annually cut for ensilage has steadily declined by 40 per cent from 114,000 acres in 1930-31 to only 68,000 acres in 1938-39, despite greatly increased numbers of dairy cows. The amount and quality of winter feed reserves have undoubtedly been considerably improved in recent years but even today far too high a proportion of dairy cows calves in such low condition that production in the ensuing lactation frequently is substantially reduced. Altogether, despite recent advances in grass-farming policy considerable improvements are not only possible but essential if complete efficiency of pasture utilisation in relation to the feed requirements of dairy cows at all times of the year is to be attained, and fullest advantage taken of the hereditary production capacity of dairy stock.

The top-dressing of pastures has been an important factor in increasing farming efficiency in recent years, operating through a reduction in production costs by raising output per labour unit. Between 1930 and 1934, the area of pasture land top-dressed showed a slightly declining tendency, despite State assistance to farmers in the purchase and transport of fertilisers. Since prices for produce improved, however, the percentage of pasture-land top-dressed has rapidly increased, from 15.4 per cent in 1934-35 to 22.7 per cent in 1938-39. The total area top-dressed last season was slightly more than four million acres, but, although this is a record figure for the Dominion, it is apparent that much dairying land is, at most, top-dressed only at intervals, for holdings devoted wholly or mainly to dairying occupy an area of about five million acres; and, further, the return quoted includes pasture land topdressed on other than dairy-farms. Progressive farming opinion has confirmed the results of research

work that regular annual top-dressing with suitable quantities of different types of artificial fertilisers is the most effective method of intensifying pasture production to supply economically the year-round feed requirements of dairy stock. Obviously much further progress yet remains to be achieved in efficient land utilisation by means of increased attention to pasture top-dressing.

In recent years a great deal of extremely valuable work has been carried out through State administered research and experimentation in the breeding of improved strains of the principal pasture species. High yielding, persistent strains of perennial rye-grass, Italian rye-grass, cocksfoot, white clover and red clover have been developed and made available to farmers through the successful seed certification scheme. Lack of demand for such "pedigree" seed, however, has tended to restrict the quantities produced by growers - so much so, in fact, that according to Connell, it would take from thirty-five to forty years, at the present rate of certified seed production, to sow with one bushel per acre of perennial rye-grass the entire seven or eight million acres of dairying and fat-lamb territory which can undoubtedly be expected to benefit from such a policy. Clearly, although considerable improvements have already been brought about in grass-farming efficiency, there still remains very great scope for increasing production by means of a more widespread use of the specially selected superior strains of pasture species now available.

During the years of financial depression, greatly increased attention was paid to the economic utilisation of skim-milk and whey in the production of pig-meats as a means of offsetting low prices received for butterfat. The Dairy Industry Commission expressed concern that the importance of pig-raising should be consciously recognised "as a permanent and integral part of efficient dairy-farm management" at all levels of prices for butterfat. There is reason to believe that this has indeed largely occurred for, despite a decline of 16 per cent in the numbers of breeding sows from the peak total of 116,000 in 1935-36, the number of pigs ^{per breeding cow} slaughtered has advanced from 9.0 to 10.8 (20 per cent) over the same period. The total weight of pig-meat has also been largely increased, due to the rearing of an increasing proportion of pigs

to bacon weights. It is clear that a substantial improvement in efficiency of pig-farming has been brought about, but that considerable profitable expansion is yet attainable both on dairy-farms already engaged in pig-production and also in the extension of pig-keeping to all farms where surplus dairy -by-products are not at present utilised to maximum economic advantage. With the objectives of consolidating advances made and of further improving efficiency in dairy farm management through economic exploitation of pig production, the pig industry has recently been reorganised under the aegis of the Department of Agriculture, which, in conjunction with farmers, has introduced a scheme for pedigree sow recording (1936), a national scheme of instruction (1937) and a system of grading bacon carcasses (1938) as well as the provision of general services to pig breeders.

From data collected in a recent study of dairy production in the Wellington Province, R.P. Connell concludes that the size of the farm business (not the farm area) is of basic importance in the economics of butterfat production. It is clearly demonstrated that the trend in production costs is markedly downwards as the gross output of butterfat from the farm is increased. The two common methods of increasing the size of the farm business, by raising the level of butterfat ^{per acre} production, are each shown to result in decreased working -, interest-, labour- and net-costs of production.

It is further emphasised that, since labour costs are reduced as the size of the farm business is increased, farm output is of fundamental importance in increasing labour efficiency. Labour reward comprises 50 per cent of the gross production costs in New Zealand dairying today, and a reduction in labour costs per unit of output has become a national endeavour. In view of the low Dominion average returns for butterfat production per acre (85 pounds) and per cow (225 pounds) much progress is possible. Considerable advances have been made in recent years through the introduction of labour-saving devices into farm practice but the guiding force has tended to be more a desire to retain the family basis in dairy-farm undertakings and also the difficulty of securing qualified permanent labour than any conscious endeavour to increase labour output.

The labour complement on dairy-farms in the Dominion is determined by the labour requirements of the milking process, and the number of milking plants in use has increased almost fourfold since 1919, and by 42 per cent since 1930. At the present time nearly 81 per cent of dairy cows are milked with the aid of machinery but this figure represents only 42 per cent of the national dairy herds. Since machines are used mainly on herds of more than 15 to 20 cows, the return furnishes additional evidence of the very small size of the majority of New Zealand dairy herds. Large increases have occurred of recent years, also, in the numbers and types of cream separators, electric motors, harvesting and other grassland machinery on dairy farms. It is very possible that advances in labour efficiency due to a lesser labour requirement through increased mechanisation, have even exceeded improvements due to increased size of the farm business. Clearly, the major function of future progress in increasing dairy-farming efficiency lies in a complete and detailed attention to all phases of the breeding, feeding and management of the dairy cow.

Many far-reaching changes in the organisation of other sections of the industry have taken place during this phase of consolidation in dairying. Market conditions have remained exceedingly difficult and prospects for the sale at increasingly higher prices of further greatly increased surpluses of butter and cheese do not appear reassuring. The United Kingdom market continues to be flooded by dairy produce supplies from overseas and British agriculturalists are clamouring for protection against alleged 'dumping' of surplus butter; Eastern markets remain closed to a profitable trade for New Zealand; and the limited international demand for casein and other processed products indicates that expansion by means of such diversification in manufacture is unlikely to prove profitable.

The main avenues of disposal for future profitable expansion in production would appear to be :

- (a) The complete penetration of markets in the United Kingdom; the present per caput consumption of butter is approximately 25 pounds in the United Kingdom as compared with 40 pounds

in New Zealand; it is highly probable that greatly increased supplies could only be disposed of at correspondingly lower prices.

- (b) The utilisation within the Dominion of greatly increased quantities of all dairy produce, but particularly of liquid milk and cream, cheese, ice cream and butter; the organisation of the local market for liquid milk in particular is chaotic at the present time, with the consequence that equivalent amounts of milk produced in New Zealand are sold in the United Kingdom and in the Dominion for 6 pence per gallon (as butter) and 28 pence per gallon (as fluid milk), respectively; the per caput consumption of all the products mentioned (with the exception of that of butter) is at the present time low and is capable of very considerable expansion.
- (c) The development of trade in export butter and cheese with the United States - which is rapidly becoming highly industrialised and may at some future time provide a profitable market for New Zealand primary produce.

The period of marketing difficulties and the lower level of produce prices have concentrated attention on the need for general cost-reductions -- not only in production but also in other phases of the dairy organisation. The Executive Commission of Agriculture was instrumental in bringing about considerable cost reductions through the institution of a zoning scheme whereby existing undesirable overlapping in cream collection amongst factories was eliminated; and badly situated or uneconomic establishments were closed down. The trend is now in the direction of a larger manufacturing unit; and better roads, with cheaper and more rapid and frequent transit between farm and factory have had the twofold effect of reducing manufacturing costs and improving the quality of produce. Quality in butter and cheese has also been greatly improved as the result of a general tightening-up of grading standards in both the raw and finished products, as well as increased attention to detail in production and manufacture.

The institution of guaranteed purchase prices for export butter and cheese under the Primary Products Marketing Act, 1936, has induced further marked and significant changes in the general

organisation of practically all phases of the industry. The main function of the scheme is to protect dairy-farmers from market fluctuations by the payment of a fixed price uniform throughout the season. A degree of stability and security is provided which has already proved exceedingly valuable in the budgeting and forward planning of the dairy farm economy, opening the way to a complete rationalisation of production methods.

The attempt, under the scheme, to provide a general standard of living for persons engaged in dairying, comparable with that enjoyed by other sections of the community, has been less successful, owing largely to the distinct inflationary trend of State financial policy generally. Cost difficulties, though probably somewhat exaggerated in the great majority of cases, have however, led to a series of investigations into the economics of dairy farming, which have provided exceedingly valuable information hitherto unavailable, on the general status of the industry.

In marketing, the Crown, through the Dairy-produce Export Division of the newly established Primary Products Marketing Department, acquires ownership of all export butter and cheese at f.o.b., and, further, controls the local market through the Internal Marketing Division. The efficiency of the single-unit procedure for the marketing of export produce has received universal commendation and has resulted in savings in costs amounting to about £200,000 annually.

Payments are made to dairy factories by a basic guaranteed purchase-price which is subject to additions or deductions according to the quality of the butter or cheese under the points grading system. These differential payments for quality provide an incentive for the maintenance and improvement of the quality of the produce, particularly necessary in the case of cheese. In addition, by means of a differential price for cheese over butter, a margin is provided to compensate producers for the higher production and transport costs and lesser return from by-products, as compared with production of cream for butter-factory supply. There are indications that the margin of twopence maintained during the past two seasons has been to some extent effective in partially arresting the decline in cheese production of recent years.

The responsibilities of the Executive Commission of Agriculture and the main functions of the Dairy Board have been transferred to the Marketing Department. The Dairy Board continues to act for the industry as a whole, and has, in addition, been constituted the statutory authority for Group Herd Testing which was reorganised in 1936 under the Herd Recording Council of the Dairy Board.

A national system of farm dairy instruction was initiated during 1938 under the direction of the Department of Agriculture with the object of linking farm production with factory processing in the systematic improvement of methods of handling milk and its products. Officers of the Department are available for advising farmers on numerous other phases of farm production. Further instructional and investigational work in the interests of producers can be expected as the result of the recent establishment of an Animal Health Division by the Department of Agriculture and of Herd Improvement Associations at the instance of the New Zealand Dairy Board. In the sphere of stock diseases and in connection with the relation between breeding and feeding, proper services have hitherto not been available, and the extent of annual loss to the industry through disease and through lack of application of fundamental principles in the breeding and feeding of dairy stock, is very considerable, although precise data are not available.

It seems clear that this phase of consolidation is by no means yet concluded. It is perhaps not too much to say that on present evidence, the future of dairying in the Dominion depends upon a full consolidation of advances already achieved. A small proportion of farms is already producing to an economic maximum under the particular set of conditions obtaining; the problem of consolidation is the problem of raising the great bulk of dairy farms in the Dominion to a level of productive efficiency at present attained only in isolated cases.

Great advances have been made in farming efficiency, but still greater improvements are still possible - and, indeed, essential if the benefits of a dairy-farm economy based on scientific planning are to be fully exploited. The whole organisation of the dairy industry centres about the breeding, feeding and manage-

ment of the dairy cow yet, relative to the exceedingly high general efficiency of most phases of marketing, transport and processing, that of farm production is capable of immense improvement. The present dairying lands of the Dominion can without doubt support a population of at least two million milking cows, providing a gross national output of 600 million pounds of butterfat, at an average level of 300 pounds of butterfat per cow and a minimum of 120 pounds of butterfat per acre. Such an objective is readily attainable if enlightened attention is paid to all those phases of farm production embodied in a detailed consideration of breeding, feeding and management in relation to the dairy cow. In the words of the Director-General of Agriculture: "Evidence.....shows that our herds are very sensitive to the degree of efficiency in their feeding, and suggests that any substantial upward trend in average herd production must be based upon an improved general standard of feeding. In short, in the future, better breeding without better feeding of our stock does not promise much general advancement in average production per cow".

The outbreak of another European War at the commencement of the 1939-40 dairying season, brings with it problems for the future of New Zealand dairying, the nature of which is as yet wholly undetermined. Immediate marketing problems, assuming a satisfactory solution of transport hazards, are apparently resolved in that a call has already been issued for a greatly increased output of dairy products, particularly of cheese and other normally less important milk products. Prices are likely to be maintained under proper control and there seems every probability, provided labour forces are not greatly depleted, that much progress in the evolution of a more generally efficient dairy industry can be expected. There can be but little doubt that, in the event of a prolonged war, unparalleled changes are likely to be brought about in world social and economic structure, changes that cannot leave the New Zealand dairy industry unaffected.

g. SELECTION AND DEVELOPMENT.

(1) Development.

Several broad trends are apparent in the selection of breeding stock as dairying developed in the Dominion.

At first, in the absence of native cattle, Shorthorn cattle were imported and bred in large numbers to provide milk and beef to meet the immediate needs of the scattered but increasing population. Selection for milk production was at a minimum because there was a heavy demand for cattle of any type that would give an average quantity of milk and be useful also for meat purposes. However, the milk producing capacity of cows imported was probably more than average, on account of the primary need for milk both by the passengers carried on ships in the journeys from England, Scotland or Australia, and by the colonial population.

Shorthorns that were neither very good milk-producing nor very good beef-producing stock dominated the cattle situation in New Zealand for more than a hundred years. As the towns and village settlements increased in numbers and size, herds were maintained and selected for milk production; but in the Colony as a whole the dual-purpose Shorthorn was the supreme influence in the cattle population until long after refrigeration made possible the export trade in dairy produce. During this time, improvements were assuredly brought about in the economically valuable milk and beef characteristics of the Shorthorn both by systematic selection in New Zealand and through the numerous importations of improved cattle from Scotland, England and Australia. Herd Books for the registration of Shorthorn cattle possessing special merit were published in the Colony at intervals from 1866 onwards although the breed society was not established until 1914.

Depressed economic conditions and a tendency to regard dairying merely as a sideline to other types of farming, retarded the growth of an export industry in dairy produce for some years after the success of mechanical refrigeration in the 'eighties. In consequence, although cattle of the specialised dairy breeds were now present in the Colony in fairly considerable numbers, the

importance of milk producing capacity in dairy stock was not fully recognised until, with the improvement of prices and the erection of numerous dairy factories in the 'nineties, the potentialities of an export dairy industry became generally apparent.

As dairying became more systematic and better organised from about 1895 onwards, more attention began to be devoted to the selection of improved milking strains in the Shorthorn and numerous importations of superior dairy-type animals were imported from overseas. But, side by side with these developments, the single-purpose dairy breeds rose rapidly to prominence. From 1893 until shortly before the outbreak of war, high-class animals of the Jersey, Friesian, Ayrshire and Shorthorn and Red Poll breeds were imported in exceedingly large numbers from England, Scotland, Canada, the United States of America, Jersey Island and Australia. More than 700 head of cattle (including a few of the purely beef breeds) came into the country in the twenty-year period. The important feature of this development was that these cattle were bloodstock, imported with the object of improving the milking ability of the general cattle population in the Colony, the majority of them being breeding bulls. Moreover, between 1903 and 1915, breed societies were formed in the Dominion and local herdbooks issued of the world's principal dairy breeds - the Jersey (1903), the Ayrshire (1910), the Friesian (1911), the milking Shorthorn (1915). Organised breed publicity and the relatively impressive achievements in milk production of purebred and crossbred or graded herds of the single-purpose breeds caused a definite swing in favour of Jersey, Ayrshire and Friesian sires to head milking herds.

With the gradual spread of herd-testing (1909) and the milk-recording of individual purebred cows (1913), direct and reliable measures of herd and per cow production became generally available in New Zealand for the first time. The immediate effects were to demonstrate the poor average level of milk production in Shorthorns and to emphasise the potentialities of Jerseys and Friesians - cattle which had been bred for several hundred years almost solely for butter and milk production, respectively. The practice of using sires of the dairy breeds upon hitherto predom-

antly Shorthorn herds in the effort to improve milking capacity became a feature of the rapidly developing dairy industry.

The speed of the change-over to Jersey-Shorthorn, Friesian-Shorthorn and Ayrshire-Shorthorn crossbred herds for dairy purposes was greatly retarded by the disruptive influences of the war but, gradually, significant changes took place. More and more herds of purebred cattle of the specialised dairy breeds were established in response to the continued insistence by commercial dairymen upon dairybred sires for use in grading-up their originally Shorthorn stocks. The general dairy cattle population was of a very mixed nature at this time and it is likely that in many cases little continuity was maintained in the breed of successive sires used. The Jersey breed, however, showed most marked expansion and, while numerous herds of improved milking Shorthorn cattle remained, the proportion of Shorthorns in the general milking stock population diminished as the numbers of predominantly Jersey, Friesian and Ayrshire crossbred cattle were increased. By 1921, the beginning of the phase of intense expansion in dairying, the crossbred dairy cattle population was approximately balanced between stock predominantly of Jersey, Friesian and Ayrshire extraction and stock still mostly Shorthorn but improved for milking purposes.

Three major phases of development are discernible in this early history of selection for milk production:

- (a) the phase of an almost entirely Shorthorn population of cattle that were neither very good milkers nor very good beef-producers.
- (b) A phase when the Shorthorn was being gradually improved for dairy purposes and cattle of the more strictly dairy breeds were becoming established in the Colony.
- (c) A phase of heavy importations and improvement of all breeds, of the establishment of herd books and the commencement of milk-recording, of the rapid rise to prominence of the specialised dairy breeds, the decline of the Shorthorn, and the evolution of a mixed crossbred dairy cattle population.

Selection, clearly was based upon broad differences between breeds in respect to milk production, an instance of mass selection in its broadest sense. The early, rather nondescript Shorthorn

slowly gave way to an improve type which in turn was superseded through a wide use of breeds long known to be outstanding in dairy qualities. Development was initiated and accelerated by the demands of an expanding interest in dairying as a major branch of the farm economy.

In the post-war period, two further major phases in selection can be recognised:

- (a) A phase of expansion in numbers of dairy cattle, accompanying intensification in dairy farm production, and characterised by greatly increased production from dairy stock in consequence of improvements in breeding, feeding and management.
- (b) A phase of growing realisation that genetic improvement in the production capacity of dairy stock is urgently necessary; that the methods of raising the productivity of dairy stock made use of in the past, are no longer wholly satisfactory; that, for most economical production, an even balance must be secured in the farm enterprise between feeding and breeding.

During the post-war era, the significant changes already noted to be taking place in the breed composition of the milking population were consolidated and extended by increasingly wider use of sires of the special-purpose breeds in grading-up the Shorthorn-crossbred foundation stock towards the level of the purebreds. By 1928, the Jersey dominated the breed situation and the influence of the Shorthorn had been greatly diminished. Whereas in 1921, 46 per cent of the bulls of all ages were Shorthorn purebred or crossbred and 34 per cent were Jersey purebred or crossbred, in 1928 71 per cent of dairy bulls two years old and over were Jersey purebred or crossbred, while only 13 per cent were Shorthorn purebred or crossbred. Amongst purebred dairy bulls only, comprising 32 per cent of the dairy bull population in 1928, Jerseys amounted to over 80 per cent and Shorthorns to less than 4 per cent of the total. No more recent data are available but it is believed that the breed situation has not greatly altered in respect of Jersey ascendancy in the past ten years. It is probable, however, that

purebred bulls now constitute a much greater proportion of the active bull population and that variations have occurred in the influence of the lesser breeds.

The proportions of the various breeds represented in the dairy bull population at 31st January 1928, are as follows. (Dairy bulls two years old and over for stud).

<u>BREED</u>	<u>PUREBRED</u>	<u>CROSSBRED</u>
Jersey	80.1	68.6
Friesian	10.3	11.3
Ayrshire	4.8	3.2
Milking Shorthorn	3.9	16.4
Red Poll	0.9	0.5
	100.0	100.0

This greatly extended use of sires of the single-purpose dairy breeds (and particularly of the Jersey breed) corresponded to the rapid and phenomenal expansion which occurred in dairy farm production during the period after 1920.

Improvements in farm practice directed at the more intensive utilisation of dairying lands, more particularly in respect of pasture topdressing, closer subdivision, organised rotational grazing and pasture conservation, resulted on many farms in the production of larger amounts of feed than could be profitably dealt with by existing herds. Economic stimuli and the prospects of a further greatly improved feed position caused an immediate enlargement of numerous herds. Since the rate of natural increase was insufficient to meet the pressing demands for young stock in greatly increased numbers, expansion was attained through a partial suspension of the normal culling of aged and low producing cows. Meanwhile abnormally large numbers of heifer calves were raised in anticipation of an eventually much higher replacement requirement. The net effect was to diminish the intensity of selection for improved productivity practicable among young stock, both in that so many more calves were reared and also ⁱⁿ that calves were in many

cases saved from inferior producing cows.

Expansion in dairy cow numbers was thus achieved but it was recognised that the stock replacement position was unsound. The dairy cow population increased by 50 per cent between 1920 and 1925, yet in spite of a decline in the general quality of breeding stock consequent upon relaxation of selection, average per cow production increased by 20 per cent, from 152 pounds of butterfat in 1919-20 to 182 pounds in 1924-25. The effect of greatly improved feed conditions upon production is clearly apparent. Not only was more feed available but through more efficient grazing management it possessed on the average a distinctly higher nutritive value than had been the case under the former conditions of extensive farming. It is important further to note that when per cow production is at so low a level as 150 to 180 pounds of butterfat, relatively great improvement may be effected by paying attention to feed conditions. While the more extended use of dairy bred sires had already begun gradually to raise the general level of genetic capacity for milk production in the dairy stock of the Dominion, the significant trend towards a dairy population consisting almost wholly of high grades (and mainly of high Jersey grades) was a later development.

Though the general dairy cattle population was of a very mixed nature, with Shorthorn stocks still predominating, it was towards the close of this early phase of expansion that the use of purebred sires began to emerge as an essential feature of progressive dairying policy. In view of the fact that per cow production was rising fairly rapidly, it became necessary to ensure as far as possible that young stock brought into dairy herds possessed a sufficiently high degree of genetic capacity for milk and butterfat production to enable the herd average production level to be maintained. The method adopted was the use of registered purebred sires as offering a reasonably greater degree of certainty of transmitting producing qualities to their offspring than unregistered bulls less carefully bred. This system was a reliance upon the theory of mass selection - that the average hereditary productive capacity of registered purebred dairy stock was higher than that of the heterogeneous general dairy cattle population, and therefore that on the average, the use of breeding stock from

the higher producing group would be of assistance in increasing production in the less productive group. The efficacy of the scheme in working was highly satisfactory at first, mainly because the differences in productivity between the average of the registered purebred stock and that of the general non-registered population were initially large. Later, as the result of long-continued grading towards the various purebreeds, these differences in average productivity became less significant and fresh problems arose. At the period under review, however, the success of the method resulted in an increasing demand for registered purebred sires, mainly of the Jersey breed, in the breeding of replacement stock for commercial dairy herds. The rapidly expanding influence of the Group Herd Testing movement, founded in the Waikato in the 1922-23 season, was of outstanding importance as a factor advancing the use of registered purebred sires in herd improvement.

Following the phase of rapid multiplication in dairy cow numbers between 1920 and 1923, there ensued a short period of adjustment to the new conditions before the resumption of expansion in 1927-28. The dairy cow population had continued to increase during 1924 and 1925 - but at a declining rate - and small actual decreases in cow numbers were recorded in 1926 and 1927. As a result of more young stock being available for replacement purposes, it was now possible to embark upon an extensive culling programme, aged and low producing cows being eliminated from many herds. Exceptionally unfavourable climatic conditions early in the 1925-26 season undoubtedly affected the position by accentuating the poor producing qualities of many cows that had been retained in herds to meet the demands of expansion. Although large numbers of young animals were required to maintain herd size and selection was therefore not intense, the general quality of the replacement stock was, on the average, satisfactorily high, mainly on account of the greater use of purebred sires as part of a constructive herd-building policy.

The upward trend of the cow population was resumed, rather slowly at first, with the season 1927-28. It is probable that the culling of inferior producing stock was a feature of herd management through out the years 1924- to 1930. This was possible because the

replacement position was now relatively sound in that sufficient numbers of comparatively well-bred dairy heifers were available annually to meet the needs of normal expansion on a basis of progressive improvement in per cow production. It is likely also that some advancement was attained in the genetic production capacity of dairy stock for it was by this time standard practice in constructive breeding to make use of successive crosses with sires of a single breed where herds were maintained by the addition of home-bred stock. At the same time, however, significant progress had been achieved in the efficiency of farm practice, and increasingly greater amounts of higher quality feed were becoming available for the purposes of dairy cow production. The combined effects of improved heredity and a markedly more satisfactory environment for dairy stock led to a large and consistent improvement in average per cow butterfat production between 1925 and 1930 (20 per cent).

The influence of herd-testing was an exceedingly important factor in this development, not only because it provided an actual measure of production performance upon which breeding and culling programmes could be soundly based, but also because it afforded a reliable indication, through herd average production, of the general effects of feeding and management in relation to the breeding programme. Progressive farmers were now becoming accustomed to the use of registered purebred sires as an essential feature of the farm business. Further, more discrimination was being exercised in the selection of sires to head commercial herds in that a premium was paid for bulls from tested ancestry. The breeding of registered stock was evincing rapid development, the various breed societies were active in advancing the interests of breeders, and numerous consignments of valuable breeding animals were imported from abroad.

The most recent figures available with regard to importations of stud dairy cattle (based on quarantine station returns) indicate a considerable traffic in recent years, mainly of bulls :

Year	Jersey	Friesian	Ayrshire	Shorthorn	Red Poll	Totals
1921	17	14	-	3	1	35
1922	14	-	3	5	-	22
1923	-	-	-	-	-	-
1924	a total of 105 head (including beef breeds)					105
1925	-	-	-	-	-	-
1926	22	1	-	-	-	23
1927	2	-	-	-	-	2
1928	26	1	-	-	-	27
1929	20	-	3	1	7	31
1930	41	-	9	-	-	49
1931	31	-	2	-	-	33
1932	-	-	-	-	1	1
1933	1	-	1	1	-	3
1934	1	-	2	2	1	6
1935	1	-	-	5	1	7
1936	1	-	-	7	3	11
1937	15	-	6	1	5	27
1938	8	-	1	7	6	22
1939	2	-	6	1	1	10
TOTALS:	202	16	32	33	26	414

The Marked Calf Movement, instituted in 1925 by the New Zealand Co-operative Herd Testing Association, was important in furthering the use of purebred sires and in drawing attention to the need for strict selection of replacement stock on a basis of potential milk producing ability. By 1930, the general dairy cattle population was tending markedly towards the level of the purebreds, the Shorthorn-crossbred influence had greatly diminished, and the ascendancy of Jersey strains in the grade population was firmly established.

The continuous and rapid increase of 34 per cent in gross output of butterfat between 1926 and 1930 was determined by the 10.5 per cent rise in dairy cow numbers and the 22 per cent improvement in average butterfat production per cow, consequent upon efficiency increases in farm and herd management over the period. The extent of advancement is indicated by the following table showing : The total number of cows in milk and dry, the estimated average butterfat production per cow, the percentage of tested cows of all cows in milk and dry, the tons of fertiliser available for top-dressing per cow in milk and dry (assessed), and the number of acres of hay and silage cut per cow in milk and dry.

Season	Cows	Average Fat	% Tested	Fertiliser	Hay and Silage.
1925-26	1304	179	13.0	-	-
1926-27	1303	199	13.1	0.14	0.17
1927-28	1352	195	16.6	0.18	0.21
1928-29	1371	210	18.9	0.22	0.20
1929-30	1441	218	19.7	0.23	0.24
1930-31	1602	201	16.9	0.15	0.26
1931-32	1702	200	15.3	0.11	0.21
1932-33	1846	215	15.5	0.14	0.29
1933-34	1933	221	16.4	0.13	0.36
1934-35	1952	210	13.6	0.13	0.31
1935-36	1952	218	12.6	0.15	0.34
1936-37	1936	229	13.9	0.19	0.37
1937-38	1873	227		0.25	0.34
1938-39	1854	203		0.24	0.30

The figures for fertilisers and hay and silage include undetermined quantities used in connection with other farm stock as well as dairy cattle, but the major proportion under each heading has been utilised on dairy farms.

Clearly, from the first part of the table, there were very substantial increases between 1926 and 1930, in the amounts of feed available to dairy cows and in the percentage of cows herd-tested as well as in average butterfat production per cow and the total number of dairy cows. Each production season, with the exception of the first (1925-26) was more than usually favourable and no doubt this factor, in conjunction with the greatly increased amounts of fertiliser available and of surplus pasture growth saved for supplementary feeding, was largely concerned in the sharp rise in per cow production. The 50 per cent increase in the proportion of cows under test indicates, however, that breeding was also receiving attention.

Larger numbers of cattle, however, were urgently necessary to take maximum advantage of the improved feed position. Fawcett has shown that, in the attainment of high per acre production, a high per acre concentration of stock is more essential than high herd average production. In other words, where other stock is fed to maximum economic capacity, it is not sound practice to cull known inferior producing cows unless high producing animals are available to replace them. Unless the farm is stocked greatly beyond the capacity of the quantity and quality of the

feed available, the elimination of low-yielding cows does not result in increased butterfat production per acre, because, in the absence of a sufficient number of grazing units for efficient pasture control, much feed is wasted that could profitably have been utilised by even a cow producing only 100 pounds of butterfat per annum. Where, however, a high carrying-capacity of heavy-yielding cows can be maintained, production per acre reaches a high level.

The natural response of New Zealand farm lands to such intensive production methods as the heavy topdressing and more efficient management of improved grassland had become such, by the late 'twenties, that difficulty was encountered in the economic utilisation of the feed available. These conditions supplied the initial impetus to a further remarkable expansion in dairy cow numbers.

Increased numbers of heifers had been available annually for some years, to meet the abnormally high replacement needs of a population ^{which inferior cows were} from being eliminated and which at the same time was consistently if slowly expanding. With the renewed urgent demand for further rapid expansion as a result of the favourable feed position, increasingly large numbers of young stock were reared and selection was inevitably relaxed. Believing that they could safeguard their stock against too great deterioration, many dairy-men continued to rely upon purebred sires for improvement. Circumstances now operating, however, made this policy of mass selection less effective than formerly.

In the first place, the difference in average level of production between the registered purebreds and the non-registered general cattle population was now less significant on account of the considerable improvement which had occurred in the heredity of commercial dairy cattle for dairy qualities as a result of the grading-up process.

Second, the general standard of feeding in commercial herds had been so improved in relation to that of the registered purebred population, that differences in productivity were now less apparent and it became a matter of increasing difficulty for farmers to select sires capable of giving satisfactory results, particularly

in higher producing grade herds.

Third, in the case of untried bulls, the pedigree information with which the farmer was supplied was frequently misleading and almost invariably inadequate as a sound basis for selection.

Fourth, the long period of phenomenal demand for registered sires had undoubtedly greatly weakened the intensity of selection practised in many registered purebred herds, and, further had encouraged the establishment of numerous small herds of registered stock in which little constructive breeding was attempted and the proportion of inferior bulls bred was high.

Even for some years before the slump, owners of high producing grade herds had had serious reason to be dissatisfied with the breeding results of purebred sires, and in some instances, homebred or purchased non-registered animals were used in preference to registered stock. Such a policy was frequently successful in maintaining or increasing herd average production, but usually resulted in an increased heterogeneity of producing qualities amongst replacement stock.

With the serious slump in produce prices in 1930, 1931, 1932 and their further collapse in 1933, 1934 and 1935, the multiplication of dairy cow numbers which had commenced as a movement designed to achieve balanced efficiency in production, became an urgent economic necessity as part of a cost-reduction programme. The addition of more than 500,000 cows to the national dairy herds, at the rate of more than 100,000 per annum in 1931, 1932 and 1933, was attained through an enlargement of existing herds brought about by the absorption of a further increased proportion of young stock and by the retention of those aged cows and low-producers which normally would have been culled from herds. Selection for higher production was therefore relaxed in two directions: amongst young stock coming into the herds, and through a certain amount of breeding from cows that in normal circumstances would have been culled on a production basis. At this time, too, many small herds on mixed and sheep holdings were temporarily enlarged by the addition of cows frequently possessed of very inferior milking qualities, including an estimated total of 50,000 beef-type animals. Young stock bred in such herds was sold for use on true dairy farms.

Although very many farmers continued to select their herd-sires on the formerly justifiable and satisfactory basis of butterfat production records in the immediate female ancestry, the results from the use of such sires became more and more frequently disappointing where the herd average butterfat production level was reasonably high. It was gradually being more widely realised that evidence of production performance in the pedigree is not a certain indication of the potential ability of an untried sire to transmit reasonably high producing qualities uniformly to all his daughters.

Climatic conditions between 1930 and 1937 were on the average rather unfavourable to grasslands production, and further, owing to the prevailing adverse economic conditions, a serious decline occurred in the amounts of fertilisers available per cow for topdressing, and the area of grassland topdressed, instead of being greatly increased to meet the increased stocking of dairy farm lands, was substantially diminished.

As a result of these deficiencies in both the breeding situation and the general feed position, a fall in average butterfat production per cow was inevitable. The average for the season 1929-30 reached a record high level but a reduction of 8 per cent occurred in the following two seasons, accentuated by unfavourable climatic conditions but mainly due to the inferior production capacity of many cows added to dairy herds at this time. The average yield for the ten seasons ending 1938-39, indeed, was below that of the initial season, 1929-30.

From the peak attained in 1934-35, cow numbers declined by some 100,000 to a total of 1,854,000 (including 1,744,000 cows in milk) for the past season, 1938-39. The reduction was accomplished mainly by retrenchment in herds temporarily increased for dairy purposes on mixed and sheep farm holdings during the years of economic depression. In herds on true dairy farms, reductions were made in some cases, but more often herd numbers were maintained by the replacement of aged and low-producing cows with suitably bred young stock. In spite, however, of these several seasons of consolidation, butterfat production per cow was not markedly improved. the average for the 5 year period 1935-39 being less than

3 per cent higher than that of the five years 1930-34.

Between 1920 and 1939, average butterfat production per cow was increased approximately 50 per cent, but of this gross improvement, 40 per cent had been achieved before 1930. It is clear that progress in raising per cow yields proceeded four times more rapidly between 1920-29 than from 1930- to 1939. It is, of course, a matter of relatively less difficulty to lift production averages over the range 150-200 pounds of butterfat than over the range 200-250 pounds of butterfat, but such improvement as has occurred since 1930 has been so extremely slow, in view of the improved organisation of most phases of dairying, that the national average butterfat production per cow would seem to constitute at the present time the main limiting factor to the increased efficiency of the dairy industry as a whole.

It is necessary to emphasise, however, that the New Zealand average butterfat production per cow is an estimated return, embracing all cows kept for dairy purposes in the Dominion, in milk and dry, on dairy farms, sheep farms, mixed holdings, farmlets, etc., etc. It represents a lower level of production than prevails on true dairy farms, because it includes records of production from cows on holdings where dairying is not normally part of the farm business but exists simply to supply household requirements of milk and sometimes butter. The breeding, feeding and management of such stock are of a low order, standards consistently lagging behind the more advanced methods developed on holdings where dairying is the main or only farm enterprise. As the level of production in commercial herds is raised, so, after a time, that in household or mainly non-commercial herds is also raised, but the improvement so attainable is limited by the care and attention bestowed on the herd.

The proportion of such stocks contained in the dairy population is, however, small and the low Dominion average production is not attributable entirely to their depressing influence. Clearly, the level of productivity in many herds, the sale of products from which constitutes a major portion of the farm income, is also exceedingly low. In a detailed survey covering 19,307 farms where dairying was at least a major source of farm income and which

carried at least 5 dairy cows and supplied at least 1500 pounds of butterfat (or equivalent in milk) to a dairy factory in the 1935-36 season, the Census and Statistics Department obtained the following distribution according to herd production.

Butterfat per cow	No. of Farms	Percentage
Under 100	129	0.7
100 and under 160	2516	13.0
160 and under 200	3637	18.9
200 and under 260	7892	40.9
260 and under 300	3663	19.0
300 and over	1470	7.6
(Av: 227 lbs per cow)	19,307	100. 0

These figures are regarded as fully representative of dairy farms in the Dominion, yet more than 70 per cent of herds average less than 260 pounds of butterfat per cow. (The average overall area per farm was 169 acres, including 29 acres unused, 49 acres devoted to other purposes, 91 acres being used for dairying; the average size of herd was 42 cows and the average production per acre was 105 pounds of butterfat).

In view of the only slight upward trend in per cow production of recent years, it seems unlikely that the present position is markedly different from that of 1935-36, despite the elimination of many low producing animals from dairy herds, the rearing of fewer replacement heifers, the recent advances in farm, pasture and herd management, and the stimulus of more stable economic conditions. Ward, in an examination of the records of 60 herds over a period of eight seasons showed that when herds were grouped according to different levels of production, there was a clearly marked "tendency for herd levels under present selection methods to show a definite trend towards the general average of all stock". (This would appear to be in the vicinity of 275 pounds of butterfat). It is suggested that until complete selection methods are employed (that is, by testing the producing qualities inherent in the sire) this will continue to be the trend

evident over sufficiently large and representative number of herds". Ward maintains that, while other factors affecting farm efficiency in general (such as the production and utilisation of feed, carrying capacity, disease incidence, etc.) are important influences on herd averages, "the herd sire is on the average the greatest single influence on the productive level of the herd". He finally concludes that :

- (a) "Selection of replacement stock from tested dams, whilst superior to selection by other methods of appraisal, is definitely limited by the average ability of the herd sires used".
- (b) "The greatest immediate means to improvement in dairy stock may be said to be in :
 - (1) A general and continuous improvement in the standard of stock from which sires are reared, and
 - (11) Selection of sires for continued use in the industry on the basis of complete progeny records".

If the economical production of maximum amounts of butterfat (measured as milk, butter, cheese, etc., as the case may be) per acre is accepted as the common aim of those engaged in dairying as a business enterprise, then the establishment and maintenance, at low cost, of a herd of dairy cows uniformly high producing and reproducing over a period of years, is a basic requirement. High butterfat production per acre is associated with high carrying capacity, high herd average butterfat production, high per acre costs of labour and fertilisers, but low net total costs per pound of butterfat produced. In short, production per unit area is a satisfactory measure of general farming efficiency. At the present time, production costs in general are relatively high but conditions have arisen which assure the profitable disposal of a greatly increased export surplus of dairy produce.

Attention to the following points, however, is a necessary preliminary to expansion of output.

- (1) A large proportion of dairy cows in the Dominion does not at present receive feed of adequate quality in sufficient quantity to permit maximum economic expression of hereditary production capacity.

2. Herd management, additional or complementary to the feed position, is frequently a limiting factor to increased efficiency in herd and per cow production, due to the losses (often avoidable) incurred through faulty arrangements in regard to time of calving, length of the dry period, disease prophylaxis, general handling, etc.
3. Selection for high production within the herd is often seriously impeded by the incidence of diseases such as mastitis, contagious abortion, temporary sterility, tuberculosis etc, which reduces the degree of true culling practicable at any one time and, further, diminishes the intensity of selection possible amongst young stock.
4. Selection amongst replacement stock is limited by carrying capacity of the farm unit, labour attention available, and farm management factors determining the maximum number of calves to be raised in each production season.
5. Selection amongst registered purebred stock is relatively less intense than in many grade herds where purebred sires are intended to be used, with the consequence that, in view of the greatly improved average production of commercial stock due to the grading-up- process and to more efficient feeding and management, the average registered purebred sire available for use in the industry is no longer capable of raising or maintaining herd average production in reasonably high grade herds, through the production qualities of his daughters.
6. The use made of herd-testing services available to both registered purebred and commercial dairy herds is so slight as to negative constructive endeavours to place national breeding procedure upon the sound basis which is readily possible by the practice of systematic culling on a basis of production records, by the retention of all sires in use until their usefulness or otherwise to the industry is proven on the evidence of all their daughters' production performances, and by the thorough utilisation of evidence contained in the herd-test returns on the correlation between feeding and management methods on the one hand and herd production records on the other.

(11) The Influence of Herd Testing.

Individual cows have long been selected or rejected for breeding purposes on dairy ability as judged by the dairyman's arbitrary estimate of "milk flow" or by the results of intermittent weighings of milk produced at a series of milkings or by the records of churning tests. Such experiments were designed to provide private information for use in the herd-owner's breeding programmes. The first independent authorities which carried out systematic cow-testing were the Holstein-Friesian Breeders' Association of America (1883), The English Dairy Show (1886) and the Friesian Herd-Book Society of Holland (1893).

Systematic herd-recording was commenced for the first time in 1895 when a number of breeders at Vejlen in Denmark formed a society for the specific purpose of measuring the production of dairy cows. The invention of the Babcock Test (1890) and the Gerber Test (1892-95) had provided relatively simple methods of testing milk for its butterfat content and the cow-testing movement spread rapidly, both in Denmark and in other European and overseas countries, as follows :

Denmark	1895	England & Wales	1914
Germany, Hungary	1897	Tasmania	1915
Finland, Norway, Sweden	1898	Union of South Africa	1917
Netherlands	1899	Belgium, Danzig	1919-20
Austria	1900	South Australia	1920
Scotland, Ireland, Czecho	1903	Northern Ireland	1921
Latvia, Poland, Canada	1904	Victoria	1921-22
France	1905	Switzerland, Italy	1922
United States	1906	Lithuania	1923
Estonia, New Zealand	1909	Rumania	1930
Irish Free State, Queensland	1910	Southern Rhodesia	1929-32
Argentina	1911	Western Australia	1932
New South Wales	1912	Spain, Luxembourg	1933

The first Babcock tester reached New Zealand in 1892 and experimental cow-testing for milk and butterfat yields commenced almost immediately. Benjamin Wayte, a Dairy Instructor and Grader, initiated a series of investigations on a Waikato farm in 1896. From 1900 until 1960 when he published an important paper on the subject, J.G. Harkness was active in stressing the advantages of herd-testing. In the season 1904-05, systematic testing of the dairy herd was instituted at the Weraroa State Farm under the aegis of the Department of Agriculture; milk weights were taken night and morning and tests for fat content were carried out monthly. In 1905-06 systematic testing was carried out on private farms at Rata, Rongotea and Woodvil

During the 1906-07 season, J. Burgess, Warea, commenced testing and became an important influence in the extension of the movement by means of published articles and addresses; he was able to demonstrate the value of herd-testing to herd improvement and used superior purebred Ayrshire sires in his own breeding operations.

In 1908, the Dairy Commissioner visited Denmark and on his return to New Zealand was active in advocating the institution of herd-testing associations similar to the Danish system, in this country. In the season 1909-10, the Dairy Division in conjunction with the Dalefield Dairy Company and some of its suppliers, established a model cow-testing association in the Wairarapa, 815 cows being under test. On two days in each month, the farmer was expected to weigh and sample the milk from each cow, enter weights on a special form and forward this with the samples to his dairy-factory or other testing-depot where a responsible officer carried out tests for butterfat, entered records of cow performances on the special form and returned it to the farmer.

Farmers were at this time developing a deep and growing appreciation of the importance of milk and butterfat records to breeding for production, and the movement spread rapidly. At the outbreak of war in 1914, 25,000 cows were being tested under the system. The numbers declined during the war period but rose again to a total of 45,564 cows tested in the season 1921-22. The peak was reached in the season 1923-24 with 108,070 cows, since which time the number of cows tested under the "association" system (later known as the "Association own Sample Test") has gradually declined due to the institution and rapid extension of the Group Herd Testing movement.

Unquestionably, the testing movement has exerted a wide influence upon dairying since the earliest days of its establishment, particularly in focussing attention upon the value and importance of a direct measure of milk and butterfat producing capacity in dairy cows as a guide to farm as well as herd management. The value of herd-testing has been recognised by progressive dairy-men not merely as a means of increasing herd average production for its own sake but because of the data which it provides are fundamental to rationalisation and reduction in farm costs.

In the early post-war period, with the development of intensification in production, dairy herds were enlarged, new herds established, milking machines were increasingly widely used and a heavy demand arose for herd-testing services. Deficiencies became manifest in the Association system. The wide use of releaser-type milking plants, a reduced labour complement in milking sheds, the inability of untrained dairymen to take milk samples correctly as well as the fact that production records so obtained were not generally acceptable to buyers of stock militated against the continued success of the system.

In 1922, as the result of collaboration between the Farmers' Union and the New Zealand Co-operative Dairy Company Limited, the Waikato Farmers' Herd Testing Association was founded in Hamilton. During the 1922-23 season, this body operated six groups in the South Auckland district, officers being employed to visit farms, record production of cows at 30-day intervals and take samples for testing. Special plant was provided each officer for dealing with machine-milked herds. In 1923-24, the association was reorganised under the title of the New Zealand Co-op. Herd Testing Association; further groups were established in the Bay of Plenty, Wairarapa, Manawatu and Northern Wairoa. In 1925-26, groups were organised in Otago, Southland, and Taranaki, and the number of cows tested had risen to 97,575.

During this time, a variety of methods of testing and recording had been developed by the several associations to which the various groups were attached, and the need arose for a co-ordinating body.

In July 1926, the Dominion Group Herd Testing Federation was formed, with the following objects:

- (a) "Through group herd testing associations and/or societies to improve the standard of dairy cattle in the Dominion of New Zealand by systematic and efficient testing, by the marking and registering of calves, by the elimination of unpayable cows, by the eradication of scrub bulls, by the encouragement of the use of purebred bulls bred on the best butterfat record, and by any other means which may be deemed necessary and expedient.

- (b) "To standardise and/or assist in standardising the group herd testing methods throughout the Dominion of New Zealand;
- (c) "To assist in the extension of the group herd testing system in New Zealand."

Administration of the Heifer Calf Marking Scheme instituted by the New Zealand Co-operative Herd Testing Association in 1925-26 was one of the primary functions of the Federation. Previously, herd-testing was mainly utilised as a means of detecting and eliminating low producing cows from dairy herds but a need became apparent for the full recognition of the value of progeny of high grade cows in herd improvement. The Calf Marking Scheme was designed, therefore, to tattoo, register and certificate heifer calves from cows meeting minimum standards of butterfat production, sired by registered purebred bulls. In 1931, the further qualification was added that the dam of the sire should have produced at least the minimum butterfat record required under C.O.R. testing.

Although the Federation was (and still remains) the coordinating authority amongst herd-testing associations, it was without statutory power to control the national testing organisation and fully to safeguard testing interests. The Dairy Industry Commission recognised these limitations and realising that "herd testing is..... one of the most progressive movements for increasing the efficiency of dairy herds and of dairy farm management," recommended the establishment of a "New Zealand Herd Testing Council which would prescribe standards and methods, and which would control all testing in New Zealand". These proposals proved unacceptable to the breed societies but, in view of the necessity for adequate control over group herd testing, further representations were made by the Federation. As a result, group herd testing in February 1936 was placed under the statutory authority of the New Zealand Dairy Board, advised by a Herd Recording Council representative of dairying interests.

Herd testing associations are now required to be licensed by the Dairy Board acting through its Herd Recording Department and Advisory Council. The Dominion Group Herd Testing Federation

remains the co-ordinating body for association interests, membership being confined to licensed herd testing associations, each operating in defined territory.

In 1937, recognising that systems of determining merit in herd-tested stock possessed a fundamentally genetic weakness in that selection was practically restricted to the female side of the pedigree only, the Board introduced a sire survey scheme, in order to :

1. "provide a service for all testing members whereby the general effect of the sire in the herd may be ascertained: this will complete the information which should be available from herd testing data concerning the breeding, management and culling of dairy stock.
2. "obtain much needed data on the inheritance of milk and butterfat producing qualities, and to provide a basis for future investigational work into all factors affecting milk and butterfat production.
3. "survey the economic aspect of present breeding trends in the Dominion and to suggest a basis for policy in future breeding practices".

The scheme requires that a sire and daughters and daughters' dams be individually identifiable at the commencement of the survey; that all daughters in milk be included, the total to be not less than ten; that the herd must have been under test during at least the two previous seasons. A preliminary survey is issued on the results of the daughters' first lactations, an intermediate survey at the conclusion of these daughters' second lactations, and the survey in final form when the daughters have completed three lactations. The survey is presented in diagrammatic form, the production of daughters and dams being converted to an "average maturity value" by means of an age correction factor, in a standard lactation period of not less than 200 and not more than 320 days for all cows. Dam productions are plotted along a base axis in order of production, and each daughter is placed in the same order as her dam, but also according to her own production. The result is a picture of the effect of the sire upon the herd. In addition, an indication of the net effect of the sire is obtainable

from a comparison of the average maturity equivalent production of all daughters with that of all dams.

The results of sire surveys issued up to 31st August, 1938, are as follows :

Dams' Production (lbs. fat)	No. of Surveys.	Improving No. %	Maintaining No. %	Lowering No. %
under 320	9	7 78	1 11	1 11
320-339	12	4 33	6 50	2 17
340-359	30	7 23	14 47	9 30
360-379	29	8 28	7 24	14 48
380-399	9	3 11	4 45	4 44
400 & over	11	1 9	2 18	8 73
TOTALS:	100	28 28	34 34	38 38

From these figures it would appear that, on the average, less than one sire in three in use in the industry (if the returns constitute a random sample of the population) is capable of improving the average production of his daughters over that of their dams. Further, since only 34 per cent of sires are capable of maintaining production, it is clear that more than one-third of dairy sires are causing actual serious harm in the herds in which their progeny are being milked.

When the returns are analysed according to the effect of the sires in various ranges of production of dams, it is found that nearly 80 per cent of sires used with cows producing less than 320 lbs butterfat are successful in leaving daughters superior in average productive merit to that of their dams. Less than 10 per cent of sires mated with cows producing more than 400 lbs butterfat, however, are capable of improving on this level of production through their daughters from such cows, and over 70 per cent of these sires leave daughters lower in production, on the average, than their dams. While the number of surveys included in each production group is limited, the marked tendency, except in the lowest production group, of bulls generally to prove themselves incapable of siring daughters of higher average productive merits than their dams is exceedingly evident. The net effects of the use of so many unsatisfactory sires in the industry is apparent from the herd-testing returns during recent years.

The progress of herd-testing since the inauguration of the group system is as follows :

SEASON	COWS TESTED twice or more (000)	Cows in Milk 100 days or more (000)	Av. yield of cows in milk 100 days or more (lbs. fat)	% cows test- ed twice or more to total cows in milk. %
1922-23	85	51	234	7.5
1923-24	151	108	213	12.7
1924-25	197	152	224	16.4
1925-26	170	146	221	14.4
1926-27	170	155	240	14.4
1927-28	224	206	225	18.0
1928-29	260	246	241	20.1
1929-30	284	273	254	20.4
1930-31	271	260	241	18.0
1931-32	260	251	237	16.4
1932-33	286	276	256	16.6
1933-34	298	287	262	16.4
1934-35	266	257	252	14.5
1935-36	245	237	258	13.5
1936-37	269	268	267	14.9
1937-38			258	

The number of herds tested under the group system has varied between 4,500 to 5,000 per annum for the past several seasons; the number of herds under "association" test has diminished by more than half since the total of 1242 herds tested in 1932-33. The average size of herd group-tested is between 50-54 cows and that under association test, between 18-20 cows.

Although the average butterfat yield per cow of all cows in milk 100 days or more since 1930 shows approximately a 10 per cent increase over the average for the preceding 8-year period, the fact is very apparent that the average yield is practically stationary at the present time. This condition, together with the unsatisfactory state of the breeding situation as disclosed by preliminary returns under the sire survey scheme, has clearly demonstrated that the benefits available through herd-testing services are not being used to maximum advantage, either by farmers at present testing their herds or by the industry in general.

The Herd Recording Council, concerned at the lack of progress in herd-building and impressed with the urgent necessity for reduction in production costs on an industry-wide basis, has formulated (1939) a national Herd Improvement Plan, designed to enlarge the scope and influence of herd-testing services. Emphasising the necessity for exploring all methods of cost reduction, the Council

concludes that, in view of the generally high plane of efficiency obtaining in the phases of the manufacture and marketing of dairy produce, if further substantial savings are to be achieved, then a state of greater efficiency in dairy farm production itself offers the main prospect of permanent improvement.

The Council has listed a series of seven exceedingly important points emphasising weaknesses in the present state of dairying and measures by which greater efficiency may be attained:

1. The average production per cow has been practically stationary for the past six seasons;
2. The average production of pedigree cows under Group Herd Test is now no higher than that of grade animals tested under similar conditions;
3. The most reliable data from the farm end of the industry is collected from those farmers who are consistently testing their herds;
4. The most reliable measuring rod to determine the efficiency of varying methods of stock improvement is the data derived through the Herd Testing organisations;
5. The most practicable methods of reducing the ratio of farm costs is by increased production per cow and per acre;
6. The Herd Testing organisations provide the most convenient channel for collecting reliable information on which can be based a comprehensive and scientific attack on disease problems that are causing annually an abnormally high percentage of stock replacement;
7. Consistent herd testing is essentially one of the main factors in educating the dairy farmer to raise his plane of farm and stock management."

In the operation of the Plan, herd testing Associations have been reorganised into six Herd Improvement Associations, five of which are in the North Island and the other in the South. Each Association will maintain a field staff, additional to testing officers already employed, so that an advisory service will be available to testing farmers and a mechanism provided for the prosecution of an educational campaign designed to encourage the

testing of more herds. With the aid of a State subsidy, the cost of testing has been considerably reduced per cow, and a system of rebates introduced with the purpose of encouraging the consistent annual testing of dairy herds. Further attempts are being made to obtain the co-operation of breed societies in raising the standards of production and breeding performance in registered purebred stock from which sires are selected for use in the industry.

The Plan, in short, aims at providing the maximum possible of detailed information on all points affecting the efficiency of dairy farm production, with the emphasis upon the breeding, feeding, management and diseases of dairy stock. This clearly is the only sound and rational basis for a programme of national cost-reduction in dairying. Through herd-test returns is provided the essential link between the level of herd production and farm management as a whole. The Sire Survey work properly utilised in association with the Heifer Calf Marking Scheme, supplies a relatively certain means of maintaining or improving herd production. The collection of disease statistics, already initiated by the Council through the mastitis-testing scheme introduced into herds at the beginning of the 1938-39 dairying season and through preliminary investigations into the causes of culling, is a source of exceedingly valuable data for the prosecution of further research into problems of inheritance of resistance or susceptibility to various diseases and for use as a basis for assisting in the education of dairymen on disease prevention in dairy herds.

It is evident that if the benefits of these services are to be fully availed of by the industry as a whole, a vastly greater number of dairy herds will need to be placed under test. At the present time, approximately 6,000 herds are tested per annum, representing about 15 per cent of all herds on true dairy farms (35,000 to 40,000) and only about 8 per cent of the Dominion total dairy herds (approximately 75,000). Of the total population of dairy cows, about 16 per cent are tested per annum, probably about 10 per cent are tested continuously on a life time basis, and possibly more than 20 per cent have been tested occasionally. Continuous testing of dairy herds is essential if the maximum

benefits are to be secured from herd-test services both within the individual herd and ultimately in the industry as a whole. Life-time records of reasonable production per cow are an important aid in building up herds of animals that will produce and reproduce regularly year after year, thus reducing herd wastage, for herd replacement constitutes one of the major costs in present day farming. Continuity of production records from year to year is, further, essential to the functioning of the Sire Survey Scheme, necessary to the thorough investigation of problems on disease incidence, exceedingly important from the farm management point of view in relating per cow production and breeding policy to the growth and utilisation of feed over a period of years, and, finally, provides a mass of reliable data for the study of dairy farm production problems as a whole.

The advantages of herd-testing in providing a definite index of actual per cow production, as contrasted with the former indefinite and unreliable estimates of productivity based upon considerations of dairy type, have made it possible within the herd to compare the production of one cow directly with that of another in the selection of breeding stock, and the productions of daughters with those of their dams under similar conditions in assessing the breeding value of the herd sire. In addition, however, to supplying a logical basis for breeding policy, herd-testing has exerted an increasingly wide influence upon farm management through the monthly and yearly check which it provides on the plane of feeding and management of the dairy herd in relation to the general activities of the farm. In establishing a sound basis upon which the interrelationship between herd production and farm practice may be thoroughly examined, herd-testing has been an essential guide in the attainment of farming efficiency.

At the present time, with the existing urgent necessity for cost reductions in dairying, the achievement of high production per acre through a suitable balance between high carrying capacity and high production per cow, will depend very largely upon the extent to which maximum advantage is taken of the many services available through the herd-testing movement.

SECTION II: THE REGISTERED PUREBRED STOCK.

a. GENERAL.

In the use of the term "purebred", a distinction must be drawn between "genetically" purebred and "purebred" as it is commonly applied to those of our present-day cattle stocks which are registered in the herd books of the various breed associations. From the strictly genetical standpoint, "purebred" necessarily implies homozygosity - i.e. purity of hereditary constitution for some specific characteristic or characteristics. Thus, a polled bull that produces none but hornless progeny, no matter with what cows he is mated, can be described as "purebred"- for the factor of hornlessness.

But the same bull may have been registered in the herd book of his breed, in which case he is known as a "registered purebred bull". Yet, be it emphasised, his admission to registry depends less upon his individual ability to produce polled offspring than upon the fact that both his parents had been listed in the herd book. "Purebred", then, in this sense is only an assurance (which is open to falsification) of freedom from adulteration with the "blood" of other breeds or crosses in the animal's record of ancestry as set out in the herd book. In this wider sense, purebreeding should (but often does not) also imply a relative degree of purity of (or homozygosity for) breed type - that animals admitted to the herd book can be expected to breed stock that will conform to the accepted standards of general appearance as laid down for the breed by the society.

An even more important aspect of the subject is that "registered purebred" dairy stock are far from being purebred for milk production. True, superiority in milk production is presumably the major "raison d'être" of registered purebred stock, but in too many cases, animals expressing excellence in breed type have proved complete failures in milking capacity and/or in production transmitting ability. Complete homozygosity

for high milk production is probably, of course, impossible of attainment in the dairy cow, owing to the large number of genes that are believed to be involved, but a certain degree of concentration in hereditary material should be able to be counted upon in registered purebred stock. That this is not always so is largely due to faulty breeding methods in that inbreeding and linebreeding systems are not, generally speaking, made use of sufficiently to justify the keeping of pedigrees to the extent they are kept under the herd book system. The chief value in breeding of records of ancestry lies in the fact that family groupings are definitely known and hence the development of strains within the breed is facilitated. Herein lies (or should lie) the value of registered purebred stock in providing superior stock for use in grading-up the general dairy cattle population.

Further, the fact should not be lost sight of that many herds of grade dairy cattle (particularly in the Dominion, where pedigree sires are so widely used in grade herds) are virtually equal to much of the registered purebred stock. Where grading-up has been carried out with care and over a long period of time per media of high class sires, certain grade herds are certainly equal in respect to milk production to many of the so-called stud herds. From the standpoint of breeding, however, registered purebred stock will produce greater certainty of results if a degree of close breeding has been practised. If linebreeding has not been practised for at least four generations, then registered purebred herds are no better in supplying breeding stock than good grade herds where high class pedigree sires have been used consistently and carefully over a period. The distinction between registered purebred stock and high grade stock thus disappears, for a good individual in the fourth generation of a pedigree means almost nothing unless the blood has been concentrated by some form of close breeding. Both stocks are for all practical purposes "purebred", the ancestry is known in

each case for, say, at least four or five generations, and the only remaining difference, the fact of registration in the herd book, ceases to have any practical value.

The fact, however, should not be overlooked that in any one breed, the registered purebred stock of the present are held, by virtue of the evidence in successive issues of the herd book, to be descended from an originally small number of animals whose qualities were outstanding. A concentration of these qualities in the immediate descendants was usually obtained by a period of intense inbreeding whereby a definite type of animal with definite dairy capabilities was established. Upon this foundation the breed was constituted and developed both numerically and functionally. Hence in the case of the great dairy breeds, high class registered stock preserves, as a general rule, an unbroken line of descent free from outside adulteration and relatively concentrated by some degree of close breeding, from a small group of superior individuals. Herein lies the greatest value of registered purebred stock -- in the provision, ideally, of a source of superior selected "seed stock" for the grading-up and general improvement of the dairy cattle population as a whole.

b. ORIGINS AND DEVELOPMENT OF THE BREEDS.

The domestication of animals is a relatively recent development in the progress of civilisation, for although man made his appearance in Europe approximately half a million years ago, there is no evidence that cattle were living there under conditions of domestication before 6000 B.C. It apparently never occurred to Paleolithic man "that by forming herds of tame animals life would be relieved from the constant dread of famine and, above all, time saved and leisure gained which could be occupied with experiments fruitful in results for the advancement of civilisation". (Macalister).

The huge "urus" of Caesar was a species of ox living in the wild state in Britain long before man made his appearance there. Following the Pleistocene age the species degenerated and decreased in size, approaching more nearly the more modern progenitors of the wild white cattle which are still preserved in a few parts of the United Kingdom. By about 1000 B.C. this wild undomesticated ox had died out in practically all parts of Great Britain.

Meanwhile small cattle of various kinds, domesticated probably in North Africa, had come to Britain in large numbers with the migrating Iberian peoples and for many centuries the type of cattle remained small. But the Angles and Saxons had evidently obtained a cross between the Urus and their smaller domesticated cattle for, following the Saxon invasion of Britain, the character of the existing domestic cattle population rapidly changed. The Normans continued the work which the Saxons had initiated and, in addition, introduced red cattle to some of the counties on the coast.

The heterogeneous nature of the early domestic cattle populations resulted in the formation of a large number of more or less isolated types scattered in various parts of the country. Long association with one particular district doubtless also

developed gradual changes in the characteristics of the stock. Thus when the eighteenth century dawned, with its promise of radical change in methods of cattle-breeding, Britain contained large numbers of "native" cattle, peculiar in many cases to a particular district. The action of natural selection under the varying environmental conditions over a long period of years, the primitive condition of transport and inter-communication, the undeveloped nature of the countryside and the influence of selective breeding practised by early husbandmen had brought about a considerable amount of differentiation into more or less uniformly breeding strains amongst cattle which ultimately, at the time of their introduction to Britain, had been closely related in type as well as in ancestry. It was upon these different types of "native" cattle that the celebrated master craftsmen worked, developing from them animals from which are ultimately descended some of the great modern breeds as we know them today.

At about the beginning of the 18th century, too, methods of farming were being consistently improved and, with the enclosure of the common lands and the introduction of clovers, turnips and other root crops into farm practice, farmers were beginning to take a genuine interest in breeding improved cattle better equipped to take advantage of the superior environment. Prices for farm produce showed a general rise under the stress of the frequent wars and through an increasing urban population consequent upon the rise of manufacturing industries. As cattle stocks were improved, increasing demands for better quality animals came from overseas and a new phase of English agriculture set in - the breeding of blood stock for export. With it came the formation of the Stud Books and the organisation of the Breed Societies.

Mention must be made of the work of Robert Bakewell (1725-1795), sometimes called "the founder of animal breeding". Working with Longhorn cattle, Shire horses and Leicester sheep, Bakewell, in his home at Dishley, Leicestershire, was successful in producing new animal types so superior in merit to the

stock from which they were derived that stock-men came from all parts of Britain to study his methods and later to apply the system to the best of their own stock. He initiated the system of bull-letting - i.e. males of his breeding were first hired out to breeders in various parts of the country and no bull that had not given evidence of ability to sire high quality progeny was used in his own herd. Obviously he had a very high appreciation of the ideal type of animal to be aimed at; equally evident is his realisation of the value of and means of inducing prepotency; he made full use of the basic principles of breeding: "like begets like" and "mate the best to the best"; his epoch-making system of sire-letting is now being duplicated, after a lapse of nearly 200 years, in the new emphasis on progeny testing and the importance of bull associations. Undoubtedly Bakewell's influence extended over a wide sphere, not only through the widespread use of animals of his breeding by means of sales and the hiring-out of male stock, but also on account of the attention which he attracted as a resourceful and adventurous pioneer in demonstrating how guesswork in animal breeding could be supplanted by the application of well-formulated principles.

After Bakewell, came what J.L. Lush has described as "a golden age of stock-breeding". It was a period during which unparalleled advances were made in developing from the native cattle some suggestion of the modern organisation of the breeds. Lush summarises the main general steps in development, as follows:

"First came the existence of a type which was more useful and desirable than the ordinary type, but which was not yet distinctly different in pedigree from the other animals in the community. Second, some of the best animals of that type were gathered into one or a few herds which then ceased to introduce much outside blood. Then followed some rather intense inbreeding among these animals and their descendants until the animals of those herds became distinct from the other animals in the community, not

"only in type but also in inheritance; that is, until they were really welded into a breed. Third, as this process had been moderately successful in producing a desirable kind of animal, the breed became more and more popular and more and more herds of them were established. Fourth, necessity for a central herdbook arose when the breed became so numerous and the breeders so many that no man could remember all the information needed for the proper use of pedigrees. Fifth, a breed society was formed to safeguard the purity of the breed, conduct the herdbook, and promote the general interests of the breeders."



Consideration can now be given briefly to the main points in the formation and development overseas of the five dairy breeds used now in New Zealand.

(1) THE SHORTHORN.

The present-day Shorthorn originated in the old North-East of England cattle once found in large numbers in Northumberland, Durham and Yorkshire, particularly in the districts bordering the river Tees. It is probable that Dutch cattle, imported during the sixteenth and early seventeenth centuries and crossed with the native cattle, produced the Shorthorn's distinctive characteristics of large size, short horns, broken colour and dairy qualities. Careful breeding and selection had been practised amongst this stock even before the Colling Brothers commenced to improve the cattle about 1750. The Collings had both spent prolonged periods of study with Bakewell and they applied his methods. Aiming at utility and beauty of form, early maturity and flesh production, they succeeded in developing, by means of

close inbreeding, rigorous selection and progeny testing, strains of cattle that were greatly superior, in general merit and in breeding ability, to the stock from which they were derived.

Thomas Booth and his sons carried on the traditions of the Collings, pursuing the same breeding system and using Colling-breed bulls on cows of good Shorthorn character. The Booth cattle exerted a deep influence on the breed for the early maturing, compact, short-legged, blocky, fleshy type of beef animal became widely known and appreciated. Thomas Booth "regarded flesh-making capacity and breadth of back and loin of more value than a persistent flow of milk". This was the rock upon which Shorthorn breeders were subsequently to split, for Thomas Bates claimed for his famous "Duchess" strain "all the good qualities, including that of milk production, which the Shorthorn breed possessed."

The original Bates "Duchess", purchased from Charles Colling in 1804, was a "deep, rich milker, making as high as 14 lb. of butter per week, and when fed off at seventeen years of age is said to have made an excellent carcase of beef." Bates pursued a policy of closest inbreeding, stating in regard to his "Duchess" cattle that he could find nothing good enough to mate with them. But hereditary infertility was evidently fixed in the strain for large numbers of the cattle proved sterile. Yet the Bates cattle continued to be favourably known for their deep milking qualities and with the growth of an export trade in stud stock, numerous animals were sent to America, Australia and New Zealand, in which countries they were preferred to cattle of the Booth strain until in later years beef-bred Cruickshank stock supplanted them in popular favour.

Shorthorn cattle were introduced into Scotland during the early part of the 19th century by several breeders - most prominent of whom was Amos Cruickshank (1808-1895). Unlike his fore-runners, Cruickshank was for over twenty years unconcerned with inbreeding or matters of pedigree. He looked for individual merit in his breeding stock and animals to suit this

purpose were drawn from the Colling, Booth, Bates and other herds, irrespective of line of breeding. Cruickshank cattle became noted for massiveness and robust constitution and were exported in large numbers to the United States, Canada, Australia, and New Zealand, for beef production.

The famous Coates' Shorthorn Herd Book appeared in 1822. George Coates was a Shorthorn breeder in a small way who had made a private collection of the pedigrees of many of the well-known improved cattle of the breed. While breeding records of the better bulls had been available for a period of about fifty years before this time, pedigrees containing names on the female side were extremely rare and few extended back beyond 1800. The Coates' collection, while it received much initial criticism from breeders, later proved its value in keeping the breeders in unison, in preserving the freedom of the breed from outside adulteration, and in enhancing the commercial value of registered stock.

The Coates' Herd Book continued to be issued more or less as a private venture until 1876 when the Shorthorn Society of the United Kingdom took over its publication. The development of the herd book movement is significant as indicating the rapid growth of cattle breeding which, from being a local affair centring about a small number of herds where details of the ancestry of breeding stock could readily be memorised, had progressed to a stage where the number of herds had become so great and the cattle so widely distributed that some permanent record of pedigree became essential if the breed was to be preserved. The necessity for a herd book gradually became universally admitted and, to prevent extortionate charges for registration, as well as to safeguard the official recognisance of the register of pedigrees, the breed society was formed to represent the interests of the breeders as a whole and to issue the herd book. In the Coates' Shorthorn Herd Book, "No bull is eligible for insertion unless it has five crosses, and no cow unless it has

four crosses of Shorthorn blood, which are, or are eligible to be, inserted in the Herd Book."

The Shorthorn has always been recognised for its milking qualities but strains within the breed have from time to time been selected for beef production primarily and milking capacity has been neglected as a major function of the animal. Thus the Booth and Cruickshank cattle were bred deliberately for carcase quality, the overweening importance of these strains in the Shorthorn world tending for some time to overshadow the breed's natural deep milking proclivities. The Bates' Shorthorns were of course selected for the dual characteristics of milking capacity and beef production, but the breeding of true Dairy Shorthorns capable of equalling any of the avowed dairy types in production of milk and butterfat, and at the same time of preserving certain of the fattening qualities of the breed, is a relatively recent development in Shorthorn history.

In 1899, the British Shorthorn Society instituted prizes for Shorthorns of outstanding dairy capacity that were entered in the Coates' Herd Book, and classes for Dairy Shorthorns were established at the leading shows in 1901. The Dairy Shorthorn (Coates' Herd Book) Association was formed in June 1905, by fifty members of the Shorthorn Society, all being men of long experience with the breed. The Chairman of the inaugural meeting of the Association explained that : "It was necessary that something should be done to maintain the position of the Shorthorn as a dairy cow. The farmer required an animal which would yield a large amount of milk and which was capable at the same time of carrying flesh; the Dairy Shorthorn was the ideal animal for this purpose. The Association would, by offering prizes for milk tests, by securing classes for Dairy Shorthorns, and by recommending judges, do their best to sustain and popularise the Shorthorn for dairy purposes - a breed which had for many years been so justly famous for beef. There was no question

of starting a separate herd book, and they had the approval of the Shorthorn Council."

The Dairy Shorthorn Association is of particular interest in that it was the first breed society to publish authentic milk records. At the Dairy shows, all bulls shown must be the progeny of cows that have qualified as milkers under the rules of the Association, and their paternal grand-dams must also have so qualified. The Association also records the milk yields of non-pedigree Dairy Shorthorn cows (which are bred in large numbers in most parts of the United Kingdom and particularly in the North of England and in Cheshire) with a view to the entry of their progeny by registered Shorthorn bulls into the Coates' Herd Book.

Shorthorns were first exported to North America in 1783 and throughout the nineteenth century large numbers of cattle of the most famous English and Scottish strains passed into the country. The first American Shorthorn Herd Book was published by Lewis F. Allan of Black Rock, New York, and it continued to be issued as a private venture until the American Shorthorn Breeders' Association was organised in 1882. Coates' Shorthorn Herd Book qualifications are now practically accepted by the American Association although, unlike the former, the American Shorthorn Herd Book has been closed to all but the descendants of registered cattle since the beginning of pedigree registry in that country.

The first Shorthorn Herd Book in Canada was the Canadian Shorthorn Herd Book, published in 1867. The first volume of the British-American Shorthorn Herd Book appeared in 1881, but with the publication of the Dominion Herd Book in 1887, all the interests and records of the first two herd books were acquired. All Shorthorn registrations in Canada are now conducted through the Dominion Herd Book.

2. THE AYRSHIRE.

The original habitat of the Ayrshire was Cunningham, the upper part of the three divisions of the county of Ayr, a region where only a hardy active race of cattle could adapt itself to the humid climate and sparse hillside pastures. The native progenitors (before 1750) of the modern Ayrshire were of the so-called "Celtic shorthorn" type - small inferior unshapely cattle, mostly black in colour. Investigation has tended to show that it was upon this hardy foundation stock that various outside crosses were made, from which emerged by careful selection and better methods of feeding and management, the forerunners of the present-day Ayrshire.

Dutch cattle, valued for their milking capacity had been imported into various parts of England and Scotland from earliest times and it is probable that it was through the mating of superior imported animals with the native stock that the modern Ayrshire derived much of its distinctive colouring and milking qualities while preserving its inherent hardness of constitution. It is possible that the Dutch strain was introduced also through crosses, on the native Ayrshire stock, of cattle brought into Scotland from Teeswater where the ancestors of the modern Shorthorn were being bred. In early portraits of the breed published before 1828, can be traced some of the essentials of the modern Ayrshire - the wedge-shaped deep body, the short legs and the well-formed udder. A.D. Buchanan Smith concludes that "The Ayrshire as we know it now, derives its milk vessel from the native cow of the district, from which, together with the importation of some Dutch blood through Yorkshire, it gets its capacity for milk production."

A Highland heifer introduced into the Swinlees herd of a prominent breeder, Thomas Paton, is believed to be mainly responsible for the characteristic turned-up horns of the breed, for Swinlees stock became widely distributed amongst breeders. But while this infusion of Highland blood through the Swinlees

herd largely effected the stronger set of the horns, there is no equal certainly that the same cow assisted in the same measure to fix the compact udder and well placed teats, for there is evidence that the earlier breeders had aimed at these features in their stock.

In 1865, Lawrence Drew Jr. of Merryton bred the bull "Burnhouses" whose female progeny "were full of style, with grand frames and rightly hung vessels, while their teats were rightly planted and of the proper dairy size", and whose sons were widely used. Shortly after this, however, Drew acquired a cow (Mrs. Baird) of unknown breeding, which, although undersized had a very tight and level vessel with small teats. In virtue of her excellence in this one feature, the cow was extremely successful in the showring. The subsequent widespread use of her male progeny began the evolution by a certain group of breeders of the "vessel-bred cow" in which sheer beauty of form and symmetry, particularly of udder attachment, were emphasised at the expense of milk production. As a result of this development, Ayrshire breeders split into two schools of thought - not as between milk and beef as in the Shorthorn breed - but as between two kinds of "dairy type".

The Ayrshire Cattle Herd Book Society was established in 1877 and the first volume of the herd book was published in 1878. Animals graded up from the common stock of the South West of Scotland have continually been admitted to registration after four top crosses with pedigree sires.

Milk-recording began in Scotland in 1903 and sharply accentuated the difference between vessel-bred cows and those bred for milking capacity. The milking qualities of their stock had been maintained by many breeders despite the exigencies of a show system which made high awards to cows on vessel alone and to bulls on so-called "show appearance". This had been effected by the selection of sires, not upon prize-

winning ancestry but upon milking capacity in the pedigrees; the introduction of milk-recording showed the failure of the Ayr Show System where general utility in milk production had been to a large extent forgotten as the primary function of dairy stock. In 1921, the Ayr New Show was instituted, where animals were judged on a points system which took into account both conformation and milk yield.

As previously, in vessel-breeding, so after the War, in breeding for milk production, there became noticeable in some quarters a tendency to go to extremes - to select for very high yields, at the expense of vessel, legs and body conformation generally. While the cows giving very high yields may be desirable from the viewpoint of improving the production of others, it is very questionable, particularly with regard to the Ayrshire, whether an extravagantly high general average of production is to be sought after. High yields can only be attained at the expense of those features of leg, udder and constitution which have made the Ayrshire breed outstanding as an economical milk producer under relatively hard conditions.

Following the emphasis on maximum yield to the detriment of other constitutional qualities, certain "milk" breeders began to incorporate "vessel-bred" strains into their herds. Moreover, amongst recorded vessel-bred herds, there has been a steady increase in the milking capacity of the stock. Thus, of recent years, there have been evidences of a willingness to co-operate between the two schools of breeding, while at the same time the two distinct types are preserved. A.D.B. Smith states: "While it is not possible for the dispassionate observer of the Ayrshire breed to praise the craze which led to the development of the vessel type, it is only justice to state that this type has recently made a definite contribution to the breed, and probably will continue to do so in the future. It must never be forgotten that one of the great characteristics of the breed - the character most envied by supporters of other breeds - is the shape of the udder".

Modern developments in Ayrshire breeding in Scotland include: the spread of the tuberculin testing, the vast majority of tested herds in Scotland being Ayrshires; the institution by the Society of a register of proven sires - i.e. bulls having ten or more high yielding daughters entered in the records of the Scottish Milk Records Association between 1917 and 1934: the standard of production is a yield of 280 pounds of butterfat as a cow, 224 pounds of butterfat as a heifer, with the subsequent recalving at 15 months; the publication in the quarterly "Ayrshire Journal" of a record of living proven sires with daughter-dam comparisons.

The exact date of the introduction of Ayrshires into England is not definitely known but a large herd of non-pedigree cows is recorded as being at Cockermouth in 1876. In 1916 there were only eight members of the Society resident in England but, largely through the influence of the London Dairy Shows from 1923 onwards and the growing importance of liquid milk production, the English membership had increased to 216 by 1937. The development of tuberculin testing and the importance of disease-free herds in the supplying of market milk has fostered an extensive trade in in-calf heifers between Scotland and the T.T. herds of England for the majority of Scottish cattle are free from tuberculosis.

Although the first exportation of Ayrshire cattle to the United States is not recorded before 1822, it must be concluded that milch cows of the breed were frequently carried, for the convenience of passengers, upon many of the ships sailing from Glasgow to North America. The first American Herd Book was published in 1863- 15 years before the issue of the Scottish Herd Book; and the American Ayrshire Breeders' Association, founded in 1875, preceded by two years the establishment of the Scottish Society. Concentrating on production and economy of feed conversion, the Americans paid less attention than the Home breeders to vessel-breeding. Ayrshire

cattle are in great demand in the United States for liquid milk production, the regulation 4 per cent test having done much to focus attention upon the breed's ability to produce the maximum volume of milk at a 4 per cent test.

The first importation into Canada took place about 1845 and Ayrshires were subsequently imported with great rapidity. The Canadian Ayrshire Breeders' Association was found in 1898 through the amalgamation of two former Associations formed in 1870 and 1872 respectively. The first Canadian Herd Book of the breed was published in 1872. There are nearly 2000 breeders in Canada and the annual Canadian Royal Winter Fair is the greatest show of Ayrshires in the world.

Ayrshires first reached Norway in 1855-60 and the breed has been widely used in crossing with the native cattle. The Red Troughjem cattle are nearly pure Ayrshire and the Maselvfø breed in the far north is also of Ayrshire origin, having been developed as a result of continued use of Ayrshire bulls upon the native cows.

Ayrshires were first imported into Sweden in 1844. The Swedish Ayrshire Cattle Breeders' Association was formed in 1899 and shortly afterwards importations ceased owing to the successes of Ayrshire crosses with the native cattle, animals with five top crosses of Ayrshire blood being eligible for registry in the Herd Book. Swedish breeders, although retaining the name of Ayrshire until 1927, have evolved a different type from the Scottish breed, but one that is well adapted to the husbandry conditions of the country. Crosses of Ayrshire and Shorthorn upon native cattle in Middle Sweden about the same time developed another red-and-white dairy breed, but the two were amalgamated in 1927 under the name of "Swedish Red-and-white Cattle" (S.R.B.). About two-thirds of all registered cattle in Sweden are of the Red-and-White breed.

The Ayrshire was imported into Finland for the first time in 1847-48 and numerous heavy importations have continued to be

made since, until at the present time the Ayrshire is the only foreign breed of importance in the country, ranking equally with the native breeds. The Finnish Ayrshire is hardly to be distinguished from the Scottish type and is very different from the rather fleshy Red-and-white cattle of Norway and Sweden. With milk-recording, the major emphasis, as in Norway and Sweden, is laid on life-time rather than on lactation yields, and standards have been established for proving sires through the production of their daughters. An interesting development particularly in Finland, is a register of feed consumption whereby herds are listed which attain a high average production with comparatively small amounts of fodder, but with ample grazing.

3. THE JERSEY.

Claimed to be one of the oldest and purest of the breeds, the Jersey originated, it is believed, in the cattle of the mountainous parts of Brittany and Normandy on the adjacent French Coast. Even in 1734, however, the cattle which had been transplanted to the small Island of Jersey, were asserted to be "superior to the French" (Falle). Of these early days, Colonel le Couteur wrote in 1843 "most Jersey farmers, conscious of possessing a breed excellent for the production of rich milk and cream..... sought no further. (They were) content to possess an ugly ill-formed animal with flat sides, wide between the ribs and hips, cat-hamned, narrow and high hips, with a hollow back. She had always possessed the head of a fawn, a soft eye, her elegant crumpled horn, small ears, yellow within, a clean neck and throat, fine bones, a fine tail; above all, a well formed capacious udder, with large swelling milk veins. Content with these qualities, the only question in the selection of a bull, among the most judicious farmers was 'Is the breed a good one?' meaning, solely, had its progenitors been renowned for their milking and creaming qualities' But the mere attention to this was one of primary importance in a circumscribed spot like

Jersey; it may have been quite sufficient to establish a hereditary superiority in the most needful quality. It may also have established it with a rapidity that could not have been obtained in a wide-extended country like France. Hence perhaps the present superiority of the Jersey over the French breed".

This early superiority to nearby cattle was preserved by means of the famous "Acts of the States of Jersey", which, in 1763, 1789, 1826, 1864 and 1878, prescribed heavy penalties for the fraudulent importation of cattle from France, with the object of excluding disease, preserving the purity of the breed, and fostering the export of Jersey cattle to England. But it was not until after the formation of the Royal Jersey Agricultural and Horticultural Society in 1833 that serious attention was paid to the external appearance of the animals. In 1834, "A few gentlemen, presided over by the then Lieutenant-Governor, Major-General Thornton, selected two beautiful cows, with the best qualities, as models. One of these was held to be perfect in her barrel and fore-quarters, the other equally so in her hind quarters". From these two, a scale of points dealing almost entirely with the external appearance of the animal was set up. Colonel le Couteur and later, Colonel le Cornu - the two great names in Jersey history - were in the forefront of breeders concerned in the endeavours of the Royal Jersey Agricultural and Horticultural Society to improve the general character of the breed on the Island, and to develop its valuable dairy qualities. In 1936, the Society recommended that one superior bull be kept in each parish, and that breeders be encouraged to keep high class heifers on the island in view of the high prices offered for export animals. About 1853, when Island Jerseys became greatly in demand for export to the United States, the Society ruled that prizes gained by bulls would be forfeited if the animals were not kept on the Island for a year, and this rule, slightly modified, still remains in force.

In 1862, the Society stated "It is an established fact that the renown which the Jersey cow enjoys is attributable to

the peculiar richness of its milk, as well as to its docility of temper and neatness of form. Now, as this richness is not so marked in some specimens as it is in others, it becomes advisable to make such selections in breeding as will ensure further amelioration in this most essential and highly important point". Thus, Jersey breeders had placed most emphasis upon quality of milk, upon quantity of butter and, latterly upon neatness of form, but little attention had been paid to milk quantity. In 1865, however, a committee of the Agricultural Society, concerned that breeders should pay greater attention to milk production in their stock, suggested that every cow with the least tendency to weakness in that direction should be "weeded out", and, further, that judges should specially consider this factor in making awards. High milk production per se has therefore figured prominently in Jersey breeding principles only for approximately the last 70 years in its breed history of 200 years, Although quantity of butter had been an emphasised desiderandum throughout its early development.

Coat-colour has never occupied a high position in the attention of the Island breeders, although "colour-grazes" have from time to time swept the history of the breed in other parts of the world - notably in England and America where solid colour Jerseys with black points became the fashion in the 1870's. The Society of Jersey, however, watchful of the future interests of the breed, was active in condemning this development when, in 1873, it reported: "Let henceforth such fanciful ideas as black tails and black tongues be estimated at their proper value, but let the large and rich yield of milk be ever the breeder's ambition to procure".

The Herd Book of the Island was commenced in 1866 and much of the improvement and present high standing of the breed is due to its influence. Unlike overseas Herd Books, evidence of purity of breeding is not sufficient for registration for, actually, owing to the stringent regulations against the importation of live cattle except for slaughter, all the cattle on

the Island may be regarded as pure-bred in the sense that no foreign blood has been introduced into the breed. Moreover, on the Island, with its restricted area (eleven miles long and six miles broad) it has been possible to insist on the inspection of every animal as an unconditional precedent to registration in the Herd Book. Approved cattle which are not the progeny of registered parents but which are of sufficiently high merit are entered as "Foundation Stock" and those born of registered parents as "Pedigree Stock".

The following are the conditions necessary to registration

- (1) Every animal must be inspected by competent judges, and, if approved, it obtains a qualification - namely commended (c) or highly commended (H.C.):
- (21) Every bull submitted for qualification must be accompanied by his dam, in order that the merits of the latter may be taken into consideration in awarding a commendation to the former.
- (111) No heifer, although she may be descended from registered parents, can be entered in the Herd Book until she has had a calf, and if at the time of her examination she is a poor milker, she receives no commendation.

A system of milk recording was instituted on the Island in 1912.

Out of 10,000 Jersey cattle on the Island in 1936, only 173 were not entered in the Herd Book.

A system of milk recording was commenced on the Island in 1912, in connection with the Jersey Herd Book. Only 8-9 per cent of cows are tested in Jersey but "the testing is very thorough and the cost of testing very high." A list of heifers producing more than 1.3 pounds of butterfat and of cows yielding more than 1.7 pounds of butterfat on official tests is published fortnightly. Silver medal, Gold Medal and Medal of Merit Certificates are now issued to cows attaining certain standards of production in 305 to 361 day lactations and complying with certain calving requirements. A bull having three or more daughters qualifying in any one of these divisions is entitled to be called a Silver Medal Sire or Gold Medal Sire or Medal of Merit Sire, as the case may be.

The seventyfirst annual volume of the Jersey Herd Book issued in October 1937, contained the registrations of 197 bulls and 2273 heifers, qualifications for 87 bulls, 905 pedigree stock cows and 10 Foundation Stock cows, and export certificates were listed for 1241 animals. An extremely important source of revenue to Island breeders is from the sale of stock for export, and exceedingly high prices have been paid, particularly by American buyers, for Jersey-bred cattle. In 1937, 716 head of cattle were shipped to England, 462 to the United States, 57 to South Africa, 4 to Kenya and one each to Brazil and New Zealand. For the past twenty-five years, the export of stock has exceeded 600 animals annually, the greatest number (1444) being shipped in 1929 when the American trade was at its height.

Jerseys were first imported into England in 1835 and large numbers of stock were shipped during the 'forties. The English Jersey Cattle Society was founded in 1878 and issued the first volume of its Herd Book in the following year. The Society took the initiative in establishing butter test classes at the principal English dairy shows in 1886.

Jersey cattle were first exported to the United States in 1850, and large further consignments were made, amounting to more than 2000 per head per annum between 1860 and 1890. The Association of Breeders of Thoroughbred Meat Stock was the first organisation in America to issue Herd Books of the breed. Six volumes of the American Jersey Herd Book had been published by 1878 when the responsibility was assumed by the newly established America Jersey Cattle Club. Only cattle that trace directly to Jersey Island are admitted to registry. Jersey cattle rank in numbers next to Holstein-Friesians and Guernseys in the United States and purebred stock registered in 1937 numbered 8436 bulls and 35,246 cows. Jersey strains are widely dispersed in dairy herds throughout the country.

4. THE FRIESIAN.

The name Friesian derives from the Dutch province of Friesland lying north-east of the Zuider Zee, where the raising of cattle mainly for dairy purposes has been the chief occupation of the inhabitants for over two thousand years. About 300 B.C., the Friesians, a pastoral people possessing numerous white cattle, dwelt along the shores of the North Sea; about two hundred years later the Batavians

history are vague, it is known that large broken coloured cattle have existed in the Netherlands for many centuries and it is probable that these originated from interbreeding between the two early races. In the course of time these cattle have been evolved into three prominent breeds, two or three lesser breeds and many mixed breeds; but the Friesian, predominantly black and white with a characteristic colour pattern, and of pronounced dairy type, is certainly the most important and most highly improved of all the Dutch breeds.

The province of Friesland consists largely of very fertile reclaimed sea-marshes upon which highly productive pastures have been sown, and the climate, moist and comparatively fresh, is also favourable to dairying. Under these advantageous natural conditions, the objects of the breeders have largely been fulfilled. "The Friesland farmer has for his aim in rearing a cow, which being fed and treated normally, regularly produces a good quantity of milk and butterfat for years; which is handsome, healthy and of strong build, and when slaughtered yields meat which is not too fat but of excellent quality". (Blink). It is probable that the Friesian cattle have remained in the same territory, without new blood, for at least 2000 years, and have been famous for dairy purposes during the entire period. Although the Dutch have laid considerable emphasis upon beefing qualities, high dairy capacity has always been insisted upon, and the ideal type of the breed which has become constant in North Holland and Friesland is designated as "milk and beef form". The central situation of the Netherlands and its easy access to large markets in England, Germany, Belgium and France have greatly assisted the development of export trade. Pirtle states that both before and during the Middle Ages Friesland carried on an extensive export trade in cattle and dairy products. Also, according to Motley, the cattle industry was very important during the early seventeenth century, and the value of butter and cheese exported annually amounted to millions. The Dutch view, therefore, appears to favour close attention to conformation, substance and constitution, while yet

preserving the breed's extraordinary milking powers. The type has been influenced to some extent from time to time by the relative demands by overseas customers for fat cattle and dairy products.

"The great development of the Dutch cattle industry began in the fifties of last century, largely owing to the opening up of a large market for fat cattle in Great Britain. The demand for the beef type and the intercourse with Britain that were the immediate results, led at this time to considerable importations of Shorthorns which were used for crossing. Twenty years later, however, it was seen that the results were much less satisfactory than had been hoped. Moreover, an export trade in breeding cattle of the pure native types sprang up soon afterwards, and the relative importance of the trade in fat cattle diminished. Hence it happened that the Shorthorn blood was largely eliminated, and the ultimate result of the importations appears to have been small as regards the cattle of the country generally, and negligible as regards those of Friesland. The high value of Dutch cattle soon became widely realised, and extensive exportations were made during the seventies and eighties". (Wallace).

The Friesian Herd Book Association (Friesch Roundvee Stamboek) was organised in 1879 with the object of locating and registering those animals of the greatest value for breeding purposes. All animals submitted for registry are carefully examined on outward appearance by competent judges of the breed. Cows are inspected when they have reached the age of 2 years 10 months and have produced their first calves. Bulls are judged at 13 months of age. The Friesland cattle Herdbook covers all the Black and White cattle of Friesland, but although all are purebred, only 11-12 per cent are registered. The Herdbook Association also keeps a careful record, for pedigree purposes, of certificates of service and birth, and records of the milk production and butterfat of the entire lactation period of pedigree cows.

In connection with the herdbook associations, there

are local societies of three kinds:

1. Bull Societies: Found in all parts of the country, these societies encourage the keeping of high-producing cows, minimise the expense of keeping good bulls, and prevent the exportation of specially high class bulls.
2. Control Societies: These societies control the milk and butterfat records of the cows of the members. The first milk recording association was established in 1899 and 781 were in operation in 1932.
3. Breeding Societies: These organisations generally exercise the functions of both the other societies and also keep records of breeding and young stock.

Dutch cattle had been imported into Great Britain from time to time over a period of several hundred years, but were of relatively slight proportions until the latter part of the nineteenth century when, for the twenty years ended 1892, nearly 50,000 Dutch cattle were imported annually. No widespread efforts were, however, made to preserve the breed and only in a few cases did owners endeavour to improve their stock. With the formation of the British Friesian Cattle Society in 1909, herd book registration (on inspection) was begun. The need for fresh blood of unquestionable purity arose shortly after this time and, by special permission of the Board of Agriculture since all importations of live cattle had been prohibited in 1892, a consignment of 39 bulls and 20 cows was imported from Friesland in 1914. In 1921, negotiations for a consignment of cattle from Canada proving unsuccessful and importation from Holland impracticable on account of disease in that country, a shipment of 95 young bulls and

and heifers was made from South Africa. The Society has established an advanced register of production, the qualification for entry being a milk yield of 1300 gallons for a 5 year-old cow. Several bulls have qualified for recognition as advanced register sires, having ten or more daughters listed on the register.

The early Dutch settlers brought their cattle with them to America but W.W. Chenery, Belmont, Massachusetts, with importations between 1852 and 1861, was the first to establish and maintain a purebred herd. Numerous other importations followed and many purebred herds of Dutch cattle became established. In 1871, the United States Department of Agriculture recognised the breed as "Holstein" and in the same year an Association of Breeders of thoroughbred Holstein cattle was formed. The Dutch breeders in Holland, after protesting vainly against this gross error, assisted Thomas E. Whiting, Massachusetts, to select and purchase a herd of their cattle on condition that he should establish in America a herd book maintaining the correct name of the breed. Accordingly the Dutch-Friesian Cattle Breeders' Association of America was formed in 1879, so that there were two associations and two herd books in the United States. After much controversy a compromise was effected in 1885 when the two conflicting organisations united to form the Holstein-Friesian Association of America. The Dutch-Friesian Association in 1883 had originated a system of advanced registration owing to the fact that many cattle of doubtful merit and unknown breeding were being entered in the Holstein Herd Book. The qualifications for entry in the case of bulls were determined by a special scale of points and in the case of cows by an additional scale of productiveness.

5. THE RED POLL.

Hornless cattle are known to have existed in the county of Suffolk since the beginnings of English history, the breed probably having been brought from North Denmark, via Holland, by invading Angles in the 5th century. Young (1792) describes these Suffolk Dun cattle as renowned for their butter - "justly estimated the pleasantest and best in England".

In contradistinction to these polled Suffolk Duns, the old Norfolk cattle nearby, belonging to the Norse and Danish settlers, were a horned breed described by Marshall (1782) as "A small hardy thriving race; fattening as freely and finishing as highly at three years old as cattle in general do at four or five; the favourite colour a blood-red with a white or mottled face".

The blending of the two very distinct breeds was commenced well over 150 years ago, but for some considerable time however, the Norfolk Polled cattle remained of the hardy early maturing beef type with poor milking qualities, while the Suffolk Polled cattle were remarkable for milk production.

In the early years of last century, John Reeves and Richard England, Binham, set about blending the two breeds for form a "new m kind" of general purpose animal. This was to be without the horns of the "true Norfolk Red" and the bullocks were to fatten to about fifty or sixty stones, with as little coarse meat as could be expected". At the same time, too, one George, of Eaton, began to collect a herd of blood-red Polled Suffolks. Thus the Norfolk and Suffolk breeds were "mixed" and close inbreeding systematically practised through the use of home-bred bulls.

Interchange of cattle of the improved types continued to occur between the two counties, and it became apparent that breeders in Norfolk and Suffolk, both striving to produce blood-red polled stock with dual-purpose qualities, were gradually working towards the same ideal. Show-ring competition between the Norfolk and Suffolk types led to their further admixture on the basis of the blood-red colour and it can be said that from about the year 1846 the two types were finally merged into each other. The constant interchange of the best blood brought about improvement and similarity in the two strains so that at the Royal Agricultural Society's Show in 1862 they were found to be indistinguishable and became publicly recognised as "the Norfolk and Suffolk Red Polled" breed. Twenty years later the name was shortened for convenience to "Red Polled", and further abbreviated in 1909 to "Red Poll" in order to deny any suggestion that the breed was artificially polled.

Modern Red Poll Cattle have attained to what is designated as "ideal dual-purpose form" - i.e. the cows are not wedge-shaped to the extent found in the more specialised milking breeds, but tend rather to retain the old Norfolk body-form in combination with the high milking qualities and polled condition of the Suffolk Dun cattle. Thus an endeavour has been made to preserve and blend within the same animal the outstanding characteristics of the two widely divergent parental strains.

The Herd Book was commenced in 1874 as a private venture and was unusual in that group letters and numbers were allotted so that breeders would be able to discover rapidly and accurately "which of the families breed stock that will give the best results". As Wallace states: "A self-acting process of selection was thus created". For the second issue in 1877, animals were required to have "proof of 20 years' Red Polled inheritance, or four generations of Red Polled blood". Until 1905, a section for "Probationers" prevented the complete elimination of the progeny of meritorious animals unable to comply with these conditions.

The Red Polled Society of Great Britain and Ireland was founded in 1888 and "the Council made a regulation that any record sent in for publication at the Society's cost in the Herd Book should show the milk yield for all the cows in the herd." In 1899, it formulated rules for judging which provided for the taking of morning and evening records under normal conditions and subject to independent inspection. "They also provided for pail and butterfat tests in the show-yard, and for the judging there of the cow by quality and appearance as a dual-purpose cow; One-third of a specified number of points being allotted to milk, a third to butterfat and a third to quality.....a dual-purpose cow must be able to give a fairly good account of herself in the dairy and be able to produce calves which, when

steered, will grow well and fatten into good butchers' beasts."

The first importation of Red Polls into the United States for systematic breeding purposes was made in 1873. The Red Pelled cattle Club of America was organised at Chicago in 1883 and the first volume of its Herd Book issued in 1887. Following the example set by the English Herd Book, the American issue also allotted letters of the alphabet to indicate the families of the foundation cattle registered. Until 1901, the American Herd Book included all of the cattle entered in the English series.

c. THE DEVELOPMENT OF THE BREEDS IN NEW ZEALAND.

New Zealand offers exceptional advantages for the breeding of purebred dairy cattle.

Conditions of climate and topography are in general similar to those of the countries in which the various stocks were originated, but with this difference that extremes of heat and cold, the necessity for housing and artificial feeding of stock and periods of real feed scarcity, are not usually to be found in the Dominion. In short, the new environment in which the imported cattle were placed, was such as to offer every encouragement to natural increase, to the full expression of hereditary characteristics, and so to the rapid development of superior strains.

Further, there were no native cattle in the Dominion and the characteristics of the improved introduced stock did not offer thorough adulteration with the "blood" of an inferior race.

Moreover, the long distances over which the cattle had to be transported meant that only stock of superior individual merit and of constitutional qualities sufficiently robust to withstand successfully the arduous nature of the journey, could profitably be imported. The number of average and inferior individuals that were brought into the Dominion tended therefore to be small.

1. THE SHORTHORN.

The preponderance of the Shorthorn in the cattle stocks of the Colony for the first sixty years of settlement, compared with the lesser importance of the breed in this country since the turn of the century is one of the most striking features of the development of cattle breeding in New Zealand. The early settlers of Australia and New Zealand came for the most part from England and Scotland and the cattle that they favoured were, naturally, the established breeds of the United Kingdom. During the nineteenth century, the Shorthorn was the most highly improved and most widely distributed breed in the British Isles, Shorthorns,

therefore, were brought in large numbers to Australia and to New Zealand by the colonists. The qualities of the breed, its adaptability and docility and hardiness of constitution and, especially its general utility value in milk and beef production soon made the Shorthorn highly prized for its performance under the rather different conditions of its new environment, as well as on account of its traditionally high reputation and widespread use in Great Britain.

While it is assumed, on account of the early importance of the breed in Australia, that the cattle of the Rev. Samuel Marsden were of Shorthorn extraction, the first recorded importation of "nearly pure" Shorthorn cattle was made by W.B. Rhodes, Canterbury, when he brought 48 females and 2 bulls from New South Wales in November 1839. In 1850, the Deans Brothers, Canterbury, who already had about 130 head of cattle, landed the large consignment of 168 heifers and 4 bulls, all being purebred Shorthorn cattle from the Potter McQueen strain of Australina Shorthorns at Hunter River. From this herd, Shorthorn stock was supplied to most breeders in Canterbury.

The first cattle census of the Colony was made in 1851 when a total of 34,787 head was recorded and there can be no doubt that practically all these were Shorthorn or predominately Shorthorn. Immigrant ships began to arrive in considerable numbers from this time onwards and they nearly all carried a few cattle, most of which were Shorthorn. The bulk of the cattle stocks of the Colony was obtained from the New South Wales, but a large number of excellent individuals (again mainly Shorthorn) came from Great Britain with the colonists. A further enumeration of cattle made in 1864 gave the total as 249,760 head and again practically all these were Shorthorn or of Shorthorn extraction, although Ayrshires were beginning now to become numerous, particularly in the Southern provinces in the vicinity of the Scottish settlements.

Herd book registration in New Zealand began in 1866 when a Shorthorn Herd Book was established by Sir George Whitmore, of Rissington, Hawkes Bay. Three volumes had been published by 1870 when the interest in the book passed to Mr. W.J.G. Bluett, of Leeston, Canterbury, who edited Volumes IV and V. In 1870 also, the Canter-

bury Agricultural and Pastoral Association began to publish the Canterbury Herd Book, five volumes of which had appeared by 1880. In 1884, by arrangement with Mr. Bluett, the two herd books were combined in the New Zealand Herd Book of Short-horned Cattle (New Series) Volume I, published by the Canterbury A. and P. Association. It was decided to continue the register of bulls as in the Bluett Herd Book, and the register of cows as in the Canterbury Herd Book. Thus volume I of the new series contained the registrations of 380 bulls (numbers 240 to 619) and of 648 cows, (numbers 792 to 1439).

A New Zealand Shorthorn Cattle Breeders' Association was formed in November 1914 as the result of a meeting of breeders held in the Canterbury A. and P. Association's rooms in Christchurch. The new association arranged to purchase the copyright of the New Zealand Shorthorn Herd Book from the Canterbury A. and P. Association and has since carried on the publication.

In 1938, the New Zealand Shorthorn Society (Inc.) as the Association is now known, published the 28th volume of the Herd Book, in which it is shown that 7,267 bulls and 15,520 cows have been admitted to registry since the herd book was commenced. Polled cattle were also included in this volume, importations having been made from the United States.

The conditions of entry in the present-day Herd Book include :

- (a) A bull to be eligible for insertion in the Herd Book must be by a registered bull, and must have five top crosses of registered sires on the dam's side, the foundation cow to be of Shorthorn descent.
- (b) A cow to be eligible for insertion in the Herd Book must be by a registered bull, and must have four top crosses of registered sires on the dam's side, the foundation cow to be of Shorthorn descent.
- (c) Should breeders desire, the Council will publish results of semi-official tests in the Herd Book.
- (d) Bulls or heifers being the progeny of cows which have been tested for butterfat production under any recognised system of testing, viz. Group, O.H.T., or

C.O.F. test, will be indicated in the Herd Book as such by the insertion of the word "tested" in the pedigree of the bull or heifer concerned, provided that the entry form shows the record of production of the dam and the year and system of test. The production of the dam of the sire may also be shown, and records may be published with the pedigree.

- (e) Commencing with volume 28, cattle of polled breeding or polled cross will be entered and numbered in a separate section of the herd book, and cattle previously entered will be renumbered. A bull shall be deemed to be polled unless it has five top crosses of registered horned sires on the dam's side and a cow shall be deemed to be polled unless it has four top crosses of registered horned sires on the dam's side.

There are now 83 registered herds of Shorthorn cattle in the Dominion, the majority being kept solely for beef purposes.

2. THE MILKING SHORTHORN.

A brief outline has been presented of developments in Shorthorn breeding in New Zealand, more particularly as they have affected the Breed's capabilities in beef production. But, the Shorthorn, in addition to its importance in beef production, also predominated in the Colony's dairy cattle population for a period of more than seventy years, extending from the time of the first settlements until the first decade of the present century. "In the early days of settlement in this Dominion there were many fine herds of Shorthorn cattle established, which were not only good for beef but had great milking qualities as well, and in the early 'sixties and 'seventies when cheese and butter were made on the farm, the breed was very much thought of, and considered the most profitable at that time.

With the commencement of the export trade in refrigerated products, the early establishment of freezing and meat-preserving works, and initially higher prices for meat than for dairy produce, caused a greater emphasis to be placed upon beef production rather than on milk production in the cattle stocks of the colony. The

Shorthorn at this time was, generally speaking, by no means a specialised dairy animal. The transplanted British farmers, imbued with the traditions of the Old Country, had continued to expect a fair degree of beefing qualities in their milking stock and it can reasonably be said of the general cattle population of the time that, while there were numerous herds and strains of cattle bred primarily for milk production, the dairying capacity of the great bulk of the stock was low. Under these circumstances, an adjustment towards meat rather than milk production was easily and rapidly carried out.

With the increasing importance of dairying as an export industry consequent upon improved organisation and the higher prices of the 'nineties, there arose a heavy demand for specialised high producing dairy stock for breeding purposes. This demand the predominantly Shorthorn population was unable completely to supply. A new emphasis on breeding for milking capacity was developed and since it became increasingly apparent that the general cattle stocks of the country would require very considerable improvement in their milking capacity, large numbers of stud cattle were imported, principally from Australia, the United Kingdom, Canada and the United States of America. Initially, a large proportion of these was Shorthorn and while some were introduced with a view to improving the breed's beef-producing qualities, the majority were descended from notable milking strains. The New Zealand Government was active in supporting the movement and established milking herds of Shorthorn cattle at some of the State Experimental Farms, at which centres, bulls were available for service at a small fee and young stock could be purchased. Later on, when herd-testing had become established, the State herds were in a position to supply the industry with registered purebred sires backed by records of milk and butter-fat production. The stimulus of these developments to Shorthorn breeding was such that during the 'nineties and early years of the present century, Shorthorns accounted for between 65 and 70 per cent of the total purebred population.

But from the figure 67.2 per cent in 1904, the percentage of purebred Shorthorns in the total purebred cattle population de-

clined to 9.6 per cent in 1928. Amongst the more important factors operating to bring this about were the rapidity of development of the dairy industry and the consequent urgent need for high producing specialised dairy stock. The expansion of dairying proceeded very rapidly under the stimulus of a rising price-level for produce, the establishment of numerous dairy factories and developments in the general organisation of the industry. A heavy demand set in for good milking cattle and the system of crossing 'specialised dairy bulls upon the female grade population (mainly Shorthorn) became firmly established. Jersey, Friesian and Ayrshire bulls were widely favoured for this purpose but the Shorthorn was still considerably used, and of course a proportion of milking as well as beef Shorthorn herds remained purebred.

From about 1908 onwards, the Jersey became increasingly important for crossing purposes and Jersey purebred cattle increased very rapidly in consequence of the high values of and heavy demand for registered purebred Jersey sires for use in grade herds. At the same time, purebred Shorthorn cattle, declined in numbers very considerably. By 1918, the respective populations were approximately equal in numbers, but by 1928, when Jersey purebred cattle comprised 55 per cent of the total purebred cattle population, purebred Shorthorn cattle accounted for only 9.6 per cent, of which Milking Shorthorns represented 5.9 per cent.

<u>BREEDS AS PERCENTAGES OF TOTAL PUREBRED CATTLE</u>		
<u>Year</u>	<u>Purebred Shorthorns</u>	<u>Purebred Jerseys</u>
1897	75.7	3.3
1901	71.0	3.6
1904	67.2	3.9
1909	55.9	8.9
1918	21.8	25.9
1921	22.7	34.4
1924	12.7 (M.S. 5.2)	49.7
1928	9.6 (M.S. 5.9)	55.3

In 1913, the New Zealand Milking Shorthorn Association was formed in Palmerston North and the Waikato Dairy Shorthorn Association in Hamilton, but the two societies amalgamated in 1917 under the title of the former and with a membership of about 50. The objects of the Association include the following :-

- "a. To maintain the purity and improve the breed of Milking Shorthorn Cattle in New Zealand.
- b. To collect, verify and publish information relating to Milking Shorthorn cattle and to compile and publish a Book of Milking Shorthorn cattle in New Zealand.
- c. To offer prizes for Milking Shorthorn cattle; to ensure the representation at important shows in New Zealand or abroad of the best specimens of the breed.
- d. to encourage testing of pedigree Milking Shorthorn cattle for production of milk, butterfat and solids (1926-27).
- g. to improve the breed generally to such an extent that New Zealand in the future may reasonably hope to export high-class Milking Shorthorn Cattle to Australia, Africa, America, China, Japan and elsewhere. "

The formation of the society was a resultant of the declining popularity of the Shorthorn as a milking animal and was aimed at the preservation, by means of herd book registration and cohesive organisation amongst breeders, of those Shorthorn cattle with good milking capabilities; and, further at the establishment of an improved type of the Milking Shorthorn breed in which superior milk-producing qualities (the primary aim) would be combined to the fullest possible extent with early maturity, good frame, docile temper and readiness to lay on flesh when dry.

The first Milking Shorthorn Herd Book was issued in 1915, and contained the registrations of 50 bulls and 362 cows. Volumes I, II and III admitted non-pedigree females but the practice was discontinued after 30th June 1918. Up to and including Volume IV, all animals eligible for admission to the Herd Book were subject to inspection before registration but, after 1925, entries were accepted on pedigree records. A tattooing system for the purpose of giving greater security in the identification of animals was instituted as from 1st June 1926. In volume VIII, 1926-27, an appendix to the Herd Book was established for the purpose of registering non-pedigree Milking Shorthorn cows fulfilling the following conditions:

- "a. That they complete the undermentioned butterfat records

under the supervision of a Group Herd Testing Association or Official Herd Testing conducted by the New Zealand Department of Agriculture.

If 2 years old at the commencement of test, 240.5 lbs. fat

" 3	"	"	"	"	"	"	"	277.0	"	"
" 4	"	"	"	"	"	"	"	313.5	"	"
" 5	"	"	"	"	"	"	"	350.0	"	"

b. That such cows be subject to inspection by an Official Judge of the Association or the Official Inspector. Applicants pay inspection expenses.

c. That female progeny only from such cows by registered bulls be eligible for entry in the Appendix for the next 4 generations, subject to inspection by an Official Judge of the Association or the Official Inspector".

In Volume IX, 1927-28, Certificate of Record and Group Herd Test records for pedigree cows were published, as well as Group Herd Test records for Appendix cows.

The most recent issue of the Herd Book (Volume XIII, 1935-36) lists 919 bulls, 1942 cows and 670 Appendix cows. There are now 400 members of the association and, since the herd book was commenced, the total admissions to registry are :

9,076 bulls

29,149 cows

3,314 non-pedigree cows.

Milking Shorthorn breeders have participated from time to time in the C.O.R. scheme for recording purebred dairy cows, the progress to date being as follows :-

Age Group	MILKING SHORTHORN PERFORMANCES ON C.O.F.										
	Present Class			Average yields				Average Yields			
	Leaders			1938				1914-1938			
	Days	Milk	Fat	Cows	Days	Milk	Fat	Certs.	Days	Milk	Fat
Jr.2-yr old	365	14573	592	1				59	349	8440	348
Sr.2-yr old	365	13273	581	1				47	350	9015	376
Jr.3-yr old	365	14033	678	1				30	338	9772	401
Sr.3-yr old	365	14640	748	1				34	342	10949	456
Jr.4-yr. old	358	17688	630	1				27	350	15286	640
Sr.4-yr old	365	20136	731	2				37	342	11548	435
Mature	365		857	9				298	342	11915	478

A total of 532 Certificates has now been issued to 482 registered purebred Milking Shorthorn cows, the average seasonal production being : 344 days : 11,028 lbs milk: 4.03 per cent fat: 445 lbs butterfat.

3. THE AYRSHIRE

The first Ayrshires to come to New Zealand were a bull ("Rob Roy") and several cows, which were landed in Otago in 1848. Further importations were made from time to time, including a shipment to Southland by the New Zealand and Australian Land Company in 1859. Most of these cattle continued to be located in Otago and Southland, near the Scottish settlements and although numbers were greatly multiplied in these districts, the breed did not spread to other parts of the Colony to any marked extent.

Nevertheless, Ayrshires in 1897 ranked next in importance to Shorthorns, accounting for 5.2 per cent of the total purebred cattle population. Numerous importations were made in the latter part of the 19th century and during the early years of the present century, but though the breed has tended towards greater prominence, progress has been slow.

<u>BREEDS AS PERCENTAGES OF TOTAL PUREBRED CATTLE</u>			
Year	Purebred Ayrshires	Purebred Jerseys	Purebred Shorthorns
1897	5.2	5.3	75.7
1901	5.0	3.6	71.0
1904	4.0	3.9	67.2
1909	5.0	8.9	55.9
1918	5.5	25.9	21.8
1921	5.7	34.4	22.7
1924	6.7	49.7	12.7
1928	6.9	55.3	9.6
			(M.S. 5.2)
			(M.S. 5.9)

Occasional importations of breeding stock from Scotland and the United States were made by leading breeders between 1910, when the Association was founded, and 1930. Since the latter date, the Association has been exceedingly active in advertising the merits of the breed and has itself organised the importation of three consignments of Canadian-bred Ayrshires, totalling fifteen bulls and 2 in-calf heifers.

The first volume of the Ayrshire Herd Book of New Zealand was published in 1910 by the Ayrshire Cattle Breeders' Association of New Zealand, a society then of 46 members. The objects of the Association include the following :

- a. "To maintain the purity of the breed of cattle known as Ayrshire cattle.
- b. "To collect, verify, preserve and publish an Ayrshire Herd Book, with the pedigree of the said cattle and other useful information concerning them.
- c. "the promotion of fellowship amongst Ayrshire breeders, and the furtherance of their mutual interests generally in so far as the breeding of Ayrshire cattle is concerned."

The volume contained a register of 53 bulls and 159 cows, and an appendix of 23 bulls and 136 cows, the respective qualifications for entry being:

- a. Herd Book "The name, age, colour of each animal, and full name of the breed of each animal, together with the names of sire and dam of each animal for five (5) generations, except in cases of animals (imported) from Scotland or Canada and entered in the

Ayrshire Herd Book of Scotland, Canada or Australasia".

b. Appendix: "For registration without a number, of animals approved by the Committee, but not tracing directly through both dam and sire for five generations, and therefore not eligible for entry. Registered in the Appendix in order to qualify their produce for entry in future volumes. Such produce to be by registered sire or dam".

The Appendix was continued for the first eight volumes of the Herd Book after which no animals were admitted to registry unless both the sire and dam had been registered.

The sixth volume (1916-17) contained a list of show-winning Ayrshire stock and in Volume VII (192) was published a list of C.O.R. certificates gained by Ayrshire cows.

With volume XVIII (1932) a register was initiated of Record of Performance cows (R.O.P) i.e. cows conforming to the following standards of production.

<u>Age</u>	<u>C.O.R. (365 days)</u>		<u>G.H.T. O.H.T.</u>		<u>C.O.R. (305 days)</u>	
	<u>Milk</u>	<u>Fat</u>	<u>Milk</u>	<u>Fat</u>	<u>Milk</u>	<u>Fat</u>
Mature	10925 lbs	437.5 lbs	9,000	360		
4 yrs old	10150	406.25	8,000	323		
3 yrs old	8280	331.25	7,000	287		
2 yrs old	7650	306.25	6,000	250		

A total of 803 R.O.P. cows has been listed to date.

Ayrshire performances on C.O.P. testing are as follows:

<u>Age Group</u>	<u>Present Class Leaders</u>			<u>Average Production - 1912-1938</u>			
	<u>Days</u>	<u>Milk</u>	<u>Fat</u>	<u>Certs.</u>	<u>Days</u>	<u>Milk</u>	<u>Fat</u>
2-yr old	365	12,281	674	73	344	8,959	372
3-yr old	365	16,508	647	41	347	10,112	416
4-yr old	365	14,208	714	27	346	11,378	460
mature	365	20,306	833	110	348	11,943	486

A total of 251 certificates has now been issued to 224 registered purebred Ayrshire cows, the average seasonal pro-

duction being : 347 days :10,715 lbs milk ; 4.09 per cent fat; 439 lbs butterfat.

An advanced Register of bulls was instituted in Volume XV (1929), registered bulls being eligible for separate classification as follows :

a. Class A.A. "A bull may be registered as an A.A. bull provided that his dam and his sire's dam have qualified according to the standard of production" (for P.O.P. cows).

b. Class A. "A bull may be registered as an A. bull if his dam only has qualified according to the standard of production" (for R.O.P. cows.).

Up to and including Volume XXIII (1937-38) a total of 653 bulls had been registered in Class A.A. and 162 in Class A.

In the two most recent volumes of the Herd Book, a proven sires' list has been published, the requirement being a ~~minimum~~ of 10 registered daughters conforming to the standards of production for R.O.P. cows; so far six bulls have been listed as proven sires.

With Volume 23 (1937-38) total registrations of Ayrshire cows have reached 20,279 and bulls 7,566. The number of members of the Association is now 234, embracing 207 registered herds.

At the most recent enumeration (1928) there were 4,905 purebred Ayrshire cattle and 48,192 crossbred Ayrshire cattle in the Dominion.

4. THE JERSEY.

Pedigree Jerseys were introduced into New Zealand for the first time in 1862 when Mr. Thomas Dyers, a native of Jersey Island, brought a bull ("the old Marquis") and two cows ("Duchess" and "Lucy"), to Wanganui from Jersey Island. The cattle passed to Mr. Lawrence Daniels, Rangitikei, and thence into the possession of Mrs. A.W.F. Halcombe, Marton. A daughter ("Jenny") of "Lucy" sired by "the Old Marquis", was sold to Mr. W.K. Hulke, Bell Block, Taranaki in 1876 and led on foot to Taranaki (130 miles) where she became known as "the champion dairy cow of Taranaki" winning the championship over all breeds at the New Plymouth show.

In 1879, Mrs. Halcombe's herd, then numbering about 20 head, was dispersed, most of the stock going to breeders in various parts of the Colony who had not previously owned Jersey cattle.

In 1878, Mr. H.P. Hill, Christchurch, imported stock (including the bull "Primrose") from a Shropshire herd, one of the few purebred herds in England at the time. At about the same time the Rev. J.G. Bluett imported the Island-bred bull "Jersey". Messrs. Hill and Bluett also imported a number of cattle from Australia at this time.

The notable bull "Cicero 2nd" and a cow "Lady Bountiful" were imported from Jersey Island in 1880.

Auckland and Christchurch were the most prominent Jersey breeding centres during the 'eighties and 'nineties and a Christchurch breeder, Mr. George Gould, who had acquired his foundation stock from Messrs. Bluett and Hill, was responsible for importing from England in 1892, the two well-known bulls named "Dry Monopole" and "Monopoly". Many of the early Jersey cattle in the southern part of the North Island, including particularly the Waikarapa and Manawatu, came from the Christchurch herds.

On the other hand, Taranaki, known as "the home of the Jersey" drew most of its stock from herds which had been established near Auckland. "It was not until about 1906 that Jerseys came to be really regarded as commercial propositions, and it was in Taranaki, then the leading dairying district of the Dominion, that they first began their triumphal march as the dairy farmer's cow". Mr. Charles Clarke brought a large number of Jersey cattle from Auckland and the Waikato in 1905 and 1906 and Taranaki rapidly became noted as a Jersey province. It was in this way that the great pedigree Jersey herds of Taranaki were established. Later on, Taranaki supplied purebred and grade Jersey cattle to many parts of the Dominion, including several thousand head sent to the Waikato in the days of the rapid Auckland expansion.

A number of outstanding sires came to New Zealand during the early years of the present century. The famous bull "K.C.B." sire of "Grannie's Knight", was imported from England in 1902 by Mr. Gould. "Eminent's Fontaine" came from the United States to

Mr. C.G.G. Dermer, Fielding in 1908, and in the same year "Majesty's Fox" was imported from Jersey Island by Mr. G.D. Lancaster, Palmerston North. "Lord Twylsh" and three of his sons were imported from Victoria by Mr. H.W.B. Watson in 1909 and subsequent years. In 1910, "Soumise Majesty" came from Jersey Island to Mr. Charles Goulter, Blenheim. The bulls "Roberts" (from England), "The Squire" (from Jersey Island), "The Owl's Victor" (from Jersey Island), "V.C." (from England) and "Viola's Golden Laddie" (from the United States) were notable amongst the stock introduced to the Dominion between 1911 and 1916.

During the past twenty years also, numerous importations of high class breeding stock have been undertaken by leading breeders, principally from well known stud herds on Jersey Island and in the United States.

In 1886, appeared Volume 1 of the New Zealand Herd Book of Breeds of Cattle other than Shorthorns. The book was edited and published by the Canterbury Agricultural and Pastoral Association and contained the registration of purebred cattle of the Hereford, Ayrshire, Polled Angus, Channel Islands (i.e. Jersey), Devon, and Dutch Friesian breeds. Of the Jerseys listed, 11 were bulls and 26 cows. Volume 11 appeared in 1891, containing cattle of the Polled Angus, Hereford, Ayrshire, Jersey and Devon breeds. The Jerseys totalled 24 bulls and 46 cows, including offspring of the Island-bred bull "Cicero II" and of several bulls imported from Australia.

At a meeting held on 9th April 1902 in Palmerston North at the instigation of two prominent Jersey breeders, Messrs. A. Buchanan and S.R. Lancaster, an attendance of nine persons decided to form a New Zealand Jersey Association. The New Zealand Jersey Cattle Breeders' Association was incorporated on the 6th November of the same year. The first volume of the New Zealand Jersey Herd Book appeared in 1903 and in the preface to the volume it was stated "For a long time past the desirability and necessity for a record of the purity, history and progress of the Jersey breed in this Colony has been felt. With this end in view the New Zealand Jersey Cattle Breeders' Association has been founded. That the movement has re-

Mr. C.G.C. Dermer, Fielding in 1908, and in the same year "Majesty's Fox" was imported from Jersey Island by Mr. S.R. Lancaster, Palmerston North. "Lord Twylsh" and three of his sons were imported from Victoria by Mr. H.W.B. Watson in 1909 and subsequent years. In 1910, "Sousise Majesty" came from Jersey Island to Mr. Charles Goulter, Blenheim. The bulls "Roberts" (from England), "The Squire" (from Jersey Island), "The Owl's Victor" (from Jersey Island), "V.C." (from England) and "Viola's Golden Laddie" (from the United States) were notable amongst the stock introduced to the Dominion between 1911 and 1916.

During the past twenty years also, numerous importations of high class breeding stock have been undertaken by leading breeders, principally from well known stud herds on Jersey Island and in the United States.

In 1886, appeared Volume I of the New Zealand Herd Book of Breeds of Cattle other than Shorthorns. The book was edited and published by the Canterbury Agricultural and Pastoral Association and contained the registration of purebred cattle of the Hereford, Ayrshire, Polled Angus, Channel Islands (i.e. Jersey), Devon, and Dutch Friesian breeds. Of the Jerseys listed, 11 were bulls and 26 cows. Volume II appeared in 1891, containing cattle of the Polled Angus, Hereford, Ayrshire, Jersey and Devon breeds. The Jerseys totalled 24 bulls and 46 cows, including offspring of the I land-bred bull "Cicero II" and of several bulls imported from Australia.

At a meeting held on 9th April 1902 in Palmerston North at the instigation of two prominent Jersey breeders, Messrs. A. Buchanan and S.R. Lancaster, an attendance of nine persons decided to form a New Zealand Jersey Association. The New Zealand Jersey Cattle Breeders' Association was incorporated on the 6th November of the same year. The first volume of the New Zealand Jersey Herd Book appeared in 1903 and in the preface to the volume it was stated "For a long time past the desirability and necessity for a record of the purity, history and progress of the Jersey breed in this Colony has been felt. With this end in view the New Zealand Jersey Cattle Breeders' Association has been founded. That the movement has re-

ceived a most cordial support from lovers of the herd throughout New Zealand will be seen from the representative list of breeders appended to this volume, and by the large number of entries enrolled.

"A study of the pedigrees of the animals entered in Volume I will show that the Jersey stock of New Zealand is drawn from the best blood of the best herds in Jersey, Great Britain and America".

The first three volumes of the Herd Book allowed the registration of cattle whose parents were not entered in a recognised Herd Book but it "had to be clearly and definitely proved to a committee that such animal traced back to Jersey Island, and no possibility of any impurity of blood was permitted to arise". Volume I (1903) contained 126 bulls and 178 cows; Volume II (1905) 65 bulls and 108 cows; Volume III (1906) 78 bulls and 149 cows.

In Volume VII (1910) was published a Register of Merit of authenticated 7-day Butterfat Records, conducted under the rules of the Association, the standard being 12 pounds of butterfat for cows and 10 pounds for heifers. The Register of Merit (R.O.M.) continued to be published until Semi-Official Testing (C.O.R.) was instituted by the Department of Agriculture, when an advanced Register of Merit (A.R.M.) of 12-months' milk and butterfat records was established. The A.R.M. was first published in Volume XI (1914) when 79 Jerseys received certificates.

With the publication of test records of milk and butterfat production, the prestige of the Jersey breed in the eyes of the dairy farming community rose considerably. Previously there had been a widespread tendency to compare the relatively small Jersey cow unfavourably with the large rather fleshy animals which dairymen generally, in their traditional appreciation for the Shorthorn, had long been accustomed to associate with milk production. When, however, it became apparent that the Jersey was capable of high yields of milk and butterfat, the breed became extremely popular. Pedigree Jersey sires were widely used in the improvement of grade milking herds and as the dairy cattle population of the Dominion rapidly increased, more and more registered purebred herds were established to supply sires to the industry. From a total of 39 members in 1903, the membership of the Association grew to 279 in 1913, to 1184 in 1923 and to 1987 in 1938.

In 1929, the Association introduced its Type Classification Scheme, a measure designed to improve the general standard of type within the breed. "The System adopted is to classify the animals submitted - only cows over three years nine months old are eligible - into one or other of the three divisions, V.H.C., H.C., or C. To gain entrance into the C (commended) class a cow must be a passably good specimen of the breed with no serious faults; a cow, in fact, whose bull calf could with every confidence be recommended for use in a grade herd. In an H.C. (Highly Commended) cow something better is looked for. She must be a cow of sufficiently good quality to warrant the use of her son in the herd of the average breeder. The V.H.C. (Very Highly Commended) standard is even higher and it is only the very best specimens of the breed that are included in this extremely select class.

"The classification is done by a committee consisting of judges elected by a ballot of all the official judges in New Zealand. An application fee of one guinea is charged to breeders participating in the scheme, with an additional 5/0 for every cow to which a Certificate is issued". The object of the scheme is to obtain a quantitative measure that will be as useful in indicating type in the pedigree of a young animal as C.O.R. figures are in indicating production.

Results of type classification were published for the first time in Volume XXVII (1930) of the Herd Book, when, in a total of 267 cows receiving certificates, 16 were graded V.H.C., 111 were graded H.C., and 140 commended. In the 1931 Herd Book (Volume XXVIII) an additional award ("C.P." - commended for superior Progeny) was made to 36 cows having two or more daughters with the qualifications V.H.C. or H.C. In Volume XXXV (1938), no less than 1125 cows received Type Classification Certificates - 91 V.H.C. cows, 702 H.C. cows, and 332 cows commended. In addition 109 cows received the C.P. award.

Age Group	JERSEY PERFORMANCES ON C.O.R.										
	Present Class			1938 Averages			Averages 1912-1938				
	Leaders										
	Days	Milk	Fat	Cows	Days	Milk	Fat	Certs.	Days	Milk	Fat
Jr.2-yr old	365	15467	899	154	349	7699	437	3614	349	7316	413
Sr.2-yr old	365	12689	816	57	342	8478	483	978	347	7976	452
3-yr old	365	15073	951	73	349	9210	519	1349	347	8743	490
4-yr old	365	17333	1221	53	344	9136	520	944	348	9310	522
Mature	365	18523	1056	97	342	10172	573	2170	347	9658	533

A total of 9,055 certificates has now been issued to 8,088 registered purebred Jersey cows, the average seasonal production being 348 days; 8,369 lbs milk: 5.6 per cent fat; 469 lbs butterfat.

5. THE FRIESIAN

The first Friesians introduced into New Zealand were a bull and seven cows purchased in Holland by Mr. J.C.N. Grigg, Longbeach, Canterbury in 1884. Owing to embargoes on further importations through the prevalence of foot-and-mouth disease on the Continent, the Grigg consignment remains the only shipment made directly from Holland to New Zealand. In consequence, Longbeach cattle have been greatly in demand and the strains are now widely diffused through the herds of the Dominion.

The breed came to the North Island in 1888 when Mr. Coleman Phillips brought two Longbeach bulls to the Wairarapa.

The next consignment from abroad was organised by Messrs. Newton King and Street Bros., Taranaki, who imported eight animals from leading American herds in 1902; in 1903; Messrs. Lovelock and McKenzie, Palmerston North, imported a bull and three in-calf heifers.

Large numbers of cattle directly descended from the Dutch-bred stock were introduced into New Zealand from New South Wales and the United States. American-bred cattle, both from the United States and Canada, were greatly sought after when the institution

of semi-official and herd-testing emphasised the importance of high producing strains. Importations from these sources have been made in recent years by the Hobson Farm Ltd., Messrs. H. North and Sons, and the New Zealand Government.

Volume I (1886) of the New Zealand Herd Book of Breeds of Cattle other than Shorthorns, included the registrations (13) of the "Dutch-Friesian" cattle and descendants, imported by Mr. Grigg. The cattle were so named in order to emphasise the distinction between "Dutch-Friesians" (Friesland cattle) and "Holstein-Friesians" (The American-applied misnomer, Holstein being a province two hundred miles from Friesland, the home of the breed).

No Friesian cattle were entered in the second volume (1891) of the New Zealand Herd Book.

The New Zealand Friesian Association was formed in Palmerston North on 23rd June, 1910; the aims and objects of the society include :

- a. "to maintain the purity and improve the breed of purebred Friesian cattle in New Zealand.
- b. "To collect, verify, and publish information relating to Friesian cattle, and to compile and publish a Herd Book of Friesian cattle in New Zealand.
- c. "To promote shows and sales of pedigree Friesian cattle and to recommend the appointment of judges.
- d. "To promote an export trade of New Zealand Friesian Cattle.
- e. "To encourage testing of Pedigree Friesian Cattle for production of milk, butterfat and solids.
- f. "To investigate cases of doubtful and suspected pedigrees.
- g. "To settle disputes and questions relating to or connected with New Zealand Friesian Cattle.
- h. "To offer prizes for purebred Friesian Cattle; to ensure the representation at important shows in New Zealand or abroad of the best specimens of the breed and to contribute from the funds of the Association towards the expense of the carriage of animals recommended for exhi-

bition by the Association".

The first volume of the New Zealand Friesian Herd Book (1910) contained the registrations of 129 stud bulls and 350 stud cows, submitted by 22 breeders. "It was agreed that all cattle that Mr. J.C.N. Grigg guaranteed pure should be accepted as pure. He kept his purebred animals on one farm, but their tabulated pedigrees were not kept,..... as he did not consider it necessary.

"In order to classify the entries, the Committee of the Association decided to have three sections in the first volume of the Herd Book:

1. Animals whose full pedigree is produced.
2. New Zealand and Australian cattle guaranteed pure.
3. Appendix cattle which had to be declared purebred. "

The Appendix was confined to female stock.

The present conditions of entry in the Herd Book make it obligatory for all births of pedigree Friesians (alive, dead, premature, etc.) to be notified within 30 days of the end of the calendar month of birth. Applications for registration are required to be made within 12 months of the birth of an animal; heavier fees are charged if animals submitted are more than 12 months old, and no cattle over the age of 24 months can be registered. Each application for registration must be accompanied by a right-side photograph of the animal. Only progeny of sires and dams already registered in the New Zealand Friesian Herd Book are now eligible for entry. Cattle exhibiting certain "colours that bar" may not be registered. Imported cattle, properly identified, can be registered within six months of landing in New Zealand.

The Friesian Association has participated in C.O.R. testing since the inception of the scheme, performances being as follows.

Age Group	Present Class Leaders			Average yields 1938				Average yields 1912-1938			
	Days	Milk	Fat	Cows	Days	Milk	Fat	Certs.	Days	Milk	Fat
Jr.2-yr old	365	22147	837	14	343	14278	511	708	347	12082	429
Sr.2-yr old	365	22672	820	5	349	14141	518	290	348	12091	460
Jr.3-yr old	365	21609	800	3	332	12598	584	204	344	13603	484
Sr.3-yr old	365	25885	989	2	365	16767	617	210	337	14285	513
Jr.4-yr old	365	22364	947	4	302	13915	515	147	344	15363	546
Sr.4-yr old	365	27108	1079	3	330	15525	528	148	346	16248	568
Mature	365	31313	1145	15	354	16934	638	641	344	16279	576

A total of 2,348 certificates has now been issued to 1889 registered purebred Friesian cows, the average seasonal production being 345 days: 14,126 lbs milk: 3.55 per cent fat; 502 lbs butterfat.

The Association now numbers 384 members and there are 334 registered herds. The most recent issue of the Herd Book (Volume 27, 1938) records that a total of 16,205 bulls and 42,952 cows has been entered since registration was commenced. In 1928, these were 10,670 purebred and 231,022 crossbred Friesian cattle in the Dominion.

6. THE RED POLL

The first purebred Red Poll cattle to come to New Zealand were a bull and three cows imported from the herds of J.J. Coleman and Garrett Taylor, Norwich, England, to form the foundation of the "Otahuna" herd of Sir Heaton Rhodes, Tai Tapu, Canterbury. A further importation for the breeder was made in 1905 when a bull and three cows were introduced from the herds of Lord Rothschild, C.H. Berners and John Hammond.

The second herd of Red Poll Cattle in New Zealand was that founded in 1905 by Mr. M.H. Strachan, Gisborne, who brought English-bred cattle from Australia and imported stock from the herds of Alfred Smith, Suffolk, and the Hon. Sir. A.E. Fellowes, Norwich, England.

These two original herds, together with a herd imported from Australia by the New Zealand Government in 1917, supplied the

foundation stock of the breed in New Zealand.

The New Zealand Red Poll Cattle Breeders' Association was formed in June 1921, with the following aims and objects:

- a. To maintain the purity and improve the breed of purebred Red Poll cattle in New Zealand
- b. To collect, verify and publish information relative to Red Poll cattle and to compile and publish a Herd Book of Red Poll Cattle in New Zealand.
- c. To promote shows and sales of pedigree Red Poll Cattle and to recommend the appointment of judges.
- d. To promote an export trade of New Zealand Red Poll Cattle
- e. To encourage testing of Pedigree Red Poll Cattle for production of milk, butterfat and solids.
- f. To investigate cases of doubtful and suspected pedigrees
- g. To settle disputes and questions relating to or connected with New Zealand Red Poll Cattle.
- h. To offer prizes for purebred Red Poll Cattle, to ensure the representation at important shows in New Zealand or abroad of the best specimens of the breed.
- i. To co-operate with any other society having similar objects.

Volume I of the New Zealand Red Poll Herd Book appeared in 1922 and contained the registrations of 82 bulls and 272 cows, representing the entries of the 33 members of the Association.

The Association makes a number of stipulations to registration in the Herd Book, including:

- a. Herd History Prior to applying for registrations, members are required to supply all details of the origin and subsequent development of the herd; this statement has to be attested by a Justice of the Peace or a Commissioner for taking affidavits..
- b. Annual Herd Record: Members are required annually to submit returns of all Red Poll Cattle held, including details of births, deaths, castrations, sales, purchases, transfers this statement also has to be properly attested.
- c. Registration; Cattle are eligible for registration according to the following classification :

"Class A.A. Imported animals registered in the English or American Red Poll Herd Book, or animals whose progenitors trace on both the sire's and the dam's side to imported stock registered in either of these Herd Books.

"Class A. Animals sired by a known pure Red Poll bull", and with five maternal dams sired by known pure Red Poll bulls.

"Class B. As for Class A, but with four maternal dams fulfilling the conditions

"Class C. As for Class A., but with three maternal dams fulfilling the conditions.

"Class D. As for class A., but with two maternal dams fulfilling the conditions.

"Animals registered in the A.R.P.H.B. may be registered in the N.Z.R.P.H.B. in their corresponding classes."

"The Progeny of animals from different classes shall be entitled to entry in a class immediately higher than that of its dam, providing the sire is in a class higher than the dam; but in no case shall a beast be entered in a class higher than that of its sire."

The grading-up process was arrested as from October 1927 when it was decided not to recognise the progeny of any cattle, except those already in a recognised Red Poll Herd Book, or the female progeny of those graded up cows from which calves were admitted to Volumes, I, II and III."

The following analysis of the registrations in the fourteen volumes of the herd book indicates the mode of operation of the grading-up process:

NUMBERS OF CATTLE IN CLASSES.

<u>BULLS :</u>	<u>Vol.</u>	<u>AA.</u>	<u>A.</u>	<u>B.</u>	<u>C.</u>	<u>D.</u>	<u>Total</u>
	1	28	16	6	20	12	72
	2	28	33	34	65	29	1 89
	3	18	30	49	50	33	180
	4	13	32	34	16	2	97
	5	13	37	57	30	-	139
	6	30	65	67	34	-	196
	7	28	58	33	20	-	149
	8	31	37	12	3	-	83
	9	31	30	17	3	-	81

NUMBER OF CATTLE IN CLASSES (Con.)

<u>BULLS:</u> (con)	<u>Vol.</u>	<u>AA.</u>	<u>A.</u>	<u>B.</u>	<u>C.</u>	<u>D.</u>	<u>Total</u>
	10	44	51	31	6	-	132
	11	72	70	20	7	-	169
	12	46	76	16	1	-	139
	13	48	92	17	5	-	162
	14	64	104	18	3	-	189
<u>FEMALES</u>							
	1	51	12	15	60	124	262
	2	36	43	29	130	46	284
	3	31	52	71	75	92	321
	4	18	33	49	47	28	175
	5	22	34	53	44	14	167
	6	29	69	58	63	28	247
	7	37	60	71	42	6	216
	8	33	94	66	14	4	211
	9	45	82	73	23	-	223
	10	36	96	71	20	1	224
	11	64	127	76	20	-	287
	12	65	137	54	16	-	272
	13	72	184	54	10	-	320
	14	90	168	34	3	-	295

" cc. Inspection Certificate. Animals submitted for registration in Classes, B, C D may be required to undergo inspection before admission to the Herd Book.

"f. Birth Notification. The birth of all calves must be notified to the Secretary within 3 calendar months of dropping together with ear-marks, tattoo marks, or firebrand, which must have been applied previous to notification. Subsequent registration of a calf whose birth has not been so notified, will not be allowed."

"g. Registration Annually. All calves dropped during the breeding year (July 1st - June 30th) must be registered before June 30th of the same year. After first registration of a member's stock, no stock over one year old bred by such a member will be registered unless on payment of a fee of £5 per head."

The standard of type and character in Red Poll cattle, as adopted by the Association, is as follows .

"a. Colour: Red: blood red or deep red for preference; tail switch may be white; teats or whole udder may be white.

b. Head : Hornless or Poll (i.e. not artificially polled or dehorned) without horns, slugs, buttons or abortive horns.

c. Nose : Pale or flesh colour

"d. Hips: Broad, evenly rounded, not prominent.

e. In all other particulars, the commonly accepted constitution and symmetry of a superior animal together with the accepted indications of milk production, to be regarded as essential as applying to Red Polls."

"General Appearance : A typical Red Poll is a very graceful animal, exhibiting those dual purpose qualities which are so characteristic of the breed. The cows are deep, well-fleshed animals with a soft and pliable skin and carrying a well-developed udder. The bulls are well-formed animals full of masculine character and carrying beef which is worth top price in the market. Size is of great importance both in males and females".

The most recent issue of the Red Poll Herd Book (Volume XIV, 1938) contains the entries of 180 bulls and 297 cows. The number of members of the Association is now 98; the total number of cattle admitted to registry since the Herd Book was instituted comprises 1980 bulls and 3515 cows. At the last enumeration (1928) purebred Red Poll cattle numbered 831, being 1.2 per cent of the total purebred cattle population, and crossbred Red Polls numbered 6909.

Since 1918, the Association has participated in the C.O.R. system of testing purebred dairy cattle and performances to date are as follows :-

Age Group	Present Class Leaders			Average Production 1918-1938			
	Days	Milk	Fat	Certs.	Days	Milk	Fat
2-yr old	365	11,228	511	43	345	7576	337
3-yr old	365	9,491	459	17	345	7920	350
4-yr old	365	13,290	580	8	349	9,807	431
Mature	365	12,682	538	26	341	10,501	444

A total of 94 certificates has now been issued to 69 registered purebred Red Poll cows, the average seasonal production being :

344 days: 8,637 lbs milk: 4.36 per cent fat: 377 lbs butterfat.

d.

FUNCTIONS OF THE BREED ASSOCIATIONS.

All dairy cattle breed associations in New Zealand are primarily concerned with "maintaining the purity of the breed", i.e. with preserving in present-day stocks a line of descent from animals of known purity of breeding that is unbroken by any suspicion of crosses with animals of other breeds or crosses. "Safeguarding the purity of a breed does nothing to increase its merit but does act to some extent as a ratchet mechanism to maintain whatever special merit the breed already has and to hold any future improvements which individual breeders may make".

At the establishment of the herd books in New Zealand, extreme precautions were taken to ensure that only animals of undoubtedly pure descent were admitted to registry. The New Zealand Shorthorn Herd Book still remains "open", but in the case of the other Associations the herd book was "closed" within a very few years of its institution and if the admission of doubtful or graded-up stock was permitted at all, such entries were classified and kept strictly separate from the main body of registrations.

The effort to secure accuracy in recording pedigrees in the early herd books is retained as a fundamental object of the associations. Ultimate responsibility for the registration of none but cattle descended from stock of admitted purity of breeding rests with the individual breeder, but, by exercising strict supervision of all applications for registry and, to some extent by prescribing standards for the external appearance of stock, the Associations are able to reduce errors due to carelessness or fraudulence to a point where herd book pedigrees may be generally accepted without reserve as accurate records of descent.

Herd Books are now published annually by the Jersey, Friesian, Ayrshire and Red Poll Societies, and every two or three years by the Milking Shorthorn and Shorthorn organisations. In all cases breeders are required to register their stock at under twelve months of age, heavier fees being payable for non-compliance with this regulation. The main object is to ensure as far as possible that records of parentage are not lost or forgotten through

delays in applying for registrations, but the system also has value in simplifying office work and publication details. In the case of the New Zealand Friesian Association, the notification of all births (dead and living) is insisted upon as a pre-requisite to registration at up to twelve months. The recording of transfers of registered stock also forms part of the office duties of the associations.

All the Associations are actively concerned in improving the merit and expanding the numbers and influence of their respective breeds, but the emphasis on each of these objectives has shown a tendency to vary a good deal in accordance with the growth and development of the breeds over a period of years. With the organisation of the breed societies, while breed improvement was frequently stressed, the main emphasis at first was directed towards expanding the influence of the breed. The establishment of new herds of purebred cattle was encouraged through publicising the special intrinsic merits and current achievements of the breed at stock shows and in the production field. As the value of good purebred sires in improving grade cattle became more fully recognised, the various breed societies were prominent in extolling the virtues of each particular breed. In consequence, dairymen who had successfully used pedigree sires of a given breed, in many cases subsequently became breeders of registered purebred stock. Transfers of female stock for use in newly established stud herds, and sales of registered sires for use in grade herds became numerous and the breed greatly expanded in numbers and influence.

Of recent years in New Zealand, the various breeds of dairy cattle have continued to expand but the emphasis in breeding has shifted to the necessity for breed improvement, and, in the face of keen inter-breed competition, the special merits of each particular breed have been loudly proclaimed. Thus: Jerseys have been extolled for adaptability, and high butterfat production at low cost; the Friesian association has emphasised the value of maximum yields of low-testing milk in respect to cheese-manufacture and pig-keeping; Ayrshire breeders have been active in stressing

the special ability of the breed to produce well under circumstances of inferior environment, and the virtues of 4 per cent "soft-curd" milk in cheese and butterfat production; the Milking Shorthorn has been extensively advertised as the "good old British breed" with high constitutional qualities and an ability to fatten readily; Red Poll breeders have stressed the importance of maximum yields of milk and beef from the same animal. The heavy continuous demand for high class purebred sires for use in grade commercial herds has greatly stimulated breed expansion, inter-breed competition and, of latter years particularly, breed improvement.

Responsibility for breed improvement, like that for the registration of none but purebred animals, rests ultimately with the individual breeder, but the Association as a body is able to exert a degree of influence by guiding the ideals of breeders generally and by listing records of performance. Thus each association publishes, or otherwise makes available to breeders, standard descriptions and/or drawings of ideal cattle, prescribes a scale of points for judging cattle, arranges classes at A. and P. Shows at which the entries are placed by judges appointed on the recommendation of the association and in many cases offers special prizes either in cash or as trophies for certain classes exhibited.

The five dairy breed associations all officially support the Department of Agriculture's systems of milk recording of registered purebred stock - the C.O.R. (Certificate of Record) and G.O.H.T. (Government Official Herd Test). Some of the societies (e.g. the Jersey and Friesian Associations) pay liberal subsidies to encourage breeders to take part in testing, and prizes are awarded for cows giving outstanding yields. Lists are published either in the Herd Book (e.g. the Ayrshire Association) or in a special Advanced Register (e.g. the Jersey and Friesian Associations) of all cows that have gained certificates of production under the C.O.R. and G.O.H.T. Systems, and also of bulls having a certain minimum number of daughters with C.O.R. performances.

The Associations, representing the breeders collectively, are active in furthering the interests of members through encouraging breed expansion and emphasising the value of registered sires in grade herds. Breed propaganda, designed to attract new members, to encourage the formation of new herds and to stimulate the demand for pedigree stock, is carried out by all the associations by means of advertisements at A. and P. Shows, the distribution of pamphlets descriptive of the breed's attainments, advertisements in farm journals and magazines, and regular features published in "the official organ of the Association", usually some well-known, widely-circulated farming periodical. (e.g. the "New Zealand Dairyman", a monthly publication, is an official organ of the Friesian, Ayrshire and Red Poll breed Associations).

Each of the five breed associations is affiliated to the New Zealand Dairy Breeds' Federation, a body consisting of representatives nominated by each breed society and having no other functions than to act in matters where breeders of pedigree dairy cattle are concerned collectively.

e. THE INSTITUTION OF C.O.R. TESTING.

The Certificate-of-Record system of testing registered purebred dairy cattle for milk and butterfat production was introduced by the Dairy Produce Division of the Department of Agriculture in co-operation with the Friesian and Jersey breed Associations in the season 1912-1913. The scheme was originally known as "Semi-official Testing", but the title was changed to "C.O.R." as from the 1915 season.

The project originated with the Dairy Division as the result of a growing demand from commercial dairymen for pedigree bulls from dams with authenticated records of production. The practice of using purebred sires in improving the production of grade herds was gradually increasing at this time but there was no means of determining whether a bull was from a good milking strain. Breeders of registered stock generally considered that the Association system of herd testing being operated in many parts of the country carried with it insufficient authenticity or official standing to make it suitable for application to pedigree cows. Registered purebred stock therefore was in demand only where the recorded purity of ancestry was believed to have special merit in itself. Pedigree breeders made their selections on outward appearance, on flow of milk, and on nearness of relationship to much valued individuals.

The rapid extension of the herd testing movement amongst grade dairy herds, however, focussed attention upon the need for production records in registered purebred cows if pedigree sires were to continue in demand for use in commercial herds. The C.O.R. scheme was introduced therefore with the object of:-

- (1) Assisting the breeder in "selecting his best strains and standardising his herd",
- (2) Being "of benefit to the ordinary dairyfarmer",
- (3) Having a "potent influence in improving the treatment meted out to much of the purebred stock".

"Better breeding will be accompanied by better feeding not only in the ordinary crossbred herd, but in the purebred

herd as well. This should be conducive to the building-up of better-constituted and more productive dairy herds".

The general conditions governing C. O. F. Testing are (1938) as follows :-

- (1) Only purebred cows registered in a New Zealand Herd Book and individually identifiable are admissible.
- (2) An official Government testing officer may visit the farm at any time, and an ordinary testing visit is made once in each calendar month. The officer supervises and takes milk weights at the first milking and then weighs and samples the milk for testing purposes at the two (or three, if the cow is milked thrice daily) subsequent milkings.
- (3) The owner of a cow is personally responsible for weighing and recording the quantity of milk at every milking and the record is forwarded monthly to the Dairy Division.
- (4) The monthly fat production of a cow is calculated by figuring the total milk credit for the month at the average test for the day obtained by the testing officer.
- (5) Four-year-old and mature cows are required to have calved within 455 days of calving for the commencement of the test.
- (6) Dates of service while on test must be notified and all cows tested are required to recalve within 455 days of calving for the test period.
- (7) Strict precautions are taken against fraud and no certificates are issued where the Director of the Dairy Division is not satisfied that all requirements have been fulfilled.
- (8) Certificates are issued to cows and heifers which have conformed to all the conditions outlined above and have exceeded the following standards of production:

C. O. R. (YEARLY) TEST.

If 2 years old at commencement of test	275.5 lbs fat
" 3 " " " " " "	312.0 " "
" 4 " " " " " "	348.5 " "
" 5 " " " " " "	385.0 " "

For the C.O.R. (305-day) test, the butterfat requirements are 25 lbs lower for each age-group.

The standards of production are based upon an increased yield of 0.1 lb butterfat for every day by which the age of a cow commencing test exceeds 2 years.

Certificates are endorsed "first class" when a cow recalves within 455 days of the commencement of a 365-day test, and within 395 days of the commencement of a 305-day test. "Second class" certificates are issued to cows producing the required amounts of butterfat but calving up to 30 days after the limits for a first class certificate.

The C.O.R. test "is essentially a breeder's, rather than a dairyfarmer's test; it is an individual cow test rather than a herd test, and is comparatively expensive in both time and money. It is naturally a test for selected individuals, for the reason that breeding is based on selected individuals. Testing Fees are comparatively high because of the thorough checks necessary when the country's most valuable animals are bought on their production records".

The C.O.R. test forms the basis of most of the various Advanced Registers of Merit established by the breed societies for listing high producing cows, and of the various registers of Proven Sires.

Since the inception of the scheme in 1912-1913, a total of 10,763 registered purebred cows has received 12,290 certificates. Approximately 90 per cent of the cows are tested once only.

f. GOVERNMENT OFFICIAL HERD TEST (.O.H.T.)

In the season 1927-28, the Dairy Division, with the support of the breed societies introduced the .O.H.T. system as an auxiliary to the C.O.R. test, with the objects of drawing attention to the very small proportion of registered purebred cows with authenticated records of production and of providing a ready, accurate and inexpensive means of herd-recording for pedigree stock. "A stage seems to have been reached where one must recognise that the mere fact of an animal being in the herd book of one of the dairy breeds is not sufficient, and that there is need for the testing of a larger proportion of our purebreds, together with a consequent classifying and weeding-out by means of an advanced or selective register or some other method. The O.H.T. linked up with the C.O.R. test, provides the foundation of an effective and economical movement in this direction".

Breeders who have at least one cow on C.O.R. test may enter any other cows in the herd for recording under the O.H.T. system for a period of not more than 305 days at a fee of 5/- per cow. The last cow entered for O.H.T. must have calved not more than 90 days after the last cow entered on C.O.R. test. Milk weights and samples are taken by the Government Official Testing Officer on his visits to the farm in connection with the C.O.R. test, and the farmer is not required to keep a record of daily milk weights as in the case of cows on C.O.R. test.

The progress of the O.H.T. Scheme is indicated by the following details for cows in milk 180 days and more at 30th September in each year :-

Season	No. of Breeders	No. of Cows	Average Butterfat (lb).	Average Days
1927-28	102	1127	283	268
1928-29	142	1636	288	275
1929-30	130	1304	294	279
1930-31	170	2008	298	278
1931-32	158	1506	290	280
1932-33	163	1525	310	283
1933-34	179	1995	312	280
1934-35	178	1876	310	285
1935-36	175	1753	326	287
1936-37	203	1904	333	282
1937-38	203	1986	329	279

Cows of all breeds (including Red Poll, Guernsey and Shorthorn) have been tested under the scheme but Jerseys have consistently been most largely represented, as the most recent figures show (Season 1937-38):

Breed	No. of Breeders	No. of Cows	Days	Milk (lbs)	Fat (lbs)
Jersey	176	1527	280	6118	331.93
Friesian	20	362	276	9050	323.86
M. Shorthorn	6	58	271	6490	273.88
Ayrshire	2	39	282	7649	350.45
Totals & averages	203	1986	279	6693.3	329.13

SECTION III

ORGANISATION OF THE GENERAL DAIRY CATTLE
POPULATION

a

THE IMPORTANCE OF COMMERCIAL DAIRY
HERDS

The dairy herds of the Dominion are located on farms ranging from units where the keeping of dairy cows plays a very subsidiary part in the farm enterprise, to true dairy farms where products of the dairy herd are the ultimate source of the entire farm income. On grassland farms carrying both sheep and dairy stock, the gradation is from properties where the produce of the small dairy herd is used solely for consumption on the farm, through farms where proceeds from dairying add to a farm income derived mainly from sheep, to holdings where returns from sheep are secondary to sales of dairy produce. In mixed agricultural and dairy farming, proceeds from sheep and cash crops are usually more important than returns from the dairy herd. Farms wholly devoted to dairying include both small holdings where the size of herd seldom exceeds 15 cows, and the owner finds seasonal and/or part-time employment off the farmlet, and the large-scale commercial dairy farms which carry the greater proportion of the national dairy cow population.

In 1934, it was estimated that the herds in the Dominion totalled some 75,000. Although the number of dairy cows decreased by nearly 80,000 between 1933-34 and 1938-39, the movement is probably represented less by a decline in the number of herds milked on true dairy farms than by a reduction in the size and number of herds on sheep farms and mixed farm enterprises; accordingly, the total herds in the Dominion are probably still in excess of 70,000. At the most recent enumeration (1935-36) some 40,000 holdings outside of borough boundaries were classified as being wholly or almost wholly

devoted to dairying. Suppliers to dairy factories in the same year totalled 70,258, hence it may be assumed that there are probably rather less than 30,000 herds on mixed farms from which surplus produce is sent to dairy factories, and probably up to 5,000 herds producing solely for farm or home consumption.

Size of herd ranges from 1 to 5 cows (in a very large number of cases) to 300 cows and over (in a few instances), the average for the Dominion being 24.2 cows. The general distribution is as follows (1933-34):

Herd Range	% of Total Herds	Average Size of Herd	% Total Cows in Milk	% Total Butter-Fat	% Total Dairying Area
1-9	44.0	4.0	7.2	7.1	7.3
10-19	10.7	14.0	6.1	6.8	6.2
20-34	18.8	26.6	20.7	21.7	20.7
35-49	12.0	41.1	20.4	20.8	20.4
50-74	8.8	60.3	22.0	21.9	21.9
75 and over	5.7	99.3	23.6	21.7	23.5
100.0 (75,000 herds) 24.2 (average) 100.0 (1,816,000) 100.0 (426,699,242 lbs) 100.0 (5,000,000 acres)					

Although 44 per cent of the total herds average no more than 4 cows, it is apparent that their contribution to the national total butterfat is insignificant, relative to that of herds composed of 20 cows and over. The latter group represents mostly the true commercial dairy farms of the Dominion, but it also contains a considerable number of herds developed and enlarged on mixed farms in attempts to increase returns by diversification of production during the years of financial depression.

Fawcett, in an investigation into movements in the size distribution of dairy herds on specialised and non-specialised

dairying holdings between 1929-30 and 1933-34, showed that for the four-year period:

- (a) with low prices for all primary produce there were substantial increases in the number of holdings carrying dairy herds and in the number of farmers sending surplus cream to factories;
- (b) dairying assumed a dominant position in an increasing number of farm enterprises but the major increases in dairy cows took place on specialised dairying holdings, particularly on farms carrying 40 cows or more;
- (c) although a number of non-specialised holdings carried large dairy herds, their relative importance in the dairying industry was small.

Percentage figures included in the investigation are as follows :-

Herd Range.	<u>Specialised</u>		<u>Non-specialised</u>	
	1930 %	1934 %	1930 %	1934 %
1-9	29.9	27.4	68.5	59.8
10-19	14.0	13.5	13.6	17.9
20-39	27.2	24.3	10.5	11.9
40-59	16.0	16.8	4.3	5.3
60-99	10.4	13.3	2.3	3.7
100-149	2.1	3.6	0.5	0.9
150 and over	0.4	1.1	0.2	0.5
	100.0 (33,301 herds)	100.0 (42,579 herds)	100.0 (32,195 herds)	100.0 (27,855 herds)

The tendency for specialised dairy herds to be generally larger than herds on non-specialised holdings is further emphasised in the following table based on figures used in the same investigation :

Herd Range	Total Herds.	1930		Total Herds	1934	
		Specialised herds No.	% of total		Specialised herds No.	% of Total
1-9	32,015	9,196	31.1	28,292	11,653	41.2
10-19	9,027	4,656	51.6	10,769	5,788	53.7
20-39	12,437	9,045	72.7	13,652	10,340	75.8
40-59	6,710	5,316	79.2	8,632	7,155	82.9
60-99	4,195	3,449	82.2	6,679	5,655	84.7
100-149	864	688	79.6	1,784	1,516	85.0
150 & over	248	183	73.8	626	472	75.4
TOTALS:	65,496	33,031	50.43	70,434	42,579	60.5

By far the greater proportion of the total dairy cows are contained in the herds on specialised dairy farms:

Year	Total Cows	Cows on Specialised Dairy Farms	
		Number	% of total
1930	1,413,854	1,001,650	70.9
1934	1,908,076	1,466,009	76.9

Of the 70,000 to 75,000 dairy herds in the Dominion, there are at the present time probably some 40,000 on holdings devoted wholly or almost wholly to dairying. These farms carry herds comprising about 60 per cent of the Dominion total, representing approximately 75 per cent of the total dairy cattle population and producing probably 80 per cent of the gross national output of butter-fat.

While there is a considerable number of large dairy herds, particularly on mixed sheep and dairy grassland holdings, the greater proportion of herds on non-specialised dairy farms is normally of small size and milked mostly for home-farm supply. When prices for other products are depressed, such herds tend to be increased in size and larger numbers of farmers send surplus

cream to dairy factories. Herds on non-specialised holdings pay number 30,000 to 35,000.

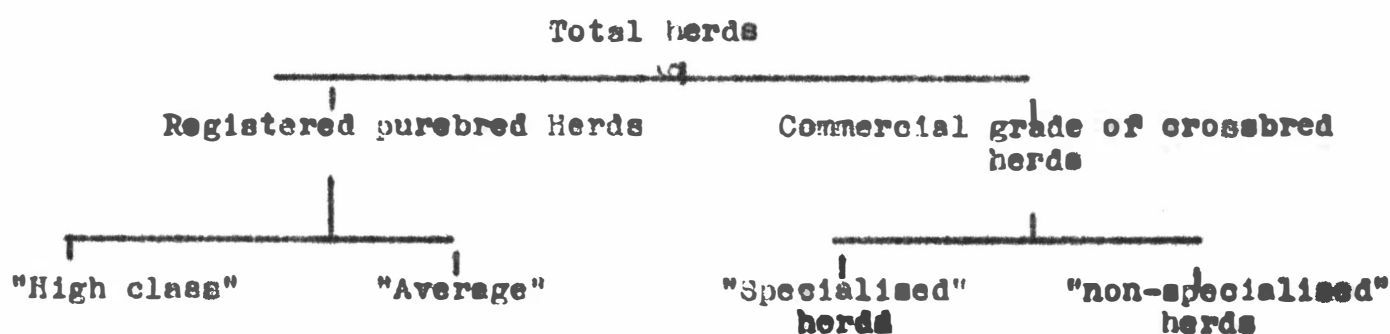
The third important section of the national dairy herds comprises the registered purebred dairy cattle population. The pedigree herds are located for the most part on the specialised dairy farms but, particularly in the South Island, are also to be found on mixed holdings. No official data are available to show the numbers of registered purebred herds but the following figures, based on the most recent herd books in each breed, give an indication of the current position.

Breed	No. of Members.	No. of Registered Herd Names.
Jersey	1987	2,039
Milking Shorthorn	400	355
Friesian	384	334
Ayrshire	234	207
Red Poll	98	119
Shorthorn	87	83
TOTALS:	3,190	3,137

Since many of the Shorthorn herds and some of the Red Poll herds are not being developed along dairying lines, it can be said that there are approximately 3,000 herds of registered purebred dairy cattle in the Dominion, representing about 4 per cent of the total dairy herds.

b THE ROLE OF THE REGISTERED PUREBRED SIKE.

The national dairy cattle population may be described in general terms as exhibiting the following stratification :



In the improvement (however slight) in the productivity of the dairy cattle of the Dominion that is continuously though gradually taking place, the stratification of the dairy herds into grades of differential average productivity is of very marked importance. When varying environments have been allowed for, the improvement that occurs in any one grade is brought about mainly by the addition of superior germ plasma from a higher grade, though the discriminate use of sires able to transmit producing qualities above those of the population into which they are introduced. Thus, the dairy herds of the Dominion may be grouped in grades of decreasing average merit as follows :

- A. "High class" registered purebred herds
- B. "Average" registered purebred herds
- C. Grade herds on specialised dairy farms
- D. Crossbred herds on specialised dairy farms
- E. Larger herds on non-specialised dairy holdings
- F. Small herds on non-specialised dairy holdings

Such classification is quite arbitrary and there is almost certainly considerable overlapping as between grades from a production point of view, but it illustrates a prominent feature in New Zealand dairy cattle breeding - namely, the grading-up process, whereby sires bred in the grades of higher average productivity are

used in the improvement of the lower grades. If such a process is to be continuous, there is implied also a constant improvement of the higher grades so that as the lower grades increase gradually in merit, stock of still higher productivity will always be available from the higher grades for the purpose of further improvement. In the Dominion, there is a steady stream of bulls from the average registered purebred herds for use in grading-up the specialised dairy herds and to some extent also the herds on non-specialised holdings. The average purebred herds in turn depend for their improvement upon breeding stock from the high class studs. Ultimately the responsibility for national production rests with a few breeders of high class stock, for while the large scale commercial dairy herds produce the vast bulk of the Dominion's butterfat, they depend for the maintenance or improvement of the average hereditary producing ability in their cattle upon the availability of superior sires from the registered purebred herds.

The high class registered herds (A) in any one breed represent a small nucleus of the most valuable germ plasma in the breed. It is into these stud herds of the industry that high class animals from abroad are imported. Selected superior individuals are exchanged amongst herds within a breed. The aim of the stud breeder is to obtain in his stock a high degree of relationship to certain selected individuals of proved superior merit and in consequence it is in these "seed stock" herds that breeding in the true sense is practised. The establishment and development of superior families through the use of varying degrees of line-breeding is the usual policy and in many cases a considerable degree of uniformity in breeding and producing qualities is attained. Competition for surplus stock from well-known established studs is exceedingly keen amongst both other breeders of studs and amongst breeders of average pedigree stock anxious to grade-up their herds to "stud standard". Values for stud stock are therefore exceedingly high and returns from the sale of surplus bulls and heifers form a more important part of the farm income than proceeds from butterfat production in the case of stud herds.

These stud herds constitute by no means a static population. Herds unable to maintain an output of stock of high average excellence (as measured by the prices which other breeders are willing to pay for them) are reduced in standing to the level of the herds of average registered purebred stock whose surplus bulls are sold for use in commercial herds. Moreover, a few herds included in the "average" group are always to be found on the borderline between the high-class herds and the average pedigree herds. As the market rating of their surplus cattle improves (usually an indication of improved breeding and producing qualities) such herds will be included amongst the elite herds of the breed.

The herds of average registered purebred cattle (B) constitute probably about 90 per cent of the total registered herds and range in merit from herds that have almost attained the status of stud herds to others that are inferior to many herds of grade cattle. In the former (the upper sector of the population) proceeds from the sale of surplus stock have become, or are tending to become, more important as a source of farm income than returns from butterfat production; in the lower sector of the population butterfat production provides the main income and returns from the sale of surplus stock range from incidental to prominent accordingly as the average productive merit of the herd increases, and a more active demand and higher prices are obtained for stock.

The better herds of this average group (B) exercise a keen demand for bulls bred in the stud herds in their efforts towards obtaining status as stud herds. In turn they supply surplus stock to less meritorious purebred herds lower in the same group, and also are active in providing male stock for use in high class grade commercial herds at the head of the succeeding group (C).

Many of the registered purebred herds in the group (B) are bred and managed as part of a frequently larger grade herd. Registered purebred sires are mated with both grade and purebred cows and little or no constructive breeding is attempted, the sires purchased being chosen with less regard to their relationship to the cows in the herd than to adequate butterfat backing in the ancestry. Proceeds from the sale of registered yearling bulls form an unimportant proportion of a farm income mainly derived from butterfat production.

The grade commercial herds (group C) on specialised dairy holdings constitute probably the most important butterfat-producing section of the industry. They are for the most part the large-scale dairy herds in which registered purebred sires of a given breed have been used for so many generations that the cattle are practically "purebred". In some cases the herd average butterfat production is above the average for the registered purebred population and considerable difficulty is often experienced in obtaining a suitable registered sire to maintain the herd average. In the grade commercial dairy herds butterfat is relied upon (frequently in conjunction with returns from pig-rearing) to produce the gross farm income, and the sale of surplus stock (e.g. marked calves or in-calf heifers) is not usually a regular policy nor (like the sale of cull stock) does it contribute largely to gross receipts.

The crossbred commercial dairy herds (group D) are not largely represented on specialised dairy holdings. Before the emphasis was laid upon the value of registered purebred sires in grading-up, the great bulk of the milking population was in varying degrees crossbred, developed on a predominantly Short-horn base. Such crossbred herds as now exist are those where registered sires of one breed have been displaced by those of another, or where grade, crossbred, scrub, or homebred non-registered sires are used. Large numbers of the latter type still continue to be used in the industry but as more reliable registered sires from proved high producing strains are avail-

able, the practice is being discontinued. True crossbred herds, where sires of two different breeds are used alternately as a matter of deliberate policy, are not of common occurrence but are an interesting development that requires full investigation with respect to the economics of cheese production.

The larger herds on non-specialised holdings (E) are grade or cross bred, usually of lower average merit than similar herds on specialised dairy farms. On true dairy farms where butterfat production is the most important source of revenue, every effort is made to maintain and improve the herd average production through systematic culling and the use of superior sires. The attention devoted to the breeding, feeding and management of the dairy herd on non-specialised holdings tends to vary in proportion to the importance of the contribution from sales of butterfat towards the gross farm receipts. Where dairying is practised as a sideline to sheep or arable farming, attention bestowed upon the herd tends to be secondary to that given to the flock or to arable crops, and herd averages are low. Average production figures are probably higher where the herd produces a major proportion of farm receipts; but, generally speaking, dairy herds on mixed farm enterprises are below the average merit of those on specialised dairy farms, and registered sires are used to a lesser extent.

Small herds on non-specialised dairy holdings (F) are milked mainly for home supply of milk and cream but surplus produce may be sent to a nearby dairy factory either as a matter of usual practice or only when prices for the other products of the farm are depressed. Herds are extremely numerous, since farm enterprises of all kinds carry a few "house-cows.", but usually small, ranging from one or two cows up to fifteen or twenty, but seldom exceeding the latter figure. Cattle may be of all breeds and crosses, several breeds being represented not infrequently in the one herd of three or four cows. The main requirement is that the cows shall give a reasonable quantity of milk and while in most cases scrub bulls of the dairy breeds are used as sires, it is not uncommon to find Hereford, Polled

Angus or Shorthorn Station bulls used to get the dairy cows in calf; occasionally the crossbred progeny are milked. The average productive capacity of herds throughout the group (F) is low.

C. THE RISE OF THE JERSEY.

The widespread use of purebred sires in commercial non-registered dairy herds consistently over a considerable period has had the effect of changing the composition of the general population of milking cows from predominantly Short-horn crossbred to mainly grade Jersey. Whereas in the early days of the dairy industry it was customary, in the herds of mainly Shorthorn extraction, to breed from any type of sire from a milking strain, the bulk of the milking herds of the present time consist of grade cattle - i.e. registered sires of a single breed have been used consistently for a number of generations. Initially, there was a very large difference in average merit between the purebreds and the general crossbred population so that the effects of using registered sires in herds of mixed extraction were often spectacular both in raising production and in bringing about greater uniformity of external appearance. A stage has been reached within recent years, as a result of this policy, where many herds of grade cattle exceed in average production merit, the average for the registered purebred herds. The general trend is towards a population of grades so meritorious that the ability of the purebreds to bring about further improvement is being seriously challenged. In order to preserve the market for registered sires used in grading-up a constantly improving general population, continued improvement in the purebred population itself is essential if the distinction between purebreds and grades is to be maintained.

It is apparent that mass selection in the form of using sires from high producing herds for the purpose of maintaining or increasing herd average production in lower-producing herds is a dominant feature of the Dominion's dairy cattle breeding. The value of purebred sires as a rapid means of improving the quality and efficiency in production of breeding stock had been emphasised by prominent authorities some considerable time even before the establishment of herd books for the (now) major dairy breeds in New Zealand. Thus, the Department of Agriculture,

in its Annual Report for the year 1896, deplored the fact that 60 per cent of the bulls in use in the Auckland District "were of a nondescript breed", and pointed out that "if such a system (were) continued the progeny (would be) certain to show signs of deterioration".

With the rapid development of dairying subsequent to 1900, and the formation of herd books at about the same time, the value of purebred sires became more widely realised and an increasing demand for registered purebred bulls set in from owners of crossbred herds. From about 1910 onwards, interrupted to some extent by the War, the expanding market for purebred sires led to the establishment of more and more herds of registered cattle. Development was rapid for all the prominent breeds of dairy stock, but although herds of milk-recorded Shorthorn, Ayrshire and Friesian cattle had been established at the various State Experimental farms, it was in the Jersey breed that the greatest immediate and sustained expansion took place.

The inception of herd testing in 1909 and of purebred testing in 1912 had contrasted the general Shorthorn crossbred dairy cattle population very unfavourably from a production point of view with the relatively more highly specialised dairying qualities of the Jersey. The comparatively recent institution of the payment for milk according to its fat content, together with the spread of home separation as recognised practice, also tended to favour the Jersey more than other breeds for crossing purposes.

Following the War came the rise to prominence of the Auckland dairying districts, the emphasis on butter-production, the movement towards greater carrying capacity, and the necessity for reduction in production costs. The small bodied high-testing high-yielding Jersey became increasingly popular for commercial dairying, and the numbers of registered purebred Jersey cattle greatly advanced in response to the demand for sires. While cattle of other dairy breeds also greatly increased numerically, their proportions in the total registered purebred dairy cattle population showed an actual decline, due

to the rapidity with which the Jersey progressed. Reliable figures to illustrate the position are available only for intervals covering the ten-year period 1918-1928, but the trend is plain.

NUMBERS AND PROPORTIONS OF PUREBRED DAIRY CATTLE								
Breed	1918		1921		1924		1928	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Jersey	6228	43.9	12997	52.7	28554	64.0	39,379	65.7
Friesian	4033	28.4	5091	20.6	8,177	18.3	10,670	17.8
Ayrshire	1,319	9.3	2,169	8.8	3,832	8.6	4,905	8.2
Red Poll	-	-	118	0.5	1,054	2.4	831	1.4
Milking) Shorthorn)	2,620*	18.5	4,293*	17.4	2,969	6.7	4,199	7.0
Totals:	14,200	100.0	24,668	100.0	44,586	100.0	59,984	100.0

*Milking Shorthorns were not separately enumerated in 1918 and 1921, and the figures quoted represent estimates only for these two years being an arbitrary 50 per cent of the total cattle listed as "purebred Shorthorn".

The rapidity with which the Jersey breed has risen to prominence has been, of course, assisted to a considerable extent by an almost complementary decline in the popularity of the Shorthorn for milking purposes. This point is hardly sufficiently emphasised in the above table owing to the estimated figures adopted, but is well brought out in a subsequent table illustrating changes in the proportions of the various breeds represented in the general dairy population of cows and heifers two years old and over. At the same time, the general inadequacy of the former crossbred Shorthorn population for high dairy production has tended to obscure the considerable merit of the true Milking Shorthorn as a specialised dairy breed. The above table, however, does indicate that at least in pure breeding the breed was tending in 1928 towards greater development.

While many herds of grade Friesian, grade Milking Shorthorn, grade Ayrshire and grade Red Poll cattle have been considerably developed, the popularity of registered purebred Jersey sires has far exceeded that of any other breed. In the following table purebred sires of each breed are shown as percentages of the total

purebred Dairy bulls two years old and over:

<u>Breed</u>	<u>1924</u>	<u>1928</u>
Jersey	71.1	80.1
Friesian	16.9	10.3
Ayrshire	5.3	4.8
Milking Shorthorn	5.2	3.9
Red Poll	1.5	0.9
	<u>100.0</u>	<u>100.0</u>

Although details for years subsequent to 1928 are not available, there can be little doubt, in view of herd book registrations for the various breeds, but that the Jersey has continued to maintain its numerical superiority.

Of the total dairy bulls two years old and over in use in the industry, purebred and grade or crossbred Jersey sires greatly outnumber all other breeds and crosses. In point of fact, from the few figures available, while Jersey total bulls have largely increased, crossbred bulls of other dairy breeds have shown a tendency to decrease both numerically and proportionately to Jerseys, thus:

<u>STRAIN</u>	<u>1924</u>		<u>1928</u>	
	<u>No.</u>	<u>Percent</u>	<u>No.</u>	<u>Percent</u>
Jersey Purebred	6,458	13.8	11,349	23.8
Jersey Crossbred	18,855	40.3	20,905	43.9
Other Purebred	2,620	5.6	2,825	5.9
Other Crossbred	14,633	31.3	9,576	20.1
Unspecified	4,232	9.0	2,969	6.2
Total dairy bulls	<u>46,798</u>	<u>100.0</u>	<u>47,624</u>	<u>100.0</u>

Although, for purposes of classification, non-registered cattle are described as "crossbred, with predominant strain of —"

it can be assumed that the bulk of such so-called crossbreds are more truly "grade stock, i.e. progeny of several crosses of pure-breds or improved sires upon mixed ancestral stock". Lush states that "most of the experiments with the use of purebred sires for grading have shown that the averages of grades with more than two crosses of pure blood (that is, with more than 75 per cent pure blood) are very little below the average of the pure breed concerned". This statement may also assist in explaining the very larger numbers of "crossbred" bulls in use, for, in cases where it was difficult or very expensive to obtain purebred sires, or in herds of the high grades where purebred sires had been used over a long period, homebred bulls from high producing cows and sired probably by registered bulls would tend to be used. In many instances such bulls prove highly satisfactory, emphasising the fact that all non-registered bulls are not necessarily "scrubs".

The net result of the increasing use of Jersey purebred and crossbred sires in commercial dairy herds has been to produce a population of milking cows predominantly Jersey in strain. The most recent enumerations of the general population of dairy cows and heifers two years old and over, according to the predominant strain, are as follows:-

<u>STRAIN</u>	<u>1924</u>		<u>1928</u>	
	<u>No.</u>	<u>Percent</u>	<u>No.</u>	<u>Percent</u>
Jersey	539,636	43.9	820,431	63.5
Milking Shorthorn	489,727	39.9	286,534	22.2
Friesian	159,076	13.0	150,065	11.6
Ayrshire	34,041	2.8	32,379	2.5
Red Poll	1,773	0.1	2,585	0.2
Other	3,946	0.3	879	0.0
TOTALS	1,228,199	100.0	1,292,873	100.0

Notable features of the table are the 50 per cent expansion in the Jersey and a further decline of 40 per cent in the Milking Shorthorn numbers. It is probable that reduced totals in the Friesian and Ayrshire breeds are merely temporary recessions, but the development may be borne in mind

as a possible indication of further specialisation in Jerseys. It is one of the minor extraordinary aspects of the dairying situation in New Zealand that although a mass of data has been carefully and expensively investigated recently with reference to Guaranteed Price Analyses, statistics relative to the capital position have either never been collected at all (e.g. incidence of disease) or have been collected only sporadically (e.g. it is now eleven years since the breed distribution was last enumerated).

The facts of Jersey expansion may now be briefly summarised:

- (a) The milking capacity of the original, dominantly Shorthorn dairy cattle population was low.
- (b) The beginnings of large-scale dairying based on an export trade, the establishment of herd books of the specialised dairy breeds, importations of high class dairy stock, and the inception of milk recording, focussed attention upon the need for improvement in the average productive ability of the ordinary milking cattle population.
- (c) Rapid multiplication in the numbers of milking stock necessitated a rapid means of improving its average general productive capacity: mass selection, by the use of registered purebred sires of the specialised dairy breeds for crossing on the mixed types of the general population, was increasingly widely adopted as the means to improvement.
- (d) Of the registered sires used, the Jersey rapidly attained the widest popularity for the following reasons :
 - (i) Jersey milk has a higher fat content than that of any/other of the major dairy breeds in use in the Dominion, and dairy factory payouts for both milk and cream are made on a butterfat basis;
 - (ii) The Jersey in its native home has been bred for generations free from adulteration with other breeds, as a highly specialised butter-producing animal.

- (iii) The productive merit of the strains of the Jersey breed introduced into New Zealand was on the average relatively high.
 - (iv) The small size of cows of the breed generally, allowed more stock to be carried on a given area of land.
 - (v) The Jersey has proved very suited to the climate and general conditions of New Zealand dairying.
 - (vi) The "creamy" appearance of Jersey Milk probably has had a psychological effect in stressing the breed's butterfat producing qualities.
- (e) The special individual characteristics of the Jersey breed received further emphasis in the post-war era, due to :
- (i) The greatly increased importance of butter production, as compared with cheese;
 - (ii) The development of the Auckland dairying districts where butter production became the major industry.
 - (iii) The inception and rapid development of group herd-testing in which seasonal butterfat yield became the accepted measure of production performance.
 - (iv) The national movement towards intensification in grassland farming wherein increased carrying capacity could most spectacularly be effected through exploitation of the Jersey's small size.
 - (v) The Jersey characteristics of low maintenance requirement in relation to high production which assisted the movement towards reduction in farm costs by increasing butterfat production per acre.
 - (vi) The possibility that the Jersey as a breed possesses inherent efficiency in the conversion of feed into butterfat.

It is pertinent now briefly to consider to what extent the pervasive influence of the Jersey breed in the cattle stocks of the Dominion is reflected in the general dairying economy. It is necessary to consider the value of high butterfat production per acre with regard to the present or potential disadvantages of

high colour of butter in relation to consumer preference;

low milk output in relation to production of pig-meat;

high fat content of milk in relation to the economics of cheese production;

ultimate emphasis on butterfat production alone in relation to market conditions.

The Jersey potentiality for high butterfat production per acre depends upon (a) the relatively small size of the breed and (b) the high average capacity of the breed in butterfat production. In general, the requirements of an animal for maintenance vary according to its body weight (or, more accurately, according to area of body surface). As a breed, therefore, the Jersey requires proportionately less feed for the vital processes than larger breeds. In so far as production is concerned, the Jersey, under the field grazing conditions of New Zealand dairying, yields on the average at least as much butterfat per individual cow as the larger breeds. It is possible that superior foraging ability may be a factor concerned since under high feeding conditions (as in C.O.R. performances) the Friesian breed tends to average about 8 per cent higher butterfat production per cow than the Jersey at the same age. This is in accordance with the general expectation that with dairy animals, cows of heavier weights tend to give greater yields, when all are well fed.

As a result of lesser total feed requirements for maintenance and production combined, the total amount and cost of feed required per unit of production in the Jersey are lower than for the larger breeds and more cows can be carried per acre. Since Jerseys under field conditions are equally high butterfat producers as Friesians or other larger breeds, the result is that in general a high output of butterfat per acre is possible with the smaller breed.

Dr. F.H. McDowall, in a discussion of the value of three prominent dairy breeds in relation to cheese producing capacity, concluded that under the particular set of conditions studied

(including indoor feeding and C.O.R. performances), the average feed ratio was 10 Jerseys : 9.4 Ayrshires : 7.6 Friesians. While it is emphasised that these conclusions are based on a number of assumptions that may not be applicable to New Zealand field grazing conditions, it is perhaps permissible to apply such tentative feed ratio merely to illustrate the Jersey's potentiality in high butterfat production per acre.

e.g. A given area of land (say, 200 acres) will carry 100 mature Jersey cows or 76 mature Friesian cows. The total production from the 200 acres, based on the average yields of mature cows in the C.O.R. system up to 1938, may be estimated at :

(a) - For Jerseys: 100 (533 lbs. butterfat; 9,658 lbs milk)
= 53,300 lbs. butterfat; 965,800 lbs milk
i.e. per acre = 267 lbs butterfat; 4,829 lbs milk.

(b) - For Friesians: 76 (576 lbs butterfat; 16,279 lbs milk)
= 43,776 lbs butterfat; 1,237,204 lbs milk
i.e. per acre = 219 lbs butterfat; 6186 lbs milk.

Thus on a per-acre basis, Jerseys yield on the average about 25 per cent more butterfat than Friesians, and Friesians yield about 25 per cent more milk than Jerseys.

While the above calculations are by no means a final and reliable indication of the Jersey-Friesian situation they do emphasise the value of smaller but high producing animals in attaining high yields of butterfat per acre. It is possible that the superior foraging ability of the Jersey under field grazing conditions may further influence the position since figures for purebred cows under Group Herd Test tend to indicate that the Jersey is at least as high a butterfat producer as the Friesian breed. In general, the lesser total feed requirement and higher carrying capacity of the smaller breed tend towards greater efficiency in the conditions under which New Zealand Dairying is practised.

It is well known that the yield of milk per individual cow is considerably lower on the average in the Jersey than in all the other major breeds of dairy stock. In order to deter-

mine which is the most profitable type of cow for pig production, it is again necessary to take into consideration the relative numbers of the different types of cows which, on the average could be grazed on the same area of pasture. In the present state of knowledge on the point, it would seem that the smaller-bodied Jersey tends towards a lesser volume of production of milk per acre and a lesser output, therefore, of pig products per acre. But the position is complicated by the expectation that, on the average, the percentage of solids-not-fat in Jersey milk is higher than that in Friesian milk, or in the milk of other larger-bodied breeds. It is not clear to what extent, under field grazing conditions, this more "concentrated" nature of Jersey milk would compensate, in relation to output of pig products, for a larger per-acre volume of less "concentrated" Friesian milk. Dr. McDowall, in the article previously referred to, reached the conclusion that the average annual cheese production per unit of feed consumed would be approximately the same for Jersey, Ayrshire and Friesian cows, under the conditions studied. While the various assumptions upon which this conclusion was based may make the results inapplicable to field grazing conditions, it can perhaps be deduced that in general there is unlikely to be a great difference in output of pig products per acre as between the Jersey and larger bodied, higher milk-producing breeds. From the point of view of the individual dairy-farmer, net returns per acre from sales of butterfat and pig-products will tend to be higher on the average where Jerseys are the type of cows carried, assuming a higher butterfat production per acre and a rather lower output of pig-products per acre than for larger-bodied breeds.

From the long-term national standpoint, it may be objected that undue further specialisation in butterfat production is to be regarded as disadvantageous in the light of the congested state of the main butter market, and that a policy of diversification in production towards a greater output of pig-products should be followed.

With the increasing proportion of Jersey strains in the milking cattle of the Dominion, the average fat contents of milk supplied to cheese have risen correspondingly but factory yields of cheese per pound of butterfat have declined. The cheese-yielding capacity of milk depends on the casein content as well as on the butterfat content of milk, and while the casein content increases as the butterfat content increases, the rise is not in proportion, so that although high testing milk yields more cheese per hundred pounds of milk, there is less cheese produced per pound of butterfat than in low testing milk. Since payments for cheese-milk are made on a butterfat basis, suppliers of low-testing milks tend, where factory average yields are low, to receive a lesser return than the actual cheese-yielding capacity of the milk they supply entitles them to expect.

Dr. McDowall's results indicate that, on the data studied, the annual average cheese production per unit of feed for Jersey, Ayrshire and Friesian cows is approximately the same, but it is not known whether this relation holds for cheese production per acre.

New Zealand cheeses, due to the large proportion of high testing milk used in manufacture, tend generally to contain not only a great deal more butterfat than the regulations require, but also more than is desirable for making a satisfactory article. Hence, in the long term view, in the interests of the national dairying economy, there are objections to a widespread use of high-testing milks in cheese manufacture, quite apart from the individual farmer's concern for differences in cheese-producing capacity per acre as between different types or breeds of dairy-cows.

While little is known of the relation (if any exists) between heredity and the casein content of milk, it is possible that a combination of high butterfat production per acre with high cheese production per acre may be achieved through breeding policies embodying the following principles : (P.H. McDowall)

- (a) Selection for high casein content, large volume, and high fat content, of milk.

- (b) Selection within a breed for high butterfat yield
large volume of milk and low fat content of milk.

The successful use of Jersey strains in attaining high yields of butterfat per acre has tended towards an emphasis on butterfat production per se that, in the long run, is not perhaps in the true interests of the national dairy-economy. The trend in breeding has been towards selection on the basis of butterfat yield even where the production of milk for cheese-factory supply was the objective. The rising test of milking cows generally, the increasing importance of production for butter-factory supply, the tendency to describe per-cow yields almost exclusively in terms of butterfat production are other factors indicative of the situation.

Selection directed towards higher fat content of the milk has successfully assisted in raising average per cow butterfat yields, and, since payment for cheese-milk is made on a butterfat basis, has also produced greater returns per cow on farms supplying cheese factories; but the policy has had the serious disadvantage of bringing about a declining average annual factory yield of cheese per pound of butterfat. This factor in turn has caused an increasing number of suppliers to transfer from cheese- to butter-factory supply and the gross national output of cheese has been reduced, while a growing proportion of the national output of butterfat has been utilised in butter manufacture.

In view of the increasingly congested condition of the United Kingdom butter market, the revival of British agriculture, and the probability of quantitative regulation of butter imports, there is abundant evidence that further specialisation in the production of butter for export to the United Kingdom is likely to be exceedingly dangerous from the standpoint of the economic stability of the New Zealand dairy industry. Obviously, ⁱⁿ the production of milk and butterfat, as with other farm commodities, diversification in the ultimate product is an important method of assisting towards stability by spreading the

effects of price fluctuations. In order to encourage, in the interests of the national dairying economy in particular and the national economic stability of the Dominion generally, a more reasonable balance in the utilisation of butterfat produced as between cheese and butter manufacture respectively, it is suggested (Dr. F.H. McDowall) that if average fat tests continue to rise and average annual factory cheese yields to decline, it may ultimately be necessary for the butter industry to subsidise the cheese industry so that a sufficient differential premium per pound of butterfat might be obtainable by suppliers of milk for cheese-making.

The emphasis on butterfat production alone which is associated with the growing predominance of Jersey strains in the national dairy herds, is causing increasing concern both in regard to production and manufacture within the Dominion, and also in the profitable disposal of maximum quantities of butterfat in the form of butter and cheese on the United Kingdom market.

New Zealand butter, in general, possesses a deeper yellow colour than butter made in England, Ireland and certain Northern European countries also supplying the British market. Certain sections of the United Kingdom market, mainly in the North of England, Northern Ireland and the West Coast of Britain, have long been accustomed to paler butters and do not readily accept the relatively highly coloured New Zealand product. Since New Zealand is so largely dependent upon the United Kingdom Trade, and since it is mainly the undisposed surpluses of New Zealand butter that are basically responsible for variations in the price-level of the Dominion's produce on the Home market, the need for a complete penetration of trade into all districts is evident.

"The rather deep yellow colour of New Zealand butter is indicative of its high vitamin A content, and is due mainly to the fact that our cows are fed almost entirely on pasture and to a lesser extent to the predominance of Jersey strains in New Zealand herds". The fat-soluble organic pigment carotene occurring so abundantly in lush green pastures is the precursor of vitamin A and is responsible for the deep yellow colour in dairy products when present in quantity. A ready assimilation of

carotene from feed into the milk and body fats is known to be a specific characteristic of the Jersey breed, but it may be argued from the long-term point of view that it is preferable rather to undertake methods of gradually educating consumers, by means of advertising and other forms of propaganda, towards an appreciation of the high nutritive value represented in the deep yellow colour of New Zealand butter, than to make radical alterations in our methods of pasture management and of breeding stock.

C. THE ROLE OF SELECTION IN DAIRY CATTLE IMPROVEMENT.

Since "the ultimate destiny of every form of farm livestock is the market", the aim in animal breeding has consistently been towards increased production through improved productivity and greater productive efficiency per individual animal unit. Selection has been of varying importance in attaining these objectives.

Under the influence of natural selection, the common stocks, from which modern races of cattle are descended, showed degrees of specialisation according to environmental and nutritional conditions. Thus, small hardy muscular cattle became typical of highland regions, and larger less active animals came to predominate on the lower country where feed and other natural conditions tended to be more favourable.

Later, man began to adapt stock according to his own purposes and natural selection was supplemented and, later still, almost completely supplanted, by artificial selection. Races of cattle were developed to meet certain special needs of the human race: work oxen were bred and strains of cattle selected for meat or milk production. The latter were as yet neither very good beef animals nor very good dairy animals, judged by modern requirements, but they met the not very exacting demands of the time.

As populations grew and cities increased in size and number, special purpose breeds were developed for beef production and for milk production. In response to demands for hugely increased quantities and higher standards of quality of produce, selection for important economic characteristics in livestock became more intense. The development of international trading on a large scale added further economic incentives to the breeding of better and more productive stock, and, in the case of dairy cattle, selection was increasingly directed towards the attainment of greater productivity and improved efficiency in production.

In the breeding of improved forms of livestock, the emphasis has been, for hundreds of years, upon "selection of the best for breeding stock", but the progress made has depended very largely upon the degree of accuracy with which the excellence could be measured.

The old method of judging by external appearance proved itself of very considerable value in the foundation of the great beef breeds but was less successful in determining dairy capacity, except in so far as it assisted in broadly distinguishing between beef-type and milking-type animals.

Early methods of measuring excellence on the basis of individual production performance consisted in arbitrarily estimating or perhaps weighing the milk and/or butter yields of selected cows over short periods. As measurements even of phenotype, these did not of course compare in accuracy with modern records of lactation and lifetime production which in turn have been shown to be largely inadequate by themselves as measures of genotype or production transmitting ability.

Realisations of the value of relationship in regard to milking capacity led ultimately to the establishment of herd books and thence, undesirably, to the widespread belief that registered animals all possessed merit of a high order. Progressive breeding opinion, however, while admitting the value of pedigree selection in conjunction with other methods of estimating breeding worth, has insisted upon the provision of full details of production performance and transmitting ability in the near ancestry and amongst collateral relatives.

The progeny test is the ultimate measure of the worth of a given animal and those capable of producing high quality offspring have long been greatly esteemed for their value in improvement. Ultimately also, progeny testing is the final criterion of all other methods of selecting breeding stock. Thus, in the breeding of dairy cattle during the past 50 to 100 years, the emphasis in selection has shifted from a definition of "best" based almost entirely upon phenotypical considerations, to one that is based on obtaining the nearest possible approximation to the genotype of the individual.

Productivity in livestock is conditioned by breeding, feeding and management, and the highest expression of any one of these factors is contingent upon the degree of development attained in the others. Improved production in dairy cows can be effected through better feeding and better management up to a point at which further increases are limited by hereditary inability to produce higher yields. Conversely, genetic capacity for high production is dependent upon adequate feeding and efficient management for its full expression. Only where husbandry conditions are satisfactory can attention profitably be directed towards improving hereditary productive capacity.

Although, generally speaking, husbandry methods in New Zealand dairying have shown a vast improvement in recent years, feeding and management frequently still are limiting factors to increased production. Thus, where herd averages are low, attention to improved feeding and management is more likely to produce favourable results than an improvement in breeding methods. Conversely, where herd averages exceed, say, 300 pounds of butterfat per cow, conditions of feeding and management can be assumed to be reasonably satisfactory and the use of improved breeding methods is essential if the herd average production is to be improved or even maintained.

In general, the steady increase achieved in average per cow butterfat production during the past fifteen or sixteen years, has occurred more as a reflection of the application of more scientific methods in form, pasture and stock management than as a result of improved breeding in dairy stock. While registered purebred sires have been widely used and herd-testing largely availed of (particularly in some districts), there is evidence that a lag has recently developed of stock improvement methods behind feeding and management methods.

The following figures of estimated New Zealand average butterfat production per cow in milk and dry, and of the annual Group Herd Test averages, are indicative of the gradual retardation which has occurred in recent years.

<u>SEASON</u>	<u>N. Z. Average</u> (all cows)	<u>Group Herd Test Average</u>	
	<u>BUTTERFAT</u>	<u>BUTTERFAT</u>	<u>DAYS</u>
1927-28	195 lbs	225 lbs	
1928-29	211 "	241 "	242
1929-30	218 "	254 "	247
1930-31	201 "	241 "	247
1931-32	200 "	236 "	253
1932-33	215 "	256 "	257
1933-34	221 "	262 "	255
1934-35	210 "	252 "	258
1935-36	218 "	258 "	258
1936-37	229 "	267 "	254
1937-38	227 "	258 "	250
1938-39	203 "		

The influence of environment is apparent from the Group Herd Test figures where, apart from the last two climatically unfavourable seasons*, there is a notable increase in the average length of the lactation period. This is, almost certainly, more largely attributable to improved feeding than to conscious selection for persistency of milking, and probably accounts for a large proportion of the increase in average butterfat production.

A number of factors has contributed to the declining rate of increase evident in per cow production:

- (1) Dairy cows in general are now reasonably well fed and managed and the gap between nutritional conditions governing production and hereditary influences limiting maximum production has been considerably narrowed. While further attention to feeding and management is still highly desirable, it, alone, is unlikely to produce spectacular increases in average yields per cow.

* The method of calculating lactation productions has also been changed by commencing from the fourth day after calving instead of from the day of calving, as in previous seasons.

- (11) The huge annual increases in the dairy cow population characteristic of the first and last phases of post-war development in dairying, necessarily involved the retention in dairy herds of aged and inferior cows that normally would have been culled, and, further, by requiring large numbers of young stock additional to those normally kept for replacement purposes, reduced the intensity of selection practicable amongst herfer calves. The Dominion bulk output of butter-fat was greatly increased but the average production per cow did not rise in proportion.
- (111) Registered purebred sires became so widely demanded in the industry during the period of rapid expansion that the selection intensity amongst purebred stock was inevitably reduced and large numbers of inferior bulls were registered annually and sold for use in the industry. Moreover, although the value of the progeny test was well-known and the services of Group Herd Testing were available in all districts, few sires were kept in service long enough for their qualities in transmitting production to be discovered, owing to the small size of many herds and to a widespread distrust of inbreeding. The rate at which dairying grew necessitated some such rapid means of dairy stock improvement as the widespread use of registered purebred sires in the grade herds. But this form of mass selection wherein breeding stock is chosen according to individual production performance is essentially based upon phenotypical considerations and does not provide a means of consistently and indefinitely improving the average level of productivity.
- (iv) A widespread belief in the fallacy that stock numbers per farm are more important than production per selected cow also assisted in retarding improvement in

production capacity. A high per acre concentration of dairy stock is necessary if high production per acre is to be secured - but is economical only when all cows are well fed. High producing cows need more and better quality feed than poor producing cows, but this significant factor tended to be lost sight of in the rapidity with which dairy cow numbers increased. There is a growing realisation of the need for attaining a proper balance between carrying capacity and per cow production so that maximum economic returns per acre can be secured.

If increased volume and greater economy in production are to be secured, then in breeding for improved levels of productivity in livestock, greater use will need to be made of scientific methods in stock selection. Forms of mass selection carried out in New Zealand dairy herds have now brought about the maximum degree of improvement possible by the use of the system as practised. The attainment of further and more consistent improvement in the level of productivity in dairy stock generally, clearly depends upon the much more extensive use of methods of selection based primarily upon hereditary ability to transmit high production.

A striking parallel between present conditions in New Zealand dairy cattle breeding and what might reasonably be expected to be accomplished through the use of more enlightened criteria in selecting animals for breeding purposes, is furnished by Pearl's classical experiments on egg-production in poultry at the Maine Agricultural Experiment Station. For nine years, only females which had produced 160 eggs or more as pullets, and only males the dams of which had laid 200 eggs or more, were used as breeding stock. Despite this long period of stringent selection on the basis of individual production performance, the average egg-production of the flock was not increased. The basis of selection was then altered and the experiment continued for a further eight years. Females were still strictly selected for high individual egg-laying capacity, but, in addition, both males and females were also selected on proven ability to produce uniformly high-yielding progeny. The result of this new policy was a rapid increase in

the average egg-laying capacity of the flock. The fundamental importance of Pearl's results need not be further stressed than to emphasise that their practical significance to the breeding of dairy cattle in the Dominion lies in indicating the potential value of selection, judiciously applied, as a means of raising the general level of per cow production.

Other countries which have made considerable use of milk recording and progeny testing afford examples of the degree to which systematic selection on a basis of transmission of production, is effective in improving the productive capacity of dairy stock. Probably the most notable example is Denmark where "after having worked with the cattle shows for a span of 125 years, with herd book keeping, bull clubs and competitions between herds of cattle for 50 years and for 40 years with the Milk Recording Societies, Danish agriculture is now able to present to foreigners a work of cattle breeding which is fully up to date, and two national cattle breeds which as regards outward appearance and yield are ready to take up competition with any other breed".

A comparison of the seasonal average herd-testing returns for Denmark and New Zealand indicates the extent to which improvement in production is possible through the widespread use of improved breeding (and feeding) methods.

SEASON	DENMARK			NEW ZEALAND		
	Total Dairy cow population	Percentage of cows Tested.	Production per cow	Total dairy cow population	Percentage of cows Tested	Production per cow
1913-14	1,310,000	15.9	lbs. fat 253	701,000	3.6	lbs. fat -
-						
1928-29	1,579,000	34.3	293	1,371,000	18.9	241
1929-30	1,633,000	36.7	304	1,441,000	19.7	254
1930-31	1,669,000	41.9	304	1,602,000	16.9	241
1931-32	1,739,000	41.6	295	1,702,000	15.3	237
1932-33	1,770,000	39.6	286	1,846,000	15.5	256
1933-34	1,716,000	39.4	298	1,933,000	15.4	262
1934-35	1,646,000	40.6	293	1,952,000	13.6	252
1935-36	1,615,000	41.9	309	1,952,000	12.6	258
1936-37	1,570,000	45.1	322	1,936,000	14.3	267

Herd testing was instituted in Denmark as early as 1895 and has assisted towards increased production through improvement in Standards of feeding and management as well as in breeding methods. Some of the more important developments in breeding dairy stock are as follows :-

- (1) An increasing use of milk recording since 1895.
- (2) Show prizes are awarded only to cows having records of production, since 1906.
- (3) Young bulls are judged for descent as well as external appearance, and pedigrees must contain full details of build and yield for four generations.
- (4) Older bulls are awarded prizes only in respect to the yield and exterior of at least 66 $\frac{2}{3}$ per cent of their progeny.
- (5) The institution of Bull clubs in 1884 - the keeping of bulls as common sires for a number of herds.
- (6) The keeping of exceedingly detailed herd books since 1875, including exacting requirements of external appearance and production records in respect to individual cows and bulls admitted to registry, and in respect of their progeny.
- (7) The collection of details regarding every cow milk recorded, thus making new progeny performance tests of more than 300 breeding bulls available annually.

Danish breeders have long realised the fundamental importance to livestock improvement of a complete knowledge of all details of external appearance and production performance in the individual, its ancestry and progeny, if progress is to be achieved in breeding. All practices calculated to assist individual breeders towards a more rational selection of breeding stock have been instituted along co-operative lines and widely adopted by dairymen. Progeny performance tests based upon figures collected by the Milk Recording Societies dominate the breeding situation, and the level of production per dairy cow has been raised to a very high level.

Other countries are now adopting similar methods of improvement but developments are mostly on a small scale as yet.

It is apparent that in New Zealand where less than 25 per cent (as compared with 45 per cent in Denmark) of the total dairy cows average 320 pounds of butterfat, much remains to be achieved. Speculatively, if the national dairy herds of the Dominion could be raised to average 300 pounds of butterfat per annum (instead of 225 pounds as at present), gross returns (if the extra produce could as profitably be disposed of) from dairying would be increased by one-third, or, alternatively for the same bulk output of butterfat (420 million pounds) as at present, nearly 500,000 less cows would need to be milked, representing a reduction in costs to the industry of ^{approximately} £3,000,000 annually, on a basis of labour requirement.

This emphasises the point that far too many low-producing cows are in use in the industry; but if permanent improvement in dairy cow productivity is to be achieved, something more than the mere culling of poor producers is required - some plan is needed that will assure that these poor producers actually are not born. The regular annual testing of all dairy herds in the Dominion, in providing actual measurements of dairy cow production performance, would facilitate and accelerate an evaluation of all sires on the basis of transmitting ability, making possible an early elimination from the industry of bulls siring low producers, and a more widespread use of those sires able to pass on high production uniformly to their progeny.

If improvement in the general level of productivity of dairy stock is the aim in dairy cattle breeding in New Zealand, then further improvement is necessary in purebred stock as well as in cattle kept for market purposes. Since the most valuable sires on the average are those from registered purebred stock, national dairy cattle improvement depends basically upon improvement amongst the purebreds. A given cow is unlikely to leave more than two or three progeny in a herd but any one sire may leave scores of offspring. The standard of production, therefore, in the national dairy cattle population as a whole is

dependent upon the quality of the sires available. A survey of over 4,000 herd sires in the United States in 1936, disclosed the fact that less than one sire in three left daughters capable of maintaining or improving on the productions of their dams; there are no indications that the position in New Zealand is greatly different.

General improvement in the standard of registered purebred stock can be achieved through :

1. The complete and regular testing of all female stock for milk and butterfat production
2. The complete progeny testing of all sires before being widely used.
3. A greater appreciation amongst breeders for the application of genetic principles to the breeding of dairy stock.
4. "Making selection more potent through the selection of more useful characters and the application of the progeny test".

In summary, it can fairly be stated that selection does offer considerable assistance towards the attainment of improved productivity in dairy stock. It is clear however that if a policy of "selection of the best for breeding stock" is to be fully effective, measurement of that excellence must be based on hereditary capacity to transmit production qualities, and that reliance upon phenotypical considerations alone is unlikely to produce the results desired.

The objectives of selection in dairy cattle in New Zealand are :

2. To improve the Dominion average milk and butterfat production per dairy cow
2. To increase efficiency in per cow production by the selection of strains showing a high degree of efficiency in the conversion of feed into food, by the elimination of low producing cows and of sires incapable of leaving uniformly high yielding progeny, and by the selection of strains showing high constitutional vigour and resistance to disease".

Within the dairy herd, these objectives can be achieved:

1. By the regular annual testing of all cows for production performance.
2. By the systematic culling of all low-producing cows.
3. By the rearing of replacement stock bred only from the highest producing cows in the herd and sired by registered purebred bulls of proven production transmitting ability.
4. By the use of improved methods of feeding and management.

————— : —————
 :

D. THE PRESENT STATE OF KNOWLEDGE OF INHERITANCE IN DAIRY CATTLE.

1 GENERAL

In 1900, the rediscovery of Mendel's fundamental work in plant breeding not only gave a great impetus to further plant investigations, but also stimulated workers in animal breeding. It was soon established that the principles of Mendelian inheritance applied equally well to animals as to plants and a host of projects was designed to elucidate the problems of animal breeding. In the case, however, of dairy cattle and the larger farm animals generally, complete character analyses in terms of genes have so far been accomplished only for the simplest qualitative characters, such as coat-colour, hornless and lethal conditions. The great mass of research directed in recent years towards the attainment of a detailed knowledge of the hereditary bases of the economically important characters in dairy cattle has been less productive of definite results.

The dairy cow has been bred for centuries as a specialised machine for the conversion of coarse feed into extremely valuable human food, with no more than a vague realisation on the part of the dairyman that relationship and milking capacity were in some way correlated. Gowen states that "it was a case of evolution rather than exact breeding based on genetic factors and a known method of inheritance". The Iowa experiments of Kildee and McCandlish have since established beyond any doubt that genetic factors govern the yield of milk and butterfat, but the number and nature of the individual genes involved has not been definitely established, and it is even possible that a complete genetical analysis of milking capacity and other characters involving complicated gene situations may never be achieved. However, the very numerous investigations carried out on the economically important characteristics of dairy cattle (and particularly, on the inheritance of milking capacity) have accumulated a mass of valuable information which has shown that progress in breeding towards an ideal can be achieved by the use of genetic principles already established from protracted studies of more favourable

experimental material. Thus, although neither the actual genes nor their exact mode of operation in the inheritance of milking capacity have been yet demonstrated, it is commonly believed that milk production is a quantitative character dependent in heredity upon a multifactorial situation in which fairly numerous multiple genes interact with one another and with the environment in an exceedingly complex manner. The method of acting as though the individual genes and their mode of inheritance were actually known has shown itself exceptionally valuable in plant breeding projects and there is evidence that the hypothesis mentioned forms a sufficiently close approximation to the true situation as regards the inheritance of milking capacity to constitute a reasonably sound basis for constructive work in dairy cattle improvement.

The modern belief that practically all inheritance in practically all types of organisms is particulate and duplicate and operates according to well demonstrated Mendelian principles, has made it possible to apply successfully to dairy cattle breeding, results of research into such widely differing forms as the pomace fly, the guinea-pig, rat, mouse, fowl and numerous plant species. These forms possess great advantages in their small size, relative cheapness and rapid reproductive rates and various other more individual qualities, which have provided invaluable material for experimental work on the mechanism of heredity. It is largely as a result of such researches that the great body of information on theoretical genetics has become available for application to the larger, economically important species.

The findings of theoretical genetics have already attained considerable importance in their applications to livestock breeding but the proportion of professional breeders who consciously make use of the principles of genetics in their breeding operations is small. In view of the fact that dairy cattle are being multiplied practically continuously in all parts of the Dominion, it does seem economically wasteful if, merely through lack of general appreciation for Mendelian principles, at least a part of

this work cannot be utilised, as Goodale suggests, "in transforming the art of breeding from the haphazard affair of today into a system of orderly information which would in due course separate good methods from poor, and place breeding on a sound foundation of knowledge".

The basic principles of genetics have contributed to a more complete understanding of animal breeding methods and have enabled the discarding of many once strongly held superstitions; the more rapid elimination of undesirable or lethal hereditary characteristics from a breed or strain has been made possible; the probable genetic consequences of various breeding systems can be forecasted; an exact meaning has been provided for the phenomena of sex-determination, selection, prepotency. In all, the science of genetics, largely through additional knowledge of fundamentals derived from genetic studies of plants and laboratory animals, is in a position to supply valuable direct assistance on procedure and the benefits of scientific planning to the practical breeding of dairy cattle.

In the field of direct contributions by way of the genetical analyses of the economically valuable characters in dairy cattle, genetic research has so far produced little that is definite and conclusive. Planned experimentation with animals as large and as expensive as the dairy cow is a costly and extremely difficult undertaking. Self-fertilisation, a method that has proved of great value in plant breeding investigations is of course impossible; and inbreeding by continued brother x sister matings is often unsatisfactory, especially when large numbers of undesired individuals have to be discarded at financial loss, and is necessarily an extremely lengthy procedure when, as usually, the extent of genetic diversity in the foundation stock is large. Moreover, reproductive rates are very low and the interval between generations is 5 years (as compared with 12 days in *Drosophila*). The intricate nature of inheritance where

quantitative characters are concerned has already been stressed; genotypes are not readily discernible and phenotypes are classified only with difficulty and in most cases are very considerably affected by the environment. A further cardinal difficulty is that involved in the inheritance of milking capacity where the character is expressed only in the female and not before she reaches the age of 3 years, and where selection on the basis of progeny performance is usually only applicable to the male and is measured by the phenotypes of his daughters not before he has attained the age of five years.

In spite of the inherent difficulties of the subject, a considerable body of important and valuable data has been accumulated particularly in recent years as a result of direct experimental investigations carried out with dairy cattle. Further information is available also from statistical studies of herd-testing returns, Advanced Register records, Dairy Show placings, etc. While the genetic bases and modes of inheritance of the economic characters in dairy cattle remain as yet undecided, important progress has been made in evolving breeding procedures offering greater certainty of successful results than the old empirical methods of breeding.

2 ECONOMIC CHARACTERS.

Of the functions of economic value for which dairy cattle are bred, milking capacity is obviously of first importance. In former days, when dairying was a relatively unspecialised occupation and international competition in dairy produce was unknown, milking capacity was practically the sole important character, or shared importance with beefing ability. General bodily health and reproductive capacity have of course been essential at all times.

With the exploitation of the dairy cow for commercial purposes on an international scale, dairymen have bred their stock for greater yields of milk and butterfat and as international trade has become increasingly competitive, have been forced to pay attention to other characteristics in their stock in order to

reduce production costs to a minimum. Thus, at the present time a phase of rationalisation in methods of dairy cattle breeding has arisen and dairymen are becoming conscious of a need to select for their herds animals which exhibit a tendency towards hereditary resistance to certain diseases and further are inherently capable of a high degree of efficiency in the conversion of feed into milk and butterfat.

Although a highly developed capacity for milk and butterfat production in the individual cow is the main objective in dairy cattle breeding, there are several other functions of the animal without which the cow is of little use as a member of the dairy herd. Of these, fertility is probably first. Unless an animal is inherently capable of normal reproduction, it is of obviously little value in breeding. Moreover commercial milk production is the exploitation of maternity on a large scale, and regular annual calving for a long period of years is essential in the dairy cow just as ability to sire many calves each season for many seasons is a basic requirement in the dairy bull. Fecundity, or the ability to produce many offspring, is not considered important in the dairy cow in which twin births are rare. If it can be shown that, as in sheep, strains of dairy cattle can be bred for twinning capacity without deterioration in other characteristics, such strains might be exceedingly valuable both for experimental breeding purposes and also for their value in extending the degree of selection practicable amongst herd replacement stock.

Next in importance probably to fertility is constitutional vigour which is a further basic requirement in producing stock. "The capacity of an animal to produce and reproduce effectively and to survive (i.e. to live a long productive life) under the conditions of the particular environment in which it is placed" is receiving added emphasis at the present time when, under existing conditions of dairy farm production, increasingly higher yields of milk and butterfat are coming to be expected of dairy cows bred

under increasingly artificial conditions of nutrition and environment generally. The further necessity for reducing costs to a minimum level compatible with maximum economic production has caused attention to be paid to the heavy losses through wastage in dairy herds due to high annual replacement requirements. Longevity is an associated feature of constitutional vigour and the latter is tending to be measured numerically in the dairy cow in terms of lifetime records of milk and butterfat production, and in the bull by his proven ability to sire such cows.

The characteristic of efficiency of feed conversion has received a great deal of attention in overseas countries where stall-feeding is practised in conjunction with herd testing, but is beginning to attract further notice in the Dominion as per cow yields of butterfat are increased. High efficiency of feed conversion is associated with high yields. Thus, two cows each weighing 900 pounds and producing milk of 4.5 per cent. butterfat content require daily $5\frac{1}{2}$ pounds starch equivalent for maintenance. If one cow (A) produces 1 pound of butterfat per day she will require a total of $11\frac{1}{2}$ pounds starch equivalent for maintenance and production combined; if the other cow (B) produces three pounds of butterfat per day she will require a total of $23\frac{1}{2}$ pounds starch equivalent for maintenance and production combined. Cow A thus consumes 50 per cent. more feed units per pound of butterfat produced than cow B. The importance of quantity and quality of feed available to high producing dairy cows is emphasised. There are indications, also from work in New Zealand and overseas, that cows of lighter body weights tend to show inherently greater economy of production than cows of heavier weights. Clearly, if progress towards high levels of production accompanied by a high degree of efficiency in production is to become a matter of conscious breeding policy, digestive and productive efficiency may become of major importance in selection.

The possibility of developing strains of dairy cattle inherently capable of resisting various diseases is a relatively

new application of the results of genetic researches in other organisms to the breeding of dairy cattle. In plant breeding, the combination, within one strain, of highly productive stocks and stocks showing resistance to various common diseases, has been standard practice for some years; American workers have demonstrated the hereditary resistance or susceptibility of various strains of mice and guinea-pigs to such diseases as cancer and tuberculosis. In the Dominion, A. H. Ward has recently published a preliminary report which appears to confirm the widespread opinion that susceptibility to severe udder infection runs in families. The field thus opened up is exceedingly important from the herd-building and herd-replacement costs point of view, in that while it may prove impracticable to breed deliberately towards resistance to mastitis infections, it is obviously essential that families exhibiting tendencies towards inherited susceptibility should be eliminated from breeding programmes. The same of course would apply to the diseases sterility, abortion, tuberculosis, and others, should similar indications of inherited susceptibility be proved for dairy cattle.

The character of bodily conformation has considerable economic value from the points of view of constitutional vigour, breed type or beauty, and dairy character. Bodily conformation is frequently a sound guide to inherent constitutional vigour particularly in points such as the feet, legs, eyes, general build, depth of barrel, handle of skin, etc. Animals exhibiting gross faults of bodily structure that may possibly be hereditary and lead to loss of vigour, should not of course be used for breeding purposes. Breed type is believed to embody qualities of constitution and characters indicating milking capacity, as well as certain features of colour and general appearance regarded as typical of or desirable in certain breeds of registered purebred stock. Thus, beauty expressed as breed type may have economic value, for, if animals not meeting the required standards are excluded from registration in the herd book of the breed, their sale value is reduced. Dairy character has been shown to be of very slight importance as an indication of milk production in the

cow or as potential ability to sire high producing daughters in the bull, but the general appearance, size and shape of the udder and milk veins and a body that is wedge-shaped in three planes are generally held to be important indications of dairy character in the cow.

General size and body-weight in the dairy cow are characters of indirect economic importance. The feed requirements of an animal for maintenance purposes are roughly proportional to its body-weight, or, more directly, to the body surface area. Furthermore, larger cows are on the average higher producers than small cows having a lesser body weight. The characters of size and body-weight are intimately concerned in the efficiency of milk and butterfat production and in butterfat production per acre under New Zealand conditions.

Rate of growth is a further important character in dairy cattle from the points of view both of growth in mass and also of differential growth in the various parts of the animal body. Both are strongly influenced by nutrition and other environmental conditions but, fundamentally, are determined by heredity. Growth is an expression of numerous undetermined genes which order the time and rate of development of the body structure and its parts through the secretions of various endocrine glands. From the viewpoint of milking capacity, growth in mass, as represented by early maturity, is an important quality where, as in New Zealand dairying, heifers are bred to calve at 24 months of age; the phenomenon of differential growth is important in its effects upon the development of the mammary and digestive systems and of body structure generally.

The characters of major economic value in dairy cattle thus include, in addition to the supremely important qualities of milk and butterfat production, these other functions of the animal body: fertility, constitutional vigour and longevity, efficiency of feed conversion, disease resistance, bodily conformation, size and body-weight, and rate of growth. The evidence available

tends to indicate that probably all are quantitative characters, the complete expression of which represents the end-results of exceedingly complex gene interactions involving large numbers of multiple factors. Further, the ultimate expression of each one of these characters is strongly affected by other bodily activities, by nutrition and by other circumstances of the environment. Clearly, true productivity in dairy cattle depends on a high degree of development not only in capacity for milk and butterfat production, but also in all those other complex physiological characteristics which, in combination with favourable nutritional and environmental conditions, constitute the efficient organism.

3. MULTIPLE GENES.

A simple illustration of multifactorial inheritance, involving only three pairs of genes, is that of Nilsson-Ehle who first (1909) postulated the hypothesis in crosses between dark red-grained and white grained varieties of wheat. In the first crossbred generation, the kernels were of a shade intermediate between the colours of the two parental types. In the second crossbred generation an apparently concinuous series of shades was obtained, varying from dark red (1 in 64) through numerous intermediate shades to white (1 in 64). Thus, although the parental types were recovered, normal Mendelian segregation did not occur. Nilsson-Ehle assumed the presence of three independent pairs of factors, cumulative in their individually small effects on the same character, exhibiting non-dominance, and producing twice the effect of the simplex condition when present in double dose.

Making use of the letters R, S, T, to denote genes for dark red and the letters r, s, t, to denote those for not-red (i.e. white), the original parent types may be represented as RR,SS.TT (dark red kernel) and rr.rr.tt (white kernel). On crossing, the F₁ tri-hybrid Rr.Ss.Tt (pink or intermediate red) is obtained. When the tri-hybrids are interbred, the following distribution of genotypes within each arbitrary group of apparently indistinguishable phenotypes is secured:

PHENOTYPES		GENOTYPES	
Number	Character	Number	Character
1	dark red	1	RR.SS.TT.
6	red	3	(2 RR.SS.Tt 2 RR.Ss.TT 2 Rr.SS.TT
15	light red	6	(4 Rr.SS.Tt 4 Rr.Ss.TT 4 Rr.Ss.Tt 1 rr.SS.TT 1 RR.ss.TT 1 RR.SS.tt
20	intermediate red	7	(8 Rr.Ss.Tt 2 RR.Ss.tt 2 RR.ss.Tt 2 Rr.SS.tt 2 Rr.ss.TT 2 rr.SS.Tt 2 rr.Ss.TT
15	pale red	6	(4 Rr.Ss.tt 4 rr.Ss.Tt 1 RR.ss.tt 1 Rr.ss.Tt 1 rr.SS.tt 1 rr.ss.TT
6	pink	3	(2 Rr.ss.tt 2 rr.Ss.tt 2 rr.ss.Tt
1	white	1	rr.ss.tt

In this situation, totals of up to seven different genotypes, in one instance, are seen to be represented by the same phenotype(or at least by phenotypes so much alike as to be indistinguishable by visual examination one from another).

If, now, these figures are referred to milk or butterfat yields, an indication is obtained of the fundamental complexities of the milk inheritance situation. Thus, the group arbitrarily described as "intermediate red" might represent a group of 20 cows yielding, say, approximately 300 pounds of butterfat in a lactation. In such a case, it is apparent that the single phenotype would characterise 20 cows of seven different genotypes. If these 20 cows were bred to a bull of similarly heterogenous genetic constitution, the female progeny would exhibit marked variation in

in individual butterfat yields, and both male and female progeny would exhibit considerable diversity in breeding ability, in consequence of segregation and recombinations in the sampling nature of inheritance.

The situation as described, moreover, involves only three pairs of genes. Since, undoubtedly, there is a large number of genes concerned directly and indirectly in milk production, the possible diversity in genetic constitutions is therefore extreme. Dealing with quantitatively inherited traits in general, Lush states: "If the number of different genes heterozygous in a species is as large as 40 (and it may well be thousands), the number of different hereditary combinations possible in each species is millions on millions of times as large as the number of animals which can actually be alive at any one time."

Furthermore, in the situation considered, it was assumed that there was no dominance and that the effects of the genes concerned were equal and cumulative. There is some reason to believe, however, that in the quantitative characters of economic value in dairy cattle, at least some of the genes may be either completely or incompletely dominant while others exhibit non-dominance; that some genes may produce large effects and some small effects; that some genes may produce one effect in certain gene combinations and quite other effects in combinations with other genes; that many genes may produce similar effects; that some will produce the same effects as variations in the environment produce; that the conditions of multiple allelomorphism and linkage may also contribute to genetic diversity. Finally, the expression of most economic characteristics in dairy cattle is influenced by numerous bodily physiological activities, by nutrition and other environmental conditions. In consequence, when, in such complex genetic situations many individuals are classified into groups according to outward evidence (or phenotype), the groups secured grade imperceptibly into one another in the form of a continuous series and each

group is likely to contain (as in Nilsson-Ehle's wheat experiments) a considerable range of different genotypes.

The highly diverse genetic nature of such populations, coupled with the fact that in most instances phenotypes are at best very approximate guides to genetic constitution, demonstrates the importance of selection, based upon progeny performance records and continued generation after generation, as the most effective instrument for sorting out superior individuals that are believed to be capable of transmitting their desirable qualities to their offspring. Undoubtedly, present-day dairy cattle populations are exceedingly diverse in respect to genes influencing many quantitative characteristics, so that, having regard to the length of time required, great expense involved and uncertain value of securing homozygous superior strains through inbreeding, improvement in desired qualities is to be attained by the preservation of desirable gene combinations obtained through segregation.

4. THE INHERITANCE OF MILKING CAPACITY.

Of all the economically valuable characters in dairy cattle, that of milking capacity has received by far the most detailed attention of investigators. Milk secretion, is, however, a function of the animal which Lush describes as "highly environmental" - i.e. a quality, which, though basically dependent for expression upon gene interactions, is strongly affected in quantity and quality by non-genetic influences. Although the phenotype of milking capacity, as expressed by the quantity and quality of milk produced in a lactation or series of lactations, can be measured with great accuracy, due allowance must be made for many other variables if comparisons are to be made between the yields of different cows from the viewpoint of heredity. These factors include:

- the age of the animal,
- the amount and type of feed available,
- management during lactation,
- the length of the lactation period,
- the number of records considered,
- date of and condition at calving,
- length of and feed during the dry period,
- length of the service period,
- the number of times milked per day,
- seasonal effects and year-to-year variations.

Many correction factors have been devised for dealing with certain of these variables, but most have been arrived at from the study of many records and their application to the individual animal may accomplish more harm through obscuring the effects of heredity than it does good in standardising yields.

Gowen investigated the relative importance of heredity and environment by measuring the average resemblance between daughters and dams in cows listed in the American Jersey Register of merit. He concluded that about 50 - 70 per cent of the variance in milk production and about 75 - 85 per cent of the variance in fat percentage represented genetic variation between the animals, but Lush states that if there was much environmental correlation the figures appear high.

Plum, from an analysis of Sowa Cow Testing Association records, compiled the following table to illustrate the relative

importance of different causes of variation in butterfat production.

<u>Cause of Variation</u>	<u>Percent. of total variance</u>
<u>Breed:</u>	2
<u>Herd:</u> feeding policy of herd	12
other causes (genetic or environmental)	<u>21</u>
	33
<u>Cow:</u> (mostly genetic)	26
<u>Residual:</u> (year to year variations)	
feeding variations within herd	6
other year to year differences	1
length of dry period	1
season of calving	3
other factors	<u>28</u>
	39
	<u>100</u>

Since the genetic part of the variance passing between generations is 25 per cent, in the selection for breeding purposes of cows averaging 100 pounds of butterfat above the level of the herd or breed and mated to bulls equally superior, the progeny can be expected to average about 25 pounds above this same level, constituting a substantial degree of improvement per generation.

TOTAL YIELD. Experiments commenced in 1907 at the Iowa Agricultural Experiment Station on crosses between "scrub" cows from range country and registered purebred bulls of three dairy breeds, first soundly established the facts that plane of nutrition and other physiological and environmental conditions exert very considerable effects upon the quantities of milk and butterfat produced, that milking capacity is determined ultimately by genetic factors, and that butterfat in milk is inherited largely independently of milk yield. These findings have not since been seriously disputed.

There is a growing tendency to avoid the use of the term fat-percentage in genetic studies on the grounds that (1) unless fat percentage is based on the total fat produced and the total milk produced it is not a true indication of fat content; (2) when milk yield alone is increased the consequent drop in fat

percentage does not necessarily imply reduced absolute butterfat yield; (3) the relationship between fat yield and milk yield is not definitely known, and to speak of fat percentage is to presume a relationship; (4) it has been shown by Fairfield Smith that the ratio of two characters can never supply more information than can be given by a consideration of both characters separately, and that as a rule, the information of a ratio is very much less than when each character is considered separately. Finally, Espe points out that "the fat percentage of any one sample of milk is the result of a certain rate of fat secretion and a certain rate of milk serum secretion, either of which may be modified independent of the other but not without affecting the final percentage of fat in the milk, unless the changes have been proportional". Espe also stresses the fact that the fat percentage is relatively much less readily affected by nutritional and other non-genetic factors than milk yield.

Persistency in milk yield throughout a long lactation is associated with extent of glandular development which is probably influenced by heredity as well as nutrition.

Considerable work has been conducted recently by numerous investigators on the hereditary behaviour of the various other constituents of milk, but results so far achieved are for the most part conflicting and indefinite.

NUMBER OF GENES INVOLVED. Although the opinion is widely held that milking capacity is conditional by large series of multiple factors, various other hypotheses have been advanced in the course of time.

1. TWO FACTORS. Wilson (1911) concluded that milk yield was inherited in the same manner as the three Shorthorn colours. Later (1925) he revised this theory in favour of four factors producing sixteen grades of milk, stating that the yield of the poorest daughter is a sure test of transmitting ability of the sire or dam.

ii. SINGLE FACTOR. Wiret (1930) from crossbreeding experiments with Jersey and Red Danish cattle concluded that the difference in

Butterfat percentage between the two breeds was due to a single mendelian factor, and that in the crossbred cattle fat transmission was dependent upon a single factor, with perhaps another modifying factor.

iii. 7:1 RATIO. Hills and Boland (1913) in a study of advanced registry records of Holstein Friesian cattle, obtained a 7:1 ratio, suggesting the linkage of two factors, one of which is a pure dominant, and the other probably sex-linked, acting in a simple 3:1 ratio.

iv. 3 FACTORS. Funkquist (1921) suggested from a study of family pedigrees that fat transmission is conditioned by at least three homomeric factors. Hansen (1917) reported that butterfat and milk yields were each dependent upon three factors, but independent of each other. Bon Patow (1926 and 1930) using the "byre average", subscribes also to the presence of three homomeric factors whose effects are equal and cumulative, and which correspond to the three main characters which determine milk yield: (1) development of the udder to allow for sufficient capacity of glandular tissue to secrete milk; (2) the formation of interstices; (3) the innervation of the udder. A factor for basic milk yield is postulated as present always in the homozygous condition, as otherwise some animals would be born which could not produce milk. A further factor (F) is postulated for butterfat which may vary according as this factor is present as FF, Ff, or ff.

v. SEVERAL FACTORS. Von Lochnow (1921) concluded that the inheritance of milk yield is based on several factors, and that the dam has a greater influence in transmission than the sire.

vi. TEN FACTORS. Yapp (1929) assumed the presence of ten factors in the transmission of milking characters.

vii. MULTIPLE ALLELOMORPHISM. Nachtsheim (1926) suggests that the size of the mammary gland may be controlled by members of a multiple allelomorphic series. Prepotency may be explained by the possession in the duplex state of the most dominant members of the series.

will MANY GENES. Turner and Gifford (1927) suggest that (1) milk and fat yield are influenced by many genes, (2) many genes favouring high production are dominant, (3) all genes do not have the same effect. Graves (1926) states that high production is dominant to low production. Numerous independent investigators conclude that milking capacity is conditioned by multiple factors with or without connection between milk yield and butterfat.

ix. SEX LINKAGE. Smith and Robison (1931) state that milk secretion must be dependent on a fairly large number of factors, and that some of them are probably of greater importance and of these at least one or more are probably transmitted in a sex-linked manner. Buchanan Smith (1937) carried out a statistical investigation of milk yield inheritance in three Dairy Shorthorn herds, confirming previous work that the paternal grandsire has less effect than the maternal grandsire. The figures for one herd however did not agree with the other two and on being divided into two sections of high and low yielders, each section did not show any difference in the relative effect of the two grandsires. It is tentatively suggested that, if sex-linkage operates, it has a considerable effect of some 250 gallons on an average yield of some 600 gallons. The author states that as a reconnaissance, statistical studies have definite value, but planned experimentation is required to resolve the problem.

CONFORMATION. The majority of investigators are agreed that type is of only slight value, as compared with production records, of milk and butterfat yielding capacity in the dairy cow. Gowen (1924) in a series of analyses on advanced Registry data concluded that even a 7-day milk record gave a better indication of probable milk yield than any body measurements. He found that of the body measurements studied, body length and body width were most strongly correlated with milk yield, but that all correlations between body measurements and butterfat percentage were very low. He agrees with Turner that the influence upon his daughters of a sire's conformation is mainly limited to size in that the heavier the

sire, the greater the chance that his daughters will be high producers both of milk and butterfat; this influence has about half the value of actual production records. Gowen has more recently (1931) found that weight and wedge-shaped form, when viewed from the front, are indicative of milk yield.

Hammond has shown that supernumerary nipples may be inherited and that their action is one of lowering yield by preventing maximum development of the normal glands.

Swett, Graves and Miller (1928) found the skeletal structure of a highly specialised dairy cow to be much the same as that of a highly specialised beef cow. They attribute the extreme difference of external appearance to the differing actions of the various organs of internal secretion, in that certain genes act on the phenotype as a result of their actions on the organs of internal secretion.

Gowen (1933) found that, with the possible exception of weight, there is no correlation of practical significance between the body type of the sire or the dam and the productive capacity of the daughter in milk, butterfat or butterfat percentage.

Garner (1932) says that although one should never attempt to judge a cow by one point alone, the size of the milk wells is probably the best single point indicative of milk producing ability.

Copeland (1938) reporting results of American Jersey type classification, states that both good conformation and high production can be combined in the same animal, the qualities not being antagonistic to each other.

Bartlett (1938) tabulating records of type, size and production of 1st. prize winners at the London Dairy Show over a ten-year period, found a striking similarity between the body measurements of the inspection winners and the milking trial winners of the same breed, making it impossible to select any outstanding measurement as indicative of inspection or production features.

Mackintosh (1938) maintains that judging by inspection is of importance in selection, and recommends competitions, such as those organised at the London Dairy Show, where 30 - 50 per cent. of the total marks are awarded in respect of conformation. By this means it is possible to come nearest to a balanced assessment of the dairy qualities of the individual animals. Just as the true merits of a dairy cow cannot be ascertained by inspection alone, neither should they be judged by milk records alone.

EFFICIENCY OF PRODUCTION. It is known that individual cows vary in ability to convert feed economically into milk and butterfat. This productive efficiency depends on many complex physiological characters conditioned to different degrees by the effects of heredity, growth, activity of internal secretions, through their actions on the development of the mammary and digestive systems.

McDowell (1930), from the records of 100,000 cows, concluded that the larger cows usually excel the smaller ones in both milk and butterfat production.

Gaines (1931) found that when the yields of milk and butterfat were combined into a single expression ("fat-corrected-milk"), there was a distinct tendency towards decreased efficiency with increase in live-weight in all breed groups. In view of the supposed independent inheritance of milk and butterfat this result must be treated with caution.

At the South Carolina Experiment Station, attempts to correlate butterfat production with the length of the large and small intestines are being made.

Brody and Ragsdale (1935) using Gaines' F.C.M. concluded that if a large cow's extra milk is enough to pay for her extra maintenance cost, then the nutritional efficiency of large and small cows is the same. They found that the small cow tends to be slightly more efficient in the use of feed but that this is balanced by the greater overhead cost involved in keeping a larger number of smaller animals. The authors believe that udder capacity and stimuli to high production are more important than

size in profitable milk production.

Edwards (1936), using the Gaines' formula on the best representatives of the various breeds at the London Dairy Shows, found little difference in gross efficiency of milk production and that the lactation stimulus has been bred approximately in proportion to the size of the breed.

Krizenecky (1938) suggests that the relation between weight and maintenance is not linear but according to 0.15 of the live weight, thus correcting earlier studies that assumed it was linear. He concluded that while heavier cows are more economic, the relation between weight and efficiency is slight, and that within weight classes the most important factor affecting economy is milk production.

F.H. McDowall (1936) in a study of purebred Jersey, Ayrshire and Friesian cows under New Zealand conditions, has shown that large bodied Friesian cows, medium bodied Ayrshires and smaller bodied Jerseys are approximately equal in productive efficiency under conditions of feeding for maximum production (i.e. C.O.R. tests), when feed requirements for maintenance and production are computed theoretically. It would appear that under field conditions, the Jersey is on the average a more efficiently producing breed, possibly on account of superior foraging ability.

PHYSIOLOGY. It would now seem clearly established that capacity for high milk and butterfat production and a high degree of efficiency of feed conversion in the dairy cow are characters achieving their optimum development through the normal functioning of certain organs of internal secretion. Recent work by Turner and other investigators on the physiology of reproduction and lactation and the growth and development of the mammary complex has thrown new light on the hormonal reactions that are influenced presumably by the genes conditioning milking capacity. Reece and Turner have recently studied the prolactin and thyrotropic content of some 500 pituitaries from different types of cattle, including steers, bulls, heifers, cows, of different ages, and at a variety of stages in their lactation and reproduction cycles.

They were concerned whether milking capacity could in any way be related to the content of these two hormones in the pituitary gland. In order to assist in interpreting the results for cows, pituitaries from smaller animals were also collected. It was found that the average weight of the pituitary increases from 0.431 gm. in the foetus, to 0.6485 gm. in the calf, 0.9025 gm. at 4-10 months, 1.1590 gm. at 11-23 months, to 1.7521 gm. at two years or over. The prolactin in the gland was found to increase as the cow matured, due both to the increased size of the gland itself and also to a rise in its prolactin content. In the male the increase with age was due only to the enlargement of the gland. The prolactin content of pituitaries from dairy cows was consistently higher than that of glands from beef cows. When in milk, whether pregnant or non-pregnant, dairy cows were found to have some 70 per cent more lactogen than beef cows in the same condition. The content of thyrotropic hormone in the pituitary also increased with age and was greater in dairy cows than in beef cows at the same stage.

"Although so numerous, the data presented (Res. Bull. No. 266) must only be regarded as a preliminary contribution to the scheme as a whole, but the authors seem confident that it will ultimately be possible for the milk-producing capacities of dairy cattle to be judged much more reliably than they can be today, by new tests based on their endocrine systems". (J. Dairy Res., X, 1939.)

PROGENY TESTING. Although both the sire and the dam contribute in equal proportions (except for sex-linkage, the effects of which are not yet definitely known), to the genetic constitution of their progeny, the sire is usually more important within the herd than any single dam because a large proportion of the future herd is likely to consist of his daughters from different dams. In most cases, not more than about half the number of cows in the herd is likely to consist of daughters of a single sire, so that the influence of the latter will amount to about one-quarter of the total genes in the herd heredity. Since a lesser number of bulls than of cows is required in a given population and since

the sire is clearly of outstanding importance in determining future herd production, selection can and should be more severe in the case of male breeding stock.

Selection on a type basis has little value alone, since the outward appearance of a sire is no indication of the milking capacity of his daughters. A pedigree of performance is usually a good guide to the probable production transmitting ability of a bull, but, owing to the sampling nature of inheritance, may be highly inaccurate. The progeny test provides an actual measure of breeding worth.

Some of the more important factors affecting the usefulness of the progeny test are :

1. Dairy bulls cannot be proven by the performances of their offspring at earlier than five years of age. The initial selection of a herd sire must therefore be made with the aid of pedigree analyses and an estimation of individuality.

2. Large numbers of offspring must be raised both because the quality of milking capacity is expressed only in the one sex and also to reduce errors in the test due to:

- (a) the sampling nature of inheritance,
- (b) the usually undetermined genetic constitution of the other parent,
- (c) the effects of environment and of non-additive gene interactions.

3. The maximum of information should be available for all daughters of the bull. Progeny tests based on selected populations do not provide a true picture of the production transmitting abilities of the sires concerned.

4. Edwards points out that as the number of daughters is increased, the accuracy of the test improves at a diminishing rate; he concludes from a statistical study that the minimum number of daughters necessary to prove a bull is six. Lush states that if the systematic or biased errors are important in the data used, only a little accuracy is gained by increasing the number of daughters included past three or four.

At the present time, problems of dairy cattle improvement can be resolved into problems of how speedily and efficiently

progeny tests can be applied in practical breeding.

SIRE INDICES. In order to set definite numerical values on the breeding value of sires, many indices of transmitting ability have been constructed in terms of milk and/or butterfat production. All indices so far evolved have been widely criticised on the grounds that:

1. The expression of a sire's breeding worth in a single numerical figure, by obscuring the effects of variables such as the number of daughters considered, range of milk and butterfat yields, the high or low production level of the dams and variations in the plane of feeding and management of daughters as compared with that of the dams renders such an index of less value, except for pedigree record purposes, as a guide to production transmitting ability than the information obtainable from a detailed study of all the various influences operating in the test.
2. Speculation as to which is the most accurate sire index is of less value in dairy cattle improvement than the progeny testing of all bulls at the earliest possible age and the retention of all bulls in a state of full health and vigour until they are proven so that fullest use may be made of worthless sires culled as soon as their deficiencies are known.

The following sire indices have been made use of in herd improvement projects.

1. $\text{Sire} = 2 \times \text{daughters' av. production} - \text{dams' av. production.}$

This index is stated to be the "theoretically correct procedure for determining a sires breeding value from the performance of his progeny". (Lush). Such an index assumes that the effects of multiple genes are equal and cumulative, making the offspring exactly intermediate in character between their parents, thus not allowing for dominance deviations, environmental effects, or the fact that the genetic constitution of most dairy cattle populations is highly heterozygous. No allowance is made for regression to the breed average in the production of the daughters when, as

usually, the parents have been highly selected.

2. Sire = average production of daughters.

This index neglects the influence of the dams but Edwards concluded that it forms the most satisfactory figure to represent the production transmitting ability of a sire. He found that the deviations of the average production of daughters from high producing dams and that of daughters from low producing dams, from the average production of daughters from all cows were little different. He attributed this levelling effect of the sire to the fact that the average production of the daughters is an indication of the sire's genotype, whereas the average production of the dams is composed of a number of individual and unrelated phenotypes. Within a herd and for pedigree record purposes his index has considerable value and is as accurate as any other method of estimating the yields of future daughters of a bull. It may be applied satisfactorily to the first six daughters in milk.

3. The Mount Hope Index used by Prentice and Goodale at Mount Hope Farm, Massachusetts, is :

- (a). daughters' exceeds dams' production:
Milk Index : $D + 0.429 (D-d)$
Fat Index : $D + 1.5 (D-d)$
- (b). dams' exceeds daughters' production:
Milk Index : $D - 2.333 (d-D)$
Fat Index : $D - 0.677 (d-D)$

The Index includes an allowance for partial dominance of high milk yield and recessiveness of high butterfat percentage and probably applies most effectively to the Guernseyn herd from records of which it was evolved. A simplified commercial form of the Index is : "If the average mature equivalent of the dams' production is 8,000 pounds of milk, and that of the daughters is 10,000 pounds of milk, the bull is a 12,000 pound bull; if the average mature equivalent of the dams' production is 10,000 pounds of milk and that of the daughters is 8,000 pounds of milk, the bull is a 6,000 pound bull."

The Index is based on the daughter average plus the

average increase, or minus the average decrease, of daughters compared with dams.

4. $\text{Sire} = \text{daughters' av. production} - \text{dams' av. production}$.

This does not supply an index representing the yield of a bull if he had been a cow, and in a comparison between bulls, makes no allowance for different levels of production in the dams to which they have been mated. It may be greatly affected by environmental influences and does not allow for regression to the breed average in the case of highly selected parents.

Within the herd, where feeding and management conditions affecting dams and daughters are reasonably comparable, a comparison between the average mature equivalent productions of dams with that of the daughters of a sire provides a good indication of the effect of the sire in the herd. Thus, under New Zealand conditions, records of dams and daughters for as many normal lactations as obtainable are corrected for age and length of lactation period and full details are available on each dam-daughter comparison in diagrammatic form. No attempt is made to express the net increase of daughters' average productions over their dams' as an index of the sire's transmitting ability. In view of the difficulties arising from the application of age-correction factors, derived from mass data, to individual cow productions, make it appear preferable to construct a series of diagrams illustrating dam and daughter productions uncorrected and at the same series of ages.

In the present state of knowledge of inheritance in dairy cattle, it would seem that selection, dealing with genes not as units but in the mass and based on close estimations of genotype rather than on individual character or production performances, offers considerable assistance towards the rapid and permanent improvement of producing qualities in dairy cattle.

E. FACTORS AFFECTING THE INTENSITY OF SELECTION

If selection directed towards maintaining or increasing the hereditary capacity of dairy cows to produce milk and butterfat, be accepted as the major factor determining the improved production of dairy cattle in New Zealand, it is clear that progress in breeding will depend upon the effectiveness of selection in changing the inheritance of dairy stock. Rate of improvement, or the selection differential, is measured by the amount of change that can be accomplished per generation in the desired direction, by all the offspring, taken as they come, of the parents of each generation. (Goodale).

The intensity of selection practicable is influenced by four main factors:

i. The number of different characteristics being considered in selection. While milk production is the ultimate aim of dairy cattle breeding, several other qualities have to be taken into account as essential to efficient production. The attention devoted to each additional characteristic automatically reduces the intensity of selection which can be practised for milking capacity.

ii. The accuracy with which individual merit can be recognised and measured is exceedingly important if real actual advances are to be achieved. Except at low levels of production, selection on formalism or on records of performance alone is much less accurate than selection on the basis of ability to transmit inheritance conditioning reasonably high production in the progeny.

iii. The necessity to raise large numbers of offspring merely to supply herd replacement needs restricts the intensity of selection possible for the important economic characters.

iv. The incidence of disease in the herd or population determines the number of cows which can be culled purely on a production basis or on account of age, so that a high disease incidence in a herd further reduces the selection intensity practicable amongst young stock.

I. THE NUMBER OF CHARACTERISTICS.

Such characters as fertility, efficiency of feed conversion, constitutional vigour, capacity for optimum growth, are fundamental to livestock breeding and long years of attention to them in breeding projects have assisted in producing a certain degree of genetic homogeneity for such qualities in most strains of producing stock. It is not often that conscious selection for these traits has to be practised; it is usually merely a matter of routine culling of inferior individuals. When, however, through paying too much attention to other characters or through the inbreeding of unsound stock, there is perhaps a loss of vigour or decline in fertility in the herd, brought about through an increased frequency of occurrence of undesirable gene combinations, then strict selection for such basic characters is essential. Normally, however, selection is directed towards improved milking capacity as the major objective. Breeding for inherited resistance to certain diseases and for further increased efficiency of milk and butterfat production are likely to become items of great future importance in selection.

The importance of selecting for as small a number of characteristics as possible can be demonstrated numerically: "other things being equal, progress in selecting for one trait, when selection is based on that trait alone, will be the square root of N times as fast as when selection is for a number of traits equal to N ". When four characters are being considered, progress in selecting for any single character is only half as fast as it would be if selection were being directed towards it alone; and also, when selecting for one trait along with eight others, progress is only one-third as rapid as it would be if attention were being paid to the one trait alone. Improvement is not quite as slow if the various characters are positively correlated (as some of the economic characters in dairy cattle would appear to be)

Where such qualities as coat-colour, shape of horns and other fancy points are concerned, however, any correlation which exists is exceedingly small and if selection is directed towards such characters as well as to productive qualities, the rate of improvement in the latter is clearly retarded. In the same way, to cull high yielding cows from the dairy herd for any reason other than deficiency in economic characteristics, makes it so much the more difficult to breed highly productive stock.

It is clear that if selection for improved productivity in dairy cattle is to be fully effective, the ideal towards which the breeding programme is directed should be as simple as possible and all non-essentials should be discarded.

II. ACCURACY IN MEASURING EXCELLENCE.

The intensity of selection normally practised for production capacity tends to be lower amongst registered purebred stock than amongst non-registered dairy cattle. This is due, on the one hand, to a consciously reduced selection intensity amongst purebred stock due to the inclusion of a large number of breed points in the selections and to the raising of large numbers of young cattle in response to the heavy demand for and profitable trade in surplus stock ; and, on the other hand, to a high selection intensity amongst non-registered stock because attention is paid wholly to productivity and because the number of young stock raised is usually restricted to a minimum on account of feeding problems and farm management factors.

a. AMONGST REGISTERED PUREBRED STOCK. The standards used for defining and measuring excellence in registered purebred dairy cattle include many that bear little or no relationship, scientifically, to milking capacity. Despite the fact that direct measurements of the yield and composition of milk produced annually by dairy cows throughout their lifetimes is a fundamental requirement of any rational system of dairy cattle breeding, thousands of registered purebred cows in New Zealand at the present time have never been tested for milk and butterfat production.

A State-administered system for the testing of individual purebred cows (C.O.R.) has been in operation in the Dominion for more than 25 years, an inexpensive herd-testing scheme was instituted 30 years ago, and a special Government official herd test, practically restricted to registered stock, was commenced in the 1927-28 season. Although these services are utilised to a greater or lesser extent by many breeders, probably not more than 10 per cent. of the total registered purebred dairy cow population are tested annually under all systems.

TYPE. Formalism, or selection on the basis of type, still plays an important role in purebred dairy cattle breeding. Breed type, or those outward characteristics of colour and shape of the various body parts in the bull and the cow which are held to be desirable in a breed, acts as a breed "trademark" which provides some assurance of purity of breeding, additional to herdbook evidence. Lush points out that some qualities of breed type (such as the extent of spotting in the Friesian) may not be hereditary at all and therefore that the discarding of high producing animals not able to meet breed standards in such points may do actual harm to a breed. It follows too that the more attention that is paid to breed type in selection of breeding stock, the lower is the intensity of selection for productive characters, for many of the features that serve to distinguish between one breed and other, or that are held to be desirable within a breed, have no relation to productivity. Such qualities as particular patterns and shades of coat-colour, length or shape of horns, etc. may however possess value in themselves if their absence causes the rejection of an animal from herd-book registration or a reduction in its market value.

Type as an expression of constitutional vigour and bodily health is linked with productivity and therefore possesses economic importance. A dairy cow genetically capable of high yields of milk and butterfat is of little use as a member of the milking herd if her bodily structure is of such a nature as to make

impossible the maintenance of high annual production over a long period of time. From the viewpoint of economy of production costs, the most valuable cow is the one whose constitutional vigour enables her to produce, regularly every year for many years, a reasonably high yield of milk and butterfat and a healthy vigorous calf.

The characteristics held to indicate health and vitality and capacity for a lifetime of production and reproduction in the dairy cow are: a deep, full, wide chest; strong straight legs placed squarely under the body and wide apart; sound feet; a level strong back and good body framework; all parts of body well grown; soft pliable skin and fine hair; good muscular, arterial and nervous development; general healthy appearance.

In addition to breed type and constitutional vigour, the breeder of pedigree dairy cattle selects his breeding stock for milking capacity on a basis of dairy conformation. Overseas workers have been able to demonstrate no substantial correlation between milk and butterfat production and any body measurements, except in the cases of size of body and size of milk wells. Gowen has obtained a negative correlation between milk yield and heart girth, other influences having been eliminated. He interprets this to signify that the wedge-shaped form, viewed from the frong, is one of the best physical indications of milk producing capacity, although Ragsdale and Brody have shown that chest girth is closely associated with live weight. The data upon which many of these investigations have been based are hardly satisfactory from the viewpoint of lifetime productivity since much of the work has been carried out on highly selected material (Advanced Registers) and many of the production records used were short-term yields or single lactation performances. It would appear however that even a single production record is a more accurate indication of lifetime productivity than any individual body measurement or series of measurements.

The main characteristics of the cow upon which estimations of dairy type are based involve the three interrelated concepts:

angularity of forms; feeding capacity; development of the milking organs. These are as follows: angularity of form requires the ideal body to appear wedge-shaped in three planes: the rump should be long, broad and level: the entire conformation should present a clean-cut appearance and be well-proportioned generally; in feeding capacity, the size of the barrel should be large in proportion to the size of the body as a whole: large mouth, strong jaws, sound teeth; in the development of the milking organs, the importance of a wide and long but relatively shallow udder is emphasised: the udder should indicate great capacity and be well-shaped but not pendulous: it should be firmly attached to the body: there should be not more than four teats, of uniform size, easily handled and symmetrically placed one on each quarter of the udder: the milk veins should be tortuous and strongly developed: the milk wells as large as possible.

The value of including type considerations in estimations of productivity is unquestioned for, regardless of the bases upon which any kind of livestock is selected, the individuality of the animal (i.e. the external appearance and behaviour of the animal under the particular conditions of the environment in which it is kept) must always decide ultimately whether such animal is to be preserved for breeding purposes or whether it should immediately be culled from the herd or flock. Espe states that a knowledge of type should supplement but not supplant records of production performance.

Actual records of milk and butterfat production are a far more accurate indication of individual producing merit than type appraisals but even production records frequently prove unreliable guides to production transmitting capacity. Where selection is based on both type and production records it is clear that the more accurate measure of excellence may suffer in application if too much attention proportionally is paid to considerations of type in respect of breed character, "constitution" or dairy quality.

The modern emphasis in the measure of production, reproduction and constitution tends to be placed upon numerical evaluation. In overseas countries, attention is being concentrated upon the "100,000 pounds of milk" cow and the "4,000 pounds of butterfat" cow, the ideal being an animal which is capable of producing and reproducing for a period of ten years at an average annual production level of 1000 gallons of milk or 400 pounds of butterfat. In the Dominion, the ideal in the Dairy Board Herd Recording Department's sire survey scheme is based ultimately on the evaluation of the worth of all sires (for pedigree purposes at least) on a basis of daughter-dam comparisons involving actual recorded lifetime productions of milk and butterfat.

The type classification scheme operated by the New Zealand Jersey Cattle Breeders' Association has now been available to breeders for some eleven years, and more than 7000 cows have been classified in the grades V.H.C., H.C., C., and C.P. The results to date are as follows:

<u>Classification</u>	<u>No. of Cows Classified.</u>	<u>No. of Cows with C.O.R. or G.O.H.T. Records.</u>	<u>Percentage of Cows with records.</u>	<u>Av. Production of each Group.</u>
C.	382	248	64.9	532 lbs.
	3771	1819	48.2	464 "
	2390	1008	42.2	425 "
	<u>597</u>	<u>324</u>	<u>54.3</u>	<u>489</u> "
	<u>7140</u>	<u>3399</u>	<u>47.6</u>	<u>460</u>

It would seem that amongst registered purebred Jersey cattle under New Zealand conditions there is a very substantial correlation between type and milking capacity. The figures given, however, may be questioned in respect of their scientific value, as follows:

1. No details are given as to the number of cows which received no awards, being rejected by the Classification Committee. It

would not be impossible that a similar proportion (5.4 per cent.) of similarly high producing cows would be found amongst those not classified.

2. As against this, it is likely that each breeder, since entire herds are not required to be entered, would not submit his lowest yielding animals.

3. The substantial proportion of untested cows in each classification group leaves abundant opportunity for some cows of poor type to be high producers and for some cows receiving high awards for type to be low producing animals.

4. It is possible that part of the apparent correlation may have come about because large size gives an advantage both in classification and in production (Lush).

5. Breeders usually place on C.O.R. test only those cows that they expect will produce outstanding yields, others being tested under Government O.H.T. conditions, if tested at all. Their choice of cows to be placed on C.O.R. is probably greatly influenced by type considerations. (1)

6. There may be a greater proportion of Government O.H.T. records in the H.C. and C. groups than in the V.H.C. group, and conversely of C.O.R. performances in the V.H.C. group as compared with the lower groups. In view of the considerably lower feeding standard normally employed under Government O.H. testing conditions, this factor would tend also to influence the trends in the table.

7. The production records enumerated in the table were arrived at by averaging available records, irrespective of age. It is not improbable that a larger proportion of older cows, therefore with higher production records, is included in the higher award groups.

8. The discrimination of the Classification Committee between V.H.C. cows and H.C. and C. cows has clearly been exceedingly strict and may thereby have excluded all cows except those very highly developed individuals capable of very high yields.

The association has also published a list of 104 bulls having 12 or more classified daughters. One bull has as many as

12 V.H.C. daughters out of a total of 25 daughters classified.

It is clear that a very much more thorough analysis of the classification scheme is required if conclusions of definite value are to be deduced. Such an investigation would be based preferably on the lifetime production performances of all cows participating, together with details of points awarded in respect of each animal. The production records would necessarily be restricted solely to a single testing system, with suitable corrections applied for age, length of lactation period, etc., if required. The behaviour of C.O.R. performances and classification awards in inheritance should be fully investigated and correlations arrived at for various bodily measurements in relation to milk and butterfat production, including due allowances for age and body-weight.

Type in itself may be of value from the viewpoints of beauty or breed type and of health and soundness in the individual animal, but such evidence as is available tends to indicate that actual correlations between the general appearance of an animal or its detailed characteristics and its possible milk producing capacity are not significant relative to the value of production records. Conformation, further, provides no guide to the fat content of milk produced. Moreover, there is no known relationship between the type points of a sire and the milk and butterfat production records of his female progeny. Milk production, moreover, is the end-result of many complex genetic, physiological and developmental reactions in many different parts of the bodily structure. The outward appearance of an animal is likely to be a completely valueless criterion of the internal functions known to be concerned in milk secretion..

Production records are always approximate and frequently inaccurate measures of the ability of an animal to transmit inheritance for reasonably high and long sustained milk and butterfat production, but they are in most cases far more accurate than type estimations and every high producing cow culled from a herd solely by reason of type deficiencies reduces the maximum intensity

of selection practicable for hereditary production capacity.

SHOW-RING PERFORMANCE. Methods of judging at Agricultural and Pastoral shows in the Dominion have been and are probably the greatest single influence perpetuating the effete system of assessing individual merit solely on a type basis. What Lush says of American shows applies with equal force to New Zealand : "The main thing is to exalt before the public the most nearly ideal combination of visible characteristics which could be found and to give the breeders a clear picture of the perfect animal to guide them in their own selections". The chief danger of the present show system is of course not that it emphasises type per se but that outward appearance is stressed to the exclusion of other and far more accurate estimations of individual worth. There is no single class at any dairy cattle show in the Dominion where cows are judged both for type and production, no classes where pedigree examinations are taken into account in making awards to young bulls and heifers, and only a few unsatisfactory (and unpopular) classes where sires are judged with a selected few of their progeny. The true visible characters of animals are usually obscured by such show practices as skilful handling, special feeding and trimming, which are held to be of value in that the ideal form is more nearly approached by animals subjected to such treatment. If, however, through the powerful advertising value of high awards at the principal shows, a demand is created for animals which though superior in outward appearance are deficient in inheritance for milking capacity, show placings cause serious harm to a breed. 'At the present time it is possible for untested animals to win Royal Show championship awards).

Cattle shows possess real value as aids to the profitable sale of surplus stock and are a convenient meeting place at which breeders and buyers may exchange ideas and experiences. The continued emphasis on conformation alone however does not encourage breeders to make use of production records, pedigree estimates and progeny tests, all of which are much more accurate criteria

of breeding worth, in their breeding programmes.

If shows where dairy cattle are exhibited are to afford any real assistance in the breeding of productive stock, the following points, made use of in overseas countries, should receive attention.

1. All classes for cows and heifers three years old and over should require certified evidence of production records as a pre-requisite to entry and all awards in such classes should be made on a basis of type and production, or if it were possible, on a points system suitably balanced between type, production performance, pedigree and progeny performance.

2. In all classes for young bulls and heifers awards should be based on pedigrees of performance of ancestry, as well as on outward appearance.

3. In classes for mature bulls, awards should be based on the productive ancestry and individual merit of the bull together with a complete appraisal of the productivity of all his progeny, some of whom should be required to be present at the Show.

4. Lush suggests the following points:

1. All animals in every class should be graded according to merit; awards should conform to standard grades constant for a breed from show to show; written judgments should be issued in respect of every animal on a points basis; these should be placed in the animal's stall together with details of all other information taken into account at the award; all animals when judging is completed should be stalled at the Show in order of placing.

Lush believes that the provision of full information on these lines, as practised as many Continental shows, would prove of real value in the improvement of breeding methods.

ii. Showmanship, fitting and trimming should be reduced to a minimum.

Procedures such as these, if adopted in New Zealand would undoubtedly exert a wide beneficial influence upon breeding methods by emphasising the productive rather than the conformational

characters of dairy stock, and by directing the attention of breeders to the most accurate methods by which production transmitting ability may be assessed.

PEDIGREE. Under existing conditions in the Dominion, records of descent are available (at some inconvenience) for all registered purebred cattle, but pedigrees of performance are less readily obtainable. Many breeders of registered stock still believe that because an animal has been listed in the herd book of its particular breed, it automatically possesses merit of an unusually high order. This, however, is far from being the case, for unless the records of ancestry include exact and certified details of the production, reproduction and constitution of all animals mentioned therein, such pedigrees have an exceedingly low value as bases for predicting breeding worth.

Pedigree of performance are most useful in the case of young animals because when a bull has been thoroughly progeny tested or a cow has been credited with a lifetime record of productivity, the presence of exceptional individuals in the ancestry has no longer much value, except when linebreeding or inbreeding programmes are in view. In view of the sampling nature of inheritance, no pedigree however detailed is a completely reliable indication of the breeding performance of any individual animal; but, used in conjunction with individual merit, is an excellent guide to the probable inheritance for productivity which the animal has received. Lush states that when the individual performance is known, "by paying a reasonable amount of attention to the relatives it may be possible to increase the genetic accuracy of the selection more than enough to offset the decrease in the intensity of selection for individual merit".

It is in the case of young immature stock that pedigree selection is most useful; in respect to the choice of yearling bulls it is indispensable. Under present conditions in the Dominion, most bulls are bought as young untried sires, and therefore apart from the individual appearance of the animal, the

purchaser has no guide to its breeding worth except in the evidence afforded by its record of descent. The information to which the purchaser of an immature bull is entitled, is as follows:

1. The bull's dam should be, ideally, an aged cow with a long record of production and reproduction - yearly records of reasonably high milk and butterfat production, regular annual calving, denoting constitutional vigour and resistance to disease.

2. The production records of all the full sisters and maternal half-sisters should be shown, as well as the breeding performances of any full brothers or maternal half-brothers.

3. The bull's sire should be, ideally, an aged animal and the production records of all his tested daughters should be shown in detail and as an average for comparison with the average milk and butterfat production of their dams to which he was mated; breeding performances of his sons should also be detailed if available.

4. Production records and breeding performances of all the full sisters and full brothers of the young bull's sire and dam should also be listed.

5. Full details such as the above should be available for each animal in the grand-parental and great-grand-parental generations of the pedigree. It is not usually necessary to consider more remote ancestry.

6. There should be some evidence of line-breeding in the pedigree, so that the chances of the young bull's inheriting desirable gene combinations are higher than if no constructive breeding has been practised in the near ancestry.

Unfortunately, these conditions are seldom if ever realisable in the Dominion at the present time. Thousands of bulls bred from untested dams are sold annually as untried yearlings for use in grade herds; the great majority of such bulls are selected on type characters or on pedigrees containing indefinite and inaccurate information of which the following are typical examples:

"a prolific sire of prizewinners".

"a dairy cow from a high producing family".

"great daughter of great sire - owing to accident, never been tested, nor ever will be".

"sire of many fine cows, some of whom have produced as high as over 3 lb. fat in 24 hours; ordinary feed, O.H.T."

"a good lengthy type of cow and bred from the best."

It is only of recent years (1932) that for the National Jersey Show and Sale, at which more than 150 registered purebred Jersey yearling and older bulls and annually exhibited and auctioned, a production record by the bull's dam has been made a pre-requisite to entry. A single production record of course, while a more accurate indication of lifetime productivity than no information at all is of little value in itself unless the yield is an exceedingly high one, for what is required is evidence in the pedigree of production transmitting ability in the immediate ancestry. This entails lifetime records of production and reproduction for all females mentioned, including all the tested daughters and tested female relatives of all sires and dams included in the ancestry quoted. It is most important that full details rather than selected information should be available.

Clearly, if maximum advantage is to be derived from pedigree selection, the pedigree must be one of performance. It should not be a mere collection of names of ancestors but should include every observation on near ancestors collateral relatives and descendants that is likely to be of value in assessing the probable inheritance of an animal in respect to lifetime productivity. Information of this kind is detailed in the herdbooks in some overseas countries (notably in regard to the Red Danish breed in Denmark); it is essential that similar data should be made available in herd books in New Zealand.

PRODUCTION PERFORMANCE.

Goodall has defined phenotype as: "a single numerical expression of the activities of the entire group of genes concerned with any particular quantitative character, and is the only objective criterion of their activities either singly or in the mass." Milk and butterfat production is an indication therefore of a cow's inheritance for milking capacity. The same phenotype, however, may represent numerous different genotypes and so, while production performance is a far more accurate basis for selection than type or show-ring performance or pedigree, it is not an infallible index of breeding ability although, as in the case of most quantitative characters the phenotype is an approximation of the genotype.

In registered purebred dairy cattle in New Zealand, production performance, when it is measured at all, is in a large number of cases measured under the Certificate-of-Record system. About 50 per cent of cows tested in the Jersey and Friesian breeds are tested at first calving; not more than 10 per cent. of cows tested are tested more than once; the plane of nutrition is exceedingly high, the object being to achieve maximum production regardless of cost. The advantages of C.O.R. testing consist mainly in the exceedingly high advertising value of a spectacular record, and much attention is given to the careful feeding and management of the cows under test to this end. The test is also of value from the viewpoint that, if other influences are standardised, as they frequently are under C.O.R. conditions, a C.O.R. performance represents the maximum expression of a cow's genotype. As such it is held to be a reliable indication of genes or gene combinations which are favourable to high milk and butterfat production. It is on these premises that sires are selected for use in grade herds.

The difficulty here arises, however, that when sires so selected are used even in moderately high producing grade (or registered) herds there is a large regression to the breed average that is accentuated by the much lower standard of feeding in such herds, for the level of feeding and management is here aimed at the maximum economic butterfat production per acre, and is greatly different from that obtaining under C.O.R. conditions. The exact relationship between C.O.R. and commercial herd production conditions is therefore not defined. It would seem that for superior grade herds only a sire from female ancestry capable of producing a minimum of 600 pounds of butterfat as 2 year olds under these artificial conditions, would be likely to produce satisfactory results. Moreover a wide variety of excuses is usually found by pedigree breeders whose cows are unable to attain high levels of production. These excuses are usually based on feeding or climatic factors prevailing at the time and add to the difficulties of arriving at the correct value of a C.O.R. performance as a basis for selecting herd sires.

Since only a small number of cows is tested more than once under C.O.R. conditions it is not often possible to overcome these various confusing influences by averaging a series of successive C.O.R. performances. Since the type of cow that the dairy-farmer needs and is trying to breed is one that will produce and reproduce over a long period at an economical level of feeding, it would appear desirable that registered purebred cows should be reared and tested under conditions comparable to those under which their male progeny are most likely to be used. In this way, genes and gene combinations favouring high annual production at an economical level of feeding would be made available for selection to act upon.

The Government O.H.T. system further complicates the position. Here, groups of selected registered cows are

maintained at a level of feeding rather higher than that prevailing under group herd test conditions. Again, the results of using sires selected on the basis of Government O.H.T. performances in the female ancestry, cannot be predicted with any satisfactory degree of certainty.

Under group herd test conditions at the present time, the average productions of grade cows and registered purebred cows are very similar. The results obtained from using sires bred from such cows are certainly on the average no more satisfactory at the present time than sires selected on C.O.R. and Government O.H.T. performances.

If the dairyfarmer is satisfied that in selecting his sires from ancestry containing high C.O.R. production performances, his herd average production is being improved, then he is probably justified in continuing to select his sires for production (i.e. on C.O.R. performances) and his dams on constitution (i.e. on lifetime average production). Under existing conditions, however, as disclosed by the preliminary sire survey figures, only one sire in three is capable of improving the average production of the herd in which he is used.

More important probably than the difficulties encountered in comparing the productions of cows or herds tested at different levels of feeding and management, is the fact that so few registered purebred dairy cows are tested at all for milk and butterfat production. About 500 are tested annually under the C.O.R. system, about 2,000 under Government O.H.T. conditions and about 5,000 under Group Herd Test conditions. The proportion of the total registered purebred dairy cow population tested annually is unlikely to exceed 10 per cent. Untested cows are frequently selected to be the dams of bulls on the basis of type or show-ring performance

or pedigree. These criteria have a relatively low value as indices of breeding or productive worth even under highly favourable conditions. In New Zealand where the information available to breeders on these points is seldom definite or accurate, it is clear that the testing of all registered pure-bred dairy cows is a basic requirement in projects for the improvement in milking capacity of the general dairy cattle population.

PROGENY TESTS.

In dairy cattle, where the characteristics of main economic importance are expressed only in the one sex and where it is seldom possible to select female stock on progeny performance records, progeny testing presents special difficulties. Nevertheless, Goodall states that "improvement is next to - if not actually - impossible when bulls are selected for breeding at random, which is what selection without a progeny test amounts to." It is evident, in view of the confusion existing with regard to the selection of sires on the basis of production performance in the ancestry, that Goodall's statement is not without justification in its application to existing conditions in New Zealand.

Evidently, if further progress in breeding for improved productivity in dairy cattle in the Dominion is to be achieved, the most pressing requirement is a radical alteration in present methods of sire selection - from selection on pedigree and individuality as a yearling, to selection on the performances of his female progeny relative to those of their dams. Since under such a system of selection no bull can receive even a preliminary appraisal until he has attained the age of five years, it is apparent that the most rapid means of effecting the change-over is to continue all existing bulls in use, all their progeny being tested, until the breeding worth or worthlessness of each is finally and

satisfactorily determined. At this stage wide use could be made of the satisfactory animals and the worthless culled from the industry. Such a system entails the regular and systematic testing of all the female progeny of a sire in order to determine his breeding value with certainty.

In this respect progeny-testing schemes as operated by some of the breed societies are totally unsatisfactory since bulls may qualify as proven sires on the production records of a selected group of their progeny. This is notably the case in regard to the Champion Butterfat Bull scheme of the N.Z. Jersey Cattle Breeders' Association, where the designation "C.B.B." is awarded to bulls having 5 or more daughters which attain certain prescribed standards of production. No reference is made to the production level of the dams to which the bulls were mated. The same Association also lists sires at least 6 of whose daughters have produced more than 100 lbs. butterfat above the standard production required under C.O.R. testing. Although in this case, since the qualifying standards for the C.O.R. test are exceedingly low, the progeny are probably not highly selected, again no reference is made to the performances of the dams.

It would seem that either more scientific and reliable criteria should be utilised in progeny tests of purebred sires, or commercial dairymen with large herds should select their sires as at present, reserving final judgment until complete progeny performance records are available.

b. AMONGST NON-REGISTERED STOCK.

The average dairyman milking a herd of grade cows does not consciously select his animals for conformation. Breed type in his stock has no market value and although he may pay some attention to beauty in his breeding cattle, his main means of obtaining this characteristic is through the herd sires he employs, by paying a slightly higher purchase price for a "typey" bull which otherwise met his requirements. In his female stock, productivity is the essential and culling is on this basis alone. He probably pays attention to constitutional vigour in so far as cows with definite structural faults or disabilities would not be used for breeding purposes if he considered that the defects were likely to be hereditary. Dairy type is still largely used by numerous dairymen as a means of selecting for productivity. It is usually made use of in conjunction with arbitrary (and usually highly inaccurate) estimates of milk yielding capacity based on the ability of cows to "fill the bucket" at milking time. Even testing farmers pay some attention to type points in their dairy cows but this is mainly directed towards gross faults of conformation, particularly in regard to jaws, feet, legs, back, barrel, udder and teats.

Production performance is the main criterion by which the progressive dairyfarmer judges his cows. Butterfat production is his major source of income and unless his animals are capable of sustaining reasonably high regular annual yields of milk and butterfat over a lengthy period, they are culled - provided, of course, that they can readily be replaced by younger but higher producing cows, so that the herd level of production is maintained. In this respect, herd-testing dairymen have made considerable use of the Calf-Marking Scheme,

the results of which have proved very satisfactory in that cows raised as marked calves produce on the average at a level of about 30 pounds of buterfat higher than that of tested cows in general.

Thus, in his selections, the commercial dairyfarmer raises heifer calves for replacement purposes as far as possible from only his highest producing cows, sired in a majority of cases by a registered purebred bull. Selection on a basis of production performance therefore receives the main emphasis in the breeding of non-registered stock. Again, the proportion of the total dairy cow population that is tested regularly year after year remains exceedingly small (probably little more than 10 per cent.) and obviously this constitutes a major barrier to increased average production per cow. Herd-testing determines which cows should be culled and which should be used for breeding purposes, and decides ultimately whether the herd-sire is satisfactorily maintaining the herd level of productivity. The failure of many sires in use in the industry today to accomplish this purpose is likely to be a prominent and important influence in the extension of herd-testing to many farms which hitherto have not participated in the benefits conferred by the services available.

III. THE REPLACEMENT RATE.

"The annual replacement percentage is the number of heifers drafted annually into a herd or breed as first calvers, expressed as a percentage of the total number of actively producing cows in the herd or breed." (Smith and Robison).

In the ideal case where losses from the herd occur only on account of cows culled for age, the annual replacement rate is 10 per cent. Sanders (1928) and Kay and M'Candlish (1929) have shown that on the average a dairy cow reaches her maximum milk production at approximately her 6th lactation when she is in her 8th year of age. The decline from this maximum does not take place to any substantial degree until the cow reaches her 12th year (i.e. 10th lactation). From these data, it can be assumed that the maximum economic producing life of a dairy cow is on the average 10 lactations. Thus if there were no losses through disease, accident, low production, each age group in an efficient herd would contain 10 cows. Smith and Robison (J. Agr.Sc, Vol. 31), found that in four leading breeds of dairy cattle in Great Britain the average annual replacement rate was approximately 29 per cent.

In New Zealand, replacement rates are as follows:-

<u>Season.</u>	<u>Cows in Milk,</u> (000)	<u>Replacement Heifers^a</u> (000)	<u>Replacement Rate.</u> (%)
1930-31	-	3392	-
1931-32	1583	3531	21.4
1932-33	1724	3525	20.8
1933-34	1816	3578	19.4
1934-35	1823	3568	19.6
1935-36	1823	3163	19.6
1936-37	1805	2860	17.5
1937-38	1764	3165	16.2
1938-39	1744	-	18.1

8 The number of heifers coming into the herds has been arrived at from the figure "number of heifers one and under 2 years old" for the year mentioned, less 2 per cent. losses assumed to have occurred before January 31st of the year following. According to Group Herd test returns (13.7 per cent. 2-year-olds in 1937-38) the present figures are somewhat high, but even so they compare very favourably with the British figure for pure breeds.

The effect of the final stage of rapid additions to dairy herds is clearly apparent from the table. A high annual replacement rate means that more heifers have to be reared and hence a decline in the intensity of selection that can be practised for milking capacity is brought about. It is obvious that selection for productivity was greatly relaxed early in the present decade when huge annual increments totalling 550,000 cows were added to the national dairy cow population, but that as the number of cows milked has declined so the annual replacement percentage has fallen also. For last season 1938-39, it would seem that some slight increase to the national herds was imminent or that further considerable culling of aged, low producing, or diseased animals was in prospect.

Tentative figures based on Group Herd test returns would tend to indicate that replacement rates in the pure breeds of dairy cattle are somewhat higher than those for the general population, being in the vicinity of 20 per cent. for some breeds. Without doubt, a heavy demand for surplus stock of certain breeds has considerably reduced the intensity of selection practised amongst young stock.

In commercial dairy herds, the number of heifer calves kept and reared annually is maintained at a bare minimum in view of the cash value of milk and butterfat used in calf-feeding, for factory supply, or pig production, and the need to conserve labour supply and pasture feed at the busy season of the year.

It would appear that although a replacement rate of, say, 17 per cent is a quite moderate average, there are many herds in which the percentage must be considerably higher. A reduction in the average rate, and particularly in herds where the rate is very high, is an important feature in a policy of reduction in farm costs through improvement in producing capacity of replacement stock due to more strict selection, and through reduction in herd wastage and maintenance costs.

IV. THE INCIDENCE OF DISEASE.

Whenever low-producing cows have to be retained in the herd because many other animals have had to be culled for disease, so is the intensity of selection that can be practised for improved milking capacity correspondingly reduced. This diminution occurs in two ways: low producing cows are retained in the herd and perhaps used for breeding purposes, and larger numbers of heifer calves are raised for replacement purposes.

In a preliminary analysis of winter culling returns (Jan. 1938), A.H. Ward was able to show that approximately half the total number of cows removed from herds during the winter months, was culled on account of disease. Only one-third of the total number disposed of represented true culling on account of low production and even here it is not improbable that some part of the low production was itself due to disease conditions.

Mastitis and Sterility were the two principal diseases concerned in the total diseases losses, accounting for 40 per cent. and 36 per cent respectively of cows culled for diseases of various kinds. Tuberculosis and abortion were each responsible for 4 per cent of disease losses, the remainder (about 16 per cent) being caused through conditions mainly preventable by efficient management methods.

The Dairy Board Herd Recording Department is at present conducting an investigation into the nature and incidence of mastitis infection in dairy herds with a view to its effective control. From information obtained from agglutination tests carried out at Wallaceville Laboratory, it would appear that about 30 per cent. of dairy cows react to the test for contagious abortion. Field observations would indicate that approximately 12 per cent of heifers and 5 per cent. of cows actually abort. Based on tuberculin tests and post-mortem examinations, the estimated incidence of tuberculosis in cattle over the whole of the Dominion is approximately 9 per cent.

These figures indicate the extent of annual losses to

the dairy industry through herd wastage due to disease. The corresponding losses due to retardation in dairy cattle improvement owing to reduction in the selection intensity practicable for high milking capacity in young stock consequent upon the need to maintain a high replacement rate, though not so readily apparent, is none the less real.

F. THE GENERAL IMPROVEMENT OF NEW ZEALAND DAIRY CATTLE.

If the general improvement of dairy cattle in New Zealand implies increased and more economical productivity per cow and per acre, then improved breeding methods must be accompanied by more efficient methods of feeding and management, and the effective control of disease.

1. THE LIMITATIONS OF SELECTION. The value of selection to practically all kinds of breeding systems is unquestioned but by itself is a slow process. It usually produces its largest effects when first practised and sometimes is unable to make further progress in a direction in which it has made rapid progress at first. Lush summarises "the main obstacles to quick success in reaching one's ideal merely by selection" as :

- "1. Low reproductive rates which prevent intense culling.
2. Paying attention to so many things that progress for any one of them must be slow.
3. Mistaking the effects of environment for the effect of genes, thereby causing a large regression from the average of the parents toward the average of the population from which the parents were selected.
4. Being deceived by dominance, thereby causing some further regression toward the average of the population from which the parents were selected.
5. The ideal being genetically an intermediate".

Clearly, points 1, 2 and 3 are of great significance in dairy cattle breeding, while points 4 and 5, though usually somewhat obscured by the complex nature of milk producing capacity are nevertheless likely to be of considerable importance also.

a. CLOSE BREEDING. Variability is the raw material upon which the breeder practises his selections as between individuals more rapid progress is however possible when selection is carried out between families produced in consequence of some degree of inbreeding. Inbreeding reduces variability within a group of individuals and therefore may be of considerable value in perpetuating valuable gene combinations by keeping relationship to a desirable individual high.

Inbreeding may be so intense, however, as to uncover undesirable genes so rapidly that it may prove impossible to discard all individuals homozygous for them, in which case undesirable characteristics may become fixed in the whole herd.

Less intensive forms of inbreeding however, particularly linebreeding (which Lush describes as "a form of selection directed toward the ancestors") are not perhaps made sufficient use of in New Zealand. It is very probable that in the Dominion more harm is done to the progress of dairy cattle breeding by not using some form of inbreeding when it would be advisable to do so, than harm is actually caused through uncovering defectives.

b. OUTBREEDING. Outbreeding or the crossing of unrelated strains or individuals, including inbred or linebred families, immediately restores uniformity to a stock which has been differentiated by diverse breeding policies. Outbreeding frequently results in increased vigour and size of the individual, but breeding value is reduced. Outbreeding is most useful between inbred strains when undesirable characteristics show a tendency to become fixed. Desirable genes or gene combinations may be introduced so that losses due to discarded individuals are substantially reduced and, following a single out-cross, the inbreeding system may be resumed.

The combination of moderate degrees of inbreeding and outbreeding would seem to have much to recommend it as a policy which could profitably receive further attention by breeders of registered purebred stock. There is clearly still much scope for selection based on scientific criteria of breeding worth and assisted by the discriminate use of inbreeding and outbreeding systems.

II. MASS SELECTION. Mass selection, signifying the elimination of low-producing strains by using only high-producing individuals for breeding purposes, is at first a rapid means of increasing the number of high-producing individuals in a population. The rate of improvement achieved, however, gradually becomes progressively

slower until a point is reached at which it is necessary to supplement this phenotypic selection by selection of individuals proven to be capable of breeding high-producing progeny. It would seem that, in general, dairy cattle breeding in New Zealand has, in fact, reached this point; and further progress must be looked for as the result of improved breeding methods based on the complete utilisation of progeny performance records as the principal aid in selection.

There are, however, two special forms of mass selection which offer reasonable prospect for the further elimination of low-producing animals from breeding herds.

a. SELECTIVE REGISTRATION. "Selective registration is a form of official mass selection which consists in preventing individuals deemed inferior from leaving any registered descendants." (Lush). Most breed associations in the Dominion publish Advanced Registers of tested cows and/or records of production performances of cows and breeding performances of bulls. No attempt however is made to cancel the registrations of inferior animals. In some overseas countries the standards for registration are exceedingly strict and only a limited number of proven superior individuals are admitted to registry, this is notably the case in Denmark where a maximum of 500 Red Danish cows can be registered annually. All cows must have been in milk for at least three consecutive years and the actual uncorrected production is required to have averaged at least 400 pounds of butterfat per annum. Some breed societies in America, in order to encourage the testing of registered purebred herds, allow breeders to omit the lowest-producing cows from the annual published herd averages - provided that the registrations of such animals are surrendered. It would seem that this procedure could with profit to purebred and grade stock alike, be introduced into New Zealand practice. Any means that will confer real value on the herd books in any breed must receive serious consideration. Such schemes are probably best approached through the method of "deferred registration" whereby births of calves are

notified but registration is not effected, until standards of production and reproduction have been met in respect of female stock, and standards of progeny performance in the case of male animals.

The practice of selective registration, as Lush points out, does nothing for a breed that individual breeders cannot do (if they wish) but at least it sets a certain standard to which all breeding practices would be obliged to conform.

b. REGISTRATION OF HIGH GRADES. The herd books conducted by all dairy cattle breed associations (except the New Zealand Shorthorn Herd Book) are now "closed" - i.e. registrations are accepted only in respect of animals whose sire and dam have both been admitted to registry. The Milking Shorthorn Association conducts an Appendix for the registration of graded cows and their female progeny by registered purebred Milking Shorthorn sires. In view of the fact that ancestors in the fourth generation of a pedigree make a very slight contribution on the average to the genetic constitution of the individual, it would seem that the disadvantages of admitting very superior grade females at least to tentative registration would be slight in relation to the real value of incorporating desirable genes or gene combinations into the breed constitution.

Lush states that "the genetic consequences of such a practice are : (a) some loss in homozygosity, and (b) the possibility of introducing some desirable genes which are rare or unknown in the pure breed". If grades so admitted were very strictly selected on production performance, on production transmitting ability and on breed type characters, it is very probable that on balance such a policy would be of decided benefit to a breed.

In the Dominion, where the difference between the average productivity of high grade herds and that of registered purebred herds is becoming less and less apparent, the advantages of the system would appear clear. There is the further point

that in New Zealand, certain grade herds in which proven superior purebred sires of a single breed have been used for five or six generations and some constructive breeding has been attempted with good results, are definitely superior in average productivity, type and breeding performance to countless inferior registered herds. The possibility of the formation of a "grade herd book" with an inevitable reduction in the demand for registered purebred sires is one that cannot be overlooked by the breed associations.

III. BREEDING FOR DISEASE RESISTANCE. The conscious breeding for hereditary disease-resisting qualities in dairy stock is likely to become of greater importance in dairy cattle breeding projects in New Zealand. At the present time many breeders refrain from using as breeding stock cows in whose families the incidence of any disease has seemed unusually high. A.H. Ward's preliminary report on inherited susceptibility to mastitis, the dairyman's major disease problem, tends to indicate that selection for strongly resistant strains and particularly, the use of none but herd sires from mastitis-free ancestry, is likely to prove a profitable undertaking.

The incorporation of yet another ideal in selection will of course tend to reduce the intensity of selection practicable for milk producing capacity. This, however, should be offset, if selection for disease resistance is successful, by lower replacement needs, thus enabling more rigid selection to be practised in young stock drafted into herds. At the present time much may be accomplished by practices aimed at efficient disease prevention and the proper control of such conditions as abortion and tuberculosis which by the use of tested eradication methods, can be eliminated from most herds within a few years.

IV. THE SELECTION OF SIRES. The breeding, testing and complete utilisation of proven sires throughout a long breeding life are the methods which appear to offer greatest prospect for the immediate and permanent improvement of productive capacity in New Zealand dairy cattle.

a. COMPLETE PROGENY TESTING. All bulls in use in dairy herds should be retained in a healthy and vigorous condition until, at the age of five years, the production performances of their first 6 - 10 daughters become available as a preliminary indication of the breeding value of the sires used. Clearly, a first essential is to mate the young bull at the earliest possible age with from 20 - 30 females, so that a reasonably satisfactory number of his female progeny will be available for testing purposes in due course. The usual practice of turning yearling bulls out to "run with the heifers" is to be deprecated because : (a) many more services take place than are actually required to effect fertilisation and the bull's breeding ability may be impaired, (b) calves from heifers are frequently aborted, or weakly and undersized when calved normally. It therefore appears desirable that yearling bulls should be mated under supervision with mature cows, the assistance of a breeding crate being availed of if necessary.

To minimise the danger that a bull transmitting inheritance for low production may do in a herd of high yielding cows, it seems essential that two or more bulls (depending on herd size) should be bought as yearlings at the same time. The chances are slight that both or all will prove to be unsatisfactory sires and therefore when complete progeny tests are available at 5-6 years of age, the valuable animals can be utilised very extensively in the herd, and the inferior breeders culled and sent to slaughter. It is essential that the complete and unselected performances of all daughters of a sire should be included in the tests.

A fundamental requirement in progeny testing is the regular and consistent testing of all cows in the herd for milk and butterfat production. In the present state of testing, generally, the lack of production records for the progeny and their dams constitutes a major limiting factor to the wide

utilisation of progeny tests as the only reliable basis for selecting herd sires.

b. BULL ASSOCIATIONS. Co-operative ownership of dairy bulls has long been practised in Denmark and has comparatively recently made considerable progress in the United States of America, the total being over 400 in 1932. In America, groups of farmers are encouraged to purchase, use, prove and possibly retain high class dairy bulls with the objects of reducing costs of maintaining sires on small holdings, of reducing the influence of poor breeders in any herd, of avoiding inbreeding, and of preserving the active life of all bulls until their breeding worth has been determined. In Illinois, the following rules are suggested for any group of farmers initiating a bull association:

- "1. If five men are represented they buy five bulls, each owning an interest in all five bulls.
2. Each buys a paddock and breeding pen so that all bulls will be handled in the same manner.
3. They exchange bulls each year. This practice will greatly lessen the damage that a poor bull will do to any one herd.
4. They test all cows in the herd each year in Dairy Herd Improvement Associations. This will insure the testing of the daughters of each bull.
5. If a bull dies or proves undesirable, all go together and replace him.
6. The bulls are not used on outside cows."

There is a very strong case for the adoption of similar schemes in the Dominion, particularly in regard to small herds in which the average breeding life of bulls is exceedingly low, and also in respect of larger herds where, if a bull is used extensively before his breeding value has been demonstrated, considerable damage may be brought about through the use of sires transmitting inheritance for low production. By exchanging bulls, instead of sending them to be slaughtered before their capabilities in transmission of inheritance are known, farmers could in time depend upon a continuous supply

of proven superior sires, and the maintenance or improvement of herd average production would be assured.

c. ARTIFICIAL INSEMINATION. The practicability of artificial insemination under existing conditions of dairying in the Dominion has yet to be satisfactorily demonstrated, but results of many overseas undertakings indicate that by its use bull maintenance costs can be reduced and more intense selection of sires practised. Recent figures quoted by Walton, indicate that from 10 - 15 cows can be inseminated from the single ejaculate of a bull and that the spermatozoa remain viable for periods of up to 30 days.

With the objective of making most use of the best sires, Russian workers have for some years practised the insemination of millions of cows annually. It is clear that in such large-scale projects, considerable discrimination would need to be exercised in the choice of sires to be used.

Artificial insemination makes possible the maximum use of proved superior sires, provides the services of better bulls at lower cost to small herd owners, and eliminates second-rate and inferior sires from breeding herds.

G. SUMMARY AND CONCLUSIONS.

SUMMARY.

1. The necessity for a high level of productivity in New Zealand dairy cattle and the importance of Selection in maintaining or improving upon this level are emphasised.
 2. The multiplication of dairy cattle numbers is reviewed in relation to the growth of the European population and the development of the dairy industry.
 3. The variable influence of Selection as development proceeded is explored.
 4. The origins and development in overseas countries of the principal pure breeds of dairy cattle are described and a brief review is given of the development and influence of registered purebred dairy stock in the Dominion.
 5. The relative importance of registered purebred cattle and non-registered stock in the general dairy cattle population is estimated.
 6. General implications of Selection directed towards the improved productivity of dairy cattle are enumerated.
 7. The present state of knowledge of inheritance as it affects the economic characters of dairy cattle is briefly reviewed, the genetic implications of Selection discussed, and complexities in the inheritance of milking capacity emphasised.
 8. The various factors which influence the degree of intensity of selection practicable for milking capacity under conditions of New Zealand dairy-farm production are briefly discussed.
 9. Some procedures and practices which may be of value in consolidating and furthering the improvement of productivity in New Zealand dairy cattle are listed.
-

CONCLUSIONS.

1. That selection has been of considerable importance throughout the development of dairy cattle breeding in New Zealand.

2. That in times of rapid multiplication of dairy cattle numbers, selection has had to yield in importance to sheer expansion in numbers.

3. That simple mass selection based on the widespread use of registered purebred sires selected on the basis of production performance records in pedigrees, has in general achieved the most improvement that is possible by this means.

4. That further improvement in average per cow production of milk and butterfat is not only possible but urgently necessary if the maximum economic level of production per acre is to be attained, and dairy farm production costs reduced.

5. That the selection of sires for all dairy herds on the basis of complete progeny performance records is the most rapid and accurate method by which an improved level of production may be attained.

6. That the fundamental requirements of any systematic endeavours to improve the national average productive capacity of dairy cattle are :

- i. continuous annual herd-testing.
 - ii. increased efficiency in the feeding and management of the dairy herd in relation to a balanced farm economy.
-

APPENDIX.

SOURCES OF MATERIAL.

The following select bibliography enumerates those publications to which most frequent reference has been made in compiling the information upon which the text is based.

- Agricultural and Pastoral Statistics of New Zealand. 1920 et. seq.
Annual Reports of the New Zealand Dept. Agriculture 1894 et. seq.
Bailey, L. H. Cyclopaedia of Farm Animals.
Babcock, E.B. and Clausen, R.E. Genetics in Relation to Agriculture.
Belshaw, Williams, Stephens, et al. Agricultural Organisation in N.Z.
Buchanan Smith, A.D. and Robison, O. J. Bibl. Genetica, X, 1933.
Journal of Dairy Research, 4, 1933; 6, 1935; 8, 1937; 10, 1939.
Buchanan Smith, A.D. Trans. Highland and Agric. Soc. 1937.
Buchanan, R.O. The Pastoral Industries of New Zealand.
Condliffe, J. B. New Zealand in the making.
Crew, F. A. E. Animal Genetics.
Dairy Industry Commission Report, 1934.
Espe, D. L. Secretion of Milk.
Finlay, G. Proc. Scottish Cattle Breeding Conference. 1925.
Foot, A. S. American Dairy Husbandry.
Goodale, H. D. American Naturalist: LXVII, 1933, LXXI, 1937.
" " J. Heredity XXIII, 1932.
Gowen, J. W. Manual of Dairy Cattle Breeding.
" " Milk Secretion.
Herd Books of the Jersey, Friesian, Ayrshire, Milking Shorthorn,
Shorthorn and Red Poll breeds in New Zealand. Journals of the
Royal Agricultural Society of England.
Jones, W. F. Genetics.
Lush, J. L. Animal Breeding Plans.
Marais, The Colonisation of New Zealand.
New Zealand Dairy Board Annual Reports.
New Zealand Inst. of International Affairs. Contemporary N. Z.
New Zealand Journal of Agriculture. 1912 et. seq.

New Zealand Official Year Books. 1893 et seq.

Philpott, H. G. A History of the New Zealand Dairy Industry.

Sinnott, E. W. and Dunn, L. C. Principles of Genetics.

Snyder, L. H. The Principles of Heredity.

Tausig, S. Dairy Cow Testing Throughout the World.

United States Department of Agriculture. Year Books. 1936, 1937.

Wallace, R. British Breeds of Livestock.

" " Farm Livestock of Great Britain.

Winters, L. M. Animal Breeding.

Wriedt, C. Heredity in Livestock.
