
VOLUME 62 2002

MILK PRODUCTION STUDIES

by

M.M. Cooper, Massey Agricultural College.

SCOPE OF SUBJECT.

This paper is concerned essentially with the planning of investigations in which the nutrition of dairy cattle is related to production rather than to the physiology or health of the animal. These latter aspects are considered only insofar as they affect the conduct of experiments and the interpretation of results. In any case the subject is so wide that one cannot treat any aspect with great particularity but merely try to open up for discussion a topic of vital interest to animal research workers in a country where dairying constitutes such an important part of the economic fabric.

NEW ZEALAND'S SPECIAL PROBLEMS:

Many of our problems in milk production are, to a large degree, peculiar to this country on account of the special characteristics of the dairy industry as a consequence of its extreme dependence on pasture and pasture derivatives. This has an important bearing on the methods of experimentation that may be adopted for those of our problems which are a result of our dependence on pasture. In the dairying countries of the Northern Hemisphere, where the animals are stall-fed for a long period of the year, and where animals are rationed according to production, and the individual feeding stuffs are relatively consistent in quality throughout the year, the experimenter's job is relatively simple, but only relatively so as subsequent sections will show. Even in Great Britain and America the technique of dairy experimentation is subject to differences in opinion and however difficult the problems of technique are for indoor experiments, under pastoral conditions they are increased manifold. Our dairy animals do their own foraging and we have no satisfactory means of measuring the food-intake of the grazing animal. Again, pasture is notoriously variable in respect of both quality and quantity of the nutrients it provides. Not only is there seasonal variation for individual species, but the sward as a whole differs in composition according to season and management, and the combination of these two factors makes it practically impossible to define feeding standards for our dairy cattle on pasture. As pasture is utilised by grazing, the animal is subject to the effects of weather and movement and these are factors which are extraordinarily difficult to measure. We might mow our pasture, feed it to the cows in weighed quantities and then simulate movement in foraging by muzzling the animals and turning them out to the pasture on which their feed was grown. This would have an advantage in that it would tend to preserve the effects of the grazing animal on the pasture as a result of the trampling and the return of manurial residues. This sounds complicated and clumsy but it serves as an example of the ingenuity that must be developed by the worker studying problems relating to the nutrition of the grazing animal.

GENERAL CONSIDERATIONS IN THE CONDUCT OF DAIRY NUTRITION STUDIES:

In that milk is removed from the living animal and may be weighed and analysed, the dairy nutritionalist has advantages which are not shared by the worker dealing with carcase animals, particularly if he is concerned with the component nature of growth and live-weight increase, or if he is trying to distinguish cause and effect. But there are compensating disadvantages. The normal course of milk production is not represented by a simple curve as is the case with normal growth. Milk secretion is not only affected by environmental and management factors, but it is complicated by the phenomenon of reproduction of which milk production is an integral part. The development of the mammary gland is conditioned by a succession of hormones circulating in the blood and once the gland is functioning another reproductive cycle comes along to present a further set of complicating circumstances. Meanwhile, the animal is growing and not only do we encounter the competing demands of growth but also the normal changes, related to age, in the capacity of a cow to produce milk. Add to this the liability of a dairy cow to a variety of serious diseases such as milk fever, sterility, abortion and mastitis, which are peculiar to lactating animals, and we see how the efforts of the dairy nutritionalist to secure uniform animals are defeated.

Then again quantity of milk is not the only consideration. Normally, there are considerable changes in the fat and casein content of milk over the course of lactation. The physical and chemical qualities of the milk fat are also subject to considerable changes. An increased percentage of fat in milk involves greater energy demands on the cow for each gallon of milk produced and this in turn decreases the energy available for the other constituents of the milk. In order to make comparisons between milks of different compositions, Gaines and Davidson* have devised a formula by which milks can be compared at a 4 per cent. fat level. This fat corrected milk conversion is made by multiplying the actual milk yield by 0.4 and then adding to this product the actual fat yield multiplied by 15. This method is widely used in dairy husbandry research work where milks of differing fat percentages are being compared. The same formula is used in Denmark for the large scale group trials which will be described later.

VARIATIONS FROM THE NORMAL LACTATION CURVE:

Following parturition, if the cow is properly fed and not subject to adverse environmental stimuli, there is a rise in milk production to a peak which is reached in two to four weeks, a later peak occurring with heavier producing cows. This is a period of gearing up of the appetite of the cow and her milk secreting mechanism. In passing, it is of interest to note that this early initial peak is not characteristically obtained in New Zealand where the peak in milk production is closely related to the peak of pasture production. There is an urgent need that the reasons for the delayed peak in production, under our conditions, be investigated for this information is fundamental to advice given to farmers on the basis of lactation curves as well as to considerations of experimental technique. In other words, we have got to establish a normal for our conditions that we may fully recognise the abnormal.

After the peak in milk production has been reached there is a gradual decline at a rate which is by no means constant, for with the onset of gestation, particularly five months after conception, there is an accelleration in the rate of decline. Heavier milkers tend to decline more rapidly than cows secreting less milk, while cows reaching the same peak exhibit divergent rates of decline according to their individual ability to persist in production. The fat content of the milk more or less varies inversely to the volume of milk while the total amount of fat secreted follows the same general trend of the milk curve.

A wide variety of factors, some of which have been mentioned, influences the shape and dimensions of the curve. Feeding prior to and throughout lactation is, of course, all important. The condition of the cow at calving which is the result of the plane of nutrition during the dry period, and the length of the dry period has a special importance in that the stimulus to milk production is so strong just after calving that some animals will milk on body reserves if the plane of nutrition is insufficient. Under these conditions the test of milk is particularly affected, the tendency being for cows to secrete milk which is richer in fat than they normally would if properly fed.

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* Gaines and Davidson: Illinois Exper. Station Bulletin 245, 1923.

Inadequate nutrition during lactation will not only be reflected in lower production at the time but, also, subsequently on account of retrogression of secreting cells. Both this fact and the ability of a cow to milk on reserves are of the utmost importance in a later consideration of reversal experiments where a nutritional regime may be supplemented by reserves from a previous treatment or may carry its effects on into the next phase of the experiment.

Other factors influencing the dimensions of the curve are the length of the service period, the age and size of the cow, her breed and, above all, her individuality. Even if only twenty genetic factors were involved in milk production, and we know there are many more, then possible combinations of genes would run into many millions. Add to this the complexity of environmental factors interacting with genetic factors and one obtains some appreciation of the difficulty of selecting experimental animals and maintaining them so that they are not exhibiting variations other than those which are intended as a result of experimental treatment.

Apart from these variations, which are characteristic of a lactation as a whole, there are also daily variations which are of considerable importance to the experimenter in that they affect his sampling and measurement technique. The dairy cow is essentially an individual and as such it is only to be expected that she will vary in her performance. She is affected by temperatures and other weather conditions, by handling, by speed of milking and by a host of factors which influence her daily life. It is important that the experimenter should recognise this capacity for daily variations and make due allowance in his measurement of production. At the present time an investigation is being made of daily measurement and sampling data obtained from the experimental herd at Massey Agricultural College in order to determine the optimum frequency of sampling consistent with accuracy and the economy of time.

THE ESTABLISHMENT OF AN EXPERIMENTAL HERD:

Obviously the experimenter must make the maximum endeavour to reduce unwanted variation in his experimental animals and this he can do in several ways. In the first place he can use the one breed of dairy cattle. Under our conditions this would naturally be the Jersey because of the predominance of this breed and in consequence the wider applicability of results. Even so, this course may be open to criticism on account of the varying reaction of different breeds to different nutritional circumstances. Would it be wise to generalize in dairy nutrition on the results obtained from a high testing breed? There is, for instance, a considerable school of thought in New Zealand that believes that on second-class country the Ayrshire is relatively a more profitable animal than the Jersey. Though we have no definite evidence of this, is it not possible that under the particular conditions that the Ayrshire breed has been evolved that there has been unconscious selection for ability to utilize fibre? The use of one breed might involve the replication of the experiment with another breed and this indeed might be an advantage in that substantiative results may be obtained with different material. Watson and Ferguson* used four breeds in a determination of the value of dried grass as a winter supplement but they took the precaution that the breeds were equally balanced in the groups. These animals, however, were stall-fed according to their individual production. With our pasture experimentation we would have the difficulty of large and small cows being grazed and herded together with the liability of injury and competition which could not be controlled. The use of a mixed herd for experimental purposes has been tried at Massey Agricultural College and the experience has not been a satisfactory one for these reasons.

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* Watson & Ferguson: J.Agr.Sc., 1936, 26 pp. 189-209.

As another resort to avoid unwanted variability one might suggest the use of inbred cattle. There are certain drawbacks attached to this. Firstly, progress in the segregation of a satisfactory true-breeding strain in a slow maturing species, which characteristically produces single offspring, would be very slow. It would be many years before we would be able to establish a satisfactory herd. The achievement of the herd, however, would be a worthwhile end in itself in that we would learn something of what occurs with dairy cattle under a programme of intense inbreeding. Secondly, the progress of inbreeding would create a gene complex that differed considerably from the diversity of gene complexes characterising any one breed. Could we conscientiously use Longbeach Friesians to study the utilization of a given quality of silage and say that another strain of Friesians would produce the same results on the same feed?

A possibility of reducing variation which has received recent attention in New Zealand is the establishment of a herd of identical twins. The practicability of this I will not discuss, but it would seem important that every endeavour be made to secure these twins at birth so that environmental factors affecting development could be controlled as much as possible. Once such a herd was established, then it would be necessary to make a thorough investigation of their normal variability when considered as pairs, before using them for specific trials. Their usefulness in experimentation would be confined to a consideration of only two types of treatment and in this their use would suffer from the same disability as the paired feeding method.

It seems that we have got to accept, for the present at any rate, a considerable range of inherent ability in the animals we select for experimentation. We can, however, reduce the total amount of variation by controlling environment, particularly during the period of growth and development. All animals should be tested to see that they are free from abortion or tuberculosis infections. Furthermore, they should be kept segregated from untested animals otherwise an outbreak of abortion may upset the whole course of the experiment. Shed management and hygiene should be of the highest order to avoid mastital infection. There cannot be any skimping of labour in the experimental shed because, apart from the extra work imposed by sampling and weighing, every cow needs much more individual attention than she does in a commercial herd. When it comes to the actual constitution of groups the experimenter must have a big reserve of animals of known productive history and which have been subject to a similar pre-experimental management so that he can select out as opposite numbers in the various groups animals comparable in age, date of calving, weight and productive ability, this latter feature including both quality and quantity of milk as well as persistency in production.

It must be realised that the productive history of individual cows may be very misleading, for although over large numbers of cows, subject to the same environment, there is a fairly high correlation between production in successive lactations, in individual instances, there may be wide variations. However, where one is planning an experiment which extends over one or more complete reproductive cycles, production in previous lactations is the only available criterion for selection according to production. Where only a segment of the lactation curve is being studied then the cow's performances since freshening can be used as well and this is largely the method used in selecting cows for group or reversal trials of this category.

EXPERIMENTAL METHODS AND THEIR APPLICABILITY TO N.Z. PROBLEMS:

The main methods of experimentation employed in milk production studies are as follows:

(1) Survey method.
(2) Group method.
(3) Reversal or alternate method.
(4) Individual animals.

The survey method is especially valuable as a pioneer approach. Not only can one obtain much valuable and easily applicable information from the analysis of accumulated data but also survey results often assist in the definition of problems. During the course of his visit to New Zealand, Dr. John Hammond stated that a great deal of work at the Animal Nutrition Research Institute, Cambridge, had its genesis in the survey of milk recording data made by Sanders, e.g. Woodman's work on the nutritive value of pasture. In New Zealand we are fortunate in having first-class herd test records of which Ward and Campbell are making capital use. The advantage of the survey method lies in the large numbers that can be employed to average out individual variations. It is particularly valuable, too, in regard to economic aspects of milk production studies. Fawcett's surveys of the New Zealand dairy industry provide a good example of how useful information may be obtained relating to the influences of rate of stocking, individual level of production and topdressing on production per acre. Special surveys could be conducted to obtain information on a host of dairying problems, for instance the conservation and utilization of silage and hay, or the effect of spring grazing of grass saved from the autumn on the shape of the lactation curve. The main disability of the survey method is that, particularly, under New Zealand conditions, it is often difficult to obtain precise measurement or observation data relating to the more fundamental problems, nor is it applicable where new methods or developments are being investigated. In such a case the investigator has to conduct his own objective experiments.

The group method is most popular for this purpose. There is, however, a danger that the group method may give us no more information than what occurred in the actual course of the experiment and, as Lush* has pointed out, be of little use for the formulation of principles. As a prerequisite, the experimental results must be capable of interpretation. Dunlop+ rather sarcastically infers that about the only time the group method gave significant results was in the feeding of the multitude. His attitude does emphasise the importance of large numbers and often this may be beyond the resources of one institution unless stringent precautions are taken to reduce variability or replications of the experiment are made in subsequent years. Bartlett** has devised a useful technique for a group experiment covering a segment of the lactation curve in which results capable of statistical interpretation were obtained. His method, which was applied by Watson at Jeallot's Hill, consists of putting the cows into balanced groups on the criteria of age, yield etc. and then placing all cows on a standard pre-feeding period of three weeks during which data concerning normal variations are obtained. They are then gradually changed to their experimental rations which are fed for periods as long as 17 weeks. By the application of covariance the necessity for correcting yields for such factors as the stage of lactation is obviated. As an example of what can be done, the standard error expressed as a percentage of the general mean, fell from 25.23 to 8.14 as a result of imposing a three weeks prefeeding control period in one experiment studying the use of dried grass.

The Danes have used group feeding experiments extensively and they have overcome the number difficulty by co-operating with farmers who conduct the trials according to given instructions. There the method is successful because the Danish farmer is used to rationing his cows and feeding according to standards. This application of the method would not be so successful in New

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* Lush Jay L., Proceedings of American Soc. Animal Production 1930-31, p.44.

\+ Dunlop, G., Journal of Agric. Science 23, 1933, p.580.

** Bartlett M.S., Journal of Agric.Science, 25, 1935, p.238.

Zealand on account of the extreme variability of pasture on different farms as a result of climatic factors, season, soil, and management. The group method would be adopted where experimentation is to be continued over a long period, for instance, where the cumulative effect of feed or management on lifetime production was to be determined. This almost comes under the category of a classical experiment along the lines of the famous Broadbalk Field at Rothamstead. Indeed, there is much to be said for the initiation of long term experiments in New Zealand where precise measurement and observational data are obtained from herds which are deriving all their nutriment from pasture, and comparing their performance with animals that are fed along the conventional lines of being rationed according to production.

The reversal or alternate method of experimentation which has a wide vogue in the U.S.A. and in Denmark is of two types. The simple reversal consists of placing a group of cows on a standard ration and then switching them gradually over to the experimental ration and then back to the standard ration and by comparison of yields deducing results. This method has been largely used in Denmark in the determination of the fodder-unit content of different feeds. In the U.S.A. the double reversal method is more popular. It involves the use of two groups simultaneously. Group A. will be on Ration 1. while Group B is on Ration 2, and vice versa. This is an advantage over the simple reversal in that it eliminates external effects such as climate.

The main disadvantage of the reversal method has already been pointed out while considering the normal lactation curve, namely, that residual effects may be carried from one feeding period to another. If cows are to be subjected to the reversal technique they must have milked off condition and be at a relatively stable stage of the lactation, i.e. not too close to freshening nor too well on in pregnancy. The method, therefore, is limited both in respect of time of duration and time of application. Often the period is too short to get an adequate answer to certain feeding problems though reversal trials are useful where yield data, only or information about trends are required. Particularly is this the case where the substituted food is not expected to cause any great deviations from the normal.

The use of a few animals for dairy nutrition studies may become important in New Zealand on account of the difficulty of measuring the food intake. It is possible that great reliance will have to be placed on chemical data and these will have to be used in conjunction with specific trials with individual animals to determine digestibility and food values. The idea is not a novel one in that Kellner and Armsby determined their feeding standards very successfully on a somewhat similar slender foundation of a very few experimental animals.

CONCLUSION:

It will be patent from what has been said that, in the elucidation of our milk production problems, infinite resource and ingenuity must be displayed by the experimenter if he is to be successful. He must adopt the method that best suits his particular problem but in a large number of cases he will have to work out his own methods. It would almost seem that our most urgent task is not the obtaining of further knowledge of milk production but the development of means of gaining that new knowledge. Not only is technique required, but also trained men capable of exploiting that technique are required, as well as the resources that are necessary for successful experimentation.

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