EFFICIENCY OF PRODUCTION OF NEW ZEALAND DAIRY COWS

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THE many obvious deficiencies in the standard of feeding on the average dairy farm tend to focus attention on the need for better feeding to improve production per cow and inferentially to raise farm efficiency.

However, the farm surveys made about fifteen to twenty years ago by Fawcett and the present series initiated by Hamilton have shown that high production of butterfat per acre is much more closely associated with high carrying capacity than with high production per cow. From the results of the most recent survey, Waipa County, it can be estimated that high carrying capacity is at least three times as important as high production per cow in obtaining high production per acre. Naturally, this generalisation will only apply where a large and representative group of farms is considered.

Factors affecting the efficiency of feed utilisation are probably of considerable importance. These may be subdivided into:—

(a) The proportion of the feed grown which is actually eaten by stock, and

(b) The efficiency with which the nutrients eaten are converted to butterfat.

The discussion which follows considers the second point only.

Jensen and associates analysed the results of a large series of feeding experiments carried out at a number of United States Experiment Stations. Mature cows were fed at various planes of nutrition and the relationships between the quantity of feed eaten, above maintenance requirements, and the quantity of milk produced were studied (see Fig. I). It was found that the law of diminishing returns was clearly operating. To quote them "the response to heavier feeding increases at a progressively slower rate as the level of feeding is increased and is properly represented by a curve instead of a straight line. The output for added feed is more than twice as much at the lowest level as at the highest level."

The breeds used were Friesian and Brown Swiss. Hence they were bigger than the Jerseys generally used in New Zealand and produced milk of much lower test. The results are therefore not quantitatively applicable to our dairy stock.

However, Brody has shown that the average feed requirements for maintenance varies as the 0.73 power of the liveweight and that efficiency of milk production remains constant. To put it another way, the smaller animal converts the same proportion of her feed to milk as does the larger animal. Clearly, these generalisations will only hold for large or representative groups and will not apply to comparisons between individual animals or herds.

There are a number of other points which need to be considered when using these generalisations of Brody's to transpose Jensen's data to fit our conditions, but on balance it appears that a direct recalculation will give a reasonably good first approximation. If anything, it will tend to make the levels of efficiency for average cows in milk slightly higher than is probably the case.

In this discussion, efficiency has been expressed in terms of the total quantity of digestible nutrients required per pound of butterfat, for under New Zealand conditions this is the figure of most importance to farmers.

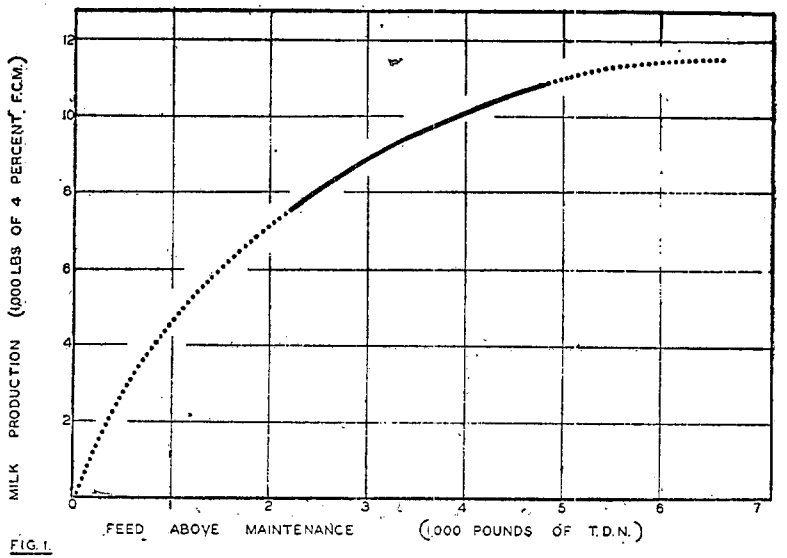
MILK PRODUCTION (1000 LBS OF 4 PERCENT F.C.M.)
12
10
8
6
4
2
0
1
2
3
4
5
6
7
FEED ABOVE MAINTENANCE (1000 POUNDS OF T.D.N.)

FIG. 1.

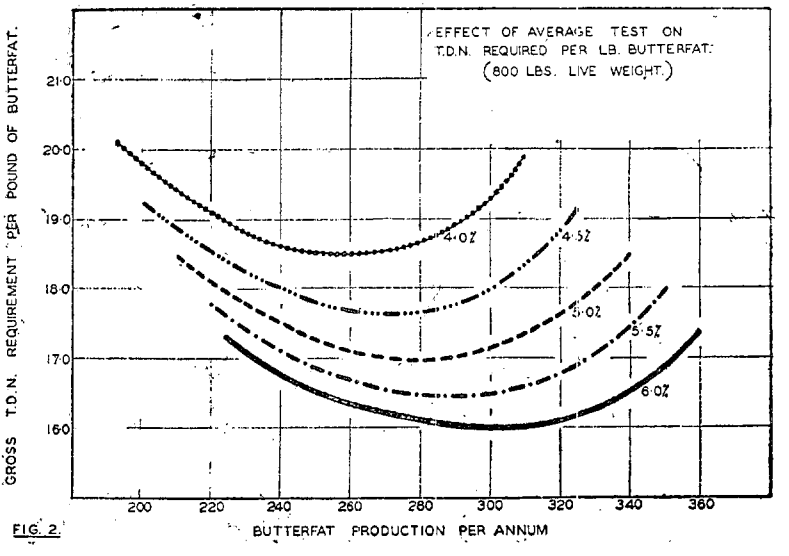
EFFECT OF AVERAGE TEST ON
T.D.N. REQUIRED PER LB. BUTTERFAT
(800 LBS. LIVE WEIGHT.)
GROSS T.D.N. REQUIREMENT PER POUND OF BUTTERFAT.
21·0
20·0
19·0
18·0
17·0
16·0
4·0%
4·5%
5·0%
5·5%
6·0%
200
220
240
260
280
300
320
340
360
BUTTERFAT PRODUCTION PER ANNUM

FIG. 2.

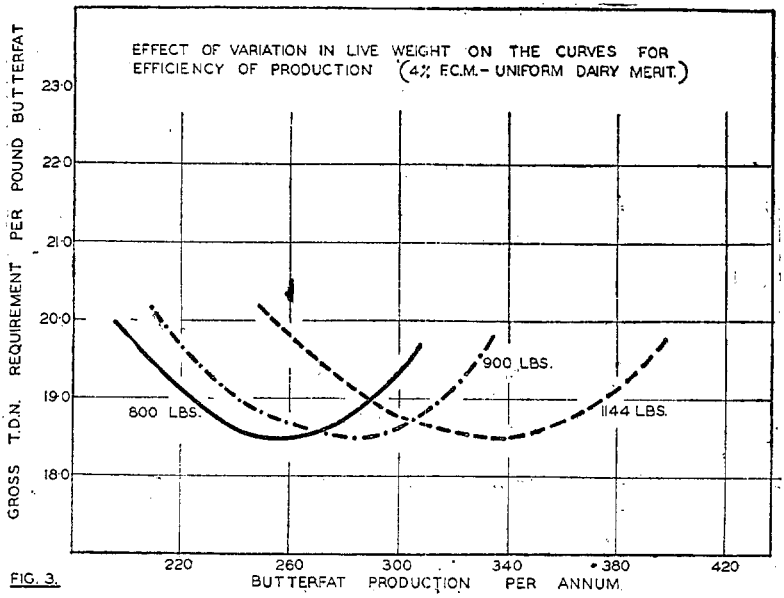
EFFECT OF VARIATION IN LIVE WEIGHT ON THE CURVES FOR EFFICIENCY OF PRODUCTION (4% F.C.M. - UNIFORM DAIRY MERIT.)
GROSS T.D.N. REQUIREMENT PER POUND BUTTERFAT
23·0
22·0
21·0
20·0
19·0
18·0
800 LBS.
900 LBS.
1144 LBS.
220
260
300
340
380
420
BUTTERFAT PRODUCTION PER ANNUM.

FIG. 3.

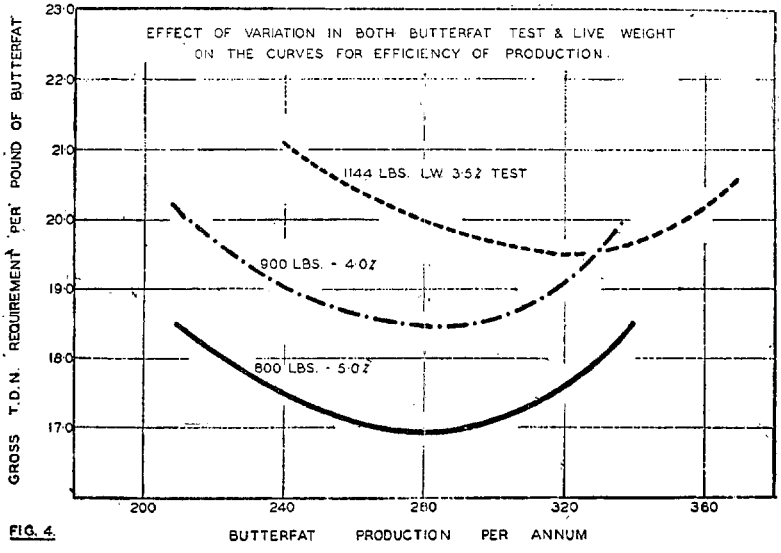
EFFECT OF VARIATION IN BOTH BUTTERFAT TEST & LIVE WEIGHT ON THE CURVES FOR EFFICIENCY OF PRODUCTION.
GROSS T.D.N. REQUIREMENT PER POUND OF BUTTERFAT
23·0
22·0
21·0
20·0
19·0
18·0
17·0
1144 LBS. LW 3·5% TEST
900 LBS. - 4·0%
800 LBS. - 5·0%
200
240
280
320
360
BUTTERFAT PRODUCTION PER ANNUM

FIG. 4.

Making allowance for 20 per cent. 2-year-olds the average live weight of a Jersey herd probably approximates 800lb. and the average butterfat test is taken as 5 per cent. On this basis the efficiency of feed utilisation at various levels of butterfat production is shown in Table I and Fig. 2. As butterfat production per cow is raised by better feeding, efficiency at first rises rapidly but then reaches a maximum and at higher levels of production declines rapidly.

Table I.—Assessment of Gross Nutrient Requirements per Pound of Butterfat for a cow of 800lbs. Live-weight Producing milk with a 3.0% Butterfat Test.

Production Per Cow Butterfat lbs.	Milk lbs.	T.D.N. for Milk Production lbs.	Maintenance T.D.N. lbs.	Gross T.D.N. Requirements lbs.	Gross T.D.N. Per 1lb. of Butterfat lbs.
180	3,300	1,074	2,533	3,607	20.03
200	4,000	1,251	2,533	3,784	18.92
220	4,400	1,448	2,533	3,981	18.09
240	4,800	1,671	2,533	4,204	17.51
260	5,200	1,925	2,533	4,458	17.14
280	5,600	2,233	2,533	4,766	17.02
300	6,000	2,603	2,533	5,136	17.12
320	6,400	3,088	2,533	5,621	17.56
340	6,800	3,769	2,533	6,302	18.53

If fed sufficient to produce 200lbs. of butterfat per annum, 18.92lbs. of digestible nutrients are required per pound of butterfat, at 280lbs. this has fallen to 17.02lbs. of nutrient, but at 340lbs. level it has risen again to 18.53lbs. of nutrient.

This curve would suggest that under farm conditions it would be increasingly difficult to push the annual butterfat production of average cows much above the 300lbs. level by merely offering them more liberal and evenly distributed supplies of grass, hay and silage, and this agrees fairly well with observations reported by farmers.

A further point is that there is no gain in efficiency, with a cow of average dairy merit, once production has reached approximately 270lbs. per annum.

In a similar fashion we can examine the influence on efficiency of feed utilisations of butterfat test, size of cow, or any combination of these.

1. As shown in Fig. 3 an increase in the butterfat content of the milk not only raises the efficiency per pound of butterfat produced but also raises the level of production at which a cow reaches maximum efficiency. The higher the test, the smaller the net gain in efficiency for each further increment in test.

2. Cows of differing body weight giving milk of the same test reach the same level of maximum efficiency but the bigger the cow, the higher the level of production required before maximum efficiency is reached.

3. The effect of varying both body weight and butterfat test is shown in Fig. 4 for three reasonably representative examples.

4. When other data of Jensen's is similarly transposed we obtain an excellent illustration (Fig. 5) of the differences between good and poor cows. A cow of high dairy merit not only requires much less feed per pound of butterfat produced, but also reaches maximum efficiency at a much higher level of production and will be much more responsive to better feeding.

The main point to which attention is directed is that for every dairy animal there is a level of feeding at which maximum efficiency of production is reached. Both above and below this level the cow will be producing at lower efficiency as measured by her feed requirements per pound of butterfat produced.

However, some of the other implications of these data deserve further comment.

The large gains to be expected from an improvement in the quality of dairy stock were shown in Figure 4, but substantial genetic improvement is essentially a long-term process. For several years to come average dairy stock will be of much the same dairy merit as at present.

For these it would appear that they reach maximum efficiency when fed sufficient to produce approximately 270lbs. butterfat per annum. This is not substantially above the levels already being attained in better dairying districts in an average to good season. Such an assessment remains very much of a conjecture, and final conclusions must await a more critical examination of all the points concerned and the assembling of input-output data, not only for superior cows under superior management, but also for average cows under average management conditions.

From the trends shown by the general curve it would also follow that for average dairy stock on a low plane of nutrition, improvements in feeding will produce big improvements in production but for similar animals on a fairly high plane of nutrition, equivalent improvement in feeding will produce much smaller increases in production. Improvement of dairy merit, i.e., breeding, becomes of much more importance.

On the great majority of dairy farms an increase in numbers of stock carried will almost automatically improve the utilisation of available feed, and if accompanied by reasonable pasture management practices, will also tend to increase total pasture production. This view is supported by the results of the dairy farm surveys.

Therefore, if these efficiency postulates are anywhere near correct, it can be stated that attempts to improve gross producion per farm, by management, will show greatest results if the farmer sets out to improve carrying capacity. Once the average herd has reached the 270lb.s of butterfat level, the improvement in efficiency per pound of feed eaten will become very small indeed unless simultaneous steps are taken to improve the quality, i.e., dairy merit, of the herd.

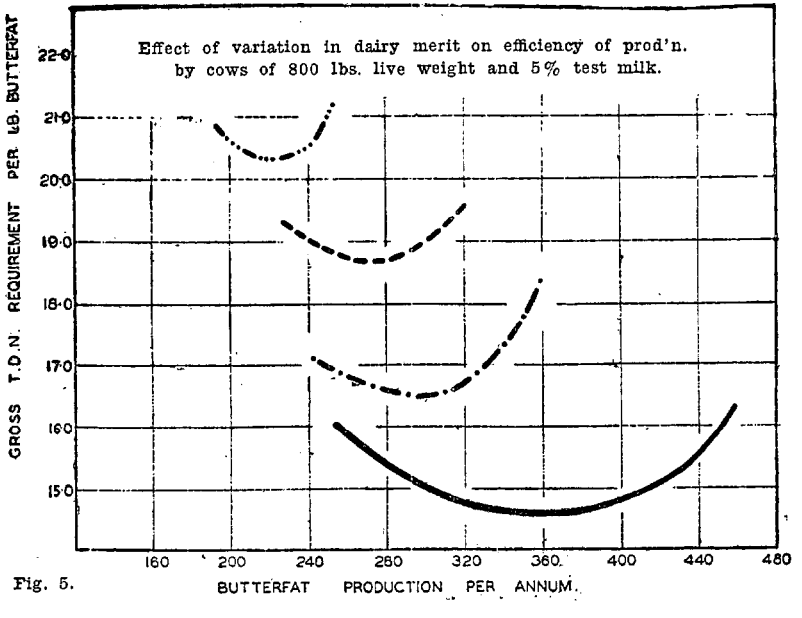

Fig. 5.

Discussion on Mr. Mitchell's Paper

Dr. HAMILTON: The general conclusions reached are implicit in the oft repeated statement that in raising production, feeding is more important in the low producing herds and breeding becomes progressively more important as the level of production is raised. It also queries Ward's generalisation that "the difference in production between any two large and representative groups of animals may be ascribed 40 per cent. to breeding and 60 per cent. to feeding," since this implies a straight line relationship. The most weighty argument in favour of the hypothesis presented, however, is provided by the first year's results of an experiment at Ruakura, given by Hancock at the Seventh Pacific Science Congress in Auckland. In an experiment with three groups of identical twins, group "A" consisted of ten animals fully fed on grass, plus concentrates; group "B" a similar group fully fed on grass; and group "C" a similar group confined to six-tenths the area of group "B." Group "C" produced approximately 50 per cent. more butterfat per acre than group "B," and almost as much as group "A," which had additional concentrates.

Dr. McMEEKAN: Dealing first of all with the main thesis as presented by Mr. Mitchell, I haven't very much quarrel with the line of attack except on these grounds; that Brody's work on efficiency of milk production was all based upon the total energy concept of secretion and that concept can be very far away from the straight butterfat point of view that dominates the picture in this country. I can remember, for example, having a strong argument with Brody himself on this particular point some years ago. He argued from his factor of 3.7 that he could see no reason for the dominance of the Jersey breed in this country and doubted our arguments for its use. He held the opinion that the milking efficiency did not vary with size. Looked at from an energy concept point of view that argument is sound, but since we are producing butterfat and since the different breeds of cows do not differ materially in average butterfat yield per cow to a lactation, then the smaller size of the Jersey with its lower overall mantenance requirement makes it a much more efficient animal per acre. Brody replied that our Jersey animal, therefore, if that were true, was of a higher dairy merit than our other stock. We would get just as high production per acre from the other breeds if we improved their genetic ability to the level of the Jerseys. I would like to suggest that this term "dairy merit" which has been used in this paper needs very clear definition before it can be applied to our particular conditions. As I interpret the figures presented, it is a term which involves the nutrients required for producing the nutrients in milk other than fat, as well as fat, and therefore that figure of 270lbs. per cow as being the optimum efficiency level, may be a figure that has a very big error, plus or minus. I am not doubting that it probably exists. My second point is in reference to Dr. Hamilton's use of some of the Ruakura data to support this thesis. Until the full story is available, I personally would not rely on their interpretation in terms of carrying capacity and butterfat per acre. I am not suggesting that there is not something very suggestive in the figures, but it is too soon yet to say much about it except perhaps this—Hancock's and Wallace's work at Ruakura is relevant to the subject of this paper. The third point is, of course, the unknown one in the whole of the business—We do not know the intake of a free-grazing animal and the whole of Mr. Mitchell's thesis is based on the assumption that production will be proportionate to consumption. Until we know whether a free-grazing cow does consume in proportion to production then these assumptions are not necessarily justified.

Dr. WALLACE: I would like to mention what I consider to be the greatest weakness in this paper. It seems to me that the whole argument hinges upon that first milk production output curve of Jensen's. That

curve is based upon points distributed over a very wide range of the curve and a tremendous amount of liberty was taken in having that curvilinear form to fit the data. On a casual examination of the curve as presented and an examination of that curve from Jensen's paper which I had occasion to do some time ago, it seemed to me that a straight line could be fitted through the points, which would give almost as good a figure as the curve which has been presented. Now a straight line would give a true figure but I doubt very much whether there is justification for drawing such a large number of conclusions from a curve. The other point I would like to raise is in connection with this question of using Brody's 0.73 power relation to calculate maintenance requirements. I understand the relationship to be one which Brody has shown will hold over a wide range of live-weights. I think he says it will hold from mice to elephants. That may be supporting evidence, but I believe that where you are concerned with an animal of a given age and with the feed that that animal's maintenance required when you are fattening to a very much heavier weight, I doubt extremely whether that 0.73 relationship holds. After all, the maintenance requirement of an animal is simply the sum of the maintenance requirements of the various organs and tissues. The proportion which the organs and tissues in an animal of adult stature bear to each other is not the same as the proportion which they bear to each other in a younger animal at a less mature stage of development. I should be extremely surprised on theoretical grounds if the maintenance requirement of a mature animal varied in the same way as does the maintenance requirement of young animals and old animals of different live-weights. I think for those two reasons we should be very careful before we attach too much importance to the conclusions that have been drawn.

Mr. SMALLFIELD: It seems to me that Mr. Mitchell's arguments are not based on the actual things that are occurring in feeding dairy cows on New Zealand farms—the well-fed herds are not uniformly well-fed during the season; the poorly-fed herds are not uniformly poorly-fed during the season. Most herds are fully fed for part of the season and receive varying degrees of under-feeding during the remainder of the season. Since from the economic point of view the farmer succeeds best, who gets the greatest butterfat production per acre, he over-stocks for certain periods of the year so that with the greatest ease, with maximum growth, he converts as much of the grass as possible into butterfat. I do not think you can say that any of our herds are uniformly well-fed or uniformly poorly-fed.

Dr. FILMER: I would like to develop that argument further. It seems to me that Mr. Mitchell's thesis applies only to the direct conversion by a milking cow of food into fat. It takes no account whatever of replacements that must be carried. He takes no account whatever of cows during the dry period. Now, without quarrelling with his conclusions as he expresses them, I am quite worried about some of the conclusions that may be based on them. In fact, I heard someone who had read the paper say that because of this a man who has a herd producing more than 270lbs. fat is under-stocked and should put some more cows on. Just to take a small example of that, with a herd of 75 cows producing 360lbs. fat, if that story is right, by increasing the herd to 100 cows and getting an average of 270lbs. fat the owner would be much better off. At the same time he has got to increase his replacements for yearlings and 2-year-olds by 25 per cent., and he has got to carry that extra number of cows and also the extra number of replacements during the winter when their requirements will be approximately the same. If Mr. Mitchell is right it may be that a man who is producing whole milk, buying replacements and simply carrying milking cows and selling as soon as they stop milking, is right in keeping cows producing 270lbs. fat. However, that is different from suggesting that the man under our conditions who has to breed replacements would be

better off with a herd of 100 cows producing 270lbs. fat than he would with 75 cows producing 360lbs. fat. In regard to some stock, at least with cattle, the incidence of disease has gone up with intensity of stocking. If that is true, an increase in stocking capacity will shorten the life of the dairy cow. This means that the proportion of unproductive life becomes higher and that again works against the suggestion of over-stocking. For those reasons I think we should be a little bit cautious about accepting any suggestion that over-stocking would be in the best interests under New Zealand conditions.

Dr. HAMILTON: I think there are several points Dr. Filmer has raised that need answering. Firstly, in Mr. Mitchell's calculations he does take account of the maintenance requirements for the full year. If we know the requirements of the animal during the two years before it comes into production, we would in fact raise the maintenance requirements during the producing years and would thereby raise the point at which maximum efficiency was reached from 270-280 to some higher figure. The question as to whether or not a herd which is producing 360lbs. fat at the present time is more efficient or less efficient than a herd producing 270lbs. fat is not specifically raised by this paper. Mr. Mitchell specifically points out that the level of maximum efficiency is influenced by the inherent productive capacity of the animals that are being used. The figure of 270-280 is concerned solely with the average dairy merit of stock. Obviously there can be, and are, herds of considerably higher dairy merit and the question in respect of any particular herd therefore becomes a case as to what is the dairy merit of the stock comprising it. The point that still has to be argued away is the fact that when we take a large and representative sample of herds we do get a positive correlation of about 0.93 between carrying capacity and production per acre and a correlation of a much lower order or about 0.6 between butterfat per cow and production per acre. In other words, it would seem—and all the evidence that we have from surveys of two counties seems to indicate this—that higher rates of stocking lead to higher butterfat per acre than does too much emphasis on high production per cow. Now again we have to decide whether or not that is the most economic thing to do. Obviously that varies with the farm. For some farmers who have perhaps reached the maximum number of cows that they can handle with their available labour it may well be economic to feed at a lower efficiency in terms of pounds of T.D.N. required per pound of butterfat at the sacrifice of butterfat per acre.

Mr. HANCOCK: I would like to corroborate Dr. Wallace's view that the curvilinear relationship between production level and efficiency may be a myth. There is quite a body of experimental evidence suggesting that this relationship is mainly rectilinear, at least not becoming curvilinear until a very high level of production is reached. Nevertheless, I believe that a high carrying capacity with a consequent lower production per cow may lead to greater productive efficiency under New Zealand conditions. This fact depends, however, on a condition which has not yet been pointed out. To take an example, if a cow has a ceiling production capacity of 350lbs. butterfat and she is fed to that capacity she will fail to utilise all the grass which is growing. If on the other hand she is fed to a level of only 300lbs. butterfat she will eat every bit of grass which is available to her. In other words, lower efficiency of a cow producing at the limit of her production is due to a poorer utilisation of the grass that is provided.

Dr. McMEEKAN: I would like to hear Dr. Hamilton's reply to that as one of our quarrels is the question of utilisation. How much does this question of completeness of utilisation affect this carrying capacity —butterfat per acre relationship? It may affect it very much more than these theoretical concepts of Mr. Mitchell's.

Dr. HAMILTON: I think that is a perfectly fair question. If you recall, Mr. Mitchell specifically raised the point in the earlier part of his paper and indicated that he was dealing only with the second phase after the animal had eaten whatever grass was given to it and that there was the other side of the question, that is the percentage of the grass grown that is actually eaten by the animal. I suspect that on the average dairy farm perhaps not more than 60 or 70 per cent. of the grass that is grown is actually eaten by animals. I suspect also that on a fat-lamb farm the efficiency of utilisation of the grass that grows is very much better than it is on a dairy farm, partly because the feed requirements of the ewe and her lamb approximate much more closely to the normal curve of grass growth and that grass is eaten fairly fully as it grows. I think that on a well managed fat-lamb farm the efficiency of utilisation might well be over 90 per cent. There again we have no figures at all to guide us, but part of the high per acre production obtained by the treatment in C group at Ruakura may be due to full utilisation of everything that grows. In regard to the possibilities of the very high productions per acre that have been quoted, I think one would have to say at the outset that there are certain soil types on which the density of stocking required to achieve those figures would not be possible under present conditions. I would think that the amount of treading and pugging that would occur on some of the wet meadow soils would definitely lower the total production of grass. The ability to stock heavily at certain critical periods of the year is a limiting factor to output per acre on some soil types. One of the reasons, I think, why the Waikato with its fairly well drained, rolling hill-country has increased so much in carrying capacity has been the fact that by and large those soil types will carry whatever stock the pastures will feed. However, on certain types like the Hauraki Plains or on some of the soils derived from limestone in Northland I think that a definite limit to better production is set by the number of stock that can be carried to eat the grass that will grow.

Mr. WARD: There is one question I would like to ask concerning the intensity of the carrying capacity and production. If the production is most efficient at the 270lbs. level, then dealing with the correlation that you obtained between carrying capacity and production per acre should there not be a falling off in the intensity of carrying capacity after you have passed the 270lbs. per cow mark? In the Ruakura experiments you quoted, you have that. You have your maximum carrying capacity in C group. In the county surveys is there a falling off in the carrying capacity as the production per cow increases?

DR. HAMILTON: No. If we group the farms according to herd average there is a slight correlation between butterfat per cow and carrying capacity. It is of a very low order, of about 0.2, but there certainly is a tendency for high carrying capacity and high butterfat per cow to go together. It is difficult to separate one factor from another. The soil type, for instance, that will provide the feed for high carrying capacity is normally a soil type which has good water retaining properties and therefore tends to give a good spread of pasture production which is also conducive to high butterfat per cow. The farmer who knows how to raise carrying capacity probably also exerts some of his efforts to improving the quality of his cattle. I don't know whether you would really expect to find any reduction in carrying capacity once butterfat per cow increased past a certain point. Taking it on a district basis, however, one has the feeling that perhaps the Taranaki farmer achieves his extra 20lbs. fat per cow over the Waikato farmer by a slightly lower rate of stocking and he does that at a slight sacrifice in terms of production per acre.

Mr. TAYLOR: A previous speaker has dealt with the question of the level of feeding over the year and I think that should have an important bearing on the question of carrying capacity per acre and

production per acre. We have Dr. Hamilton's figures to show us that high production per acre is related to high carrying capacity and in all probability we should find that where there is higher carrying capacity the quality of the pasture would be better than where the carrying capacity is low and consequently the butterfat per acre production is lower. I would like to hear Dr. Hamilton's comments on the question of level of feeding over the year as distinct from the flush period and his views of the quality of the pasture where butterfat production per acre is high as opposed to those areas where the butterfat production per acre is low.

Dr. HAMILTON: I would like to see some figures. The only data I have on the subject is that the Valuation Department in carrying out their valuations make an assessment of the value of the pastures on farms. They take into account, for instance, cost of clearing the land, laying down the pasture and their general assessment of the resultant sward. They are not therefore just straight assessments of pasture quality. We have tabulated the relationships between the pasture value given by the Valuation Department in the Waipa area, and production, and we find there is a close relationship.

Mr. CANDY: Mr. Chairman, I have listened with a great deal of interest to the paper and to a number of comments that have been made relative to it. I was reminded somewhat of certain points in your own address this morning where you mentioned that we have made certain scientific achievements but it is somebody's responsibility to get that to the farmers. The point that I see is this. It is supposed that animals of different dairy quality or genetic ability reach their standard of most economic production at varying levels. From the point of view of the farmer I would like to ask the scientific worker this. Can he help the farmer of this country to judge the animal of good genetic ability under our ordinary farm grazing practice so that he would know the most economic level of production at which he should aim?