A Screening Test for Production Evaluation in Dairy Herds

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Introduction

Collecting data on production problems can be time-consuming and readily available data difficult to interpret. In day-to-day practice it is too easy to ask occasionally "How are the cows milking?" and leave it at that. This paper describes a computer-generated graph to show how the cows are milking, and help identify the source of production problems. Although as a screening test it is rarely by itself sufficient to diagnose the source of a problem, it can easily alert us to a problem before it becomes a disaster. The graph can be computed and printed automatically using data downloaded via modem from the Northeast Dairy Herd Improvement Association mainframe computer.

Looking at the dipstick in the bulk tank is an extremely crude measure of whether a herd is producing up to its potential. A herd is made up of individuals, and a herd is not producting at its potential until every individual is producing at hers. Since "normal" production for each individual varies with her age and lactation stage, normal production of a herd will vary as cows freshen, progress through their lactations, and are dried off. Each cow's production is expected to follow a curve that will have a shape fiddering with the age of the animal. When we add together curves for a hundred different animals of different ages, breed, and parity only a computer can reasonably analyze and express the results.

A Screening Test

Screening tests are well established in traditional clinical medicine and even in some areas of production medicine. For example, monthly bulk milk somatic cell count, bulk tank culture, and a count of clinical cases will often be enough to determine whether a mastitis control program is performing adequately. If mastitis control is inadequate, these screening tests may also give valuable clues about where to search for the cause, but we expect to have to do further work to isolate the problem. Similarly, our goal here has been to develop a screen for abnormal production that would be both sensitive and cost-effective for all sizes of herds.

To diagnose herd production problems we try to compensate for as many variables that are NOT directly related to management as is practical. Breed, state of lactation and age are all factors having a large effect on production for which a computer can easily compensate. Possibly we should compensate for seasonal variation as well, but we have chosen not to, out of reluctance to consider a seasonal drop in production as "normal" and unavoidable. It is also fairly easy to compensate informally for seasonal effects, so while we prefer to consider any seasonal drop in production a problem, we recognize that it may not be a problem we can solve economically.

Numerical Methods

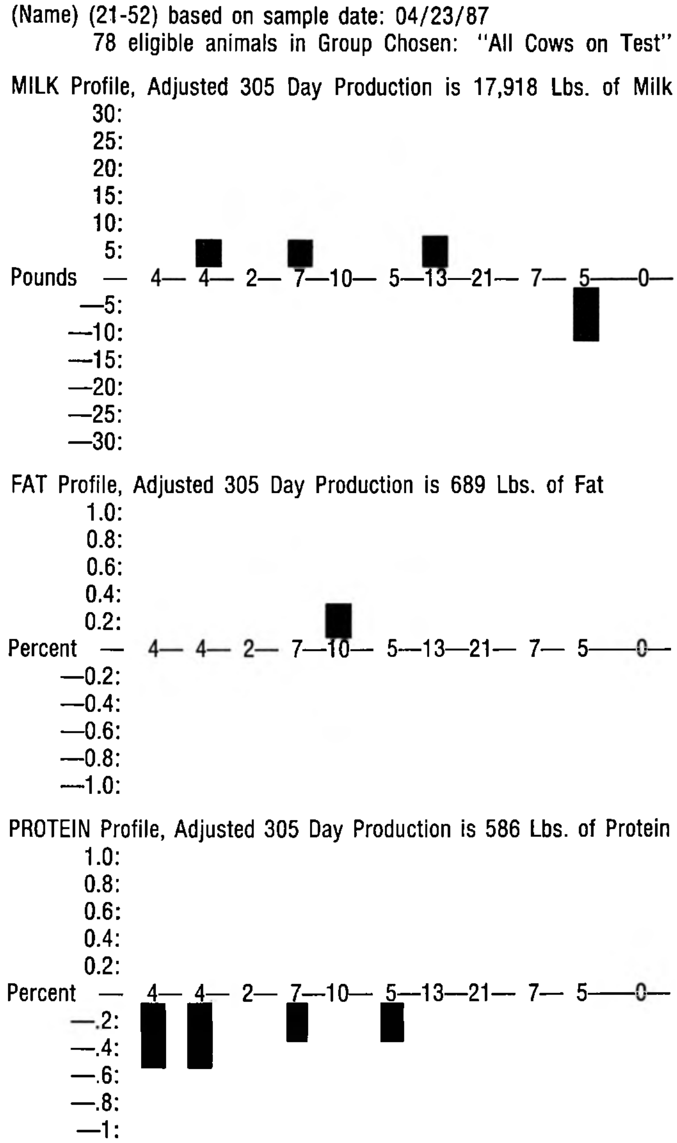
In preparation for the calculations done to compute our "Production Profile" graph we did extensive polynomial curve-fitting on normal lactation data and on published lactation curves. (This should be the topic of a separate paper.) The result was a series of mathematical equations shown in Appendix A that describe normal lactation curves for Holstein cattle of specified parity. The formulas generate standards for pounds of milk, percent fat, and percent protein for each day of a lactation. In all calculations that follow we define these production levels as "normal". They are NOT averages and NOT applicable to all situations. In particular, the formulas become inaccurate after about 325 days in-milk. However they give us a defined basis of comparison between herds. We feel they do an adequate job, for our purposes, in compensating for the effects of breed, age, and lactation stage for days 7 to 325 of a lactation.

We intend to generate similar formulas for cattle of Jersey, Guernsey, and perhaps other breeds. So far, we have been unable to get access to sufficient reliable and recent data to allow us to do so. The computer program simply ignores animals of breeds without specific production standards, but will use the appropriate formulas when we are able to provide them.

To generate a graph the program compares measured production of each cow in the herd to normal production for an animal of her breed and parity, as defined above. The herd is divided into 30-day groups based on days-in-milk and the average deviation from normal for each group is plotted along with the number of animals in the group.

Figure 1 shows the result of these calculations. It is a triple graph from one of our clients directly as it comes off the

FIGURE 1. Herd Production Profiles with 91 cows on test.



All graphs are expressed as deviation from normal curves based on a herd average production level of about 17,200 pounds. Cows are grouped according to days since freshening, in groups covering 30 day periods. The numbers on each horizontal axis are the numbers of cows in each group. Dry cows and cows fresh longer than 325 days are excluded.

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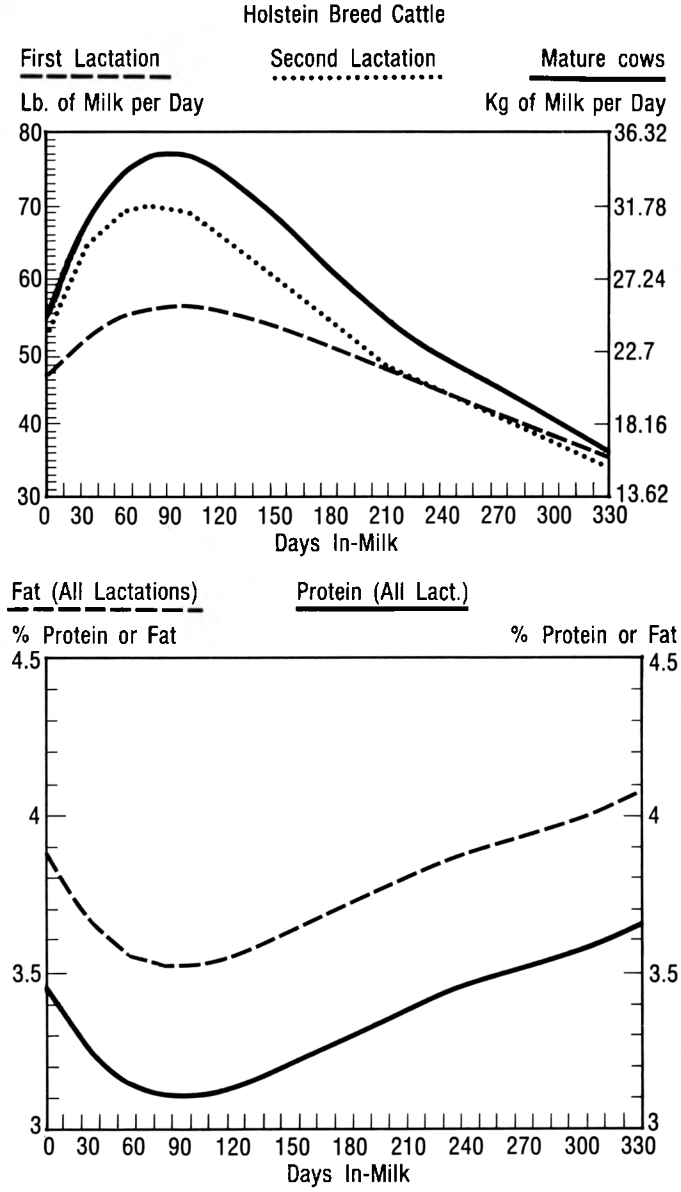
FIGURE 2. Polynomial Lactation Curves.



printer (with the client's name and herd number removed.) In addition to the graph showing average deviation from normal of milk weights there are graphs showing average deviation from normal for percent butterfat and percent protein in the milk.

The eleven bars on each graph represent groups of cows fresh 0 to 29, 30 to 59,...and on through 300 to 319 days. The groups are spread from left to right on the horizontal axis of each graph and their position along the axis indicated by a number which is the number of cows falling in that group.

The graph uses one block for each five pounds of milk or 0.2% difference in fat or protein test above or below the standard. Figure 1 says that data from the test of 4/23/87 showed 4 cows between 0 and 29 days in-milk and that, if we compare the measured milk production of each of these cows to the appropriate standard curve for that individual and average the deviations from the standard, the result is between -5 pounds of milk and +5pounds of milk. Similarly the average deviation from the standard for 4 cows between 30 and 59 days in-milk is more than +5 pounds and less than +10pounds.

Graphs for butterfat and protein are done in exactly the same manner, comparing measured milk fat and protein to polynomial standard curves and plotting the average deviation. We have chosen to plot percent concentration in milk rather than total pounds of fat or protein because we feel concentration will give a more accurate portrayal of the effect of management. We use a single standard for fat or protein concentration for all ages of cattle in a breed.

In the example shown in Figure 1, the milkfat graph shows that all groups averaged within 0.2% fat of the standards used except for the 10 cows 120 to 149 days in-milk. The Protein graph shows milk protein levels that appear slightly low in cows in the first half of their lactations.

Figure two shows graphic representations of the polynomial standards used. We can use these to show how the bars could be generated in another way. We could plot points for each cow in the herd and measure the vertical distance between the standard curve appropriate to the individual's parity and her data point. We would then group the animals according to days in-milk and average the distances between standard and measured production to get the length of the bar above or below the curve.

Figure one also shows above each graph a number we call "Adjusted 305 Day Production". All the individual deviations for the herd are averaged. This herd average deviation from the standard curves is added to the base production level represented by the standard curves (the area under the standard curves between 0 and 305 DIM). This produces a number which is conceptually similar to "Adjusted Corrected Milk" except that there are separate figures for fat and milk production, and we use a polynomial curve standard rather than the straight line standard that the Adjusted Corrected Milk formula assumes. This better represents cows in early lactation and so should be more accurate in herds with many fresh cows.

There is also a degree of age compensation in the milk "Adjusted Production" figure. We calculate it as if every herd had the same makeup of 25% first-calf heifers, 20% second-calf heifers, and 55% mature cows. We do this by using a single base production figure for each breed that is a weighted average of the base figures for the first-calf, second-calf, and mature cow milk curves.

We have the ability to generate a graph for practically any sub-group in the herd, such as first-calf heifers, or to reprint graphs from old data for comparison purposes.

Graph Interpretation

We generate these graphs monthly for selected clients and use them to monitor overall production. We examine each graph in a series of steps.

First we scan the numbers on the horizontal axis to get an idea of the **Lactation Stage Distribution** of a herd. Many of our clients want a heavy Fall calving period. It is immediately apparent how successful we have been in breeding for Fall calving. Of course there are other reasons for wanting to know this distribution. The graph is no better here than a standard breeding wheel (an analog computer).

Next we look at the Average Level of the bars and the "Adjusted Production" figure. Since all the standard curves define a particular level of production as normal, we may consider it normal that a herd with cows of superior genetic potential should have bars evenly above the horizontal axis and a herd with genetically inferior cows would have bars evenly below the axis. Consistent superior or inferior management might be reflected in the same way. Remember that all the information on one graph comes from a single sample if a herd is on AM/PM test, or at most two samples from each cow. Factors such as starting milking an hour late on test day will effect the level of the curve and the "Adjusted Production" figure. After these factors are taken into consideration we have an estimate of the overall production level of the herd.

Finally we scan the **Shape** of the curve, keeping in mind the number of cows in each group. Clearly it doesn't mean much if you have a group of two or three cows with a bar that is far out of line, but we can pick up patterns. If, for example, the first three or four bars are relatively lower than the later bars, either the cows are not peaking well or tail-enders are doing exceptionally well. A glance at graphs from previous months will tell which it is. Now it is the vererinarian's job to figure out why and what to do about it.

Discussion

Lactation curves have become a familiar tool for retrospective analysis of production of individual cows or groups. Since the data used extend back in time as much as a year, lactation curves are not very sensitive for use as a screening test for production problems that may easily appear and disappear in less than a month. We feel that the "Production Profiles" that we generate provide a similar sort of information with more immediacy. This could as well be drawn in the same format as is commonly used for lactation curves, but we should keep in mind that a lactation curve properly refers only to a particular individual or group of individuals followed through time, while production profiles are a section through the herd at a moment in time. We think it is a good idea to keep the distinction clear by using a different format. By plotting deviation rather than the actual averages for each group we also emphasize the information we want—"Is the herd deviating from normal?"

Persistency analysis can be used to detect rapid changes in productivity by calculating persistency over a two-month period. The production standard used in calculating persistency is, in effect, the previous sample data, so we are constantly having to decide whether poor persistency means good performance last month or poor performance this month. The Production Profiles avoid this problem by using an external standard.

We could also make Production Profiles plotting Standard Deviation for each group rather than average deviation and in fact are already doing that on an experimental basis. Plotting standard deviation emphasizes samples that are farthest from the standard, and may make more sense for a test that is trying to detect abnormal production with high sensitivity. However it is harder to explain to clients.

The same information could be plotted by hand just as a ration can be calculated by hand. The advantages of automation are both in speed and accuracy. Humans make more mistakes than computers do, and they get bored sooner. The disadvantage of automation is that many people still tend to think of anything produced by a computer as either nonsense or absolute truth. We want to emphasize that we are proposing a diagnostic tool that is useless or dangerous if not used with good judgment.

On the basis of experience to date with these graphs we can make a few preliminary observations.

Low Peak Production (first four bars relatively low) seems to be commonly associated with herds whose cows dry off and freshen with inadequate body condition, though we might expect the same with overcondition. In our area, at present, undercondition at freshening seems to be a common problem. Of course low peak production can as easily be an indication of other nutritional problems, and we are looking forward to work correlating specific nutritional problems with specific production patterns.

Low Tail-end Production might easily be indication of a herd problem with sub-clinical mastitis.

A particular *Group* that is performing poorly may be an indication of a problem in managing that group. For example if dry cows are ignored during corn-cutting (and subsequent hunting season), that group might show as a couple of low bars that move down the graph one step each month.

Protein Curves may be a very sensitive measure of the adequacy of energy nutrition with milk protein levels dropping in peak-production groups before other signs appear.

Butterfat Curves should be useful in a case of fat depression in determining whether the problem arises from the entire herd or a sub-group, and therefore where to look for the source of the problem.

Profiles done for *First-calf only* or *Second-calf Heifers only* are useful for analyzing feeding of those groups and also for evaluating "freshness" distribution. We encourage our clients to have heifers calve before the normal calving season.

Summary

The increasing availability of data and computing power provide us with powerful new tools of diagnosis. We have developed a way of presenting data from DHI production records that we believe allows us to screen herds for production problems. Currently it costs us less than $2 to get data on 100 cows. This is an easily justified monthly expense, even in small herds. As with all highly condensed information, interpretation requires considerable familiarity with the herd examined to avoid incorrect analysis.

Appendix A (Formulas)

M = Daily Milk Production (in Pounds)
F = Percent Fat in Milk
P = Percent Protein in Milk
D = Days Since Freshening

Holstein Breed Cattle

First Lactation

$M = -1.15e{-8} \times D^4 + 9.71e{-6} \times D^3 - 0.00298 \times D^2 + 0.305 \times D + 46.2$

305 Day Production Level: 15,026 Pounds of Milk (6,821 Kg)

Second Lactation:

$M = -3.21e{-8} \times D^4 + 2.62e{-5} \times D^3 - 0.00720 \times D^2 + 0.621 \times D + 53.2$

305 Day Production Level: 16,745 Pounds of Milk (7,602 Kg)

Third of Later Lactation

$M = -3.74e{-8} \times D^4 + 3.07e{-5} \times D^3 - 0.00873 \times D^2 + 0.825 \times D + 52.3$

305 Day Production Level: 18,428 Pounds of Milk (8,366 Kg)

All Lactations:

$F = 4.86e{-10} \times D^4 - 4.09e{-7} \times D^3 + 1.20e{-4} \times D^2 - .012 \times D + 3.90$

Average 305 Day Fat Percent: 3.73%

$P = 4.86e{-10} \times D^4 - 4.09e{-7} \times D^3 + 1.20e{-4} \times D^2 - .012 \times D + 3.48$

Average 305 Day Protein Percent: 3.31%

References

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