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Abnormal Milk Evaluations in Eastern South Dakota Milk Plants and Dairy Herds

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ABNORMAL MILK EVALUATIONS IN EASTERN SOUTH DAKOTA MILK PLANTS AND DAIRY HERDS

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ABNORMAL MILK EVALUATIONS IN EASTERN SOUTH DAKOTA MILK PLANTS AND DAIRY HERDS

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Advisor　　　Date

Head, Dairy Science Department　　　Date

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INTRODUCTION

For many years bovine mastitis has been a major problem for dairy producers, the seriousness of which can be measured by the volumes of literature which have been written about it as well as the economic losses incurred by the dairy industry because of it. The fact that mastitis is still a virulent disease in spite of the vast amount of research conducted on it would suggest either that the underlying causes of mastitis still are not completely understood or that the knowledge gained through research has not been presented effectively to those who need it most -- namely the dairy farmer.

The purpose of this study was to determine the prevalence of mastitis in Eastern South Dakota and to identify, in-so-far as possible, those factors which were related to the production of abnormal milk.

The first part of this thesis contains the results of a study of the amount of abnormal milk being shipped to three milk plants in Eastern South Dakota over a twelve month period. The objectives were to determine the severity of the problem in Eastern South Dakota and to identify those herds which were producing abnormal milk. However, there was no attempt made to define the causes related to the production of abnormal milk.

The second part of this thesis presents the results of research with thirteen herds in Eastern South Dakota for twelve consecutive months. The major objective of this phase was to investigate individual cow variation and to determine, if possible, the factors responsible for abnormal milk secretion.

REVIEW OF LITERATURE

The most common labels used in the description of degrees of mastitis infection are those of the National Mastitis Council (NMC) (6), namely subclinical or nonclinical, clinical and chronic. "Subclinical mastitis" is the term used by the Council to designate the condition which manifests itself in an abnormal milk secretion detectable by special tests but accompanied by no gland swelling or visual abnormality of milk secretion. "Clinical mastitis" designates a condition in which abnormal secretion is visible and gland swelling obvious. "Chronic mastitis" refers to persistant gland infection which is often dormant but which erupts on occasion into an active clinical state. Plasteridge (39) used the designations "subclinical", "mild", and "severe" to refer to essentially the same conditions.

A 1964 report by the American Veterinary Medical Association (15) estimated that mastitis afflicts 50% of the cows harboring pathogenic organisms in two or more quarters. However, seventy-five percent of these conditions may be classified as subclinical mastitis which require special tests for detection.

Determination of Mastitis

<u>Direct Tests</u>. Direct or cultural tests must be employed to determine the presence and identity of mastitis causing organisms in the milk. These tests are useful in the adoption of a mastitis control program because measures of control may be highly dependent on the kind of organisms involved (8). The detection and identification of specific

pathogenic bacteria is dependent upon specific laboratory procedures. Generally specific agar or broth type mediums are employed. A comprehensive description of accepted methods and procedures for cultural tests may be found in the Standard Methods for the Examination of Dairy Products (3).

Indirect Tests. The tests most commonly used for detection and/or identification may be classified as indirect and direct. The indirect tests as described by Little and Plasteridge (26) require the development of palpable lesions in the udder or changes in the composition of the udder secretions. These tests include the palpation of the udder to detect lesions in the mammary gland and the use of the strip cup to check the composition of the milk secretion. Other indirect tests as described by Little and Plastridge (26) which indicate the presence of abnormality in milk and/or the udder include the Chloride Test which is used to determine the presence of excessive chlorides in milk. Chlorides in excess of 0.14% are regarded as abnormal. The Bromocresol Purple Test and the Bromothymol Blue Test are used to detect changes in the pH value of milk; normal pH of milk is 6.6 to 6.8. The Catalase Test and the Whiteside Test (60) estimate the number of leucocytes in milk. The California Mastitis Test (CMT), a modification of the Whiteside Test developed by Schalm and Noorlander in 1956 (47), also estimates the leucocyte count of milk and is widely used in field work because of its simplicity and readability. The CMT, a very sensitive indicator of inflammation in the udder, was originally designed to be made at the cows side. However, other investigators (5), (4), (43) have found the CMT to be a reliable screening test on bucket and bulk tank samples also.

The Direct Microscopic Leucocyte Count (DMLC), developed by Prescott and Breed in 1910 (26), has been widely used as a screening test and is considered to be the most accurate of the indirect tests.

The various tests for determining leucocytes are based on the theory that leucocytes play an important part in the defense of the body against infectious organisms and irritation. It may be expected that the number of leucocytes in milk will increase as pathogenic bacteria invade the udder or as the udder tissue is irritated. The type of leucocyte referred to herein is defined by Schalm (45) as a neutrophil or polymorphonuclear (PMN) leucocyte. The PMN leucocyte engulfs bacteria and tissue debris by phagocytosis. In the process the leucocyte may die and release its chemical substances which attracts more leucocytes. Some of the leucocyte chemicals act specifically to increase permeability of blood vessels so that fluid and proteins of the blood escape into the tissues. This action of PMN leucocytes is prominent in acute mastitis and it is responsible for the edema which is characteristic of acute mastitis.

The purpose of exudation of PMN leucocytes into milk is to destroy the irritant and permit repair to take place. Injury to mammary tissue other than infection results in exudation of numbers of leucocytes in proportion to the extent of the injury. Because a high leucocyte count may result from irritation as well as infection or invasion by pathogenic bacteria, a high leucocyte count does not necessarily indicate that mastitis is its cause. The leucocyte count is presently regarded, however, as a reliable indicator of the degree or severity of inflammation (6). The number of leucocytes present in milk which indicates inflammation has been a matter of conjecture among research workers. Hucker (19) concluded that samples containing 300,000 or more leucocytes per ml usually indicated a past or present infection. In some later work Hucker (20) stated that samples containing more than 500,000 leucocytes per ml indicated an abnormal condition in the udder. Little and Jones (25) found that the leucocyte count of milk infected with streptococci or hemolytic staphlococci exceeded 1,000,000 per ml. Bryan (9) regarded udders as being free from mastitis when there were less than 1,000,000 leucocytes per ml. Halverson (16) regarded counts in excess of 100,000 per ml as indicative of udder infection as did Prouty (43). Little (23) described leucocyte counts under 300,000 per ml as being normal for first calf heifers. He considered counts ranging between 500,000 and 1,000,000 as normal for older cows. Plastridge (40) examined 2,983 chronic staphylococcus infected quarters of 2,125 samples that contained no mastitis organisms as shown by microscopic and cultural examination. Eight percent exhibited fewer than 100,000 leucocytes per ml; 17.7%, from 100,000 to 500,000; 2.0%, from 500,000 to 1,000,000; and 0.9%, in excess of 1,000,000. The average leucocyte count of 298 samples containing nonhemolytic staphlococci was 220,000 per ml; of 559 samples containing hemolytic staphylococci the average count was 1,250,000. The normal concentration of leucocytes in milk as defined by the National Mastitis Council is 100,000 per ml and a count in excess of 500,000 per ml is indicative of mastitis or other abnormality.

Little and Plastridge (26) listed indirect tests in their order of effectiveness for detection of abnormal milk secretion as follows: DMLC, Chlorine Test, Catalase Test, Whiteside Test, Bromothymol Blue Test, Strip Cup and abnormal appearance of milk. The United States Department of Health, Education and Welfare in a 1965 publication (56) listed current indirect tests as follows: California Mastitis Test, Catalase Test, Direct Microscopic Leucocyte Count, Modified Whiteside, and the Wisconsin Mastitis Test. These are all based on the number of leucocytes in the milk. They are classified as screening tests and are not intended for diagnosing mastitis.

Little and Plastridge (26) concluded that indirect tests are useful in control and eradication programs; however, there are certain disadvantages which include the following: failure to detect S. agalactiae infected cows, failure to give consistently positive findings when applied to known S. agalactiae infected cows, failure to distinguish between contagious and non-contagious mastitis, failure to differentiate between inflammation resulting from bacterial infections and abnormality caused by injuries. In addition, they frequently give positive reactions when used on non-infected cows in the first two and last four weeks of lactation.

Brazis et al. (5) suggested that better results would be obtained with screening tests if test scores were classified as 1) negative, 2) weak positive, and 3) strong positive. His contention was that these classifications would minimize overlapping of screening test scores and would facilitate interpreting of test scores.

Appleman et al. (1) related that when properly administered the CMT, Modified Whiteside Test, and Catalase Test can be used with equal effectiveness. However, they considered the speed, efficiency, and economy of the CMT plus the fact that the same test is widely used for bucket milk and at the side of the cow as the major factors leading to the adoption of the CMT as the official test in California.

Table 1. Relationship of bulk tank, CMT scores and cell counts to the percentage of milk volume and of cows with CMT 2 and CMT 3 scores.

Estimate bulk tank CMT score	Range of estimate tank count (cell/ml)	CMT 2 and CMT 3	
		Milk present	Cows present
		(%)	
T	300,000 - 500,000	0 - 5	0 - 6
1	500,000 - 800,000	5 - 13	6 - 15
1 - 2	800,000 - 1,500,000	13 - 31	15 - 36
2	Over 1,500,000	Over 31	Over 36
3	Over 3,500,000	Over 75	Over 80

Interpretation of CMT Bulk Milk Classification

It is assumed that a CMT score of Negative is an excellent score for bulk tank milk. Appleman et al. (1) also considered a CMT score of Trace as an excellent score for bulk tank milk. Their research indicated that there is a predictable relationship between the bulk tank CMT score and the percentage of cows scoring CMT 2 and 3 (See

Table 1).

The figures from Table 1 indicate that 80% of the cows in any size herd must score either CMT 2 or 3 for the tank to score CMT 3. Likewise, between 36% and 80% of the cows must score CMT 2 and 3 for the tank to score CMT 2. When 15% to 36% of the cows score CMT 2 and 3 the tank CMT will vary between CMT 1 and 2. Not more than 6% of the cows in any given herd can score CMT 2 and 3 if the tank is to score CMT trace. From these observations it would appear difficult for particularly large herds to consistently maintain a CMT tank score of negative. It could also be inferred that a CMT tank score of Trace would indicate high quality milk.

Braund (4) compared CMT quarter scores from forty-five Wisconsin herds with bulk tank scores of the total milk from each herd. He considered a cow positive if one or more quarters scored a 2 or 3 on the CMT. Positive cows in each herd which scored a Trace CMT bulk tank score ranged from 24.1% to 68.3% and averaged 58.9% positive cows in 28 herds. Quarters scoring positive for a trace bulk tank score in the 28 herds ranged from 8.6% to 45.9% with an average of 27.8% quarters per herd. These data differ considerably from those already mentioned of Appleman et al.

At least a part of the explanation for these variances may be explained by work conducted by Schalm (47) regarding the influence of hour to hour variation of cells in milk on the CMT. Schalm considered the fraction of milk used for cell counting an important consideration. In successive tests on one herd he used the CMT on residual milk taken four to five hours after the morning milking and on foremilk and strippings milk at the next milking. He considered quarter reactions of CMT 2 and 3 as positive. The results of his work are shown in Table 2. Paajse and Tucker (36), Smith and Schultze (51), and White and Rattray (59) recorded similar results to those of Schalm. Braund (4) collected quarter samples from residual milk; the average percent of positive quarters was 27.8 quarters per herd. For Schalm the average percent of quarters was 25.0 on residual milk. These figures do not differ appreciably. Thus it would appear that the fraction of milk collected does have a significant bearing on the actual status of the cow for comparison purposes of cows within a herd and the bulk tank CMT score.

Table 2. CMT scores by successive lactations for foremilk, strippings, and residual milk.

Number lactation	Number Quarters	CMT 2 and 3 Reactions		
		Foremilk	Residual Milk	Strippings Milk
		-(%)-		
1st	188	4.7	16.0	8.0
2nd	100	15.0	26.0	20.0
3rd	112	14.3	27.6	17.8
4th	84	19.0	39.2	21.4
5th Plus	108	22.2	28.7	21.3
Total	592	13.5	25.0	16.2

Gray and Schalm (14) worked with 8,265 cows from 126 herds over a ten month period recording CMT scores on milk from individual mammary quarters, bucket milk, and bulk tank milk from these herds. Bulk tank samples were scored as Negative, Trace and 1, 2, or 3. One of their conclusions was that any bulk milk sample with a CMT score of one or higher indicates that milk from individual quarters or cows would score CMT 2 or 3 and that a significant degree of mastitis exists. They further stated that a CMT score of negative on bulk milk samples does not imply that a herd is free from mastitis. Tests showed an average of 17.8% positive cows on bucket milk samples although bulk tank scores were negative.

Predisposing factors

It is generally agreed among research workers that the bacteria, the principal causes of mastitis, usually enter through the teat canal. Since its introduction, the milking machine has received much of the attention given to predisposing factors; however, other predisposing factors must also be considered. These include chilling, feed, hereditary factors, stage of lactation, and age of the cow.

Chilling. Reid (44) observed high rates of clinical mastitis when cows were pastured over night in the Spring and Fall. Reid also noted that exposure to cold and dampness on wet floors is a factor in increasing rates of clinical mastitis.

Feed. Excessive levels of concentrates in feed has popularly been charged with contributing to the incidence of mastitis. Experimental studies disprove this contention. In feeding from 5 to 12 pounds of linseed and cotton seed meal to two groups of cows daily for a six month period Huffman and Moore (21) failed to show that these protein concentrates aggravated mastitis. Hotis (17) concluded that feeding had little if any effect on the incidence or severity of mastitis. Udall and Johnson (55) were of the opinion that the mastitis condition was greatly aggravated when animals already infected with chronic mastitis were fed heavily with high protein concentrates.

Stage of lactation. The incidence of mastitis related to the stage of lactation has not been fully determined. Oliver (34) reported that a lack of uniform methods of diagnosis and testing at irregular intervals may be reasons for differing results. Murphy (31) found a high incidence in early lactation while in a herd with a high incidence of *S. agalactiae*. Spencer and Kraft (53) found an increase of about 20% for each successive three month period. Watts (58) in a survey of many herds found a high incidence of mastitis in the first three and last three months of lactation. Marshall and Edmonson (29) reported on data collected from 8,837 quarter samples of milk collected from nine herds over a one year period. Maximum udder infection as defined by the CMT occurred during April and August. The investigators lacked controls to fully explain why these peaks occurred but suggested the following: temperature effect on cows, increased activity of micro-organisms during the warmer period, breeding programs, predominant stage of lactation, unbalanced freshening patterns as related to age of the cows, and a combination of two or more of these factors.

Little (24) postulated that the alveoli regress during advanced lactation. He further stated that it would appear that as the alveoli regress they become more permeable to the components of the blood. This transition may account in part for the increase in pH, chloride percentage and cell counts of milk during advanced lactation.

Heredity factors. Murphy (30) considered the potency of the natural inhibitory or bacteriostatic substance in the udder, the competency of the teat sphincter and the normalcy of the teat cistern as influential hereditary factors in the epidemiology of mastitis. Murphy was the first to observe that some teat canals permitted the passage of bacteria more readily than others. He found that the removal of a small amount of the soft, waxy keratin lining the lumen of a resistant teat canal rendered the gland susceptible to an experimental challenge. Murphy concluded that the lipids in the keratin lining of the teat canal were the substances responsible for the bacteriostatic action observed. Treece et al. (54) postulated that anatomical differences in the individual teat canals might be responsible for differences in resistance to mastitis. The physical properties of the keratin itself may be the most important factor.

Reid (44) found that of 18 daughters of one sire, 55% developed serious udder trouble in one of their first two lactations. Of 15 daughters sired by other bulls, 14% of the daughters developed serious udder trouble in the same study. The results of this study are in agreement with similar studies conducted by Lush (27) and Murphy (32).

Dodd and Neave (11) found that fast milking cows tend to become infected more readily than slow milkers. However, they stated that differences in milking rates can not account for the large differences in mastitis incidence rates found in separate herds. They suggested that either a large or weak teat sphincter or the machine left on longer than necessary for the fast milkers may facilitate passage of bacteria into the udder.

McEwen and Cooper (28) recorded observations on one herd of 180 cows. They found that the percentage of animals yielding milk with clots associated with bacterial infection was 18% for "hard milkers," 15% for "moderate milkers," and 33% for "easy milkers".

It would appear that hard milking cows may have teat sphincters that close more completely than easy milking cows. Thus, the easy milking cows may have greater chance for infecting bacteria to enter than the hard milkers.

Age. There is high agreement among research workers that the rate of udder infection increases with age. Over a seven year period, Murphy (31) studied a Holstein herd and a Guernsey herd, each containing 60 cows. He found the percentage of quarters infected with streptococci increased and decreased directly in relation to the average age of the herd. Murphy observed than an age factor independent of teat injury, milking rate, and degree of exposure is involved. Plastridge (39), in a review article, agreed with this observation and offered support for this explanation by reporting on the findings of Lancaster and Stuart (22). They milked 18 cows for 15 weeks and exposed the hands of the milkers prior to milking with S. agalactiae infected milk. Two of seven first calf heifers, four of five second calf heifers, and six of six older cows became infected during the 15 week period. In their study, Ormsby and Schalm (35), and Plastridge et al. (41) did not rule out an age factor but concluded that the degree and extent of exposure are major factors affecting the rate of infection in heifers as well as in older cows. Spencer and Kraft (53) found that the incidence of infection increased regularly with advancing age for several years but tended to remain constant. They took issue with the age factor relationship postulated by Murphy and pointed out that if susceptibility of cattle increased there would be little or no new infection during the first few years of lactation and a rapidly increasing incidence of new infection in older animals. They pointed out that many older animals are infected in only part of the quarters and any hormonal innate physiological factor, or aging factor, should be the same for all four quarters of these cows.

Milking machine

Little and Plastridge (26) suggested that the improper use of milking machines may cause injuries or aggravate an existing chronic infection. As improper uses they mentioned excessive vacuum, overmilking, procedure and timing of the removal of the milking unit from the teats, and improper machine stripping of infected udders.

Burkey and Sanders (10) completed a comprehensive review of the literature up to 1949 on the contributions of milking machines to the incidence and severity of mastitis outbreaks. They emphasized the adverse effects of attaching the machine before let-down had occurred, excessive vacuum, and long duration of milking. In a 1958 review of Bovine mastitis by Plastridge (39), abusive machine milking, especially prolonged milking and use of worn or poorly designed teat cup liners were mentioned as factors tending to increase the rate of clinical mastitis in infected quarters.

Most research indicates that vacuum levels of 10 to 15 inches of mercury (Hg) is within safe limits. Most milking machines in the United States are designed to operate at a vacuum of 10 to 15 inches of Hg. The 10 to 15 inch range of Hg vacuum is stated because there is a variance among milking machine manufacturer requirements for operating the milking system. If a particular milking machine is designed to maintain a vacuum of 15 inches of Hg, it should have the capacity to remove all of the incoming air and still maintain a constant level of 15 inches of Hg; if it is designed to operate at 12 inches of Hg, it should have the capacity to remove all of the incoming air and remain a constant level of 12 inches of Hg. Fluctuations from specific predetermined levels within the range of 10 to 15 inches or more may be an important predisposing factor to mastitis.

Research conducted by Wilson (61) led him to the conclusion that an inadequate reserve of vacuum will result in wide fluctuations in vacuum during milking. He cited one example in a herd in which the working vacuum was low and mastitis was a definite problem. After the installation of a new vacuum pump which provided a constant vacuum, there were no new cases of mastitis. The California Mastitis Team (50) reported that in some pipeline installations fluctuating vacuum is a problem of great significance. This is due to the fact that several inches of vacuum are expended in milking the cow and lifting the milk.

A reduced vacuum at the teat is in effect only as long as milk is still being secreted from the udder. In order to provide adequate vacuum to lift the milk, the vacuum regulator is often set to increase the vacuum in which case there is excessive vacuum when milk is no longer being secreted.

Schalm and Noorlander (48) suggested that an air admission or "breather" in the claw would greatly reduce fluctuating vacuum at the teat end, particularly where milk had to be raised several feet. Hopkirk, Palmer, and Whittleston (18) observed that when these breather holes became obstructed, mastitis became more prevelent particularly when vacuum was high.

Pulsator. The function of the pulsator is to allow atmospheric air into the area between the shell and the liner. This air is then withdrawn through the vacuum system when the pulsator closes. The liner, being elastic, responds by opening the chamber around the end of the teat during the vacuum phase and collapses around the teat when the atmospheric air enters. The teat follows the movement of the liner. During the open phase of the liner, the sphincter muscle on the end of the teat is opened, and milk flows from the teat into the liner. The admission of air between the shell and liner forces the liner to collapse around the end of the teat creating a massaging effect. The pulsator rate defines how many times a pulsator opens and closes in one minute--one complete cycle of opening and closing of the liner is a pulsation. The pulsator ratio defines the percent of time the liner is open and the percent of time the liner is closed. As the pulsation ratio is widened, the speed of milk removal is increased.

There are conflicting reports as to whether or not the pulsation rate or ratio has an effect on the incidence of mastitis. Wilson (62) reported that pulsation speed did not appear to play a major role in causing mastitis. However, he stated that the volume of air which entered the system increased with the increased speed of the pulsator. This caused vacuum fluctuations when the vacuum reserve was inadequate. Smith et al. (50) found that air leaks in pneumatic type pulsators were a serious problem. Worn pulsators which virtually eliminated the rest phase interfered with blood circulation in the teat. Widening the pulsation ratio (shortening the massage phase) increased the rate of milk flow; however, Smith and Peterson (52) reported an increase in the congestion of the teats during this procedure. Noorlander (33) concluded that in addition to the danger of providing insufficient stimulation or vacuum relief to the teat, the advantages of widening the pulsation ratio to decrease cow milking time were offset by additional udder stress due to overmilking. Beckley and Smith (2) concluded that a full, "snappy" pulsation action is a major factor contributing to fast and thorough milking with minimum teat irritation. Oliver (34) pointed out in a review that speedy and efficient milking help to maintain udder health and, provided that no irritation to the mammary gland takes place, pulsation rate and ratio which leads to reduced milking time is desirable. Schalm and Noorlander (48) consistently refer to the danger of malfunctioning pulsators, e.g. sticky or worn valves which produce vacuum recorder graphs different from that which is regarded as optimal. These statements are based on collections of large numbers of CMT observations confirming their statements.

Teat cup and inflation design. Many reports suggest that the different designs of teat cup inflations have very different effects on the teat and vary in milking efficiency; therefore the design of the liner is often associated with the incidence of mastitis. Wilson (62) considered that the internal diameter of the inflation and its tension and the softness of its mouthpiece were significant factors in its relationship to mastitis.

Watts (57), Gambrel (13) and Wilson (63) reported that molded, rather than extruded type inflations, have been commonly associated with mastitis. Dodd, Oliver and Neave (12) conducted a within cow, half-udder trial and confirmed this with an 84 cow herd. The molded liners resulted in 32.8% infected quarters; the extruded liners were associated with only 12.3% infected quarters. Greater elasticity of the extruded liner is credited with producing lower incidence of mastitis.

Schalm and Noorlander (49) maintained that the larger the liner used the greater the potential for stress on the teat because of the ballooning of the teat. They explained this ballooning effect is created by the positive pressure within the udder pushing against the vacuum produced by the milking machine around the outside of the teat. They further maintained that when the inter-mammary pressure is reduced, through the removal of milk from the udder, there is not enough milk in the teat to maintain this ballooning effect. As the inter-mammary pressure is reduced, the teat begins to shrink, and the larger liner tends to crawl up on the teat thereby closing the orifice in the teat through which the milk must flow. When there is a complete closure and no more milk is in the teat, a vacuum is created inside as well as outside of the teat. When there is no milk in the teat to buffer the collapsing effect of the liner, the pressure created by the collapsing liner will have injurious effects on the teat. Brown et al. (7) conducted a three year study in which the milking units were assembled so that both quarters on the left half of the cows' udders were milked with wide bore inflations (1¼ inches inside diameter). The right half of the udders were milked with narrow bore inflations (3/4 inches inside diameter). The effect on udder health in the study was measured by the California Mastitis Test (CMT). A cumulative total over the three year study revealed that of 6,260 quarters involved, 5,169 showed a negative CMT test; 1,091 quarters showed a positive CMT test. The number and percent of positive CMT quarters by type of inflation was as follows: 520 (47.4% narrow bore inflations and 571 (52.3%) wide bore inflations. Of the positive CMT quarters 54.7% were front quarters, and 45.3% were rear quarters. The researchers postulated that the larger percentage of positive front quarters indicated over milking since front quarters tend to milk out more rapidly on many cows. It was also noted that the lowest reaction to the CMT was recorded during the periods of the year in which the cows were in full production.

Vacuum. Petersen (37) considered two major objections to machine milking. First, the mechanical milker causes injuries to the teats and udder, and second, that many cows will not milk out completely by machine. He used an excised mammary gland to record the following observations:

1. No vacuum was detected within the teat sinus when milk flowed freely from the gland into the teat. (He did not indicate maximum mm of Hg pressure built up prior to milk removal, but he did state that the rate of withdrawal began decreasing when pressure was decreased to 30 mm Hg. The range was from 10 to 30 mm Hg).

2. When intro glandular pressure was reduced, the tissues became more flacid. The teat cups crawled upward and caused a complete closure of the orifice between teat and gland sinuses. This action accounted for incomplete milking.

3. Pulling down on the teat cups prevented closure of the orifice and permitted complete evacuation of the milk.

4. When the teat cups were allowed to crawl upward and close the orifice, the vacuum within the teat became identical to that in the milk line. He postulated that this would have an injurious action upon the tissues within the teat being compressed.

5. He concluded that when the mechanical milker is properly operated, particularly when it is removed as soon as milk ceases to flow, there is less danger of injury to the teat and udder than from hand milking.

Pier, Schalm and Hage (38) developed a radiographic technique to visualize the action of the rubber liner and vacuum effects on the teat structure. They were able to demonstrate that liners of large diameter tend to collapse completely at the center but leave channels at the margins of the collapsed portions in a figure eight pattern. They also demonstrated the progressive constrictions at the base of the teat from the beginning to the end of milking. They established that the positive pressure of the milk within the udder keeps the orifice open between the teat and the gland sinus. They advised machine stripping to reestablish the opening between the orifice and teat sinus for more complete removal of the milk. They further demonstrated an altering of the teat structure when milk ceased to flow because of the vacuum which was created both externally and internally. The teat wall became progressively thickened due to the presence of blood and tissue fluids. They concluded that negative pressure (vacuum) is capable of injuring tissue when improperly applied. Witzel and McDonald (64) measured pressure changes within the intact udder during mechanical milking. They were able to record pressure readings simultaneously from the teat sinus, gland sinus, pulsator line and milk line. Intramammary pressure recordings before milk let-down were 0 to 8 mm Hg. Within 20 to 90 seconds after the udder was washed with warm water, the pressure was increased from 35 to 55 mm Hg. The pressures within the gland and teat sinuses were similar when both contained milk. Pressure readings followed a gradual decline during milk flow. Near the end of milk flow, 0 to 5 mm Hg vacuum was recorded within the udder. However, as the milk flow ended, the teat sinus vacuum abruptly increased from 216 to 312 mm Hg with each inflation dialation. Their results indicated that vacuum changes within the teat sinus resulted from two factors during mechanical milking namely the dilation and collapse of the teat sinus and inflation occurring together, and the extension of milk line vacuum through the teat sinus during inflation dilation. They were not able to demonstrate a method of relief for the residual vacuum within the udder, but they suggested that if the vacuum were relieved via the teat canal, the possibility existed for aspiration of microorganisms into the teat sinus. They concluded the following: (1) After the end of milk flow, rèsidual vacuum develops within the teat sinus and remains after inflation collapse, (2) A slight residual vacuum develops within the gland sinus at the end of milk flow, (3) The pressure changes within the teat sinus are apparently due to inflation action upon the teat and the extension of milk line vacuum through the teat canal.

The work of Peterson, Pier, et al., and Witzel and McDonald appears to agree that overmilking is a predisposing factor to mastitis through injury to the teat ends, to the mucosa of the teat canal and to the delicate membranes at the base of the teat. Their work indicates that the injuries are due to the exertion of vacuum on the empty teat and pressure on the base of the teat caused by the creeping of inflations.

PART I

VARIATIONS IN BULK MILK SAMPLES TESTED WITH THE CMT FROM THREE SOUTH DAKOTA MILK PLANTS OVER A TWELVE MONTH PERIOD

EXPERIMENTAL PROCEDURE

Three milk receiving plants, through the cooperation of the South Dakota Mastitis Council, were used in this part of the study. The California Mastitis Test (CMT) was the screening test used for the study. The CMT was selected for its simplicity, accuracy, cost, and convenience (36). The screening test was conducted at each of the three milk plants twice each month from January through December, 1966.

Sample collection. The milk samples used to perform the test were collected on the farms from bulk tanks by the bulk milk truck drivers between the 10th and 15th days and the 25th and 30th days of each month. The maximum length of storage time for the total volume of milk in the bulk tanks was forty-eight hours prior to collecting the samples. Before collecting the samples, the driver turned on the agitator in the bulk tank for a minimum of five minutes. The samples were collected with a one ounce dipper from four different locations in each bulk tank while the milk was pumped out of the bulk tank. The samples were stored in an insulated ice chest until delivered to the plant where the screening tests were completed within 24 hours.

Testing procedure. The samples were tempered in a hot water bath stabilized at 95°, then mixed by hand shaking ten times. The CMT was conducted as described by Schalm and Noorlander (47). The recommended quantity of milk from four samples was poured into separate cups of the standard CMT paddle. The paddle was tipped to drain off any excess milk until a quantity of approximately two ml of milk remained in each cup. An equal amount of standard reagent (Mastest) was added to the milk by holding the paddle at approximately a 45^{o} angle and squirting the reagent from a polyethylene wash bottle into each cup at the upper end of the cup. This method allowed the reagent to flow into the milk. The mixture of reagent and milk was made to swirl by a gentle circular motion of the paddle for approximately 10 seconds. The mixture was scored while the paddle was in motion.

Scoring and grading. The scoring procedure was based upon the precipitate formed by the chemical reaction of the CMT reagent when mixed with the leucocytes in the milk. A CMT Negative (-) score reaction was scored when the mixture remained liquid with no evidence of precipitate formation. This was interpreted as less than 200,000 leucocytes per ml. A Trace (T) score indicated a precipitate formation but no thickening of the mixture. A Positive (P) score was defined by a distinct precipitate along with a thickening of the mixture. A gel formation was also observed on Positive scores which was indicative of a more distinct Positive reaction.

After the scores were recorded, the paddle was rinsed in two pails of cold water. The excess moisture was shaken off, but not completely dried off since a trace of moisture does not interfere with the test. This procedure was repeated until all of the bulk samples were tested.

The recorded scores of the individual producer were kept by each plant. At the end of each month the total number of -, T, and P for each plant was mailed to the Dairy Extension Office at South Dakota State University.

Gray and Schalm (14) considered a CMT reaction of 1, 2, or 3 as a mastitic condition. Brazis (5) concluded that classification of CMT scores of negative (less than 200,000 cells per ml), trace (200,000 - 500,000 cells per ml), and positive (over 500,000 cells per ml) would suffice. This was in general agreement with the original cell count range for the various reaction scores of the CMT published in 1956 by Schalm and Noorlander.

The original grading and interpretation is as follows:

Symbol	Suggested meaning	Interpretation (cells per ml)
-	Negative	0 - 200,000
T	Trace	150,000 - 500,000
1	Weak positive	400,000 - 1,500,000
2	Distinct positive	800,000 - 5,000,000
3	Strong positive	Over 5,000,000

The Levowitz - Weber modification of the Newman - Lampert stain was utilized in preparation for the DMLC (3). A .01 ml mechanical syringe was used to transfer the milk from the sample to a clean slide utilizing an area of one square centimeter. The preparation of the slide and the method used for determining the number of fields to be examined was described in Standard Methods. Before use and between samples the needle on the mechanical syringe was wiped clean, and the syringe was rinsed three times in clean water at 30°C. After the films were spread, they were fixed by drying at 40°C. for four minutes. Each slide was then submerged in a jar containing Levowitz - Weber stain for two minutes. Upon removal from the staining solution, the edge of the slide was placed on absorbent paper to drain off excess stain. After the slides were dried thoroughly, they were rinsed in three changes of tap water at 38°C. and allowed to dry.

The microscopic examination of the stained milk films was made using the oil immersion objective lens of a microscope with magnification of 500,000. The number of fields examined was dependent on the number of leucocytes observed after the examination of ten fields. The ranges were as follows:

Range of leucocytes	Number of fields examined
30,000 - 300,000	50
300,000 - 3,000,000	20
Over 3,000,000	10

The formula used to determine the leucocytes per ml was:

$$\frac{\text{leucocytes counted in all fields}}{\text{number of fields examined}} \times 500{,}000$$

The DMLC ranges for each CMT score were as follows:

N = less than 200,000 cells per ml

T = 200,000 - 500,000 cells per ml

P = Over 500,000 cells per ml

In order to develop accuracy in interpreting and scoring the CMT a one day training program was conducted for technicians who would be scoring the samples. A series of milk samples of known count as determined by DMLC were used to develop score evaluations with the CMT. The ease of interpretation of the CMT may have been due to the fact that the classification of samples was modified to negative, trace and positive. Thus any samples with a CMT classification of 1, 2, or 3 were classified as positive.

RESULTS AND DISCUSSION

Variations in the CMT. A total of 32,960 bulk tank samples was scored with the CMT at three plants. Of this number, 37.9% (12,428) were classified negative; 51.2% (16,853) were classified trace; and 10.9% (3,669) were classified positive.

Plant variation. The overall variation of CMT results for the three milk plants over a twelve month period is shown in Table 3. Total negative samples for the three plants ranged from 17.45 to 54.41%. Total trace samples ranged from 34.42 to 64.40%. Total positive samples ranged from 5.29 to 18.15%. Observations of the sampling techniques and scoring procedures did not disclose any reasons for these wide plant variances. Therefore, it was suspected that there may have been wide differences in individual herd management and/or incidence of infection on individual farms. No attempt was made to analyze the possible variances of the herds from which the samples came. However, techniques of sampling and scoring the results were observed. DMLC's were made randomly on each classification for the purpose of evaluating scoring procedures.

During the first thirty days of this project, there was some misinterpretation of scoring the CMT at Plant I and Plant II. The misinterpretation at Plant I resulted from the scoring of negative and trace samples. At Plant II there was some difficulty in scoring Trace and Positive samples. There was no adjustment made for these misinterpretations because they occurred only once and were not considered serious enough to affect the results over the twelve month period.

Table 3. Negative, trace, and positive CMT scores in three plants.

	Plant 1	Plant 2	Plant 3
Negative (no)	5592	1885	4961
Negative (%)	42.89	17.45	54.41
Trace (no)	6756	6959	3138
Trace (%)	51.82	64.40	34.42
Positive (no)	690	1961	1018
Positive (%)	5.29	18.15	11.17
Total samples	13,038	10,805	9,117

Monthly receipts and bulk tank CMT scores of plant 1. Plant 1 was the largest receiving plant in this study; the average monthly receipts were 22,120,481 pounds of milk.

The monthly trends of bulk tank milk CMT scores and monthly receipts are summarized in Figure 1. The highest milk receipts occurred in March, April, May, and June. The lowest period of milk receipts was September, October, November and December. It may be assumed that a higher percentage of cows freshened during the early spring season and that spring pasture also influenced production, particularly in May and June. The fact that the receipts declined continuously from June through November indicated either fewer cows milked and/or less milk produced per cow.

There was a total of 5,592 CMT negative samples of bulk tank milk, averaging 466 negative samples (42.89%) per month. There were three definite peak months for negative samples - January, June, and October. There were no controls established to explain these peaks. It is suggested that the decline in milk receipts from the peak in June and the near season low production in October could have some bearing on the June and October negative levels. During March and April the negative scores reached their lowest levels. The number of negative scores for this period was 343 (26.39% less than average) and 377 (19.10% less than average). Temperature, weather, and other environmental factors also may have been influential during these two consecutive months. It is generally agreed that chilling and exposure of the udder to damp and cold ground temperature is a factor in mastitis incidence (13, 19).

The CMT trace bulk tank scores are in nearly inverse proportion to the negative scores. The peak trace scores occur in exactly the same months as the low months of the negative scores as illustrated in Figure 1, suggesting that the trace and negative scores are related. The average number of trace samples was 563 or 51.82%. The average number of negative (466) and trace (563) samples per month or 94.71% of the total monthly samples suggest that the herds shipping milk to Plant 1 were not experiencing high incidences of mastitis. According to Table 1 (page 7) not more than 6% of the cows could be scoring CMT 2 or 3 (positive). Figure 1 reveals, however, that there are gradual trends, both up and down from the peak months of March and August. It appears that March, when production was sharply increasing, and August and September, when production was sharply decreasing, were important transitional months.

The average number of CMT positive scores was 58 per month. The high months for positive scores were April and December when there was 88 and 96 samples recorded. The average percent over the twelve month period was 5.29. There was not any direct relationship of positive to negative or trace scores nor did there appear to be any relationship of the number of positive scores to milk receipts. The lowest number of positive samples was recorded in June when there were 25 samples. The number of positive samples from July through October varied between 43 and 47 indicating that there was a relatively stable number of herds producing abnormal milk through the summer and early fall and also during a period when production was continually decreasing. The number of positive samples increased sharply to 96 in December when milk receipts increased. This increase possibly indicated freshening cows with a high incidence of mastitis. There was a continuing upward trend of positive samples from January through April indicating an increasing number of herds having more positive scores or more mastitis during the winter, early spring, and fall months with a fewer number having CMT positive scores in the summer months. There is a somewhat similar pattern in trace and positive samples from January through June although not nearly as dramatic as the pattern of trace and negative scores.

A complete summary by months appears in Tables 1, 2, and 3.of the Appendix.

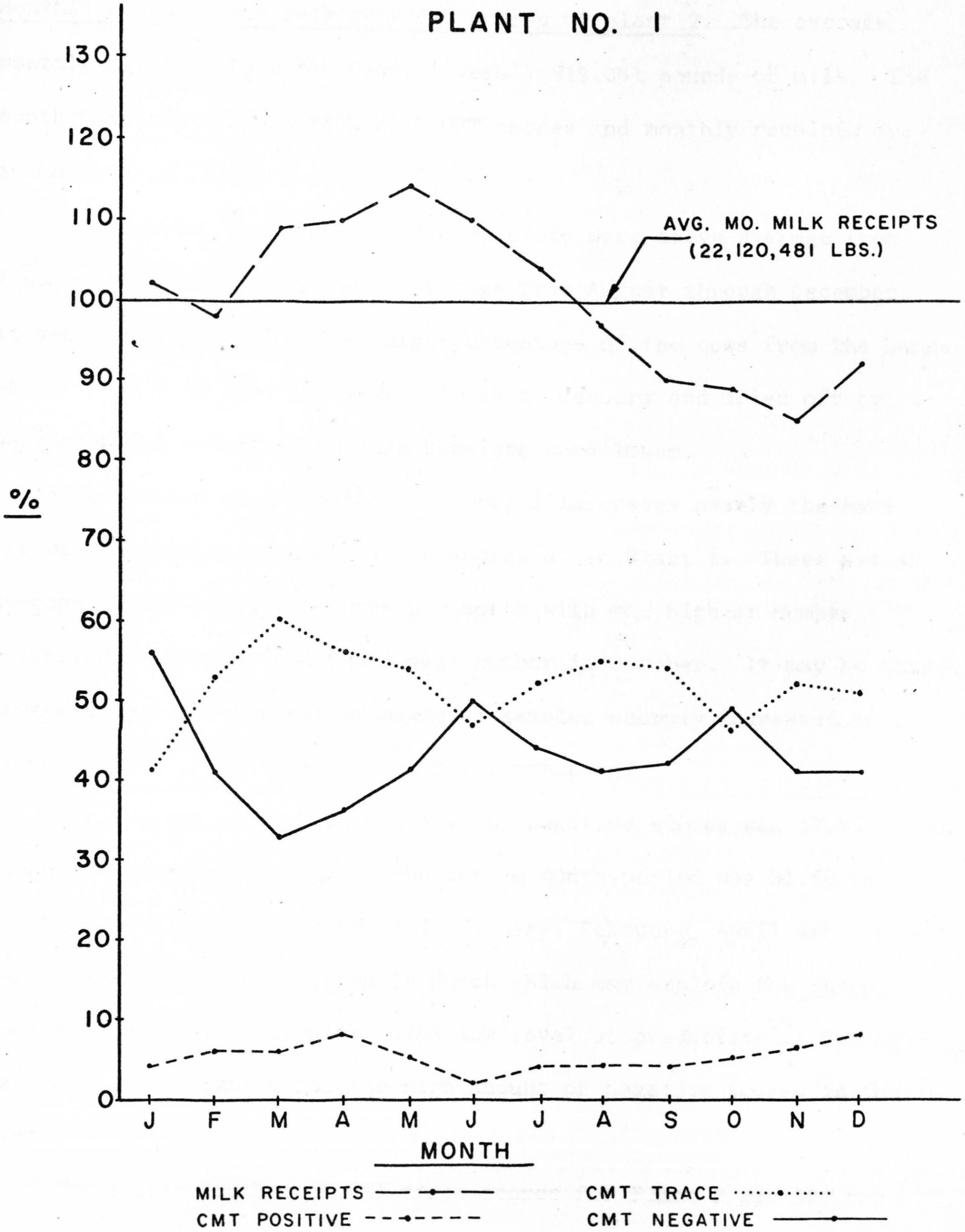

FIG. I. MONTHLY TRENDS IN MILK RECEIPTS AND CMT SCORES FOR PLANT I

Monthly receipts and bulk tank CMT scores of plant 2. The average monthly milk receipts for Plant 2 were 7,919,041 pounds of milk. The monthly trends of bulk tank milk CMT scores and monthly receipts are summarized in Figure 2.

As depicted in Figure 2, milk receipts were above average from January through July and below average from August through December. It seemed apparent that the large percentage of the cows from the herds shipping milk to this plant were fresh by January and dried off by September and October when milk receipts were lower.

The percent of CMT negative scores illustrates nearly the same inverse relationship to CMT trace scores as in Plant 1. There was an average of 157 negative scores per month with the highest number occurring in January and the lowest number in October. It may be noted, however, that the percent of negative samples sharply increased in December when production was sharply increasing.

The average percent of monthly CMT negative scores was 17.45. The range of negative scores over the twelve month period was 31.60 to 8.65%. The high peaks occurred in January, February, April and September. Severe weather occurred in March which may explain the sharp decrease in negative samples. The low level of production in September may be a casual factor for the high amount of negative scores in that month.

The average number of CMT trace scores for Plant 2 was 580 per month. The highest number of trace scores occurred in March (664 samples). Other high peaks occurred in May, August, and November;

however, these peaks occurred during a continuous downward trend over the remaining ten month period. The percent of total samples scoring trace in March was 79.23, and the range was from 53.24 to 79.23%.

The number of CMT positive samples per month ranged from 6 in January to 338 in November. There was a consistent upward trend in the number of positive samples over the first ten months of the study. The sharpest increases in the positive scores occurred during the declining period of milk receipts from June through October; the range was from 16.16 to 35.71%. The range from the average pounds of milk receipts for this same period was from 115% (9,076,989 lbs.) to 72% (5,698,619 lbs.). The number of samples scored during this same period ranged from 937 to 966. Because the samples were scored twice monthly on each herd this indicated a range from 467 herds to 483 herds from June through October. The drop in production in comparison to the relatively small difference in number of herds producing milk would lead to the conclusion that a high number of the cows were producing abnormal milk from June through October.

<u>Monthly receipts and bulk tank CMT scores of plant 3</u>. Plant 3 was the smallest receiving plant in this study. The average monthly receipts were 6,998,515 pounds of milk. Fluctuation of monthly receipts was more pronounced than in Plant 1 and 2. The fluctuating receipts from January through March may have been related to a withholding action by the National Farmers Organization. The peak milk receipts occurred during May and June at which time they were 26.22% and 24.10% above the average production. The lowest period of milk receipts occurred in

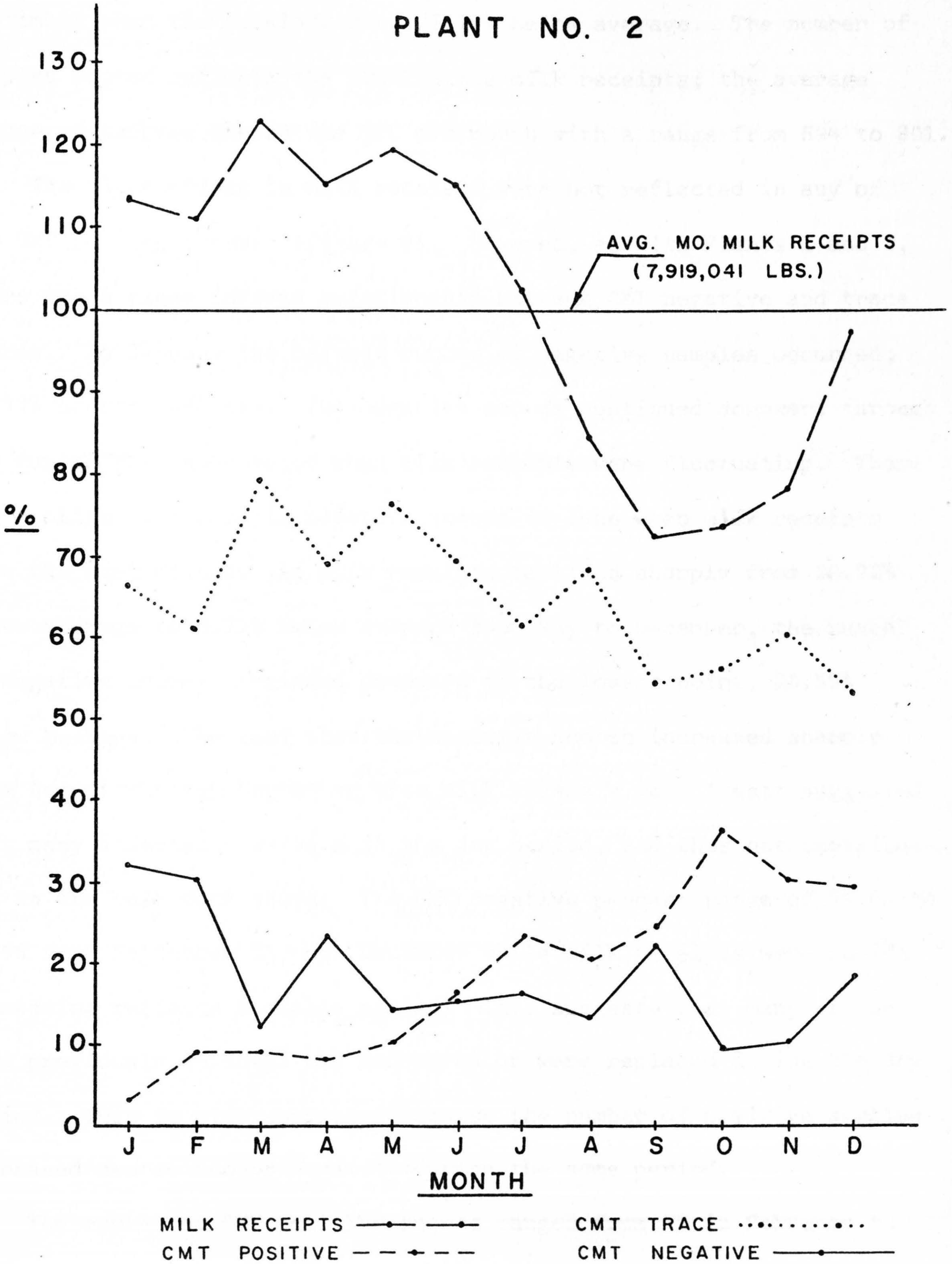

FIG. 2. MONTHLY TRENDS IN MILK RECEIPTS AND CMT SCORES FOR PLANT 2

September when the receipts were 27.72% below average. The number of samples scored reflects the fluctuating milk receipts; the average number of samples scored was 760 per month with a range from 694 to 801.

The fluctuations in milk receipts were not reflected in any of the CMT scoring trends, (Figure 3). However, as with Plants 1 and 2, there was a close inverse relationship between CMT negative and trace scores. In January the highest number of negative samples occurred; 64.42% scored negative. The negative scores continued downward through May during the same period when milk receipts were fluctuating. There was a slight increase in negative scores in June when milk receipts were the most stable. As milk receipts declined sharply from 26.22% above average to 5.71% below average from May to December, the number of negative scores continued downward to the lowest point, 20.59% below average. The fact that the negative scores increased sharply from August through September when milk receipts were lowest suggested that many infected cows were in the dry period, and thus not contributing to the bulk tank score. The CMT negative percent range of 54.61 to 57.68 from September through December while milk receipts were rapidly increasing reflects a stable period. This suggests that many of the cows previously infected had recovered or were replaced during the dry period. This is also suggested because the number of positive samples decreased nearly proportionately during the same period.

The number of CMT positive scores ranged from 49 in February to 127 in September at Plant 3. The positive scores generally increased from January through September when milk receipts were fluctuating or rapidly declining. The number of positive scores decreased from 127 to 74 from October through December when milk receipts were rising. A comparison between the positive and trace scores indicates that the season from January through May may have been influential in the incidence of mastitis and there also were apparently fewer cows being milked in July and August. If the increased milk receipts from September through December can be interpreted to mean that more cows were freshening, then this would suggest that the incidence of mastitis in herds is lessened with an increase in production. It is possible that management related to other farming practices such as increasing field work may be related to the higher incidence of trace and positive scores in April and May. With increasing field work, the milking technique may have been more neglected.

Figure 4 illustrates an average of the milk receipts and CMT scores of all three plants. The average monthly receipts were 37,038,000 pounds of milk. Milk receipts remained above average from January through July and were below average from August through December. The milk receipts ranged from 17 percent to 15 percent below average in October and November.

The negative and trace scores maintained a high inverse relationship throughout the twelve month period. The average negative score was 37.9% of the total samples ranging from 51.2 in January to 31.7% in August. The negative samples decreased from 51.2 to 33.2% during January and February and thereafter ranged from 31.7 to 39.1% for the remainder of the study.

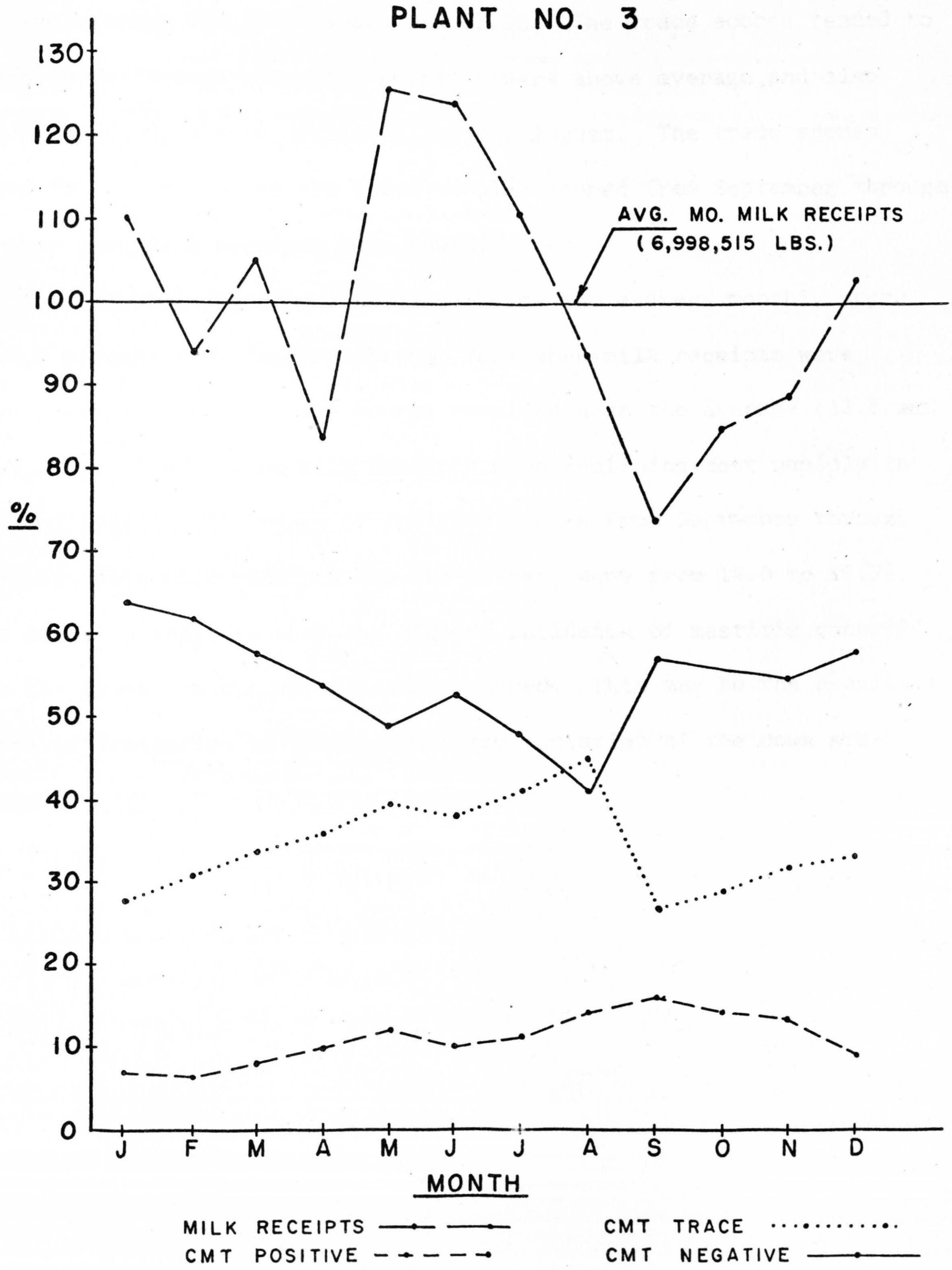

FIG. 3. MONTHLY TRENDS IN MILK RECEIPTS AND CMT SCORES FOR PLANT 3

The average CMT trace score was 51.2%. The trace scores tended to remain above average when milk receipts were above average and also when milk receipts were declining through August. The trace scores ranged from 45 to 49% of the total samples scored from September through December when milk receipts were lowest.

The CMT positive scores remained below the average monthly score of 10.9 percent from January through June when milk receipts were above average. The positive scores remained near the average (12.5 and 10.9% respectively) when milk receipts were declining most rapidly in June and August. The range of positive scores from September through December, when milk receipts was the lowest, were from 14.0 to 17.2%. This seems to indicate that the highest incidence of mastitis occurred when the lowest volume of milk was produced. This may be the result of increased irritation to the udder as the lactation of the cows progressed.

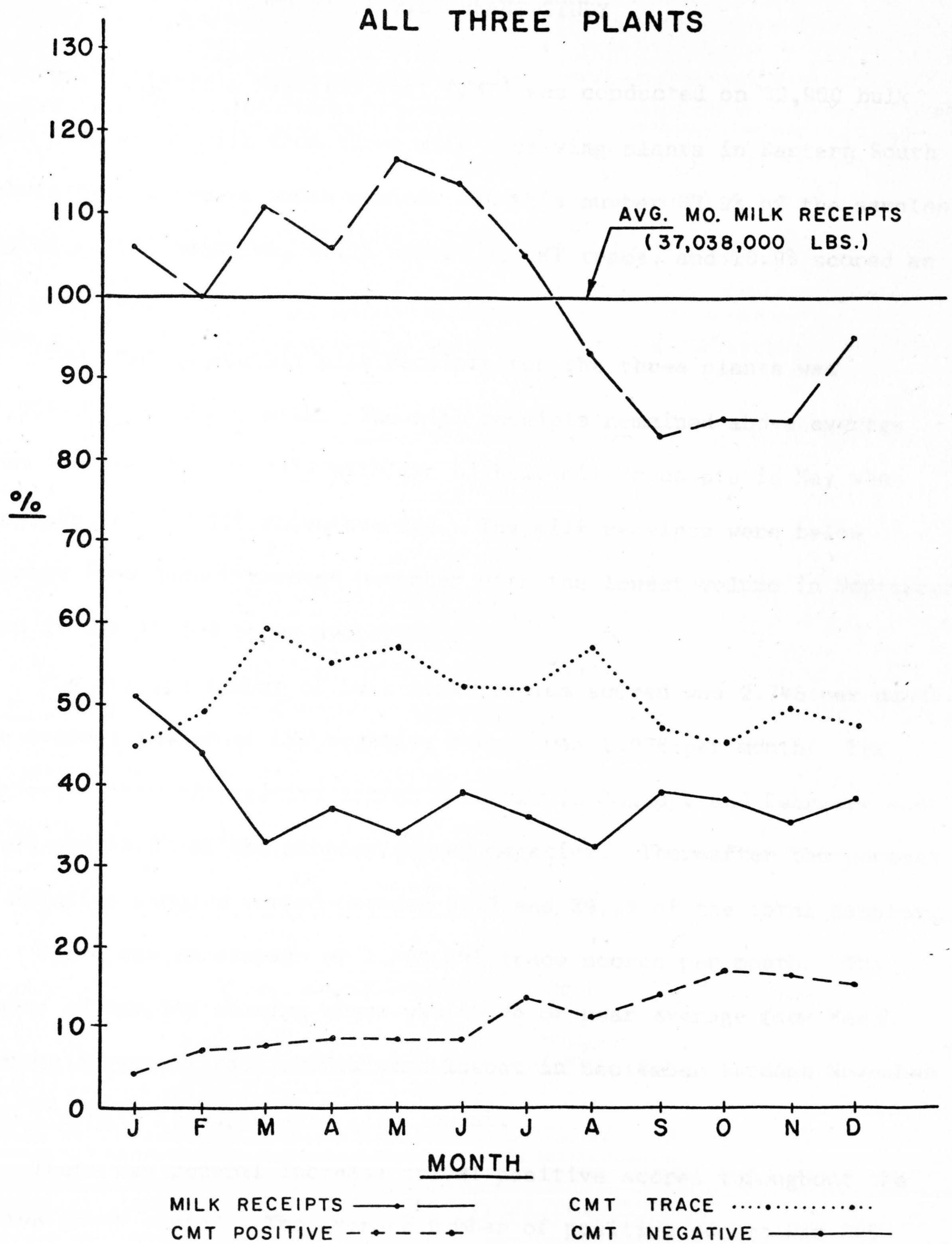

FIG. 4. MONTHLY TRENDS IN MILK RECEIPTS AND CMT SCORES FOR ALL THREE PLANTS

SUMMARY OF MILK PLANT STUDY

The California Mastitis Test (CMT) was conducted on 32,960 bulk tank samples of milk from three milk receiving plants in Eastern South Dakota over a twelve month period. Of this number 37.9% of the samples scored as CMT negative, 51.2% scored as CMT trace, and 10.9% scored as CMT positive.

The average monthly milk receipts for the three plants was 37,038,000 pounds of milk. The milk receipts remained above average from January through July with the highest milk receipts in May when receipts were 17.23% above average. The milk receipts were below average from August through December with the lowest volume in September when it was 17.14% below average.

The average number of bulk tank samples scored was 2,746 per month. The average number of CMT negative scores was 1,036 per month. The highest number of negative scores occurred in January and February when 51.2% and 43.5% of the samples scored negative. Thereafter the percent of negative samples varied between 31.7 and 39.1% of the total samples.

There was an average of 1,404 CMT trace scores per month. The number of samples scoring trace was above or near average from March through August. Trace scores were lowest in September through November when the milk receipts were also lowest.

There was general increase of CMT positive scores throughout the twelve month period. The average number of positive scores was 306 samples per month. The number of positive scores remained below average from January through June when milk receipts were highest and above average from July through December when milk receipts were lowest. The number of positive scores was 61.56 percent above average in October and 56.35% above average in November; milk receipts were 15% below average both months.

The fact of positive scores increasing during the months of lowest milk receipts while trace scores were decreasing and negative scores were remaining near the average suggests that udder irritation may be more common when milk production is low.

CONCLUSIONS

1. As plant receipts decreased CMT positive scores increased.
2. There were significant differences among plants. Plant 3 had the highest percent CMT negative scores. Plant 2 had the lowest percent CMT negative scores.
3. The CMT serves best as a general screening test only. The test was not designed as a plant quality test.

PART II

VARIATIONS IN THIRTEEN EASTERN SOUTH DAKOTA DAIRY HERDS TESTED WITH THE CMT MONTHLY FOR TWELVE CONSECUTIVE MONTHS

Part II of this project was a study of environmental and management factors which may be related to the production of abnormal milk. For purposes of this study abnormal milk is defined as that containing over 500,000 leucocytes per ml.

EXPERIMENTAL PROCEDURE

Thirteen commercial dairy herds cooperated in this project. They were selected in conjunction with the three milk plants which participated in Part I of this project.

In the thirteen herds 3,993 cows (15,796 quarters) were tested at least once during the twelve month period. There were 176 blind quarters on these cows. Herd sizes ranged from 15.9 cows to 42.7 cows; the average was 26.1. All the herds were Holstein-Friesians except for one Brown Swiss herd.

Sample collection. Samples of milk were taken at either the morning or evening milking. Wherever possible the samples were collected from a morning milking one month and an evening milking the following month. All cows were sampled immediately following udder washing and strip cup checking. Only three herds regularly used strip cups; however, during the test period the strip cup was used prior to sample collection on all herds. (Approximately 8 ml of foremilk was removed from each teat into the strip cup prior to collection of the sample.

Scoring and grading. The California Mastitis Test (CMT) was conducted in the manner described by Schalm and Noorlander (47), and the scoring procedure was the same as that described in the Experimental Procedure of Part I. Although little difficulty in interpreting the CMT scoring procedure occurred, randomly selected duplicate samples of CMT negative, trace, and positive scored milk were collected and delivered to South Dakota State University within thirty six hours. A direct microscopic leucocyte count (DMLC) was conducted on each of these samples. The procedure used for the DMLC was the same as described in Part I.

For each herd the number of quarters in milk were recorded and the percentage of negative, trace, and positive scores obtained were calculated each month. All of the herds except one (Herd No. 13) were enrolled in the Dairy Herd Improvement Program (DHIA), from which the average production per cow and the percentage of the herd in milk were taken from the DHIA record for each herd. (Appendix tables 9-21).

Scoring milking procedure and equipment. During the twelve month period, the technician collecting the samples also visually evaluated the milking procedures of the operators, the condition of the milking equipment used, and the herd environment. These observations were incorporated into a permanent record for the herd. In addition, during the first, sixth, and twelfth month, a milking machine equipment analysis conducted prior to and during the milking operation was made on each herd. The vacuum systems were tested with either the Surge[a] or the Bou-Matic[b] Flowmeter which measure the cubic feet of air movement per minute within the system. The pulsator operations and the milking operations were recorded with the Surge Lev-O-Graph which measures vacuum level at the teat cup and the speed and ratio of the pulsator. Vacuum levels and fluctuations at the teat cup were measured with a vacuum gauge while cows were being milked.

The results of tests and scoring were explained to the cooperator each time. Recommended milking procedures were also described to each cooperator after the first month and each month, thereafter, at his request. The milking machine analyses were explained after they were completed, and each cooperator was advised to consult with his milking equipment company service man about malfunctioning equipment. However, he was not obligated to change his management or equipment in order to participate in the project.

In addition to scoring each lactating quarter with the CMT, visual observations of udder preparation for milking, milking procedures, the general condition of the milking units, herdsmanship, and housing were made and results recorded.

Records of udder preparation for milking were evaluated in terms of time used by the operators washing and massaging udders. In judging the effectiveness of udder preparation by each cooperator a

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[a] Manufactured by Babson Bros. Co., 2100 South York Road, Oak Brooks, Illinois.

[b] Manufactured by Dari Kool Equipment Co., Madison, Wisconsin.

rating scale of 0 to 100 points was used. The lapse time was recorded as that time from the completion of washing and massaging to the attaching of the teat cups to lactating quarters. These time intervals were measured with a stop watch and recorded in seconds. Additional records were kept of the types of massage towels used and the percentage of time measured in months that sanitizers were used in washing solutions. (Appendix table 26).

As accurately as possible, the milking procedure was evaluated by recording the actual time each machine was used on each cow, the total operator time spent on each cow, the condition of the teats immediately following the removal of a milker, the dipping of the teats in a sanitized solution following milking, and the number of units the operator handled. Machine time covered the time from the attaching of the last teat cup to the removal of the last teat cup from each cow. This time was recorded with a stop watch and measured in seconds. Man time per cow also recorded in seconds included massage time, lapse time, and machine time per cow. Because not all of the cooperators practiced post milking teat dip, it was recorded separately rather than included in the man time per cow and calculated as a percent of the months practiced. (Appendix table 27).

Teat condition, post milking, was judged by visual observation in which the color of the teat indicating congestion or lack of it, the condition of the skin indicating normal or flooding teat cups, and the condition of the sphincter muscle were noted. The units per operator were determined by dividing the number of units in operation by the number of people actually operating them. A rating scale of 0 to 100 was used in evaluating the efficiency and effectiveness of the milking habits of each cooperator. (Appendix table 30).

Scoring of herdsmanship. Herdsmanship was evaluated on the basis of the cooperator's interest, alertness, ability to identify cows, knowledge, his care of equipment, and his sanitation. Each item was scored on a scale of 0 to 25 points providing a range from 0 to 150 points in the overall category of herdsmanship. (Appendix table 31).

Pulsator. Pulsator action was observed by the technician collecting samples; however, the recording of the rate, ratio, recovery time, and the general operation of each pulsator was done with the Babson Bros. Lev-O-Graph. The recordings, made during the first, sixth, and twelfth months of the study, were compared with the manufacturer's specifications for each particular type of unit. All pulsators, identified as pneumatic or electric, were given an overall rating on a scale ranging from 0 to 100 on the basis of the recordings and the general observations made at the time of the recordings. (Appendix table 28).

Scoring vacuum systems. A vacuum system analysis was made at the time of the pulsator recordings. For each system, the manufacturer's pump rating in cubic feet per minute (CFM) was compared with the actual CFM of the pump. Measurements were made with no milking units attached and with all units attached. The teat cup vacuum was measured at the teat cup while the unit was in operation by disengaging either the right or left rear cup and inserting the base of the vacuum gauge into the disengaged cup. Leakage of air into the teat cup was prevented by the technician attaching a rubber disc to the base of the vacuum gauge. Vacuum fluctuation of the teat cup was also observed by this visual method, but the actual values were recorded with the Lev-O-Graph. Scoring of each vacuum system on the basis of the recording and general observation was done on a scale ranging from 0 to 100. (Appendix table 29).

Scoring environment. The type of environment in which the cows were kept, the length and width of stalls, and the type and amount of bedding used comprised the housing record. A scale ranging from 0 to 100 was used in evaluating the type and condition of housing, its cleanliness, and the environment in general. (Appendix table 32).

The summary scores of overall management, equipment, and environment are presented in Appendix table 33.

RESULTS AND DISCUSSION

Monthly herd variations in the CMT results. The CMT was performed for twelve consecutive months on a total of 15,796 lactating quarters of 3,993 cows in thirteen commercial dairy herds in Eastern South Dakota. During this project 73.2% of the quarters classified negative, 14.4% classified trace, and 12.4% classified positive (Fig. 5 and Appendix tables 22, 23, and 24). The average percent of CMT negative scores ranged from a low of 64% to a high of 80%. The negative scores corresponded to the average milk production relatively closely. There was a general decline in the percentage of negative quarters as milk production declined. Similarly, as milk production increased, negative scores generally increased. During the sixth month, production decreased 11% and negative scores decreased 8.3%. The sixth month presented the largest decrease in negative scores; they generally continued to decrease until the tenth month when milk production was at its lowest point. During the tenth month, the negative samples increased 4.4% while milk production fell to 12% lower than average. As milk production increased during the eleventh and twelfth months, the negative scores increased to the highest levels of the twelve month period.

CMT trace scores ranged from a low of 9.4% in the fifth month to a high of 20.3% in the eighth month. During the first four months, the trace scores remained relatively stable and below the 14.4% average. Milk production also remained relatively stable during this period. During the fifth month, the trace scores decreased to 9.4% while milk production remained relatively stable. From the sixth through the tenth months, as milk production declined, trace scores increased to their highest levels; however, during the eleventh and twelfth months, as milk production increased, trace scores decreased to approximately the same level as that of the initial two month period.

CMT positive scores remained relatively stable the first three months. However, there was a general increase from the fourth through the tenth months. This increase in positive quarters occurred when milk production was above average and continued through the seventh month when a peak of 16.6% of all samples scored were positive. Milk production also decreased from 105.4% of average to 94.0% of average. There were 87.3% of all cows in milk in the seventh month (Appendix table 25); however, the percent of cows in milk decreased steadily the three succeeding months. This indicates that many of the cows had reached the latter stages of their lactation in the seventh month and were experiencing irritation in the udder. As milk production and the percent of cows in milk reached the lowest level from the eighth through the tenth month the percent of positive CMT scores remained above average. This type of pattern strongly suggests that many of those cows still lactating were exhibiting a high degree of irritation in the udder. On the other hand, during the eleventh and twelfth months when milk production was increasing, the percentage of positive scores decreased to the lowest levels of the twelve month study. This would suggest that a positive score during the latter part of a lactation may be a natural phenomena or there is a natural type of therapy occurring during the dry period.

The average percent of cows in milk for the twelve months was 86.0 (Appendix table 25). The range of cows in milk was 92.6% during the fourth month when production was at its highest level to 75.2% during the tenth month when production was at its lowest level. The percentage of cows in milk generally followed the level of milk production for the first nine months. There was a percentage drop in cows in milk proportionate to the percentage decrease in milk production during the tenth month. However, during the eleventh and twelfth months, the production average increased much more sharply than the percentage of cows in milk.

The general trend of milk production and the percentage of cows in milk indicate that a high percentage of the cows in the thirteen herds began their lactation shortly before or during the initial three months of the twelve month period. This trend further indicates that the largest percentage of cows in the herds completed their lactations from the eighth through the tenth months of the study.

There was a decline in the percentage of positive quarters the first three months of the study followed by a period of increase from the fourth through the seventh month. The tenth and eleventh months showed a decline, and the eleventh and twelfth months showed a much more rapid decline in positive scores. Thus, it would seem that udder inflammation as determined by the CMT increased in incidence as cows progress beyond the third and fourth months of lactation.

It is interesting to note that as the percentage of cows in milk reached the lowest point during the eighth, ninth, and tenth months of the project, the percentage of positive scores decreased slightly. Apparently cows calving again during these months sharply reduced the percentage of positive quarters during the tenth and twelfth months.

Because the percentage of positive scores was markedly reduced after the dry period, it may be postulated that the inflammation detected by the CMT before the dry period may have been caused by udder irritation. It may be further conjectured that removal of the source of irritation, presumably the milking machine, during the dry period, combined with complete physiological rest for the udder, can provide a natural type of therapy conducive to healing. The rest period may

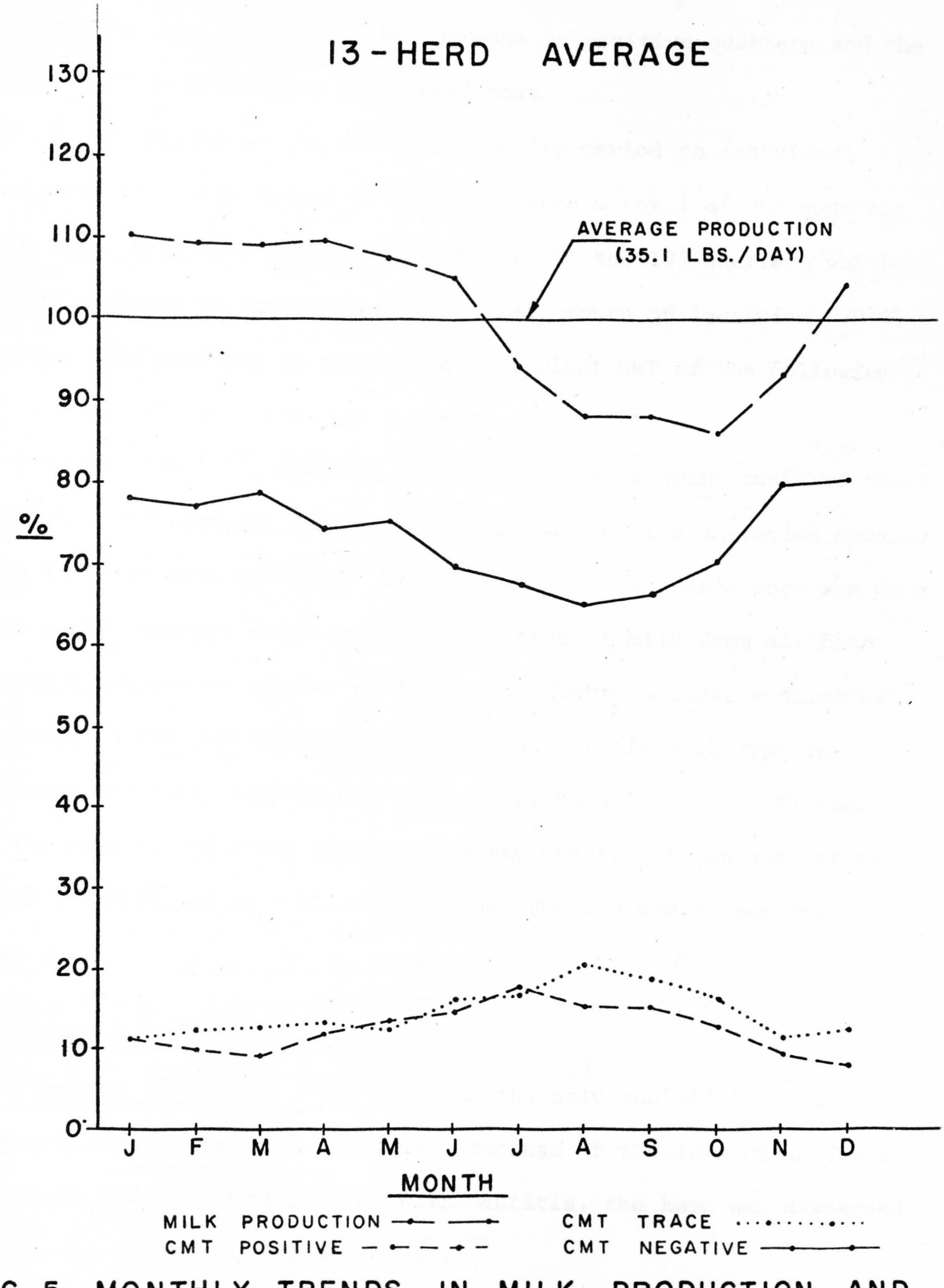

FIG. 5. MONTHLY TRENDS IN MILK PRODUCTION AND CMT SCORES FOR ALL HERDS

account, in this study, for the decrease in positive quarters and the increased milk production from fewer cows.

These results on the effect of the dry period on individual quarters agree with Braund (4). He compared a total of 368 quarters from four herds over a ten month period. Of the 122 quarters which scored positive to the CMT during the last month of lactation, 70.5% changed from positive to negative on the first CMT of the following lactations and 29.5% remained positive.

Noorlander (33), however, stated that cows showing positive reaction on bucket samples during the latter part of the lactation usually came in fresh with mastitis. The fact that Noorlander's work was done with bucket samples which contain one sample of milk from all four quarters instead of samples of individual quarters poses a dilution problem. A CMT positive bucket sample may contain milk from one severely irritated quarter and three quarters which score CMT negative or the reverse and other combinations may occur. If one quarter was severely irritated it could well be that the cow could come fresh with mastitis.

Individual herd summaries

Summary of herd 1. This herd was the only one which did not complete the twelve month schedule. Because of the loss of an operating lease and a serious problem with mastitis, the herd was dispersed during the tenth month of the study.

During the ten month period the herd was included in the study, the number of cows in milk averaged 42.7 per month. The herd was milked in a stanchion pipeline unit in which nine cows could be stalled at one time. After a group of three cows was milked, the three were released, and another group of three cows driven in and fed while the milking units were attached to three other cows. This process was repeated until all of the cows were milked. This procedure left little time for the operator to observe and attend to the three cows being milked. Neither was there adequate time allowed to thoroughly wash and massage the udders of the cows being prepared for milking. Post milking teat observation indicated considerable congestion at the teat ends and extrusion of the sphincter muscles. In addition, clinical mastitis was observed in many cows. The rapid rate of increased CMT positive scores from the fifth through the eighth month (Figure 6) may be attributed in part to irregular milking times. During this period field work received a disproportionate share of the operator's working time and energy. In general, the rapid rate of increase of CMT positive and trace scores may be attributed to lack of management rather than malfunctioning equipment.

Summary of herd 2. The number of cows in milk in this herd averaged 32.4 per month. The herd was housed in a stanchion barn which was insulated and ventilated. It contained a large number of older cows suffering from a general inflammation of the udder. The vacuum system and pulsators were initially under rated and malfunctioning, and lack of capital prevented investment in new equipment and cows.

The substantial decrease in positive scores, (Figure 7) occurring particularly during the first two months, may be attributed to

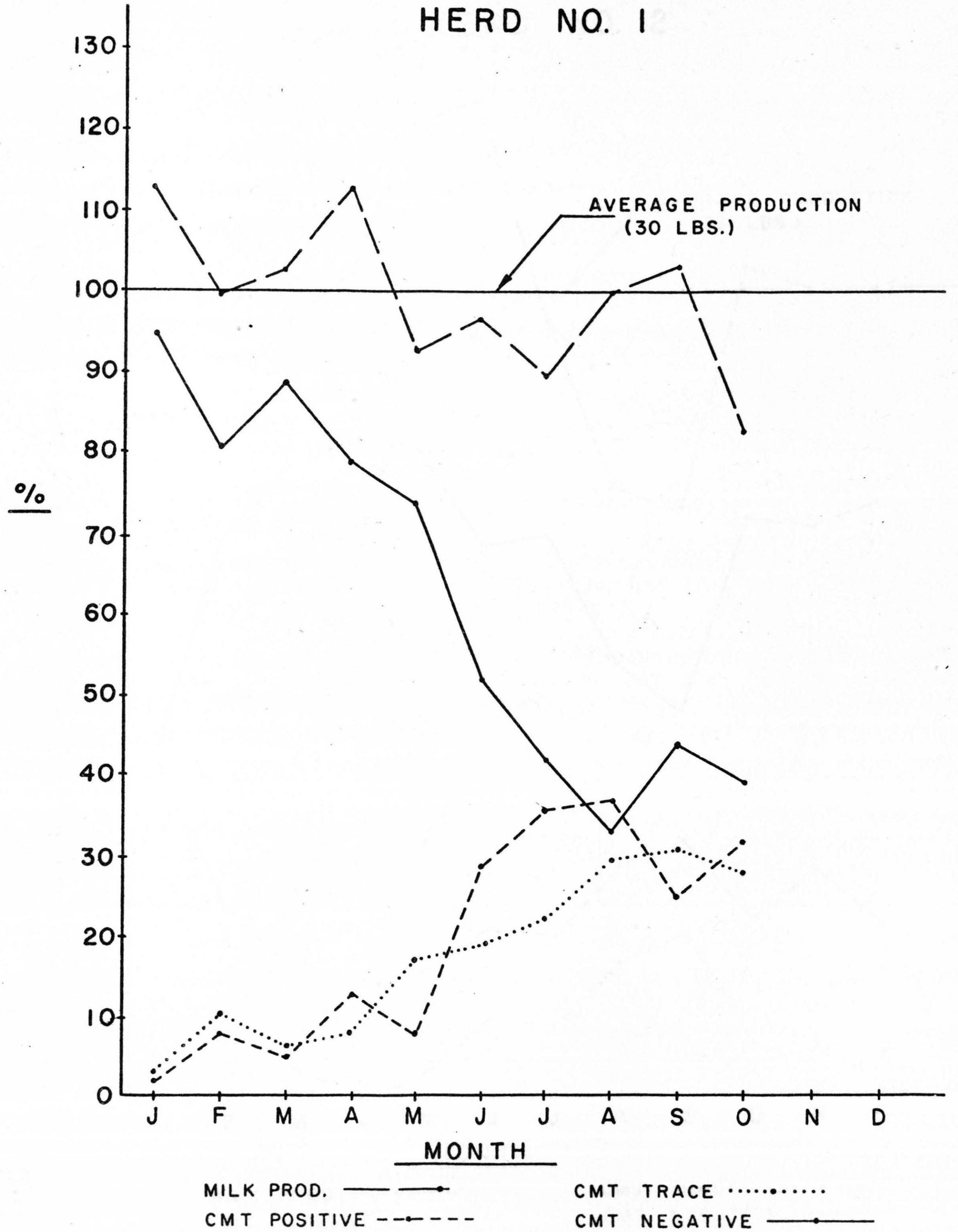

FIG. 6. MONTHLY TRENDS IN MILK PRODUCTION AND CMT SCORES FOR HERD I

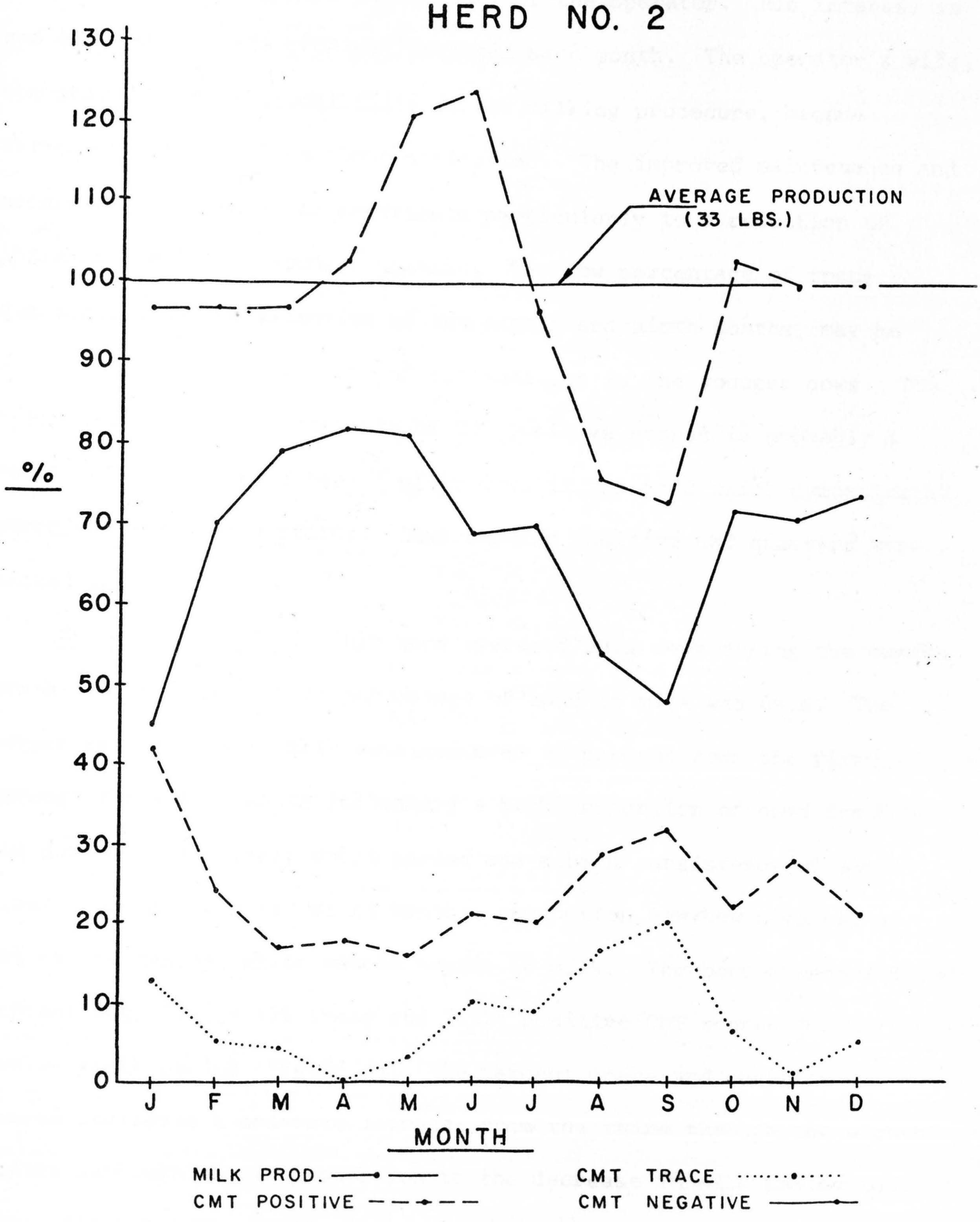

FIG. 7. MONTHLY TRENDS IN MILK PRODUCTION AND CMT SCORES FOR HERD 2

improvement in management on the part of the operator. His interest in and alertness to the problem increased each month. The operator's wife, who shared equal responsibility in the milking procedure, became extremely conscientious about sanitation. The improved maintenance and herdsmanship appeared to contribute particularly to a reduction of inflammation in the younger animals. The low percentage of trace quarters, with the exception of the eighth and ninth months, may be attributed to this reduction of inflammation in the younger cows. The relatively constant percentage of CMT positive scores is probably a result of the large number of older cows in the herd which demonstrated chronic inflammatory status. Cows showing positive CMT quarters were milked last.

Summary of herd 3. This herd averaged 28.1 cows during the twelve month period; the average percentage of cows in milk was 84.6. The percentage of cows in milk remained over 90 percent from the first through the eighth month indicating a high proportion of cows freshening during a relatively short period and a high persistency of lactation. During the first eight months, production per cow remained at 93% of the average which was 43 pounds of milk. The herd averaged 83.36 percent negative, 9.42% trace and 7.22% positive CMT scores during the twelve month period (Figure 8). The percent trace and positive scores indicated a moderate increase from the third through the eighth months although not in proportion to the decrease in milk production. These figures suggest some degree of irritation particularly during the latter stages of lactation. During the ninth through the eleventh

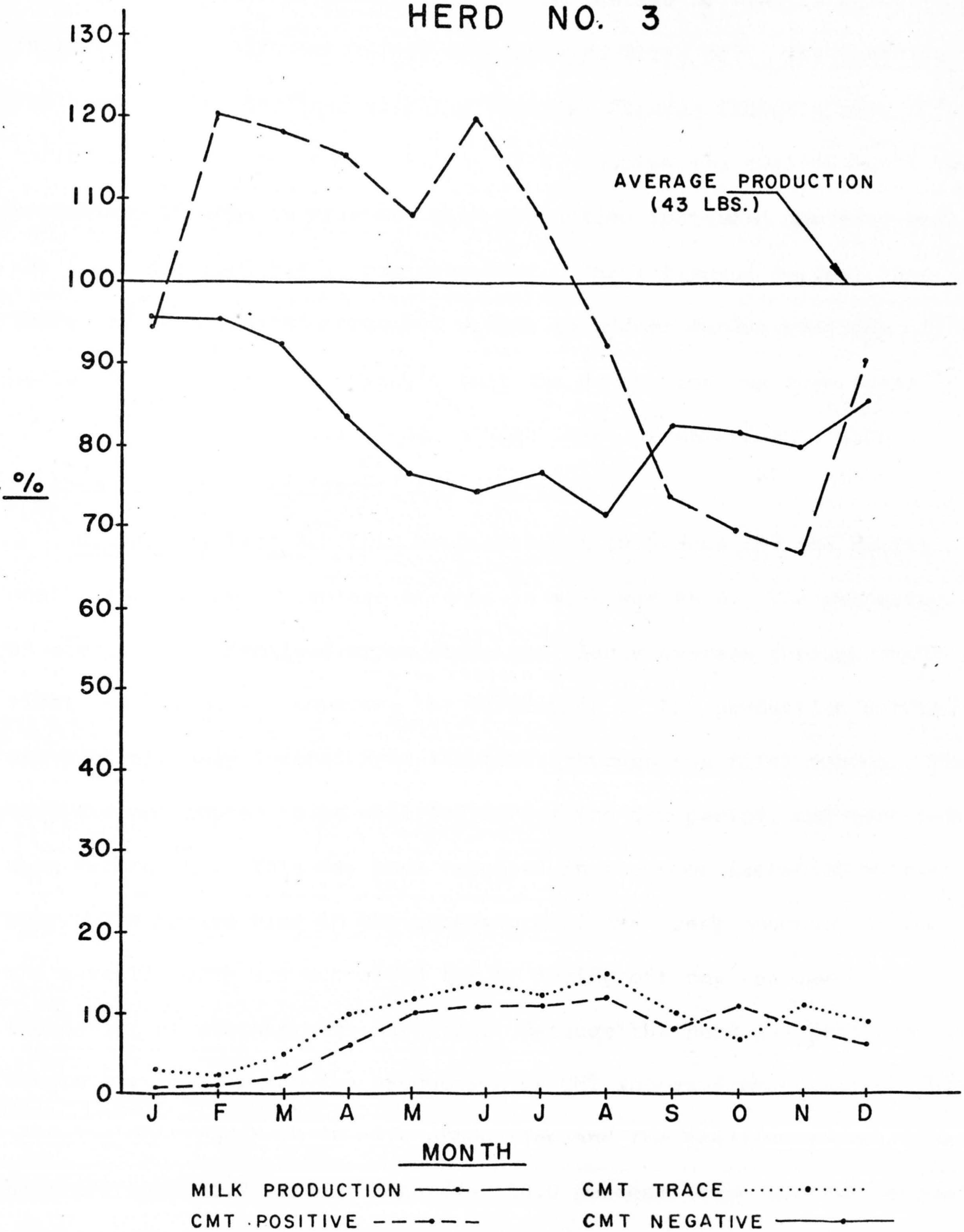

FIG. 8. MONTHLY TRENDS IN MILK PRODUCTION AND CMT SCORES FOR HERD 3

months, the average production and the percentage of cows in milk indicate that a high percentage of cows were dried off. The positive and trace scores declined slightly, but the figures indicate some inflammation in those cows still in milk. During the twelfth month the percentage of cows in milk and milk production increased markedly while the trace and positive scores decreased. These figures suggest that there had been limited permanent damage to udders during previous lactations. It further suggests that the dry period was beneficial.

The overall scores indicate a high level of management, maintenance of milking equipment, and environment.

Summary of herd 4. This herd averaged 18.0 cows for the twelve month period; the percentage of cows in milk was 88.0. The percentage of cows in milk remained at or above the yearly average through the first seven months. However, the percentage of the production average was precipitously lowered from the first through the fifth months. The cows did not appear to be well fed during the dry period, and were thin upon freshening. This may have resulted in the poor lactation persistency. The marked rise in the percentage of average production during the seventh month was accounted for by drying off one cow and the freshening of another with mastitis. Because the herd was small, a single cow could alter the production or CMT scores dramatically. This altering occurred both in milk production and the positive score. The herd averaged 82.7 percent negative, 10.0 percent trace and 7.3 percent positive CMT scores during the twelve month period (Figure 9).

From the eighth through the eleventh months, the milk production

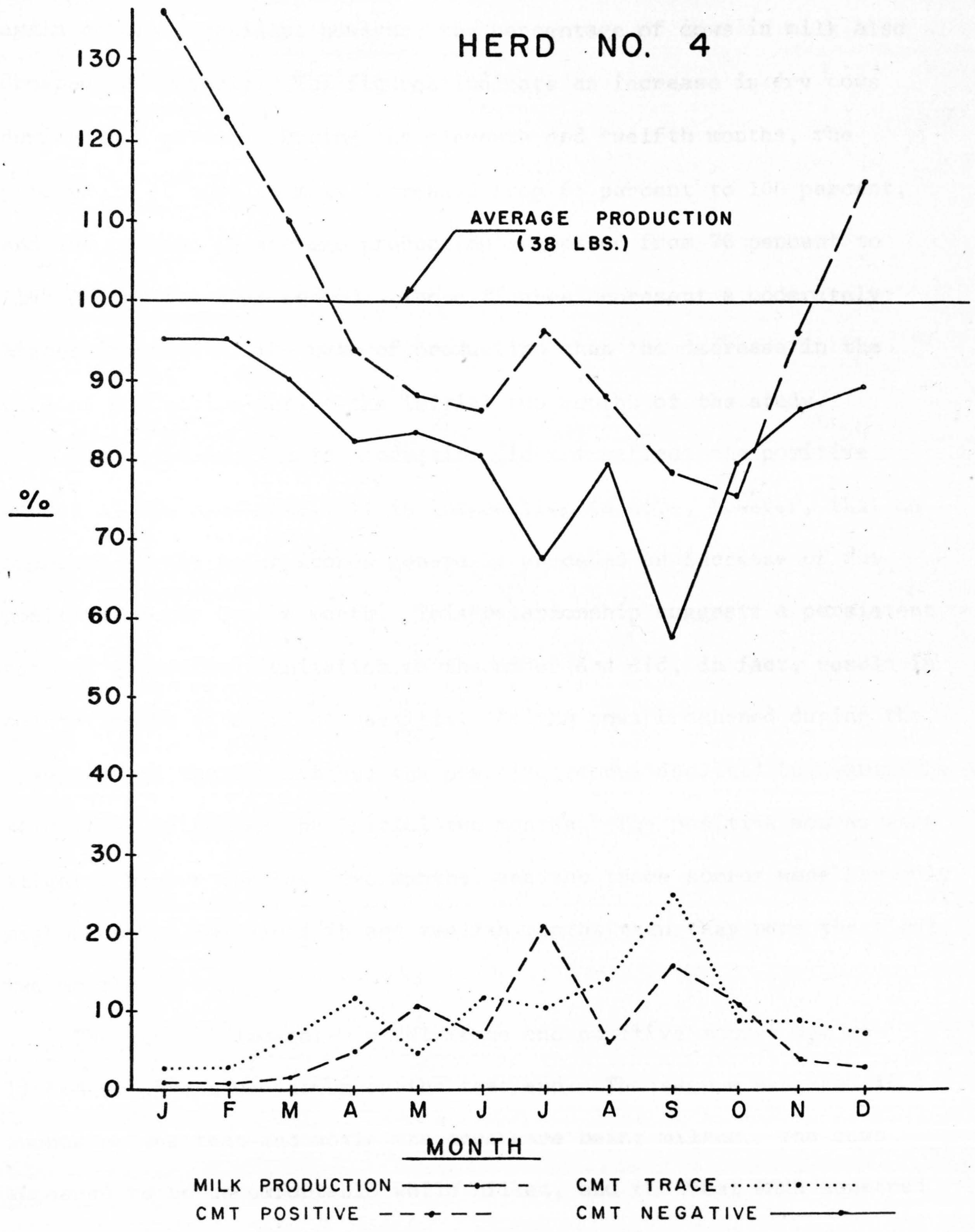

FIG. 9. MONTHLY TRENDS IN MILK PRODUCTION AND CMT SCORES FOR HERD 4

again declined rapidly; however, the percentage of cows in milk also dropped accordingly. The figures indicate an increase in dry cows during this period. During the eleventh and twelfth months, the percentage of cows in milk increased from 65 percent to 100 percent, and the percent of average production increased from 76 percent to 116% during the same period. These figures represent a moderately higher increase in the rate of production than the decrease in the rate of production during the initial two months of the study.

The rapid decline in production did not reflect the positive scores at the same rate. It is interesting to note, however, that an increase in the trace scores generally preceded an increase of the positive scores by one month. This relationship suggests a persistent rate of increasing irritation to the udder and did, in fact, result in some evidence of clinical mastitis. As the cows freshened during the eleventh and twelfth months, the positive scores declined to nearly the same level as during the initial two months. The positive scores were slightly higher the last two months, and the trace scores were markedly higher during the eleventh and twelfth months than they were the first two months.

The general increase in CMT trace and positive scores may be linked to excessive vacuum on the teat end. The vacuum measured 16.5 inches on the teat end while the cows were being milked. The cows appeared to be uncomfortable while milked, and the teat ends appeared congested and red after milking. There was evidence of a malfunctioning vacuum regulator recorded on the Lev-O-Graph; however, it was discovered later that the rubber gasket on the check valves of both units were deteriorated and not seating properly.

Summary of herd 5: This herd averaged 23.5 cows for the twelve months period; the percent of cows in milk was 87%. The herd averaged 71.5% negative, 14.2% trace, and 14.3% positive CMT scores during the twelve month period (Figure 10). Through the first six months the percent of cows in milk remained above or at the yearly herd average. During the first month when 100% of the cows were in milk, milk production was at the highest level; however, during the following five months, the production was remarkably close to the yearly average production of 41 pounds of milk per cow. The trace and positive scores showed a gradual increase during the first six months. The negative scores remained relatively stable, particularly through the first 5 months; however, from the sixth through the ninth months the negative scores were reduced and the positive scores increased proportionately.

The CMT positive and trace scores reached their highest levels during the eighth and ninth months of lowest average milk production and cows in milk. These results occurred also during the tenth month. This indicated udder irritation gradually increased through the first to the ninth months. During the tenth month trace and positive scores were markedly reduced. The positive scores remained at their lowest levels during the eleventh and twelfth months, however, the trace scores increased during this same period. Milk production increased sharply as the cows freshened during the eleventh and twelfth months. However the pattern of trace and positive scores during the last two

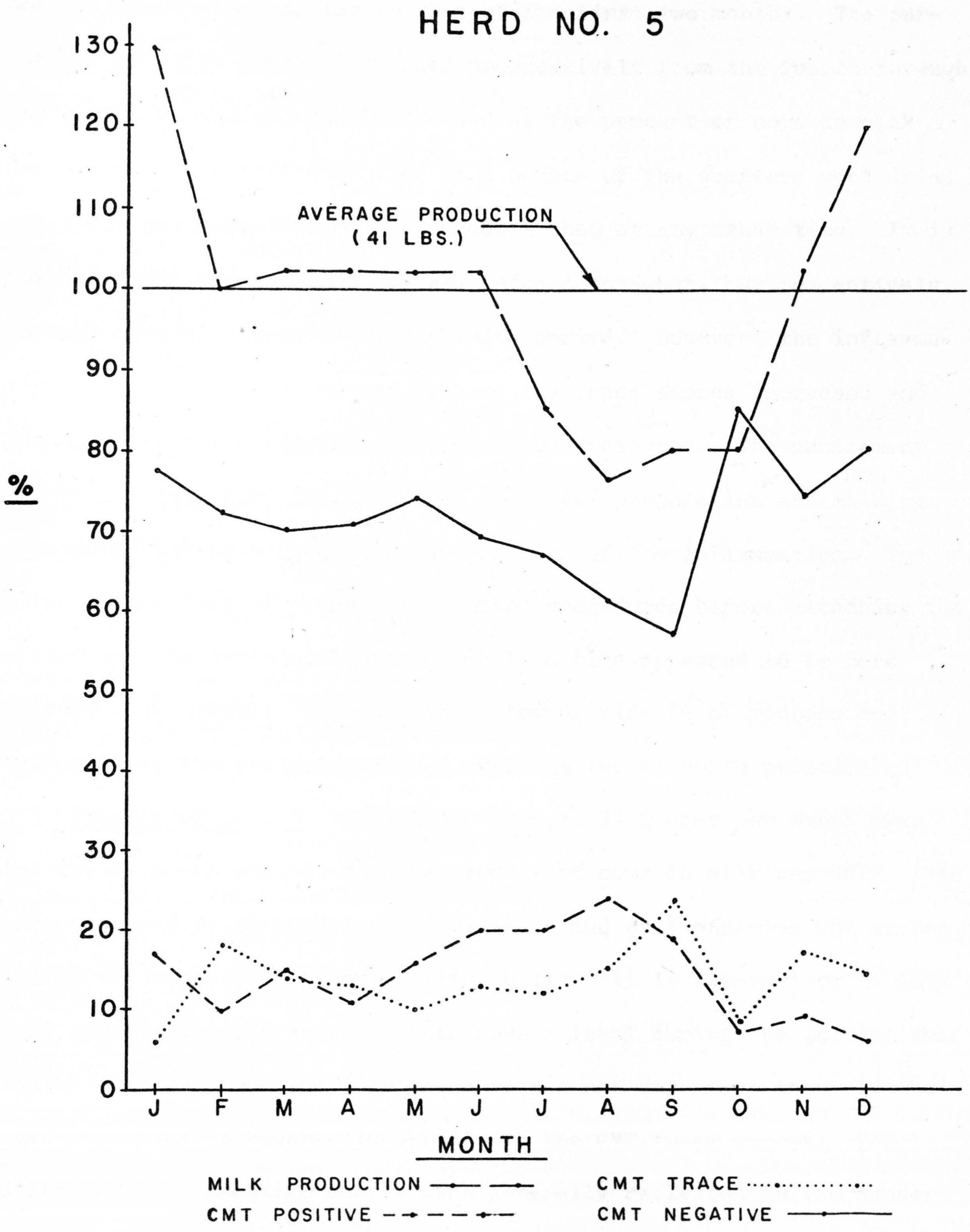

FIG. 10. MONTHLY TRENDS IN MILK PRODUCTION AND CMT SCORES FOR HERD 5

months is somewhat similar to that of the first two months. The percent of positive scores increased progressively from the fourth through the eighth months and then decreased as the percent of cows in milk decreased. This indicates that as a number of the quarters were dried off there was more inflammation present than at any other time. It is possible that the inflammation was reduced somewhat, but not entirely, through natural therapy during the dry period. However, the inflammation was not entirely reduced because the trace scores increased and the negative scores decreased as the cows freshened. The management scores for this herd indicate that the udder preparation and milking procedures may have been the cause of much of the inflammation. The effects from lack of proper stimulation procedures before attaching the milker and the extended length of machine time appeared to be more extreme than normal. The teat ends showed evidence of redness and hardening as the study progressed over the twelve month period.

Summary of herd 6. This herd averaged 24.2 cows per month over the twelve month period, and the percent of cows in milk was 88.9. The herd averaged 81.9% negative, 10.0% trace and 8.1% positive CMT scores during the twelve month period (Figure 11). It is interesting to note that negative scores were at their lowest level during the initial two months of the period and from there on did not vary more than 9%. This same phenomena in reverse occurred with the CMT trace scores. The differences in negative scores were generally reflected in the number of trace scores.

The CMT positive scores were also at the highest levels during the

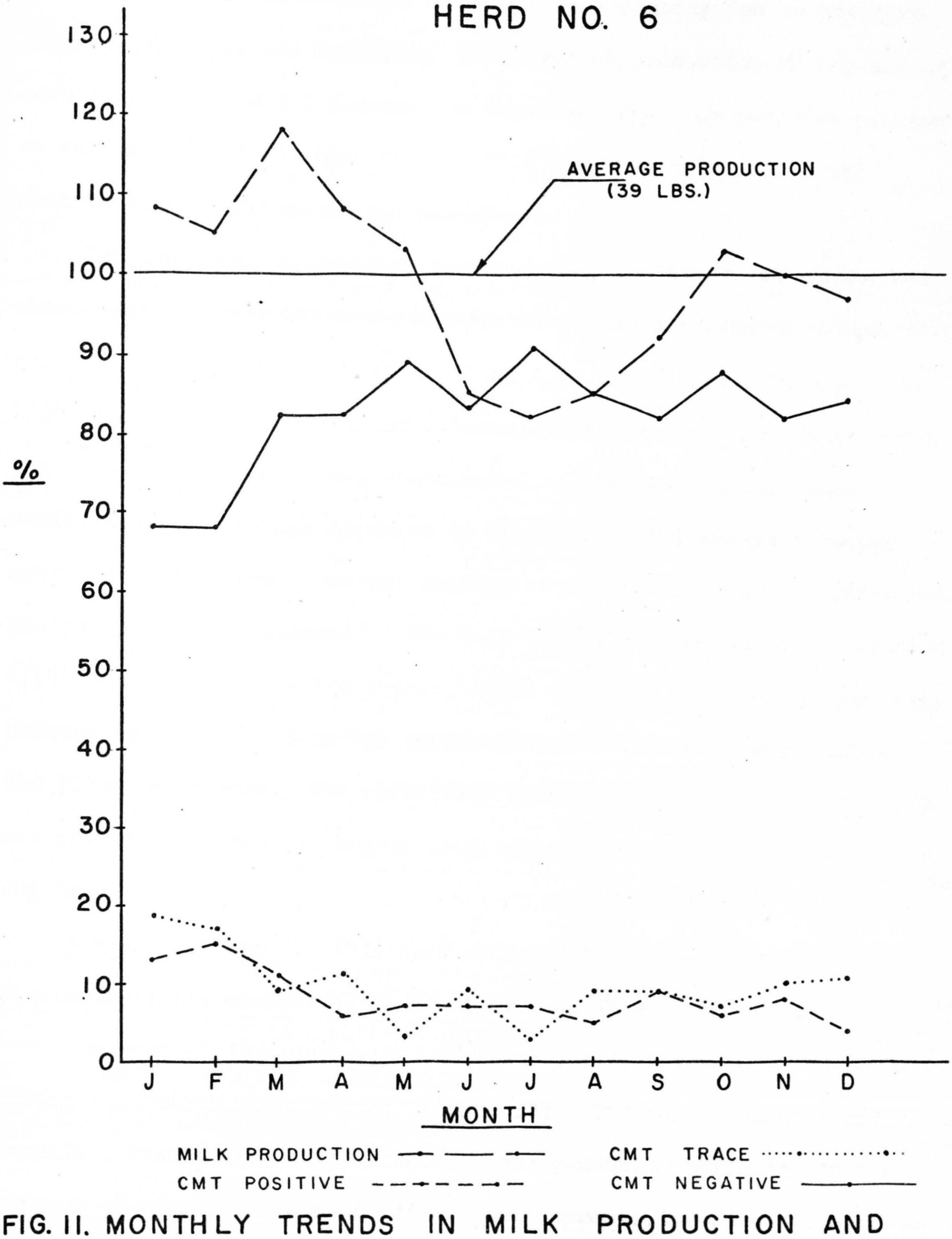

FIG. 11. MONTHLY TRENDS IN MILK PRODUCTION AND CMT SCORES FOR HERD 6

initial two months. However, there was less fluctuation in positive scores than trace and negative. The level of production or percent of cows in milk did not influence the negative, trace or positive readings as much as it did in other herds. This may be attributed to the conscientious attitude of the management.

The low level of negative scores during the first two months and consequently higher CMT trace and positive scores reflected a lack of general knowledge in management and milking procedures. However, the high degree of cooperation and interest during the entire twelve month period are believed to have contributed to the reduced incidence of positive scores. There appeared to be a somewhat inadequate vacuum system for this herd, however; because of a lack of capital, additional equipment was not purchased. The fact that the trace scores fluctuated with those of the negative scores, while positive scores were generally reduced may be related to the inflammation which was apparent during the first two months. The relatively constant percent of positive cows was probably related to chronic conditions of some of the older cows in the herd.

Summary of herd 7. This herd averaged 47.8 cows per month over the twelve month period; the percent of cows in milk was 86.25. The herd averaged 81.1% negative, 12.8% trace and 6.1% positive CMT scores during the twelve month period (Figure 12). The percentages of CMT negative, trace, and positive scores were generally reflected in the percent of average milk production. The increase in trace scores from the third through the tenth months and the increase in positive scores

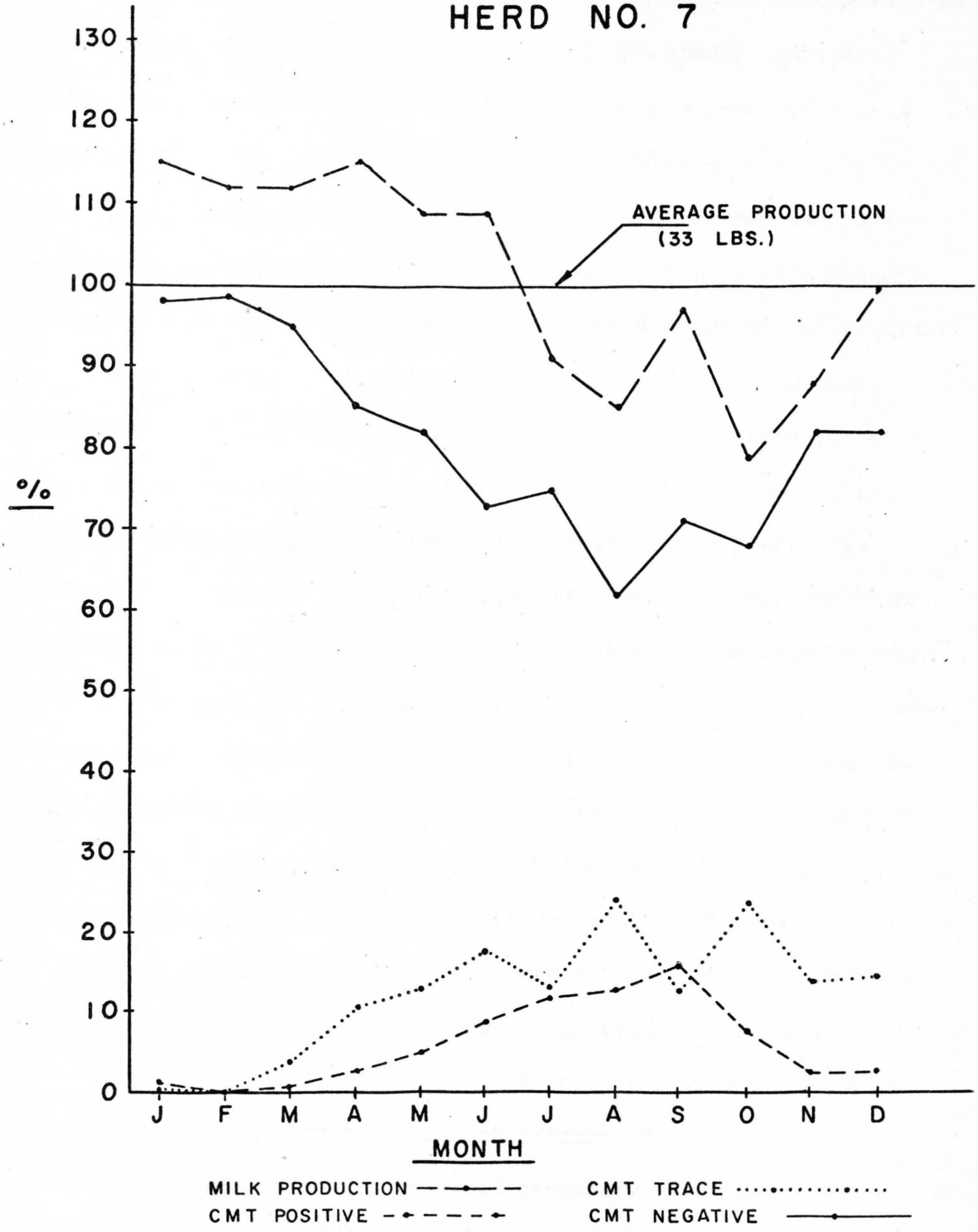

FIG. 12. MONTHLY TRENDS IN MILK PRODUCTION AND CMT SCORES FOR HERD 7

from the fourth through the ninth months was more specifically related to management. As field work progressed in the spring and summer months, trace and positive scores increased proportionately. Less thoroughness on the part of the operator was noted particularly in the areas of milking interval, udder preparation and general sanitation. The milking equipment and vacuum system generally were satisfactory. During the time of the season when field work did not interfere with the dairy enterprise, the level of management increased markedly. This probably resulted in the extremely low percentage of trace and positive scores during the initial three months of the study. The decline in positive scores during the eleventh and twelfth months was also attributed to a higher level of management. However, the low (70%) level of cows in milk (Appendix table 25) suggests that some of the positive cows were dry. It was apparent that the dry period provided therapy which reduced the inflammation that had occurred during the latter stages of the previous lactation. However, the fact that the trace scores were considerably higher during this same period may indicate that spontaneous recovery through dry cow therapy was not complete.

Summary of herd 8. This herd averaged 31.1 cows per month over the twelve month period, and the percent of cows in milk was 82.90. The herd averaged 83.9% negative, 11.2% trace and 4.9% positive CMT scores during the twelve month period (Figure 13).

The CMT negative scores remained generally relative to the average milk production. The sharp reduction in production which occurred during the fifth month was not reflected in a decrease of cows in milk

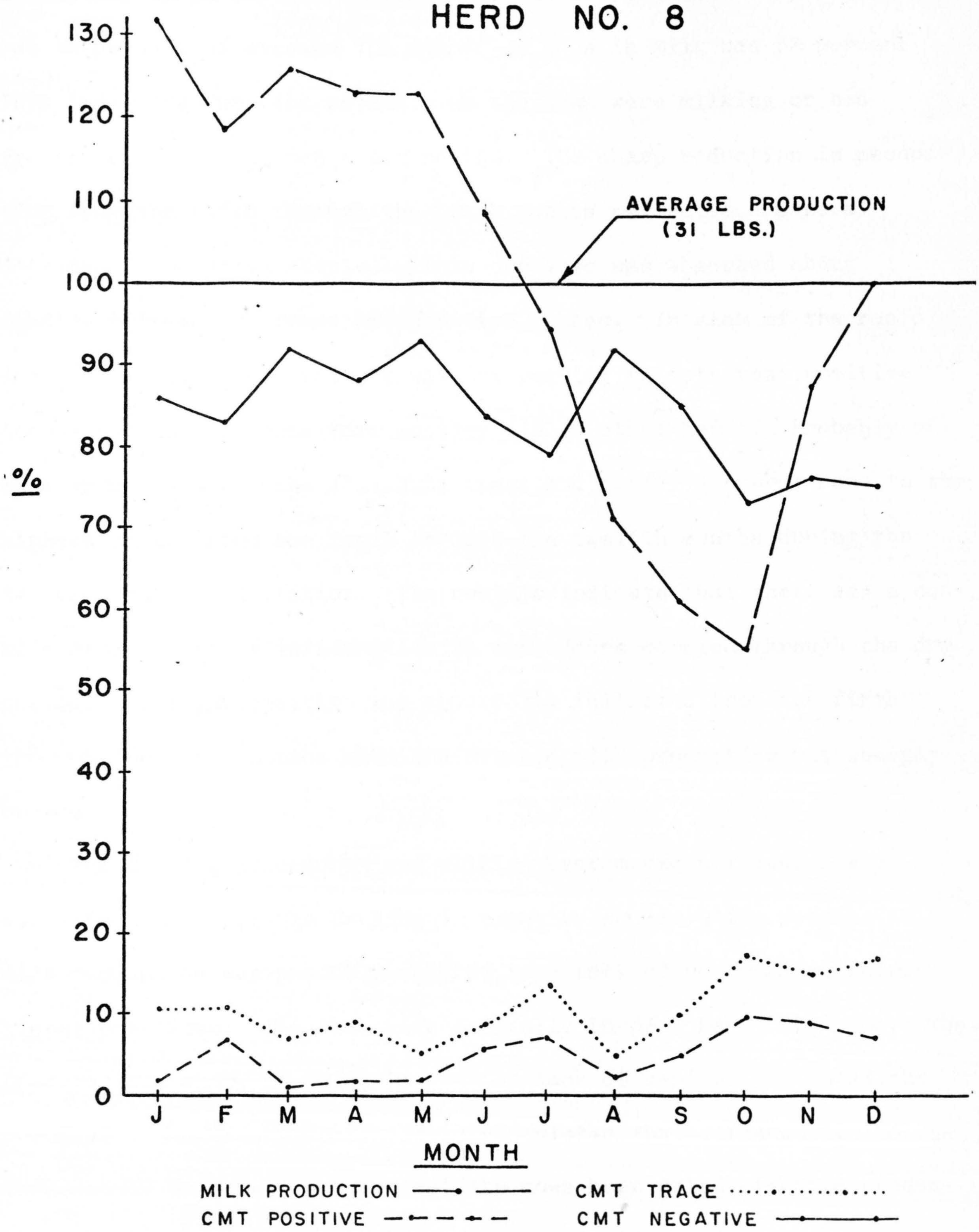

FIG. 13. MONTHLY TRENDS IN MILK PRODUCTION AND CMT SCORES FOR HERD 8

until the eighth month. During the tenth month when milk production was 55 percent of average the number of cows in milk was 57 percent. This indicates that the majority of the cows were milking or had freshened within the ten month period. The sharp reduction in production from the fifth through the tenth months reflected a general decrease in negative samples. This decrease was absorbed about equally between the trace and positive scores. In view of the rapid decline in milk production it was interesting to note that positive scores did not increase more as they did in other herds. Probably of more importance was the fact that trace and positive scores rose to the highest levels from the tenth through the twelfth months during the latter stages of lactation. The results indicate that there was a considerable amount of inflammation in the udders carried through the dry period. This inflammation was apparently initiated from the fifth through the ninth months when the average milk production was sharply reduced.

The milking procedures and milking system did not reveal any specific causes for the decline in negative scores. The decline in milk production was probably related to a lack of recommended nutritional practices. The cows were generally in poor body condition. The operator was aware of this, however, a lack of capital prevented the purchase of necessary feed. It is postulated that inflammation to the udder could have been reduced had the cows been dried off when production reached 70 percent of the average production which was 21.5 pounds per day. This would have been approximately 11 pounds of milk per milking. This occurred during the eighth month when the trace and positive scores were at 5.4 and 1.8 percent. It appeared questionable whether the milk could be effeciently removed from the udder at this low production level. It was not possible to measure intramammary pressure in this project, but this appeared to be lacking even after thorough udder preparation. It was also evident through visual observation of the teat after milking that the teat ends were congested, probably due to leaving the milkers on an excessive length of time.

Summary of herd 9. This herd averaged 17.6 cows over the twelve month period; the percent of cows in milk was 88. The herd averaged 76.0% negative, 12.1% trace and 11.9% positive CMT scores during the twelve month period (Figure 14).

The negative scores remained consistent with milk production in this herd. During the first five months when production was 13%-15% above average the negative scores ranged from 98 to 79%. During the succeeding six months when production dropped from 92 to 72% of average, the negative scores ranged from 52 to 78%. The decrease in negative scores with the corresponding decrease in milk production suggests increasing irritation to the udder. It was particularly noticeable in the evaluation of udder preparation and milking procedures that the milkers did not follow suggested milking practices. Close examination of the teats and sphincter muscle immediately after the removal of the milker unit revealed congestion in the teats and a slight protrusion of the sphincter muscles. As the study progressed from the sixth through the ninth months the teat congestion and sphincter muscle

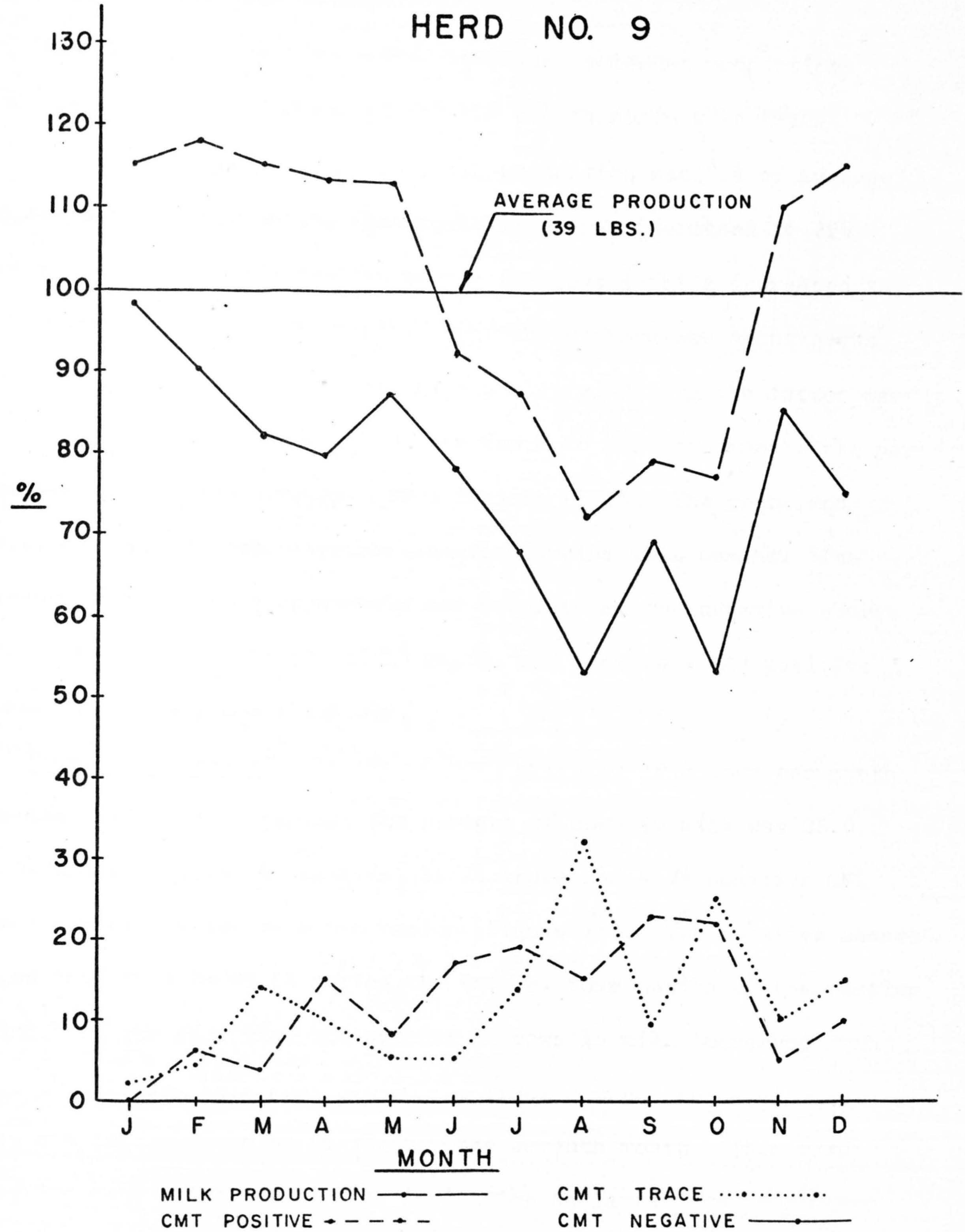

FIG. 14. MONTHLY TRENDS IN MILK PRODUCTION AND CMT SCORES FOR HERD 9

protrusions became more evident.

The trace and positive scores increased somewhat proportionately during this period except for the eighth month when trace scores increased from 14% to 32% (milk production was 72% of average) and the 9th and 10th months when positive scores increased to 22%. During the eleventh and twelfth months the cows in milk increased to 100% from 68% in the tenth month. Apparently there was spontaneous recovery from the udder irritations experienced during the latter part of the previous lactations. From the tenth to eleventh months the percent negative scores increased from 52.5 to 85.1%. The trace and positive scores decreased proportionately during this period. The recovery, however, was apparently not complete as the negative scores decreased the following (twelfth) month, and the trace and positive scores increased proportionately.

Summary of herd 10. The No 10 herd averaged 19.3 cows per month over the twelve month period; the percent of cows in milk was 85.0. The herd averaged 79.1% negative, 15.2% trace and 4.7% positive CMT scores during the twelve month period (Figure 15). The negative scores ranged from 86.9 to 89.5% during the initial four months of the testing period. At the same time the percent of cows in milk increased from 60 to 96. During this same period the trace scores increased consistently and continued to do so through the seventh month. This rise would indicate slight degrees of irritation as lactations progressed. The negative and trace scores were correlated in the decline in milk production during the entire period. As the milk production declined

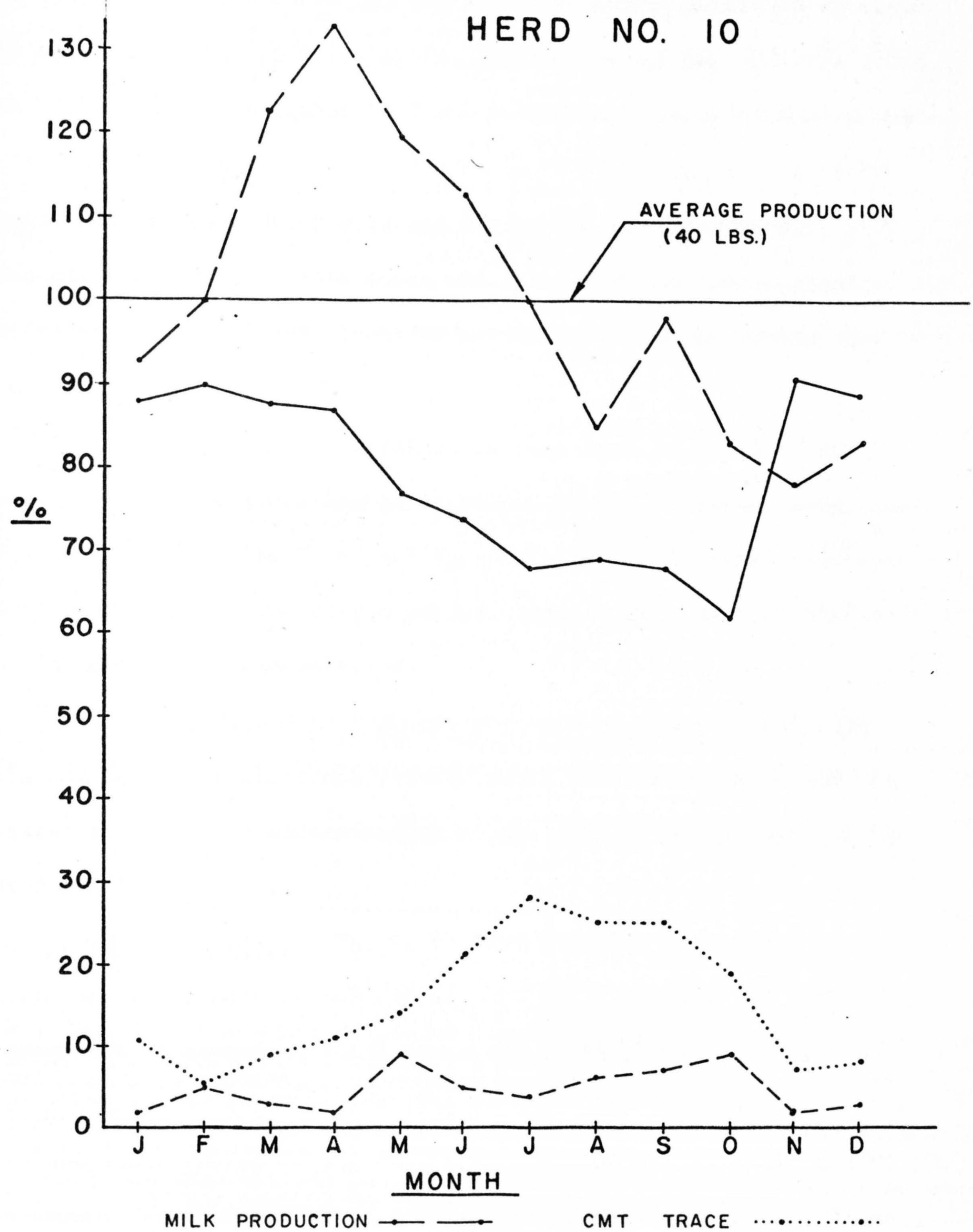

FIG. 15. MONTHLY TRENDS IN MILK PRODUCTION AND CMT SCORES FOR HERD 10

the trace scores increased and the negative scores decreased at about the same rate. The positive scores did not reveal any definite trend. The highest positive scores (8.7 and 8.75%) were recorded during the fifth and tenth months. Milk production declined during the fifth month from the peak which occurred during the previous month. Milk production during the tenth month was at the second lowest level of the entire period (the lowest level of production occurred during the preceding month).

The degree of udder irritation in this herd is revealed in the trace scores. The trace scores increased as the lactation progressed after freshening. The fact that the positive scores were relatively constant throughout the entire period suggests well managed herd with a low incidence of acute mastitis.

The management and environment scores were constant and high. This may be due to the comparatively small size of the herd and the general attitude and understanding of the problem on the part of the owner of the herd.

Summary of herd 11. The No 11 herd averaged 42 cows over the twelve month period; the percent of cows in milk was 87.6. The herd averaged 38.0% negative, 39.3% trace and 22.7% positive CMT scores during the twelve month period (Figure 16). The high percent of positive and trace scores during the first 5 months was a reflection of the management, environment and a malfunctioning milking system. A new vacuum system was installed during the fifth month of the study. Thereafter the percent negative scores increased dramatically. This increase

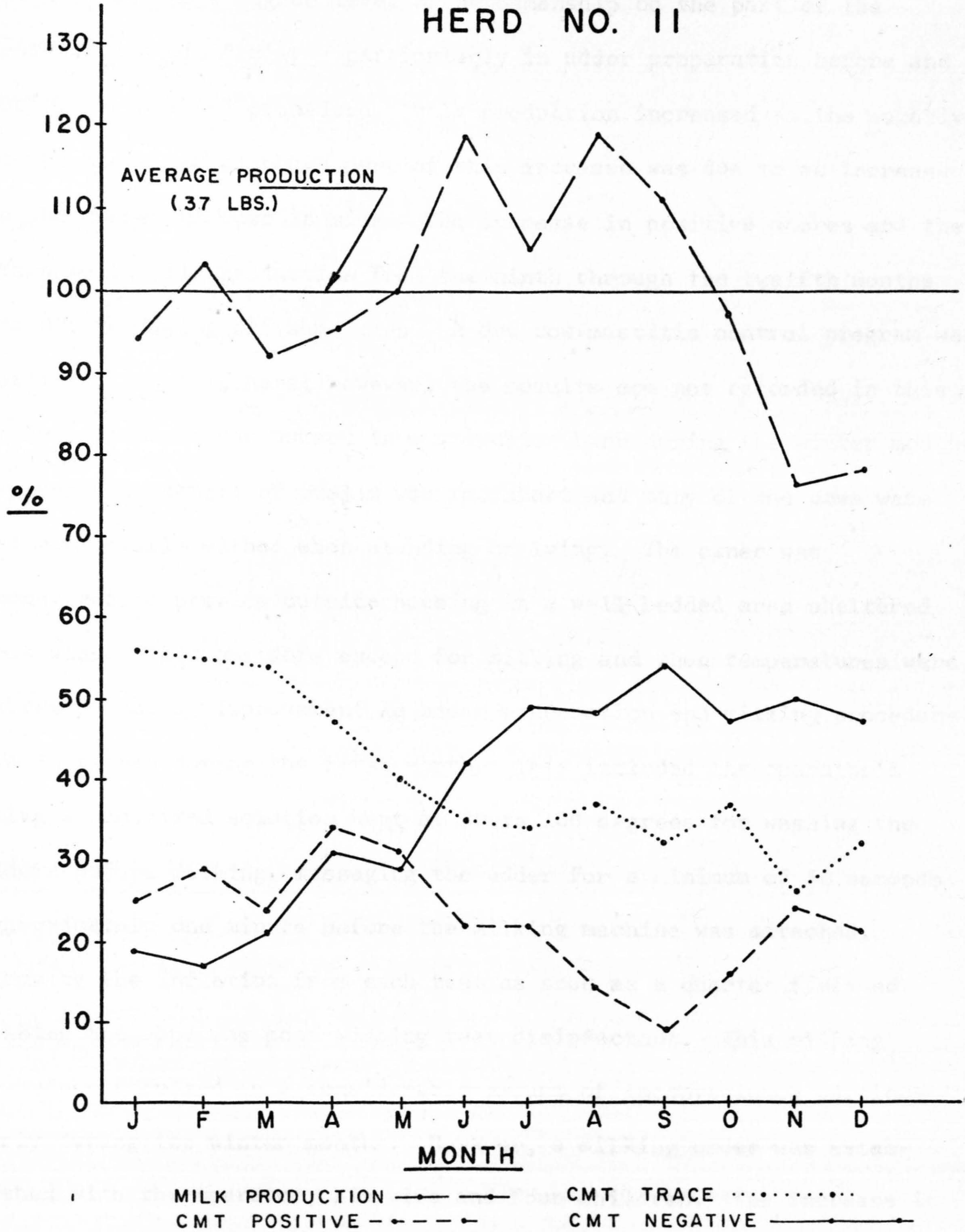

FIG. 16. MONTHLY TRENDS IN MILK PRODUCTION AND CMT SCORES FOR HERD 11

was also due to a higher level of herdsmanship on the part of the operator and his family - particularly in udder preparation before and during the milking procedure. Milk production increased as the negative scores increased although part of this increase was due to an increase in the number of cows in milk. The increase in positive scores and the decrease in milk production from the ninth through the twelfth months was due to drying off some cows. A dry cow mastitis control program was initiated for this herd; however, the results are not recorded in this study. The herd was housed in a stanchion barn during the winter months; however, the length of stalls was too short and many of the cows were not comfortable either when standing or lying. The owner was encouraged to provide outside housing in a well bedded area sheltered from wind. This was done except for milking and when temperatures were extremely cold. Improvement in udder preparation and milking procedure was initiated during the first month. This included the operator's using a sanitized solution kept at 90 to 100 degrees for washing the udders before milking, massaging the udder for a minimum of 30 seconds approximately one minute before the milking machine was attached, removing the inflation from each teat as soon as a quarter finished milking and applying post milking teat disinfectant. This milking procedure resulted in a considerable amount of inconvenience particularly during the winter months. However, a milking order was established with the operator, his wife and four children. The increase in milk production and the increase in negative scores provided an incentive for the operator to maintain a rigid milking procedure. The effects of these improvements were dramatic in the improvement in production and reduction in mastitis.

Summary of herd 12. The No 12 herd averaged 16.4 cows per month over the twelve month period; the percent of cows in milk 86.4. The herd averaged 64.0% negative, 14.9% trace, and 21.1% positive CMT scores during the twelve month period (Figure 17). A relatively constant number of cows in this herd demonstrated a positive reaction regardless of the stages of the lactations. These cows did not demonstrate the symptoms of acute mastitis; however, palpation of the udders revealed congestion. It appeared that cows were not letting milk down well and excessive machine stripping was required to remove the milk from the udders of these cows. There was little doubt that this practice induced irritation to the teats as they appeared red and irritated upon removal of the machines. The sphincter muscles on the majority of the teats protruded to various degrees. The relationship of trace and positive scores was fairly consistent and occurred in the same cows which demonstrated a positive CMT reaction.

The decrease in milk production from 24% above average to 25% below average from the third through the ninth months was due in part to the fact that machine stripping was not practiced on several of the cows previously mentioned. This resulted in less milk production and did not reduce the positive scores. In fact this practice may have increased the trace scores. These cows were dried off before a standard 305 day lactations were completed and treated for mastitis as they were dried off. Although this study was not extended to determine

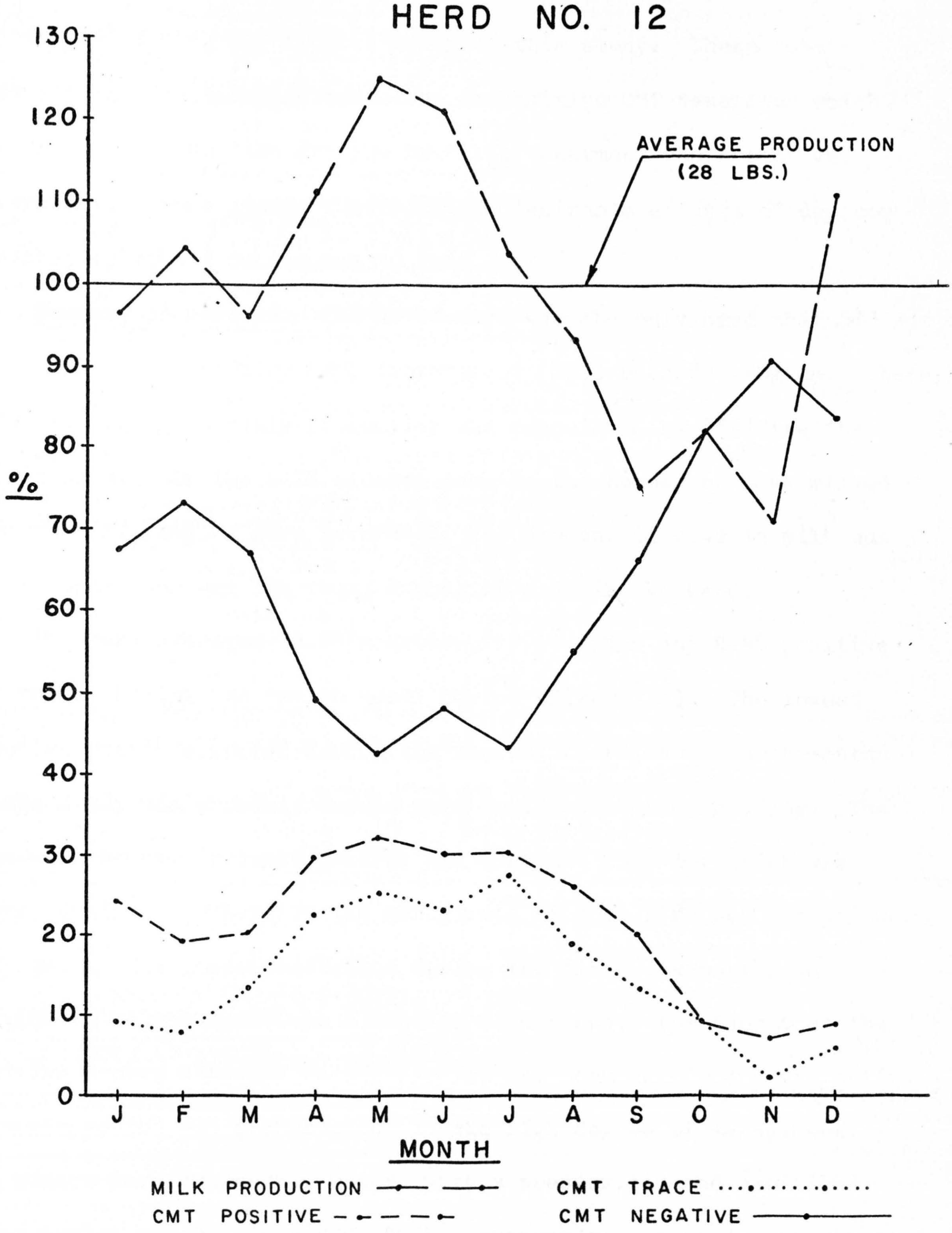

FIG. 17. MONTHLY TRENDS IN MILK PRODUCTION AND CMT SCORES FOR HERD 12

the effect of the dry cow treatment, several of the treated dry cows did freshen during the twelfth month of this study. These cows demonstrated a remarkable reduction in positive CMT reactions which would indicate that the dry cow mastitis treatment was effective. Several other herd owners confirmed the desirable effects of dry cow mastitis treatment subsequent to this study.

Summary of herd 13. The No 13 herd was the only herd that did not participate in the Dairy Herd Improvement (DHI) records program. Therefore the average monthly production was calculated by dividing the pounds of milk in the bulk storage tank by the number of cows milked when the CMT samples were recorded. The percent of cows in milk was not recorded nor was the total number of cows in the herd.

The herd averaged 78.5% negative, 13.1% trace and 8.4% positive CMT scores during the twelve month period (Figure 18). The lowest negative scores occurred during the second, third, and fourth months of the study was probably due in part to a shortage of bedding. The cows were housed in loose housing and confined to a lot which was poorly drained. Otherwise the management of this herd was exceptionally good. The lower production during the first six months was attributed to the unfavorable housing conditions. The fact that the positive scores remained relatively low and constant during the entire 12 month period was probably due to the high degree of management. The udders were thoroughly washed with a pressurized and sanitized water system which maintained 100^{o}F. temperature. A strip cup was used to remove fore milk and milking machines were attached approximately

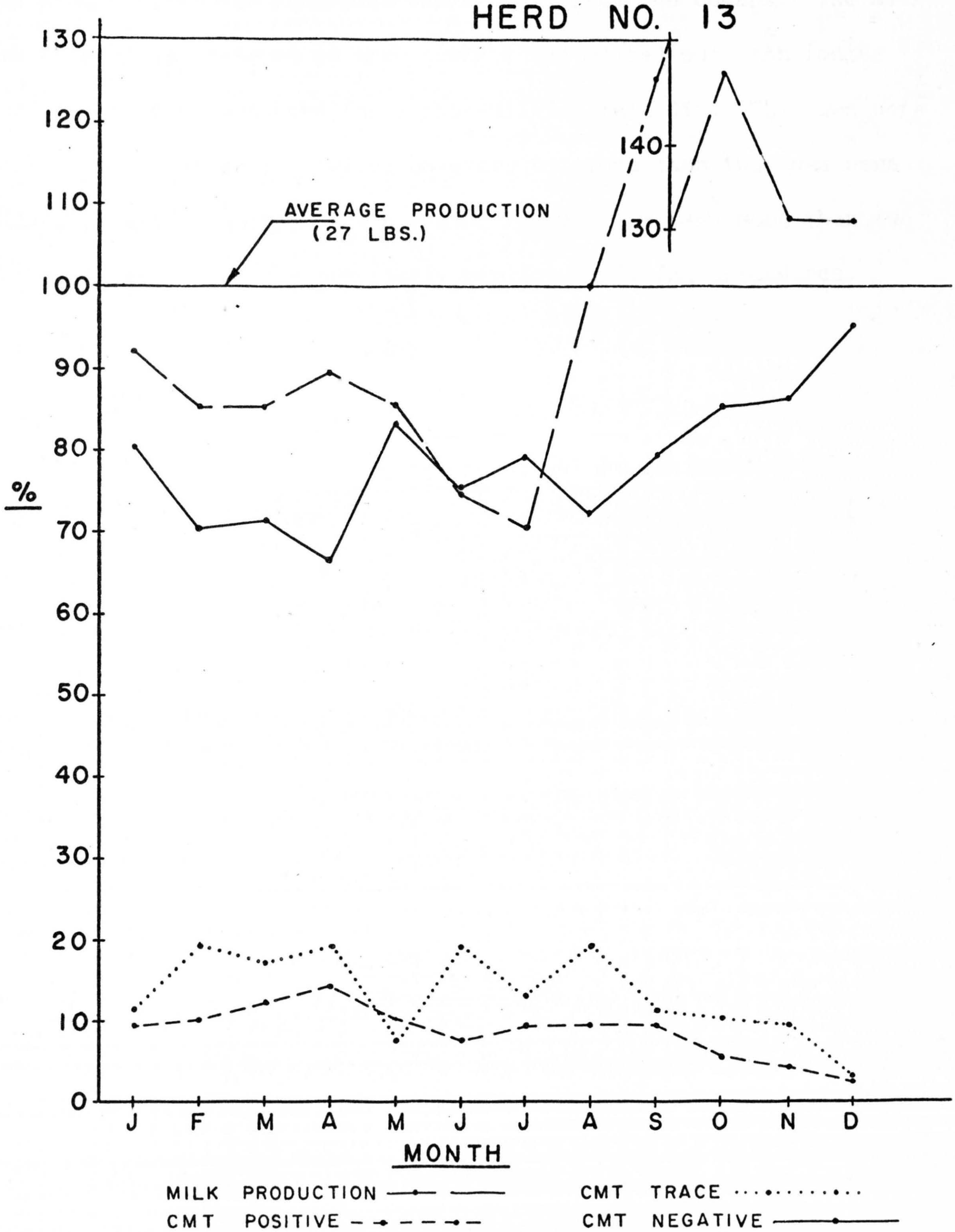

FIG. 18. MONTHLY TRENDS IN MILK PRODUCTION AND CMT SCORES FOR HERD 13

one minute after the fore milk was removed from the udders. The milking machine was removed as each quarter was milked out. An iodine sanitizing agent was used for a post-milking teat dip. The cows were milked in a four stall parlor; however, not more than two cows were milked at a time because the operator could not manage more than two units in performing the previously mentioned milking procedures.

SUMMARY OF HERD STUDY

Thirteen commercial dairy herds participated in a twelve-month study to determine the possible causes of abnormal milk production. A total of 15,805 lactating quarters (167 blind quarters) on 3,993 cows was tested with the California Mastitis Test. Milking equipment, environment, and management were evaluated on each herd to determine the relationship between these factors and production of abnormal milk.

The CMT scores for all herds revealed more negative scores as milk production was increasing or above average. Conversely, CMT trace and positive scores increased when milk production decreased.

Individual herd studies indicated that there was a positive relationship between above average production and CMT negative scores. Individual herdsmanship and a willingness to improve conditions were also important determining factors in reducing CMT positive scores.

Fluctuating vacuum levels at the teat cup were conducive to higher CMT trace and positive scores because there probably was inadequate teat massage during the massage phase of the pulsation ratio.

The most prevalent contributing cause of higher CMT trace and positive scores with properly operating milking units seemed to be overmilking. Sphincter muscles on overmilked cows protruded to various degrees throughout the twelve-month study. Congested teat ends were also observed as a result of overmilking.

Udder irritation as defined by the CMT was more prevalent at or near the drying off stage and when milk production was at a low level. This may be a natural phenomena when using the California Mastitis Test.

However, overmilking was a common management practice in nearly all of the herds with cows in the latter stages of lactation. This management practice could well be the causative factor in increased CMT trace and positive scores rather than a natural phenomenon. It is further postulated that a natural therapy action taking place during the dry period may return some CMT positive quarters to negative. However, this is probably dependent on the extent of the injury or irritation which caused the CMT positive score. Limited observations on dry cow treatments indicated desirable effects in reducing mastitis.

Other recommended practices such as proper milking techniques, sanitation, clean barn lots and bedding, with comfortable stalls were verified in this study. Correct machine installations that functioned properly appeared very important in abnormal milk control.

CONCLUSIONS

1. There were high CMT negative scores with high production and low CMT negative scores with low production.
2. Milking equipment must be functioning properly to permit a low incidence of mastitis.
3. There were highly significant differences among herds and CMT positive and negative scores.
4. There were significant differences in months for CMT positive and negative scores with the lowest positive values in January, February and March and the highest CMT positive values in July, August and September.

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APPENDIX

Appendix Table 1. Summary of monthly bulk tank CMT scores for plant 1.

Month	Negative	Negative	Trace	Trace	Positive	Positive	Total
	(no)	(%)	(no)	(%)	(no)	(%)	(no)
Jan	584	55.67	425	40.51	46	3.82	1049
Feb	429	41.01	551	52.67	66	6.32	1046
March	343	33.43	618	60.23	65	6.34	1026
April	377	35.78	590	55.92	88	8.35	1055
May	434	40.98	570	53.82	55	5.20	1059
June	536	50.18	507	47.47	25	2.34	1068
July	472	43.70	562	52.03	46	4.28	1080
Aug	435	40.54	591	55.07	47	4.39	1073
Sept	469	41.57	614	54.43	45	4.00	1128
Oct	565	49.3	538	45.94	43	4.76	1146
Nov	470	41.08	600	52.44	74	6.48	1144
Dec	478	41.07	590	50.69	96	8.24	1164
Total	5592	42.89	6756	51.82	690	5.29	13038

Appendix Table 2. Summary of monthly bulk tank CMT scores for plant 2.

Month	Negative	Negative	Trace	Trace	Positive	Positive	Total
	(no)	(%)	(no)	(%)	(no)	(%)	(no)
Jan	232	31.6	496	65.57	6	2.73	734
Feb	232	29.78	476	61.10	71	9.12	779
March	102	12.17	664	79.23	72	8.60	838
April	205	23.45	603	68.99	66	7.56	874
May	124	13.71	689	76.21	91	10.08	904
June	149	14.90	646	68.94	142	16.16	937
July	153	16.15	573	60.50	221	23.35	947
Aug	126	12.77	666	67.54	148	19.69	940
Sept	209	21.63	524	54.24	233	24.23	966
Oct	82	8.65	527	55.64	338	35.71	947
Nov	99	10.30	574	59.72	288	29.98	961
Dec	172	17.58	521	53.24	285	29.25	978
Total	1885	17.45	6959	64.40	1961	18.15	10805

Appendix Table 3. Summary of monthly bulk tank CMT scores for plant 3.

Month	Negative	Negative	Trace	Trace	Positive	Positive	Total
	(no)	(%)	(no)	(%)	(no)	(%)	(no)
Jan	478	64.42	210	28.35	54	7.23	142
Feb	448	61.96	225	31.20	49	6.84	722
March	404	58.16	232	33.50	58	8.34	694
April	379	53.88	252	36.00	71	10.12	702
May	368	48.81	298	39.52	88	11.67	754
June	391	52.59	280	37.73	71	9.68	742
July	375	48.26	319	41.05	83	10.69	777
Aug	328	41.30	356	44.83	110	13.87	794
Sept	454	56.75	219	27.37	127	15.88	800
Oct	446	56.10	234	29.43	115	14.47	795
Nov	432	54.61	251	31.73	118	13.66	801
Dec	458	57.68	262	32.99	74	9.33	794
Total	4961	54.41	3138	34.42	1018	11.17	9117

Appendix Table 4. Summary of monthly bulk tank CMT scores for plants 1, 2, and 3.

Month	Negative	Negative	Trace	Trace	Positive	Positive	Total
	(no)	(%)	(no)	(%)	(no)	(%)	(no)
Jan	1294	51.2	1131	44.8	100	4.0	2525
Feb	1109	43.5	1252	49.2	186	7.3	2547
March	849	33.2	1514	59.2	195	7.6	2558
April	961	36.5	1445	54.9	225	8.6	2631
May	926	34.1	1557	57.3	234	8.6	2717
June	1076	39.2	1433	52.2	238	8.7	2747
July	1000	35.7	1454	51.9	350	12.5	2804
Aug	889	31.7	1613	57.4	305	10.9	2807
Sept	1132	39.1	1357	46.9	405	14.0	2894
Oct	1093	37.9	1299	45.0	496	17.2	2888
Nov	1001	34.5	1425	49.0	480	16.5	2906
Dec	1108	37.7	1373	46.8	455	15.5	2936
Total	12438	37.9	16853	51.2	3669	10.9	32960

Plant 1

Appendix Table 5. Percent change in milk receipts and CMT scores by months.

Month	Monthly receipts	Negative samples	Trace samples	Positive samples
	(% change)			
Jan	+ 2.06	+25.32	-24.51	-31.03
Feb	- 2.45	- 7.94	- 2.13	+13.79
March	+ 8.99	-26.39	+ 9.77	+12.06
April	+ 9.77	-19.10	+ 4.80	+51.10
May	+13.84	- 6.87	+ 1.94	- 5.18
June	+10.10	+15.02	-19.90	-56.90
July	+ 4.04	+ 1.29	- 0.18	-20.69
Aug	- 3.42	- 6.65	+ 4.97	-18.97
Sept	-10.07	+ 0.64	+12.12	+ 0.86
Oct	-10.63	+12.12	- 4.44	-25.87
Nov	-14.46	+ 0.86	+ 6.57	+27.58
Dec	- 7.77	+ 2.58	+ 4.80	+65.51
Avg %		42.89	51.82	5.29

Plant 2

Appendix Table 6. Percent change in milk receipts and CMT scores by months.

Month	Monthly receipts	Negative samples	Trace samples	Positive samples
	----------	----------(% change)	----------	----------
Jan	+12.66	+47.77	-14.49	-96.32
Feb	+10.58	+47.77	-17.94	-56.45
March	+22.47	-35.04	+14.18	-55.83
April	+15.10	+30.57	+ 3.96	-59.51
May	+18.75	-21.02	+18.79	-44.18
June	+14.62	-15.10	+11.37	-12.89
July	+ 2.98	- 2.55	- 1.21	+35.58
Aug	-16.42	-19.75	+14.82	- 9.21
Sept	-28.04	+33.12	- 9.66	+42.94
Oct	-27.47	-47.78	- 9.14	+107.36
Nov	-21.98	-36.95	- 1.04	+76.68
Dec	- 3.27	+ 9.55	-10.18	+74.84
Avg %		17.45	64.40	18.15

Plant 3

Appendix Table 7. Percent change in milk receipts and CMT scores by months.

Month	Monthly receipts	Negative samples	Trace samples	Positive samples
	(% change)			
Jan	+10.35	+15.73	-19.85	-36.48
Feb	- 6.11	+ 8.47	-14.13	-42.36
March	+ 5.18	- 2.18	-11.46	-31.77
April	-15.52	- 8.24	- 3.82	-16.48
May	+26.22	-10.90	+13.74	+ 3.52
June	+24.10	- 5.33	+6.87	-16.84
July	+11.72	- 9.21	+21.75	- 2.36
Aug	- 5.71	-20.51	+35.87	+29.41
Sept	-27.72	+ 9.92	-16.42	+49.41
Oct	-15.08	+ 7.99	-10.69	+35.29
Nov	-11.27	+ 4.60	- 4.20	+38.82
Dec	+ 3.21	+10.89	00.00	-12.95
Avg %		54.41	34.42	11.17

Appendix Table 8. Percent change in milk receipts and CMT scores by months.[a]

Month	Monthly receipts	Negative samples	Trace samples	Positive samples
	(% change)			
Jan	+ 5.89	+24.78	-19.45	-67.43
Feb	- 0.36	- 6.94	-10.83	-39.42
March	+11.15	-18.13	+ 9.75	-36.49
April	+ 6.12	- 7.33	+ 2.92	-26.72
May	+17.23	-10.71	+10.89	-23.78
June	+13.71	+ 3.76	+ 2.06	-22.48
July	+ 5.26	- 3.57	+ 3.56	+14.00
Aug	- 6.63	-14.28	+14.88	- 0.66
Sept	-17.14	+ 9.16	- 3.35	+31.92
Oct	-15.07	+ 5.40	- 7.48	+61.56
Nov	-15.47	- 3.48	+ 1.49	+56.35
Dec	- 4.74	+ 6.84	- 2.21	+48.20
Avg %		37.9	51.2	10.9

[a] Average of plants 1, 2, and 3.

Appendix Table 9. Summary of information concerning abnormal milk for herd 1.

Month	Cows in herd	Cows in milk	Quarters	Av production per cow	CMT Negative	CMT Trace	CMT Positive
	(no)	(%)	(no)	(lbs)	(%)	(%)	(%)
Jan	48	100	191	34	95.2	3.2	1.6
Feb	51	84	171	30	81.3	10.5	8.2
March	51	82	167	31	88.6	6.6	4.8
April	50	90	178	34	79.2	7.9	12.9
May	49	80	155	28	74.2	17.4	8.4
June	53	89	187	29	51.9	19.2	28.9
July	52	79	164	27	41.5	22.5	36.0
Aug	53	74	156	30	33.3	29.5	37.2
Sept	53	77	164	31	43.9	31.1	25.0
Oct	53	79	168	25	39.3	28.0	32.7
Average	51.3	83.4	170.1	29.9	62.8	17.6	19.6

Appendix Table 10. Summary of information concerning abnormal milk for herd 2.

Month	Cows in herd	Cows in milk	Quarters	Av production per cow	CMT Negative	CMT Trace	CMT Positive
	(no)	(%)	(no)	(lbs)	(%)	(%)	(%)
Jan	42	81	130	32	44.7	13.8	41.5
Feb	40	79	123	32	69.9	5.7	24.4
March	40	80	122	32	78.7	4.1	17.2
April	41	85	135	34	81.5	0.7	17.8
May	41	88	140	40	80.7	3.6	15.7
June	40	88	136	41	69.1	10.3	20.6
July	39	85	126	32	70.6	9.5	19.8
Aug	39	71	108	25	54.6	16.7	28.7
Sept	38	72	104	24	48.1	20.2	31.7
Oct	40	78	119	34	71.5	6.7	21.8
Nov	38	84	122	33	70.5	1.6	27.9
Dec	38	88	125	33	73.6	5.6	20.8
Average	39.66	81.58	124.2	32.66	67.8	8.2	24.0

Appendix Table 11. Summary of information concerning abnormal milk for herd 3.

Month	Cows in herd	Cows in milk	Quarters	Av production per cow	CMT Negative	CMT Trace	CMT Positive
	(no)	(%)	(no)	(lbs)	(%)	(%)	(%)
Jan	26	88	92	41	95.65	3.26	1.09
Feb	28	100	112	52	96.43	2.64	.93
March	30	96	115	51	93.04	5.22	1.74
April	30	93	110	50	83.64	10.00	6.36
May	29	93	106	47	77.36	12.26	10.38
June	29	93	106	52	74.53	14.15	11.32
July	28	92	103	47	76.70	12.62	10.68
Aug	30	95	116	40	72.41	15.52	12.07
Sept	28	78	88	32	82.95	10.23	6.82
Oct	26	70	72	30	81.94	6.94	11.11
Nov	28	54	60	29	80.00	11.67	8.33
Dec	26	64	70	39	85.71	8.57	5.72
Average	28.16	84.66	95.7	42.50	83.36	9.42	7.22

Appendix Table 12. Summary of information concerning abnormal milk for herd 4.

Month	Cows in herd	Cows in milk	Quarters	Av production per cow	CMT		
					Negative	Trace	Positive
	(no)	(%)	(no)	(lbs)	(%)	(%)	(%)
Jan	19	95	72	52	95.8	2.8	1.4
Feb	18	100	72	47	95.8	2.8	1.4
March	18	94	68	42	91.1	7.4	1.5
April	17	94	52	36	82.5	12.7	4.8
May	17	94	63	34	84.1	4.8	11.1
June	17	88	59	33	81.3	11.9	6.8
July	18	88	63	37	68.2	11.1	20.7
Aug	18	78	55	34	80.0	14.5	5.5
Sept	17	65	43	30	58.1	25.6	16.3
Oct	17	65	44	29	79.5	9.1	11.4
Nov	20	95	75	37	86.7	9.3	4.00
Dec	20	100	80	44	90.0	7.5	2.50
Average	18.0	88.0	62.2	37.92	82.7	9.0	7.3

Appendix Table 13. Summary of information concerning abnormal milk for herd 5.

Month	Cows in herd	Cows in milk	Quarters	Av production per cow	CMT Negative	CMT Trace	CMT Positive
	(no)	(%)	(no)	(lbs)	(%)	(%)	(%)
Jan	24	100	96	53	77.1	6.2	16.7
Feb	24	96	92	45	71.6	18.5	9.9
March	24	92	88	42	70.4	14.8	14.8
April	24	92	88	42	75.0	13.6	11.4
May	24	96	92	42	73.9	9.8	16.3
June	24	88	84	42	69.0	13.1	19.9
July	23	87	80	35	67.5	12.5	20.0
Aug	23	78	72	31	61.1	15.3	23.6
Sept	23	87	80	33	57.5	23.8	18.7
Oct	22	68	60	33	85.0	8.3	6.7
Nov	25	80	80	42	73.8	17.5	8.7
Dec	23	83	76	49	80.3	14.5	5.2
Average	23.58	87.25	82.33	40.8	71.9	14.0	14.1

Appendix Table 14. Summary of information concerning abnormal milk for herd 6.

Month	Cows in herd	Cows in milk	Quarters	Av production per cow	CMT Negative	CMT Trace	CMT Positive
	(no)	(%)	(no)	(lbs)	(%)	(%)	(%)
Jan	21	90	75	42	68.0	18.7	13.3
Feb	20	94	75	41	68.0	17.3	14.7
March	22	100	87	46	81.6	9.2	9.2
April	25	97	95	42	82.1	11.6	6.3
May	24	87	83	40	89.2	3.6	7.2
June	24	87	83	33	83.1	9.6	7.2
July	24	80	75	32	90.7	2.7	6.6
Aug	25	76	74	33	85.1	9.5	5.4
Sept	25	92	90	36	82.2	8.9	8.9
Oct	26	92	90	40	87.8	6.7	5.5
Nov	27	92	98	39	81.6	10.2	8.2
Dec	27	80	88	38	84.1	11.4	4.5
Average	24.16	88.91	84.41	38.5	81.9	10.0	8.1

Appendix Table 15. Summary of information concerning abnormal milk for herd 7.

Month	Cows in herd	Cows in milk	Quarters	Av production per cow	CMT Negative	CMT Trace	CMT Positive
	(no)	(%)	(no)	(lbs)	(%)	(%)	(%)
Jan	47	96	180	38	98.2	0.6	1.2
Feb	44	95	159	37	99.4	0.6	0.0
March	45	96	172	37	95.3	4.1	0.6
April	46	100	184	38	85.3	11.4	3.3
May	47	96	180	36	82.2	13.3	4.5
June	50	88	176	36	72.7	18.2	9.1
July	51	88	180	30	75.0	13.3	11.7
Aug	51	88	180	28	62.2	24.4	13.3
Sept	48	81	156	32	71.2	12.8	16.0
Oct	49	67	132	26	68.2	24.2	7.6
Nov	49	70	136	29	82.4	14.7	2.9
Dec	47	70	132	33	81.8	15.2	3.0
Average	47.8	86.2	163.91	33.3	81.1	12.8	6.1

Appendix Table 16. Summary of information concerning abnormal milk for herd 8.

Month	Cows in herd	Cows in milk	Quarters	Av production per cow	CMT Negative	CMT Trace	CMT Positive
	(no)	(%)	(no)	(lbs)	(%)	(%)	(%)
Jan	26	88	89	41	86.5	11.2	2.3
Feb	28	86	92	37	82.6	10.9	6.5
March	27	89	95	39	91.6	7.4	1.0
April	25	96	95	38	88.4	9.5	2.1
May	28	96	108	38	92.6	5.6	1.8
June	24	100	96		84.4	9.4	6.2
July	30	97	116	29	79.3	13.8	6.9
Aug	33	85	112	22	92.8	5.4	1.8
Sept	36	75	108	19	85.2	10.2	4.6
Oct	35	57	80	17	72.5	17.5	10.0
Nov	36	72	104	27	76.0	15.4	8.6
Dec	38	71	108	31	75.0	17.6	7.40
Average	31.09	82.90	100.2	30.73	83.9	11.2	4.9

Appendix Table 17. Summary of information concerning abnormal milk for herd 9.

Month	Cows in herd	Cows in milk	Quarters	Av production per cow	CMT Negative	CMT Trace	CMT Positive
	(no)	(%)	(no)	(lbs)	(%)	(%)	(%)
Jan	19	84	64	45	98.4	1.6	0.0
Feb	21	81	68	46	89.7	4.4	5.9
March	20	90	72	45	81.9	13.9	4.2
April	20	100	79	44	78.5	10.1	14.5
May	19	100	75	44	86.7	5.3	8.0
June	19	84	63	36	77.8	4.8	17.4
July	18	83	59	34	67.8	13.6	18.6
Aug	18	83	59	28	52.5	32.3	15.3
Sept	21	86	71	31	69.0	8.5	22.5
Oct	22	68	59	30	52.5	25.4	22.1
Nov	22	100	87	43	85.1	10.3	4.6
Dec	21	100	84	45	75.0	15.5	9.5
Average	24	88.25	70	39	76.0	12.1	11.9

Appendix Table 18. Summary of information concerning abnormal milk for herd 10.

Month	Cows in herd	Cows in milk	Quarters	Av production per cow	CMT Negative	CMT Trace	CMT Positive
	(no)	(%)	(no)	(lbs)	(%)	(%)	(%)
Jan	24	60	56	37	87.50	10.71	1.79
Feb	23	83	76	40	89.48	5.26	5.26
March	24	96	92	49	88.04	8.70	3.26
April	24	96	92	53	86.96	10.87	2.17
May	24	96	92	48	77.17	14.13	8.70
June	24	100	96	45	73.96	20.83	5.21
July	21	86	72	40	68.10	27.80	4.10
Aug	21	86	72	34	69.44	25.00	5.56
Sept	23	83	76	39	68.42	25.00	6.58
Oct	23	87	80	33	62.50	18.75	8.75
Nov	19	14	56	31	91.10	7.14	1.76
Dec	22	13	64	33	89.06	7.81	3.13
Average	22.66	85.00	77	40.17	79.14	15.17	4.69

Appendix Table 19. Summary of information concerning abnormal milk for herd 11.

Month	Cows in herd	Cows in milk	Quarters	Av production per cow	CMT		
					Negative	Trace	Positive
	(no)	(%)	(no)	(lbs)	(%)	(%)	(%)
Jan	Not on test		153	35	19.0	56.2	24.8
Feb	Not on test		168	38	16.7	54.8	28.5
March	46	88	160	34	21.3	54.4	24.3
April	46	83	150	35	31.3	34.0	34.7
May	44	83	147	37	29.3	39.5	31.2
June	48	91	175	44	42.3	35.4	22.3
July	46	87	160	39	49.3	34.3	22.4
Aug	46	100	182	44	48.4	37.4	14.2
Sept	54	97	206	41	53.9	32.0	9.1
Oct	52	95	194	36	47.4	37.1	15.5
Nov	51	78	157	28	49.7	26.1	24.2
Dec	51	74	151	29	47.0	31.8	21.2
Average	48.40	87.6	166.91	36.6	38.0	39.3	22.7

Appendix Table 20. Summary of information concerning abnormal milk for herd 12.

Month	Cows in herd	Cows in milk	Quarters	Av production per cow	CMT Negative	CMT Trace	CMT Positive
	(no)	(%)	(no)	(lbs)	(%)	(%)	(%)
Jan	Not on test		66	27	66.6	9.1	24.3
Feb	Not on test		64	32	73.4	7.8	18.8
March	17	100	66	27	66.6	13.6	19.8
April	21	86	68	31	48.5	22.1	29.4
May	20	100	76	35	42.1	25.0	32.9
June	19	100	76	34	48.7	23.7	27.6
July	19	96	71	29	43.6	26.8	29.6
Aug	19	84	62	26	54.8	19.4	25.8
Sept	19	79	59	21	66.1	13.6	20.3
Oct	18	77	56	23	82.2	8.9	8.9
Nov	19	58	44	20	90.9	2.3	6.8
Dec	19	84	64	31	84.4	6.3	9.3
Average	19.0	86.4	64.33	28.0	64.0	14.9	21.1

Appendix Table 21. Summary of information concerning abnormal milk for herd 13.

Month	Cows in herd	Cows in milk	Quarters	Av production per cow	CMT Negative	CMT Trace	CMT Positive
	(no)	(%)	(no)	(lbs)	(%)	(%)	(%)
Jan	Not on test		90	25	80.0	11.1	8.9
Feb	Not on test		87	23	70.1	19.5	10.3
March	Not on test		82	23	70.7	17.1	12.2
April	Not on test		83	24	66.3	19.3	14.4
May	Not on test		88	23	83.0	6.8	10.2
June	Not on test		92	20	75.0	18.5	6.5
July	Not on test		80	19	78.8	12.5	8.7
Aug	Not on test		68	27	72.1	19.1	8.8
Sept	Not on test		64	34	79.7	10.9	9.4
Oct	Not on test		80	40	85.0	10.0	5.0
Nov	Not on test		94	35	86.2	9.6	4.2
Dec	Not on test		91	35	95.6	2.2	2.2
Average			83.23	27.3	78.5	13.1	8.4

Appendix Table 22. Percent negative CMT recordings by months.

Herd no	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Av Percent
1	95.2	81.3	88.6	79.2	74.2	51.9	41.5	33.3	43.9	39.3	Sold	Out	62.8
2	44.7	69.9	78.7	81.5	80.7	69.1	70.6	54.6	48.1	71.5	70.5	73.6	67.8
3	95.7	96.4	93.0	83.6	77.4	74.5	76.7	72.4	83.0	81.9	80.0	85.7	83.4
4	95.8	95.8	91.1	82.5	84.1	81.3	68.2	80.0	58.1	79.5	86.7	90.0	82.7
5	77.1	71.6	70.4	70.5	73.9	69.0	67.5	61.1	57.5	85.0	73.8	80.3	71.5
6	68.0	68.0	81.6	82.1	89.2	83.1	90.7	85.1	82.2	87.8	81.6	84.1	81.9
7	98.2	99.4	95.3	85.3	82.2	72.7	75.0	62.2	71.2	68.2	82.4	81.8	81.1
8	86.5	82.6	91.6	88.4	92.6	84.4	79.3	92.8	84.2	72.5	76.0	76.0	83.9
9	98.4	89.7	81.9	78.5	86.7	77.8	67.8	52.5	69.0	52.5	85.1	75.0	76.0
10	87.5	89.5	88.0	87.0	77.2	74.0	68.1	69.4	68.4	62.5	91.1	89.1	79.0
11	19.0	16.7	21.3	31.3	29.3	42.3	49.3	48.4	53.9	47.4	49.7	47.0	38.0
12	66.6	73.4	66.6	48.5	42.1	48.7	43.6	54.8	61.1	82.2	90.9	84.4	64.0
13	80.0	70.1	70.7	66.3	83.0	75.0	78.8	72.1	79.7	85.0	86.2	95.6	78.5
Average[a]	77.9	77.3	78.4	74.2	74.8	69.5	67.5	62.2	66.3	70.4	79.5	80.0	73.2

[a] Average of percent negative CMT scores for the 13 herds by months.

Appendix Table 23. Percent trace CMT recordings by months

Herd no	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Av Percent
1	3.2	10.5	6.6	7.9	17.4	19.2	22.5	29.5	31.1	28.0	Sold Out		17.6
2	13.8	5.7	4.1	0.7	3.6	10.3	9.5	16.7	20.2	6.7	1.6	5.6	8.2
3	3.3	2.6	5.2	10.0	12.3	14.2	12.6	15.5	10.2	6.9	11.7	8.6	9.4
4	2.8	2.8	7.4	12.7	4.8	11.9	11.1	14.5	25.6	9.1	9.3	7.5	10.0
5	6.2	18.5	14.8	13.6	9.8	13.1	12.5	15.3	23.8	88.3	17.5	14.5	14.2
6	18.7	17.3	9.2	11.6	3.6	9.6	2.7	9.5	8.9	6.7	10.2	11.4	10.0
7	9.6	9.6	4.1	11.4	13.3	18.2	13.3	24.4	12.8	24.2	14.7	15.2	12.8
8	11.2	10.9	7.4	9.5	5.6	9.4	13.8	5.4	10.2	17.5	15.4	17.6	11.2
9	1.6	4.4	13.9	10.1	5.3	4.8	13.6	32.2	8.5	25.4	10.3	15.5	12.1
10	10.7	5.3	8.7	10.9	14.1	20.8	27.8	25.0	25.0	18.8	7.1	7.8	15.2
11	56.2	54.8	54.4	34.0	39.5	35.4	34.3	37.4	32.0	37.1	26.1	31.8	39.3
12	9.1	7.8	13.6	22.1	25.0	23.7	26.8	19.4	13.6	8.9	2.3	6.3	14.9
13	11.1	19.5	17.1	19.3	6.8	18.5	12.5	19.1	10.9	10.0	9.6	2.2	13.1
Average[a]	11.4	12.4	12.8	13.4	12.4	16.1	16.4	20.3	17.9	16.0	11.32	12.0	14.4

[a] Average of percent trace CMT scores for the 13 herds by months.

Appendix Table 24. Percent positive CMT recordings by months.

Herd no	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Av Percent
1	1.6	8.2	4.8	12.9	8.4	28.9	36.0	37.2	25.0	32.7	Sold	Out	19.6
2	41.5	24.4	17.2	17.8	15.7	20.6	19.8	28.7	31.7	21.8	27.9	20.8	24.0
3	1.1	.9	1.7	6.4	10.4	11.3	10.7	12.1	6.8	11.1	8.3	5.7	7.2
4	1.4	1.4	1.5	4.8	11.1	6.8	20.7	5.5	16.3	11.4	4.0	2.5	7.3
5	16.7	9.9	14.8	11.4	16.3	19.9	20.0	23.6	18.7	6.7	8.7	5.2	14.3
6	13.3	14.7	9.2	6.3	7.2	7.2	6.6	5.4	8.9	5.5	8.2	4.5	8.1
7	1.2	0.0	0.6	3.3	4.5	9.1	11.7	13.3	16.0	7.6	2.9	3.0	6.1
8	2.3	6.5	1.0	2.1	1.8	6.2	6.9	1.8	4.6	10.0	8.6	7.4	4.9
9	0.0	5.9	4.2	14.5	8.0	17.4	18.6	15.3	22.5	22.1	4.6	9.5	11.9
10	1.8	5.3	3.3	2.2	8.7	5.2	4.1	5.6	6.6	8.8	1.8	3.1	4.7
11	24.8	28.5	24.3	34.7	31.2	22.3	22.4	14.2	9.1	15.5	24.2	21.2	22.7
12	24.3	18.8	19.8	29.4	32.9	27.6	29.6	25.8	20.3	8.9	6.8	9.3	21.1
13	8.9	10.3	12.2	14.4	10.2	6.5	8.7	8.8	9.4	5.0	4.2	2.2	8.4
Average[a]	10.7	10.4	8.8	12.3	12.8	14.5	16.6	15.1	15.1	12.9	9.2	7.9	12.2

[a] Average of percent positive CMT scores for the 13 herds by months.

Appendix Table 25. Percent of cows in milk by months.

Herd no	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Av Percent
1	100	84	82	90	80	89	79	74	77	79	Sold Out		83.40
2	81	79	80	85	88	88	85	71	72	78	84	88	81.58
3	88	100	96	93	93	93	92	95	78	70	54	64	84.66
4	95	100	94	94	94	88	88	78	65	65	95	100	88.00
5	100	96	92	92	96	88	87	78	87	68	80	83	87.25
6	90	94	100	97	87	87	80	76	92	92	92	80	88.91
7	96	95	96	100	96	88	88	88	81	67	70	71	82.90
8	88	86	89	96	96		97	85	75	57	72	71	82.90
9	84	81	90	100	100	84	83	83	86	68	100	100	88.25
10	60	83	96	96	96	100	86	86	83	87	74	73	85.00
11	Not on Test		88	83	83	91	87	100	97	95	78	74	87.60
12	Not on Test		100	86	100	100	96	84	79	77	58	84	86.40
13	Not on Test												
Average[a]	88.2	89.8	91.9	92.6	92.4	90.5	87.3	83.2	81.0	75.2	77.9	80.6	86.0

[a] Average of percent positive CMT scores for the 13 herds by months.

Appendix Table 26. Udder preparation scores.

Herd no	Massage time[a]	Lapse time[b]	Massage towels[c]	Sanitizer solution[d]	Overall rating[e]
	(sec)	(sec)		(0-100)	(0-100)
1	18	225	2	66	30
2	50	30	2	100	80
3	45	34	1	100	90
4	32	78	1	100	90
5	36	52	1	100	65
6	47	20	1	100	95
7	30	64	2	83	88
8	44	15	1	100	94
9	27	111	2	0	75
10	54	96	1	100	95
11	22	120	3	100	70
12	48	10	2	0	95
13	40	15	2	100	95

[a] Time in seconds that operator massaged the udder.

[b] Time finished massage to attachment of milking machine.

[c] 1. Individual towels. 2. Sponge. 3. Rag.

[d] Percent of months sanitizer solution was used.

[e] Overall rating from 0 to 100 on arbitrary scoring basis.

Appendix Table 27. Milking procedure score.

Herd no	Machine time on	Man time per cow	Teat condition, post milk	Post milk teat dip	Units per operator		Overall rating
	(sec)	(sec)	(0-100)	(0-100)	(men)	(units)	(0-100)
1	435	678	50	0	1	3	50
2	350	430	60	83	2	3	68
3	225	304	90	100	1	2	94
4	240	350	75	100	1	2	85
5	280	368	78	0	1	3	72
6	203	270	95	91	1	2	97
7	320	414	64	0	1	3	80
8	212	271	95	60	1	2	90
9	315	453	65	0	1	3	70
10	228	378	90	50	1	2	92
11	257	399	80	0	2	6	75
12	260	318	90	0	1	2	92
13	330	390	70	0	1	2	85

Appendix Table 28. Pulsator types and ratios.

Herd no	Type	Pulsator speed	Mfg. speed recomendation	Pulsator ratio	Recovery time	Overall rating
		(per min)	(per min)		(sec)	(0-100)
1	Electric	60	60	72:28	0	100
2	Pneumatic	50-72	48-60	50:50	0-7	60
3	Electric	55	55-66	50:50	0	100
4	Electric	55	55-66	50:50	0	100
5	Electric	60	60	72:28	0	100
6	Pneumatic	48-52	48-60	50:50	0-3	94
7	Pneumatic	50-60	48-60	50:50	0	90
8	Electric	60	55-66	50:50	0	100
9	Electric	60	60	72:28	0	100
10	Pneumatic	46-58	48-60	50:50	0-4	94
11	Pneumatic	50-62	48	50:50	4-10	70
12	Pneumatic	45-50	48-60	50:50	0	95
13	Electric	60	60	72:28	0	100

Appendix Table 29. Vacuum capacity according to New Zealand standard.

Herd no	Pump rating	Pump[a] capacity	Pump capacity, units on	Teat cup vac	Teat cup vac, fluc	Line diam	Regulator	Overall rating
	(CFM)	(CFM)	(CFM)	(in)	(in)	(in)	(0-100)	(0-100)
1	32	28	13	14	4	1.25	100	60
2	12	12	5	3	0	1.0	75	20
3	30	28	16	13	0	1.25	100	100
4	30	27	11	14.5	0	1.25	85	90
5	24	23	9	14	3	1.25	88	85
6	17	15	5	11	1	1.25	96	86
7	18	16	2	11	0	1.25	100	90
8	30	30	20	13	0	1.25	88	92
9	32	29	17	14	4	1.25	100	80
10	18	16	5	13	0	1.00	100	90
11	32	30	0	10	0	1.25	75	40
12	18	15	4	13	0	1.00	90	84
13	32	31	12	14	0-6	1.23	90	85

[a] Pump capacity, cubic feet of air per minute, end of vacuum line.

Appendix Table 30. Milking unit types, conditions and ratings.

Herd no	Type[a]	Inflation[b]	Inflation condition	Overall rating
			(0-25)	(0-100)
1	3	1	20	90
2	2	1	25	100
3	2	1	25	100
4	2	1	25	100
5	1	1	20	86
6	2	1	23	95
7	2	1	18	88
8	2	1	20	85
9	3	1	18	88
10	2	1	25	100
11	2	1&2	17	65
12	2	1	20	90
13	3	1	25	100

[a] 1 = Floor Model. 2 = Suspended. 3 = Pipeline.

[b] 1 = Narrow bore. 2 = Wide bore.

Appendix Table 31. Herdsmanship scores.[a]

Herd no	Interest	Alertness	Cow Iden	Knowledge	Sanitation Opr	Sanitation Eqpt	Overall rating
	(0-25)	(0-25)	(0-25)	(0-25)	(0-25)	(0-25)	(0-150)
1	10	15	25	10	20	20	90
2	25	20	25	15	20	25	130
3	20	25	25	20	23	23	136
4	25	25	25	20	20	22	139
5	18	20	23	18	16	20	115
6	25	25	25	20	20	25	140
7	18	20	25	25	20	20	128
8	25	20	25	22	20	18	133
9	16	18	25	16	20	20	131
10	25	22	25	23	20	21	136
11	25	22	25	15	20	20	127
12	25	20	25	15	20	10	115
13	25	20	25	20	25	25	140

[a] Arbritary scores evaluating operators.

Appendix Table 32. Housing types, stall sizes, and bedding.

Herd no	Stanchion barn	Free stall	Stall length	Stall width	Loose housing	Adequate bedding	Overall rating
			(in)	(in)		(0-10)	(0-100)
1	X	45 Sq. ft. per cow			X	7	80
2	X		60	45		8	85
3	X		60	48		8	90
4	X		65	52		8	95
5	X		60	48		7	90
6	X		65	52		9	96
7		X	70	48		10	100
8	X		55	45		7	85
9	X		60	48		10	94
10	X		65	52		10	96
11	X		55	45		6	75
12	X		55	45		8	50
13		X	70	48		10	90

Appendix Table 33. Summary scores of overall management practices and environment.

Herd no	Udder prep	Milk procd	Pulsator	Vacuum system	Milk unit	Herdsmanship	Housing	Total	Rank
1	30	50	100	90	90	90	80	500	12th
2	80	68	60	20	100	130	85	543	11th
3	90	94	100	100	100	136	90	710	1st
4	90	85	100	90	100	139	95	699	4th
5	65	72	100	85	86	115	90	613	10th
6	95	97	94	86	95	140	96	703	2nd
7	80	80	90	90	88	128	100	656	7th
8	94	90	100	92	85	133	85	679	5th
9	60	70	100	80	88	131	94	628	8th
10	95	92	94	90	100	136	96	703	2nd
11	70	75	70	40	65	127	50	497	13th
12	95	92	95	84	90	115	50	621	9th
13	95	85	100	100	100	140	40	660	6th