MASTITIS OF DAIRY COWS

by

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The disease mastitis causes greater loss of dairy cows and of production than does any other single disease in this country, and the same may be claimed for all dairying countries.

In the annual report on Herd Testing and Herd Wastage published by the New Zealand Dairy Board the culling figure given for 1940-41 season was 3.3 per cent. of all cows or 22.3 per cent. of all culled cows. As the rate of culling for all disease is only 7.56 per cent., 3.3 per cent. means that 44 per cent. of all cows culled for disease are culled for mastitis. That is a minimum figure; for, of 4.95 per cent. of cows culled additionally for low production, many will no doubt be culled under this heading because the owner does not like to admit that his losses from mastitis are so high.

Cause: Mastitis may be viewed as occurring in two degrees, the one clinical and obvious to the observer by change in secretion of the affected quarter and change in texture of the palpated tissue, and the other a milder condition showing no obvious change in the quality of milk but yet frequently recognised by a fibrous reaction in the quarter itself or by occasional flakes in the fore-milk. Both in the clinical and subclinical or latent condition, organisms are present, apparently causing the concentration of phagocytes which is present. These organisms in sequence according to ability to set up inflammatory changes, are Strep. agalactiae and other Strep. species, Staphylococci, Br. abortus, Micrococci. Rarely, Coliform types of organisms C. Pyogenes or Cl. welchii may be present each setting up grave inflammation. Fat-splitting Corynebacteria are present as saprophytes of the teat duct. The term "teat duct" is used to denote that part of the teat about 1 cm. in length from the orifice to the rosette of Furstenberg where the teat reservoir commences.

Diagnosis of Mastitis: A large number of tests have been applied to udder secretions to distinguish between normal and abnormal, but none is reliable singly. Those depending upon chemical changes in the secretion are tests for lactose, albumin, globulin, calcium and chlorides. The chloride test is also further extended by obtaining the electrical conductivity of the fluid.

Physical tests depend on the change in pH as evidenced by indicator tests, e.g. B.T.B., or by potentiometer, while tests based on the number of leucocytes present are the catalase, the Whiteside test, centrifuged deposit in Tronsdorff tubes, and lastly, a microscopic smear method, developed in New Zealand, which will be given more attention later.

There are, finally, cultural methods designed to obtain a picture of all types of organisms present, or, by selective action, to demonstrate particular organisms such as the Streptococcus growing with others in the quarter or teat duct. One simple cultural test is the incubation of milk samples for 24 hours before microscopical examination for Strep. This is said to be reliable, but great care is required in obtaining samples.

Some of the tests described have a use in the field, particularly the indicator method, but they are not to be relied upon completely. They indicate trends. The best single test for mastitis is the blood agar cultural method, but in addition a further test should be applied to procure a complete picture of the state of the quarter, and that second test in New Zealand is the leucocyte assessment of gravity cream, a test which uses a

minimum of laboratory apparatus and time. Therefore, the tests to be applied to obtain the best picture should be, first, appearance of the sample, then a cultural examination of gravity cream of that sample, and finally a leucocyte assessment of the gravity cream.

Occurrence of Mastitis: In order to study mastitis to the best advantage a team of workers has been formed composed of four consulting officers of the Dairy Board in Canterbury, Manawatu, Taranaki and the Bay of Plenty to work in with the laboratory staff at Wallaceville. This team is collecting statistics and experiences, and carrying out experimental work as it becomes advisable over a period of three years. Tables 1. and 2. are compiled from material gathered by the team.

The tables are based on the New Zealand leucocyte assessment method of judging mastitis. In this test arbitrary numbers are given from 0 - 6 to denote the incidence of leucocytes in gravity cream; 0, 1 and 2 are looked upon as normal and are grouped as A, 3 and 4 are intermediate and mildly affected with organisms of little virulence and grouped as B, and 5 and 6 are sub-acute and acute mastitis grouped as C.

TABLE 1.

	No. of Quarters	A.	B.	C. Sub-clinical	C. Clinical
North Island:					
Spring	2,741	57.0%	21.8%	15.9%	5.3%
Summer	2,892	53.0%	28.5%	11.7%	6.8%
Autumn	2,634	47.1%	35.3%	9.0%	8.6%
South Island:					
Summer	3,436	47.1%	34.2%	13.4%	5.3%
Autumn	3,164	26.6%	51.6%	21.4%	0.4%

In Table 1. it will be noted that as the season advances A. group decreases, B. group increases and subclinical C. group increases to clinical C. group.

In a number of herds where cultural work has been carried out Table 2. has been compiled to show the organisms present in the various assessment figures.

TABLE 2.

Cultural Results in Subclinical Mastitis

Leucocyte Assessment	Organisms.	Per Cent.
0 and 1	Streptococci	1.9
	Staphylococci	14.5
	Micrococci	37.0
	Negative & Miscellaneous	47.0
2	Streptococci	7.4
	Staphylococci	24.6
	Micrococci	39.0
	Negative & Miscellaneous	29.0
3	Streptococci	34.0
	Staphylococci	27.0
	Micrococci	11.6
	Negative & Miscellaneous	27.5
4	Streptococci	36.0
	Staphylococci	36.0
	Micrococci	19.0
	Negative & Miscellaneous	9.0

Leucocyte Assessment	Organisms.	Per Cent.
5	Streptococci	54.0
	Staphylococci	28.5
	Micrococci	11.0
	Negative & Miscellaneous	6.5
6	Streptococci	67.0
	Staphylococci	18.0
	Micrococci	3.0
	Negative & Miscellaneous	12.0

It will be seen that the table shows some anomalies, but they can be explained by the difficulty of obtaining samples for cultural examination free from contamination, particularly contamination by Staph. The table does show, however, that by using the leucocyte assessment as a single diagnostic test as we do in New Zealand, as the leucocyte assessment rises the greater is the certainty of finding pathogenic organisms. Were a fuller cultural test carried out as a routine to include Br. abortus, some of the higher leucocyte assessments without presence of organisms as shown in the table would have been classified, for Br. abortus itself can give a high leucocyte assessment.

There is some doubt as to how organisms gain entrance to infect a quarter and where these organisms then lodge. Accumulated evidence and experience suggest that the main portal of entry is by way of the teat orifice. Hucker and Seeleman have found Strep. in udder tissue of heifers which have not calved and they suggest that Strep. may be lymph or blood borne. However, the evidence is not quite convincing. In regular examination of milk supplies from cows, it has been noted on occasion that in certain quarters Strep. occur in blood agar culture plates without a rise in leucocytes in the milk. Swabs from the teat duct of such cases show an almost pure culture of Strep. growing or lodging on the squamous epithelium of that area, and after a few jets of milk have been discarded very few Strep. then appear in plate cultures. This suggests that Strep. may first become domiciled in the teat duct before entering the teat reservoir and before gaining the glandular tissue and it has been noted that Strep. may disappear completely from such a case. It has also frequently been noticed in these regular examinations that Strep. may appear with a high leucocytosis of the milk for a very short period and one would suggest that the Strep. have in these cases gained access to the teat reservoir particularly to the Rosette of Furstenberg at the inner orifice of the teat duct but have been overcome by the processes of resistance of the cow. Sections of this rosette have shown that leucocytes can readily pass through the double celled lining to attack organisms gaining entrance to the teat reservoir.

Where Strep. are found regularly in the milk supply with a fluctuating but nevertheless consistent outpouring of polymorphonuclear leucocytes then it would seem that the udder tissue in part or as a whole has become infected, for section of the udder tissue will show collections of leucocytes in glandular alveoli. These accumulations of cells are attracted by Strep. growth within the alveoli, for culture can show their presence high up in the mammary gland. It may very well depend on the rate of growth and the numbers of organisms unattacked by phagocytes just how serious the inflammatory reaction may be, and in those quarters where mastitis is still subclinical the leucocytes are maintaining supremacy. Thus the maintenance of latent mastitis may very well be due to the higher resistance of the animal, and the change from latent to acute mastitis occurs when the resistance of the cow is lowered by chill, by injury, by excess milk production, by indigestion, and so on.

The suggestion is, then, that Strep. mastitis is an inflammatory condition having its origin in the teat duct and from there progressing more or less quickly into the glandular alveoli of the quarter. The resistance of the cow decides whether a balance can be maintained so that milk still appears normal and production is not interfered with, or whether serious injury will develop. With Strep. present there is always some fibrous reaction which can be recognised by palpation or in microscopic section of the tissue.

Staphylococci and micrococci appear to play much the same role in producing a leucocytic reaction, but they are more common as skin inhabitants and they find the milk left in the teat orifice and duct an excellent medium for growth. Staph. and Mic. both gain entrance to the glandular tissue and appear frequently to pave the way for Strep. and finally to give way completely to a pure Strep. infection. Diphtheroids are rarely, if ever, seen in the gland alveoli, but live on the dying squamous epithelial cells of the teat duct. When injected into the teat reservoir they produce a mild, temporary inflammation only.

The heifer when first coming into production rarely has any flora present in the udder or even of the teat duct, but as she continues her career in the shed, the duct becomes infected and leucocytosis appears. Whether Strep. appear depends, I would suggest, principally upon whether there is in the shed a reservoir of infection. Examination of the environs of the cow and the outer body of the cow has not shown any regular source of infection; and, indeed, Strep. agalactiae have very rarely been found apart from the milk of an affected quarter. This fact has made it possible for English workers through very heavy culling of all cows showing Strep. in culture in any number whatever, to claim that they can keep herds free from Strep. infection. Even so some other means of spread than by udder infection must be possible if the Australian Road End experiments in Victoria are examined, for that heifer herd with no known original case of Strep. in the lactating udder became infected with Staph. but also finally in some cases with Strep.

It is believed that heifers coming in to production with inflamed quarters do so because of the breaking of the seal in the teats by suckling as calves, particularly if mastitis infected milk is being fed to the calves.

Spread of Infection: Rapid spread of Strep. infection in a herd as a rule requires a Strep. reservoir, but the mechanics of that spread are not easy to follow. It occurs by hand and machine milking and probably to a greater extent by hand milking if it be true that where hand stripping is practised there is more mastitis, as a number of farmers now claim. Stripping is conducive to the running of organism-laden moisture over the teat end and there is experimental work from Edinburgh to suggest that material can be sucked through the teat duct or into it on the release of a stretched teat. With a few Strep. contaminating the hands of the milker or contaminating the teat of a cow from the machine cups, it is possible for Strep. to become established and, as they develop in number, to pass up into the gland. Not only Strep., but other organisms such as Br. abortus may thus be passed into the udder, this latter suggestion being recently made by McEwan.

Prevention of Mastitis Infection: Control of mastitis will depend, if spread be from teat to teat, on eradication by treatment of the organisms setting up the disease in the herd, or by prevention of the entry of organisms into the udder.

It may be said at once that for economical reasons eradication of Staph. and Mic. could not be attempted and eradication of Strep. in many herds is, for similar reasons, difficult. Eradication of Strep. requires full laboratory facilties, for intensive cultural work is necessary. Were small laboratories

organised in dairy factories and laboratory assistants, under direction of the veterinarians attached to factories, employed for the work, and were an insurance fund provided to enable farmers to quit cows immediately they showed infection, the outbreaks of mastitis similar to those which appeared last October could not occur. Until such control exists, practical methods of prevention must be exercised.

Thus where Strep. reservoirs exist in the herd, there are reasonable methods of control.

First, the health of the cow demands attention. Ketosis, indigestion and chills will permit increase in numbers of organisms in the udder and the inflammatory reaction is greatly increased due to the lowered resistance of the cow. This Strep. increase which may not persist, is, for the time being, dangerous as a means of spread, for there seems not only to be an increase in number but an increase in virulence of the organisms, suggested because in a large outbreak of Strep. mastitis in a herd there are some cases which do not go through the latent phase. There is another part of the cow which demands healthy growth and that is the lining of the teat duct. The teat duct is thickly lined with epithelium which, as it grows to the centre, dies and sloughs in strips of cells or single cells to which organisms entering between milkings become attached. At each milking these strips are discharged carrying with them all the adherent organisms. While this process goes on normally the teat duct is high protective, but let any injury to the orifice or duct take place from badly fitting cups or from disease, and acute mastitis quickly develops. The skin of the teats and udder requires protection from cow-pox and from cracks and erosion brought on by mud. Cow-pox lesions on the teat orifice are a fruitful source of acute mastitis while erosion from wet mud may also set up teat lesions in which Strep. of many species thrive and from which the Strep. can, by the hands of the stripper, be conveyed to the teat orifice. Certain types of overhanging teats crack readily and these cracks adjacent to the teat orifice are always filled with a variety of organisms, particularly Staphylococci.

Disinfection of apparatus and of areas of the cow which have become contaminated with Strep. or other organisms are reasonable precautions and the first position requiring attention is the teat orifice as soon as the milking process is completed. A cup of reliable antiseptic solution into which teats can be dipped before the cows are turned out ensures that the teat end is freed from milk which is the perfect medium for growth and which may possibly, by capillary attraction, permit organisms to pass some distance up the teat duct until held up by the rough cellular lining.

Disinfection of milkers' hands and of teat cups between cows is advocated by many workers and this is seriously suggested by the Australian official Mastitis Committee as a means of preventing spread. The recommendation comes from Reading and America besides Australia that hypochlorite solution should be used after rinsing the cups first in water or soda solution. The use of hypochlorite solution is prohibited in New Zealand by the Dairy Division, and in any case, while such methods may be ideal, they are not practicable in herds of cows over forty or fifty unless plenty of labour is available.

It is necessary after milking the herd to see that all utensils and machine parts are thoroughly cleaned with boiling water or steam or with hot soda solution in order to kill organisms still clinging to surfaces.

There is one more justifiable precaution, that of milking heifers and then clean adult cows prior to known affected cows. This is a matter of common sense, for although mastitis is not a proven specific contagious disease, it is an infectious one where

the worst infectious organism must be present in the shed to gain entrance. The actual means of spread ap ear to be accidental, depending largely on chance. Farmers recognise many cows as being subject to inflammation of the udder in varying degree and these should all be kept back. Indicators or laboratory assistance will choose those other animals which the farmer himself is unable to recognise.

A further necessity is to see that cows are quickly milked. The udder should empty without need for stripping in 3-5 minutes with 8 minutes as a maximum, for the smooth muscle system will tire as will the sphincter muscle of the teat ends, and greater opportunity would then seem to occur for entry of organisms. With the idea of toning up the udder after milking some farmers douche with cold water and claim considerable success in preventing mastitis.

Treatment: Before going into details of treatment, consideration should be given to what is meant by cure of mastitis. To the farmer cure means a return to a secretion normal in appearance and so able to be used for human consumption. This idea is erroneous for many cases reduced from a clinical to a subclinical state retain the infective Strep. and are thus more dangerous in the herd than are clinical cases because they remain unrecognised as reservoirs of infection. No responsible farmer will place vacuum cups on clinical cases which frequently retain very little infectivity, yet all farmers milk subclinical cases mechanically without realising the greater danger to the herd.

The majority of cows once affected with mastitis remain infected although the organism setting up the original lession may change to one of more toxic type. The inflammatory process slowly increases from a latent stage to a clinical. At the clinical stage it has been usual to commence treatment, whereas it would have been advisable to commence treatment in the latent or subclinical stage. Possibly the fact that treatment has been carried out in the later stage of the disease has been the reason why it has been so difficult to obtain beneficial results. Yet, while production was unaffected, it would seem to the farmer criminal to treat a high producing cow affected with latent mastitis.

The simplest form of treatment when a quarter becomes clinical, and particularly if the causative organism be a Strep., is to dry off the quarter merely by not milking it. Permit it to atrophy and see in what state it returns to the shed after next calving. Three quarters may produce as much milk as four in cows not milking to capacity, for there is apparently a compensatory hypertrophy of the three normal remaining quarters.

Treatment apart from massage and frequent stripping may be divided into three main headings. Udder infusion and/or intravenous injection of drugs, and vaccine treatment. Massage and stripping do not always give favourable results and it has been suggested that massage may spread localised Strep. infections further afield and so hasten the complete atrophy and fibrosis of the gland.

Udder infusion is the oldest of all treatments, the original in New Zealand being 4 per cent. boracic acid solution. Since then considerable numbers of quarters have from time to time been injected with new drugs as they became available in this country. The usual result has been a drying off of the quarter and only rarely has one been able to claim a cure. However, overseas writers persist in publishing results which are so striking that the methods should be employed as a routine on New Zealand farms. Of drugs used for infusion Acriflavine and Entozon have been the most useful. Steck and others say that Acriflavine in a dilution of 1:10000 and Entozon at 1:1250 left in for a few minutes only in lactating cows will give a 40 - 60 per cent. cure if used once only, and 60 - 80 per cent. if used twice at an

interval of about 10 days. In dry cows the infusion is left in the udder for 24 hours, and gives better results than when cows are lactating. With the results claimed the use of Acriflavine should be encouraged on every farm in New Zealand in a dilution 1:10000.

A soluble sulphonamide, labelled E.O.S. has been used as a watery infusion in a few cases, and success has been claimed.

Iodine dissolved in ether and suspended in oil after the ether has been evaporated has also been used and perhaps has paved the way for numerous drugs being given in mineral oil. The governing idea is that drugs so suspended would be absorbed more slowly and actually in many cases the irritation to the udder is much reduced. Thus sulphanilamide was injected into the udder in mineral oil as an homogenised suspension of 58 per cent. The dose given was 40 c.c. for four days, and 94.7 per cent. success is claimed over a series of cases when treatment was repeated.

Tyrothricin is the most recent drug suspended in oil to be tried as an infusion. 20 c.c of a 1.5 mg. per c.c. of oil is injected and 90 per cent of cures in 2 - 3 treatments are claimed. Tyrothricin dissolved in water has also been used at the rate of 150 mg. to 25 c.c. water, and of 157 cows treated 141 are claimed as cured.

Novoxil in the oily preparation has proved altogether too drastic in quarters, but a number of workers claim beneficial results.

Sulphanilamide by mouth has recently been given a very intensive trial by Stableforth and others in England. In his series 9 - 7 per cent. of control quarters regained normality without treatment. 20 grams and 10 grams per 100 lb. body weight were given as initial doses and 3.3 grams per 100 lb. given every eight hours for 5 - 7 days so keeping the body saturated. They claim 34.8 per cent. cured bacteriologically, 44.9 per cent. of these being latent cases, and 24.6 per cent being clinical cases. Of the cases clinically affected in the series 55.2 per cent were reduced to latency, and some improvement was noted in a further 22.9 per cent. These workers deduce from the experiment that 10 grams per 100 lb. body weight should be given as an initial dose, and 5 grams every 12 hours for a few days to treat clinical symptoms. They do not recommend the treatment as a cure however in the sense that the cows are all freed from Streptococci.

The excretion of a selective drug through the udder is the method of treatment which one would predict will finally be successful when the chemist has synthesised a compound sufficiently selective and penetrating and able to be excreted in body fluids. Such a drug may be useful not only in Strep. and Staph.infections, but with Br. abortus.

Vaccines and anti-Strep. sera have been tried extensively the world over, but it is in New Zealand that vaccines have been perpetuated by private companies; the scientist elsewhere appears to have given up hope of success with this method of subcutaneous injection. When one quarter affected with a Strep. cannot prevent a second quarter from becoming infected, then there would seem little hope for a vaccine, but this is only true if there be relatively no absorption of antigens from the affected quarter and thus no antibodies formed which can be re-excreted through other quarters. It is known that one cannot devise reliable agglutination tests for diagnosing the disease so possibly there is yet some hope for vaccine therapy. However, up to the present, no scientific trials of vaccines or antisera in the ordinary way have given results.

Vaccines are used both prophylactically and curatively and are made up, as a rule, with both Strep. and Staph. It is possible that dosage used in the past has been too small or that the strains or organisms used have been unsatisfactory, or again that one requires a very large number of strains of the organism in a vaccine to make it active in a herd. On the other hand, autogenous vaccines have been made and given by many workers in increasing and heavy dosage without, as a general rule, having any effect on the quarter. Therefore, it is felt that while there is little to expect from vaccination yet a further trial with selected strains of organisms of known types might be carried out and with the organisation of work on mastitis by officers of the Dairy Board and the Department of Agriculture such trials should definitely decide the influence of this form of treatment and the prophylactic value of the method.

SUMMARY

To sum up: It may be said that mastitis is a disease of the udder due to a variety of organisms, but particularly to Strep. agalactiae, slow to become established, passing from a latent to a clinical state and influenced strongly by the health and resistance of the cow.

Spread is probably teat to teat and depends, in the case of Strep. infection, mainly on reservoirs of infection in the herd. Both hand and machine milking may be instrumental.

Control is a matter of elimination of Strep. reservoirs, efficient antisepsis in the shed, and application of proper curative methods, but practical measures on a scale possible in large sheds have yet to be evolved.

Curative treatment has not been satisfactory in the hands of New Zealand workers but overseas workers make attractive claims. The best methods in their hands are infusion of the quarters with Acriflavine, Entozon, or possibly Sulphonamides, particularly when the animal is dry. Treatment of latent mastitis would not, at this stage, prove popular and in any case further trials are required. Vaccine treatment in the hands of scientists has not proved effective.

DISCUSSION

Mr. Bonner: Does milking with a higher vacuum predispose to mastitis?

Reply: A high vacuum does not in itself set up mastitis. In experiments carried out at Wallaceville no difference was noted in cows milked at 19 inches vacuum compared with those milked at 15 inches or lower. The experiment suggested that when more than one part of the machine was at fault mastitis was more likely to appear, e.g. when blocking of the air hole in the teat cup was combined with high vacuum.

Mr. Bonner: Did less mastitis result from the use of a low level pipe line machine?

Reply: There is insufficient evidence to say whether less mastitis resulted from the use of low level pipe line systems. It was felt that there was less strain on the udder in a gravity system, particularly in a bucket plant where there was a large reserve of vacuum.

Mr. Ward: Asked whether Dr. Hopkirk was of opinion that the milking of dairy cows prior to calving was likely to be beneficial in reducing the incidence of certain types of mastitis?

Reply: There was very little experimental evidence available on this point, but in practice those farmers who deliberately premilked cows were satisfied that it saved the cow from getting an inflamed quarter. Theoretically there seems no reason to expect cows with a big show to contract mastitis unless the organism responsible had been retained from the previous season or unless the large unmilked udder was subject to trauma through its size. No milk is produced once the udder is fully stocked for pressure prevents the cells of the acini from secreting. This is seen in drying off of cows by simply turning them out on a given date. Resorption of milk occurs after a few hours, and no harm results.

There is nothing harmful to the cow in premilking unless she be subject to milk fever.

Mr. Ward: Is drying off of affected quarters a reasonable method of treatment?

Reply: A quarter when inflamed or normal can be dried off by simply not milking it, for the milk is resorbed by phagocytic activity. Milk is required for feeding the organism responsible for inflammation for it is only those organisms using milk as a media which develop in the udder. Therefore, to dry the quarter off is to starve the Strep. or Staph. responsible for the inflammatory reaction. During the phagocytic activity organisms are also dealt with.

Just what percentage respond to this form of treatment is not known, but even were none to recover the fact that an affected quarter was not touched because it was not producing, is beneficial, for there is less chance of transfer of organisms from the affected to other quarters. Just how far one is justified in asking the farmer to go in this method of treatment is still a matter of conjecture, for many farmers would object to drying off a quarter in a high producing cow just because the quarter was subclinical, and yet that quarter is an active reservoir of infection for the herd, and so, a dangerous one.

Dr. Campbell: Are figures available to show that there is a compensatory hypertrophy in three quarters when one is dried off?

Reply: I know of no actual trials, but it is an experiment which should be thought of when opportunity occurs. It is a general belief that such hypertrophy does occur but it must depend on the development of the udder, the amount of feed available, optimum milking capacity etc.