Economic Impact And Control Of Parasitism In Dairy Cattle

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Subclinical parasitism is a term used to describe a degree of parasitism which interferes with production but is not evident by physical and visual examination of the patient. In practice it is a state of parasitism diagnosed by a positive response in some measured parameter of production subsequent to the administration of an anthelmintic. This form of parasitism has received considerable study in beef cattle, however, only recently has its potential impact in dairy cattle, received widespread attention.

It is my purpose in this paper to examine the role of individual parasites and groups of parasites involved in subclinical parasitism, to examine the evidence presented in support of the existence of this form of parasitism in dairy cows, to comment on diagnosis of the condition, and to consider existing recommendations for its control.

Parasites Of Concern

As long ago as 1962, Cox and Todd[12] reported a survey of gastrointestinal parasites in Wisconsin dairy cattle. Utilizing a sugar flotation technique for fecal examination, a procedure now commonly referred to as the Wisconsin Sugar Centrifugal Flotation these workers examined 10 fecal samples from one dairy farm in each of 71 counties in Wisconsin during July of 1957. The researchers obtained samples from young calves, replacement heifers, and adult cows at each farm whenever it was possible to do so. While they stated in their report that the survey was limited to average to good herds, no criteria for comparison of these herds to others was presented.

In a subsequent paper, Todd, Bliss, and Meyers[23] described the typical Wisconsin dairy herd as being dominantly of the Holstein breed and fed enormously in order to force production. The majority of the animals are kept on drylot. Pasture lasts 110 to 120 days and milk cows on pasture are fed less hay and silage than when in drylot. Bred heifers and dry cows are largely turned to pasture in season. The authors state "The pasture actually functions mainly to relieve stress, and not as the principal source of food".

In this report[12], the Wisconsin authors noted that more samples contained eggs of *Haemonchus* than of any other species of nematode regardless of age group. The method of fecal analysis allowed for the quantitation of parasite eggs in terms of eggs per 5 grams feces. It was noted that the highest level of nematode infection, as measured by fecal parasite egg counts, was in cattle from 2 months to 30 months in age.

Todd, Bliss, and Myers[24] further noted that statewide surveys in Wisconsin conducted in the 1970's established the same continuous prevalence of worm parasitism as found in the earlier study. The primary genera of worms infecting dairy cattle according to Todd[21] are *Haemonchus, Ostertagia* and *Trichostrongylus* in the abomasum, *Trichostrongylus, Nematodirus, Cooperia,* and *Moniezia* in the small intestine, and *Trichuris* and *Oesophagostomum* in the large intestine. It is noted that this list of helminths is quite similar to that presented by Baker[3] as helminths of major economic importance in cattle in the United States. In addition to these gastrointestinal helminths listed by Todd[21], it seems appropriate that the potential impact on dairy economics of the helminths *Fasciola hepatica* and *Dictyocaulus viviparus,* as well as the coccidia, be recognized in this paper. Todd and co-workers[12,17] have previously noted the ubiquitous distribution of coccidia in dairy cattle.

Within the United States, *F. hepatica* is undoubtedly a local or at most a regional problem in dairy herds. Nevertheless, infection of milking cows has been associated with a reduction in quantity[20] and quality[5] of milk produced.

Ross[20], in Ireland, studied the production of cows in three herds containing a total of 215 milking cows. In the last 20 weeks of lactation 66 were shown by fecal examination to be infected with *F. hepatica.* These infected cows were divided into two groups, one which was treated with oxyclozanide in mid January. Milk yields for periods of three weeks before and three weeks after treatment were measured for the three groups, i.e. treated, untreated, and uninfected. As compared to the untreated infected cows, the production of the treated cows was 8% better and that of the "uninfected cows" was 6% better. It is possible that some cows classed as uninfected

Presented to the American Association of Bovine Practitioners, Las Vegas, March 5, 1979.

on the basis of negative fecal examinations may have harbored small to modest numbers of flukes.

Black and Froyd[5] in the United Kingdom studied the effects of treatment of fluke infected cattle with oxyclozanide as determined by the percent of milk total solids. Under the conditions of quality payments then in effect the value of the increased total solids in the two herds was £7.50 and £4.50 per 1000 gallons of milk respectively.

While the extent of *F. hepatica* infection in dairy cattle in the United States is unknown to the present writer, the probability that infections with this parasite may result in significant reduction in milk production is not. The writer is aware of a veterinary practitioner in California who years ago was concerned with low milk production in a fluke infected herd. The practitioner treated the herd with hexachloroethane and was very pleasantly surprised with the increased production.

There can be no doubt that in endemic areas where young stock is allowed to graze infective pastures *F. hepatica* infection contributes to retarded growth rates and even to death losses. Calves reared in these areas may well bring subclinical levels of fluke infections with them when they enter the milking string.

In the writer's experience the lungworm, *Dictyocaulus viviparus,* has largely been a problem in young animals recently turned to pasture. There should be no question that under appropriate conditions dictyocauliasis can be of economic concern in dairy practice. Only in rare instances in the United States would this worm be a routine month to month, year to year, concern in an established health program for mature dairy cows. It is probable that its most important impact would be in the form of retarded growth of replacement calves and heifers in endemic areas such as the north coastal region of California.

Coccidia are ubiquitous parasites of cattle and are present in essentially all dairy herds.[12,17] The writer is unaware of published data which relates milk production to coccidiosis in dairy cows. In an extensive survey Fitzgerald[14] concluded that - "Coccidiosis in dairy cattle was considered to be a minor problem by nearly all dairy producers.". Fitzgerald further states - "Probably the greatest factors causing decline in the incidence of coccidiosis in dairy operations are intense and better management practices". This is undoubtedly true in much of the United States and in dairies which provide their own replacements. It must be kept in mind that dairy calves raised on pastures, in drylots, and pens are equally susceptible to clinical coccidiosis as are beef calves and 59% of veterinarians interviewed by Fitzgerald[14] rated coccidiosis among the 5 most important diseases they treat. It is probable that the major importance of the coccidia is in the significant retardation of growth that may occur in replacement calves and heifers.

Subclinical Parasitism In Lactating Dairy Cows

As noted in the instances of infection with liver flukes, lungworms, and coccidia, losses that have been attributed to subclinical gastrointestinal parasitism do not all have their geneses assigned to infection in the mature milking cow. Todd *et al.*[24] referred to an early field trial in the 1950's where bred heifers subclinically infected with parasites and given systematic treatment with phenothiazine produced over 400 lbs. more milk in the first lactation than did untreated controls. In another publication Todd[21] alludes to subclinical parasitism in younger animals and states, "One can calculate that the 8-10 weeks slower growth in wormy heifers costs $50-75 prior to attainment of breeding size and thereby a delayed first freshening".

Adrichem and Shaw[2] reported a trial in Belgium in which 23 pairs of monozygotic twins acquired at the ages of 1-5 months were studied continuously through their first lactation. These workers[1] had previously noted that gastrointestinal parasitism in young cattle not only impaired performance at the time of exposure but for a considerable time thereafter. They wondered to what extent such effects of parasitism might carry over and influence milk production. At the time of the study they were apparently unaware of the early Wisconsin studies and stated that while they had shown such parasitism to be associated with impairment of both appetite and feed efficiency" . . . the extent which such parasitic damage in young animals affects subsequent milk production is not clear, and, in fact, there appeared to be no direct information on the subject".

In this study,[2] one twin was assigned to an anthelmintic (Cambendazole) treated group and the other to an untreated group. Six pairs were pastured from September to December in 1969 and 18 pairs went to pasture between May and August 1970 where they remained until mid-November. During the winter the calves were tethered in a barn. Two weeks after being placed on pasture the treated calves received their first anthelmintic drench and were then retreated every 2 weeks while on pasture. During the period in the stable, fecal samples were collected and if parasite egg counts exceeded 20 per gram of feces, the calves were retreated. After parturition, the heifers were kept in stables for the entire lactation and no further anthelmintic was administered. In total, a minimum of 20 and maximum of 34 treatments were administered to individual calves.

Cultivation of feces and subsequent identification of infective larvae revealed that 70% were *Cooperia* spp; 19% *Osteragia ostertagi;* 3% *Trichostrongylus axei;* 5.5% *Oesophagostomum* spp.; and 2.3% *Haemonchus contortus.* These data indicate a parasite population similar to that found in much of the United States.

The treated calves weighed 64.5 lbs more at 16 months and 51.9 lbs more immediately before calving. Compensatory gain occurred after calving and at the end of lactation there was no longer a significant difference in body weight.

Twenty three pairs of twins completed lactation at 39 to 44 weeks. Over a 41 week period the average fat corrected milk produced by untreated heifers was 6384.4 lbs while that of treated heifers was 6804.6 lbs. a difference of 420.2 lbs., or 6.58%. This difference occurred within the first 28 weeks of lactation and production after that was similar in both groups. Statistical analysis of milk yield, body weight, and age indicated that the depressed gain and lessened body weight at calving was probably the most important mechanism by which parasitism reduced milk production in this trial.

Other observations of interest in this trial were the absence of significant difference between groups in breeding performance or in birth weight of calves. Breeding of 5 sets of twins had to be delayed 1 to 3 months until the nontreated heifer reached the predesignated breeding weight of 572 lbs.

It should also be noted that the untreated calves in this trial were clinically infected during their first pasturing and that most of the control animals exhibited anorexia and a diarrhea from time to time, although at the time they were stabled for the second time and during lactation there was no longer a difference in appetite or fecal consistency, i.e. a state of so-called "subclinical parasitism" existed during lactation.

There is no question insofar as the United States is concerned that the Wisconsin workers have provided the stimulus for studies on the evaluation and control of subclinical (gastrointestinal) parasitism in mature lactating dairy cattle. This group of workers, namely, Dr. Arlie C. Todd and succession of students have provided a volume of data in support of their advocacy of routine anthelmintic administration to milking cows as part of herd health programs.

Todd, *et al.*[24] published their studies of the effect of anthelmiatic administration in clinically normal milking cows from different herds within southern Wisconsin. In this study 244 cows were given water as a placebo, 448 received copper sulfate, 183 received phenothiazine and 153 received thiabendazole. To evaluate the results, milk from 4 consecutive milkings was weighed. The cows were clinically healthy and pretreatment and post-treatment fecal samples were examined by the Wisconsin Sugar Centrifugal Flotation Technique.[12]

The worm egg counts per 5 grams feces for the test groups before treatment were: control 14.8, copper sulfate 28.5, phenothiazine 69.1, thiabendazole 34.6. Following treatment the worm egg counts in the control and copper sulfate treated groups were essentially unchanged while in the phenothiazine and thiabendazole treated groups egg counts were markedly reduced to a mean of less than 1 egg per 5 grams feces. At eight days post-treatment, milk production had decreased 0.62 lbs in the control group and had increased 1.45, 1.80, and 1.63 lbs in the copper sulfate, phenothiazine and thiabendazole groups, respectively. In this study, no effort was made to pair animals. Only after the fact were such records as the number of previous lactations and length of time the animals had been lactating when treatment was given obtained. When these records were obtained, they revealed the average cow in the placebo group had been lactating 143 days (range - 5 to 375 days). The average cow in the copper sulfate, phenothiazine, and thiabendazole groups had been lactating for 131 days (range - 20 to 365 days), 135 days (range - 2 to 290 days), and 125 days (range - 24 to 305 days) respectively. While cows in 34 herds were utilized in the control group, cows from 32, 27, and 24 herds were utilized in groups treated with copper sulfate, phenothiazine, and thiabendazole. The fact that response to phenothiazine and copper sulfate were equal to that of thiabendazole was surprising although this may be taken to indicate the worms responsible for the reduced milk production were abomasal worms of the genera *Haemonchus* and *Trichostrongylus*.[3] Another explanation could be that while copper sulfate and phenothiazine are not as effective as thiabendazole, on all species, they still reduce the worm numbers to a level below the threshold at which production losses occur.[3] The concept of such a threshold in dairy cattle does not appear to be accepted by Todd.[21]

In 1973 Bliss and Todd reported[7] a second study which in experimental design was similar to the first but utilized Dairy Herd Improvement Association (DHIA) records when possible. Milk production was measured at 16, 30, and 60 days post-treatment. In this instance clinically normal milking cows from 22 herds in southern Wisconsin were involved. Seven hundred and eight cows were treated with coumaphos (Baymix® crumbles) as a top dressing on the morning grain ration for six consecutive days, while 295 cows served as controls. The average number of days the 1003 cows had been lactating at treatment was 155. While milk production continued to decrease in both treated and control cows, the rate of decrease was less in the treated cattle during the first 16 days. Following that initial period, the daily decrease was slightly higher in the treated cows nevertheless an accumulative mean advantage over 60 days of 72 lbs milk per treated cow was obtained. In this trial pretreatment and post-treatment egg counts were conducted on 15% of the cows. The average pretreatment parasite egg count was 16.3 per 5 grams feces and the post-treatment average in treated cows was 0.84 per 5 grams feces. The authors noted at this time that while data from their first report was accepted, the question was raised as to the length of time the increased production would be maintained and whether or not it would be sufficiently long to pay for the treatment. As they concluded, data in this, the second study suggested that the increased gains in production would last for some 60 days and at 1973 prices of whole milk in Wisconsin would be worth $4.20. Data from these two studies led the Wisconsin researchers to suggest that anthelmintic treatment of milking cows in mid-lactation and averaging some 16-36 trichostrongylid eggs per 5 grams feces would be a profitable addition to existing herd health programs.

The third in the series of studies by the Wisconsin researchers[8] utilized 488 clinically normal milking cows from 12 commercial dairies. All cows used in the study had completed at least one lactation. In this study one half (244) of the cows were treated with thiabendazole on the day of parturition. Fecal samples taken from 30% of the cows before treatment averaged 10.2 parasite eggs per 5 grams feces. Twenty days after treatment representative samples contained less than 1 egg per 5 grams feces. Samples taken between 60 and 90 days after treatment averaged 7.3 parasite eggs per 5 grams feces. Results obtained from DHIA records in this trial favored the treated cattle by an actual 305 day production record of 423 lbs. milk and 16.6 lbs. butterfat per cow.

This study was followed by reports of studies in Vermont[9] and in Pennsylvania and North Carolina[22] which produced results in the main supportive of those conducted in Wisconsin. In Northern Vermont 267 clinically normal cows, which had completed at least one lactation, on nine commercial dairy farms were studied; 146 cows were treated and 121 served as controls. Treatment (thiabendazole) was administered on the day of parturition. A second deworming using coumaphos for six consecutive days was administered 60-90 days into lactation. For evaluation the calculated adjusted mature equivalent 305 day lactation of each cow for the lactation preceding treatment and after treatment was obtained. The average increase for treated cows was 1708 lbs. and for untreated cows was 1174 lbs. The difference of 534 lbs. was attributed to anthelmintic treatment. In this instance, fecal parasite egg counts from milking cows were determined on four different occasions, namely in August, October, December, and May. The average parasite egg count per 5 grams feces in cows for these months were 2.5, 3.7, 1.6, and 3.6 respectively.

In Pennsylvania 180 cows from nine herds were studied. The average number of lactations per cow in both treated and control groups was 3.7 at the start of the trials. Treatment consisted of coumaphos for 6 consecutive days immediately after freshening and then once weekly for the first 90 days of lactation. In 7 of the 9 herds, milk production was higher for the DHIA 305 day actual lactation while in 2 it was lower. The average herd difference was 1326 lbs. more in treated herds while the average difference per cow in the 9 herds was 769 lbs. In addition to the increase in total milk production, the average treated cow produced 22 lbs. more fat than did untreated cows.

In North Carolina 157 cows (82 control and 75 treated) in 5 herds were subjected to a trial identical in design to that in Pennsylvania. In this instance the treated group at all five dairies produced more than the untreated group. The average cow difference per herd was 777 lbs. of milk while the average cow difference for the entire trial was 1,075 lbs. of milk. As in the Pennsylvania trial an increase of fat was recorded, the average increase per cow for the entire trial being 44 lbs.

The enthusiastic advocacy for anthelmintic treatment of milking cows on the part of the Wisconsin workers, along with the impetus produced by inquiries of dairymen and representatives of pharmaceutical companies resulted in investigations of subclinical parasitism in dairy cattle by researchers outside of Wisconsin.

Brown and Maniscalco[11] stated, referring to conditions in Texas, "Dairy researchers have suspected that internal parasites in dairy animals have had depressing effects on milk production. Dairymen apparently have been unaware of this problem or have not taken the steps necessary to maintain their herds relatively parasite-free". In support of this statement, they report a trial involving 36 lactating dairy cattle from three herds conducted in Texas. No comment is made as to whether or not the cows were allowed access to pasture. One half of the cows were treated with coumaphos for 6 consecutive days. Daily milk weights were collected on all animals for 10 consecutive days including the 6 treatment days and DHIA records were obtained for the month preceding the trial, for a test day at conclusion of the trial, and for the month following the trial.

Fecal samples examined by a flotation procedure (not the Wisconsin Sugar Centrifugal Flotation Technique) revealed all 36 animals to be infected prior to treatment. After treatment all 16 control animals remained positive while 14 treated animals were negative and 4 had reduced numbers of parasite eggs.

At the end of the 6 day treatment period, milk production had risen by an average of 3.7 lbs. per treated cow. Production of the controls remained constant for the period. No advantage was present in treated cows at the end of a month.

It is noted that while this trial supports the early work of Todd et al.[21] in which they were rewarded with a positive response with 8 days of treatment. It does not support their later work[7] in which they found the response to extend over a period of at least 60 days.

In 1976 McQueen et al.[18] stated that while no New Zealand studies of the effect of anthelmintics on subclinical parasitism in dairy cattle had been published a number had been conducted. Of this number, he did not state the total, only 2 revealed significant increases in milkfat production as the result of anthelmintic administration. These two trials were conducted in an environment where the mean temperature was in excess of 10°C in all months except June and July (Winter), and in the years the trials were conducted, rainfall assured sufficient moisture in all months to allow translocation of infective larvae that had developed. In only the two most severe winter months would essentially all development of infective larvae have stopped.

The cattle used in these trials were Spring-calving crossbred Freisians. In the first trial there were 25 animals per treatment and in the second trial there were 40 animals per treatment. Each group was balanced for age, date of calving, and early season (lactation) production of milk or milkfat. Trial cattle were grazed and handled with the total herd which consisted of 210 cows grazed at a mean stocking rate of 1.3 cows per acre except for November and December when the stocking rate was increased 50 to 100% by withdrawing of pasture area. It was also noted that calves were intermittently allowed to graze the pastures. Average days of lactation at the start of trial 1 was 65 and for trial 2 was 40 days. In both trials, 4 groups of cows were used.

In trial 1 one group served as a control while the other three were respectively treated with, (a) dl-tetramisole every two weeks, (b) selenium once monthly, and (c) dl-tetramisole every two weeks plus selenium once monthly. Treatments were started October 16, 1970, and continued until May 4, 1971, i.e. Spring through Summer and into early Fall. In this trial the results indicated an increase of 21.12 lbs. milkfat as the result of treatment. Further analysis of the data revealed that the entire increase in production occurred from December to May with little or no response during the period of October to December. Since the average cow in this group had been lactating 65 days at the start of the trial one must conclude that the response herein obtained was in the late part of lactation.

In the second trial, one group served as a control while a second group received levamisole every two weeks from September 24, 1971, to May 1, 1972. A third group received levamisole on September 24, October 8, and December 16, 1971, while the fourth group received levamisole on December 16, and 30, 1971, and again on January 17, 1972.

In this trial comparison of data from all treated cows to that of untreated cows revealed no significant response.

When data was separated into response of two year olds, three year olds, and mature cows, it was found that a significant increase in production occurred in the mature cows. Further examination of the data revealed that the results in these mature cows was similar in cows treated every other week and in cows treated on December 15 and 30 and on January 17. The response of mature cows treated in the spring while significantly better than control cows, was not as pronounced as in those treated continuously or in the summer, again, indicating that the beneficial effects were confined to late lactation.

Dr. W. C. Stouder in an unpublished presentation to the California Veterinary Medical Association in October of 1977 reported on anthelmintic trials he had conducted in two large dairy herds in Southern California. On one of these dairies dry cows and heifers were pastured while on the other no pasture was utilized.

Cows that had completed at least one lactation were paired while in drylot. Pairing was done on the basis of similar expected calving date, same number of lactations completed, and total days in milk, milk production, and total butterfat during the previous lactation. One cow of each pair was treated with thiabendazole on the day of parturition. Performance of individual cows was taken from DHIA records. In the herd using pasture the treated cows produced an average of 953 lbs. more milk and 51 lbs. more butterfat in 297 lactation days than did the controls. In the herd which did not use pasture the controls produced 149 lbs. more milk and 9 lbs. more butterfat than did the treated cows. Fecal samples were not examined.

Examination of Dr. Stouder's report reveals the calving dates to be from August 14 to October 8, 1973. Assuming a two month dry period, pasturing would have taken place between early June and October in the herd using pasture.

As a result of the favorable results in the herd using pasture the owner instituted a program of deworming every fresh cow. The 12 month rolling herd average at that time was 17,684 lbs. of milk and 601 lbs. of butterfat. In March, 1977, the same 12 month rolling herd average was 19,124 lbs. of milk and 685 lbs. of butterfat. While Dr. Stouder was reluctant to credit deworming for all of the increase, i.e., 1440 lbs. of milk and 84 lbs. of butterfat, he did believe that it contributed to it. Of interest here, is a telephone report to me by Dr. Stouder that in 3 additional herds, using pasture and subjected to similar experimental design except for the use of coumaphos for 6 consecutive days in treatment, no benefit was detected. No fecal samples were taken.

Harris and Wilcox[15] in Florida utilized thiabendazole in one trial and coumaphos in a second trial. In the first trial 158 cows were treated with thiabendazole approximately 4 weeks prior to parturition. A control group of 157 untreated cows was used in this trial. On the basis of mature equivalents control cows produced 623 lbs. more milk, and 31.9 lbs. more fat. The fat was 0.054% higher in untreated cows. Only the quantity of milkfat differed significantly. In the second trial, 46 cows received coumaphos for six consecutive days and 39 cows served as untreated controls. Least squares means for actual milk and for fat percentages were calculated for a 60 day post-treatment period. Results favored the treated group by 8.8 lbs. milk and the untreated group by 0.22 lbs. fat. The percent fat was the same in both groups. In both of these trials, then no advantage was obtained from treatment. Similar results were obtained by Beatty *et al.*[6] in Mississippi. In this instance, 36 animals were paired according to production, age, and stage of lactation. One member of each pair was randomly assigned to treated group and the other to a non-treated group. The treated group received coumaphos for six consecutive days. Even though these cows were allowed access to sorghum-sudan grass pasture when available, deworming did not increase milk production during a nine week post-treatment period.

In attempting to demonstrate experimentally what they believe they have demonstrated in the field, the Wisconsin researchers[10] inoculated lactating cows with approximately 200,000 infective larvae of mixed culture of *Haemonchus, Ostertagia, Trichostrongylus, Cooperia,* and *Nematodirus.* The effect of these inoculations was a depression in milk production and a finding of numbers of parasite eggs in feces comparable to those observed in the field. Additional research of this nature clearly needs to be conducted.

In summarizing the foregoing trials it appears that under some conditions found in Wisconsin, Vermont, North Carolina, Pennsylvania, Texas, California, New Zealand, and Belgium, milk production is at times adversely effected by subclinical gastrointestinal parasitism in milking cows. In the United States the adverse effect is taken to be most severe in early lactation while that in the New Zealand trials occurred only in the summer which corresponded to the second half of lactation. Where response to anthelmintic treatment occurred in the United States, it has been said to occur in as short a time as 6-8 days after a single treatment and may be as prolonged as 60-90 days. In some instances, additional treatments have been said to extend the beneficial response. The beneficial response which appeared to occur was often in the range of 400-800 lbs. of whole milk per lactation. On the present market this approximates a return of $40-$80 for an expenditure of $3-$8 per treated cow. Certainly a 10-20 fold return on investment in anthelmintics appears enticing and might lead one to advocate such treatment as part of a health program for all milking cows. This appears to be the view taken by Todd *et al.*[22] when they stated "Treatment of subclinical parasitism should be included in all health programs for dairy herds". Such a view appears to ignore the more than occasional negative results obtained in the previously reviewed trials. As a matter of fact, in two Pennsylvania herds untreated cows averaged 920 and 638 lbs. more milk than the treated cows.[22] These data compare quite closely with those of Harris and Wilcox[16] in Florida wherein the average mature equivalent production of untreated cows exceeded that of treated cows by 623 lbs. of milk. These results appear to favor the lack of treatment to a degree that is quite similar to the 500 to 750 lbs. (and more) increments of milk production associated with the removal of parasites.[21,23]

While I do not doubt that "subclinical parasitism" does occur in lactating dairy cattle, I do not believe it is as widespread as suggested by others,[21] nor do I believe the routine administration of anthelmintics to all dairy cattle should be a part of all health programs.

should be a part of all health programs.

As a result of my naivete, academic ideals, or hopefully a pragmatic evaluation of the previously discussed reports, along with confidence in the diagnostic competence of consulting veterinarians, I believe a more rational approach to the question of treat or not-to-treat can be obtained. As a matter of fact, Todd[22] has reached much the same conclusion wherein he discusses the meaning of parasite egg counts and noted that in herds where he had individual worm egg counts per 5 grams feces such as "0, 1, 0, 0, 0, 2, 0, 0, 0, 0," he would not deworm the herd. He also noted that the only worm counts he has found like this were from drylot dairies in Southern California near Los Angeles. Similar results are to be obtained in some dairy herds located in Central California and I suspect in dairies located in most any part of the United States where management practices, including anthelmintic administration, are designed in a manner to minimize the infection cycle of the parasites involved. A full discussion of the infection cycle of gastrointestinal parasites is beyond the scope of this paper, however, the interested reader is referred to the papers of Baker[4], Douglas and Baker[13], Gordon[15], and Michel[19]. For the moment, let it suffice to state that unless sufficient parasites are present to inhibit performance of dairy cattle no response from the administration of anthelmintics can be anticipated! This certainly seems obvious enough, but nevertheless is the single most overlooked fact in all the studies previously reviewed. Of further consideration is the fact that if parasites are present in sufficient numbers to reduce performance, the cows either brought them with them when they entered the milking string or the infection cycle is functioning in the environment of the cows at a rate commensurate with the production of populations of parasites large enough to impair production.

Todd and co-workers have directed some effort toward this aspect of dairy parasitology and have stated[21] with regard to the previously mentioned Southern California herds; "Deworm their heifer replacements". Obviously in this instance they are concerned with cows bringing the worms into the milking string with them. Concerning the possibility of the infection cycle functioning in the environment of the lactating cows, and/or the environment of the springers and dry cows, Bliss and Todd[9] while conducting studies in Vermont examined 3 x 3 inch scrapings from around mangers and stalls and recovered as many as 702 infective larvae per scraping in the month of October.

Dr. Todd has informed me as recently as February 9, 1979, that despite ambient temperatures as low as 12F in Wisconsin, temperatures inside a barn which was housing cattle never dropped below 50F. One must assume that the presence of cattle in the barn would yield a moderate to high relative humidity and consequently temperature and moisture conditions conducive to the development of infective larvae might well exist. Indeed seven species of infective larvae were found in the manger!

If no provision in management is made to reduce contamination and/or ingestion of infective larvae under such environmental conditions it is quite possible that infection rates commensurate with "subclinical parasitism" might well occur.

One might also reflect on the New Zealand trials,[18] as previously noted, the positive results of treatment occurred only in cattle treated during the summer months. These were pastured cattle in which stocking rates were increased in the Spring. Further if one examines the expected seasonal incidence of infective trichostrongyle larvae on New Zealand pastures,[25] the positive response is found only in cattle treated after the anticipated Spring peak in pasture infectivity had occurred. This suggests that in cattle treated prior to that peak of infectivity there was insufficient numbers of parasites to influence production.

From their own findings, along with other similar evidence, Wisconsin researchers have concluded[21] that "There are no herds where worms are not present!" and have further stated, "Of course sanitation helps control parasitism but let's admit that worms surmount sanitary barriers using sheer numbers of available infective larvae".

Workers in California do not believe such sweeping conclusions are warranted and have begun studies of the impact of parasitism on production of milking cows in that state. Philosophically it was decided in initial studies to select a large dairy managed in a way believed to minimize the potential for parasite development. The reason for the initial studies in this type of dairy being that if favorable response was obtained it could be assumed that favorable response could be anticipated under most dairy management systems in California. The dairy selected was located in the San Joaquin Valley near Madera, California. The milking herd consisted of 766 registered and grade holsteins averaging 17,619 lbs. milk per lactation. The dairy utilized no pasture. Of the total milk string 544 cows (273 treated and 271 controls) were utilized in the trial. Cows were used in the trial only if they produced more than 65 lbs. milk on the first DHIA test day following parturition and only if a suitable pairing with another cow freshening during the same 30 day period could be made. Over a 12 month period, all cows which met this requirement and had freshened within the month were paired on the basis of age, lactation, production, day of freshening, and body weight. As a result of this experimental design, one may view this study as 12 trials involving an average of 45 cows, or 1 trial involving 544 cows. Members of each pair were randomly assigned to treatment or control group. Treatment consisted of coumaphos for six consecutive days. DHIA records for the following 10 months lactation were analyzed as a basis for comparing production. Fecal samples were collected from all cows before treatment and from approximately one-half of the cows after treatment. Parasite eggs in feces were counted by the Wisconsin Sugar Centrifugal Flotation Technique.[12] At no time during the year did the average parasite egg count exceed 1.1 eggs per 5 gram feces and in only 3 of 12 months did an individual count exceed 5 eggs per 5 grams feces. Analysis of all possible measurements contained within the DHIA records failed to show differences between treated and untreated groups. The same lack of response was obtained when production records were analyzed on a monthly or quarterly basis. The conclusion was that this herd, and by inference, all like it, would not show increased production as the result of the administration of anthelmintics to freshening cows. These negative results, coupled with those previously mentioned, and others not mentioned, suggest that veterinary consultants might better serve their clientele if they use appropriate diagnostic procedures and deductive evaluations of the potential for infection in individual dairy herds rather than blanket recommendations for the administration of anthelmintics to all milk cows. In this respect, it is my opinion that in the three previously mentioned trials conducted by Dr. Stouder wherein coumaphos was used to treat pastured dry cows on freshening, the reason for failure to obtain a positive response was in all probability due to absence of worms, rather than inefficiency of anthelmintic as might be suggested by some.

Diagnosis of Subclinical Parasitism

As noted by Todd, *et al.*[24] the McMaster technique for fecal examination is unsuitable for use in mature cows, either dairy or beef. The reason for this simply being that it is a dilution procedure and as usually conducted does not detect parasite egg counts of less than 50 per gram (250 per 5 grams) of feces. Some practitioners have utilized the Evsco Fecalyzer® flotation technique for relative fecal egg counts in feedlot cattle. While this technique is often suitable for that purpose, in our experience it has been necessary to multiply the eggs counted by a factor of 10-20 in order to obtain an approximation of the actual number of eggs per gram of feces. Consequently, only in samples having 50 to 100 eggs per 5 grams feces would this procedure be dependable. As a result, the author agrees with the Wisconsin workers that some form of centrifugal flotation procedure be used and in view of the volume of data now available as a result of the use of the Wisconsin Sugar Centrifugal Flotation Technique[12] see no reason why it should not be considered the method of choice in dairy cattle.

For the present, at least, I believe the *guidelines* presented by Todd[21] for interpretation of parasite egg counts are appropriate.

In that publication he stated that if parasite egg counts per 5 gram feces from 10 individual animals were 4, 21, 0, 7, 13, 6, 12, 0, 18, and 45 (average 12.6) recommendation for deworming would be made. If counts as previously indicated for the Southern California herd are encountered no recommendation for treatment would be made. If counts of 21, 78, 167, 8, 2, 131, 980, 670, 93, and 211 (average 236.1) are obtained, he would not recommend treatment until extensive changes in management practices were made. He notes, and this writer agrees, such counts would be associated with many managerial problems in addition to parasitism. Further he notes such counts would indicate clinical rather than subclinical parasitism and while the cows can be dewormed with anthelmintics, sustained increases in milk production could not be expected until the many other problems as well as the parasitic are corrected.

In the final analysis, there is no infallible diagnostic procedure for subclinical parasitism. The veterinarian and dairymen concerned with this problem should first ascertain whether parasite egg counts are indicative of the condition and whether or not conditions which are commensurate with a functioning infection cycle exist. If the first or both of these are actualities, then well conducted anthelmintic trials would be in order. Alternatively, the veterinarian and/or dairyman might conclude that the cost of the anthelmintic is minimal and proceed with routine treatment of the herd.

Control of Subclinical Gastrointestinal Parasitism in Mature Dairy Cows

This writer has no basis on which to disagree with the treatment recommendations of Todd.[21] Dr. Todd considers the best program to be one in which the cow is dewormed at freshening, again at 60-90 days, and again at 120-140 days of lactation. If only two anthelmintic treatments are to be administered, he recommends they be administered at freshening and again in late Spring. If only one anthelmintic treatment is to be administered, it is best to administer it at freshening. Dr. Todd, and the writer are in agreement that dry cows should not be dewormed in routine herd health programs.

It is the view of the present writer that "subclinical parasitism" in dairy herds offers the veterinary consultant an ideal opportunity to demonstrate his value. It is my opinion that the judicious application of knowledge concerning population dynamics of parasites and their control coupled with the appropriate use of diagnostic procedures and rational use of anthelmintics as well as other needed management practices will allow the elimination of this drain on production. When appropriate, management practices are instituted and the infection cycle adequately controlled the use of anthelmintics can be greatly curtailed or eliminated.

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