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Planning Cow Flow in a New Startup Dairy

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Introduction

The dairy industry in the Upper Midwest is changing rapidly. One of the major changes is the appearance of much larger dairies, either as new startups or as major expansions of existing dairies. Veterinarians involved with these enterprises during the first two years of operation certainly have many challenges to address. However, these situations also present some unique opportunities for veterinarians to couple their medical skills with their management expertise.

These dairies face two related (but distinct) financial concerns: liquidity and profitability. While profitability is a long-term necessity for survival, most of the financial stress in the early years will usually arise from inadequate liquidity rather than profitability. Adequate liquidity (or "cash flow") is necessary for the dairy to pay the necessary bills on time (such as feed bills, payroll, veterinarian, etc.) and begin making debt payments. If the dairy runs out of available cash to pay for feed, replace animals as needed, or have necessary repairs done, it is out of business, even if a positive profit can be shown. Additionally, they often have a very high degree of leverage, exacerbating the situation.

Cash flow is the balance of income versus expenses over the same time period. While careful purchasing and tight management of expenses is important, cost control alone will not ensure success in that the income side must be also be robust enough to cover all expenses in a timely manner. In many cases the herd owner and veterinarian has more influence over the income side than the expense side.

The income stream itself is made up of milk income, cull cow income, and calf sales income. The overwhelming majority of this income will be from milk sales. While price received per CWT is important, the pounds of milk per cow and the number of milking cows are the factors that management can affect the most.

Therefore, these dairies must:

- Find sources of high quality incoming animals
- Fill barn quickly with milking animals
- Get high production
- Save money where appropriate
- Spend money where appropriate
- Replace animals on an economic basis

It should be obvious that there are ample opportunities here for veterinary input in the areas of biosecurity, labor training, standard operating protocols for routine procedures and special need cows, design of housing, nutrition, etc.

However, there are consequences arising from freshening animals as rapidly as possible on future management. This paper will describe a simplified model to predict cow numbers by group over time, effects on total milk production, and effects on cashflow.

Culling Models

Many existing models for expansion dairies assume a "straight line" method of calculating the expected number of culls. It assumes that an equal percentage of the total culls will be culled at each point in the year. While this approach may work adequately in steady-size herds, it can present some pitfalls if used in a startup situation.

The model used here takes a slightly different approach to culling behavior. Instead of assigning culling rates for each month of a twelve month period, it assigns a culling rate for different periods of the lactation, as the behavior may be quite different in each period. See Figure 1 for a graphical display. The lactation is divided into four periods:

1. Fresh/early lactation cows
2. Mid lactation cows
3. Late lactation cows
4. Dry cows.

Fresh/early lactation cows. The tendency is for the dairies to cull only as absolutely necessary in this period, meaning that the animals leaving are the "die-ers". This is where veterinary input may have its biggest impact by providing advice on:

Purchase specifications
Biosecurity issues
Design of closeup and maternity facilities
Establishment of vaccination protocols
Training of the calving personnel
Closeup and postpartum nutritional management
Design of standard preventative protocols
Early disease detection and logical treatment protocols

However, proper veterinary input can both lessen the number culled and improve the productivity of the survivors.

Mid lactation cows. During this period here the producers will tend to keep almost any animal that is still milking. The veterinarian's goals should be to keep these animals as healthy and productive as possible while aggressively attempting to have these animals reconceive. Culls here tend to be only the catastrophic cases.

Late lactation cows. During this period producers will be forced to cull the animals that are neither milking nor pregnant. In many of these cases a wiser economic choice, at least from a profitability standpoint, would have been even earlier culling and replacement with a better animal. However, cash flow simply may not be adequate at this point to cull aggressively. Unfortunately, sometimes these less profitable animals are not replaced simply because the cull rate would be above a pre-defined target. We are developing better methods of estimating the economic impact of culling an animal with replacement on a individual cow basis, rather than merely looking at a target herd culling rate.

Dry cows. Little culling is typically done during this period.

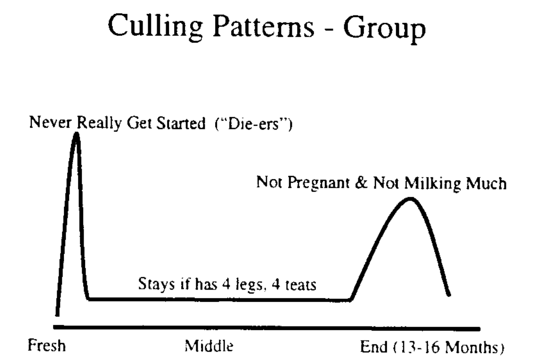

Figure 1. Graphical display of culling patterns. Expected culling rates are defined by the user in each of the three periods of culling (dry culls are assumed to be zero).

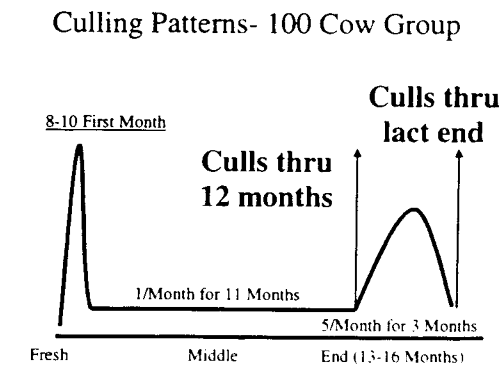

Figure 2. In this example note the difference in cull rates when defined for the first year versus to the end of the lactation.

Lactational versus Yearly Cull Rates

One pitfall of conventional cull models is the difference in the first year of operation between the number of animals culled in first twelve months versus how many of the original animals will need to be replaced prior to their next lactation. In the example in Figure 2 above, it illustrates that a 100 cow original group may still have 78-80 animals in the herd at the end of the first twelve months, but only have 65-70 animals that make it into the next lactation. These extra culls occur after the twelve month initial startup is over, but before the start of the next lactation. Note the diagram shows only the first group and succeeding monthly groups of fresh cows will compound the problem.

If projections for the second year of operation are based on the assumption that this "yearly" cull rate will continue, the dairy will be very short of milking animals in a few months. This has actually happened on more than one dairy! The owners do a good job the first 12 months, find out they have culled only 20% so far, and base their next year's replacement budget on 20%. They think they have beaten the average by a long shot, only to be caught short in a few months. On the other hand, if the cull rate is already 35% at the end of 12 months, this may be an even larger warning sign.

Example Dairy Using the Culling/CowFlow Model

Below are several graphs that were produced using the culling/cowflow model described. There are many more assumptions build into this example than will be discussed, but some of the major assumptions of concern are::

Total final herd size	**750 adults**
Time to fill	**5 months**
Calving interval	**14 months**
Culling rate/period	**6 early, 8 over mid, 16 in late(14% 1st yr/30% lact)**
Production	**See Figure 7**
Milk Price	**$13.25**
Expenses	**Assumed lower feed prices, average other costs/cow**

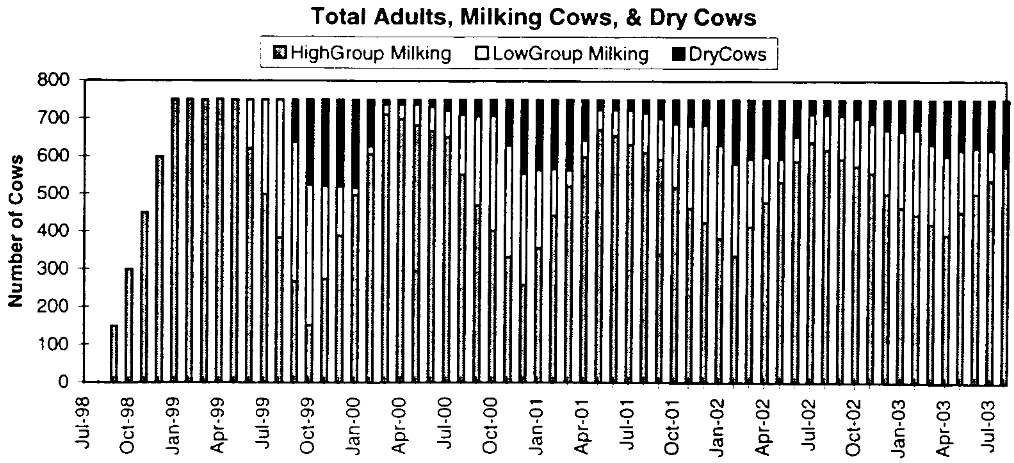

Figure 3. Example projection of animal numbers by group. Scenario is 750 total adult animals, freshened equally over first five months. Note the absence of any dry cows first 12 months, followed by large variation in counts of milking versus dry cows.

Milking Cow Numbers

Notice the large variation in the milking cow herd size, with essentially no dry cows early in the first year. Notice also that there will be times that milking numbers will drop precipitously. The purchase of additional milking animals can offset some of the drop, but often requires the active knowledge and participation of the lender. Filling these holes with additional animals solves some of the problem, but creates additional problems in that in a few months the dry cows begin freshening again and there may be too many milking animals present.

Late Lactation Cow Numbers

There will also be cycles where large numbers of later lactation cows are present. Careful attention to nutrition and to use of rBST can help to offset some of the production drop, but this drop needs to be anticipated.

Dry Cows Numbers

An issue that arises with filling a barn quickly by freshening large numbers of animals is that eventually there will be a large number of dry cows present at certain times in a cyclic manner. See Figure 3. Large numbers of dry cows present at least two problems: They either occupy space that could be used by milking cows or they must be crowded into space allocated for the "steady-state" dry cow numbers. Sometimes they can make up 30-35% of the total adults on the dairy versus the more typical 12-13%. This may have major impact on cash flow. It has been suggested that delaying rebreeding in the first year is a solution to this dilemma, but it may not be wise to suggest that a new operation be anything less than aggressive in its breeding program.

The cyclic variation in demographics have major effects on total milk production and consequently on income. Examples are shown in Figures 7 and 8.

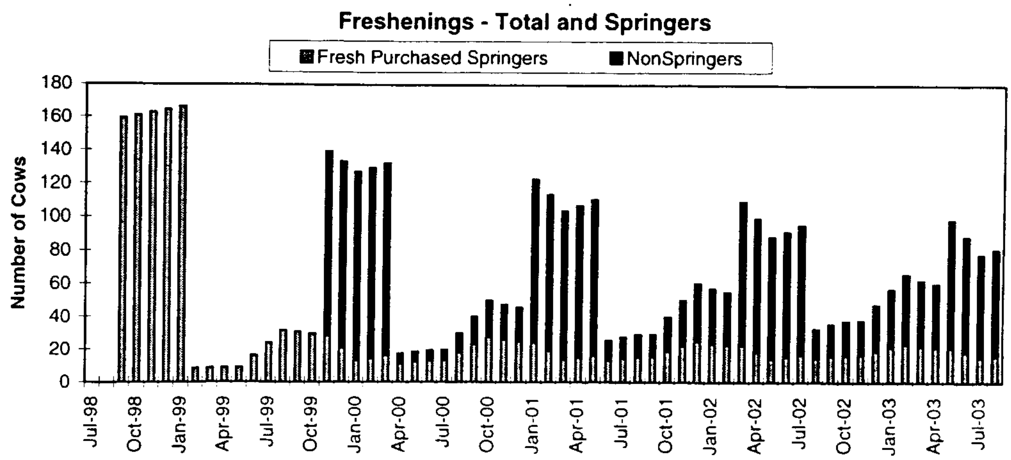

Figure 4. Example calving patterns.

Note the variability in numbers calving each month. This variation needs to be anticipated for facility design and labor allocation. Note also that there will be a need for extra springers to fresh 12 to 15 months after start of project.

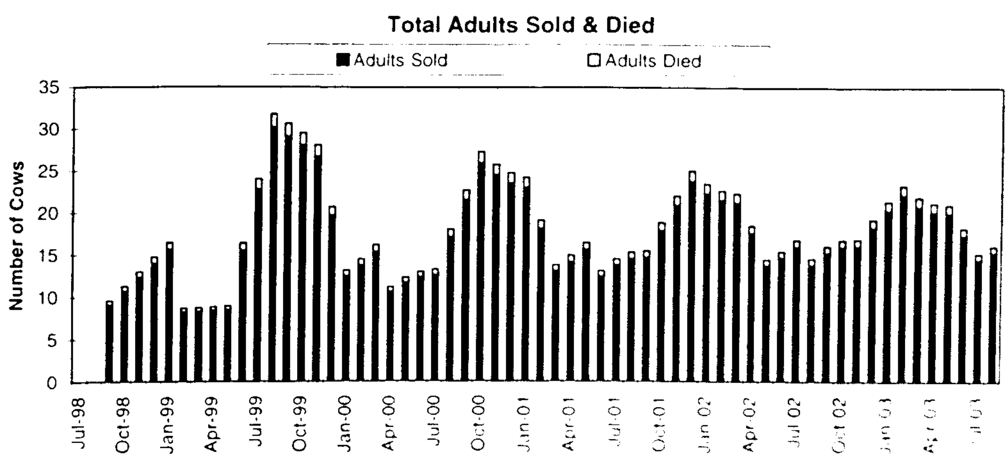

Figure 5. Example projection of culling numbers by month

Shown here is the predicted pattern and the variation in number of culled animals. These animals culled must be offset by proper strategic purchases of additional replacement animals.

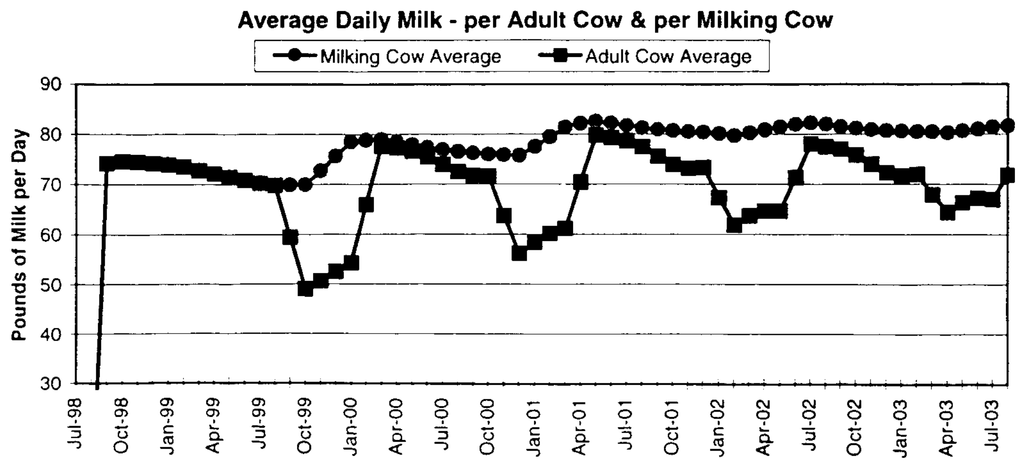

Figure 6. Example projection of production on a per milking cow and adult cow basis.

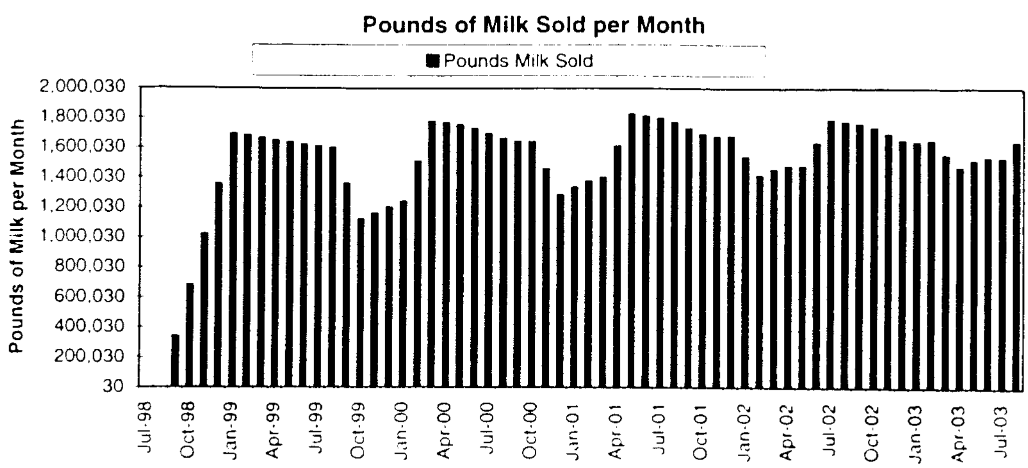

Figure 7. Example projection of monthly production.

Note the cyclic variation present. This variation occurs to some extent from having cows in later lactation, but the majority of the effect is from the drop in milking cow numbers due to culling and drying off. These drops in production need to be anticipated and a plan formulated to minimize their impact.

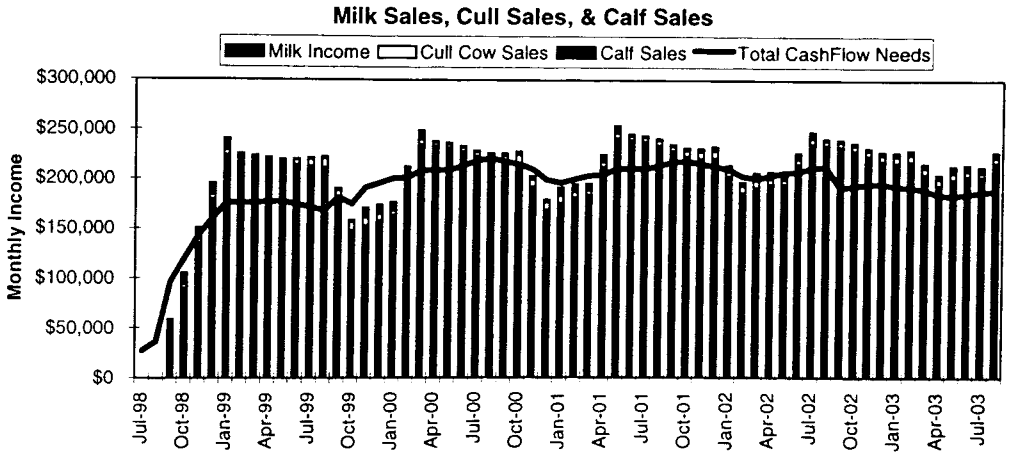

Figure 8. Example projection of income and cash flow needs.

This graph illustrates the overall effects of cow numbers, group distributions, milk production, and expenses on cash flow. Note that milk income is by far the predominant influence on overall income.
One problem that arises is that cash flow may be quite good in the 6-12 month period following startup and lead to complacency, but money must be set aside to fill upcoming deficits 12-15 months into the project. These cycles may repeat for several years.

In this example it was assumed that all feed was purchased on an "as-needed" basis. In the real world however often the year's forage needs are purchased in the fall. If the milk income deficit falls in the same time frame, there can be more severe cash flow problems than shown in the graph. Forward planning of total yearly feed purchases can be an additional service offered by the veterinarian.

It is easy to imagine this example scenario in a new, fall-starting, heavily leveraged operation that starts behind schedule (with cost overruns):

1. Corn silage projections fall short, causing the dairy to run out in June.
2. No cash is available for purchasing large amounts of corn silage, forcing the dairy to purchase different byproducts each week.
3. Production is dropping as could be expected from the herd demographics.
4. Production drops further with ration changes.
5. Every consultant recommends "cutting costs".
6. BST administration and vet services are halted to cut costs.
7. Production drops even more.
8. Low producing, nonpregnant cows need to be replaced, but no cash.
9. Fall corn silage purchases can not be made, due to low cash flow.
10. Owners face foreclosure.

4. The availability of accurate analysis of easily and safely obtained liver biopsies from live cows.
5. The interest of a group of people to fund and carry out an extensive survey of the current status of copper intake and liver concentrations of copper in dairy farms in Minnesota.

Across the country, the amount of supplemented Cu ranges from 8-10ppm using TM-salt, upwards to 30-40ppm using $CuSO_4$ and/or an organic form of Cu. Over the past several years Dr. Murphy has noted a trend upwards in the number of liver samples where Cu and other trace mineral analysis has been requested and a trend upwards in the concentration of Cu in the liver. There was also the trend of more sample analysis being in the high or cautionary concentration, above 250PPM wet weight or above 750PPM dry weight.

Survey summary

To assess the current status of Cu, and other trace minerals, liver biopsies were taken from 442 Holstein dairy cows in 30 dairy herds in 6 different geographic regions in Minnesota. Within herds, biopsies were taken at calving±10 days, 90-150 days of lactation and 270 to dry off. Three biopsies of approximately 15mg dry wt. total were taken from each animal, dry ashed and determination of mineral content made by ICP analysis. Summary statistics were categorized by; animal, region, herd, and stage of lactation. The mean ±sd Cu was 480±223PPM DM basis. Mo, Zn, and Fe were 3.81±1.05, 141±53.5, and 289±53 respectively.

Mean Cu concentrations for the 5 areas ranged from 453±186 to 499 ±246 PPM. Analysis reveal that all but 2 animals had adequate liver copper concentration (less than 75PPM DM basis and 11% of all animals had concentrations above 750PPM DM basis. Differences in liver Cu concentration between herds were greater than the differences between regions. Mean liver Cu concentration by farm ranged from 206±84 to 670±284. In 9 of the first 25 herds, more than one cow had a liver Cu concentration above 750PPM. In 3 herds, >25% of the cows sampled had liver Cu values above 750PPM. The mean liver Cu at calving was 434±292 as compared to mid and late lactation means of 481 and 507. This would be expected because of the transfer of Cu to the fetus in late gestation. The results of the survey clearly indicate that liver copper concentrations in over 50% of Holstein cows in Minnesota are in excess of the established normal ranges of liver copper concentration (75-300PPM dry matter basis or 25-100PPM wet basis).

Case of Toxicity in Jersey Cows

Two adult Jersey cows that died, revealed acute liver necrosis, generalized icterus, and hemolytic fluid in the peritoneal cavity. These two cows had 220 and 415 mg of copper/kg of liver (wet weight). This herd had received 37ppm (dry matter (DM) basis) copper in a total mixed ration (TMR) for 5 years. Serum, plasma and liver biopsies were collected from 7 other cows in the milking herd. The serum was analyzed for GGT & AST enzyme activity and plasma was analyzed for copper concentration. Liver was analyzed for copper concentration and evaluated histologically, including copper staining. Mean serum GGT and AST concentrations were 42 and 125 U/L, respectively. (Normal range = 26-93 and 5 -34, respectively.) Mean plasma copper was 1.0 PPM. Mean liver copper concentration was 583 PPM (DM basis). The 2cows livers were positive for copper staining.

Supplemental copper was reduced to 10ppm copper. Molybdenum (Mo) treatment was initiated. Each animal received 200 mg Mo (as sodium molybdate) daily for 5 weeks. Serum, plasma and liver biopsy samples were taken from 5 of the same 7 cows after they had received 24 days of molybdenum treatment. Mean GGT and AST concentrations were 38 and 93, respectively. Mean plasma copper was 1.22 PPM. Liver copper in the 5 cows decreased from 838 to 750ppm. Neither light nor electron microscopy examinations revealed hepatic lesions.

This herd averaged 50 pounds of milk/cow throughout the episode, just as they had for the previous 3 years. The National Research Council guideline stating that 100ppm copper in the diet of dairy cattle is "safe" needs revision for cattle, especially Jerseys.

Laboratory Diagnosis.

We summarized data from several publications by species dosage, duration, tissue Cu concentration, serum biochemical results and pathological and clinical findings. The biochemical results indicated that a combination of serum aspartate aminotransferase (AST), gamma glutamiltransferase (GGT), and Cu could be used as an early diagnostic test. In a case of chronic wasting disease in a flock of 80 ewes, the serum biochemistry revealed increased AST activity in all animals and increased billirubin in 2 sheep. During acute Cu poisoning in sheep induced by administration of organic or inorganic Cu, serum and blood samples were analyzed for Cu, creatine kinase (CK), GGT, and AST. Serum Cu concentrations rose sharply in all animals, shortly before death. Serum CK activity decreased with the beginning of Cu supplementation, however this enzyme was increased in 2 animals at the end of the observations. GGT activity rose in the beginning of the trial, but fluctuated during the trial in these lambs. AST increased from the beginning of the experiment in all animals; however, the concentrations decreased dramatically before death in 2 animals and remained high for the others. In another trial there was an elevation of serum acid phosphatase (ACP) activity during the pre-hemolitic phase in all sheep.
Bradley reported an outbreak of Cu poisoning in a dairy herd fed a mineral supplement providing 37.5 mg/kg for lactating cows diet and 22.6 mg/kg for dry cow's diet (on a dry matter basis). The laboratory results from 5 of 6 cows showed elevations of total bilirubin, GGT, and AST Activity. In one animal serum Cu concentration ranged from 1.05 to 2.92 mg/kg (normal levels are considered to be 0.7 to 1.7 mg/kg). In experimentally induced chronic Cu toxicity in bulls the AST and GGT activities were increased only in the bulls that received 10 and 20 mg of Cu per kg BW/d. In chronic Cu toxicity in dairy cows, blood Cu concentrations were within normal limits (1.05 ±0.08 ppm).

Treatment

Tetra-thiomolybdate, was administered intravenously in sheep with Cu intoxication. Following the administration, there was a reduction in the Cu concentration in the liver fractions, the number and size of electron-dense lysosomes in hepatocytes and the number of necrotic cells in the liver. Thiomolybdate appeared to remove Cu from the lysosomes and the cytosol of Cu-loaded liver cells. Furthermore, following thiomolybdate administration, Mo concentration in the liver and liver fractions increased indicating that Mo from thiomolybdate was entering liver cells. A group of sheep during the acute phase of Cu toxicity were treated with ammonium tetra-thiomolybdate (6 doses of 15 mg/kg of body weight) administered intravenously. Following the administration of thiomolybdate, the concentration of Cu in the liver decreased to standard values. Humphries, described a treatment in sheep that has also been successfully applied to Angora goats. The treatment involves a series of three intravenous or subcutaneous injections of ammonium tetra-thiomolybdate on alternate days. This treatment can remove up to 500 mg of Cu from the liver of a Cu- loaded animal. In a group of Merino sheep fed Cu, the authors used the cupruretic effect of chelator D-penicillamine as capsule intraruminally every 12 hours for 6 days. The results showed an increased average daily Cu excretion by about 20 fold compared to all other groups.

During Cu toxicity in a dairy herd fed a mineral supplement, the author described the use of ammonium molybdate orally as a preventive and as possible method of achieving Cu excretion from tissues. All cows, both dry and lactating, were given 500-1000 mg of the crystalline powder of ammonium molybdate daily as a top-dress on the feed for 18 days. After this treatment, serum Cu levels were significantly lowered and no further deaths or clinical signs were seen. In another case of Cu intoxication in 65 Aberdeen Angus, 55 Charolais and 15 Limousine calves, the animals recovered after the following treatment: 1) 5 calves were given a regimen of 70 mg/kg body weight intravenously sodium calcium edetate (EDTA) on 2 consecutive days, and 2) 6 calves a regimen including 2-7 mg/kg body weight intravenously ammonium tetra-thiomolybdate on 3 alternate days.

Discussion and Conclusion.

AST is usually released with changes in hepatocellular permeability, sublethal injury and necrosis. Animals that received 10 mg of Cu/kg BW/d or more experienced liver damage (plasma AST activity increased), that became detectable about day 40 of the trial. It is postulated that the cellular damage, during which individual hepatocytes are destroyed and are replaced with fibrous tissue. The result is a decrease in the functional mass of the liver. Duncan and Parse, demonstrated that the correlation between serum enzyme activity and clinical manifestation of hepatic insufficiency is poor. In chronic progressive liver disease, typically fewer hepatocytes undergo necrosis at any specific time, and serum AST may be unimpressive. Even with acute hepatic sublethal injury or necrosis, with very high serum AST activity, signs of hepatic insufficiency may be minimal. The AST results could also reflect that not all hepatocytes accumulate Cu simultaneously or at the same rates, causing some cells to be damaged before others. The fluctuating nature of the AST activity makes this enzyme an unreliable diagnostic tool for chronic Cu intoxication. GGT is associated with microsomal membranes and is usually released during lethal cell necrosis. This enzyme is most active in the canalicular surfaces of hepatocytes and bile duct epithelium and increases with cholestasis. However, the canalicular surfaces of hepatocytes and bile duct epithelium are not the primary sites of hepatocellular damage with Cu poisoning. Gummow, demonstrated an increase of GGT activity in the bulls that received 10 and 20 mg of Cu/kg BW/d. The pattern of these enzyme peaks corresponded with the AST peaks. Plasma elevations of hepatic enzymes such as sorbitol dehydrogenase (SDH), GGT, AST, and glutamate dehydrogenase (GLDH) are used as markers of active hepatobiliary disease in ruminant animals. However, the level of enzyme activities observed does not always correlate with the degree of functional impairment.

When the plasma Cu concentration of the Cu- poisoned bulls were examined, it was found that plasma Cu concentrations in the group that had received 10 and 20 mg of Cu/kg BW/d were significantly elevated as compared to the controls. Several authors have postulated that during the terminal stages of Cu poisoning, Cu is released from damaged liver cells in large quantities into the blood. However, this author supports the postulation that there is a correlation between liver cell damage and plasma Cu concentrations. Plasma Cu concentrations could act as an indicator for chronic exposure to Cu if the analytical method were more sensitive. The relatively low sensitivity of the analysis method would make it difficult to detected the small differences between normal and exposed animals under field conditions.

According to Blood et al., serum Cu is a very poor indicator of the Cu-loading of the liver. Blakley et al., demonstrated that cows, considered by serum Cu evaluation to be in the low normal and deficiency range, were found by liver biopsy and postmortem, to be at or near a toxic state. According to the majority of authors, the liver Cu concentration in ruminants is the most sensitive indicator of exposure to high concentrations of Cu in the diet. Cu analysis of a liver biopsy is the best diagnostic tool currently available.

All authors agree that the best treatment for the Cu poisoning, after Cu reduction in the diet, in ruminants is with tetra-thiomolybdate, either orally or parenterally. It is more important to prevent the disease before any clinical signs of poisoning appear. Prevention of Cu toxicity can be best achieved by carefully selecting a dosage of Cu for parenteral injection of Cu deficient animals and proper supplementation of Cu in diets. Mo supplementation should be considered for animals shown to be at high risk of acute crisis, before clinical disease is observed. Therefore, it would be helpful to know the existing levels of Cu in the liver of the cows and the Mo and Cu in the diet, when recommending Cu supplementation.

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