NUTRITIONAL MANAGEMENT OF YOUNG DAIRY HEIFERS

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INTRODUCTION

For dairy replacement animals, the first six months is when much of the labor is used, the price of feed is highest, and incidence of sickness and death is highest. While heifers over six months of age should not be neglected, if a heifer has been fed and managed properly for the first six months, feeding and management for the last 18 ± months prior to freshening is relatively easy. The period of time from birth to six months of age can logically be divided into three periods: birth to weaning, weaning to three months of age, and from three to six months of age. Each period differs according to the objectives and the things that need to be done to ensure success, and will be discussed separately. The title of this paper uses the term nutritional management because proper management of the feeds is often as important as the feeds themselves.

NUTRITIONAL MANAGEMENT AT DIFFERENT AGES

Birth to Weaning

To ensure success in the heifer replacement program, the most important thing during this time is for the calf to receive an adequate amount of high quality colostrum soon after birth. This point is covered in detail by another speaker, otherwise it would be a major point of this section.

The primary objective during this period is to facilitate the transformation of the calf from a functional nonruminant to a ruminant. Although liquid feed supplies a major part of the nutrients needed, dry feed is critical to stimulate rumen development. During this time, the calf is losing the passive immunity obtained by consuming colostrum and its own immune system is developing. Thus, those nutrients involved in function of the immune system (e.g. vitamin E) are especially important.

Liquid Feed. Consumption of colostrum during the first day of life does, and should, receive considerable attention. The benefits of consuming colostrum or transition milk after the calf can no longer absorb immunoglobulins **(Ig)** are usually not emphasized very much; however, Ig that are consumed and that prevent attachment of pathogenic microorganisms to intestinal mucosal linings are very useful. For this reason all colostrum and transition milk should be fed to calves, with the youngest and most valuable receiving first priority.

There are several advantages of having calves housed individually during the first weeks of life and several management steps which will be suggested require this. When possible, it is desirable to feed calves according to size. It is possible to achieve large gains before weaning by feeding large amounts of milk but this results in expensive gains and causes decreased dry feed intake, delaying weaning. Calves fed milk at 8% of their birth weight daily actually gained more than those fed 10% of birth weight because they ate more dry feed (Flynn, 1989). Feeding slightly under 2 quarts of milk twice daily provides 8% of birth weight for an average size Holstein calf. Flynn (1989) also observed a benefit of reducing milk intake during the last week before weaning by eliminating one feeding per day. A daily gain of one pound from birth to weaning is economical and is adequate from a health standpoint.

Dairy products are very important in diets for humans and, because of that, should bring a price such that the goal of dairy producers should be to have all saleable milk consumed as human food. In that scenario, when calves are kept on the farm where they are born, unsaleable milk suitable for feeding to calves would be used for calves and milk replacers, which are made mostly from byproducts of manufactured dairy products, would be used to supply the rest of the liquid feed

needed. The development of large calf ranches where purchased calves are grown, and the increased number of professionals who raise calves for others, has led to situations where the liquid feed for calves will be entirely milk replacer. Therefore, milk replacers are and will continue to be an important feed for dairy calves.

Several important changes have taken place in recent years in formulation of milk replacers. One of these is the use of whey protein concentrate **(WPC)** to replace much of the dry skim milk that formerly was used in large amounts. The increased consumption of cheese, and development of a method to concentrate the protein in whey have led to the availability of large amounts of high quality WPC, which is equal to casein for calves (Terosky et al., 1994). Unlike dry skim milk, WPC does not form a clot in the abomasum, therefore an older test for quality of milk replacers, based on the time required for a clot to form under controlled conditions, is not valid for use with milk replacers that contain WPC. Another change is the increased amounts of vitamin E added, based on the recognition of vitamin E as a nutrient important for function of the immune system in the calf (Reddy et al., 1987b; Hidiroglou et al., 1995) and that requirements of calves (Reddy et al., 1987a) are greater than was believed formerly. It is now common to supplement milk replacers with vitamin E at ≥ 100 IU per pound, several times the amount used a few years ago.

Still another change in milk replacers is based on the recognition that when high quality proteins are used, satisfactory gains are possible when the milk replacers contains less protein than the 22% recommended by the National Research Council (NRC, 1989). Tomkins et al. (1995a, 1995b) presented data from a large number of calves showing that growth of calves fed either 16, 18, 20 or 22% protein was not significantly different. Possibly this is related to the higher quality products that are available because of less damage during processing.

Characteristics of a good milk replacer include:

1. Provides proper nutrients, in correct amounts
2. Provides appropriate medication
3. Is palatable
4. Mixes well with water
5. Is economical

The most useful types of information provided on a milk replacer tag are:

1. Amounts of nutrients.
   Protein - Most replacers will not contain more than 22%, several now contain 20 and, as mentioned above, 18% may be used. (Sure to be an active area of Research in the near future.)
   Fat - Most replacers now contain 12-20% fat. Energy concentration is related to fat level. Higher fat levels are especially useful in cold weather.
   Maximum fiber - In most cases less is better.
   Major minerals - Calcium and phosphorus may be shown. NRC recommendations are Ca ≥ .70, P ≥ .60. These levels may be exceeded.
   Vitamins A, D, and E - NRC recommendations (IU per pound) are A-1700, D-270, and E-18. Vitamins A and D are relatively inexpensive and amounts included are usually several times recommendations. Also, most replacers now contain 100-125 IU of vitamin E per pound, which is justifiable.

2. Medication and withdrawal information.
   The four medications approved for use in milk replacers are chlortetracycline, oxytetracycline, oxytetracycline and neomycin, and decoquinate. The latter is used for prevention of coccidiosis. Choice of whether to use medicated milk replacers, and if so which medication to use, depends upon amount and type of stress to which the calves are subjected.

3. Ingredients used.
   The list may include 30 or more ingredients, of these the first few (those that supply protein and energy) are most important to consider. Those derived from milk (WPC, dried whey, sodium caseinate, dried skim milk and delactosed whey) are very valuable because they supply high quality milk protein and all except sodium caseinate

supply lactose, which is the carbohydrate of choice for calves. Minerals, especially calcium and phosphorus, are concentrated in delactosed whey, thus limiting the amount of that product that should be used.

Three soy products are used in milk replacers. High quality soy protein concentrate can be used to replace part of milk protein with reasonably good results, depending to a large extent on residual anti-nutritional factors. Soy isolate does not contain the soy carbohydrates, which are not desirable for the calf, but does contain some of the anti-nutritional factors, and the quality of soy isolate is variable. Milk replacers containing soy flour are lower quality products. Caugant et al. (1994) have recently presented data showing that soy proteins caused poor clotting of casein in the abomasum, thus providing further insight into proper use of soy products.

Several newer milk replacer protein sources have been investigated in recent years. These include plasma protein (Tomkins et al., 1994; Morrill et al., 1995), wheat gluten (Tomkins et al., 1994; Terui et al., 1996), and red blood cell protein. Some of the research has yielded promising results. More research is needed to improve quality, reduce variability, reduce cost, or determine appropriate supplementations needed to increase use of these products. Some other products supplying protein, including meat solubles and fish protein concentrates, are not recommended.

Animal fats (tallow or lard) are usually used in milk replacers. Vegetable oils must be saturated before use by calves. To aid in dispersion and utilization of fat, natural emulsifiers such as lecithin and synthetic emulsifiers such as polyethylene glycols are added.

Other additives include probiotics, which may improve performance of calves, especially if they are stressed (Ruppert, 1994), and bovine serum Ig, which has been reported to have a positive effect on calf performance and health (Drew, 1994).

4. Directions for use.

   This information is self explanatory and should be evaluated in light of logical recommendations.

Calf Starters. The calf is born with an undeveloped forestomach. If it consumes adequate dry matter, the size of the rumen increases dramatically, the rumen papillae (which are necessary for proper absorption) develop, and a population of bacteria, protozoa, and other microorganisms become established. None of these will happen if the calf does not consume dry feed. This is why early consumption of dry feed is so important, and why formulation of the calf starter is so critical. If the calf is not fed starter or does not consume any starter until it is two or three weeks of age or older, initiation of rumen development is delayed that long. While the calf may not eat much starter during the first two weeks of life, the amount that it does consume is important because it causes initiation of rumen development.

From the preceding discussion, it should be obvious that anything that influences consumption of starter is of prime importance. Some factors that influence starter consumption, and things that affect response, are:

1. Feed ingredients used.

   There is a paucity of controlled research comparing acceptability of various feed ingredients and often there may be confounding factors when feedstuffs are compared. For example, corn may be considered to be more palatable than sorghum grain for young calves. However, sorghum grain must be processed to be well utilized and, because of the physical characteristics of sorghum grain, processing often results in a fine particle size, which is not as readily consumed by the calf. To overcome this problem, sorghum grain or mixtures

containing ground sorghum grain are often pelleted, or may be conglomerated (Abdelgadir and Morrill, 1995). Corn, oats, and barley are grains that are very acceptable in starters. The value of molasses, both as a flavor enhancer and to control dust, is well known. Fats are desirable to increase energy but may decrease dry matter intake with the net result of decreasing energy intake. Kuehn et al. (1994) reported that growth or health of calves was not improved when fat was added to the diet by using whole soybeans processed to an exit temperature of 150°C in a drum roaster. Reddy et al. (1993) observed good performance of calves fed soybeans roasted at 143°C or 146°C.

2. Particle size.

Calves prefer a coarse-textured feed. It is easier to provide desirable texture if grains are processed with a roller mill than if ground with a hammer mill. It may be desirable to pellet all of those ingredients in a starter mixture that have small particle size.

3. Feed management.

This should be obvious, yet it is often one of the most neglected areas of calf management. Having the feeder at the proper height and location, far enough from the water source that water does not get in the feed, and providing fresh feed at all times encourage consumption.

4. Stimulation.

For calves that are fed milk or milk replacer from a bucket, putting a small amount of starter in the bucket at about the time the calf finishes drinking is a simple, yet effective, way to encourage early starter consumption.

5. Water.

Having water always available results in increased dry matter intake and gain and decreased scour days (Kertz et al., 1984), while avoiding water intoxication which can result from over consumption of water.

The amount and type of roughage that can or should be fed to a young calf has been a source of confusion in recent years. There has not been a clear distinction maintained between feedstuffs, nutrients, and physical properties of feed ingredients. In the past, many calves were given access to hay and were fed starter to supplement the hay. In this type of system, some calves eat so much hay that their starter intake is low, resulting in an energy deficiency and slow growth. There is no way to conveniently feed individual calves a small amount of hay each day. Some producers have supplied only a starter, along with milk or milk replacer and have observed rapid growth of calves. Later, however, some of these calves bloat and/or growth rate decreases, and rumen development is not normal. The magnitude of the problem depends in part on whether the calves were maintained on bedding, because calves will consume straw or some other types of bedding which provides a kind of roughage. Losinger et al. (1995) observed that heifers fed hay after one day of age were less likely to be infected with *Salmonella* and suggested that heifers given something to chew on were less likely to consume contaminated bedding.

It has been shown that rumen volatile fatty acids **(VFA)** are responsible for growth of rumen papillae (Brownlee, 1956) but that a certain physical characteristic of the feed is necessary for proper morphological development of the papillae (McGavin and Morrill, 1976). Thus, it is not necessary to feed hay but the feed should provide certain physical characteristics. These physical characteristics of feed have not been adequately described nor has a satisfactory method been reported to measure these characteristics. A method to measure diet abrasive values **(DAV)**, a composite of feed abrasive values **(FAV)** has recently been developed at Kansas State University (Greenwood and Morrill, unpublished data) and research is currently underway to determine correlations between DAV and animal response.

The solution to the problem is to self-feed the calf a complete calf starter formulated to contain adequate nutrients (thus allowing adequate energy intake) and adequate abrasive value. Basic ingredients such as shelled or coarsely ground corn, oats, beet pulp, or soy hulls will contribute to the DAV and additional ingredients such as

chopped hay (about 3/8 inch) can be added. The entire mixture should be one that will not separate during handling and that the calf will not be able to separate. An additional benefit of having all ingredients that have small particle size pelleted, such as protein supplements and mineral and vitamin supplements, is that the DAV is increased.

Many different starter formulations are acceptable, Table 1 shows two examples. The 18% CP recommendation of NRC appears to be satisfactory (Akayezu et al., 1994; Siciliano-Jones et al., 1985). High energy concentration, concomitant with high intake is desirable; however, addition of fat may depress intake and growth (Kuehn et al., 1994). Starters should contain ≥ 25 IU of vitamin E per pound, otherwise, mineral and vitamin recommendations of NRC appear to be satisfactory.

Before weaning the calf is consuming large amounts of protein that is not fermented in the rumen because, due to action of the esophageal groove, the protein fed in liquid form goes directly to the abomasum. Therefore, during this time it is not necessary to have rumen undegradable protein (RUP) in the starter. However, because the same feed should be fed for a while after weaning, the RUP in the starter should be considered, and will be discussed in a later section. Antibiotics should not be added to starters, but coccidiostats (when needed) should be added. Seymour et al. (1995) reported that supplemental yeast (*Saccharomyces cerevisiae*) in a starter reduced the incidence of elevated body temperature and antibiotic treatments in young calves but had no effect on growth rate or feed efficiency.

When to Wean. For the calf to grow and be healthy after weaning, it must consume enough dry matter to supply needed nutrients and be able to utilize the dry matter it consumes. Since ability to use dry matter depends on rumen development, and rumen development depends upon past dry matter consumption, it follows that past and current dry matter intake are what determines the ability of the calf to grow and be healthy if weaned. Often on dairy farms today the post-weaning management of calves is not good and the poor performance of the calf may be attributed to the age of the calf when weaned, especially if the calf was weaned early. Proper management after weaning is discussed in the next section; recommendations made concerning weaning are made assuming good management before and after weaning.

Table 1. Examples of calf starters.

Ingredient	A[1]	B[2]
	---------- %, as fed ----------	
Corn, cracked	44.45	52
Oats	26.04	20
Soybean meal	21.24	19.5
Molasses, dry	2.85	---
Molasses, liquid	---	7.1
Tallow	2.65	---
Dicalcium phosphate	.51	.15
Limestone	.71	1.00
Trace-mineralized salt	.22	.25
Vitamin and medication suppl.	1.33	+

[1]Akayezu et al. (1994).
[2]Kansas Agricultural Extension Publication C-721, 1991. Raising Dairy Heifers.

A common recommendation has been made to wean calves when they are eating 1 ½ pounds of starter per day. The optimum amount has not been established under controlled conditions. Consider weaning calves that have steadily increased starter consumption up to 1 ½ pounds on 2 consecutive days, have gained at least 20 pounds since birth and are healthy. Delay weaning if weather conditions are extreme and make no other changes in calf management at the time of weaning, i.e., do not change feed, move the calf, or impose medical procedures such as vaccinations and dehorning. Weaning can be abrupt but results will be better if milk or milk replacer feeding is reduced by one-half, i.e., fed once daily for a few days. With good management and using good feeds, wean at 4 ± 1 week for most calves.

Weaning to Three Months of Age

Assuming that the calf is in individual housing and is weaned early, the objectives for the next few weeks are for the calf first to adapt to dry feed as the only source of nutrients, then make a transition to less expensive feed, and finally to adapt to group housing. Weaning is a major stress. Do not move the calf or change the feed
at the same time. Later, moving the calf to group housing is another major stress. Again, do not chanage feed at the same time. Never limit starter intake. It is not logical to add expense to a feed by using ingredients that increase consumption, then limit the amount the calf can consume. Instead, change the calf to another feed which allows the desired rate of growth at less expense. With proper management, desired rates of growth can be maintained throughout the first six months of life by calves that are self-fed their feed. The program presented requires attention to some details, but requires less labor and feed cost than if calves are weaned at eight weeks or more, which is the practice of many producers in the U.S.

Because the calf is no longer getting milk protein delivered directly into the abomasum, the amount of RUP becomes important. The percent of the protein that should escape rumen fermentation has not been accurately determined for young calves. Maiga et al. (1994) fed diets that differed in ruminally degradable carbohydrate, with RUP ranging from 25.8 to 40.5. Gains of calves tended to be greater when they were fed diets containing nonstructural carbohydrates and protein that was less ruminally degradable. In one study, Abdelgadir et al. (1996a) observed similar performance by calves fed starters containing ruminally synchronous or asynchronous protein and starch sources, in another study (Abdelgadir et al., 1996b) performance was superior when calves consumed protein and corn sources with similar degrees of ruminal availability.

After weaning, closely monitor dry matter intake and health of the calf for a few days and take corrective action if needed. To allow this, and to prevent added stress at weaning, leave the calf in the individual pen or hutch for several (7-14) days after weaning and feed the same starter. Then, at about 6-7 wk of age, move the calf into a small transition pen with a few (no more than 6-8) other calves. To minimize the amount of stress at the time of this move, provide the same starter free choice. Water should always be available. After about two weeks in this pen (at approximately 8 wk of age) calves can be moved into another small pen to start transition to a grower feed. Because it is always desirable to make feed changes gradually for calves, the feed in this pen should be a mixture of the starter the calves have been consuming and a good grower feed. Hay could be introduced at this time if desirable and water should always be available.

For many calves, two weeks in the second transition pen will be adequate and they can then be moved into a pen where the same grower and roughage are available, either combined or separately. Because the calves should be eating concentrate very well by this time, it is not necessary to place as much emphasis on palatability; therefore, the grower can be less complex and expensive than the starter. Many different formulations could be satisfactory; the NRC recommends 16% protein, 1.18 M Cal/lb metabolizable energy, and at least 16% acid detergent fiber. The NRC recommendations for vitamins and minerals are apparently adequate except for vitamin E. Eleven IU of vitamin E per pound is not considered adequate, it should be at least twice that amount.

If hay and concentrate are fed separately the amount of concentrate provided depends on quality of hay, composition of concentrate, condition of calves, weather conditions, and other factors. About 5 pounds per calf daily would be a base point to begin with, with adjustments made

as needed. Correct proportions of chopped hay and grower could be provided free choice (see next section).

During the time the calves are in any of the three pens, monitor their growth and move any calf that is not growing as desired back into a pen it was in previously. If a calf is getting too fat, it can be moved into the next pen. Providing feed free choice eliminates many problems that occur when calves of different sizes or with different degrees of aggressiveness are fed limited amounts of feed.

Three to Six Months of Age

By three months of age the forestomach of the heifer should be well developed and dry matter intake of common feedstuffs well established. The nutrient requirements of the heifer at this age, in relation to the capacity of her digestive system, are large enough that the dietary protein and energy concentration will need to be relatively high. The objective during this time is to establish a maximum rate of growth and maturity of the reproductive tract, consistent with good health of the heifer, and good economics. Because sexual maturity and initiation of estrous cycles occur at a certain size rather than at a certain age, more rapid growth decreases the time to sexual maturity.

There is a large amount of evidence showing that if heifers get too fat their subsequent milk production is decreased, and that the effect is greatest if over conditioning occurs before puberty. Also, getting heifers too fat increases maintenance requirements and is uneconomical. Conversely, inadequate growth results in delayed puberty and conception, and increased age at calving. If increased weight gains are the result of increasing only energy consumption more of the gain is fat. Conversely, increased amounts of a balanced diet result in increased size as well as weight; therefore, weight gains alone are not a suitable criterion for evaluating growth. Assuming that a body weight of 1350 pounds (before calving) and a wither height of 54 inches at 24 months of age for a Holstein heifer ready to freshen is desirable, Table 2 shows weight and height at withers for various ages. These data are based on a weight of 220 pounds at three months

Table 2. Suggested Weight and Wither Height of Holstein Heifers[1].

Age	Weight	Wither Height	Age	Weight	Wither Height
- mo -	- lb -	- inches -	- mo -	- lb -	- inches -
3	220	35.5	14	812	49.7
4	273	37.2	15	867	50.3
5	328	39.4	16	920	50.9
6	381	41.4	17	972	51.4
7	436	42.7	18	1027	51.9
8	488	43.9	19	1080	52.4
9	543	45.0	20	1135	52.8
10	596	46.3	21	1188	53.2
11	651	47.5	22	1243	53.4
12	704	48.7	23	1296	53.7
13	759	49.1	24	1350	54.1

[1]Based on steady growth to 1350 pounds just before calving at 24 months of age. Steady growth may not be most desirable (for discussion see text). Weights and sizes should be considered minimums, age at calving should be considered maximum in most cases.

of age and a constant daily gain of 1.77 pounds from three to 24 months of age. Because Holstein heifers reach puberty at about 600 pounds body weight, those growing at the rate shown in Table 2 start coming into heat at about 10 months of age. This allows several heat periods before 13 months of age at which time the heifer is put on the breeding list. Average conception at 15 months of age results in average calving at 24 months of age.

The time table and growth rates shown in Table 2 are conservative. The growth rates are easily attained and pose no danger of over conditioning. Siciliano-Jones et al. (1995) reported that heifers gaining 1.76 pounds per day between birth and 300 pounds live weight produced more milk after freshening than heifers with lower rates of gain. Van Amburgh et al. (1994) fed heifers energy levels to allow 1.57, 1.87, or 2.1 pounds average prepubertal gain and 1.83 pounds daily gain from 704 pounds body weight until calving. Prepubertal gain did not affect milk yield or milk components. Attempt calving earlier than 21 months of age cautiously (Hoffman et al., 1995), but a heifer calving at 22 months of age need gain only 1.95 pounds per day from 3 months to weigh 1350 at calving. Again, this amount of weight gain should not result in over conditioning if the size of the heifer is increasing as it should. Radcliff et al. (1995) fed 277 pound heifers diets to achieve daily gains of either 2.77 or 1.83 pounds. When heifers were slaughtered in their 5th estrous cycle the faster gaining heifers had 23% carcass fat, the others had 15% fat.

In the previous discussion an attempt was made to show the rational for establishing a goal for growth needed and age at freshening desired. Having established that a certain daily gain is desired for the entire growth period, it does not follow that this rate of growth must be maintained at all times. An abundance of feed at a certain time (for example a surplus of pasture) may mean that it would be more economical to have heifers gaining faster one time and slower at another. Galligan et al. (1995) used dynamic programming methodologies to determine the sequence of daily gain needed to maximize returns per day of life. Using conditions observed in the Netherlands, they determined that age at calving should be between 20 and 26 months, depending on the month when heifers were born. Also, it has been suggested (Park et al., 1987) that, to take advantage of compensatory growth, heifers be underfed for short periods of time, then fed extra nutrients to allow them to catch up. Further research is needed to be able to make general recommendations based on the two previous techniques mentioned.

To summarize the previous discussion, the period from 3 to 6 months of age is a time when heifers should grow rapidly to reach puberty at an early age, yet it is also the time when over conditioning will be most detrimental and also very inefficient. An average daily gain of 1.75 to 2 pounds seems like a reasonable goal, but stay tuned for results of current and future research.

In smaller herds it is difficult to have adequate numbers of heifers in a pen without having animals that differ in size and aggressiveness, thus making it difficult to assure each heifer the right amount of nutrients if the amount of feed is limited. This problem can be eliminated by providing a total mixed ration (**TMR**) free choice. Recently Morrill and Terui (1995) presented guidelines for feeding TMR to dairy heifers from 3 to 6 months of age. The composition of the diet to be formulated depends on gain desired, feeds used, amount of feed consumed, condition of the animals, and other factors. Make adjustments as needed in individual locations. As an example, if heifers are at the right size and condition at 3 months of age, for the next 6 weeks they could be fed a ration consisting of 47% alfalfa hay and 53% concentrate. The concentrate might contain (%) 87.9 corn, 8.9 soybean meal, 2 molasses, and 1.2 mineral and vitamin supplement. They then might be changed to a diet containing 70% roughage and 30% concentrate, or kept on the same diet, depending on their growth and condition. By having pens set up with different TMR's available, the manger can move heifers to the appropriate lots, depending upon individual performance. Daily feed consumption will be about 8.8 pounds from 4.5 to 6 months of age. Quigley et al. (1986) have presented equations to predict intake of heifers under intensive management.

By three months of age the heifer should be able to use any kind of feed if properly formulated into the diet. Pasture can be used if it is high quality, but often it is nothing but an exercise lot and may be a source of parasites. Silage can be

used but may not be practical, because of the small amounts used and problems of refusals, unless used as part of a TMR. Note the need for adequate roughage to support continuing rumen development.

CONCLUSIONS

Nutritional management of dairy replacement heifers is an area where much improvement can be made on many dairy farms in the United States today. Some of the most common problems are:

- failure to ensure adequate colostrum intake soon after calving and for the first few days of life,
- use of low quality milk replacers,
- use of low quality calf starters and poor management of the starter,
- failure to provide proper management to allow early weaning, and
- poor nutritional management after weaning.

Also, many dairy producers do not provide adequate feed and management to allow the heifer to freshen as early as she should. Recommendations are presented and discussed to help correct these problems.

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