# SENIOR PROJECT APPROVAL PAGE

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# Dairy Cow Grouping

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#### **INTRODUCTION**

On a daily basis dairy producers and dairy scientists observe the behavior of dairy cattle. The dairy cow, which is now considered a domesticated animal, provides a major source of nutrition for humans. This source of nutrition is called milk and the world would be hard pressed to live without it. This brings up the point of how to get the highest yield of milk from each and every cow. To establish the highest yield feed intake has to be maximized, and what better way to do that than to make sure every cow has the time, the space, and the opportunity to get the nutrition she requires. Cow grouping is one of the primary factors that can affect feed intake. This project will look in depth at the effects of cattle grouping and how it alters cattle performance and behavior.

When grouping cows one must consider how domestication, dominance, and social hierarchies can affect the cows placed in these groups. Also, stocking density within these groups can become a key issue. In this project grouping strategies will be examined. The project will look at the groups cows are placed in and the effects of regrouping on those cows. In the end the project hopes to provide insight into the process of dairy cattle grouping.

#### LITERATURE REVIEW

One of the most important management issues on western dairies today is how to use dairy cattle behavior to maximize feed intake. It is widely know that with proper feed intake milk production will respond positively. Many factors affect the feed intake of cows on the dairy. These factors can be neatly fit into three categories; environmental, behavioral, and management factors. Environmental factors primarily refer to climate and weather. Dairy cows have a thermal neutral zone that ranges from 40° F to 70° F and begin to experience heat stress when temperatures exceed 70° F. With heat stress being a common problem, dairy producers have installed elaborate cooling systems in their barns to reduce the adverse effects of heat stress on cow health and milk production. With dominance and social hierarchy influencing the behavior of most cows in the herd behavioral issues have become a prime factor in feed intake. A dairy also needs to have the management knowledge and techniques to be able to deal with the daily issues that influence feed intake. Some of the most common management problems on dairies are making sure that every cow receives proper nutrition and that cows are separated into groups that are both functional and convenient. Cow grouping on its own has prominent affects on cattle behavior, feed intake, and milk production.

#### **Cattle Behavior**

Dairy cows are domestic animals and just like dogs and cats they have a distinct behavior. Behavior can simply be described has the way an animal reacts to an internal or external stimuli. Dairy cows acquire behavioral characteristics in two ways; heredity and experience. Heredity is the internal factors that affect behavior; these are behavioral characteristics and habits that a cow is naturally born with. The second way dairy cows acquire behavioral characteristic is through the use of experience. Dairy cows use their experiences to learn and adapt to their environment. Through experience cows are conditioned and imprinted to react differently to the environment and other animals around them (11).

### **Social Hierarchy and Dominance**

Cattle behavior has always presented a problem when it comes to running a dairy operation. Naturally, cows will establish a pecking order when placed in herds. This behavior is what makes up the social hierarchy of the different pens on a dairy. The older, bigger, multiple lactation cows will demonstrate dominance over the younger, first lactation cows. This dominance is measured by observing the number of head butts, displacements from the feed bunk, and displacements from the free stalls and computing the records into an index. The higher the index number the more dominant the cow is considered. These dominant cows frequently alter the daily activities of the submissive cows (5). This behavior is one of the founding reasons why dairy producers group cows.

Daily time budgets. Studies of cattle behaviors have shown that cows are creatures of habit. Their daily conduct does not alter from one day to another. Their basic time budgeting for each day is the same. Table 1 shows the allotment of time spent on each daily activity for a lactating dairy cow. A majority of a cow's day is spent lying down, resting. With the second largest amount of time spent on eating. When these time budgets for eating, resting, socializing, ruminating, drinking, milking and traveling are disrupted it inflicts a certain amount of stress on the cows (8). Just like a human, when your day does not go as planned, you get upset. It is the same type of reaction for a dairy cow; the difference is that an upset dairy cow does not produce milk as efficiently as she should.

TABLE 1. Daily time budget for lactating dairy cows (8).

Activity	Time Devoted to Activity/ Day
Eating	3 to 5 h
Lying/Resting	12 to 14 h
Social Interactions	2 to 3 h
Ruminating	7 to 10 h
Drinking	30 min.
Outside Pen (traveling time, milking)	2.5 to 3.5 h

*Lying down.* Dairy cows have three main functions to perform during a day; eating, resting, and milking. From the information already stated, cows spend 20

hours out of a 24 hour day on these three activities. Out of those 20 hours over half of them are spent resting. Cows will sacrifice other behaviors to lie down (6). This means that if a submissive cow is displaced from the free stall while resting, she will make up that time by sacrificing another activity.

It has also been documented that higher producing cows lay down more frequently and for a longer period of time (6). Figure 1 shows evidence that the amount of time spent lying down may affect milk production. Laying down increases the blood flow to the mammary gland, which in turn increases the amount of milk the mammary gland can produce. According to a study done by Grant (6), for every additional hour of laying down a cow receives it translates into 2 to 3.5 additional pounds of milk per day per cow. The author stated that these cows that receive additional rest are likely to have less hoof and lameness issue, and have increased feed intake.

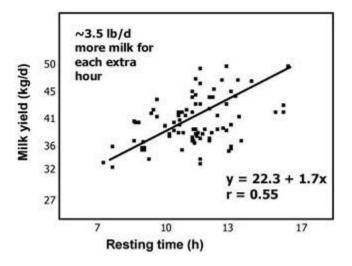


Figure 1. Relationship in lactating cows between resting time and milk yield (6).

Feed behaviors. Lactating dairy cows are naturally aggressive while feeding. A study conducted by Hansen and Pallesen (9) in 1998 showed that a cow will exert 500 lbs. of force on a feed barrier to reach feed. At 250 lbs. of force tissue damage can occur, this means that a cow will physically injure herself to reach feed. This supports the statement that cows are aggressive feeders. This aggressive behavior is also exhibited by the dominance exerted on less aggressive cows at the feed bunk. Dominant cows will displace submissive cows from the feed bunks, decreasing the feed intake of those cows.

Other factors affecting feeding behavior are feed quality, particle size of the ration, and the frequency of meals. The quality of the concentrates and forages in the ration will drastically affect the feed intake. The basic rule to follow is put good ingredients in and get good product out. Particle size is critical for rumen function and palatability (11). If particle size is to small rumen functions is repressed, but at the same time if particle size is to big it increases the occurrence of feed sorting.

Frequency of meals and pushing up feed affects feed intake greatly. Figure 2 shows that there is a spike in feed intake after each feeding, push up, and milking. This information advocates that the more times feed is distributed and pushed up the better.

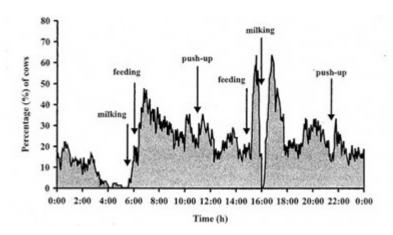


Figure 2. Dairy cow feeding activity during a 24 hour period in a competitive Environment (4).

### **Factors Effecting Cattle Behavior**

The major factor that affects cattle behavior is cattle grouping. Cattle grouping and the management of these groups could be one of the most influential aspects of running a dairy. There are many factors involved in deciding grouping patterns for dairy cattle and they are mostly based on facilities and personal opinion. The main reasons for grouping cows are to feed more efficiently, decrease the effects of dominance, and increase milk production.

General grouping. On most dairies grouping does occur, because of the difficulty to manage the individual needs of cows. Dry cows need to be separate from lactating cows and sick cows need to be separate from cows in the milking string. Cows need to be separated at the time of calving. All of these needs cannot be addressed unless cows are separated into more manageable groups. Simply put, grouping cows is good management.

Transition grouping. When grouping dairy cows it is crucial to start at the very beginning. Transition cows are where grouping can make a difference.

Traditionally dairies have a 60 day dry period for cows, during the first part of their dry period these cows are placed in a far-off dry cow pen. Then approximately 21 days or 3 weeks prior to parturition these cows are moved into a close-up dry pen.

From the close up pen these cows are moved to a maternity pen, then into a fresh pen after calving. On most dairies this adds up to five pen moves in approximately 28 days. Within these 28 days a cow is already experiencing increased stress and a decrease in dry matter intake as demonstrated in Figure 3 (12). For these reasons it is important to move and group cows efficiently during the transition period.

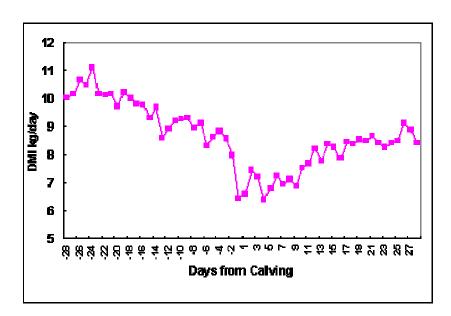


Figure 3. DMI from 28 days pre-calving to 28 days post calving (12).

Far-off cows. At the time of drying off cows are placed in what is commonly known as the far-off pen. These cows are pregnant and usually remain in this pen for the first 40 days of the 60 day dry period. During this time it is important for cows to maintain a positive energy balance to adjust body condition score and to obtain the correct nutrients to meet the needs of pregnancy. It is also crucial that cows maintain rumen fill and build up a strong immune system. The far-off pen should be clean and comfortable with room for the cows to exercise, to promote good health and to allow feet and legs to recover (10).

Close-up cows. Approximately 21 days before calving cows are moved into what is commonly known as the close-up pen. During this time period these cows experience an increase in stress and a decrease in dry matter intake. For these reasons it is very important that these cows have adequate facilities, proper nutrition, and are monitored closely.

The cows that are in the close-up pens are experiencing many changes. From being moved to another pen and having to establish social rank to decreasing dry matter intake these cows face tremendous change. This is one reason why the close-up pen needs to have adequate feed bunk and free stall space and not be overcrowded.

According to Dr. Randy Shaver (16) transition cows should be allotted 1.5 feet or more of feed bunk space to insure that these cows are able to consume the proper amount of feed without competition. He also urged that these cows should not have

to travel more than 50 feet to access clean, fresh water. If the suggested feed bunk space overcrowding tends to become an issue. Overcrowding has been proven to increase the amount of dominance observed among the cows and have adverse affects on dry matter intake (3). Figure 4 shows that as stocking density increases in the close-up pen, dry matter intake decreases (14). This figure also shows that after reaching 100% stocking density, dry matter intake decreases drastically, dropping under 25 lbs per day.

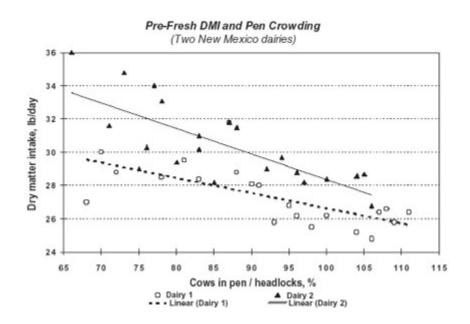


Figure 4. Group average DMI of close-up cows and stocking density of headlocks on 24-inch centers (14).

Close-up cows have specific nutritional needs and need to be monitored very closely. Like it was stated earlier close-up cows commonly experience a dramatic decrease in dry matter intake, but with this decrease in DMI it is still important that these cows maintain a positive energy balance and the correct body condition. The close-up

ration should be monitored to assure that it contains the proper energy, protein, and vitamin requirements. There needs to be an increase in energy and protein and the salt should be removed from the ration. Dietary cation-anion difference (DCAD) diets are also very important when feeding close-up cows. DCAD diets are used to mobilize the supply of calcium in the cows' bones to meet calcium requirements at the time of calving (10). This is achieved by using anionic supplements to alter the balance of potassium, sodium, chlorine, and sulfur (13). The DCAD diet can be monitored by checking urine pH, the target pH level is 6.0 (11).

Close-up cows require constant monitoring, from nutrition to overall health. Their pens need to be kept clean and dry and feed bunks need to be managed constantly. These cows also need to be monitored for any signs of health complications. This is one reason for having these cows in a convenient location. They need to be in a location where they can be easily seen, numerous times a day. Close-up cows also need to be in close proximity to the maternity pens. This will enable them to be moved to the maternity pens quickly and with the least amount of stress at the time of calving.

*Maternity pens*. Around the time of calving cows, which were previously in the close-up pens, are moved into maternity pens. When it comes to maternity pens there are two common topics that are discussed; how long should cows stay in the maternity pen and what type of pens should be used? The maternity pen usually

receives daily additions, which makes social regrouping and establishing hierarchies a daily struggle among those cows. This is why many experts, like Nigel Cook (2), recommend individual calving pens in comparison to group calving pens. He also suggests that these pens be heavily bedded and in a low traffic area (2). The picture in Figure 5 shows the type of calving pen Nigel Cook is recommending.

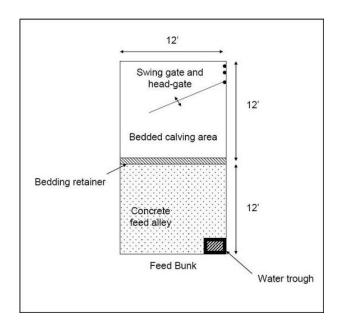


Figure 5. Layout for an individual maternity pen (2).

The second topic concerning maternity pens is how long cows should stay in the maternity pens. According to Nigel Cook (2), the shorter the stay in the maternity pen the better the cow will perform. Cook stated that, "pen moves occurring between 3 and 5 days before calving appear to have an adverse effect on cow health, NEFA concentrations, and associated risk for ketosis and displaced abomasums." Table 2 shows how the length of the stay in the maternity pen can affect cows later in

lactation (15). There is an over 500 lbs. decrease in production when cows are in the maternity pen for more than three days. This decrease in production can be simply avoided by shortening the maternity pen stay and moving cows into well managed fresh pens after calving.

TABLE 2. Effects of maternity pen stay duration on post calving performance (15).

Effect of Maternity Pen Stay on Performance Post Calving				
	Length of Maternity Pen Stay			
Outcome	Short < 3 days	Long >3 days	Difference	
Calving, no.	112	182		
Sold or dead by 60 d, %	3.6	9.3	2.6x	
1st Projection, lbs.	20,777	20,205	-572	

Fresh cow pen. After calving cows are moved into a fresh pen. It is very important that these cows not be moved into a hospital pen. They have suppressed immune systems and are susceptible to infection. The suggestion of Nigel Cook (2) is that these cows be moved into a post-fresh monitoring pen were their milk is segregated from that of the regular lactation string. Then after a period of 10 to 14 days these cows are moved to an early lactation pen. By moving cows straight from the maternity pen into a post- fresh pen, instead of into a hospital or non-salable milk pen, Nigel Cook's method eliminates one pen move from that of the conventional methods. Eliminating one move does not sound like much, but it decreases the

number of times cows must socially regroup and overcome the stress associated with that process.

Affects of grouping on social behavior. When grouping cows it is important to remember the main reason why there is a need to group cows. Grouping makes managing an entire herd much more efficient; cows in the same stage of lactation are grouped together and cows of the same number of lactations are grouped together.

The method of grouping also aids in decreasing the adverse effects of dominance in cows. The downfall of grouping cattle is that as cows change in stage of lactation or number of lactations these cows have to change groups. With every move these cows are faced with the struggle of reestablishing the social hierarchy within the group.

This period of adjustment can range from 5 to 7 days and has a great effect on the daily time budgets of those cows as shown in Table 3 (7). Resting and eating time, which are vital for good health and production, are drastically decreased by regrouping cows and number of confrontations is increased almost 8.5 times. When grouping cows it is important to make the least amount of moves to reduce the number of times cows have to socially regroup and to decrease the amount of stress.

Affects of grouping on feed intake. Feed intake is one of the most important matters on a dairy. If feed intake decreases then the amount of nutrients a cow receives decreases and so does that cows milk production. Through grouping cows feed intake can be greatly influenced. By grouping cows with the same stage of

lactation it is much easier to manage their nutrient intake and be sure that they are receiving adequate energy to meet their requirements. Grouping cows can also decrease the effects of dominance and social hierarchy (5). For example grouping first lactation cows separately from multiple lactation cows can reduce the effects of dominance and increase the amount of dry matter intake that first lactation cows consume. This increase in feed intake influences the health and production of these cows in a positive manner.

TABLE 3. Behavioral responses to shifting cows between groups (7).

Activity	Day 0	Day 1	Day 6
Eating, min/d	295	271	302
Eating bouts, /d	5.2	4.6	5.2
Lying, min/d	580	336	537
Confrontations	19	163	20

Affects of grouping on milk production. There are around nine million dairy cows in the United States, on around 110,000 dairies, and these cows produce approximately 167.7 billion lbs. of milk each year (1). With these kinds of numbers it is obvious that managing a dairy is big business. In a business it is crucial to increase productivity and keep losses as low as possible. That is why cattle grouping is important to the dairies productivity. When cattle are grouped, overcrowding is

decreased and therefore confrontations are decreased. Through grouping cattle, dairy producers are able to reduce the effects of dominance and stress on cows which improves the health and productivity of each individual cow. Also, when cows are placed in groups managing the individual cow becomes much easier.

### **Dairy Cattle Grouping**

Dairy cattle grouping has numerous effects on cattle behavior, health and production.

Yet, there are many different patterns and methods for grouping dairy cows.

- Grouping cows into one large group.
- Grouping dry cows separately from lactating cows.
- Grouping far-off dry cows, close-up dry cows, fresh cows and lactating cows separately.
- Grouping by number of lactations, with first lactation cows being separated.
- Grouping by production, high producing cows and low producing cows are grouped separately.

These are just a few of the cattle grouping options and it is evident that some of these options are not at all efficient. One thing to remember is that grouping patterns depend greatly on the facilities of the dairy and the size of the herd (14). When grouping it is also important to pay attention to how many times cows are moved and forced to socially regroup (2).

### MATERIALS AND METHODS

The literature review looked at the affects of dairy cattle grouping on feed intake.

Data was analyzed to determine how social behaviors, dominance, and stocking density affect feed intake in dairy cows that are placed in groups during the transition period. All research came from professional journals and dairy publications. The materials presented in this literature review will assist in determining whether grouping dairy cattle can affect feed intake and in turn milk production.

#### RESULTS AND DISCUSSION

Cattle behavior is affected by social hierarchy and dominance. Through the effects of dominance the cows' daily time budgets, resting time, and feeding behavior are altered (6). Grouping cows has been found to be one of the most influential ways to decrease the effects of dominance. By grouping cows into smaller more manageable groups dairy producers are better able to monitor the individual cow. When grouping cows, to make management more efficient, it is recommended to group cows by stage of lactation (14).

Transition grouping is a grouping method where dairy producers group cows together by stage in lactation. In doing so they place all dry cows (cows more than 14 or 21 days from calving), Close-up cows (cows less than 14 or 21 days from calving), fresh cows (cows less than 10 or 12 days in lactation), and lactating cows together (14). Each of these groups has specific needs whether they be nutritional or management. When all cows are in the same pen it is impossible to insure that dry cows maintain their body condition score and that lactating cows maintain a positive energy balance. If these different groups of cows are separated, then each individual group can receive the correct ration and monitoring.

Grouping has many different affects on cows' social behavior, feed intake, and milk production. It is a common occurrence when cows are separated into groups that they

must move from one group to another. As these cows move through the different stages of lactation they have to change groups. With every group change there is a period of social regrouping, during this time of regrouping dominance increases for approximately 5 to 7 days (2). This period of regrouping and restructuring the hierarchy also has affects on feed intake and milk production. The increase in dominance alters the cows' daily time budgets (7). Therefore, according to Table 3, the amount of time a cow eats and the number of meals decreases (7). The same is true for the amount of time a cow lays down (6). The decrease in these activities causes a drop in milk production.

Many experts suggest that grouping cattle is necessary, but in order to be effective groups must be managed correctly and pen moves need to be minimized. The study done by Nigel Cook (14) demonstrates how dairy producers can decrease the number of pen moves from the common five to a more effective four. By doing this the number of social regroupings and the effects of dominance are drastically decreased. Cook's method of grouping seams to be the most efficient and effective when managing dairy cattle.

#### **CONCLUSION**

This project looked at dairy cattle behavior and the many ways cattle behavior can be affected by management and other contemporaries. Cattle are creatures of habit. They maintain the same basic activities and time budgets everyday and variation from the normal activities causes an increase in stress. Another trait of cattle behavior is the establishment of social hierarchy and the dominance exerted to achieve this hierarchy. Dominance is measured by the number of physical confrontations and head butts a cow demonstrates. Dairy cattle also have naturally aggressive feeding behavior and urge to rest. Placing cattle in a confined area causes this naturally dominant behavior to become very prevalent. For these reasons dairy producers needed to find a way to separate these cows with dominant characteristics.

Through grouping cows with like behaviors and stages of lactation dairy producers are able to manage their cattle more efficiently and maximize milk production. When dairy cows are sorted into groups by stage of lactation or by number of lactations the physically aggressive actions are decreased and the effects of dominance are reduced. If the effects of dominance are minimized then cows are more likely to be successful. The main issue when grouping dairy cows is how to move them from one group to another. With every move dominant behaviors increase within that group until the social hierarchy is reestablished, this is called social regrouping.

Despite this draw back, grouping dairy cows is beneficial in managing individual cows and increasing milk production. When cows are grouped according to stage of lactation it is much easier to insure that each cows receives proper nutrition and that her overall health is monitored. Managing dairy cows through grouping equal better management and better management leads to healthy cows and increased production.

#### REFERENCES

- 1. Blayney, D.P. 2002. The Changing Landscape of U.S. Milk Production. United States Department of Agriculture. Bulletin Number 978
- 2. Cook, N. B. 2008. Makin' Me Dizzy- Pen Moves and Facility Designs to Maximize Transition Cow Health and Productivity. <a href="http://www.extension.org">http://www.extension.org</a>. Accessed Oct. 26, 2009.
- 3. DeVries, T. J., M.A.G. von Keyserlingk. 2006. Feed Stalls Affect the Social and Feeding Behaviors of Lactating Dairy Cows. J. Dairy Sci. 89:3522-3531
- 4. DeVries, T. J., M.A.G. von Keyserlingk, and K. A. Beauchemin. 2003. Diurnal feeding pattern of lactating dairy cows. J. Dairy Sci. 86:4079-4082.
- 5. Grant, R.J. 2005. Incorporating dairy cow behavior into management tools. <a href="http://www.milkproduction.com">http://www.milkproduction.com</a>. Accessed Nov. 20, 2009
- 6. Grant, R. J. 2003. Taking advantage of dairy cow behavior: Cost of ignoring time budgets. In Proc. 2003 Cornell Nutr. Conf. for Feed Manufac. October 21-23. Cornell University. Wyndham Syracuse Hotel. Syracuse, NY.
- 7. Grant, R. J., and J. L. Albright. 2001. Effect of animal grouping on feeding behavior and intake of dairy cattle. J. Dairy Sci. 84:E156-E163.
- 8. Grant, R. J., and J. L. Albright. 2000. Feeding behaviour. In Farm Animal Metabolism and Nutrition. J.P.F. D'Mello, ed. CABI Publishing. New York, NY.
- 9. Hansen, K. and C.N. Pallesen. 1998. Dairy cow pressure on selflocking feed barriers. In: Proceedings of the fourth international dairy housing conference. ASAE, St. Louis, MO, pp 312-319.
- 10. Hutjens, M. and E. Aalseth. 2005. Caring for Transition Cows. W.D. Hoard & Sons Book Department. Fort Atkinson, WI.
- 11. Jaster, Edwin H. 2008. Class notes. DSCI 333. 2008.
- 12. Kavanagh, S. and J. Murphy. 2000. Winter Feeding for Spring and Autumn Herds. http://www.teagasc.ie/publications. Accessed Nov. 18, 2009.

- Moore, S. J., M. J. VandeHaar, B. K. Sharma, T. E. Pilbeam, D. K. Beede, H. F. Bucholtz, J. S. Liesman, R. L. Horst, and J. P. Goff. 2000. Effects of Altering Dietary Cation-Anion Difference on Calcium and Energy Metabolism in Peripartum Cows. J. Dairy Sci. Vol. 83 No. 9 2095-2104
- 14. Nordlund, K., N. Cook, and G. Oetzel. 2007. Solving Fresh Cow Problems: The Importance of Cow Behavior. MS Department of Medical Sciences, School of Veterinary Medicine University of Wisconsin, Madison, WI 53706
- 15. Schoonmaker, K. 2007. Make it a short stay. <a href="http://www.dairyherd.com">http://www.dairyherd.com</a>. Accessed Nov. 22, 2009.
- 16. Shaver, R.. 1998. Feeding Systems and Strategies for Expanding Dairies.

  Department of Dairy Science. University of Wisconsin Madison. presented at 4-State Expansion Conference, March-April, 1998, New Ulm, MN and Madison, WI.

**APPENDIX** 

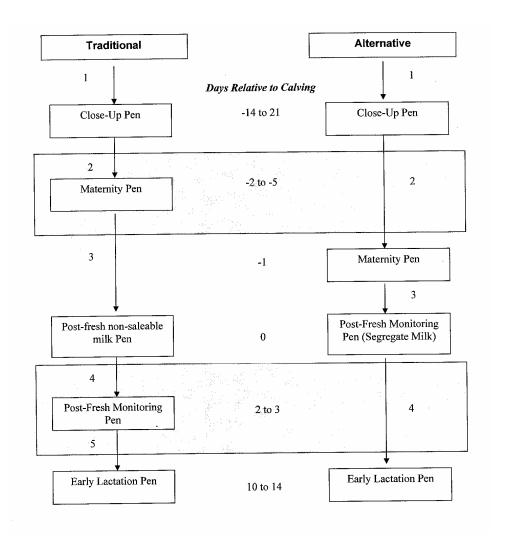


Figure 6. A comparison of the traditional sequence of pen moves in many free stall herds with an alternative strategy which removes a pen move at 2 to 3 days before and after calving. The risk periods are represented by the outlined boxes (14).