SYMPOSIUM: MANAGEMENT OF DAIRY COWS IN GROUP HOUSING

Feeding Methods and Grouping Systems

ABSTRACT

Studies of taste behavior indicate that precise nutrient allocation is never achieved by lactating dairy cows offered concentrates according to individual energy requirements and forages free-choice in conventional housing systems. Concentrate feeding via the milking parlor reduces precision of nutrient allocation even further. Studies of social and feeding behavior of cows in loose housing suggest that it is unnecessary to provide one free-stall per cow or bunk space for all cows to eat simultaneously if a complete ration is continuously available. The advantages of the complete ration system far outweigh the disadvantages. More attention should be given to social and taste behavior of cows as feeding and housing systems are designed.

INTRODUCTION

As the limitations of offering concentrates according to individual energy requirements and forage(s) ad libitum (conventional feeding systems) become more widely recognized, alternatives and modifications are being sought which acknowledge the social structure and expression of variable tastes of cows, increase the accuracy with which diets are formulated and consumed, allow the expression of genetic potential for milk production, are labor efficient, and facilitate use of least-cost formulation techniques. Those of us in the discipline of traditional animal science have been slow to appreciate the importance of social and taste behavior in cattle and slow to integrate the available knowledge into our management systems.

With a progressively increasing genetic trend in the dairy cow population, and the attendant compulsion to secrete milk, an even longer period of inevitable negative energy balance will ensue in early lactation, especially if greater use is made of forages and byproducts with low energy. If prolonged negative energy balance is detrimental, system of feeding and formulation which minimize this period are needed.

This report is intended to review research on the behavior of cows housed in groups, especially feeding behavior, the rationale for greater emphasis on complete rations (CR) with grouping systems, some economic discussion of CR’s, and the importance of viewing the feeding system as an integral part of the system of milk production.

BEHAVIORAL CHARACTERISTICS OF COWS FED IN GROUPS

Preference for Available Feeds

There is large and consistent variation among Holstein cows in their preference for excellent forages whenever they are given an option (15). This was true either with a simultaneous choice or even though the choice was limited to one forage in the a.m. and the other in the p.m. An example of this variation is in Fig. 1 in which 30 cows had a simultaneous choice of corn silage and alfalfa hay. The range in choice of dry matter from corn silage was from 23.6 to 77.7% with the lowest cow nearly 20 percentage units below the nearest herdmate. The freedom to select a preferred forage is most serious when two forages such as corn silage and alfalfa are offered because of the great difference in their protein and mineral content which seriously limits the precision of concentrate formulation to match some “average” forage base.

It seems reasonable to suggest that the same type of feed selection occurs by cows when forages and concentrate mixtures are offered nearly ad libitum in early lactation (43) and between energy fortified forage blends and protein supplements. From intensive studies of taste in cattle, Kudryavtzev (34) concluded “the sense of taste in cattle is also very well developed. A cow distinguishes very well be-
FIG. 1. Expression of forage preference by cows offered corn silage and hay simultaneously. Thirty cows were used; 20 had values which fell within the nondiscrimination zone (i.e., the mean, 61.4 plus and minus 10 percentage units, while 4 values were below and 6 above this zone).

between the main gustatory flavours—bitter, sweet, sour, salty and between different concentrations of each other.” As we attempt to reduce competition between cattle and the human population for a limited cereal grain supply, it is imperative that we increase our understanding of taste expression and exploit that knowledge to use more forages and by-products.

Social and Feeding Behavior

From careful observations, Woodbury (57) noted a order of social dominance in a herd of dairy cows that seemed to be related to horns and which was rearranged completely by dehorning. He suggested a more fundamental understanding should be possible through experimental investigation. Such studies were conducted later by Schein and Fohrman (49) and Guhl and Atkeson (25). The former workers (49) noted a social organization was established in a herd through aggressive behavior in which cows approach, threaten, and may enjoin physical contact usually by butting or bunting with the head. After recording nearly 5,000 individual contests, they concluded “the herd was organized in a straight-line peck-order.” The dominance order by rank was related significantly to age and weight, though they were unable to separate the effects of these two factors but concluded that seniority was of primary importance. The Kansas work (25) agrees well with a correlation between dominance rank and age of .84; they concluded that each cow establishes her dominance rank in the herd by fighting or bluffing at her first entrance into the group. A recent comprehensive review by Albright (2) indicates social dominance may be considerably more complex; however, the emphasis in this paper is on feeding behavior.

In a conventional loose housing system with grain fed in the milking parlor, Webb et al. (55) observed that lactating cows spent a total of 6.4 h/day eating silage and hay. Recent observations of 40 lactating cows in four 10-cow groups fed a CR of 7.5% corn silage (CS), 42.5% haycrop silage, and 50% concentrate (ratios of dry matter) showed 4.9 h/day was spent with heads in the feed manger that provided .60 m/cow (12). This compares to 4.6 and 4.4 h for 12 cows with .41 and .31 m of bunk/cow as noted by Friend and Polan (21). Reduction of feed bunk to .21 and .1 m/cow reduced time spent at the bunk to 4.4 and 3.0 h, respectively. Individual cow variation in time spent at the bunk was correlated (ca. +.60) with dominance. They concluded that .21 m of linear bunk space/cow was enough if cows have at least 4.4 h of access to a CR/day. There seems little reason to insist that all cows have the option to eat simultaneously if the same feed is always available.

Data on feeding behavior and free-stall use were obtained with time-lapse photography by Friend and Polan (20) with 21 Holstein cows during five 24-h periods. Silage was fed in a bunk, 45 kg of concentrate were spread over it once per day, and 2 bales of alfalfa hay were offered in the bunk once/day. Feed bunk space of 10.4 m (.5 ml/cow) provided space for about two-thirds of the cows to eat simultaneously. A strong competitive condition occurred at the bunk 30 min after return from milking which was expressed as a correlation of .59 with social rank. So whenever a competitive condition exists for available feed, the dominant cows will assert their position (11), and as shown in other work (49), there is a low correlation between milk production and social rank. An advantage for feeding the CR ad libitum is because it reduces competition at the bunk and reduces the length of bunk needed per cow.

The importance of feeding CR’s ad libitum

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was shown by Goings and Braund (23) with two groups of 24 lactating cows in a double reversal trial. One group received a CR free-choice (ca. 50% corn silage:50% concentrate; .63 m bunk/cow); the other group received the same diet but with the bunk empty an average of 4.5 h/day. Milk production and dry matter (DM) of diet consumed averaged 25.9 and 20.1 vs. 25.3 and 18.9 kg/day. Moreover, first lactation cows responded with increased milk production when switched to free-choice feeding. However, continuous access to a CR which includes silage may cause a problem of milk flavor. Fettman and others (19) compared milk flavor scores from cows whose CR had been withheld 0, 2, and 4 h prior to milking. Taste panel evaluation (without knowledge of sample source) ranked the samples in order of time withheld with best flavor score from cows without feed 4 h prior to milking. Feeding frequency of one, two, and three times/day of a CR (60:40 forage to concentrate) free-choice was compared with three groups of 20 lactating cows each by Goings and Braund (24). Milk production and DM intake averaged 18.9 and 19.5, 18.6 and 19.6, and 18.6 and 19.1 kg/day, for the three treatments. No effect was apparent even though the act of feeding caused cows to come to the bunk to eat. This study was during August, September, and October in New York. Ambient conditions which cause heating in a silage based CR fed once daily might reduce intake and production.

Arave et al. (4) measured a lower leucocyte concentration in milk from 17 Holstein cows after lot space was reduced from 9.3 to 2.3 m²/cow. Crowding did not appear to increase stress measured in this way perhaps because cows were acquainted previously with each other and more than one free-stall and .56 m/cow of bunk space were available. Nor did 24-h isolation (with feed and water) reduce milk yield or increase leucocyte count in this study although milk production was relatively low.

Bourne and Tucker (7) showed that when photoperiod was reduced from 16 to 8 h in bull calves, serum prolactin decreased from 57 to 8 ng/ml. Increasing photoperiod from 8 to 16 h increased prolactin from 25 to 100 ng/ml. Little attention has been paid to photoperiodism in cattle, and much work is needed to define effects of photoperiod on behavioral and physiological traits.

**FEEDING SYSTEMS**

**Conventional**

The usual procedure in the conventional stanchion or tie-stall barn is to offer cows forage(s) free-choice plus a grain mixture fed individually according to feeding guides which reflect the quality and quantity of forage eaten by the herd and individual requirements for energy based upon lactation number, body size, milk quantity, milk fat content, and gestation. However, even when a concentrate mixture is allocated carefully, a serious limitation to this system is the inaccuracy of predicting forage intake of individual cows (33) and individual cow variation in forage preference (15) even if the herd intake is known. So the accuracy with which energy and other nutrients can be provided through the concentrate mixture has never been precise even in a system where it seemed possible.

With the advent of the combination of free stall with milking parlor, new problems have arisen. Developments in parlor automation reduce the time cows spend in the parlor so that high producers do not have enough time to eat their required grain even if they have the appetite to do so. Even though additional time is provided and precision equipment is operated carefully, there is no way to be sure the appetite of the cow will induce her to consume the offered grain.

**Possible Resolutions**

To resolve this problem, some dairymen add a base amount of grain to the forage which is fed outside in a bunk. Often this merely aggravates the problem of providing a correct protein-energy ratio across the whole spectrum of the herd. In fact, low producers tend to receive too much energy by this system, but many still demand some grain as they pass through the parlor. High producers also may suffer by this approach, especially if protein supplementation is provided primarily in the parlor grain mixture because there is even less chance that a cow will enter the parlor with the desired appetite to eat the required protein supplement. In some cases we see the emer-
gence of the fat cow syndrome. In effect, feeding grain in the parlor in many cases has become free-choice grain feeding for two 10-min intervals per day.

Another approach is to offer supplemental grain through a protected stall with an enclosed feed box. With one system, a cow that carries a magnet on her collar can activate a small auger in the system to deliver feed at about .25 kg per minute (32). As long as the cow has her head in the feeder, grain is delivered slowly. Field observations (22, 32, 45) suggest that dairymen generally are pleased with their use, but economic evaluation is difficult. The feeder allows cows with magnets to eat as much grain as they wish within the constraints of appetite, time, and social competition. Lower intake of forage has resulted in depression of milk fat percentage. Hutjens (31) in time-motion studies on five farms found feeder stalls were occupied from 39 to 78% of the time, but cows without magnets were in the feeder stalls from 6 to 59% of cow-use time. Grain may be left in the box from a previous cow. A large number of aggressive acts was observed against the cow using the feeder, often by cows without a magnet. Hutjens (31) made some excellent managerial suggestions: the cow at the feeder needs protection from the sides, boss cows may cause serious disturbances, magnets should be removed from cows whose requirements for milk production do not warrant additional grain, provide one cow with magnet for each hour the feeder is available, and note that some cows with a magnet will not use the feeder.

Another device allows cows who carry an electronic key on their collar to open a door for access to a manger of feed. Although the research application of this device allows up to 50 unique identities to obtain individual intakes on group housed animals (3), the commercial application of the door is intended to allow the same key for all animals, or all cows with a key access the same door or series of doors (9). So the system permits free access by keyed cows to a manger which may have any feed available in it. An advantage of this system over the previous one is that grain left by one cow cannot be obtained by a cow without a key. Most of the managerial features listed previously for magnet-activated feeders apply to this device as well.

Another type of electronic concentrate feeding system has been developed at the University of Illinois (46). It offers the advantage of allowing individual control over the maximum concentrate allocated to each cow through an automatic system. Each cow carries a transponder on her collar that is adjustable to allow from 3 to 50 min (.45 kg/min) concentrate eating time per 24 h. Studies (17, 26) indicated that lactating cows (averaging about 18.5 kg/day) produced as well on this system as when fed grain in the parlor or a CR. In a study of performance and behavior of cows using this system, cows received about 76, 84, and 98% of required concentrate when there were 30, 20, and 15 cows/feeder. In addition, the stalls were occupied 84, 77, and 75% of total time with concentrate actually dispensed 41, 34, and 30% of the occupancy time for the corresponding feeder carrying rates. However, cows may eat some grain left by a previous user. Any system designed to allocate concentrate individually and forages ad libitum suffers the same imprecision listed above for conventional stanchion barn feeding systems. These three systems of supplementing concentrate will have greatest merit in loose housing systems where grouping is not feasible.

Complete Rations

This term is used to define a quantitative blend of all diet ingredients mixed thoroughly enough to prevent separation and sorting, formulated to specific nutrient levels and offered ad libitum. Although the CR concept has been used extensively for other classes of livestock, dairy nutritionists have been slow to recognize its advantages, perhaps because of the large range in milk production and corresponding variation in nutrient requirements within any herd. Much of the early research (36) on CR’s was with byproduct roughages including corn cobs, cottonseed hulls, rice hulls, etc., in an era of expensive forage—inexpensive grain when the primary objective was to use minimum forage. More recent experiments (1, 13, 35, 51) used conventional forages and forage percentages. Reviews include those by Rakes (47) and McCullough (37). Recent surveys of dairymen who were using CR’s (10, 41) show that a high percentage is pleased with the system. Included among the advantages of CR’s are:

1) No expression of choice among feeds is
permitted. Consequently, each bite consumed is a uniform, definable, and, as nearly as one can make it, a nutritively complete diet. This aspect of CR’s is especially valuable whenever one attempts to troubleshoot a herd characterized by a high incidence of some disorder.

2) High production with CR’s has not only been demonstrated in research trials (51) but by dairymen who with large herds have demonstrated production of over 8,500 kg per cow/year.

3) Free-choice mineral supplements are unnecessary.

4) Complete rations coupled with lactation groups permit special formulation for high producers (extra protein) who cannot consume enough feed energy to sustain their production.

5) Complete rations fed ad libitum result in few digestive upsets early in lactation as cows are changed from high forage diets to high concentrate diets immediately postpartum (27). The reason seems to be that cows eat these diets slowly, and only a little concentrate can be consumed in a short time. Even though not feeding ad libitum, Holter et al. (29) found the efficiency of converting metabolizable energy to milk was 63% by cows fed a CR compared to 59% by cows fed the diet component in meals.

6) Nonprotein nitrogen compounds, especially urea, release ammonia rapidly upon contact with rumen fluid. For maximum efficiency urea should be fed several times throughout the day and with an energy source which contains starch. Consequently, an easy way to achieve multiple feedings is to offer the CR ad libitum (16).

7) A CR with a forage base of silage serves to dilute and mask the flavor of unpalatable ingredients such as urea. This feature offers significant advantage because it increases the flexibility and minimizes the number and magnitude of constraints which must be imposed on least cost computer formulated concentrate mixtures (30). In effect, one can make large changes in formulation as prices change without inducing an off-feed problem. On the other hand, dairymen are impressed especially with the sudden changes in forage types which are possible without depressing intake or milk production.

8) Some reduction in labor required for feeding grain may accrue through this system.

9) By providing a specific and obligatory ratio of forage to concentrate, one can prevent some cases of milk fat depression by insuring fiber in the consumed diet necessary to maintain milk fat test.

10) It is no longer necessary to feed grain in the milking parlor although some adjustment will be necessary by cows accustomed to receiving grain there.

   a) No parlor grain feeding equipment is needed and construction costs are reduced.
   b) Field observations indicate cows are quieter during milking and defecate less.
   c) There is less feed dust in the parlor.
   d) Movement from the parlor is quicker because cows do not delay to finish eating.
   e) More cows per man are possible when parlor operators do not spend time dispensing grain.

11) It is possible to mechanize a conventional tie-stall barn for complete rations. A stationary horizontal mixer can be mounted on a conventional platform scales in the feed room, diets can be mixed in that device quantitatively, and a self-propelled feed cart can be used to deliver the blended mix to the cows.

12) The total diet can be formulated quantitatively.

Included among the disadvantages of CR’s are:

1) Hay that is stored in baled or long form must be chopped before it can be blended with silage or grain. Hay crops should be stored as silage.

2) Mixer wagons which thoroughly blend ingredients are expensive and electronic load cells are highly recommended to quantitate the blending process, but they are costly.

3) Many barns are designed for one large group from which formation is awkward for smaller groups.

4) There are limited experimental data on which sound recommendations for the number of cows per group and the exact ration specifications which will permit efficient use of concentrates.

5) It is probably not economically feasible to use CR’s in small herds. For those herds that are pastured, complete rations are not applicable during the pasture season.

6) More arithmetic calculations are necessary.
on the farm to implement the use of the CR, especially if silages are used.

Grouping the Herd

Advantages for grouping herds fed CR’s include:

1) Production groups allow cows to move to higher forage-lower energy diets as lactation progresses and production declines. By definition, a CR will be fed ad libitum to minimize effects of social dominance at the feed manger. Dry cows offered a high energy diet suitable for early lactation will exceed their requirements for maintenance plus pregnancy (40, 42). The fat cow syndrome (39) has resulted in high losses in some herds where dry cows were permitted too much energy. A forage diluent would be helpful when only high-energy forage (e.g., corn silage) is available. Although some researchers suggest (37, 51) that lactating cows offered a balanced diet consume to meet their requirements for energy, it seems that especially with diets based on corn silage there is marked tendency to overconsume in late lactation as shown by serious health disorders and high death losses in cows fed corn silage ad libitum through the dry period (39, 42, 54).

2) Production groups allow lower producing cows to be fed a less expensive diet when energy and protein are less costly in forages and low energy byproducts. Smith (52) obtained $60/cow greater income over feed cost in a two-group system vs. a one-group system even with 194 kg less milk per lactation.

3) When cows are grouped by production, the highest producing group can be fed a diet with a higher concentration of those nutrients (e.g., protein) for which the cow has limited capacity for storage. A high-energy diet fed in early lactation should minimize the period of negative energy balance and perhaps result in higher conception (28).

4) Heat detection and other features of herd management are simplified if cows are grouped by production and/or stage of lactation.

5) More uniform milk-out in the parlor will occur if cows are grouped by production.

Disadvantages of grouping herds fed CR’s include:

1) Labor and time are required periodically to regroup cows.

2) Some housing facilities were not designed for grouping, and redesign may be awkward and expensive.

3) Although the arithmetic of formulating CR’s is not complex, more calculations are necessary with additional groups and when silages are used which cycle in DM content (14).

4) An important disadvantage of grouping cows is that a significant drop in milk production often occurs when cows change groups from high energy to lower energy diets (1, 40). However, a change of groups usually means two changes, a dietary change plus a social change.

First, look at the effect of social change. In early work by Schein and others (50) the addition of 15 lactating cows to a group of 35 heifers and dry cows (diet constant) caused a predictable social disturbance, and milk production dropped 5.5% more than for control cows. Arave et al. (5) required cows to change social rank (same diet) and could show no effect on total corticoids of plasma, indicating no detectable stress by this method. Recent work by Brakel and Leis (8) in which four cows were added to a 20-cow group in five trials showed only a modest decline in milk production of about .5 kg or 3% on the 1st day after regrouping, but there was no indication of continued adverse effects on production after day 1. Higher milk production might have resulted in a more severe drop, but it appears that the effects on milk production of social change are relatively minor if cows have been housed together or have face to face contact (2) across a fence or bunk and have had experience changing groups (11, 53). Results of field trials (6, 44, 53) indicate that under some commercial dairying conditions, cows can be regrouped without social disturbances that seriously depress production.

Dietary changes which accompany group changes can cause sharp reductions in milk production (1, 18, 40). To examine only the effect of dietary change in a CR on milk production, Moseley et al. (40) fed cows in a conventional tie-stall barn. Sudden dietary changes to simulate a group change at wk 12 of lactation from 40:60 to 60:40 (forage to concentrate DM) depressed intake of energy and DM and milk production. Dietary changes at wk 30 from 40:60 and 60:40 energy to 80:20 and 95:5 also caused sharp drops in intakes of energy and DM and milk production.
Although some recovery in DM and energy intake occurred during the 5-day post-ration change, there was no corresponding increase in milk production (Fig. 2). It is probably important that the energy of the new diet is high enough to permit the transferred cows to remain in positive energy balance if only cows will be transferred that are beyond peak production. Although the social and dietary effects of changing groups have not been factored clearly in a single experiment, the limited evidence suggests dietary effects are usually greater. It is possible that the social and dietary effects of changing groups are not additive.

In contrast to the problem of transferring cows from high concentrate to high forage, Hernandez et al. (27) showed that it was possible to switch cows abruptly from a high forage CR (95:5) to a high energy CR (40:60) 4 days postpartum without the cows going off feed, experiencing digestive disturbance, or accumulating lactic acid in the rumen. These results are explainable from observations of eating behavior of cows fed CR ad libitum in which cows ate 11 meals of 29 min per day (12). In conventional systems of feeding concentrate and forages separately, increases in energy often cause disturbances, but decreases can be gradual; the reverse occurs in CR systems. How can the drop in production which occurs as cows are switched to lower energy groups be minimized?

1) Group heifers and/or cows which freshen in the same month so that dietary changes can be gradual as lactation advances.

2) More groups mean smaller dietary changes between groups; I suggest a minimum of three groups of lactating cows.

3) High-energy forage (minimum concentrate) will mean smaller dietary energy changes.

4) Extra grain may be fed in the parlor, especially during transition to a new group (18).

5) Gradual changes might be made by increasing the energy of the receiving group, and after cow transfer by gradually returning to lower dietary energy.

The important criteria for grouping are: 1) milk production energy or stage of lactation; all cows should enter a high energy group postpartum which allows them to express their genetic ability for milk production, 2) parity (need for additional growth) and 3) body condition.

Wiktorsson and Stone (56) discussed the effect of variation of production within herd and calving pattern on grouping systems. This and other work calls attention to the urgent need for an analysis by modeling systems of this complex and interrelated subject. Available information allows one to build a strong case for at least three groups of lactating cows. This feature is especially important as new housing facilities are designed (38) and old ones re-modeled. More attention should be given by engineers to the feeding system in the design of housing systems.

**ECONOMICS OF CR**

Little work has been done on this topic; Rakes and others (48) found greater income over feed cost for a 100-cow dairy fed conventionally with forages produced on the farm compared to an all purchased CR. Based on
TABLE 1. Partial budget comparison of a complete ration vs. a parlor grain feeding system in a new 80 cow, free-stall set up with horizontal silos, haycrop silage and corn silage\textsuperscript{a}.

<table>
<thead>
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<th>Items that add to net income</th>
<th>Added returns</th>
<th>Reduced costs</th>
<th>Total added returns and reduced costs</th>
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<td>Added returns</td>
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<tr>
<td>1. Added milk production\textsuperscript{b}, 1217 kg on 12 cows</td>
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<td>2. 3 percent more silage saved</td>
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<tr>
<td>Total</td>
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<td>Reduced costs</td>
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<td>3. Lower veterinary bills (10%)</td>
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<td>4. Lower average annual ownership costs on alternative feeding system</td>
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<td>5. Savings on grain purchases\textsuperscript{c} (5%)</td>
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<tr>
<td>6. Savings on ownership on parlor feeding system</td>
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<td>7. Faster milking and cleanup — 30 min/day @ $3/h</td>
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<tr>
<td>Total</td>
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<td>8. Mixer wagon — average annual ownership and operating costs</td>
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<td>9. Moisture tester and calculator</td>
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<td>10. Management, feeding and formulating time</td>
<td>1,100</td>
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<td>11. Crowd gate</td>
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<td>12. Additional 12 ton grain bin — average annual ownership and operating costs</td>
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<td>Total</td>
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<td>$2,434</td>
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\textsuperscript{a}Data from Napper (41).
\textsuperscript{b}Milk price assumed was $8.64/cwt.
\textsuperscript{c}Used two grain mixes and savings on free-choice minerals.

Information in the literature and from a detailed survey of 42 dairymen using CR’s In New York, Napper (41) made a partial budget analysis of two dairy feeding systems, a complete ration vs. a parlor grain feeding system representative of an 80-cow New York dairy farm in 1975. Some of the components and data are in Table 1 which show a net increase in annual farm income of $2,434 for the CR system. A number of assumptions were necessary because of a scarcity of research data, but these results help to answer an important question: What are the economic consequences of using a CR system vs. a conventional parlor grain feeding system? Sensitivity analysis revealed that the effect of milk production was much more critical than silage savings, feed costs, or labor use on the optimum solution. If one can accept the assumptions in this analysis, one can advocate and justify the CR system with economic validation.

**CONCLUSIONS**

Social behavior and taste expression gradually are being recognized as important characteristics of cows housed and fed in groups. It appears unnecessary to provide one free-stall per cow or feed bunk space for all cows to eat simultaneously if a CR is offered ad libitum. Even in conventional feeding systems where concentrate was allocated carefully on energy requirements, large variation in forage selection and intake severely limited accurate diet formu-
lation. One alternative method of concentrate allocation allows high producers concentrate free choice. There is little reason to believe that cows arbitrarily will select an appropriate forage-concentrate ratio when each is available free choice.

The complete ration system has a significant number of advantages especially when used with production groups. Although one does not eliminate variation among cows in consumption with a CR, the precise composition of the consumed diet can be controlled by quantitative blending of CR components. The CR system also has a number of disadvantages; some may be resolved with additional research, but others may be inherent in the system.

Limited work on the comparative economic advantage of a CR system vs. parlor grain feeding suggests a definite plus for the CR. More attention should be given to the feeding system as new housing systems are designed and old ones modified.

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