ABSTRACT

Scientists at 16 experiment stations have been involved in cooperative research to study methods of increasing efficiency and for improving management of dairy replacements. This research is part of the Regional Research Project NC-119 "Improving Large Dairy Herd Management Practices." Research objectives have concerned means of increasing efficiency of producing replacements for large dairy herds. Through cooperative research, important answers were found to questions involving nutrition, housing, and management for replacement animals. Between 1977 and 1982, over 50 articles have been published in journals and trade magazines on replacement animal rearing from research of the NC-119 project. These results should have wide impact and use on livestock management.

INTRODUCTION

Rearing dairy herd replacement animals represents long-term investment in feed, labor, and other resources to ensure high quality replacements for the lactating herd. Calf-related research of nutrition and management often is limited by few or inadequate numbers of research animals. One purpose of the NC-119 Regional Project was to stimulate cooperative research in specific areas of dairy cattle management. Through cooperative research a more thorough integrated study of management techniques is possible.

Regional project NC-119, "Improving Large Dairy Herd Management Practices," originated in 1972 and was revised in 1977 and 1982. This project is multiregional in scope and involves personnel from 16 experiment stations. Research by this committee (1972 to 1977) was reviewed by Lamb (21). The intent of this publication is to summarize research in dairy replacements by members of the NC-119 committee from 1977 to 1982 for use by personnel in industry, education, and extension.

REVIEW AND DISCUSSION

Colostrum Feeding

A summary of research on colostrum by the NC-119 group was reviewed by Lamb (21). In addition, numerous articles on feeding of fermented colostrum were compiled and evaluated by Foley and Otterby (13). Their review includes information on storage, treatment, composition, and feeding value of fermented, fresh, and frozen colostrum. Additional research during the last 5 yr on early colostrum feeding and use of excess colostrum will be discussed.

Muller and Ellinger (23) observed concentrations of colostral immunoglobulin (Ig) among five breeds of dairy cattle. Colostral Ig (%) concentrations were 7.8, 6.7, 6.3, 5.6, and 9.0 for...
Ayrshire, Brown Swiss, Guernsey, Holstein, and Jersey cows. The authors speculated that the high calf mortality frequently reported for Guernsey calves may be related in part to low IgA and IgM concentrations in the dam’s colostrum, resulting in lower concentrations in blood serum of the calf. Concentrations of Ig in colostrum were lower for first-calf heifers (5.7%) than for cows in third (7.9%) and fourth or later (7.5%) parturition. These data agree with results of Oyeniyi and Hunter (30). Foley et al. (12) evaluated absorption of colostral proteins by newborn calves fed unfermented, fermented, and fermented colostrum buffered with sodium bicarbonate. Absorption of colostral proteins was evaluated by serum concentrations of γ-globulin and IgG in calves with blood collected by jugular puncture at 0, 4, 8, 15, 24, and 48 h postbirth. Concentrations of γ-globulin and IgG were highest for unfermented, lowest for fermented, and intermediate for buffered colostrums. The authors concluded that a potential benefit may exist for fermented colostrum buffered with sodium bicarbonate. Raiten et al. (32) surveyed the intestinal morphology of neonatal calves fed various liquid diets and then challenged with *Escherichia coli*. Diets fed at 8% of the calves’ body weight were: 1) whole milk (WM), 2) fermented colostrum (FC), 3) milk replacer (MR), 4) MR plus *Lactobacillus acidophilus*, and 5) WM plus *Lactobacillus acidophilus*. By scanning electron microscopy, intestinal morphology of calves fed the various diets was compared with that of control-fed (WM) calves. Calves fed MR showed the most severe effects of infection, whereas those on FC showed the least. The data suggest that the liquid diet influences intestinal morphology of the young calf.

Foley and Otterby (14) compared colostrum stored by either feeding, fermenting, or treating with lactic (1%) or adipic acid (1%). The use of frozen, fermented, or lactic acid-treated colostrum as the liquid portion of the calves’ diet resulted in acceptable growth and health. Adipic acid treated colostrum was refused more frequently than fermented or frozen colostrum and was not recommended.

Use of Nonsalable and Waste Milk for Calves

Feeding of nonsalable, mastitic milk was reviewed by Kesler (15). Schaffer and McGuffey (36) fed either whole milk (WM) or antibiotic containing mastitic milk (MM) that had been fermented for 7 days. No differences were detected between calves fed WM or MM for weight gain, starter intake, or incidence of scouring. Fermented mastitic milk had higher titratable acidity, nonprotein nitrogen, and less total solids than comparative whole milk. These changes during fermentation agree with those with fermented colostrum (13).

Chardavoyne et al. (9) evaluated the use of antibiotic-containing waste milk (AWM) as the liquid fraction of the diet of young calves. In these trials, AWM was collected for 72 h postantibiotic treatment from cows treated for mastitis or other disorders and was fed fresh (within 2 days) or preserved with 0.05% (wt/wt) formaldehyde. Calves were weaned at either 5 or 6 wk of age depending on the trial. Control diets were either whole milk or fermented colostrum. Fresh AWM was equal to or superior to control diets for calf growth. Treatment of AWM with formaldehyde resulted in reduced growth rates, greater incidence of nutritional scours, and feed refusals during wk 1, 2, and 3 after birth.

Keys et al. (17) evaluated the effect of starter culture, temperature, and antibiotic concentration on fermentation rate of pooled mastitic milk. Starter cultures of *Streptococcus cremoris-S. lactis* or no culture were added to postantibiotic treatment milkings (PATM) 1, 3, or 5 from cows treated intra two quarters with 100,000 IU penicillin G and 150 mg neomycin sulfate. Cultures were effective in reducing time to ferment to pH 4.7 for PATM 3 and 5 but not for PATM 1. In this case, antibiotic concentration was apparently high enough to inhibit fermentation. In a second trial, PATM 1, 2, 3, 5, and 6 from cows treated in one quarter with 100,000 IU penicillin G and 150 mg neomycin sulfate, mastitic milk without antibiotics, and normal milk were inoculated with commercial buttermilk (1% of sample volume) and incubated at 4.4, 21.1, and 32.2°C. Buttermilk was chosen as a readily available inoculant for the commercial dairy farmer, and temperatures were selected to mimic seasonal ambient temperature variations. Increasing temperature decreased the time necessary to ferment to a pH of 4.7 in all milks tested. Addition of buttermilk inoculant to treated mastitic milkings 1 and 2 was not effective in reducing pH of the
milk, apparently due to high antibiotic concentrations. Fermentation rates of treated mastitic, untreated mastitic, and normal milk from third to sixth PATM milkings were similar. The researchers concluded that concentrations of Penicillin G in mastitic milk greater than .06 IU/ml and novobiocin concentrations greater than .35 μg/ml reduced fermentation rates of milk from postantibiotic milkings. Otterby et al. (24) fed milk replacer, fermented colostrum, or fermented colostrum for 14 days followed by fermented unsalable milk (14 to 28 days). Unsalable milk was defined as milk from cows treated for mastitis, metritis, or other problems that required antibiotic treatment. No differences in weight gain (6 wk), starter intake, or total dry matter intake were noticed. In a second trial, acidified colostrum, acidified nonsalable milk, or combinations of the two were compared to whole milk. Acidified diets were less acceptable than whole milk if pH was lowered to approximately 4.0. Addition of sodium bicarbonate (.6% wt/wt) to raise the pH of acidified colostrum to 6.0 decreased refusals of liquid diet during the 1st wk of feeding, and consumption was similar to that for fresh frozen colostrum.

Replacement Nutrition and Management

A substantial amount of research has been on nutrition and management of the young calf. Thomsen and Rindsig (37) conducted an experiment to determine whether commercially available feed flavors of butter (B), milk aroma (MA), or maple (MP) would influence feed consumption or growth when added to milk replacer or starter rations of calves. No effect of flavor added to milk replacer on starter consumption were noted for calves as compared to calves fed control diets. When flavors were added to the starter ration, inclusion of MP resulted in more starter intake to 8 wk and from 6 to 8 wk as compared to control calves. Average daily gains to 8 wk were greater for calves fed starters flavored with MA (.431 kg) or MP (.469 kg) than for calves fed control diets (.367 kg). Calves fed flavored starters had numerically greater mean starter intake and daily gain compared with calves fed unflavored control starters.

Anderson and coworkers (3, 20), in two experiments, fed newborn calves one of three rations: 1) chopped alfalfa hay plus regular concentrate, 2) chopped alfalfa hay plus regular concentrate with whole cottonseed at a ratio of 3:1, and 3) no hay and the same concentrate mix as in ration 2. Calves fed ration 3 had significantly more propionic acid (molar %) in ruminal fluid; however, pH, total volatile fatty acids, and ratio of acetate:propionate in the rumen were not affected by ration. Weight gains (net gain for 12 wk) were greater for calves fed ration 2 (47.3 kg) and ration 3 (49.2 kg) than for control fed calves (41.5 kg) but were not significantly different. No ration effects were observed for weight, volume, and tissue thickness of rumen compartments.

Pennsylvania State workers (11, 40) studied if addition of sodium bicarbonate to diets for dairy calves would improve performance. In the study of Wheeler et al. (40), calves were fed complete pelleted diets for ad libitum intake that contained either 35% alfalfa or 35% grass hay from birth to 12 wk of age. Sodium bicarbonate was added at 3.5 or 5% of the starter ration. Bicarbonate addition increased concentration of ruminal acetate and butyrate but decreased propionate concentrations. The incidence of free-gas bloat was greater for calves fed sodium bicarbonate. The authors concluded no benefit of sodium bicarbonate addition to the starter rations tested in this experiment. Curnick et al. (11) studied the influence of added sodium bicarbonate (3%) on calf performance when calves were fed high energy diets that varied in protein percent. Addition of sodium bicarbonate stimulated greater growth preweaning and higher feed intake for the 10-wk trial, although most improvements of performance occurred immediately pre- or postweaning.

Owen (25) prepared a fact sheet of criteria for selecting milk replacers for dairy calves. Larson et al. (22) developed guidelines to standardize information collected on calf digestion and management experiments.

Owen and Larson (27) compiled information on calf raising procedures, and Owen (26) discussed calf hutches for baby calves. Clark (10) summarized data of calves raised in hutches in South Dakota, and Porterfield (31) evaluated growth of calves in hutches or conventional housing in North Carolina. Schaffer (35) studied solar heating for calf hutches but concluded that the design tested was not efficient or practical.
By-Product and Waste Utilization

By-products and waste materials may be used effectively to promote growth of heifers and lower feed costs. Limited research has been conducted on nutrition and feeding systems of growing replacement animals, and additional research is required.

Rakes and Davenport (33) evaluated incorporation of salt in concentrate mixtures in an attempt to limit free-choice concentrate feed intake of heifers maintained in dry lot and, thus, reduce feeding labor. Heifers fed diets containing 15 and 20% salt were compared with heifers consuming chopped, good quality, alfalfa hay free choice. Heifers consuming concentrate mixes containing salt had access to poor quality grass hay in stacks. Weight gains were .76, .64, and .34 kg/day per head for heifers fed control, 15% salt, and 20% salt diets. Gains for control and 15% salt rations were acceptable for Holstein heifers. A digestion trial (34) used Holstein heifers fed hay-concentrate diets containing either less than 1 or 11% additional salt. Heifers fed the 11% salt diet consumed more water and had lower digestion coefficients for acid detergent fiber, neutral detergent fiber, and dry matter. Digestibilities of protein and ether extract were not affected. Differences in digestibility might be attributed to a faster ruminal turnover because of added salt.

Keys and Smith (18, 19) utilized fresh poultry excreta (FPE) or dried laying hen excreta (DPE) in diets of yearling Holstein heifers fed varying amounts of corn silage and stover. Diets with DPE added at approximately 11% (dry matter) produced acceptable gains when fed to yearling Holstein heifers, whereas weight gains of heifers fed rations containing 25% DPE were substandard. This difference in weight gain was likely attributable to differences in available energy versus ammonical, nonprotein nitrogen (NPN) content of the diet. When FPE was added to and ensiled with corn stover and silage at 0, 9.3, 10, and 12.3% of the diet dry matter, weight gains were .50, .41, .39, and .25 kg/head per day. These weight gains were less than anticipated and were unexplained. It is possible that undesirable fermentations occurred with all rations ensiled. Silage pH were not unrealistic for corn silage-type diets.

Rakes and Davenport (33) compared the use of a complete mixed ration fed once daily containing 58% screened manure solids (SMS) with a concentrate mix containing 15% salt (S) offered in a self-feeder with additional access to cottonseed hulls. Gains of .71 and .51 kg/head per day were achieved for S and SMS diets.

Owen and associates (28) utilized chopped brome hay and soy hulls as fiber sources in calf starter rations. Calves group reared with soy hulls at 15% or chopped brome hay at 17% of the ration dry matter in calf starter rations gave adequate performance. Owen et al. (29) included ground corn cobs at 0, 12, 24, and 36% of the starter ration dry matter. Calves were weaned at 21 days of age. The authors concluded that utilization of 12 to 24% corn cobs in starter rations improved performance of early weaned calves. Van Horn et al. (38) utilized sugarcane bagasse pellets or cottonseed hulls as fiber sources for calves, young heifers, or yearling heifers. In general, cottonseed added at 15% of the starter ration, and 40 to 55% in diets fed from 80 to 180 days of age gave adequate growth rates. Bagasse pellets were not accepted as well as cottonseed hulls, and results were variable.

Animal Behavior

Behavior in the young calf has been observed and reviewed (1, 4) regarding feeding (nursing), response to hand feeding methods, frequency of feeding, early feeding and rearing experiences, learning ability, and vice of self-sucking and sucking other cows.

Arave and coworkers (6, 39) conducted a series of experiments to evaluate if housing and handling of Holstein heifers had any effect on animal behavior. In their first trial (39), calves were assigned to three housing situations: group housing, individual calf hutches, or isolation calf hutches. Isolated hutches were hutches modified with plywood sheets such that the calf had no other visual interaction with other calves. All groups of calves received identical treatment, with the exception of housing assignment from birth to 10 wk, at which time they were weaned. Post weaning all calves were housed and raised together. Calves reared in isolation hutches had lower weight gains than individual hutch or group reared calves. Behaviorally, group-reared calves had higher social dominance, learned faster to compete for feed, and consumed more hay and concentrate at an...
earlier age than calves raised under the other housing situations. Calves reared in hutches (individual and isolation), however, were more nearly free from disease and adjusted quickly to group-rearing situations. At 15 mo of age, heifers from the respective treatment groups were equipped with transmitters allowing each access to only one feed door (7). Transmitters were changed daily between heifers, and animals were observed for behavioral activities. Group-reared heifers had the highest dominance rank, tried entry to the doors more times, and had more successful entries earlier than hutch reared heifers. Heifers reared in isolation hutches were lowest for all variables tested.

In a similar experiment by Arave and co-workers (8), 67 heifer calves were assigned at birth to one of four rearing treatments: 1) groups of six, 2) individual hutch, 3) isolation hutch, and 4) isolation hutch with 10 min daily interaction with calf feeder. After weaning (10 wk), calves were assimilated into the regular herd and managed similarly. Forty-eight heifers (treatments 3, 4) produced more fat-corrected milk (FCM) (P<.05) during the first lactation than nonisolation-reared heifers (treatments 1, 2). Least square means were 7182, 7318, and 8103 kg FCM for treatments 1, 2, and 3 and 4 pooled, respectively. This research prompted an NC-119 seven station cooperative research trial, organized by Utah, to evaluate weight gain, health, and future milk production of calves reared in isolation or traditional hutches or housing.

Arave and Anderson (5) evaluated feed intake, weight change, and behavioral activity of heifers fed in a tie stall or transmitter controlled feed gates. They found that feed intake was similar or greater when heifers were assigned to electronic feed gates than to tie stalls. The authors concluded that electronic feed gates, maintained properly, allow natural interaction and feeding behavior of heifers housed in group situations while still allowing individual feed intake data.

Keys and others (16) assessed feedbunk stocking density in relation to weight gains of yearling Holstein heifers. They determined that a linear headspace of .27 m per heifer is required to ensure adequate feed intake and growth of heifers fed a restricted complete ration.

Albright and Miller (2) evaluated behavior and comfort of calves reared in elevated metal stalls constructed of metal rods versus conventional pens. They observed that calves reared in conventional pens were more comfortable with less abnormal behavior than calves reared in elevated pens.

CONCLUSIONS
Through cooperative research, the NC-119 Regional Research Committee studied and answered many important questions concerning management of dairy replacement animals. Objectives for ongoing studies from 1982 to 1987 involve development of dairy management practices to result in optimum returns through research toward improved a) animal performance, b) labor efficiency, and c) decision making.

REFERENCES

Journal of Dairy Science Vol. 67, No. 12, 1984
Dairy Science Update, DSU 82-3, South Dakota State Univ., Brookings.


Journal of Dairy Science Vol. 67, No. 12, 1984