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Effects of Group, Individual, and Isolated Rearing of Dairy Calves on Weight Gain and Social Development

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EFFECTS OF GROUP, INDIVIDUAL, AND ISOLATED REARING OF DAIRY CALVES ON WEIGHT GAIN AND SOCIAL DEVELOPMENT

by

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A thesis submitted in partial fulfillment
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Val D. Warnick

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by

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Thirty-six dairy calves were observed for four months to determine the effect of three housing methods, group, individual and isolated on body weight gain, feed consumption, age when started to consume grain, daily activity patterns, open field test of behavior and social rank. Six calves were assigned to each of the three treatments in two separate trials of eighteen calves. These calves were raised in their treatment for approximately two months and then weaned and placed together in a group of eighteen for two more months.

Treatments ranked in order from high to low according to least squares means for weight gain over four months were: group, individual and isolated. The differences were, however, not significant ($P>.05$). There was a significant difference in weight gain from weaning until four months between the group calves and the isolated calves, with the group calves gaining weight faster during this weaned period ($P<.05$). Group calves began consuming grain at a younger age ($P<.01$) than the calves on the other two treatments, but

total feed consumed over the first 10 weeks was not significantly different (P>.05).

Isolated calves tended to spend a greater portion of the time lying down than calves in the other two treatments but the difference was not significant (P>.05). In the open-field test isolated calves entered more squares than the group or individual calves, but the group calves were the most vocal of the calves in the three treatments (P<.01). The group calves placed higher in the social order and won a higher percentage of encounters (P<.01) than the individual or isolated calves during the weaned period.

(56 pages)

INTRODUCTION

Extensive research has been conducted over the last 30 years to determine the effect of different feeding programs on the growth and social development of dairy calves. Major emphasis has been placed on once-a-day versus twice-a-day feeding. Other research has been conducted on whole milk versus milk replacers, the benefits of colostrum and more recently the effects of feeding sour colostrum. Little research has considered environmental factors affecting the growth and social development of dairy calves.

Increasing use in recent years of automated calf feeding systems and new enclosed housing systems have caused some concern as to whether a lack of contact with humans and other calves may detrimentally affect the calves themselves. Detrimental affects of isolation have been shown to occur in many species of laboratory animals. These detrimental effects of isolation included: less rapid increase in body weight, nervous behavior, and inability to function normally when returned to an environment that included others of their own kind.

In recent years because of the higher cost of labor required to raise calves individually some dairymen have switched to raising calves in small groups of six or eight calves. The effects of group rearing of calves on their body weight gain and social development have not been thoroughly studied.

The objectives of this study were to determine the effect of group, individual, and isolated rearing of dairy calves on body weight gain, and social development.

REVIEW OF LITERATURE

One of the most costly losses dairymen suffer is calf mortality or the unsuccessful raising of replacement heifers. Blackmer estimated that nearly 2 million calves die every year representing over a $100,000,000 loss (11). Calf mortality varies considerably from farm to farm and is a major problem in many herds. In a survey of 477 dairy farms in Michigan, herds averaged 70 calves born per year with an average mortality of 17.7% (48). Other surveys indicate that better management practices, including more careful attention at calving and improved methods of raising calves could reduce these losses (1, 27, 32, 46).

During the last 20 years many studies concerned with what and how often to feed calves have been made. Ackerman et al. (2), Willet et al. (54), Broadbent (14), and Hartman (28) reported that once-a-day feeding of dairy calves can be successful. Morrill (40) made recommendations on the use of milk replacers and other feeds, but few studies have considered the effect of management and the environment on the growth rate and development of dairy calves.

Appleman (6) pointed out a need for further study of calf rearing procedures in his excellent review of calf management studies.

Housing Systems

Appleman and Owens (5) reported that regardless of the type of housing, to successfully raise calves, the key is to keep them clean, dry, and away from drafts. Reports on the effects of housing on the

growth and development of calves are contradictory. Jorgenson et al. (33), reported that indoor vs. outdoor rearing had no significant effect on average daily gain, consumption of hay, and incidence of scours or pneumonia, Mitchell and Broadbent (39) reported that housing environment affected age of weaning and intake of milk substitute. Willett et al. (53) indicated individual outdoor pens were equal to closed barns even in specially designed barns. Gonzalez and Blaxter (22) reported indoor specialized calf barns as too expensive because of the cost of the construction materials and the need to provide artificial heating and ventilation.

Other researchers during the past 20 years have studied the use of individual portable outside pens. Davis et al. (16), Erb and Murdock (19), Murley and Culvahouse (41), Murley et al. (42), and Willet (52) have all reported individual portable outdoor pens equal to or better than the conventional closed calf barn. Individual calf pens have also been shown by Alexander (4), Giddes (21), and Hoyer and Larkin (30) to successfully reduce the undesirable habit of calves sucking either one another or inanimate objects.

Housing calves in groups is another method of raising calves that needs additional study. Hafez and Schein (25) reported that group action plays a vital role in the life of dairy cows. Coppock et al. (15), showed that group fed cows consumed 7% more dry matter than individually fed cows without a concomitant increase in actual milk or fat production. McCullough (37) estimated that group feeding of cows, fed silage, increased their maintenance requirement about 20% above stall fed animals although group feeding had little effect

on milk production or body weight change. Hafez (26) made the general statement that group fed animals ate more and gained more weight than isolated animals.

Many modern large and some small calf raising facilities where feeding is done by automation and calves are housed in enclosed pens place a calf in a near state of isolation with very little human contact and very little contact with other calves. The effect of isolation at this sensitive period on dairy calves has not been studied. Isolation studies have been done by Guiton (24) on chickens and Boyd and Fabricuis (12) on mallard ducks showing that isolation in these species resulted in a slower rate of weight gain, a lower ranking in the hierarchy when returned to a normal environment, and a decreased learning ability.

Body Weight Gain

Each calf is an individual and as an individual gains weight at a unique rate, but as a group they all follow a general trend. Lamb and Perkes (35) reported that weight gains were slowest early in life, being less than 1 pound per day for the first few weeks. The rate of gain increases rapidly, however, reaching its highest rate of almost 2 pounds per day at about 4 months. Willett et al. (53) and Jorgenson et al. (33) reported that differences in average weight gain or average daily gain between calves in various housing systems was not significant.

Feed Consumption

The intake of food is essential for the survival of most living things including calves and the amount they consume has an effect on their daily weight gain. Mitchell and Broadbent (39) reported that housing environments affected the intake of milk substitute by calves but both Willett et al. (53) and Jorgenson et al. (33) reported no difference in consumption of hay between calves housed differently.

Another important aspect of feed consumption by young dairy calves is the development of rumen activity which tends to reduce the occurance of digestive upsets. Rumen activity can be increased by a calf consuming hay and grain early in life. Flatt et al. (20), Miller et al. (38), Hibbs et al. (29) and Bartley (9) have shown that feeding young calves hay and grain enhances rumen development.

Daily Activity

The amount of activity can affect the weight gain of calves. Some who raise calves for veal have restricted pen size so the calf can barely stand or lie down and cannot turn around. This is done theoretically to reduce the activity of calves so they will grow faster on less feed. But Appleman (5) reported that calf health and growth improved when bedded pens with 26 sq. ft. of space were compared to calves with only 20 sq. ft. The amount of daily activity can be measured by the amount of time the calf spends either standing up or lying down.

Open Field Test

Hafez (26) reported many approaches have been made to equate temperament in cattle with nervousness or skittishness. The Pavlovian approach to temperament, defined in terms of the strength of the nervous system, involves a time-consuming process of conditioning.

Baryshnikov and Kokorina (8) have correlated temperamental differences in higher nervous activity in cows with their level of milk and fat production, the shape of their lactation curves, the peculiarities of the milk ejection reflex, the speed of milk ejection and other characteristics. Tulloh (50) rated temperament on a one-to-six scale for beef cattle. Scott (47) used a one-to-three scale and Dickson et al. (17) a one-to-four scale for dairy cows. Only the milkers know the animals well enough to rate them, but their assessments tend to be biased. In order to upset their subjects Ely and Peterson (18) threw kittens on the backs of unsuspecting cows or exploded paper bags in their ears every two minutes and recorded the inhibition of the milk ejection reflex without success. Most attempts to assess temperament or emotionality in large farm animals have failed to satisfy criteria of objectivity.

Over the years an open field test has been used successfully to assess the exploratory behavior of laboratory animals. Kilgour (34) used it to assess the exploratory behavior of cows in trying to correlate it to milking behavior without success because an accurate method was not found to evaluate milking behavior. The open field test is currently recognized as one of the best methods for evaluating the exploratory behavior of animals.

Social Rank

Social dominance whereby one animal causes a subordinate to yield space through threat, force, or mere presence is known in all domesticated animals. This type of relationship was recorded for dairy cattle as early as 1853 by Low (36). Work was also done in 1901 by Brigham (13). Pioneer work was done by Schjelderup-Ebb (45) on dominance-subordinance relationships or "peck order" in poultry. Several studies have been made in more recent years further documenting this phenomenon in that species (23, 25).

Schein (44) in a herd of 87 Jersey and Red Sindhi cows on pasture found a straight line social order, i.e., cow 1 dominated all others; cow 2 dominated all except cow 1; cow 3 dominated all cows except 1 and 2. However, Beilharz and Mylrea (10) found several traingular or higher order relationships and were unable to assign a linear order but rather ranked a group of Holstein cows on pasture by the ratio of wins to total encounters. Arave and Albright (7) found a low correlation between dominance rank and fat corrected milk production in Holstein cows.

MATERIALS AND METHODS

A total of 36 Holstein dairy calves at the Utah State University Dairy Farm, Logan, Utah were placed in one of three different rearing treatments to determine the effect on weight gain and social development of the calves. The experiment was conducted during two trials with eighteen calves in each trial.

Trial I calves were born from September 10, 1975 through October 25, 1975. Data were recorded until the calves were four months of age. Trial II calves were born from December 9, 1975 through January 9, 1976. Data were also recorded until the calves were four months of age. Both male and female calves were in the experiment.

In both trials there were six calves in each of the three treatments. Calves were assigned to a treatment in order of birth with the first six calves in trial I being in treatment I, the second six in treatment II, etc. This allowed for calves on a treatment to be as near the same age as possible considering the herd size. Treatments were as follow: Treatment I group--six calves born within 10 days of each other were placed in a pen 10' x 20'. Treatment II individual --each calf was put in an individual portable outdoor pen. Treatment III isolated--each calf was placed in an individual pen with the front, back and sides enclosed to prevent contact between calves and to permit only brief contact with the feeder, when each isolated calf was fed. The order of filling the treatments was reversed for trial II: isolated treatment first, then the individual treatment followed by the group treatment.

Housing

Since each treatment was housed differently an explanation of the housing units is necessary. The calves in treatment I, or group treatment, were housed in a pen made of 1 inch pipe in panels 5 feet x 5 feet. They were joined together to make an area 10 feet x 20 feet. This is proportional to the area given each calf in the other two treatments. The pen was located under a loose housing shed which served as a wind break and protected the calves in wet weather. The calves were fed milk in a round tub 30 inches in diameter. Hay was fed in one large 15 gallon container and grain in another 15 gallon container.

The calves in treatment II, or individual treatment, were housed in individual pens. They were outdoor portable calf hutches with an area of 4 feet x 8 feet with a 4 foot x 4 foot sloped galvanized metal roof covering the back half of the pen. The pen front opened to a covered manger where hay, grain, and milk were fed. Milk was fed in a 6 quart bucket.

The calves in treatment III, or isolated treatment,were housed in outdoor portable calf hutches of the same design as in treatment II. However, the front and sides were modified by enclosing with plywood up to five feet in height. Milk, hay, and grain, were fed in separate six quart buckets attached with brackets to the inside of the hutch itself.

All pens were kept clean with new straw bedding added weekly or as needed to keep the calves clean and dry.

Feeding

All calves received colostrum for the first three days after birth. The calves were fed discarded milk (colostrum, mastitic milk, and milk from cows treated with antibiotics) mixed with whole milk from the milk barn. Calves were fed milk twice a day according to body weight, (four percent of body weight) up to two quarts per feeding, until they were weaned and taken off the three treatments. The average age of the calves at weaning was 74 days.

On the second week hay and grain were placed in front of the calves. The hay was good quality alfalfa hay and the grain was 79% barley, 14% beet pulp, 5% molasses, 1% salt, and 1% dicalicum-phorphorus. They were given free choice up to three pounds of grain and one pound of hay per day. Daily recording of weighbacks of refusals were made to measure daily hay and grain consumption. As soon as the calf was consuming at least one pound of grain for each of three consecutive days its age was recorded. At weaning calves were taken out of the three treatments and placed together in a large group. This larger group was called the pooled group. The pooled group continued to receive hay, and water free choice and up to four pounds of grain per calf per day until the end of the experiment.

Weight

All calves were weighed within 12 hours of birth, before being placed on the treatments. Calves in treatments I and II were weighed bi-weekly until pooled at weaning. Calves in treatment III were not weighed again prior to weaning in order to maintain the integrity of

their isolation until they were weaned and placed in the pooled group. All calves were weighed when they reached four months of age.

Twenty-Four Hour Observation

The activity of each calf was observed and recorded at 15 minute intervals for 24 hours. This was done October 29 and October 30, 1975 for trial I and February 7 and February 8, 1976 for trial II. After the observations were completed, the daily activity was analyzed with emphasis given to the percent of time spent lying down. Other activities observed were: side the calf laid on, time spent eating or drinking, chewing cud or ruminating, urinating, defecating, and sucking other calves or inanimate objects.

Open Field Test

The open field test is now a relatively standardized method used in measuring the exploratory behavior of laboratory animals. To give adequate room for the calves yet keep construction within manageable size, the open field arena built for this study was a circle with a diameter of 20 feet. It was constructed of panels 5 feet x 5 feet with canvas placed over the panels. A grid of squares 3 feet x 3 feet was marked off with lime on the floor. Scoring was done from an observation tower 12 feet high. It was decided to use the open field test on each calf for three minutes each day for three consecutive days. Three parameters were recorded: (1) number of squares entered, (2) number of vocalizations, and (3) number of defecations and urinations. The order the calves began the test was changed each day

and the point of entry into the arena was also changed each day to elminate biases. An example of the actual open field results is included in Appendix E.

Social Rank

Calves were observed for behavior two or more times per week for one hour at feeding time for seven weeks during the weaned period. Social encounters between herdmates were recorded. An encounter was won if the lower yielded space to avoid either forceful ejection or to avoid contact. A total of 150 encounters were recorded during both trials. Dominance rank was assigned from 1 to 18 within each trial according to the percentage of encounters won by each calf. The most dominant calf was ranked with the highest number and the most submissive calf was ranked 1 in both trials.

Health

General health of each calf was noted twice daily and a record was kept of medication given. Examples of medication given would be a series of injections of an antibiotic for pneumonia or "pectin plus" for scours. At the conclusion of both trials the total number of calves receiving medication and the number of times treated was summarized.

RESULTS AND DISCUSSION

The purpose of this experiment was to determine the effect of group, individual, and isolated rearing of the weight gain and social development of dairy calves. Factors considered to be important indicators of the effects of different rearing systems were body weight gains, feed consumed, daily activity, and social behavior.

Statistical Model

The statistical analysis was done with STATPAC series of statistical programs developed by R. Hurst (31) for use with the Burroughs B6700 computer. The data were analyzed with Least-squares procedures with covariance using the following complete model:

$$Y_{ijkl} = \mu + t_i + p_j + s_k + t_{pij} + t_{sik} + P_{sjk} + \Sigma b_e x_e + e_{ijkl}$$

where:

Y_{ijkl} = an observation on the lth calf of the kth sex in the jth trial under the ith treatment.

μ = population mean.

t_i = the effect of ith treatment; i = 1, 2, 3.

P_j = the effect of jth trial; j = 1, 2.

j_k = the effect of kth sex; k = 1, 2.

t_{pij} = interaction of ith treatment with jth trial.

t_{sik} = interaction of the ith treatment with kth sex.

p_{sjk} = interaction of jth trial with kth sex.

$\Sigma b_e x_e$ = the effect of the covariates.

e_{ijkl} = random deviation associated with individual observation.

This full model was used in the preliminary analysis. Following the preliminary analysis the full model was reduced by removing effects that did not approach significance as indicated by an F test in analysis of variance. The degrees of freedom for the effect removed were pooled with the error term to provide a more sensitive test of the effects retained in the model.

The series of covariates varied with the dependent variable. The covariates that were non-significant in the preliminary analysis were also removed from the model.

Adjusted Weights

The actual body weights on calves were taken bi-weekly, on Wednesday, but as calves were born on different days during the two week period this resulted in calves being weighed at different ages. Age adjustments were necessary to obtain comparable data for body weight gain during the experiment.

The actual weights indicated an atypical growth curve because, by chance, all other things being equal, larger calves were weighed at a younger age and smaller calves were weighed at an older age. Because of the atypical growth curve it was necessary to make weight adjustments for age on the basis of regressions outside the present study. The regression used to make adjustments was calculated using data from an earlier study by Stoddard et al. (49) of the same herd, but including only female calves. A cubic curve best explained

regression of body weight on age for the period from birth to seven months of age.

The body weights in the present study were adjusted by multiplicative factors according to the regression relationship described for ages of 65, 74, and 124 days for "two month," "weaned or pooled age," and "four month" weights, respectively. The three weights above were adjusted to their respective means to minimize any error introduced by the multiplicative adjustment factors.

The data in Table 1 indicates isolated calves gained less than either the group or individual reared calves in each of the four time intervals studied. This difference in gain was not significant from birth to 65, 74, and 124 days of age. There was a difference ($P<.05$) in body weight gain between group and isolated calves from 74 days until the 124 day age.

The independent variables that were included in the above model were: treatment, trial, treatment x trial interaction, birth weight, and age when weaned. Of these independent variables trial and age when weaned had the most significant effect on body weight gain.

There was a significant difference between trials I and II in body weight gain for calves from birth to 65 days and from 74-124 days of age. During the period from birth until 65 days, trial I calves' adjusted weight gain was 74.3 pounds, and trial II calves' adjusted weight gain was 57.2 pounds. The decrease in weight gain for the calves in trial II may have been caused by colder weather during that time period. From 74 to 124 days of age the adjusted weight gains of calves were lower for trial I (84.8 pounds) and higher for

Table 1. Summary of the effect of different rearing systems on body weight gain of calves.[1]

Treatment	Number of Calves	Adjusted Body Weight Gain in Pounds: Birth to 65 Days Mean ± S. E.	Birth to 74 Days Mean ± S. E.	Birth to 124 Days Mean ± S. E.	74 Days to 124 Days Mean ± S. E.
Group	11	67.5 ± 4.9	83.0 ± 5.2	183.8 ± 8.7	100.6 ± 4.8[a]
Individual	12	66.7 ± 4.9	84.9 ± 5.1	175.9 ± 8.7	90.1 ± 4.8[ab]
Isolated	12	63.1 ± 4.9	79.0 ± 5.0	163.9 ± 8.8	84.5 ± 4.8[b]

[1]Means with different superscripts are different (P<.05).

trial II calves (98.6 pounds). Again the difference between the two trials in body weight gain could be due to the colder weather during trial I. The calves in trial I experienced coldest weather during the 74-124 days of age period, while calves in trial II experienced coldest weather from birth to 65 days of age. The calves in trial I experienced coldest weather during the 74-124 days of age period (mean temperature during 74-124 days of age period was 26.4 F as compared to a mean temperature of 37.7 F for the birth to 74 days of age period). Calves in trial II experienced coldest weather from birth to 65 days of age (mean temperature during birth to 65 days of age period was 23.5 F compared to a mean temperature of 35.0 F for the 65-124 days of age period). This data was taken from records kept by the Department of Climatology, Utah State University. Trial II calves that grew slower during the first 65 days may have compensated by growing faster during the last 50 days.

Age when calves were weaned had a significant effect on body weight gain during the 74-124 days of age period. Age adjustments removed any direct relationship between age and weight. The older calves generally were larger and more dominant and, therefore, kept growing at a faster rate during the weaned period than the calves that were weaned at a younger age. The effect of age when the calves were weaned on body weight gain may also have been simply the nutritional benefits of calves being fed milk for a longer period of time.

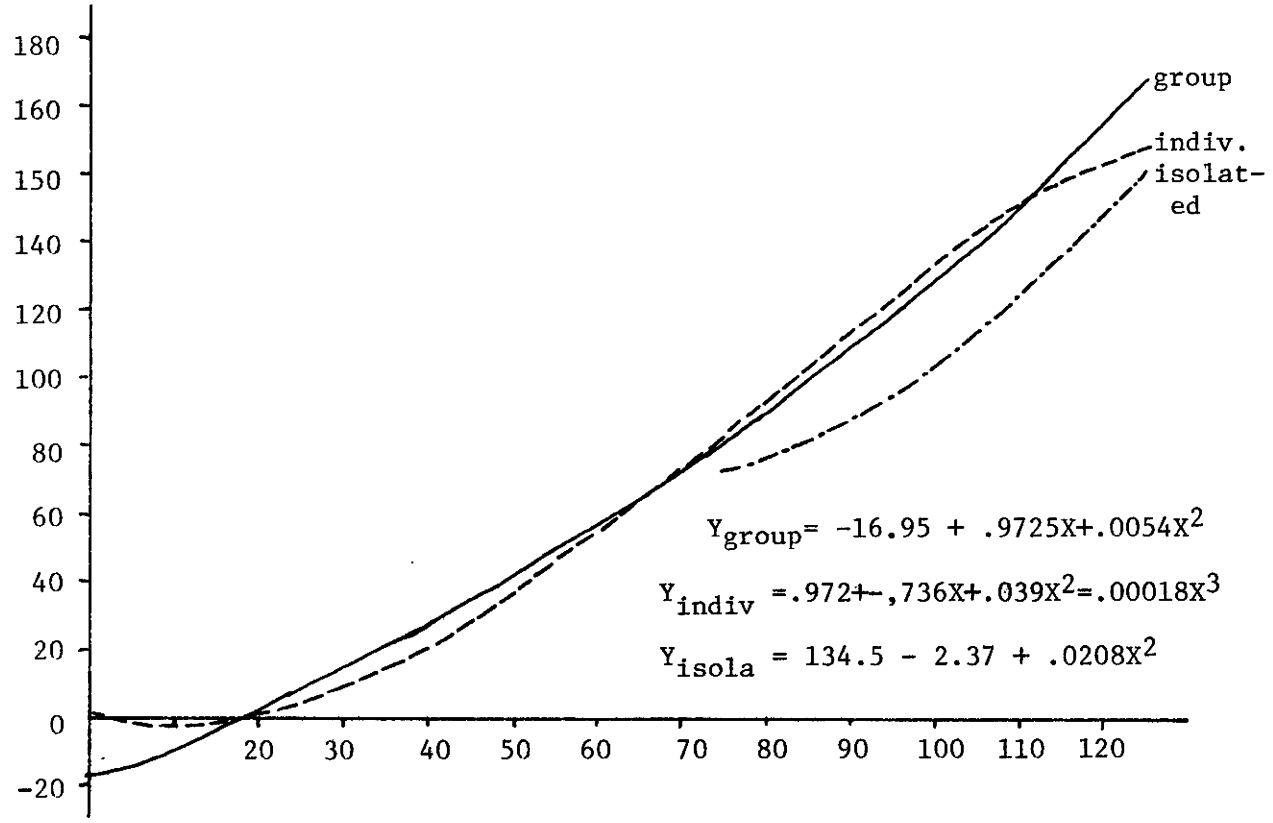

Figure 1. Polynomial regression of total weight gain on age by treatment for calves from birth to 124 days.

Isolated calves were not weighed from birth until they were weaned, therefore, the regression should not be extrapolated before 74 days of age. It was interesting to note from figure 1 that the order of body weight gain from most to least at 124 days of age was: group, individual, and isolated. Also at 124 days group calves weighed slightly more than individual calves and significantly more than isolated calves.

Table 2. Summary of the effect of different rearing systems on feed consumption of calves.

	Pounds grain/calf/day			Pounds hay/calf/day		
Week	Group	Individual	Isolated	Group	Individual	Isolated
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	.99	.07	0	.05	0	0
4	1.20	.95	.68	.27	.12	.06
5	1.48	1.48	1.13	.60	.37	.33
6	2.22	2.23	2.20	.71	.64	.59
7	2.68	2.70	2.60	.79	.74	.69
8	2.78	2.86	2.81	.86	.86	.76
9	3.00	3.00	2.97	1.00	.93	.86
10	3.00	3.00	3.00	1.00	1.00	1.00
Mean	1.73	1.63	1.54	.53	.46	.43

The data in Table 2 indicate that total feed consumption over the first 10 weeks did not differ significantly among treatments. This may have been due to limiting feed to three pounds of grain and one pound of hay per calf per day. There was a definite trend (Table 2) for group calves to begin consuming hay and grain earlier than calves in the other two treatments. Group calves consumed an average of nearly one pound of grain per day by the third week; individual calves did not consume a pound of grain per calf per day until the fourth week and it

was the fifth week before the average isolated calf consumed a pound of grain per day. This trend can be more easily seen in table 3.

Table 3. Summary of the effect of different rearing systems on age when calves consumed over one pound of grain for three consecutive days[1]

Treatment	Number of Calves	Age in Days	
		Range	Mean ± S.E.
Group	11	17 - 26	22.22 ± 1.72[a]
Individual	12	20 - 38	29.24 ± 1.69[b]
Isolated	12	26 - 51	36.57 ± 1.70[c]

[1]Means with different superscripts are different (P<.05).

The data in table 4 indicates that the overall treatment effect for age when calves started to consume grain was highly significant (P<.01). The independent variables in the above model were treatment and sex. Sex only approached significance (P<.10) but was left in the model because of the effect that a near significant variable can have in accounting variability in the model. The male calves generally started consuming grain at a younger age perhaps because the male is usually the adventuresome sex in almost all species.

Another phase of this study consisted of two twenty-four hour observation periods in which daily activity was recorded. More variability among treatments occurred for the percentage of the day the calf spent lying down than for other activities recorded.

Table 4. Summary of the effect of different rearing systems of calves on the time spent laying down.[1]

Treatment	Number of Calves	Percent of the Day	
		Range	Mean ± S.E.
Group	11	66 - 76	72.67 ± 1.41[a]
Individual	12	63 - 79	73.66 ± 1.36[a]
Isolated	12	72 - 95	78.50 ± 1.67[b]

[1]Means with different superscripts are different (P<.05).

The data in table 4 indicated that the overall treatment effect for percent of the day spent lying down was not significant (P<.05), even though some significance did exist in the mean comparisons. The independent variables in the model were: treatment, trial, age and age squared.

There was a significant difference between trials I and II in percent of time spent lying down, with calves in trial I lying down a greater percentage of the time. This may be due to a negative regression of age on percent of time spent lying down during the first two weeks of life. After the first two weeks the regression levels off, but part of the observations were taken during this two week period. Therefore, percent of the day spent lying down decreased as age increased.

Results of the open field test are in table 5. Recorded were the number of squares entered and the number of vocalizations. The number of urinations and defecations observed were insufficient for analysis.

Table 5. Summary of the effect of different rearing systems of calves on open field test results.[1]

Treatment	Number of Calves	Number of Squares Entered: Range	Number of Squares Entered: Means ± S.E.
Group	11	12.33 - 52.33	28.15 ± 3.33[a]
Individual	12	6.33 -149.67	64.47 ± 11.88[b]
Isolated	12	19.00 -186.00	98.80 ± 16.45[c]

Treatment	Number of Calves	Number of Vocalizations: Range	Number of Vocalizations: Means ± S.E.
Group	11	0 - 17.66	6.27 ± 1.71[a]
Individual	12	0 - 2.67	0.72 ± .25[b]
Isolated	12	0 - 10.33	1.89 ± .91[b]

[1]Means with different superscripts are different (P<.05).

The overall treatment effect for both the number of squares entered and number of vocalizations was highly significant (P<.01). Independent variables considered in the model were: treatment, trial and age. Treatment was the only variable that was significant.

Isolated calves were more nervous and excitable in the new environment as shown by their increased activity, but calves from the group treatment were more vocal during the test, showing they were uneasy when placed alone in a pen.

The results of the observations on the social rank of the calves were also interesting. Since the experiment was conducted in two trials

with different calves, it was not feasible to combine social rank observations as was done in the other observations.

Table 6. Summary of the effect of different rearing systems of calves on social rank, trial I.

Treatment	Number of Calves	Mean Dominance Rank ± S.E.	Mean % of Wins ± S.E.
Group	5	15.0 ± .71[a]	79.04 ± 6.5[a]
Individual	6	8.0 ± .97[b]	36.10 ± 6.6[b]
Isolated	6	4.8 ± 1.58[b]	16.50 ± 8.7[b]

[1]Means with different superscripts are different (P<.05).

The data in table 4 indicates that the overall treatment effect for dominance rank and percentage of wins in trial I was highly significant (P<.01). The only variable in the model was treatment. Initially the full model contained other covariates. In trial I under the full model no significance was found. By eliminating the non-significant variables from the model it was possible to pool their degrees of freedom with the error degrees of freedom giving a more sensitive test for significance.

Table 7. Summary of the effect of different rearing systems of calves on social rank, trial II.

Treatment	Number of Calves	Mean Dominance Rank ± S.E.	Mean % of Wins ± S.E.
Group	6	14.5 ± 1.80[a]	70.96 ± 8.6[a]
Individual	6	7.78 ± 1.57[b]	42.21 ± 7.5[b]
Isolated	6	3.20 ± 1.69[b]	18.04 ± 8.1[b]

[1]Means with different superscripts are different (P<.05).

The data in table 7 indicated that the overall treatment effect for dominance rank and percentage of wins in trial II was also highly significant (P<.01). The independent variables considered in the model were: treatment, sex, treatment x sex interaction, weight when weaned, and the square of the term "weight when weaned." The only significant variable, other than treatment, was sex (P<.05) with male calves tending to rank higher and win a greater percentage of their encounters.

A possible reason for the significance of the treatment effect could be the learning experience that the group reared calves had being raised in a group environment. This enabled them to achieve a higher place in the heirarchy and to win a higher percentage of their encounters.

Table 8. Summary of the incidence of disease problems.

Treatment	Number of Calves	Number of Calves Requiring Medication	Number of Treatments of Medication Given
Group	12	5	8
Individual	12	2	2
Isolated	12	4	12

Disease data (table 8) were more difficult to evaluate than other more objective traits measured during this study. There were many factors that could have influenced the results obtained. Even considering uncontrollable factors such as blocking some sunlight by modified pens of isolated calves it was interesting that fewer individual calves received medication and that isolated calves tended to require more medical treatments than other calves in the experiment. The only mortality in the experiment was in the group treatment during trial I when one calf died from scours-pneumonia complex on its 12th day.

SUMMARY AND CONCLUSIONS

Summary

Thirty-six dairy calves were assigned one of three rearing systems, group, individual or isolated. Birth weights and bi-weekly weights, feed consumption and other observations were made and recorded. One calf died while on experiment and these data were deleted from the analysis.

Treatments ranked in order from high to low according to least squares means for weight gain over four months were: group, individual, and isolated. The differences, however, were not significant ($P>.05$). There was a significant different in weight gain from weaning until four months between the group calves and the isolated calves with the group calves gaining weight faster during this weaned period ($P<.05$).

While there was no significant difference among treatments for hay and grain consumed, there was a significant difference ($P<.01$) for age when calves started to consume grain. Group calves began eating grain earliest, followed by the individual and the isolated calves last. Isolated calves spent a higher percentage of time lying down but this was not significantly different than time spent lying down by calves on the other treatments.

The open field test revealed significant differences ($P<.01$) in the behavior of calves as a result of the treatments with isolated calves being the most active and group calves the most vocal.

During the weaned period, the calves raised in the group treatment had an advantage in hierarchy over calves raised individually

or isolated. The differences among treatments for dominance rank was significant ($P<.01$) in both trials.

Calves raised individually tended to be more free from disease and required less medication than calves in the other two treatments.

Conclusions

Systems of rearing dairy calves play an important role in their weight gain and social development. Weight gains were not drastically different at four months, but group reared calves weighed more than calves reared in isolation.

Calves reared in isolation did have a slightly lower weight gain than the other two systems, and the isolated calves did rank lower in the social order and win a lower percentage of their encounters during weaned period (74-124 days). Isolated calves also tended to require more medication than individual or group reared calves.

Calves reared in groups evidently learned to compete during their early exposure to the group environment and were able to compete more agressively during the weaned period (74-124 days). The group reared calves also started to consume grain at an earlier age than the two other rearing systems, but this had no effect on the total amount of grain eaten during the first 10 weeks.

Calves reared in individual portable hutches tended to be more free from disease and adjusted reasonably well to a group environment during the weaned period.

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APPENDIXES

Appendix A

Table 9. Background history of calves and adjusted weights.

Calf I.D.#	Treatment	Date of Birth	Sex	Sire	Birth Weight	Adjusted Weights 65 Day	74 Day	124 Day
4616	Group	9-10-75	Female	Shamrock	87	140	150	252
4618	Group	9-14-75	Female	Ultimate	85	149	161	277
4620	Group	9-15-75	Female	Shamrock	120	201	224	328
4641	Group	9-12-75	Male	Combination	115	193	212	313
4643	Group	9-14-75	Male	Black Knight	90	---	---	---
4645	Group	9-14-75	Male	Shamrock	125	206	212	358
4668	Group	12-31-75	Female	White Eagle	65	101	111	175
4670	Group	12-31-75	Female	Spartacus	104	140	153	236
4697	Group	1-6-76	Male	Spartacus	99	162	177	272
4674	Group	1-7-76	Female	White Eagle	93	189	207	335
4678	Group	1-9-76	Female	Shamrock	100	202	221	327
4699	Group	1-9-76	Male	Dutchman	97	151	165	258
Mean				Mean	98.3	166.7	181.2	284.6
						105 1/2		
4647	Individual	9-18-75	Male	Combination	87	169	190	304
4649	Individual	9-22-75	Male	Combination	99	174	198	301
4651	Individual	9-25-75	Male	White Eagle	108	191	203	308
4622	Individual	9-15-75	Female	Combination	90	161	176	262
4624	Individual	9-19-75	Female	Warrior	83	144	160	249
4626	Individual	10-03-75	Female	Ron	82	177	193	240
4658	Individual	12-18-75	Female	Spartacus	95	147	166	262
4693	Individual	12-18-75	Male	Ruburke	115	176	187	301
4695	Individual	12-23-75	Male	Ron	85	151	166	252

Table 9. Continued

Calf I.D.#	Treatment	Date of Birth	Sex	Sire	Birth Weight	Adjusted Weights 65 Day	74 Day	124 Day
4660	Individual	12-23-75	Female	White Eagle	110	165	185	277
4662	Individual	12-25-75	Female	Combination	82	133	147	248
4664	Individual	12-27-75	Female	Lancer	118	155	196	282
Mean				Means	96.2	162.0	180.6	273.8
4653	Isolated	9-26-75	Male	Warrior	76	147	163	252
4655	Isolated	9-27-75	Male	Bob	100	184	211	304
4657	Isolated	10-13-75	Male	Combination	99	176	193	235
4628	Isolated	10-23-75	Female	Combination	94	171	187	235
4661	Isolated	10-25-75	Male	Spartacus	92	161	176	215
4630	Isolated	10-25-75	Female	Shamrock	106	162	178	242
4652	Isolated	12-08-75	Female	Shamrock	95	129	142	252
4687	Isolated	12-07-75	Male	Warrior	97	147	160	304
4689	Isolated	12-09-75	Male	Lancer	115	163	178	235
4691	Isolated	12-13-75	Male	White Eagle	92	144	158	235
4654	Isolated	12-15-75	Female	Shamrock	95	156	182	215
4656	Isolated	12-15-75	Female	White Eagle	88	164	179	242
Mean				Means	95.8	159.7	175.6	256.9

Appendix B

Body Weight Adjustment Factors

Body weights were adjusted to 65, 74, and 124 days for a two month, pooled, and four month weight respectively. The equation used for the adjustment were derived from Stoddard's (41) study of calves on the same farm. The regression equation used was as follows:

$$89 + .440x + .118X^2 - .0000278X^3.$$

The following adjustment factors were calculated:

Table 10. Body weight adjustment factors.

Adjustments to 65 Days or Two Month Weights		Adjustments to 74 Days or Weight When Pooled		Adjustments to 124 Days or Four Month Weight	
Age (days)	Correction Factor	Age (days)	Correction Factor	Age (days)	Correction Factor
47	1.203	47	1.316	114	1.082
49	1.178	49	1.290	115	1.073
56	1.096	57	1.188	117	1.065
57	1.085	59	1.164	117	1.056
				118	1.048
58	1.074	60	1.152	119	1.040
59	1.063	65	1.094	120	1.032
60	1.052	69	1.051	121	1.023
61	1.039	71	1.030	122	1.016
62	1.031	73	1.010	123	1.001
63	1.021	75	.990	124	1.000
65	1.000	76	.980	125	.992
68	.970	77	.971	126	.985
69	.960	78	.961	127	.977
75	.905	80	.943	128	.970
76	.896	81	.934	129	.963
80	.862	83	.916	130	.956
81	.852	84	.907	131	.949
83	.837	87	.882	133	.935
88	.799	88	.874	140	.890
90	.784	90	.858		
		92	.842		

Appendix C

Table 11. Recorded actual weights of calves.

Calf	Birth Weight	Age (Days)	Weight	Age	Weight	Age	Weight	Age	Weight	Age	Weight	Age	Weight	Age	Weight	Age	Weight
Group																	
4616	87	9	85	21	84	35	101	49	123	63	137	77	155	92	178	133	269
4618	85	5	82	17	80	31	100	45	117	59	140	73	160	88	184	129	288
4620	120	4	114	16	115	30	133	44	157	58	187	72	217	87	254	128	338
4641	115	7	111	19	106	33	134	47	168	61	186	75	213	90	247	131	330
4643	90	5	86	DIED													
4645	125	5	117	17	119	31	148	45	178	59	194	73	226	88	266	129	372
4668	65			25	76	39	90	52	95	65	101					123	175
4670	104			25	112	39	120	52	130	65	140					123	236
4697	99			20	105	34	109	47	129	60	154					117	258
4674	93			19	110	33	129	46	140	59	178					116	315
4678	100			17	115	31	130	44	150	57	186					114	302
4699	97			17	108	31	116	44	125	57	139					114	238
Individual																	
4647	87	13	85	27	96	41	120	55	147	69	176	84	210			125	306
4649	99	9	95	23	94	37	118	51	147	65	174	80	210			121	294
4651	108	6	103	20	104	34	128	48	154	62	178	77	209			117	292
4622	90	4	85	18	84	30	98	44	126	58	150	72	173	87	200	128	270
4624	83	12	84	26	84	40	107	54	125	68	148	83	175			124	249
4626	82	12	90	26	101	40	129	54	154	69	184					140	270
4658	95			21	93	38	101	52	120	65	147	78	173			118	250
4693	115			21	111	38	129	52	136	65	176	78	195			117	285
4695	85			16	89	33	105	47	120	60	144	73	164			130	266

Table 11.Continued

Calf	Birth Weight	(Days)	Weight	Age	Weight	Age	Weight	Age	Weight	Age	Weight	Age	Weight	Age	Weight	Age	Weight
4660	110			16	112	33	123	47	139	60	158	73	183			130	290
4662	82	14	86			31	103	45	115	58	124	71	143			128	256
4664	118	12	117			29	128	43	142	56	161	69	187			126	286
Isolated																	
4653	76											76	166			116	237
4655	100											75	203			115	283
4657	99									59	166					131	248
4628	94							49	145							124	235
4661	92							47	134							122	212
4630	106							47	135							122	238
4652	95													90	165	127	236
4687	97													90	187	128	265
4689	115													88	204	126	295
4691	92											83	172			122	242
4654	95											81	195			120	290
4656	88											80	190			119	265

Appendix D

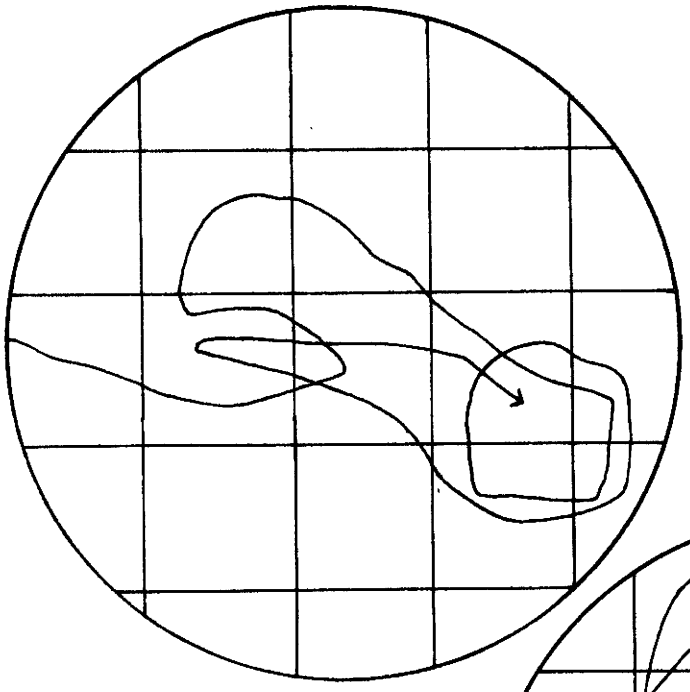
Table 12. Results of open field test on calves

Calf #	Day 1		Day 2		Day 3		Mean	
	Number of Squares Entered	Number of Vocalizations	Number of Squares Entered	Number of Vocalizations	Number of Squares Entered	Number of Vocalizations	Number of Squares Entered	Number of Vocalizations
				Group Calves				
4616	33	2	78	11	46	10	52.33	7.67
4618	62	1	20	0	35	2	39.00	1.0
4620	16	1	57	11	34	6	35.66	6.0
4641	17	2	27	9	17	7	20.33	6.0
4645	26	1	25	0	38	4	29.66	1.67
4668	29	7	11	7	13	6	17.66	6.67
4670	36	1	17	2	16	1	23.00	1.33
4697	31	12	40	21	16	20	29.00	17.66
4674	45	19	17	15	14	11	27.00	15.0
4678	24	6	33	7	19	5	25.33	6.0
4699	29	0	4	0	4	0	12.33	0.0
Mean	31.6	4.73	29.9	7.55	22.9	6.55	28.15	6.27
				Individual Calves				
4647	8	0	4	0	7	0	6.33	0.0
4649	86	0	7	0	71	0	54.67	0.0
4651	184	0	76	0	37	1	99.00	.33
4622	79	0	29	0	37	0	48.33	0.0
4624	62	0	127	0	41	0	76.67	0.0
4626	7	0	16	0	19	8	14.00	2.67
4658	15	0	27	1	13	4	18.33	1.67
4693	27	2	168	0	7	0	67.33	.67
4695	141	2	59	1	70	1	90.00	1.33

Table 12. Continued

Calf #	Day 1		Day 2		Day 3		Mean	
	Number of Squares Entered	Number of Vocalizations	Number of Squares Entered	Number of Vocalizations	Number of Squares Entered	Number of Vocalizations	Number of Squared Entered	Number of Vocalizations
4660	107	0	204	0	138	3	149.67	1.0
4662	29	3	53	0	84	0	55.33	1.0
4664	12	7	139	0	131	0	94.00	0.0
Mean	63.1	1.17	75.8	.17	54.6	1.42	64.47	.92
				Isolated Calves				
4653	197	0	10	1	68	0	91.67	.33
4655	281	0	27	0	166	0	158.0	0
4657	73	0	56	0	7	0	45.33	0
4628	160	1	50	1	68	4	92.67	2.0
4661	15	0	12	2	26	0	17.67	.67
4630	16	0	123	0	74	0	71.00	0
4652	34	6	5	5	18	7	19.00	6.00
4687	200	11	165	7	134	13	166.33	10.33
4689	251	0	162	0	145	0	186.0	0
4691	104	5	27	0	105	0	78.66	1.67
4654	42	5	227	0	52	0	107.0	1.67
4656	157	0	166	0	135	0	152.7	0
Mean	127.4	2.33	85.8	1.33	73.2	2.0	98.8	1.89

Appendix E



Example of group calf

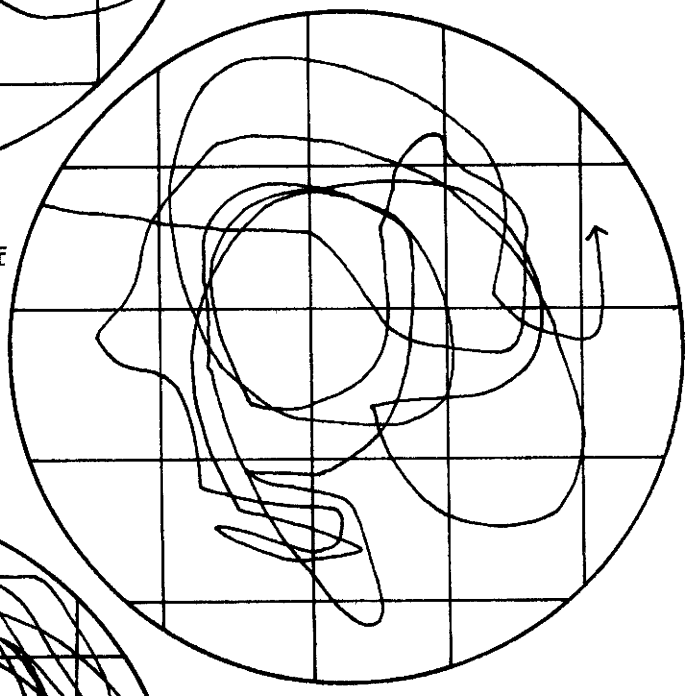
Calf: 4678

Day: 3/4/76

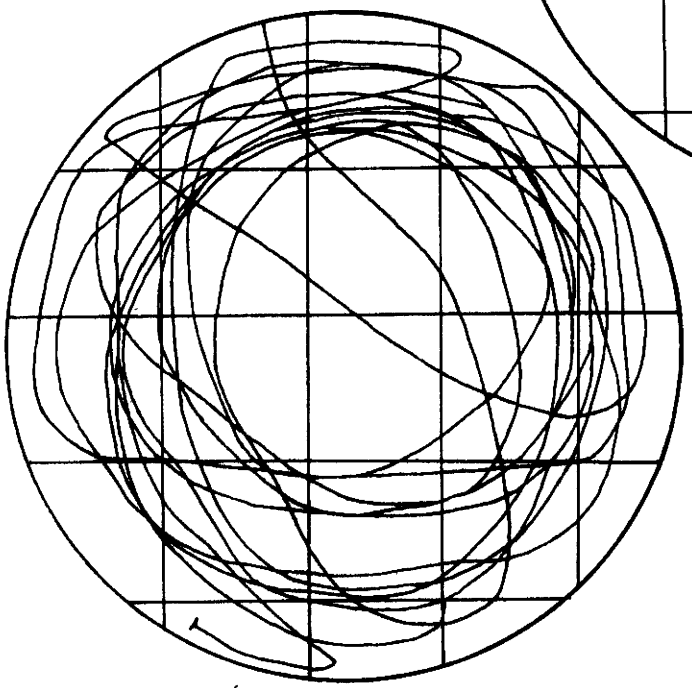
Vocal: 15

Def: 0

Squares Entered: 18



Example of Individual Calf
Calf: 4695
Day: 3/4/76
Vocal: 1
Def.: 0
Squares Entered: 59



Example of Isolated Calf
Calf: 4656
Day: 3/4/76
Vocal: 0
Def.: 0
Squares Entered: 166

Figure 2. Examples of open field test results on calves.

Appendix F

Table 13. Recorded observations on lie down time, age when started to eat grain, age when placed in pooled group, and weight when pooled.

Calf #	Percent of Time Lying Down	Age Started To Eat Grain	Age When Placed in Pooled Group	Weight When Pooled
		Group Calves		
4616	69	23	92	178
4618	78	24	88	184
4620	71	25	87	254
4641	73	22	90	247
4645	76	20	88	266
4668	76	26	65	101
4670	71	26	65	140
4697	66	20	60	154
4674	67	25	59	178
4678	64	17	57	186
4699	68	17	57	139
Means	70.8	22.3	73.5	183.4
		Individual Calves		
4647	71	31	84	210
4649	77	27	80	210
4651	79	35	77	209
4622	74	27	87	200
4624	76	34	83	175
4626	63	33	69	184
4658	72	38	78	173
4693	72	24	78	195
4695	73	22	73	164
4660	67	26	73	183
4662	67	32	71	143
4664	72	20	69	187
Means	71.9	29.1	76.8	186.1
		Isolated Calves		
4653	77	39	76	166
4655	81	26	75	213
4657	91	30	59	166
4628	88	41	49	145
4661	94	38	47	134
4630	95	38	47	135
4652	79	48	90	165
4687	75	28	90	187

Table 13. Continued

Calf #	Percent of Time Lying Down	Age Started To Eat Grain	Age When Placed in Pooled Group	Weight When Pooled
4689	77	26	88	204
4691	80	51	83	172
4654	72	35	81	195
4656	72	33	80	190
Means	81.75	36.1	72.1	172.67

Appendix G

Table 14. Results of social rank observations.

Calf #	Number of Encounters	Number of Wins	Number of Losses	Percentage Wins/Encounters	Dominance Rank
		Group Calves			
		Trial I			
4616	12	8	4	.667	14
4618	16	10	6	.625	13
4620	36	32	4	.889	16
4641	5	4	1	.800	15
4645	35	34	1	.971	17
Means	20.8	17.6	3.2	.846	15.00
		Trial II			
4668	14	1	13	.071	2
4670	18	5	13	.278	6
4697	39	28	11	.718	17
4674	19	12	7	.632	14
4678	19	12	7	.632	13
4699	12	8	4	.667	16
Means	20.2	11	9.17	.545	11.33
		Individual Calves			
		Trial I			
4647	15	8	7	.533	11
4649	18	8	10	.444	9
4651	22	6	16	.273	7
4622	21	11	10	.524	10
4624	16	4	12	.250	6
4626	14	2	12	.142	5
Means	17.67	6.5	11.17	.368	8.00
		Trial II			
4658	18	7	11	.389	9
4693	22	20	2	.909	18
4695	14	4	10	.286	7
4660	27	14	13	.519	10
4662	26	6	20	.231	5
4664	13	5	8	.385	8
Means	20	9.33	10.67	.467	9.5

Table 14. Continued

Calf #	Number of Encounters	Number of Wins	Number of Losses	Percentage Wins/Encounters	Dominance Rank
			Isolated Calves		
			Trial I		
4653	15	8	7	.533	11
4655	5	0	5	.000	2
4657	8	0	8	.000	1
4628	11	1	10	.091	4
4661	16	5	11	.313	8
4630	19	1	18	.053	3
Means	12.33	2.5	9.83	.203	4.83
			Trial II		
4652	10	1	9	.100	3
4687	18	11	7	.611	12
4689	5	3	2	.600	11
4691	7	0	7	.000	1
4654	5	1	4	.200	4
4656	34	22	12	.647	15
Means	13.17	6.33	6.83	.481	7.67

Appendix H

Table 15. Record of calves receiving medication

Date	Calf #	Reason for Medication	What Medication
		Group Calves	
9/25/75	4643	Scours-Pneumonia Complex	Combiotic
9/25/75	4616	Cough	Combiotic
9/25/75	4618	Scours	Pectin Plus, Eltrad
12/31/75	4668	Cough	Combiotic
1/11/76	4697	Scours	Pectin Plus
1/20/76	4670	Cough	Combiotic
1/30/76	4668	Pneumonia	Tylan 200
2/7/76	4668	Pneumonia	Tylan 200
		Individual Calves	
9/25/75	4649	Scours	Pectin Plus
1/1/76	4652	Pneumonia	Tylan 200
		Isolated Calves	
10/1/75	4653	Scours	Pectin Plus
10/7/75	4653	Cough	Combiotic
10/30/75	4630	Cough	Combiotic
11/10/75	4630	Pneumonia	Tylan 200
1/1/76	4652	Cough	Combiotic
1/15/76	4652	Pneumonia	Tylan 200
1/17/76	4691	Pneumonia	Tylan 200
1/21/76	4652	Pneumonia	Tylan 200
2/1/76	4691	Pneumonia	Combiotic
2/9/76	4652	Pneumonia	Combiotic

VITA

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