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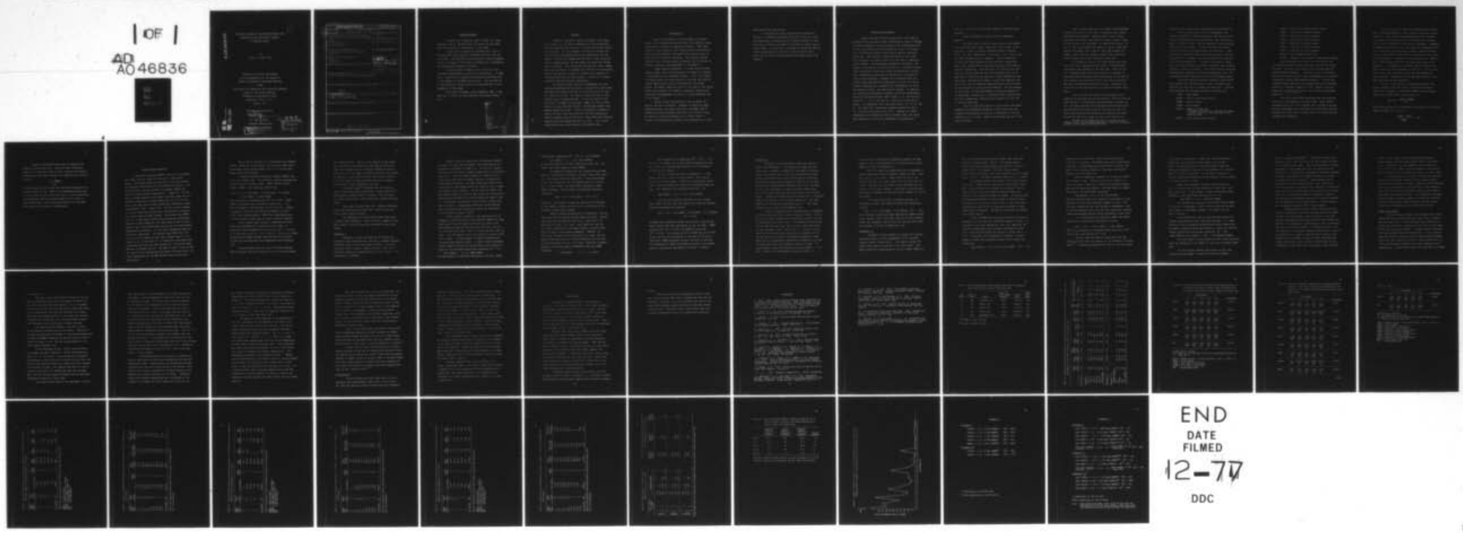

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PATTERNS OF MORBIDITY AND REDUCED WEIGHT GAIN ASSOCIATED WITH RESPIRATORY DISEASE IN FEEDLOT CALVES

By

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Submitted in Partial Fulfillment

of the Requirements for the Degree of

MASTER OF PREVENTIVE VETERINARY MEDICINE

(MPVM)

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ABSTRACT

Morbidity, mortality, medical treatment, and weight gain records for 748 calves originating in the southeastern United States and fed 56 days in a southern California feedlot were analyzed. The total number of calves that became sick on each day of the feeding period was tabulated as was the number of calves that became sick from one to four times during the feeding period, and the number of calves that became sick on each day. The relationship between the calves' weight gains and the amount of sickness they suffered was established. Data on the amount of sickness in animals were compared to the mean weight gain of those animals. Patterns of sickness occurrence and duration were established.

The arrival weight variable overshadowed any other variable explaining the variation in average daily gains (ADG). The number of times a calf was sick was of no value for use as a predictor of ADG. The number of days sick was of only limited value in predicting ADG. It was not possible from these data to suggest an arbituary number of times of sickness or of days sick after which a calf (having reached that number) should be culled. A lack of sufficient treatment of calves the first time they were sick may have predisposed them to sickness later in the trial. Many calves had elevated temperatures even though they were not sick. The lighter calves did not get sick as much as the heavier ones.

INTRODUCTION

Every year thousands of calves bought in auction barns in the southeastern United States are loaded on trucks and hauled to feedlots in southern California. When they arrive at these feedlots, they undergo various vaccinations, medications and surgical procedures before being placed in feed pens for growth and fattening. Most feedlot disease problems occur in young animals suffering from the stress of weaning, marketing, and adjustment to the feedlot.[1]

Though disease prevention has a high priority among feedlot owners, the total elimination of disease in feedlots is impossible for the following reasons: First, the competition among buyers for calves dictates that some poor quality animals whose health status is marginal will be bought. Second, the feedlot owner has little or no control over calves before they arrive at the feedlot; therefore, previous mishandling or mismanagement may result in calves becoming sick in the feedlot.[6]

Certain losses associated with calf sickness are obvious and easy to quantify. Examples of these are death, medication costs, and labor costs for a treatment crew.[8] Another loss which decreases the profit on a load of calves but which is much more difficult for a feedlot owner to assess is the depression of weight gain experienced by calves which become sick and recover.

A retrospective study using records on morbidity, mortality, treatments, and weight gains of a group of calves was undertaken to characterize the temporal pattern of sickness and to quantify the effect of sickness on weight gain in these calves. Our goal was to describe relationships between health and weight gain (profit) of feedlot calves which could then be used in decision making by feedlot owners and managers.

MATERIALS AND METHODS

Between October 1974 and January 1976, five loads of crossbred bull and steer calves (identified as loads 12 through 16) were purchased at cattle auctions in the southeastern part of the United States and were shipped by truck to the University of California Imperial Valley Field Station, Meloland, California. Upon arrival at the field station, the calves were processed in a manner similar to that used by commercial cattle feeders. The processing included the following: ear tagging, implantation of diethylstilbestrol, blackleg-malignant edema vaccination, infectious bovine rhinotracheitis vaccination, intramuscular injection of 500,000 units of vitamin A, pour-on grub treatment, treatment with oxytetracycline (10 cc/100 pounds body weight intramuscularly if the calf had an elevated temperature), treatment with thiabendazol for internal parasite control, and castration as needed. In addition the calves were individually weighed, had rectal temperatures taken, and had blood samples taken (loads 14, 15, and 16 only) on days 0, 7, 14, 21, 28, and 56. Since load 13 arrived on Sunday, its subsequent "test" days were days 6, 13, 20, 27, and 55. For each load, calves were randomly assigned to one of six pens used in various feed trials. Because the midday temperatures in Meloland are often extremely high, the calves were scheduled to arrive for processing at approximately

6:00 A.M., and on "test" days were worked in the early morning hours.

General information on each load is summarized (Table I).

The daily health status of each calf was ascertained by an over-the-fence visual inspection of the calves in the feed pens. Signs of sickness included dyspnea, anorexia, lack of gut fill, depression, listlessness, nasal exudate, and any other abnormal signs or behavior. Calves identified as being sick were removed from the feed pen, temperature taken, and treated with the appropriate drugs if they had an elevated temperature. They were kept in a hospital pen (except for load 16 which was not near a hospital pen) for an additional 3 days or until they had a normal temperature and appearance, whichever was longer. Calves that appeared sick but did not have an elevated temperature were often retained in the hospital pen to be fed and observed. For the purposes of this study, the feed-and-observe status was regarded to be equivalent to being sick. Individual health records showing date, temperature, diagnosis, and treatment for each day of sickness were kept.

Load 12 calves were used in a nutritional study which compared 72% concentrate receiving rations which were comprised of either barley or milo or a combination of the two grains in a 1 to 1 ratio. Each of the rations was fed to two pens of calves.

Load 13 calves were part of a longer term experiment in which the effect of the time of castration upon feedlot performance was studied. Calves in pens 41 and 46 were castrated upon arrival and served as control animals. Those in pen 42 were to be castrated six weeks after arrival; in pen 43, when they reached 400 pounds; in pen 44, when they reached 550 pounds; and in pen 45, when they reached 700 pounds. Few of the test animals reached their castration weights during the 56 days covered by this study.

For animals in load 14 the three rations mentioned for load 12 were compared and the effect of administering electrolytes was assessed at the same time. Three of the six treatment groups received 10 pounds of a mixture of electrolytes[a] per 50 gallons of drinking water on the day before shipment and during the first three days at Meloland. The other three pens received plain water. Beginning the fourth day at the Field Station, all animals received plain water.

Load 15 calves were used in an experiment which compared the influence of oral antibiotics, chlortetracycline and bacitracin, on the health and performance of feeder cattle. Two pens received 700 milligrams of chlortetracycline per head per day on their feed for the first 28 days, two other pens received 250 milligrams of bacitracin per head per day for the first 5 days of each of two 28-day time

[a]A mixture of sodium chloride, potassium chloride, sodium citrate, calcium glycerophosphate, magnesium gluconate, saccharin and glucose oligosaccharrides.

periods, and two control pens received no oral antibiotics.

Load 16 calves were used in an experiment that studied the effect of sodium bicarbonate and the oral antibiotics, chlortetracyline and bacitracin, upon the performance of feedlot calves. One pen received a control ration consisting of 72% barley. Two pens received the control ration plus either chlortetracycline or bacitracin. Three pens received a ration consisting of the control ration supplemented by 9.7% $NaHCO_3$, and either nothing else, bacitracin, or chlortetracycline. In short, the calves in these five loads were handled in a manner consistent with standard commercial feedlot procedures. Their basic ration, which was experimentally modified as previously mentioned, was a 72% concentrate ration without hay for a 56-day feeding period.

The health data and related records on these calves were punched onto IBM data cards so that information was available for each day of sickness for each calf. A second card contained the following variables for each calf:

CESC -- load number

BULLST -- bull or steer upon arrival

ARRWT -- arrival weight

DEPWT -- final weight

TIMSIK -- number of times sick (a separate sickness was counted each time a calf was moved from the feed pen to the hospital pen)

FSTNO1 -- first day of first sickness

NONO1 -- duration of first sickness in days

FSTNO2 -- first day of second sickness

NONO2 -- duration of second sickness

FSTNO3 -- first day of third sickness

NONO3 -- duration of third sickness

FSTNO4 -- first day of fourth sickness

NONO4 -- duration of fourth sickness

DAYSIK -- total number of days sick

NOT RX -- diagnosis not related to respiratory disease

Using the above data cards, an evaluation of the relationship between sickness and weight gain of the calves was made. The basic tools used in this analysis were the Burroughs B6700 computer, the card sorter at the University of California at Davis, Texas Instruments SR-16 and SR 51 calculators, and the BMD computer programs.[2] Statistical procedures used were simple and stepwise multiple regression, analysis of variance, Student's t-test, Duncan's multiple range test, correlation analysis, and stepwise discriminant analysis.[3, 5, 12, 14, 15]

The first statistical procedures were run using the data of all the animals in all five loads. After several procedures were run, it was decided that in order to produce the most meaningful data concerning the relationship between sickness and weight gain in these calves, the data should be divided into subsamples.

The calves were divided three different ways yielding three different subsamples, and an analysis was made on each subsample. Since these three subsamples were all obtained by dividing the original data in a different way, the same calves could be present in more than one subsample. Subsample I consisted of calves from all the loads, but excluded calves that either had a non-respiratory disease, received electrolytes in their water or had been put on pasture in the course of the experiment. Subsample II was made up only of loads 14 and 15 and excluded calves for the same conditions as did Subsample I. Subsample III contained only the animals that were controls in the experiments on each load. These calves had all been fed 72% barley rations and had undergone no other maneuver. Subsample III also excluded calves for the same conditions as did Subsample I.

By use of the computer transgeneration cards, the weight gained by each calf during the 56-day feed period (GAIN) was calculated as DEPWT minus ARRWT and the average daily gain variable (ADG) was calculated as

$$\text{ADG (lb)} = \frac{\text{DEPWT - ARRWT}}{56}$$

The 56-day gain was also calculated as a percent of the arrival weight (% GAIN) by the formula

$$\frac{\text{DEPWT - ARRWT}}{\text{ARRWT}} \times 100$$

Special consideration was given in computing the weight of calves that died. Since they had a departure weight of 0, they had a gain of zero. Because the computer computations would have resulted in a negative gain from the formula

$$\frac{0 - \text{ARRWT}}{56},$$

the data cards for all calves that died were punched with an arrival weight of zero. While this programming method gave a gain of zero for all calves that died, it also necessitated our recomputing the mean arrival weight for all loads in which calves died. All statistical analyses in this paper were done at the 5% level of significance.

RESULTS AND DISCUSSION

A descriptive program, BMD07D, was run on the overall data (from the five loads) of 748 calves. Among other things, the program stratified the data by load and printed the frequency distribution of each variable by stratum. For each variable a one-way analysis of variance (ANOVA) was printed to help identify load effects (Table II). The results of ANOVA together with Duncan's multiple range test for pairwise comparisons of means showed that for all the variables there were statistically significant differences among the different loads (Table III). The mean arrival weights of all the loads were statistically significantly different; the overall mean was 289.6 pounds. The overall mean TIMSIK was 1.24. There were statistically significant differences between the mean TIMSIK for all loads except loads 12 and 15. Loads 14 and 15 had FSTNO1 means which were not statistically significantly different; all the other comparisons were statistically significant. The overall mean FSTNO1 was 1.99. As for the total number of days sick (overall mean = 5.19), loads 12, 15, 16 and loads 14, 15 respectively had means that could have come from the same populations. The overall mean ADG was 2.61 pounds per day. The ADGs of loads 15 and 16 were not statistically significantly different from each other. All other comparisons for the ADG variable were statistically significant.

Ten of the 748 calves (1.3%) died during the feeding period. Seven out of 657 calves (1.1%) sick at least once, died during their second illness; and 2.1% (1 of 48) died during their third illness.

A stepwise multiple regression program, BMD02R, was run on the overall data. The available variables entered the equation in the following order: ARRWT, DAYSIK, BULLST, FSTNO1, TIMSIK. The resulting equation was

$$ADG = 1.1 + 0.0054\ ARRWT - 9.9333\ DAYSIK + 0.1\ BULLST - 0.016\ FSTNO1 + 0.0234\ TIMSIK.$$

The coefficient of determination (R^2) was 0.3798. ARRWT, DAYSIK, and BULLST had significant F-ratios ($\alpha = .05$). With only ARRWT in the equation, the R^2 was 0.341. DAYSIK increased it by 0.032, but BULLST increased it by only 0.0042 after DAYSIK entered. ARRWT thus contributed more to the variation in ADG than the other variables combined.

After running these programs, examining the histograms and considering the variation in the calves, we examined certain subsamples of the data in order to control for confounding variables. First, however, calves with certain characteristics were excluded from the study in an effort to make the resulting data more homogeneous and representative.

Seven excluded calves in load 12 had been removed from the feedlot and put on pasture for up to 48 days during the feeding period. The fact that several of the calves were returned to the feed pen on the same day indicated that they probably were not returned immediately upon recovery but at a time when a roundup was held in the pasture. In addition, these calves may have been no more severely sick than calves in other loads but were put on pasture only because it was available at the time.

An earlier study[16] indicated that the calves in load 14 that were given electrolytes in their water had a significantly greater amount of sickness than did those not given electrolytes; these calves were removed from the study.

There were 32 calves that had disease conditions other than respiratory-related ones. These calves were also excluded from the sample.

The remaining 652 calves were divided three ways yielding three subsamples. Table II gives a summary of the mean values of the most important variables for each subsample.

Subsample I

Subsample I, which contained all 652 calves not excluded by the above criteria, was used to compare sickness and weight gains of the five loads of calves. As can be seen from Tables I and II, there was still a great deal of interload variation in arrival dates, arrival weights, and experimental treatments.

Duncan's multiple range tests for pairwise comparisons were run after one-way ANOVAs were performed on the variables in Subsample I (Table IV). All multiple comparisons made with the arrival weight variable were statistically significant. The mean TIMSIK values for loads 12 and 13 (loads with light arrival weights) were not statistically significantly different; this same result was found in the comparision of mean TIMSIK values for loads 14 and 15 (loads with medium arrival weights). As was true for TIMSIK, the mean DAYSIK values for loads 12 and 13 were not statistically significantly different nor were the means for loads 14 and 15. In addition, the mean for load 14 did not differ from that for load 16. Comparisons involving the ADG variable were all statistically significant except the comparison of the values for loads 14 and 16.

Table V gives a summary of the characteristics of Subsample I calves that were sick different numbers of times. Ninety-one of the 652 head (14.0%) were not sick at all. Four hundred and one (61.5%) were sick only once, and 132 (20.25%) were sick twice. Only 4.3% were sick more than two times. The five calves (2.1%) that died did so during their first illness. The mean number of TIMSIK increased with increasing mean arrival weight. A simple linear regression of mean number of times sick versus mean arrival weight resulted in the following significant regression (R^2 =.91):

mean TIMSIK = - 11.37 + (0.044 ARRWT).

The mean number of times sick increased as the mean FSTNO1

A significant regression ($R^2 = .90$) was the following:

mean TIMSIK = 3.5 - (1.02 mean FSTN01).

As would be expected, the more times calves were sick, the higher their mean number of total DAYSIK.

An unexpected finding was that though the mean ADGs were not significantly different, the more times calves were sick, the higher were their mean ADGs. Closer observation of the data showed that the relationship was not a causal one. As noted above, the mean TIMSIK increased as mean ARRWT increased. Arrival weight and ADG were positively correlated:

ADG = 1.15 + (.005 ARRWT) ($R^2 = 0.32$).

Therefore, the increase in mean ADG seen with the increase in the number of times sick was really a reflection of the increase in mean arrival weight.

Table VI gives characteristics of Subsample I calves that were sick for various periods during the trial. Ninety-one calves (14.0%) were not sick at all, while 50 (7.7%) were sick for only 1 or 2 days. This points out that not all calves identified as sick were actually treated a minimum of 3 days as the protocol suggested. However, the facts that 215 head (33.0%) were sick 3 or 4 days, and 140 head (21.5%) were sick 5 or 6 days indicated that over half of the calves were ill for 3 to 6 days. There was a general increase in the mean number of DAYSIK as the mean ARRWT increased:

mean DAYSIK = - 52.7 + (.206 ARRWT).

The regression was significant ($R^2 = 0.64$). It is difficult to comment on the relationship between mean number of days sick and mean ADG because of the differences in mean arrival weights.

Of the 5 calves that died in Subsample I, 3 died within the first 4 days of their illness. Only one was sick for more than 8 days. There was a significant difference in the mean FSTNO1 for calves sick different number of days. The regression was significant with $R^2 = .65$:

mean DAYSIK = 13.32 - (2.55 mean FSTNO1).

With all the variables eligible for entry except CESC, DEPWT, NOT RX, GAIN, and %GAIN, the following stepwise multiple regression was computed:

ADG = 1.33 + 0.005 ARRWT - 0.031 DAYSIK - 0.021 FSTNO1.
($R^2 = 0.344$).

Although other variables entered the equation, they did not have F-ratios that were significant at the .05 level. ARRWT entered first ($R^2 = 0.3197$), and DAYSIK entered next ($R^2 = 0.0178$). The increase in R^2 by FSTNO1 was only 0.0064. As was the case in the analysis of the data of the entire 748 calves, ARRWT explained the most variation in ADG and the combination of ARRWT and DAYSIK gave nearly the maximum amount of explanation obtainable from these variables.

Subsample II

Subsample II was obtained by using only loads 14 and 15 from Subsample I. The reason for using this subsample was to attempt to control for the effect of arrival weight upon weight gain so that the relationship between sickness and weight gain could be more easily visualized. Although the mean arrival weights of loads 14 and 15 were statistically significantly different, $\alpha = 0.05$, they were so much more comparable in terms of arrival weight than any of the other loads that they were used to form the subsample. Subsample II consisted of 233 calves with a subsample mean arrival weight of 326.6 pounds (Table II). The mean TIMSIK was 1.56 and the mean DAYSIK was 5.77. The mean FSTNO1 was 0.01, and the mean ADG was 2.83.

Table VII summarizes the characteristics of Subsample II calves that were sick a varying number of times. All the 233 calves (100%) became sick at least once, and 232 (99.6%) of them became sick on day zero. One hundred and thirty-one (56.2%) were sick one time, and 77 (33.1%) were sick twice. In this subsample, which controlled for arrival weights, there were no statistically significant differences in the arrival weights of calves sick different numbers of times. There was no statistically significant difference in the ADG of calves that were sick different numbers of times. The total number of days sick increased with the number of times sick. Except for a difference in the mean FSTNO2, there were no statistically significant differences between the mean values of any of the variables for the groups sick varying numbers of times in Subsample II.

Table VIII shows the characteristics of Subsample II animals that were sick for different numbers of days. None were sick 0, 1, or 2 days. Ninety-four (40.3%) of the calves were sick 3 or 4 days, and 65 (27.9%) were sick 5 or 6 days. The only calf that died in this subsample did so on day 7 of its first sickness. There was no statistically significant difference in the mean arrival weights of any of the groups.

In a stepwise multiple regression allowing all variables to enter, only ARRWT and DAYSIK had significant F-ratios:

ADG = 1.78 + 0.004 ARRWT - 0.045 DAYSIK. (R^2 = .116).

As in previous stepwise multiple regressions, ARRWT entered first; however, due to the small variation of the variable within the subsample, the R^2 after one step was only 0.068. The increase in R^2 due to DAYSIK was 0.047.

Subsample III

Subsample III was designed to compare the sickness and weight gains in calves homogeneous in all possible respects except arrival weight. The sample included 200 calves that served as controls in the five trials. They were divided into three groups by arrival weight (Table II).

The low arrival group had arrival weights that were less than 239.5 pounds (mean = 184.5). The medium arrival weight group had arrival weights that were 239.5 to 329.5 pounds (mean = 270 pounds). The high arrival weight group had arrival weights that were greater than 329.5 pounds (mean = 373.4). The entire subsample mean was 277.1 pounds.

One hundred seventy-one calves (85.5%) were sick at least once. There was no statistically significant difference in mean sickness data between groups except that the heavy arrival group was different from the others with respect to the variables TIMSIK and FSTNO1. We believe that the misclassification of a small number of healthy calves in loads 14 or 15 (loads in which 95.6% of the calves were classified as sick on day 0) could have resulted in these significant differences. The ADG was positively correlated with arrival weight.

Table IX summarizes the characteristics of calves in Subsample III that were sick different numbers of times. As was seen in the other subsamples, there was a positive correlation between mean arrival weight and number of times sick. Mean arrival weights for groups of calves sick 0, 1, 2, or 3 times were not significantly different, but mean number of times sick regressed on mean arrival weight was significant:

mean TIMSIK = -7.32 + (0.031 mean ARRWT). (R^2 = .92).

Calves that were sick more times had an earlier mean first day of sickness. The FSTNO1 means were significantly different. The mean ADG was not different for groups that were sick for varying numbers of times when analyzed by Duncan's multiple range test.

Table X summarizes variables of calves sick different lengths of time. Though it was not as strong as in other subsamples, there was a positive correlation between mean arrival weight and DAYSIK. The mean number of DAYSIK increased as the mean FSTNO1 decreased:

mean DAYSIK = 11.43 -(2.09 mean FSTNO1).

Duncan's multiple range test revealed no differences in the mean ADG of calves sick different numbers of days. This fact was a deviation from the findings of Subsamples I and II and was probably due to the fact that there was a smaller correlation between arrival weight and number of days sick.

In a stepwise multiple regression ARRWT and DAYSIK entered with statistically significant F-ratios:

ADG = 1.37 + 0.0049 ARRWT - 0.028 DAYSIK.

The R^2 for the equation containing ARRWT alone was 0.2705 and for the total equation $R^2 = 0.29$.

The fact that the lighter calves were sick less than the heavier ones was contrary to the findings of another study.[10] A possible explanation for this is that the calves in the present study were so light that they had different physiologic characteristics than those in the earlier study. Purchasing calves of this light-weight class may have had accidentally resulted in the selection of a certain breed[11] or stage of maturity. It would be of interest to further investigate breeds and arrival weights versus sickness in a similar group of cattle.

Within each subsample the more times calves were sick, the shorter was the mean duration of their first sickness (Table XIA). As an example, a simple regression using Subsample I was significant and had an R^2 of .95.

mean NONO1 = 4.78 - (.289 mean TIMSIK)

This pattern was repeated in mean NONO2 versus TIMSIK but was not as consistent. Such a pattern could not be seen with respect to mean NONO3; however, the sample size was small (25 head).

Also observed was the fact that the mean duration of sickness decreased with each succeeding sickness, i.e., mean duration of first sickness > second > third > fourth (Table XIA). An example regression using the Subsample I calves gave the following statistically significant regression (R^2 = .80):

MEAN DURATION OF A SICKNESS = 4.68 - (.84 SICKNESS NUMBER)

The mean number of days between the first and second sickness also decreased as the number of times sick increased (Table XIB).

The relationship between the duration of the first sickness and the number of times sick could be evidence that, as suggested elsewhere,[4] calves not treated long enough the first time they were sick had a higher probability of becoming sick again. Since the incidence of disease decreased as time passed and since the sensitivity and specificity of the diagnosis (diagnostic criteria) remained the same, the proportion of healthy calves in the group classified as sick increased.[17] These healthy calves remained in the sick category only a short time before being classified as "recovered" and, therefore, lowered the mean duration of sickness which could explain why the mean duration of sickness decreased in succeeding sicknesses. The decrease in time between the end of the first sickness and the beginning of the second might be further evidence that inadequate treatment led to early relapse.

Intepreting the data in a more intuitive way with regard to duration of the first sickness versus the number of times sick could lead to the belief that a calf that quickly recovered from its first sickness had a higher probability of becoming sick again because it was at risk more days after its first recovery. In addition the fact that the duration of succeeding illnesses became shorter could be an indication of a general improved health status of the entire group of animals to such an extent that even when calves became sick, they returned to health more rapidly. Furthermore, calves that were sick several times were more likely to have fewer healthy days between sicknesses simply because they had fewer healthy days in the entire trial. Therefore, the mean number of days between the end of the first sickness and the beginning of the second would be expected to be shorter for calves sick more times.

An analysis was done to see if calves that arrived as bulls had different sickness or gain characteristics from those that arrived as steers. There were no differences between the mean values of any variables in any subsample except for the fact that the steers' mean arrival weights were higher than those of bulls. It followed that the mean ADG was higher for steers; however, we feel that this discrepancy in ADG is the result of higher arrival weights rather than differences in their physiologic status.

General Discussion

This study was designed to investigate light calves during the first 56 days after their entry into a feedlot. One might feel that it would have been more informative to follow the calves for a longer period to see the long range effects of this early sickness. A longer period of observation would probably have been preferable. It has, however, been found that if calves are given a weight gain advantage during the first month after arrival, they probably will retain that advantage throughout the entire feeding period.[9] Consequently, a study of this length may have been as valuable as a longer one.

The gain of such light calves on feed for only 56 days may have been distorted by the amount of rumen fill the calves had when they were weighed. If it is assumed that all the calves had relatively empty rumens when their arrival weights were recorded and uniformly full rumens when they were weighed on day 56, then there was probably an upward bias in the gain, but the relationship between the individual calves should have remained the same.

The question arose whether to use ADG or %GAIN as the measure of weight gain in the calves. Analysis of the data revealed that the amount of correlation between each of these and ARRWT fluxuated, and neither could be identified as the best to use. ADG was chosen because it is a more common industrial term.

As was mentioned earlier, load 13 calves arrived on a Sunday and were, therefore, "tested" and weighed on days 0, 6, 13, 20, and 55. Since the method of computer determination of ADG could not be varied for each load, the ADG for this load was based on a 56-day feed trial instead of the actual 55 days. The computed mean ADG for load 13 calves was actually .043 pounds less than the true mean ADG. We feel that this small difference did not seriously prejudice the results of this study.

There were certain days of the experiment on which there was either so much uniformity or so much variation in the number of calves diagnosed as being sick that our suspicions were aroused. On the day that the calves arrived at the feedlot, the percentages of sick calves for every load were as follows: load 12 (186 head) had 0%; load 13 (160 head) had 11.3%; load 14 (120 head) had 100%; load 15 (174 head) had 99.4%; and load 16 (108 head) had 24.1%. The possibility that this variation may have been due to the ambient temperature at the time of arrival was investigated. Loads 14 and 15 arrived in June and August when even early morning ambient temperatures may have been high. Loads 12, 13, and 16 arrived in October, December, and November when the weather was cooler. It was found that although most of the load 14 and 15 calves had temperatures above 103.5 upon arrival, some that did not were still classified as sick. Further investigation uncovered no source of error, and the data was used as it was received.

A noticeable amount of clustering of sickness was noted on days when the calves were weighed and bled and had temperatures taken. Research into this phenomenon revealed that when the calves were worked early in the morning, they could not be visually evaluated for sickness because of the darkness and crowded conditions in the chutes. Therefore, calves with elevated temperatures were considered as sick. A graph of the number of calves diagnosed as sick on each day (Figure 1) showed that when the diagnosis was based on temperature more than clinical signs, more sickness was diagnosed. Of the 623 diagnoses of sickness in loads 12, 14, 15, and 16 during the trial, 351 (56.3%) were made on a "test" day (day 0, 7, 14, 21, or 28). Excluding the ones diagnosed on day 0, there were 365 diagnoses made with 93 (25.5%) made on "test days"(Table XII).

The number of calves expected to be diagnosed as sick on a particular day was defined as the mean of the 3 days before and the 3 days after that day. The actual number diagnosed on each test day divided by that day's expected gave the following results: day 0 = 7.2, day 7 = 1.9, day 14 = 4.7, day 28 = 6., i.e., from 2 to 7 times more calves were treated when using the rectal temperature as when using clinical observation alone. This indicated that many calves that were neither sick nor in the incubation stage of sickness had elevated temperatures. This finding was consistent with an earlier report.[7] Though the misclassification of the health status of certain animals may have hurt the accuracy of the sickness data in this study, it may also have positive importance of its own. If a feedlot manager were using body temperature as the main criterion for treating animals, he might be going to the expense of treating animals that were neither sick nor becoming sick.

The overall death loss in the 748 calves was 1.3% (10 calves) which is less than figures reported for calves shipped to feedlots in the High Plains area of the United States.[10] Though calves from the southeastern United States must be hauled 20 to 30 hours longer to get to the Imperial Valley feedlots, they appear to experience lower death losses there. The atmospheric and weather conditions, which are different in the High Plains from those in the Imperial Valley, are the basis for certain theories concerning the difference in death losses.

First, in the High Plains area weather fronts with their accompanying barometric pressure changes are common. These pressure changes stimulate the calves to change their eating patterns to the extent that they may consume a whole day's ration in a short time, a pattern difficult to prevent.[11]

Second, the fact that the High Plains or at such a higher elevation (4,000 feet or higher above sea level) than the Imperial Valley (below sea level)[13] means that the partial pressure of oxygen in the air is much lower in the High Plains. This lower oxygen pressure may make respiratory diseases be more severe for calves in the High Plains when compared with those in the Imperial Valley.[11]

Problem Areas

Certain difficulties that could lead to bias or inaccuracy were encountered in the course of this study. The "feed and observe" status of health was used frequently regarding these calves. This status indicated that calves were put in the sick pen but were given no medication. It was decided that since the calves were put in the sick pen and, therefore, treated differently from the other calves, a day in the "feed and observe" status should be regarded as a day of sickness. Load 16 calves were in a feed pen which did not have a sick pen with it. Since these calves were not near a sick pen, none of them were reported as being in the "feed and observe" status; however, calves that were diagnosed as being sick had to be walked to the treatment chute, treated, and returned to the feed pen. This was not true for any of the other loads.

The individual animal health records were sometimes not specific enough concerning the diagnosis of a sickness or the exact day when a calf was transferred from the sick pen to the feed pen. Though the calves in this experiment were basically the same type of calves handled in the same manner, there was still a certain amount of variation among the loads (Table I and II).

One must remember that this study dealt with young, lightweight (mean = 288 pounds) calves just entering a feedlot on to a 72% concentrate ration, without supplemental hay. The types and patterns of sickness may be different for calves of different ages, weights, or planes of nutrition.

CONCLUSIONS

Differences in arrival weights contributed so heavily to the variation in ADG that a true linear relationship between sickness and ADG could not be seen. However, using the stepwise multiple regressions in this study lead us to believe that it is of no value to base culling decisions on the number of times a calf has been sick. Likewise a decision to cull a sick animal should not be based only on the number of days it has been sick.

The fact that light calves (ARRWT) were sick fewer days than heavy calves (ARRWT) leads to the conclusion that a study is needed to investigate the feed efficiency in relation to sickness and arrival weight. More specifically a design for this type study would call for the stratification of the load of calves into light, medium, and heavy arrival weights. A treatment and control group could be randomly selected from each stratification. Health and feed consumption records could be kept on each pen so that conclusions could be drawn concerning sickness, gain, and feed efficiency for each weight group.

In further studies of this type criteria for classifying a calf as sick or as healthy, i.e., recovered, should be more precise and uniformly applied over the entire feeding period.

Since more calves were diagnosed as sick on "test days" (the only days when rectal temperatures were used as diagnostic criteria), it can be concluded that many of the calves with elevated temperatures would never have become clinically ill. Medicating calves only because they have elevated temperatures may not be economically productive.

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Table I. General Information on Five Loads of Calves Fed at the Imperial Valley Field Station, October 1974-January 1976.

Load number	Number of calves	Origin	Mean calf arrival weight (pounds)	Arrival date	Transit time (hrs)
12	186	De Quincy, La.	202.2	3 Oct 74	33.5
13	160	Austin, Tex.	246.7	14 Dec 74	35.5
14	120	Carlos, Tex.	337.0	5 Jun 75	32.5
15	174	Austin, Tex.	323.3	22 Aug 75	42*
16	108	Montgomery, Ala.	395.9	22 Nov 75	82**

*Includes a 12 hour rest stop.

**Includes a 22 hour rest stop.

Table II. Summary of Mean and Total Values of Certain Characteristics of Five Loads of Cattle (748 Head) Fed at the Imperial Valley Field Station, October 1974-January 1976.

	Number of calves	Mean arrival weight	Mean average daily gain	Total calves sick	% sick	Calves died	Mean days sick	Mean times sick	Mean 1st day sick	No. calves sick exactly 0 (times)	1	2	3	4
All Calves	748	289.6	2.61	657	87.8	10	5.19	1.24	1.99	91	437	172	43	5
Subsample I														
Load 12	159	203.9	2.19	126	79.2	1	3.81	0.93	3.63	33	105	21	0	0
Load 13	158	246.9	2.38	111	70.3	2	3.32	0.82	5.13	47	94	16	1	0
Load 14	59	336.3	3.23	59	100	1	5.56	1.70	0	0	29	21	7	2
Load 15	174	323.3	2.70	174	100	0	5.85	1.51	0.01	0	102	56	15	1
Load 16	102	395.9	3.12	91	89.2	1	5.01	1.11	1.97	11	71	18	2	0
All 5 loads	652	288.2	2.61	561	86.0	5	4.58	1.15	2.2	91	401	132	25	3
Subsample II	233	326.58	2.83	233	100	1	5.77	1.56	0.01	0	131	77	22	3
Subsample III														
Arrival Weights														
Low	39	184.51	2.14	31	79.5	0	4.21	1.00	2.87	8	23	8	0	0
Medium	115	269.97	2.58	94	81.7	0	4.39	1.15	2.54	21	61	28	5	0
High	46	373.37	3.01	46	100	0	5.50	1.41	0.28	0	31	11	4	0
All 3 groups	200	277.09	2.59	171	85.5	0	4.61	1.18	1.99	29	115	47	9	0

Table III. Statistical Analysis of Mean Values of Variables Related to Sickness in Five Loads of Feedlot Calves (748 Head) Fed at the Imperial Valley Field Station, October 1974-January 1976.

	Load number					
	12	13	14	15	16	F-Statistic
BULLST	1.09 (186) A	1.18 (160) B	1.54 (120) C	1.35 (174) D	1.38 (108) D	25.88*
ARRWT	201.83 (186) A	246.83 (160) B	337.73 (120) C	323.29 (174) D	395.40 (108) E	350.03*
TIMSIK	1.03 (186) A	0.82 (160) B	1.85 (120) C	1.51 (174) D	1.12 (108) E	51.96*
FSTNOI	3.44 (153) A	5.22 (113) B	0 (120) C	0.01 (174) C	1.97 (97) D	166.49*
DAYSIK	5.11 (186) A	3.29 (160) B	6.85 (120) C	5.85 (174) AC	5.02 (108) A	12.00*
ADG	2.13 (186) A	2.39 (160) B	3.05 (120) C	2.70 (174) D	3.13 (108) C	56.00*

*Significant at 5% level.
A-E: Means that have the same letters are not significantly different.
( ): Sample size.

BULLST = Whether was bull or steer upon arrival: Bull = 1; Steer = 2.
ARRWT = Arrival weight.
TIMSIK = Total number of times sick.
FSTNOI = First day of first sickness.
DAYSIK = Total number of days sick.
ADG = Average daily gain.

Table IV. Statistical Analysis of Mean Values of Variables Related to Sickness in Five Loads of Feedlot Calves (Subsample I, 652 Head) Fed at the Imperial Valley Field Station, October 1974-January 1976.

	Load number					
	12	13	14	15	16	F-Statistic
BULLST	1.09 (159) A	1.18 (158) B	1.51 (59) C	1.35 (174) D	1.36 (102) D	16.4*
ARRWT	203.92 (159) A	246.87 (158) B	336.31 (59) C	323.29 (174) D	395.96 (102) E	423.22*
TIMSIK	0.925 (159) A	0.816 (158) A	1.70 (59) B	1.51 (174) B	1.11 (102) C	39.80*
FSTNO1	3.64 (126) A	5.13 (111) B	0.0 (59) C	.011 (174) C	1.97 (91) D	134.74*
NONO1	4.18 (126) A	4.23 (111) A	4.09 (59) A	4.32 (174) A	5.26 (91) B	4.04*
FSTNO2	15.81 (21) A	12.35 (17) B	10.33 (30) B	11.24 (72) B	10.95 (20) B	4.29*
NONO2	3.76 (21) A	3.12 (17) AB	2.4 (30) BC	3.17 (72) ABC	1.5 (20) C	3.59*
FSTNO3	N/A (0)	13.00 (1) A	15.22 (9) A	16.81 (16) A	10.00 (2) A	2.46 NS
NONO3	N/A (0)	3.00 (1) A	2.00 (9) A	2.38 (16) A	1.00 (2) A	0.48 NS

(cont.)

Table IV. (cont.)

	Load number					
	12	13	14	15	16	F-Statistic
DAYSIK	3.81 (159) A	3.32 (158) A	5.56 (59) BC	5.85 (174) B	5.01 (102) C	18.05*
ADG	2.19 (159) A	2.38 (158) B	3.23 (59) C	2.70 (174) D	3.12 (102) C	58.54*

*Significant at 5% level.
NS: Not significant at 5% level.
A-D: Means that have the same letters are not significantly different.
( ): Sample size, N/A Not applicable.

BULLST = Whether was bull or steer upon arrival: Bull = 1, Steer = 2.
ARRWT = Arrival weight.
TIMSIK = Total number of times sick.
FSTNO1 = First day of first sickness.
NONO1 = Duration of first sickness (days).
FSTNO2 = First day of second sickness.
NONO2 = Duration of second sickness (days).
FSTNO3 = First day of third sickness.
NONO3 = Duration of third sickness (days).
DAYSIK = Total number of days sick.
ADG = Average daily gain.

Table V. Mean and Total Values for Certain Characteristics of Calves* That Were Sick Different Numbers of Times (Subsample I, 652 Head).

Number times sick	Number of calves	% of calves	Number died	Mean ARRWT	Mean FSTNO1	Mean DAYSIK	Mean ADG
0	91	13.96	0	251.22	N/A	0	2.51
1	401	61.50	5	288.30	2.61	4.46	2.62
2	132	20.25	0	303.79	1.18	7.30	2.61
3	25	3.83	0	334.04	0.16	8.24	2.76
4	3	.46	0	330.67	0	10.00	2.88
All groups	652	100.00	5	288.2	2.2	4.58	2.61

*Fed at the Imperial Valley Field Station, October 1974-January 1976.

ARRWT = Arrival weight.
FSTNO1 = First day of first sickness.
DAYSIK = Total number of days sick.
ADG = Average daily gain.
N/A = Not applicable.

Table VI. Values of Certain Characteristics Related to Number of Days Sick (Subsample I, 652 Calves*).

Number days sick	Number of calves	%	Number died	Mean arrival weight	Mean average daily gain	Mean first day of sickness
0	91	13.96	0	251.2	2.51	N/A
1-2	50	7.67	2	275.0	2.37	5.56
3-4	215	32.98	1	289.0	2.68	2.74
5-6	140	21.47	0	300.0	2.74	1.59
7-8	84	12.89	1	299.6	2.66	0.73
9-10	40	6.13	1	295.2	2.45	1.03
11-12	19	2.91	0	324.1	2.22	0.37
13-14	7	1.07	0	304.6	2.59	1.14
15-16	3	0.46	0	333.7	2.66	0
17-18	3	0.46	0	302.3	1.51	0.33
All groups	652	100.00	5	288.2	2.61	2.2

*Fed at the Imperial Valley Field Station, October 1974-January 1976.

N/A = Not applicable.

Table VII. Mean and Total Values for Certain Characteristics of Calves* That Were Sick Different Numbers of Times (Subsample II, 233 Head).

Number times sick	Number of calves	% of calves	Number died	Mean ARRWT	Mean FSTNO1	Mean DAYSIK	Mean ADG
0	0	0	0	N/A	N/A	0	N/A
1	131	56.22	1	326.93	0.12	4.41	2.87
2	77	33.05	0	324.23	0	7.20	2.78
3	22	9.44	0	332.18	0	8.36	2.79
4	3	1.29	0	330.67	0	10.00	2.88
All groups	233	100.00	1	326.58	0.01	5.77	2.83

*Fed at the Imperial Valley Field Station, October 1974-January 1976.

ARRWT = Arrival weight
FSTNO1 = First day of first sickness.
DAYSIK = Total number of days sick.
ADG = Average daily gain.
N/A = Not applicable.

Table VIII. Values of Certain Characteristics Related to Number of Days Sick (Subsample II, 233 Calves*).

Number days sick	Number of calves	% of calves	Number died	Mean arrival weight	Mean average daily gain	Mean first day of sickness
0	0	0	0	N/A	N/A	N/A
1-2	0	0	0	N/A	N/A	N/A
3-4	94	40.34	0	328.9	2.99	0.02
5-6	65	27.90	0	326.0	2.82	0
7-8	40	17.17	1	321.5	2.73	0
9-10	17	7.30	0	327.4	2.63	0
11-12	8	3.43	0	329.8	2.36	0
13-14	4	0.71	0	311.3	3.20	0
15-16	3	1.29	0	333.7	2.66	0
17-18	2	0.86	0	340.5	1.47	0
All groups	233	100.00	1	326.58	2.83	0.01

*Fed at the Imperial Valley Field Station, October 1974-January 1976.

N/A = Not applicable.

Table IX. Mean and Total Values for Certain Characteristics of Calves* That Were Sick Different Numbers of Times (Subsample III, 200 Head).

Number times sick	Number of calves	% of calves	Number died	Mean ARRWT	Mean FSTNO1	Mean DAYSIK	Mean ADG
0	29	14.50	0	230.14	N/A	0	2.45
1	115	57.50	0	281.23	2.47	4.44	2.63
2	47	23.50	0	286.47	1.19	6.98	2.57
3	9	4.50	0	326.56	0.11	9.22	2.66
4	0	N/A	0	N/A	N/A	N/A	N/A
All groups	200	100.00	0	277.09	1.99	4.61	2.59

*Fed at the Imperial Valley Field Station, October 1974-January 1976.

ARRWT = Arrival weight.
FSTNO1 = First day of first sickness.
DAYSIK = Total number of days sick.
ADG = Average daily gain.
N/A = Not applicable.

Table X. Values of Certain Charactersitics Related to Number of Days Sick (Subsample III, 200 Calves*).

Number days sick	Number of calves	% of calves	Number died	Mean arrival weight	Mean average daily gain	Mean first day of sickness
0	29	14.50	0	230.1	2.45	N/A
1-2	11	5.50	0	243.9	2.33	5.73
3-4	63	31.50	0	287.5	2.74	2.81
5-6	48	24.00	0	277.8	2.57	1.65
7-8	29	14.50	0	301.8	2.67	0.55
9-10	13	6.50	0	283.0	2.41	0.46
11-12	3	1.50	0	327.3	2.38	0
13-14	3	1.50	0	306.0	2.47	0
15-16	1	0.50	0	286.0	2.05	0
17-18	0	0	0	N/A	N/A	N/A
All groups	200	100.00	0	277.09	2.59	1.99

*Fed at the Imperial Valley Field Station, October 1974-January 1976.

N/A = Not applicable.

Table XIA. Mean Duration of Sickness (Days) for Calves* Sick 1,2,3, or 4 Times

	Exact number of times sick	Sickness number 1	2	3	4
Subsample I	1	4.47	-	-	-
	2	4.29	3.02	-	-
	3	3.80	2.28	2.16	-
	4	3.67	2.33	2.33	1.67
Subsample II	1	4.47	-	-	-
	2	4.07	3.13	-	-
	3	3.77	2.36	2.23	-
	4	3.67	2.33	2.33	1.67
Subsample III	1	4.49	-	-	-
	2	4.02	2.96	-	-
	3	3.56	3.78	1.89	-
	4	-	-	-	-

Table XIB. Average Time Between Sicknesses (Days) for Calves* Sick 2,3, or 4 Times.

	Exact number of times sick	Between sickness 1&2	Between sickness 2&3	Between sickness 3&4
Subsample I	1	-	-	-
	2	7.06	-	-
	3	4.96	4.64	-
	4	3.67	4.67	4.33
Subsample II	1	-	-	-
	2	7.82	-	-
	3	5.36	5.00	-
	4	3.67	4.67	4.33
Subsample III	1	-	-	-
	2	7.94	-	-
	3	5.00	4.78	-
	4	-	-	-

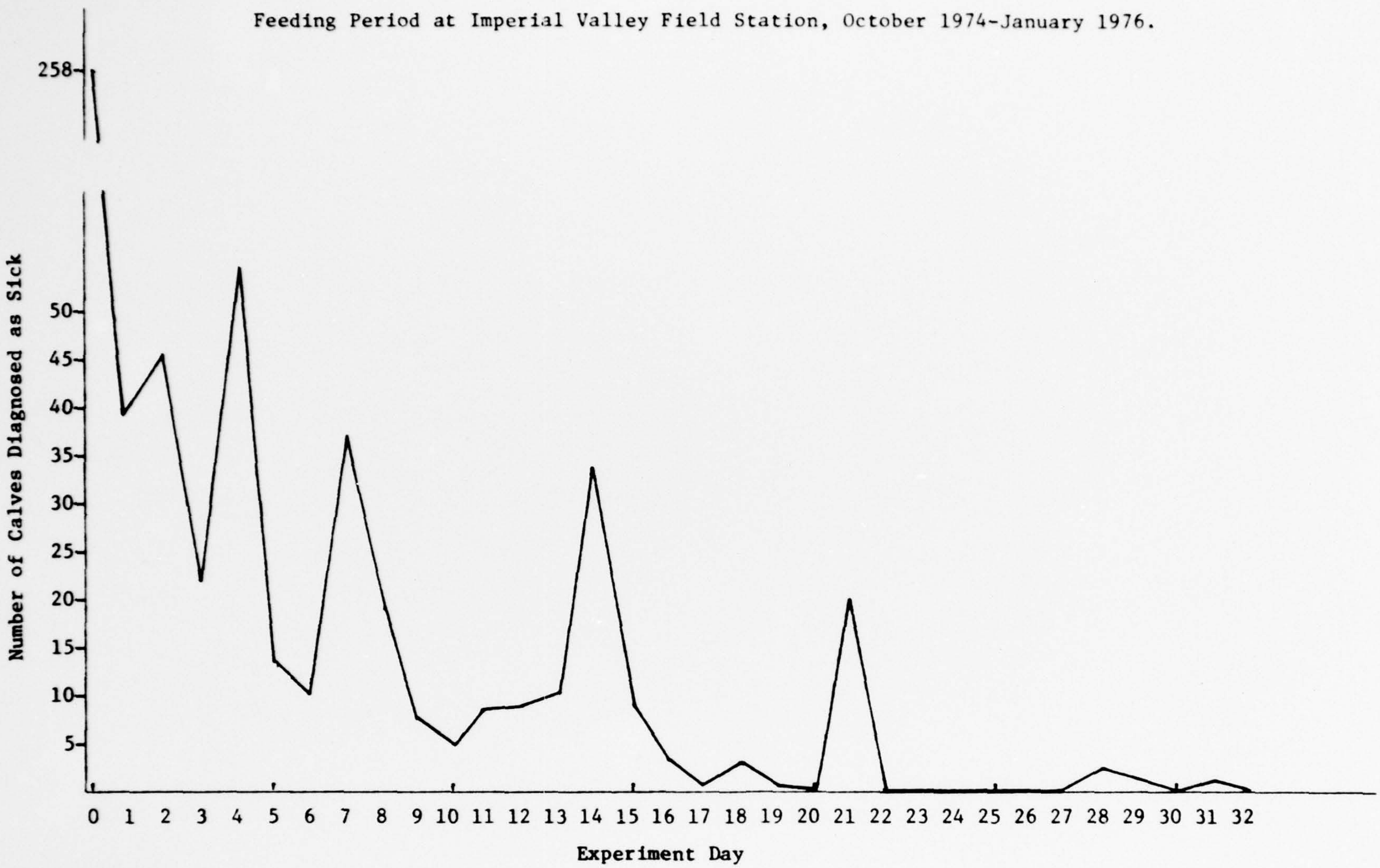
*From loads 12-16, 748 calves fed at the Imperial Valley Field Station, October 1974-January 1976.

Table XII. Actual and Expected Number of Calves in Loads 12, 14, 15 and 16 Diagnosed as Sick on "Test" Days, Imperial Field Station, October 1974-January 1976.

	Expected* number of diagnoses of sickness	Actual number of diagnoses of sickness	Difference between actual and expected	Actual ÷ expected
Day 0	35.7	258	222.3	7.2
Day 7	18.8	36	17.2	1.9
Day 14	7.3	34	26.7	4.7
Day 21	0.8	20	19.2	25
Day 28	0.5	3	2.5	6

*For day 0, Expected = mean of days 1, 2, and 3; for days 7, 14, 21, 28, Expected = mean of the 3 days before and the 3 days after that day.

Figure 1. Number of Calves in Loads 12, 14, 15 and 16 Diagnosed as Sick on Each Day of Feeding Period at Imperial Valley Field Station, October 1974-January 1976.



APPENDIX I

Subsample I

TIMSIK = 1.45 - 0.052 FSTNO1* (R^2 = .067)

TIMSIK = 1.00 + 0.001 ARRWT* (R^2 = .024)

DAYSIK = 6.11 - 0.364 FSTNO1* (R^2 = .13)

DAYSIK = 4.23 + 0.004 ARRWT* (R^2 = .01)

NONO1 = 4.75 - 0.261 TIMSIK^{ns} (R^2 = .004)

Subsample II

TIMSIK = 1.11 + 0.001 ARRWT^{ns} (R^2 = .013)

DAYSIK = 6.16 - 0.384 FSTNO1* (R^2 = .177)

* Significant at the 5% level

^{ns} Not significant at the 5% level

APPENDIX II

Subsample I

mean TIMSIK = -11.37 + (.044 mean ARRWT)* (R^2 = .91)

mean TIMSIK = 3.5 - (1.02 mean FSTNO1)* (R^2 = .90)

mean DAYSIK = - 52.7 + (.206 mean ARRWT)* (R^2 = .64)

mean NONO1 = 4.78 - (.289 mean TIMSIK)* (R^2 = .95)

mean NONO2 = 3.58 - (.344 mean TIMSIK)^{ns} (R^2 = .70)

mean days between sickness 1 & 2 = 10.32 - (1.7 mean number of times sick)^{ns} (R^2 = .98)

Subsample II

mean TIMSIK = - 78.0 + (.245 mean ARRWT)^{ns} (R^2 = .48)

mean DAYSIK = - 47.6 + (.18 mean ARRWT)^{ns} (R^2 = .10)

mean NONO1 = 4.67 - (.27 mean TIMSIK)* (R^2 = .94)

mean days between sickness 1 & 2 = 11.84 - (2.1 mean number of times sick)^{ns} (R^2 = .99)

Subsample III

mean TIMSIK = - 7.32 + (.03 mean ARRWT)* (R^2 = .92)

mean TIMSIK = 3.06 - (.85 mean FSTNO1)^{ns} (R^2 = .998)

mean DAYSIK = - 30.1 + (.13 mean ARRWT)* (R^2 = .55)

mean NONO1 = 4.95 - (.47 mean TIMSIK)* (R^2 = .999)

* Significant at the 5% level

^{ns}Not significant at the 5% level

Note: Some regressions had a very large R^2 but were not significant at the 5% level because there were very few observations used in determining the regression.