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I am submitting herewith a dissertation written by Roger Dale Billingsley entitled "Market-Transit Shrink and Post-Transit Feedlot Performance of Weanling Feeder Steers." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Animal Science.

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MARKET-TRANSIT SHRINK AND POST-TRANSIT FEEDLOT PERFORMANCE

OF WEANLING FEEDER STEERS

A Dissertation

Presented for the

Doctor of Philosophy

Degree

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Roger Dale Billingsley

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ABSTRACT

The objectives of this study were to determine effects of year, breed, farm of origin, feeder-calf grade, and calf size and shape indexes on market-transit shrink, feedlot performance, morbidity patterns, and carcass traits of stressed feeder steers. Indexes of calf size and shape were the result of principal-component analysis.

The data were obtained on 458 steer calves, weighing 137 to 296 kg, purchased in the falls of 1976 and 1977 from 21 Tennessee farms of origin. Thirty days prior to marketing, all calves were weighed and measured at the farm of origin. The body measurements taken were height, length, depth, width, and back fat over the 12th rib. These weights and body measurements were used in a principal-component analysis to determine weighting factors for calculating individual calf size and shape indexes.

Each year all calves were transported 40 to 100 km on the same day to the auction barn where purchase weights were taken. Feeder-calf grades were assigned by 2 Tennessee State Department of Agriculture feeder-calf graders. During the first 24 hr in the barn, auction-barn barn environment was duplicated by keeping calves in close confinement without feed and water. Calves were reweighed at the end of the auction-barn phase. Order-buyer-barn environment was duplicated during the last 72 hrs in the barn by allowing steers 1.8 to 2.3 m² each access to feed and water. After the order-buyer-barn phase, the calves were weighed and transported by truck 1,600 km to the USDA Southwestern Great Plains Research Center at Bushland, Texas.

Immediately after unloading at the feedlot, calves were weighed, branded, and assigned to pens. All calves were given free access to a 50%-concentrate starter diet. In addition, grass hay was provided at a level of .9 kg/steer/day for two days. One-half of the pens received a B-vitamin supplement in the starter ration for the first 14 days post-arrival. On feedlot day 15, the ration was changed to a 75%-concentrate ration, and on feedlot day 25, the ration was changed to a 90%-concentrate finishing ration.

Farm of origin was a major factor affecting ($P < .01$) market-transit weight change and post-transit performance. Percentage of calves sick ranged from 19.6 in calves from farm 13 to 87.1 in calves from farm 3. Large-framed, heavy calves lost more ($P < .01$) weight in the auction barn and during the total market-transit scheme, but had a smaller percentage sick, were sick fewer total days, had a lower effective sickness index, and gained faster in the feedlot than small-framed, light calves. Tall, thin calves lost more weight in market-transit, were sick longer, and had a higher effective sickness index, but gained faster in the feedlot, than short, fat calves. Angus (A) calves had a lower percentage sick (33.8) and effective sickness index (2.11) than Hereford (H) (70.1 and 5.82, respectively) and crossbred calves other than A-H (55.7 and 4.53, respectively). Good-grade steers gained more weight than prime-, choice-, or X-grade steers in the order-buyer-barn and at all phases in the feedlot. The prime steers tended to have a higher percentage sick. The grading system used by the Tennessee State Department of Agriculture separated the calves into groups by frame size and thickness. Calves shipped in 1977 lost more ($P < .01$) weight in the auction barn and during

the total market-transit scheme but gained more in the order-buyer-barn than those shipped in 1976, the mean weight changes (kg) being -16.38, -27.42, 6.48, and -10.99, -22.69, 4.50 in 1977 and 1976, respectively.

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CHAPTER I

INTRODUCTION

The Southeast is an intensive cow-calf producing region with most of the animals marketed as feeders at weaning and shipped to the Western or Northern feedlots for finishing. Economic losses due to bovine shipping fever complex represent one of the greatest problems facing feeder-calf producers and feedlot operators. These losses were estimated at \$500 million by Flemming (1975). Some investigators (Hoerlein, 1973; Woods et al., 1972) have suggested that the incidence of shipping fever in feeder calves during marketing, transportation, and adaptation to feedlot environment is affected by a variety of stresses and by exposure to bacterial and viral pathogens. Numerous reports have delineated the effect of specific factors on the performance of market-transit stressed calves (Jensen and Mackey, 1971); however, the literature contains inconsistencies with respect to the effects of each factor and efforts to alleviate these factors. However, the effects of the entire management and nutritional regimes of the cow-calf herd at the farm of origin have not been studied.

Feedlot managers not only desire groups of cattle which appear uniform at purchase, but also those which attain the necessary condition for marketing at the same time. Therefore, it appears necessary for someone in the industry to sort the calves into outcome groups with respect to time of finishing. These outcome groups appear, at the present time, to need to be uniform in appearance for acceptability to

the feedlot operators. In an effort to accomplish these goals, the Tennessee State Department of Agriculture has established a statewide grading service available for any auction barn or feeder-calf seller desiring such service. Tennessee Department of Agriculture feeder-calf graders sort all thrifty calves into 4 feeder-calf grades, referred to as prime, choice, good, and X. McLaren et al. (1971) fed calves sorted by Tennessee Department of Agriculture feeder-calf graders and observed differences among the grades with respect to feedlot performance.

Brown et al. (1973a) and McCurley (1977) used principal-component analyses and related the indexes obtained to growth and performance, but the relationships of these indexes to incidence of shipping fever and feeder-calf grades have not been reported.

The objectives of the present study were:

1. To evaluate the influences of year, breed, farm of origin, and calf size and shape on the performance of market-transit stressed feeder steers.
2. To evaluate market-transit shrink, feedlot performance, carcass traits, and morbidity patterns of feeder calves of different grades.
3. To evaluate the effectiveness of the present feeder-calf grading system on the separation of feeder calves into uniform lots based on size and shape.

CHAPTER II

REVIEW OF LITERATURE

A. SHIPPING FEVER COMPLEX

Shipping fever complex is one of the major problems facing feeder-calf producers and feedlot managers. Flemming (1975) estimated economic losses due to shipping fever to be one-half billion dollars.

Reports of failure to experimentally produce clinical cases of shipping fever with bacterial pathogens are numerous and have led investigators to postulate that other agents are involved in causing outbreaks of shipping fever (Frey and Ball, 1971; Hamdy et al., 1963). Hoerlein (1973) reported the etiology of shipping fever to be complex and imperfectly understood. He suggested the following hypothesis: shipping fever = stress + nonbacterial infection + bacterial infection, to be the hypothesis upon which shipping fever research should be based.

Market-Transit Shrink

The importance of shrink can easily be seen when the feedlot manager weighs the steers off the truck and finds a 10% weight loss from purchase weight. If the feedlot manager had paid \$70.00/cwt for the calves and they arrived at the feedlot 10% lighter, then he has effectively paid \$77.00/cwt for the calves on arrival at the feedlot. Therefore, shrink is important when feedlot managers estimate the prices they can afford to pay for a set of feeder cattle.

Self and Gay (1972) indicated that data on shrink are limited and that opinions vary regarding the range and mean of shrink in feeder

cattle and the time required to regain shipping shrink. Greathouse et al. (1969) found that calves transported directly from the farm 150 miles to the feedlot by truck lost 10 lb (3.3%), compared to a 15-lb (4.9%) loss for calves trucked 260 miles and worked through an auction barn. Direct shipment of feeder calves from a ranch or other grazing facility resulted in lower weight losses than procurement from some type of sale facility (Self and Gay, 1972) or preweaning and feeding a preconditioning ration for 30 days prior to shipment (Pate and Crockett, 1978). The improvement and standardization of order-buyer-barn environment has been considered by some researchers as a possible method of reducing shipping fever outbreaks. The improvement of order-buyer-barn environment by feeding practices and the length of time an individual feeder calf stays in the barn has been examined by Phillips et al. (1978). They reported that feeder calves that stayed 4 days in the order-buyer-barn lost 9.9 lbs during transit, compared to a 17.1-lb loss during transit for calves that remained in the order-buyer-barn for 10 days. Gay (1976) suggested that a feeder calf is unduly stressed and will be more susceptible to disease organisms when shrink exceeds 10-12% of "normal" weight. He also suggested that 10-12% shrink can occur with 24-26 hr in transit.

The feedlot manager is interested in how long it takes a calf to regain shipping weight loss. McKerley et al. (1959) reported that only 4.5 to 6 days were required for weanling calves to regain shipping weight loss; however, Self and Gay (1972) reported an average of 10.4 to 10.9 days to recover shrink. They reported further that cattle shipped in the spring tended to recover shrink sooner than cattle shipped in the fall.

Approximately 47% of the weight lost during transit was accounted for by loss of material from the digestive tract (Self, 1972). The remaining 53% was from tissue weight losses. He reported further that the liver actually increased in weight during shipment.

Feeder Calf-Size

Since heavier animals tend to be fatter, they tend to shrink less on a percentage basis. Self (1969) reported yearlings and calves had purchase weights of 679 and 506 lb, with a percent shrink of 9.2 and 9.5%, and number of days to regain purchase weight of 16 and 19 days, respectively.

Feedlot death loss increases as the purchase weight of feeder calves decreases, according to Norman (1974). Considering calves weighing over 500 lb to have normal (100%) death losses, the comparative losses of calves weighing under 350, 351 to 400, 401 to 450, and 451 to 500 lb were 292, 238, 316, and 180 percent of normal, respectively.

Preconditioning Treatments

According to Herrick (1969), preconditioning is a term applied to the factors necessary to get the animal from site of production to the feedlot with the least amount of stress and to facilitate favorable feedlot adaptation. Therefore, the term encompasses disease prevention measures, management practices, and safe and sane handling.

Weaning and starting a calf on feed is reputed to aid the calf in adjusting to movement and adaptation to the feedlot with less shrink and susceptibility to disease. A calf will shrink 3 to 5% when weaned and will require 10 to 15 days to regain the lost weight (Herrick, 1979).

However, in a 30-day preconditioning period, calves will gain 20-60 lb Greathouse et al. (1969) reported that early weaned calves (preconditioned) gained 25 lb more than calves that remained on the dam for the last 29 days on the farm of origin. They also reported that unusually dry weather and poor pastures may have kept the calves that remained on the dam from gaining more weight.

The feeding of a high-energy, high-antibiotic ration in the order-buyer-barn has been suggested and tested by some researchers. Koers et al. (1975) reported a significant reduction in shipping fever due to feeding a 50%-concentrate, high-antibiotic diet for 2 to 3 days at the assembly point during marketing in 1 of 3 trials. Feeding a high-energy, high-antibiotic ration for 10 days before shipment did not increase shipment loss but did increase weight gains during the first 20 days after arrival (Phillips et al., 1978). The feeding of a small amount of palatable forage at frequent intervals during the time animals are exposed to high airborne concentrations of pathogenic substances has been suggested by Veit and Farrell (1978). They stated that such a practice would stimulate constant and increased salivation and, hence, reduce laryngopharyngeal contamination. Gale et al. (1959) reported that the development of shipping fever in feedlot cattle was not reduced by injection of vitamin A shortly before transportation to the feedlot.

As well as different feeding regimes, Herrick (1969) considered the use of vaccines and drugs as an important portion of a preconditioning program. *Pasteurella multocida*, *Pasteurella hemolytica* (Collier, 1968; Frank and Marshall, 1972; Heddlestone et al., 1962) myxovirus para-influenza 3, infectious bovine rhinotracheitis virus (Frank and Marshall,

1972; Hamdy et al., 1964), and bovine enterovirus (Hamdy et al., 1964) are some of the agents which researchers have associated with shipping fever. Several investigators have reported that various vaccination programs were successful in lowering the incidence of shipping fever (Hamdy and Trapp, 1964; Smith et al., 1976; Woods et al., 1978). However, other investigators (Hamdy et al., 1965; Mansfield et al., 1978; Woods et al., 1962) have reported vaccination programs to be ineffective in reducing outbreaks of shipping fever. Knight et al. (1972) reported that time of vaccination significantly affected morbidity, mortality, and weight gains of feeder calves.

Control of the output of adrenocortical hormone as an aid in combatting shipping fever was discussed by Nichols (1962) as a reasonable addition to future preconditioning programs.

The cost of preconditioning and who should pay have been evaluated and discussed by researchers. A cost of \$2.54 to \$3.17 per hundred-weight (Meyer et al., 1970) or \$20 to \$27 per animal (Herrick, 1979) are representative of the cost most researchers report for a preconditioning program. However, there is not as much agreement as to the economic value of preconditioning. Howard (1969) and Meyer et al. (1970) reported greater expense in the preconditioning program than was saved by the reductions in shipping fever cases. In contrast, Herrick (1979) suggested that, regardless of economic cost, the feeder-calf producer should precondition because of the value of pride in his product and his image as a cattleman being at stake.

Genetic

Veit and Farrell (1978) suggested that genetic selection in cattle for greater digestive capacity, muscle mass, milk production, or growth rates is collectively increasing total body oxygen requirements relative to the anatomical pulmonary gaseous exchange capability, making the animals more susceptible to shipping fever. They suggested further genetic selection for physiological gaseous exchange capacity. In addition to selection on individual phenotype, the selection could also be done through the use of progeny testing in a program similar to that described for mastitis resistance by Lindstrom and Syvajarvi (1978).

B. PRINCIPAL-COMPONENT ANALYSIS

Measures of size and shape in cattle and other species have been reported in the literature for many years. One of the first attempts at the use of a multivariate procedure, factor analysis, on biological measurement data in species other than man was done by Tanner and Burt (1954). Since then, numerous studies pertaining to optimum size and shape, as defined by principal-component analyses of growth and production in cattle, can be found in the literature (Brown et al., 1973a; Carpenter et al., 1978; Eller, 1972; Hammack, 1973; McCurley, 1977). The reports indicate that there are 2 primary components, the first defining size and the second defining shape.

These studies indicate that principal-component analysis can be used to combine body weight, measurements, and condition into components defining body size and shape. However, indexes calculated from

principal-component analyses have not been used in evaluating effects of size and shape on the incidence of shipping fever or feeder-calf grades.

C. FEEDER-CALF GRADES

Anderson et al. (1964) found no differences in steers in rate of gain attributable to feeder grade, but good heifers did gain faster than choice heifers. No differences in average daily gain between good and choice heifers were found by Corrick and Hobbs (1970). McLaren et al. (1971) reported that good and medium cattle gained at similar rates and that choice cattle gained at a slightly slower rate. X-grade steers gained more slowly on spring-summer pasture than did good steers but tended to gain faster in the feedlot (Hughes, 1976).

Minish et al. (1967) reported that choice feeder steers were superior to standard feeder steers in conformation, marbling, quality grade, final carcass grade, rib-eye area, and dressing percent, but gained more slowly in the feedlot.

The Tennessee State Department of Agriculture trains its graders to group feeder calves into uniform lots which are supposed to finish together. However, evaluation of actual body measurements of feeder calves within a grade has not been done.

CHAPTER III

EXPERIMENTAL PROCEDURES

A. PRE-TRANSIT

During the fall of 1976 and 1977, 458 steer calves, weighing 137 to 296 kg, were purchased from 21 Tennessee farms, hereafter designated farm of origin (FO). The 21 farms represented a cross-section of cow-calf management systems used by Tennessee producers; however, some farms were included only 1 year. The calves on each farm were weighed, their temperatures were taken, they were clinically examined, the fat thickness over the loin between the 12th and 13th ribs was measured,* and body measurements were taken 30 days before the calves were transported to the auction barn (AB). The 4 body measurements were height at withers, width at the point of shoulder, depth of body at chest, and length from the anterior end of the first thoracic vertebra to the posterior prominence of the pin bone. On each FO, one-third of the calves were weaned and fed a 50%-concentrate ration (Table 1) for 30 days prior to transport to an AB (preweaned--PW). The remainder of the calves were weaned the day they were shipped to the AB. The effects of these pre-transit treatments were removed statistically in this study and will not be considered in subsequent discussion.

Prior to initiating the large cooperative shipping fever project, including the studies reported herein, the cooperating groups conducted an intensive survey to determine prevailing marketing procedures for

*Bronson Sonoray, Model 12.

TABLE 1
INGREDIENT COMPOSITION OF PRE-TRANSIT RATIONS^a

Ingredient	IRN ^b	Ration ^c	
		PW	HE
Corn, grain, flaked	4-02-859	31.2	32.0
Cotton, seed hulls	1-01-599	42.0	45.0
Soybean, seed solv-extd, grnd, mx 7 fbr	5-04-604	15.0	7.0
Sugarcane, molasses	4-04-696	5.0	4.0
Alfalfa, aerial part, dehy meal	1-00-23	5.0	-
Animal-fat, heat rendered	4-00-375	1.0	-
NaCl, trace mineralized	6-04-152	.5	.5
Limestone, grnd nm 33 Ca	6-02-632	.3	.7
Calcium phosphate dibasic, commercial	6-01-080	-	.3
Propylene glycol	----	-	5.0
Vitamin A palmitate, commercial ^d	7-05-143	+	-
Oxytetracycline ^e	----	+	-
Vitamin-antibiotic premix	----	-	5.5

^aPercent, dry matter basis.

^bInternational Reference Number.

^cPW = preweaned ration; HE = 3-day high-energy ration.

^dTo supply 5000 IU of vitamin A and 20 mg of oxytetracycline per kg of ration.

^eTo supply 1100 mg of oxytetracycline and 5000 IU of vitamin A per kg of ration.

feeder calves in the Southeast. In addition, mean intensities of normal industry stress factors during the market-transit phases of feeder-calf shipment were estimated. The survey indicated that Southeastern cow herds are small (28 cows per herd in Tennessee and Kentucky) and that direct shipment of calves from the FO to feedlots is infrequent. Most calves are sold at AB and purchased by order buyers who assemble the calves at their barns (OBB) until a truckload of similar calves is available for a specific feedlot order. Calves spend from 18 to 36 hr at the AB without feed or water, with the mean time being about 24 hr. A truckload of calves is generally assembled by the order buyer in 1 to 4 days during the intense marketing season (fall), but up to 10 days may be required during other seasons. The mean time required to assemble a specific load of calves is about 72 hr, during which hay and water are available. Pen space provided at the AB ranges from .65 to .95 m² and 1.42 to 2.80 m² at the OBB.

A market facility at Algood, Tennessee, which is used as a weekly auction market facility and as an intermediate assembly point by several order buyers was provided for this study by the owners of the facility. Pen space and time in the AB and OBB used in this study were based on means from the survey in the hope of duplicating as nearly as possible mean industry AB and OBB environments.

Each year all calves were transported 40 to 100 km on the same day to the AB, where purchase weights and temperatures were taken. Feeder-calf grades were assigned by 2 Tennessee State Department of Agriculture feeder-calf graders. During the first 24 hr in the barn, AB environment was simulated by keeping the calves in close confinement

(.65 to .85 m²/steer) without feed and water. Calves were re-weighed and temperatured at the end of this AB phase. OBB environment was simulated during the last 72 hr in the barn by allowing steers 1.8 to 2.3 m² each and access to feed and water. PW calves and one-half of the newly weaned calves (controls--C) were given free access to a dried grass hay and water during the 72-hr OBB phase. The remaining calves were fed a 50%-concentrate ration (Table 1) containing oxytetracycline and propylene glycol (high energy--HE). After the OBB phase, the calves were weighed and temperatured, and transported by truck 1,600 km to the USDA Southwestern Great Plains Research Center at Bushland, Texas. Calves from each FO were equally represented on each of the trucks. Total time from loading to unloading ranged from 26 to 34 hr. Each year the trucks traveled together, and differences in transit time were removed with year effects.

B. POST-TRANSIT

Immediately after unloading at the feedlot (FL), calves were weighed, temperatures taken, given a clinical examination, branded, and assigned to 12 pens, with 4 pens per pre-transit treatment. All calves were given free access to a 50%-concentrate starter diet (Table 2). Grass hay was provided at a level of .9 kg/steer/day for 2 days. One-half of the pens received a B-vitamin supplement (Table 3) in the starter ration for the first 14 days post-arrival. On FL day 15, the ration was changed to a 75%-concentrate ration, and on FL day 25 the ration was changed to a 90%-concentrate finishing ration (Table 2).

TABLE 2
INGREDIENT COMPOSITION OF FEEDLOT RATIONS^a

Ingredient	IRN ^b	Ration ^c		
		1	2	3
Sorghum, milo grain ^d	4-04-444	40.9	48.2	57.0
Corn, grain, flaked	4-02-859	-	19.4	23.0
Corn, aerial part ensiled	3-02-822	6.8	12.5	5.5
Alfalfa, hay s-c, grnd	1-11-111	30.7	12.5	5.6
Sugarcane, molasses	4-04-696	4.0	2.8	3.3
Cotton, seed hulls	1-01-599	13.6	-	-
Animal-fat, heat rendered	4-00-375	-	1.2	1.6
Supplement	----	4.0	3.4	4.0

^aPercent, dry matter basis.

^bInternational Reference Number.

^cStarter = 1; intermediate = 2; finish = 3.

^dSteam flaked.

^eSupplement composition: cottonseed meal (5-01-621), 48.8%; ground limestone (6-02-632), 18.3%; trace mineralized salt (6-04-152), 10.3%; urea (5-05-070), 5%; ammonium sulfate, 5%; defluorinated rock phosphate (6-01-780), 4%; KCl, 2.5%; ground sorghum grain, 3%; cane molasses, 3%; vitamin-A palmitate (7-05-143), 150,000 IU per kg.

TABLE 3

B-VITAMINS SUPPLEMENTED DAILY FOR THE FIRST 14 DAYS IN THE FEEDLOT

Vitamin	Mg Per Kg Supplement	Mg Per Head Per Day
Thiamine	1,660	35
Riboflavin	1,640	35
Pyridoxine	1,740	35
Panthenic acid	4,110	80
Niacin	10,280	205
Choline	232,000	4600
B ₁₂	12.3	2.5

The calves were observed daily by the FL manager and/or a research veterinarian. Those determined to be morbid were placed in sick pens, where they continued to receive the same diet as their pen mates plus hay *ad libitum*. Criteria for designating a calf as sick and for moving that calf from its assigned pen to the sick pen were subjective and similar to criteria used in High Plains commercial feedlots. During the first 7 days in the FL, no sick pen calves were treated with antibiotics because serological studies were being conducted. After FL day 7 each year, morbid calves were weighed and treated by the FL manager and/or research veterinarians for at least 3 successive days or until they were determined to be healthy enough to return to their assigned pens. Only calves that exhibited signs of shipping fever complex were included as sick calves in calculation of percent calves sick, date first sick, and number of days sick in this study. In order to evaluate the total effect of year, breed, and FO on FL sickness, a continuous variable, effective sickness index (ESI), was defined. ESI was calculated as the product of the percentage of morbid calves in a classification (i.e., FO, breed, etc.) times the mean number of days that the calves in that classification were sick. Chi-square analysis indicated that mortality (3.1% overall) was not significantly affected by any of the independent variables; therefore, mortality data were eliminated from subsequent analyses.

On day 38, all calves were implanted with 30 mg of diethylstilbestrol and vaccinated against blackleg, malignant edema, hemophilus, and enterotoxemia. Calves were weighed on days 0, 7, 14, 30, 56, and 140, and all intermediate and final weights were adjusted by subtracting an assumed 3% shrink.

C. PRINCIPAL-COMPONENT ANALYSIS

A multivariate technique, principal-component analysis, was used to generate orthogonal indexes to define calf size and shape. This technique has been used previously (Brown et al., 1973a; Carpenter et al., 1978; Eller, 1972) to analyze biological measurement data. The advantage of this analysis procedure was that the independent separate effects of all body measurements on shrink and performance were considered simultaneously rather than separately after the effects of the other independent variables had been considered, as in multiple regression.

The principal-component analysis used weight at FO, fat thickness, and the 4 body measurements on a within-year basis to develop a correlation matrix from which coefficients (analogous to partial regression coefficients used in multiple regression) for each of the body measurements were calculated.

In this study, only the first 2 principal components (size and shape) were included in the regression analysis because:

1. Other components had little biological meaning; and
2. The first 2 components explained 78 to 82% of the total variation in the dependence structure of the 6 parameters.

Brown et al. (1973a) and Eller (1972) used these same 2 reasons for using only these 2 components to classify animals according to body size and shape. The first principal component (size) accounted for 63.3% and 67.3% of the variation in the total dependence structure in 1976 and 1977, respectively. The second principal component (shape) accounted for an additional 14.7% and 15.0% of the variation in the dependence structure in 1976 and 1977, respectively.

Two index values (size and shape) were calculated for each animal using the coefficient for the respective component. The procedure involved multiplying the factor coefficient for a variable by the respective individual standard deviate for the variable and summing the product across variables on a within-animal basis.

D. LEAST-SQUARES ANALYSIS

A least-squares model for size and shape with year, breed, FO, pre-transit treatment, and feeder-calf grade as discrete variables was used as the basis for analysis. The complete model was as follows:

$$Y_{ijkl} = \mu + T_i + B:T_{ij} + F:TB_{ijk} + Z_\ell + G + b_1(S - \bar{S}) + b_2(S^2 - \bar{S}^2) + b_3(P - \bar{P}) + b_4(P^2 - \bar{P}^2) + e_{ijkln}$$

where Y_{ijkln} = an individual calf's value for the dependent variable in question; μ = the population mean; T_i = the effect common to all animals in the i^{th} year; $B:T_{ij}$ = the effect common to animals in the j^{th} breed within the i^{th} year; $F:TB_{ijk}$ = the effect common to animals from the k^{th} farm within the i^{th} year and j^{th} breed; Z_ℓ = the effect common to all animals in the ℓ^{th} pre-transit treatment group; G = the effect common to all animals in the n^{th} feeder-calf grade; $b_1(S - \bar{S})$ = the effect due to partial regression of the dependent variable on size; $b_2(S^2 - \bar{S}^2)$ = the effect due to partial regression of the dependent variable on size squared; $b_3(P - \bar{P})$ = the effect due to partial regression of the dependent variable on shape; $b_4(P^2 - \bar{P}^2)$ = the effect due to partial regression of the dependent variable on shape squared and e_{ijkln} = random error. Year and pre-transit treatment were regarded as fixed effects, and breed within year and effects of farm within breed-year were considered random. Therefore, the residual mean

square was used to test only the covariates and farm within breed-year. The mean square for farm within breed-year was used as the error term to test the significance of breed within year, and the mean square for breed within year was used as the term to test the significance of year effect. Pre-transit treatment was included in the model to remove that source of variation and will not be considered in subsequent discussion. Percentage of calves sick was analyzed by chi-square procedures.

CHAPTER IV

MARKET-TRANSIT SHRINK AND POST-TRANSIT FEEDLOT PERFORMANCE OF WEANLING FEEDER STEERS

A. SUMMARY

In 1976 and 1977, 458 steer calves, weighing 137 to 296 kg, were purchased from 21 Tennessee farms of origin (FO). Thirty days prior to marketing, all calves were weighed and measured at FO with respect to height, length, depth, width, and back fat over the 12th rib. These weights and body measurements were used in a principal-component analysis to determine weighting factors for calculating individual calf size and shape indexes. The calves were subjected to normal auction-barn (AB) environment for 24 hr, normal order-buyer-barn (OBB) environment for 72 hr, were transported 1,600 km to a feedlot (FL), and were fed for 140 days. FO was a major factor affecting ($P < .01$) market-transit (MT) weight change and post-transit performance. Percentage of calves sick ranged from 19.6 in calves from FO 13 to 87.1 in calves from FO 3. Large-framed, heavy calves lost more ($P < .01$) weight in the AB and MT but had a smaller percentage sick, were sick fewer total days, had a lower effective sickness index (ESI), and gained faster in FL than small-framed, light calves. Tall, thin calves lost more weight in MT, were sick longer, and had a higher ESI than short, fat calves and gained faster in FL. Angus (A) calves had lower percentage sick (33.8) and ESI (2.11) than Hereford (H) (70.1 and 5.82, respectively) and crossbred calves other than A-H (55.7 and 4.53, respectively). Calves shipped in

1977 lost more ($P < .01$) weight in AB and MT but gained more in OBB than those shipped in 1976, the mean weight changes (kg) being -16.38, -27.42, 6.48, and -10.99, -22.69, 4.50 in 1977 and 1976, respectively.

Key words: Stress, Feeder Calves, Size, Shape, Shipping Fever.

B. INTRODUCTION

Economic losses due to bovine shipping fever represent one of the greatest problems facing feeder-calf producers and feedlot operators. These losses were estimated at \$500 million by Fleming (1975). Some investigators (Hoerlein, 1973; Woods et al., 1972) have suggested that the incidence of shipping fever in feeder calves during marketing, transportation, and adaptation to feedlot environment is affected by a variety of stresses and by exposure to bacterial and viral pathogens. Numerous reports have delineated the effect of specific factors on the performance of market-transit stressed calves (Jensen and Mackey, 1971); however, review of the literature indicates inconsistencies with respect to the effects of each factor and efforts to alleviate these effects. Weaning and feeding a concentrate diet for 30 days before marketing may reduce the incidence of shipping fever (Algeo, 1967; Pate and Crockett, 1978); however, Cole et al. (1979) reported no response to such treatment. Koers et al. (1975) reported a significant reduction in shipping fever due to feeding a 50%-concentrate, high-antibiotic diet for 2 to 3 days at the assembly point during marketing in 1 of 3 trials. However, the effects of the entire management and nutritional regimes of the cow-calf herd at the farm of origin have not been studied.

Studies of the effect of calf size, defined as body weight, indicate that heavier calves are less susceptible to shipping fever than

lighter calves (Norman, 1974; Woods et al., 1973). Brown et al. (1973a) and McCurley (1977) used principal-component analyses and related the indexes obtained to growth and performance, but the relationships of these indexes to incidence of shipping fever have not been reported.

In this study, the influences of year, breed, farm of origin, and calf size and shape on the performance of market-transit stressed feeder steers were examined.

C. EXPERIMENTAL PROCEDURES

Pre-Transit

During the fall of 1976 and 1977, 458 steer calves, weighing 137 to 296 kg, were purchased from 21 Tennessee farms, hereafter designated farm of origin (FO). The 21 farms represented a cross-section of the cow-calf management systems used by Tennessee producers; however, some farms were included only 1 year. The calves on each farm were weighed, fat thickness over the loin between the 12th and 13th ribs was measured,* and body measurements were taken 30 days before the calves were transported to the auction barn (AB). The 4 body measurements were height at withers, width at the point of shoulder, depth of body at chest, and length from the anterior end of the first thoracic vertebra to the posterior prominence of the pin bone. At each FO, the calves were randomly allotted to 3 pre-transit treatments (Cole et al., 1979). The effects of these pre-transit treatments were removed statistically in this study and will not be considered in subsequent discussion.

*Bronson Sonoray, Model 12.

Prior to initiating the large cooperative shipping fever project, including the study reported herein, the cooperating groups conducted an intensive survey to determine prevailing marketing procedures for feeder calves in the Southeast. In addition, mean intensities of normal industry stress factors during the market-transit phases of feeder-calf shipment were estimated. The survey indicated that Southeastern cow herds are small (28 cows per herd in Tennessee and Kentucky) and that direct shipment of calves from the farm of origin to feedlots is infrequent. Most calves are sold at AB and purchased by order buyers, who assemble the calves at their barns (OBB) until a truckload of similar calves is available for a specific feedlot order. Calves spend from 18 to 36 hr at the AB without feed or water, with the mean time being about 24 hr. A truckload of calves is generally assembled by the order buyer in 1 to 4 days during the intense marketing season (fall), but up to 10 days may be required during other seasons. The mean time required to assemble a specific load of calves is about 72 hr, during which hay and water are available. Pen space provided at the AB ranges from .65 to .95 m² and from 1.42 to 2.80 m² at the OBB.

A market facility at Algood, Tennessee, which is used as a weekly auction market facility and as an intermediate assembly point by several order buyers, was provided for this study by the owners of the facility. Pen space and time in the AB and OBB used in this study were based on means from the survey in the hope of duplicating as nearly as possible mean industry AB and OBB environment.

Each year all calves were transported 40 to 100 km on the same day to the AB where purchase weights were taken. During the first 24 hr

in the barn, AB environment was simulated by keeping the calves in close confinement (.65 to .85 m²/steer) without feed and water. Calves were weighed at the end of this AB phase. OBB environment was simulated during the last 72 hr in the barn by allowing steers 1.8 to 2.3 m² each and access to feed and water. After the OBB phase, the calves were weighed and transported by truck 1,600 km to the USDA Southwestern Great Plains Research Center at Bushland, Texas. Calves from each FO were equally represented on each of the trucks. Total time from loading to unloading ranged from 26 to 34 hr. Each year the trucks traveled together, and differences in transit time was removed with year effects.

Post-Transit

Immediately after unloading at the feedlot (FL), the calves were weighed, branded, and assigned to pens. All calves were given free access to a 50%-concentrate starter diet. In addition, grass hay was provided at a level of .9 kg/steer/day for 2 days. On day 15 after arrival, the diet was changed to a 75%-concentrate intermediate diet, and on day 25, the diet was changed to a 90%-concentrate finishing diet. All pre-transit and post-transit diets were reported and discussed by Cole et al. (1979).

The calves were observed daily by the manager and/or a research veterinarian. Those determined to be morbid were placed in sick pens, where they continued to receive the same diet as their pen mates plus hay *ad libitum*. Criteria for designating a calf as sick and for moving that calf from its assigned pen to the sick pen were subjective and similar to criteria used in High Plains commercial feedlots. During the

first 7 days in the FL, no sick pen calves were treated with antibiotics because serological studies were being conducted. After FL day 7 each year, morbid calves were weighed and treated by the manager and/or research veterinarians for at least 3 successive days or until they were determined to be healthy enough to return to their assigned pens. Only calves that exhibited signs of shipping fever complex were included as sick calves in calculation of percent calves sick, date first sick, and number of days sick in this study. In order to evaluate the total effect of year, breed, and FO on FL sickness, a continuous variable, effective sickness index (ESI), was defined. ESI was calculated as the product of the percentage of morbid calves in a classification (i.e., FO, breed, etc.) times the mean number of days that the calves in that classification were sick. Chi-square analyses indicated that mortality (3.1% overall) was not significantly affected by any of the independent variables; therefore, mortality data were eliminated from subsequent analyses.

On day 38, all calves were implanted with 30 mg of diethylstilbestrol and vaccinated for blackleg, malignant edema, hemophilus, and enterotoxemia. Calves were weighed on days 0, 7, 14, 30, 56, and 140, and all intermediate and final weights were adjusted by subtracting an assumed 3% shrink.

Principal-Component Analysis

A multivariate technique, principal-component analysis, was used to generate orthogonal indexes to define calf size and shape. This technique has been used previously (Brown et al., 1973a; Carpenter et al., 1978; Eller, 1972) to analyze biological measurement data. The advantage of this analysis procedure was that the independent separate effects of

all body measurements on shrink and performance were considered simultaneously rather than separately after the effects of the other independent variables had been considered, as in multiple regression.

The principal-component analysis used weight at FO, fat thickness, and the 4 body measurements (Table 4) on a within-year basis to develop a correlation matrix from which coefficients (analogous to partial regression coefficients used in multiple regression) for each of the body measurements were calculated (Table 5).

In this study, only the first 2 principal components (size and shape) were included in the regression analysis because:

1. Other components had little biological meaning; and
2. The first 2 components explained 78 to 82% of the total variation in the dependence structure of the 6 parameters.

Brown et al. (1973a) and Eller (1972) used these same 2 reasons for using only these 2 components to classify animals according to body size and shape. The first principal component (size) accounted for 63.3% and 67.3% of the variation in the total dependence structure in 1976 and 1977, respectively. The second principal component (shape) accounted for an additional 14.7% and 15.0% of the variation in the dependence structure in 1976 and 1977, respectively.

Two index values (size and shape) were calculated for each animal using the coefficient for the respective component. The procedure involved multiplying the factor coefficient for a variable by the respective individual standard deviate for the variable and summing the product across variables on a within-animal basis.

TABLE 4

UNADJUSTED MEANS OF WEIGHT, BODY MEASUREMENTS, AND FAT THICKNESS*
USED TO CALCULATE PRINCIPAL COMPONENTS

Measurements	275 Steers Shipped in 1976		183 Steers Shipped in 1977	
	Mean	SE	Mean	SE
Weight, kg	192.0	1.550	203.7	2.488
Height, cm	96.9	.267	94.5	.366
Length, cm	94.4	.291	96.4	.475
Depth, cm	48.8	.165	49.2	.253
Width, cm	33.2	.166	32.1	.244
Fat, mm	2.1	.079	2.0	.073

*Taken at the FO.

TABLE 5

SCORE COEFFICIENTS OF PRINCIPAL COMPONENTS OBTAINED
FROM BODY MEASUREMENTS OF STEERS

Body Measurement	Coefficients for Principal Component Number		Principal Component	Description of Steers With Large Positive Indexes
	1	2		
-----Steers Shipped in 1976-----				
Weight	.24802	-.03937	1	Large-framed and heavy
Height	.20245	.52301		
Length	.23112	.20307	2	Narrow, tall, and thin
Depth	.21485	.25305		
Width	.15725	-.77249		
Fat	.19073	-.39819		
-----Steers Shipped in 1977-----				
Weight	.23771	-.03895	1	Large-framed and heavy
Height	.22133	.30720		
Length	.21856	.20607	2	Tall and thin
Depth	.20312	.16890		
Width	.19959	-.13632		
Fat	.11525	-.96204		

Statistical Analysis

A least-squares model for size and shape with year, breed, FO, and pre-transit treatment as discrete variables was used as the basis for analysis. The complete model was as follows: $Y_{ijkl} = \mu + T_i + B:T_{ij} + F:TB_{ijk} + Z_\ell + b_1(S - \bar{S}) + b_2(S^2 - \bar{S}^2) + b_3(P - \bar{P}) + b_4(P^2 - \bar{P}^2) + e_{ijkl}$, where Y_{ijkl} = an individual calf's value for the dependent variable in question, μ = the population mean, T_i = the effect common to all animals in the i^{th} year, $B:T_{ij}$ = the effect common to animals in the j^{th} breed within the i^{th} year, $F:TB_{ijk}$ = the effect common to animals from the k^{th} farm within the i^{th} year and j^{th} breed, Z_ℓ = the effect common to all animals in the ℓ^{th} pre-transit treatment group, $b_1(S - \bar{S})$ = the effect due to partial regression of the dependent variable on size, $b_2(S^2 - \bar{S}^2)$ = the effect due to partial regression of the dependent variable on size squared, $b_3(P - \bar{P})$ = the effect due to partial regression of the dependent variable on shape, $b_4(P^2 - \bar{P}^2)$ = the effect due to partial regression of the dependent variable on shape squared, and e_{ijkl} = random error. Year and pre-transit treatment were regarded as fixed effects, and breed within year and effects of farm within breed-year were considered random. Therefore, the residual mean square was used to test only the covariates and farm within breed-year. The mean square for farm within breed-year was used as the error term to test the significance of breed within year, and the mean square for breed within year was used as the term to test the significance of year effect. Pre-transit treatment was included in the model to remove that source of variation and will not be considered in subsequent discussion. Percentage of calves sick was analyzed by chi-square procedures.

D. RESULTS

Overall unadjusted means of weight change by steers during market-transit (MT) (Table 6) reflect the intermittent fasting-feeding and other stress situations that are predominant in the movement of feeder calves from FO to FL for finishing. In the AB, where the MT scheme is generally initiated, newly weaned calves are usually crowded into small pens without feed or water. The 12.2-kg (5.6%) AB weight loss and the total MT weight loss of 25 kg (11.6%) in this study were similar to the 5 and 9% body weight shrink reported by Britt and Henderson (1973) for calves purchased locally and for those transported 1,582 km, respectively.

The overall percentage of sick calves was 48.9. The average date on which these calves were first designated sick was FL day 6.2, and the average number of days sick was 8.1. The overall ESI was 3.9.

Mean FL gains of 42.9, 72.7, and 167.0 kg during the first 30, 56, and 140 days, respectively, indicate that rapid weight gains are possible after shipment intervals of 26 to 36 hr. These gains are within the range of post-transit gains reported in other studies (Great-house et al., 1969; Woods et al., 1973).

Market-Transit Performance

The analysis of variance of MT weight changes (Table 7) indicates the effects of the various independent variables on shrink. Calves lost more ($P < .01$) weight in the AB in 1977 (16.4 kg/calf) than in 1976 (11.0 kg/calf) (Table 8) but gained more ($P < .01$) in the OBB in 1977 (6.5 kg/calf) than in 1976 (4.5 kg/calf). The fact that OBB weight changes during both years were positive reflects the importance of the

TABLE 6

OVERALL UNADJUSTED MEANS OF MARKET-TRANSIT WEIGHT CHANGES,
MORBIDITY, AND FEEDLOT PERFORMANCE

Item	Mean	SE
Initial weight auction barn, kg	214.8	1.590
Market-transit weight change, kg		
Auction barn	-12.2	.373
Order-buyer barn	4.6	.338
Total ^a	-25.0	.355
Morbidity		
Date first sick ^{b,c}	6.2	.557
Percentage of calves sick	48.9	2.334
Average number of days sick	8.1	.491
Effective sickness index ^d	3.9	.282
Days to regain purchase weight ^e	11.5	.44
Feedyard gain, kg ^f		
First 30 days	42.9	.698
First 56 days	72.7	.779
Total 140 days	167.0	1.212

^aTotal market-transit weight changes include auction barn, order-buyer barn, and transit changes.

^bNumber of days after arrival at feedlot when a steer was subjectively determined to be sick; the day of arrival was day 0.

^cOnly morbid calves with signs of shipping fever complex were included.

^dPurchase weight = weight on arrival at auction barn.

^eEffective sickness index = no. of days sick x percent of calves sick.

^fActual weights were shrunk 3%.

TABLE 7

ANALYSIS OF VARIANCE TO TEST SIGNIFICANCE OF EFFECTS OF YEAR, BREED/YEAR, FARM/BREED-YEAR, TREATMENT, SIZE, AND SHAPE ON MARKET-TRANSIT WEIGHT CHANGE, MORBIDITY, DAYS TO REGAIN PURCHASE WEIGHT, AND FEEDLOT PERFORMANCE

Source	df	Market-Transit Weight Change					Mean Squares					Feedlot Performance			
		Auction Barn	Order Buyer Barn	Total Market- Transit	Date First Sick	Morbidity ^a		Effective Sickness Index	Days to Regain Purchase Weight	Gain First 30 Days	Gain First 56 Days	Gain After 140 Days			
						Number of Days Sick	Number Sick								
Year (Y)	1	956.78**	317.67**	648.11**	219.58	40.07	1.92	1.92	6.34	1059.88	336.57	1084.78			
Breed/Year (BY)	6	63.75	72.74	48.26	57.24	25.02	95.86*	95.86*	26.12	324.23	369.47	1018.25			
Farm/BY	42	58.20**	82.72***	77.72***	50.88	31.23	30.70	30.70	78.60	394.12***	525.72***	994.39***			
Treatment	2	4597.87***	2910.12***	78.42	8.90	8.67	12.15	12.15	225.60*	885.15**	690.66*	1156.20			
Size															
Linear	1	563.20***	4.33	3110.23**	17.75	282.90**	446.18***	446.18***	148.51	3290.68***	6880.83***	6634.60***			
Quadratic	1	111.48	.16	154.92*	1.04	83.10	4.14	4.14	40.91	192.58	909.45*	2208.46*			
Shape															
Linear	1	43.58	61.53	212.76*	131.24	180.05*	107.19*	107.19*	165.79	923.54**	2190.41***	4251.70**			
Quadratic	1	53.27	58.15	20.67	5.48	16.25	.33	.33	1.95	493.45	709.65*	866.05			
Residual		34.06	32.60	38.25	54.13	40.76	30.11	30.11	71.25	152.45	189.98	507.54			
Residual df		402	402	402	201	201	395	395	387	387	387	387			
R ²		.534	.455	.424	.218	.228	.266	.266	.142	.303	.362	.305			

^a Morbidity parameters were described in Table 3

Note: * P < .05, ** P < .01, *** P < .001.

TABLE 8

LEAST-SQUARES MEANS OF YEAR, BREED OF CALF, FARM OF ORIGIN, AND COEFFICIENTS OF PARTIAL REGRESSION OF THE RESPONSE VARIABLES ON CALF SIZE AND SHAPE WITH PRE-TRANSIT TREATMENT HELD CONSTANT

Market-Transit Weight Change, kg				Morbidity				Days to Requit Purchase Weight	Feedlot Gain, kg		
Auction Barn	Order-Buyer Barn	Total Market-Transit	Date First Sick	Percentage of Calves Sick	Number Days Sick	Effective Sickness Index	0-30 Days		0-56 Days	0-140 Days	
Year:											
1976	-10.99 ^b	4.50 ^b	-22.69 ^b	7.37	58.27	6.59	3.84	10.79	41.80	75.56	173.62
1977	-16.38 ^c	6.48 ^c	-27.42 ^c	4.21	52.25	8.21	4.29	11.90	45.54	70.43	165.70
Breed:											
Angus (A)	-13.68	5.78	-25.37	8.16	33.76	6.25	2.11 ^b	11.86	43.96	72.23	165.19
A-H Crosses	-13.78	7.92	-25.28	4.26	55.49	7.01	3.82 ^{b,c}	9.79	49.98	80.02	181.21
Hereford (H)	-12.64	3.42	-25.46	4.92	70.96	8.20	5.82 ^c	12.48	41.80	71.86	170.36
Other Crosses	-14.66	4.84	-24.12	5.82	55.72	8.13	4.53 ^c	11.26	39.25	67.88	162.26
Farm: ^{d,e}											
1	-12.85	7.78	-24.99	9.46	60.13	6.22	3.74	9.43	55.84	74.59	178.03
3	-10.95	0.94	-26.50	5.11	87.14	10.89	9.49	9.89	42.17	81.09	186.12
6	-14.75	3.72	-24.06	6.59	26.38	4.96	1.29	10.10	37.39	66.80	154.91
12	-12.87	5.87	-24.32	6.87	43.39	7.49	3.25	9.36	45.47	80.09	162.55
13	-13.91	9.99	-26.43	6.99	19.63	5.96	1.17	10.87	48.69	84.54	187.16
28	-15.41	1.92	-27.30	3.23	59.16	13.15	7.78	12.00	40.99	64.75	155.88
34	-23.05	5.67	-33.65	2.62	60.29	9.04	5.45	16.07	42.94	62.26	148.13
Regression:											
Size											
Linear	-1.39**	-.12	-3.26**	.40	-.10**	-1.64**	-1.24**	.73	3.41**	4.94**	4.92**
Quadratic	-.39	-.01	-.46*	.06	.01	-.53	-.08	.24	.53	1.14*	1.80*
Shape											
Linear	-.36	.43	-.81*	.98	.00	1.17*	.58*	.73	1.71*	2.65**	3.74**
Quadratic	.26	.28	.16	.16	.00	-.27	-.02	-.05	.81	.98*	1.09

^a Percentage of calves sick were calculated as ratios of means. Differences among breeds and farms were significant ($P < .01$) when tested by Chi Square.

^{b,c} Means within a column superscripted with different letters are different ($P < .05$).

^d Only a sample of the 21 farm means is presented in order to simplify the table. Those included are representative and indicate the variation among farms.

^e Differences between farms were significant ($P < .01$) for auction barn, order-buyer barn, total market-transit weight change, percentage of calves sick, and 30-, 56-, and 140-day feedyard gain.

Note: * $P < .05$, ** $P < .01$, *** $P < .001$.

OBB in standardizing marketing environments and strengthens the belief that improvement in OBB environment could reduce MT shrink and/or post-transit morbidity.

Total MT shrink (27.4 kg/steer) was greater ($P < .01$) in 1977 than in 1976 (22.7 kg/steer). This difference between years is similar to the difference between 2 shipments (9.2 and 6.7% shrink) reported by Britt and Henderson (1973) and reflects problems associated with improving and standardizing MT environment.

Breed of calf did not significantly affect weight change during marketing or transporting of the calves. However, calves from different farms responded differently ($P < .01$) with respect to weight change in all phases of the MT system. Subjective evaluation of FO practices did not offer a reasonable explanation for the large FO differences. For example, FO management practices at farm 6 and farm 34 were considered similar, but the total MT shrink was 24.1 (11.3%) and 33.6 kg (15.8%), respectively, and the percentage of calves sick was 26.4 and 60.3, respectively.

Calf size affected MT weight change more than did calf shape. Large calves lost more ($P < .01$) weight than small calves in the AB and during the total MT system (Figure 1). In this study, calf size was represented by a principal-component index based on weight, fatness, and frame size (4 body measurements). The relationship between calf size index and MT shrink supports earlier reports (Norman, 1974) that heavier calves lost more weight during MT. Calf weight loss in the AB was linear with size ($P < .01$); however, as size increased the rate of loss during the entire MT system increased in a non-linear fashion ($P < .05$). Tall, thin calves lost more weight ($P < .05$) during the entire market-transit scheme than short, fat calves (Figure 1).

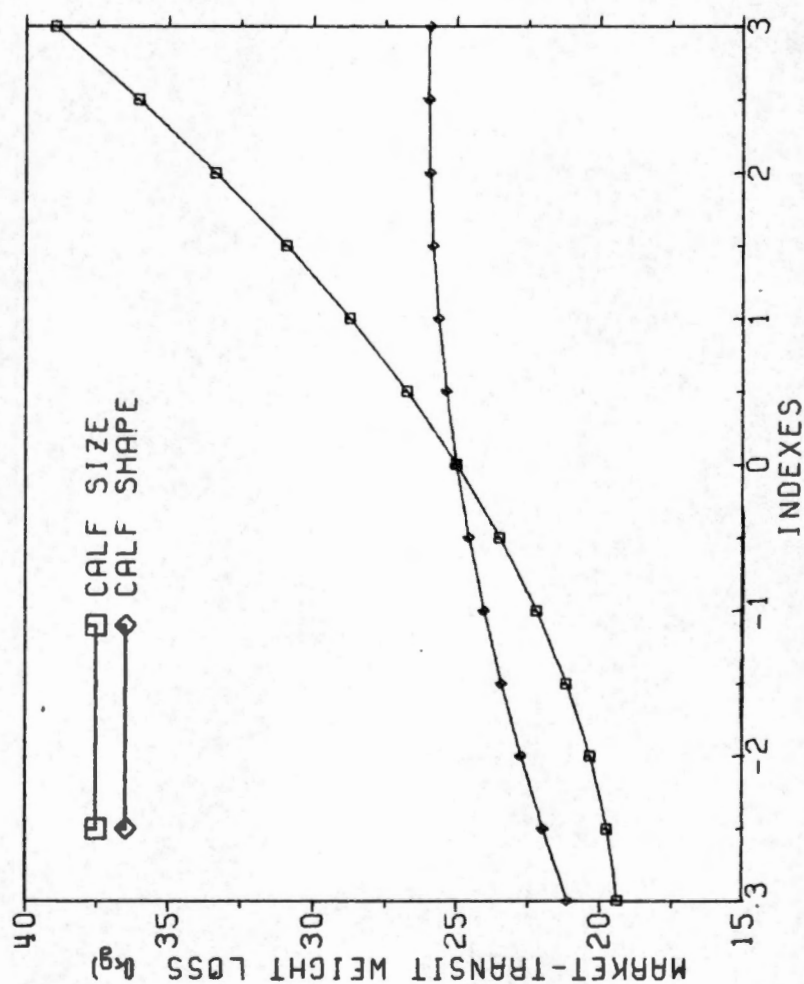


FIGURE 1. EFFECT OF SIZE AND SHAPE
ON MARKET-TRANSIT WEIGHT LOSSES

Morbidity

Analysis of variance of the subjective morbidity data (Table VII) indicates that calves became sick earlier ($P < .01$) in 1977 than in 1976. Least-squares means were 7.4 and 4.2 post-arrival days, respectively, for the 2 years (Table 8). Year did not significantly affect the number of days the calves were sick, percentage of calves sick, or ESI.

Angus (A) calves had a lower ESI ($P < .05$) than Hereford (H) and crossbred calves other than A-H. The date first sick, number of days sick, and ESI were not significantly different among FO, but percentages of calves sick were different ($P < .01$) and ranged from 19.6 to 87.1.

Neither calf size nor shape affected the date on which calves first became sick. As calf size increased, the number of days sick, ESI, and percentage of calves sick decreased linearly ($P < .01$) with size. Large-framed, heavy calves had lower ESI than small-framed, light calves (Figure 2). Tall, thin calves were sick longer and had higher ESI ($P < .05$) than short, fat calves, but shape did not effect the percentage of calves sick.

Post-Transit Performance

None of the independent variables included in this analysis (Table 7) significantly affected the number of days required for calves to regain purchase weight. Neither year nor breed affected ($P < .05$) any performance trait. However, FO affected ($P < .01$) all FL measures of performance. In general, differences in FL performance attributable to differences in FO, which were observed at 30 days, were observed also at 56 and 140 days. The wide range between farms in 30-day (37.4 vs 55.8 kg),

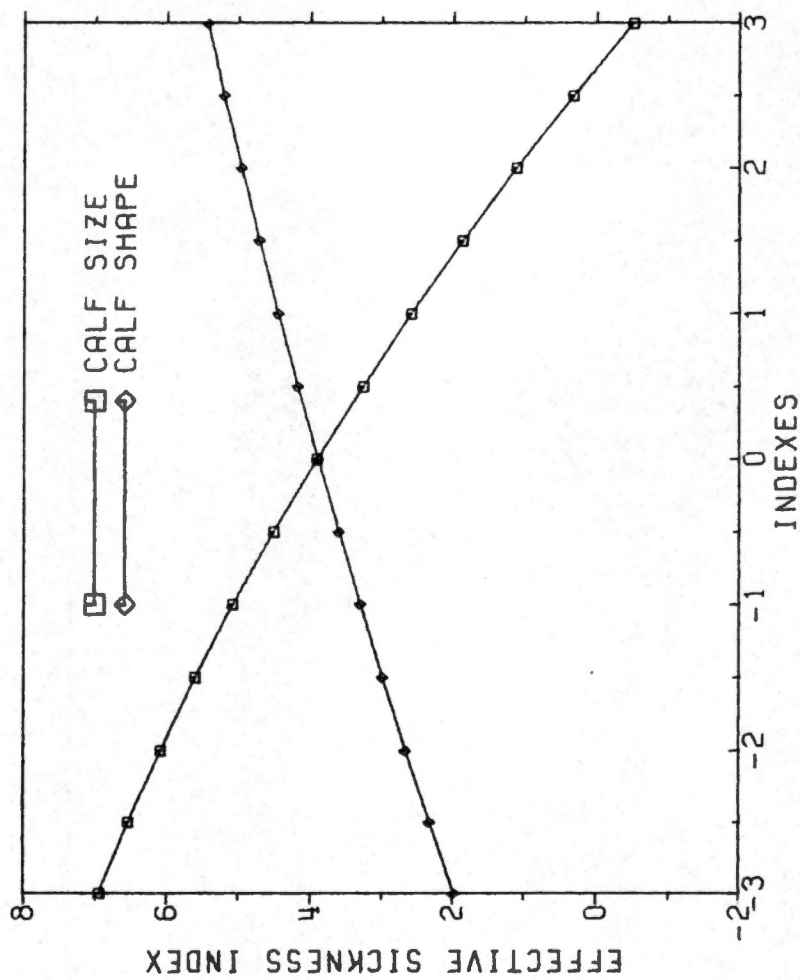


FIGURE 2. EFFECT OF SIZE AND SHAPE
ON EFFECTIVE SICKNESS INDEX

56-day (62.3 vs 84.5 kg), and 140-day (148.1 vs 187.1 kg) FL gain indicates the variability existing in feeder calves from different farms.

Large-framed, heavy calves gained more ($P < .01$) weight throughout the finishing period than small-framed, light calves. This increase in rate of gain as size increased was linear ($P < .01$) at 30 days (Figure 3), but the rate of gain to 56 and 140 days increased in a non-linear ($P < .05$) fashion as size increased (Figure 4). Calf shape had a linear effect on gain to 30 days ($P < .05$) and on total gain to 140 days ($P < .01$). Tall, thin calves gained faster ($P < .01$) than short, fat calves. The effect of shape on FL gain to 56 days was non-linear ($P < .05$).

Discussion

The fact that FO was one of the major factors affecting MT weight change and post-transit performance in this study indicates that various FO management practices and average farm genotype affected the response of calves. Although FO did not significantly affect ESI in this study, it did account for large amounts of variation. Therefore, any shipping fever research that fails to consider FO as a source of variation is omitting a large percentage of explainable variation and risks confounding response to treatments with FO effects.

Size of calves being shipped was another major factor affecting variation in the dependent variables. Although large-framed, heavy steers lost more weight than smaller framed, lighter calves during marketing and shipping, they also gained more rapidly in the feedlot. These results agree with those reported by Greathouse et al. (1969), who found that differences in shrink due to shipping were nonexistent 35 days after arrival at the feedlot. Large-framed, heavy calves were sick fewer days

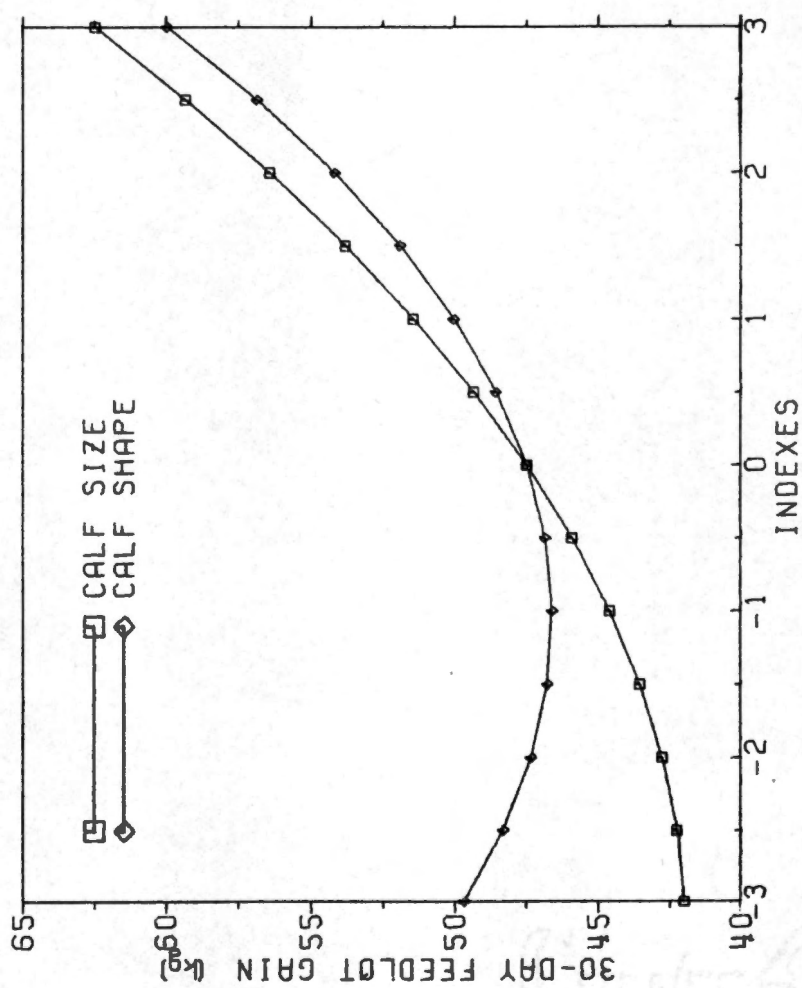


FIGURE 3. EFFECT OF SIZE AND SHAPE ON 30-DAY GAIN IN THE FEEDLOT

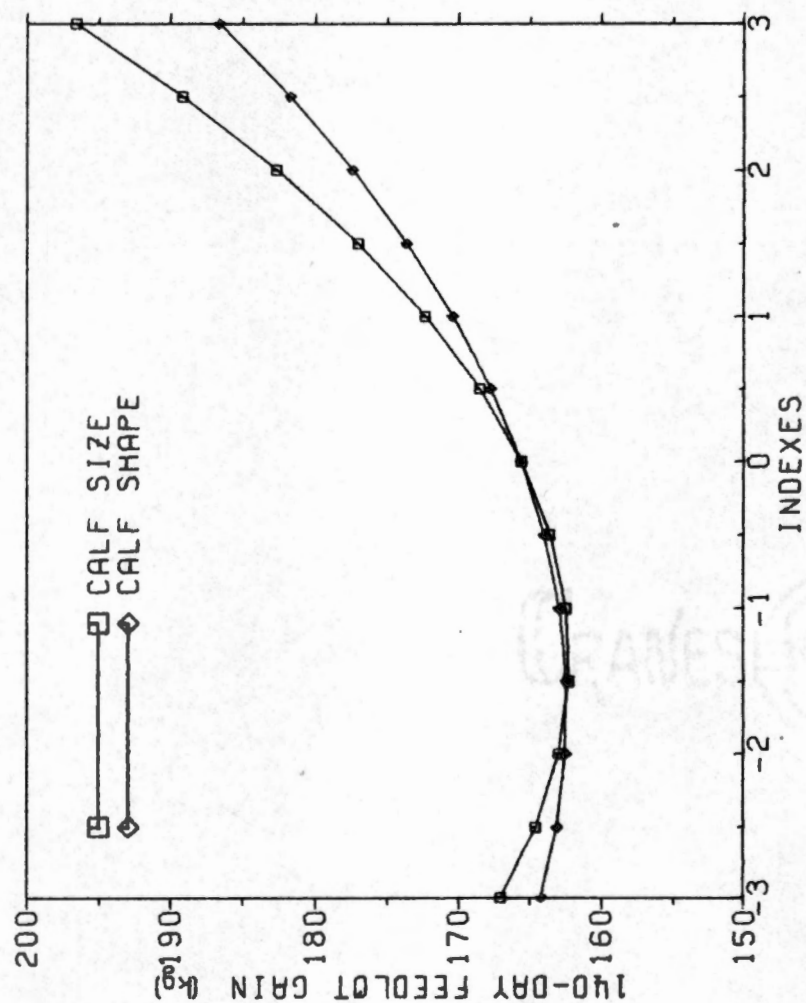


FIGURE 4. EFFECT OF SIZE AND SHAPE ON 140-DAY GAIN IN THE FEEDLOT

and had lower ESI than small-framed, light calves. However, size did not significantly affect the number of days required to regain purchase weight.

Tall, thin calves lost more weight during shipping, were sick longer, and had higher ESI than short, fat calves. However, tall, thin calves outperformed the short, fat calves in the FL. Brown et al. (1973b) reported a similar observation, *viz.*, that a wide, short phenotype in bulls at 8 months was responsible for slower gains than the narrower, longer phenotype.

The advantage of Angus (A) calves with respect to lower percentage of sick calves and fewer days sick over the Hereford (H) and crossbred calves other than A-H suggests an influence of heredity. Crossbred (A-H) steers were not different ($P < .05$) from either parent group and were approximately intermediate between the 2 parental breeds with respect to morbidity. This intermediate morbidity suggests the possibility of an additive mode of inheritance of resistance to shipping fever. If such a genetic factor does exist, the incidences of shipping fever could be reduced through selection or crossbreeding or both.

Yearly differences in environmental factors caused calves shipped in 1977 to lose more weight than those shipped in 1976. This greater weight loss occurred both in the AB and during the total MT phase. These additional weight losses could be associated with earlier FL sickness and a trend toward a greater number of days sick, higher ESI, and more days required to regain purchase weight. This variation in stress due to environment is a possible reason for the sporadic results with respect to the incidence of shipping fever reported by Koers et al. (1975) and is similar to results cited by Jensen and Mackey (1971).

CHAPTER V

MARKET-TRANSIT SHRINK AND POST-TRANSIT PERFORMANCE OF STEERS OF DIFFERENT FEEDER GRADES

A. SUMMARY

A total of 458 steers marketed and shipped in the falls of 1976 and 1977 were purchased from 21 Tennessee farms of origin. These calves were weighed on the farm 30 days prior to marketing. All calves within each year were delivered to the auction barn on the same day, where purchase weights were obtained and feeder-calf grades assigned. The normal marketing procedures for calves in the Southeast were maintained by duplicating auction-barn and order-buyer-barn environments for 24 and 72 hr, respectively. Performance data indicated that prime steers gained more than choice, good, and X steers the last 30 days during the farm of origin and that choice steers gained more than the good and X steers during the same period. However, good steers gained more weight than prime, choice, or X steers in the order-buyer barn and at all phases in the feedlot. There were no differences among calves of different grades in weight change in the auction barn, during transport, for total marketing and shipping shrink, for the number of days required to regain purchase weight, or for the days on feed during the finishing period. There were no differences among steers of the different grades in percentage sick or in date first sick; however, prime steers tended to have a higher percentage sick. Choice steers had a lower number of days sick than prime, good, or X steers. Choice steers also had a lower effective

sickness index than prime steers. There were no differences among the 4 grades in slaughter weight, back fat, kidney, pelvic, and heart fat, rib-eye area, or yield grade. Prime steers averaged in the upper high good grade (11.6) in carcass quality compared to low choice for choice, good, and X feeder steers (12.0, 12.2, and 12.6, respectively). The prime and choice steers had heavier carcasses than good steers.

B. INTRODUCTION

The Southeast is an intense cow-calf producing region, with most of the animals marketed as feeders at weaning and shipped to the Western or Northern feedlots for finishing. Feedlot managers not only desire groups of cattle which appear uniform at purchase, but also reach market condition at the same time. Therefore, it appears necessary for someone in the industry to sort the calves into outcome groups with respect to time of finishing. These groups need to be uniform in appearance for acceptability to the feedlot operators. The Tennessee State Department of Agriculture has established a statewide grading service available for any auction-barn or feeder-calf seller desiring their services. The Tennessee Department of Agriculture graders sort all thrifty calves into 4 feeder calf grades, referred to as prime, choice, good, and X. Tennessee organized feeder-calf sales use this service to sort calves into uniform lots by weight and sex groups. McLaren et al. (1971) fed calves sorted by Tennessee Department of Agriculture graders and observed differences among the grades with respect to feedlot performance.

The objectives of this study were to evaluate market-transit shrink, feedlot performance, carcass traits, and morbidity patterns of feeder calves of different grades.

C. EXPERIMENTAL PROCEDURES

Pre-Transit

During the falls of 1976 and 1977, 458 steer calves, ranging in weight from 300 to 650 lb, were purchased from 21 Tennessee cow-calf producers. The steers were weighed at the farm of origin 30 days before being transported to the auction barn.

Within each year, all calves were transported on the same day to the Algood Livestock Market in Algood, Tennessee, where individual purchase weights were taken and feeder-calf grades assigned. The feeder-calf grades were assigned by Tennessee Department of Agriculture graders using the same criteria as those used in Tennessee organized feeder-calf sales. During the first 24 hr in the barn, auction-barn environment was maintained by keeping the calves in close confinement without feed and water (Billingsley *et al.*, 1979c). At the end of the auction-barn phase, steers were reweighed to determine auction-barn weight loss. During the last 72 hr in the barn, order-buyer-barn environment was maintained by increasing pen space allowance and providing access to feed and water. After 72 hr in the order-buyer barn, the steers were weighed and transported by truck 960 miles to the USDA Southwestern Great Plains Research Center at Bushland, Texas. Total time in transit ranged from 26 to 34 hr.

Post-Transit

Immediately after unloading, the steers were weighed, branded, and assigned to pens. All calves were given free access to a 50%-concentrate starter diet. Grass hay was provided at a level of 2.0 lb/steer/day

for 2 days. On feedlot day 15, the diet was changed to a 75%-concentrate intermediate diet, and on feedlot day 25 the diet was changed to a 90%-concentrate finishing diet.

On feedlot day 38, all steers were implanted with 30 mg of diethylstilbestrol and vaccinated against blackleg, malignant edema, hemophilus, and enterotoxemia. Steers were weighed on feedlot days 0, 7, 14, 30, 56, and 140. Individual steers were slaughtered when their back fat was visually appraised to be one-half inch.

Morbidity

The steers were examined daily, and those that were subjectively determined to be morbid were placed in sick pens, where they continued to receive the same ration as their pen mates plus hay *ad libitum*.

The morbidity parameters used in this study were percentage of calves sick, date first sick, number of days sick, and effective sickness index. The percentage of calves sick represents the fraction of the steers in a given classification that were subjectively determined to be sick. The date first sick and the number of days sick are the number of days after arrival in the feedlot when a steer was first placed in the sick pen and the number of days a steer spent in the sick pen. Both of these variables include only those steers that were subjectively determined to be sick and that were exhibiting signs of shipping fever. The effective sickness index was calculated by multiplying the percentage of sick steers in a classification by the mean number of days steers in that classification were sick.

Statistical Analysis

All means reported are least-squares means of the dependent variable by feeder-calf grades adjusted for weight of steer. Differences between means were determined by paired T-tests.

D. RESULTS AND DISCUSSION

Mean performance during various segments of the market-transit and finishing phases is presented, by feeder-calf grade, in Table 9. Prime steers gained significantly more weight during the last 30 days on the farm of origin than choice, good, or X steers. Choice steers gained 14 lb more than good steers and 17 lb more than X steers during the last 30 days on the farm of origin. Differences in gain at the farm of origin could have improved the overall appearance and thereby influenced the evaluation of a calf. According to Billingsley et al. (1979a), prime steers were fatter than other steers, and good steers were thinner. Differences in gains during the last 30 days at the farm of origin could have accounted for part of the difference in fatness and indirectly influenced the grade assigned to the steers.

Auction-barn weight losses were not different among steers of various feeder grades. However, during the 72 hr in the order-buyer barn, good steers gained 10 lb more than prime steers, 6 lb more than choice steers, and 7 lb more than X steers. The higher order-buyer-barn gains of good steers could possibly be due to compensation for the lower gains of these steers during the last 30 days at the farm of origin. Another possible explanation is that the dams of good steers may have milked for a shorter lactation or may have been lower milk producers

TABLE 9

MEAN PERFORMANCE DURING THE LAST 30 DAYS AT THE FARM OF ORIGIN,
DURING THE MARKET-TRANSIT PHASE, AND IN THE FEEDLOT^a

Location	Feeder-Calf Grades			
	Prime	Choice	Good	X
Farm of Origin				
Gain last 30 days at the farm of origin, lb	55 ^b	42 ^c	28 ^d	25 ^d
Market-Transit Weight Changes				
Auction barn, 24 hrs, lb	-26	-28	-28	-27
Order-buyer barn, 72 hrs, lb	6 ^c	10 ^c	16 ^b	9 ^c
Truck, 24 to 36 hrs, lb	-36	-38	-42	-39
Total shrink, lb	-56	-56	-55	-56
Feedlot Gain, Lb				
0 to 30 days	86 ^d	95 ^c	107 ^b	90 ^{c,d}
0 to 56 days	153 ^d	161 ^c	171 ^b	159 ^{c,d}
0 to 140 days	361 ^c	369 ^c	383 ^b	360 ^c
Number of Days Required to Regain Purchase Weight				
	12	11	11	12
Number of Days on Feed in Feedlot				
	205	205	205	213

^aWeight was held constant statistically.

^{b,c,d}Means in the same row superscripted with different letters are different ($P < .05$).

than the dams of the other steers. The stress of weaning and marketing could be less drastic on steers accustomed to increased forage consumption to supplement a decreased milk supply from the dam. Since they are almost completely weaned and accustomed to eating a forage diet, the physical effect on the rumen and a psychological effect were probably less. There were no significant differences in transit weight loss (weight loss during transport from Algood to Bushland) among calves of different feeder grades. However, differences in mean truck weight loss among steers of various feeder grades were almost identical to the differences among steers of different feeder grades in mean weight loss in the combined auction barn and order-buyer barn. There was no difference in shrink during marketing and transit among the steers of the 4 feeder-calf grades.

Feedlot gain was measured at 30, 56, and 140 post-arrival days. A similar pattern of gain was observed during all periods. Good steers gained more rapidly than prime, choice, or X steers during all 3 feedlot periods. Choice steers gained faster than prime steers after 30 and 56 days and held an 8-lb, nonsignificant advantage at 140 days. These feedlot gains were similar to results reported by McLaren et al. (1971). Prime and X steers exhibited similar growth rates during all periods in the feedlot.

The number of days required to regain purchase weight was defined as the feedlot day on which a steer's feedlot weight equalled its arrival-auction-barn weight. While X steers tended to stay on feed longer than the other steers, there were no significant differences among steers of the different feeder grades in the number of days on feed, when they were visually determined to be at a low choice slaughter grade.

The measures of feedlot morbidity used in this study are reported in Table 10. Feeder-calf grade did not significantly affect the percentage of sick calves or the date on which the calves were first sick. However, 56% of the prime steers were subjectively determined to have shipping fever, compared to 46% of the choice steers, 45% of the good steers, and 41% of the X steers. Choice steers were sick fewer days (7.2) than prime (9.4), good (8.4), and X (9.1) steers. Choice steers had a lower effective sickness index (3.2 vs 5.3) than prime steers, with good and X steers tending to have lower effective sickness indexes than steers in the prime feeder grade.

Means of carcass characteristics by feeder-calf grade are presented in Table 11. Differences in weight at slaughter, fat cover over the loin between the 12th and 13th ribs, percentage kidney, pelvic-heart fat, rib-eye area, and yield grade were not significant among feeder-calf grades. Good steers produced lighter carcasses than either prime or choice steers. However, prime feeder steers produced carcasses (at the end of the finishing period) that averaged slightly below low choice in quality grade compared to mean carcass grades of low choice or slightly higher for choice, good, and X feeder steers. Also, prime steers tended to have higher yield grades than the choice, good, or X steers.

The results reported herein indicate that good or choice feeder steers give more satisfactory results in a finishing operation and, therefore, should be the steers for which the highest prices were paid. However, the summary of Tennessee organized feeder-calf sales reported prime, choice, and good steers to average \$69.99, \$68.80, and \$66.77/cwt, respectively, in 1978 (Rawls, 1979). X steers performed similarly to

TABLE 10
MEAN FEEDLOT MORBIDITY^a

Parameter	Feeder-Calf Grade			
	Prime	Choice	Good	X
Percent calves sick	56.44	45.98	44.72	40.82
Feedlot date calves were first sick	5.66	6.52	6.02	5.24
Number of days sick	9.39 ^b	7.22 ^c	8.41 ^b	9.07 ^b
Effective sickness index	5.27 ^b	3.21 ^c	3.80 ^{c,b}	3.71 ^{c,b}

^aWeight was held constant statistically.

^{b,c}Means in the same row superscripted with different letters are different ($P < .05$).

TABLE 11
CARCASS TRAITS^a

Parameter	Feeder-Calf Grade			
	Prime	Choice	Good	X
Slaughter weight, lb	959	957	952	936
Carcass weight, lb	615 ^d	605 ^d	594 ^e	598 ^{d,e}
Back fat, inches	.60	.61	.57	.60
KHP, percent ^b	2.79	2.85	2.92	2.92
Marbling	4.40 ^d	4.60 ^e	4.80 ^e	4.90 ^e
Quality Grade ^c	11.60 ^d	12.00 ^e	12.20 ^e	12.60 ^e
Rib-eye, square inches	11.50	11.60	11.40	11.90
Yield Grade	3.20	3.20	3.10	3.00

^aWeight was held constant statistically.

^bKHP = Kidney knob, heart, and pelvic fat.

^cLow choice = 12.00.

^{d,e}Means in the same row superscripted with different letters are different ($P < .05$).

steers from the other 3 feeder grades but were discriminated against by the buyers. Some of this discrimination could be due to the fact that X steers do not finish as uniformly as those of other grades and that often they produce lighter carcasses. The name of this feeder grade, X, suggesting an unknown quality, may result in negative "feedback" to potential buyers. If this is true, a more descriptive name for the present X grade could improve the prices paid for these calves. These data suggest that although X-grade calves do not gain as fast in the feedlot as other calves, their performance indicates that they have utility in many feeding programs.

CHAPTER VI

A DESCRIPTION OF FEEDER-CALF GRADES BY BODY MEASUREMENTS AND SIZE AND SHAPE INDEXES

A. SUMMARY

A total of 458 steer calves were purchased from 21 Tennessee feeder-calf producers in the falls of 1976 and 1977. The calves on each farm were weighed, and height, length, depth, width, and back fat cover were measured on the farm of origin 30 days prior to marketing. All calves within each year were transported to an auction barn on the same day, where they were immediately weighed and graded by Tennessee State Department of Agriculture feeder-calf graders. The body measurements were later used to construct size and shape indexes through principal-component analysis, as well as some simple indexes constructed by linear combinations of various body measurements. Prime steers were longer and taller than choice or X steers. Good steers were not significantly different in height or length from steers in any of the other grades. There were no differences among grades in depth or in length to height ratio. Prime, choice, and X steers were similar in width and shape, with good steers being narrower and having a larger shape index value than steers of the other 3 grades. Prime steers carried more fat and had a larger body volume than steers in the other 3 grades. Choice and X steers were similar in back fat cover and body volume, while good steers were the thinnest and had the smallest body volume. The size index values for good and X steers were similar, being smaller than the size

index value of either prime or choice steers. Prime steers had a larger index than did choice steers. The length to fat ratio increased as grades went from prime to good, with X steers being intermediate between prime and choice steers and not significantly different from either group.

B. INTRODUCTION

The objectives of a feeder-calf grading system are to classify feeder cattle into groups that are similar in appearance and/or to sort them into groups such that calves in each group will finish at about the same time. The United States Department of Agriculture (1979) suggested that frame size and muscle thickness are the 2 most important factors in identifying feeder cattle of economic value. However, Lidvall (personal communication) found that subjective muscle scores were of little value in predicting feedlot time required for a steer to reach slaughter finish or in predicting carcass characteristics when steers were fed to a constant fat thickness.

The Tennessee organized feeder calf sales have used a grading system for several years in an attempt to offer feedlot operators more uniformly desirable groups of calves. The Tennessee organized feeder-calf sales use graders trained by and working for the Tennessee State Department of Agriculture. The 4 primary grades--prime, choice, good, and X--used by the Tennessee State Department of Agriculture were described by Billingsley et al. (1979b).

The purpose of this study was to evaluate the effectiveness of the current Tennessee State Department of Agriculture grading standards in identifying cattle of different frame sizes and body shapes.

C. EXPERIMENTAL PROCEDURES

General

During 1976 and 1977, 458 steer calves, weighing 300 to 650 lb, were purchased from 21 Tennessee feeder-calf producers. The calves on each farm were weighed, estimates of back fat thickness were obtained, and body dimensions were measured, 30 days before the calves were transported to an auction barn. The body dimensions measured were height at withers, width at the point of shoulder, depth of body at chest, and length from the anterior end of the first thoracic vertebra to the posterior prominence of the pin bone.

On the same day each year, all calves were transported to a commercial auction barn in Algood, Tennessee, where purchase weights were taken and feeder-calf grades were assigned. The feeder-calf grades were assigned by 2 Tennessee State Department of Agriculture graders working together. The grading standards used in this study were the same as those used in Tennessee Demonstrational sales and other graded feeder-calf sales. All calves were subjected to normal auction-barn and order-buyer-barn environment and were then loaded onto trucks and transported 960 miles to the USDA Southwestern Great Plains Research Center at Bushland, Texas. On arrival at the feedlot, all calves were placed on a 50%-concentrate starter ration which was gradually changed to a 90%-concentrate finishing ration by feedlot day 25.

Statistical Analysis

A multivariate technique, principal-component analysis, was used to generate orthogonal indexes to define calf size and shape (Table 12).

TABLE 12
SCORE COEFFICIENTS FOR PRINCIPAL COMPONENTS OBTAINED
FROM BODY MEASUREMENTS OF STEERS

Body Measurement	Coefficients for Principal Component Number		Principal Component	Description of Steers With Large Positive Indexes
	1	2		
-----Steers Shipped in 1976-----				
Weight	.24802	-.03937	1	Large-framed and heavy
Height	.20245	.52301		
Length	.23112	.20307	2	Narrow, tall, and thin
Depth	.21485	.25305		
Width	.15725	-.77249		
Fat	.19073	-.39819		
-----Steers Shipped in 1977-----				
Weight	.23771	-.03895	1	Large-framed and heavy
Height	.22133	.30720		
Length	.21856	.20607	2	Tall and thin
Depth	.20312	.16890		
Width	.19959	-.13632		
Fat	.11525	-.96204		

This technique has been used previously by Brown et al. (1973a) and McCurley (1977) to analyze similar body measurements. In addition to the principal-component indexes, individual body dimensions and linear combinations of body dimensions and fat thickness were used as simple size and shape indexes. These indexes were length-height ratio, length-fat ratio, and body volume (body length x body depth x width at the shoulder). These index values were used to evaluate variation among calves within the different feeder grades with respect to frame size and body shape. A least-squares regression procedure was used to hold weight constant and evaluate differences among feeder grades.

D. RESULTS AND DISCUSSION

Body Measurements

Overall means and their standard errors are shown in Table 13. Mean body measurements and fat with weight statistically held constant are presented by feeder grade in Table 14. Prime steers were taller at the withers than choice or X steers but were not different in height at the withers from good steers. In agreement with the above, prime steers were longer bodied than choice or X steers and similar in length to good steers. The above results indicate that Tennessee State Department of Agriculture feeder-calf graders are separating calves into grades by differences in frame size, prime and good steers being similar in frame size and choice and X steers smaller framed than prime steers. X steers were the shortest bodied steers of the 4 grades, in accordance with the concept that the X grade is composed of the shorter, more compact type of steers. There were no significant differences among steers of the

TABLE 13
OVERALL MEANS OF BODY MEASUREMENTS

Body Measurement	Mean	SE
Height, cm	96.1	.17
Length, cm	95.3	.15
Depth, cm	49.0	.10
Width, cm	32.9	.11
Fat, mm	2.1	.05

TABLE 14
MEAN BODY MEASUREMENTS BY FEEDER-CALF GRADE^a

Measurement	Prime	Choice	Good	X
Height, cm	96.8 ^b	95.8 ^c	96.3 ^{b,c}	95.3 ^c
Length, cm	95.9 ^b	95.1 ^c	96.6 ^{b,c}	93.9 ^d
Depth, cm	48.9	49.0	49.4	48.6
Width, cm	33.4 ^b	33.0 ^b	31.4 ^c	33.5 ^b
Fat, mm	2.3 ^b	2.1 ^c	1.5 ^d	2.0 ^c

^aWeight was held constant by statistical methods.

^{b,c,d}Means in the same row superscripted with different letters are different ($P < .05$).

different grades in depth of chest. Good steers were not as wide at the point of the shoulders as prime, choice, or X steers. Good steers were thinner, with a mean fat thickness at the 12th rib of 1.5 mm, compared to 2.3, 2.1, and 2.0 mm for prime, choice, and X steers, respectively. Prime steers had slightly more fat thickness over the loin at the 12th rib than choice and X steers. The differences among grades in width and fat indicate that graders are separating calves on a thickness criterion.

Evaluation of Grades by Indexes

Mean size and shape index values for each feeder calf grade are presented in Table 15. The size and shape indexes were derived by a principal-component procedure. Based on their size index values, prime steers were larger than steers in any of the other grades, and choice steers were larger than good or X steers. The differences in the size index values indicate that prime steers were largest in their overall body dimensions. Choice steers were larger than good and X steers, which were approximately the same in overall body size. The good steers were not as wide or fat as steers in the other grades and, therefore, their size index values are smaller but do not represent differences in frame size as much as differences in thickness. Body shape was similar among prime, choice, and X steers; however, good steers were taller, thinner, and narrower, possessing larger shape indexes than steers in the other 3 grades.

Evaluation of Grades by Ratios

Mean ratios by feeder calf grades are presented in Table 15. There were no differences among feeder grades in length to height ratio.

TABLE 15
MEANS OF INDEXES AND RATIOS BY FEEDER-CALF GRADES^a

Body Measurement	Prime	Choice	Good	X
Indexes				
Size	14 ^b	2 ^c	-7 ^d	-10 ^d
Shape ^e	-19 ^c	-12 ^c	69 ^b	-34 ^c
Ratios				
Length/Height	0.99	0.99	0.99	0.99
Length x Depth x Width ^f	15.79 ^b	15.47 ^c	15.08 ^d	15.33 ^c
Length/Fat	48.69 ^b	54.18 ^c	70.27 ^d	51.58 ^{b,c}

^aWeight was held constant by statistical methods.

^{b,c,d}Means in the same row superscripted with different letters are different ($P < .05$).

^eActual value = table value $\times 10^{-2}$.

^fActual value = table value $\times 10^4$.

X steers were smaller in both length and height but were not short-bodied for their height, as indicated by the length-to-height ratio. It was assumed that the body of a steer was best represented by a cube, and the volume was calculated as length x depth x width. Choice and X steers were of approximately the same body volumes and had a smaller mean body volume than did prime steers but a larger mean body volume than that of good steers. While choice and X steers were of approximately the same body volume, choice steers were longer and X steers wider at the shoulders. Good steers had the smallest body volumes in this study due to being narrower at the point of the shoulder but were as tall and deep-bodied as prime, choice, and X steers. A length-to-fat ratio was calculated and found to be 48.7 for prime, 54.2 for choice, and 70.3 for good steers, with X steers (51.6) midway between prime and choice steers and not significantly different from either group. These differences in length-to-fat ratio indicate that Tennessee State Department of Agriculture feeder-calf graders are separating calves into groups based on height and fat. Height is an indicator of frame size, while differences in fat often appear as differences in thickness.

Conclusion

The results of this study strengthen the idea that Tennessee State Department of Agriculture feeder-calf graders are separating calves into the current grades on the basis of size and shape. Prime calves were tall, long-bodied, thick, fat calves that are intermediate in depth (Table 16). Choice steers were intermediate in all body dimensions. Good steers were narrow, thin, deep-bodied, and intermediate in height and length. X steers were thick, short, low, wide, and

TABLE 16

RANK OF FEEDER-CALF GRADES^a BY INDIVIDUAL BODY MEASUREMENTS,
RATIOS, AND PRINCIPAL-COMPONENT INDEXES

Method of Ranking	Rank ^b			
	1	2	3	4
Individual body measurements				
Length of body	P ^c	G ^{c,d}	C ^d	X ^e
Height at withers	P ^c	G ^{c,d}	C ^d	X ^d
Depth of body	G	C	P	X
Width of shoulders	X ^c	P ^c	C ^d	G ^d
Fat over the 12th rib	P ^c	C ^d	X ^d	G ^e
Ratios				
Length/height	P	C	G	X
Volume ^f	P ^c	C ^d	X ^d	G ^e
Length/fat	G	C	X	P
Indexes				
Size	P ^c	C ^d	G ^e	X ^e
Shape ^g	G ^c	C ^d	P ^d	X ^d

^aFeeder-calf grades assigned by Tennessee State Department of Agriculture graders. P, C, G, and X represent prime, choice, good, and X (compact) grades, respectively.

^bA ranking of 1 indicates the highest value for that particular trait.

^{c,d,e}Grades in the same row superscripted with different letters are different ($P < .05$).

^fVolume = length x depth x width.

^gLarger shape indexes indicate the longer, taller, thinner calves.

relatively fat. The largest differences between good, prime, and choice steers was in body shape. X steers were similar in condition and body volume to prime and choice steers.

CHAPTER VII

SUMMARY

The objectives of this study were to determine effects of year, breed, farm of origin, feeder-calf grade, and calf size and shape indexes on market-transit shrink, feedlot performance, morbidity patterns, and carcass traits of stressed feeder steers. Indexes of calf size and shape were the result of principal-component analysis.

The data were obtained on 458 steer calves, weighing 137 to 296 kg, purchased in the falls of 1976 and 1977 from 21 Tennessee farms of origin. Thirty days prior to marketing all calves were weighed and measured at the farm of origin. The body measurements taken were height, length, depth, width, and back fat over the 12th rib. These weights and body measurements were used in a principal-component analysis to determine weighting factors for calculating individual calf size and shape indexes.

Each year all calves were transported 40 to 100 km on the same day to the auction barn, where purchase weights were taken. Feeder-calf grades were assigned by 2 Tennessee State Department of Agriculture feeder-calf graders. During the first 24 hr in the barn, auction-barn environment was duplicated by keeping calves in close confinement without feed and water. Calves were reweighed at the end of the auction-barn phase. Order-buyer-barn environment was duplicated during the last 72 hr in the barn by allowing steers 1.8 to 2.3 m² each and access to feed and water. After the order-buyer-barn phase, the calves were weighed and transported by truck 1,600 km to the USDA Southwestern Great Plains Research Center at Bushland, Texas.

Immediately after unloading at the feedlot, calves were weighed, branded, and assigned to pens. All calves were given free access to a 50%-concentrate starter diet. In addition, grass hay was provided at a level of .9 kg/steer/day for 2 days. One-half of the pens received a B-vitamin supplement in the starter ration for the first 14 days post-arrival. On feedlot day 15, the ration was changed to a 75%-concentrate ration, and on feedlot day 25 the ration was changed to a 90%-concentrate finishing ration.

Farm of origin was a major factor affecting ($P < .01$) market-transit weight change and post-transit performance. Percentage of calves sick ranged from 19.6 in calves from farm 13 to 87.1 in calves from farm 3. Large-framed, heavy calves lost more ($P < .01$) weight in the auction barn and during the total market-transit scheme, but had a smaller percentage sick, were sick fewer total days, had a lower effective sickness index, and gained faster in the feedlot than small-framed, light calves. Tall, thin calves lost more weight in market-transit, were sick longer, and had a higher effective sickness index, but gained faster in the feedlot than short, fat calves. Angus (A) calves had a lower percentage sick (33.8) and effective sickness index (2.11) than Hereford (H) (70.1 and 5.82, respectively) and crossbred calves other than A-H (55.7 and 4.53, respectively). Good-grade steers gained more weight than prime, choice, or X steers in the order-buyer barn and at all phases in the feedlot. The prime steers tended to have a higher percentage sick. The grading system used by the Tennessee State Department of Agriculture separated the calves into groups by frame size and thickness. Calves shipped in 1977 lost more ($P < .01$) weight in the auction barn and during

the total market-transit scheme but gained more in the order-buyer barn than those in 1976, the mean weight changes (kg) being -16.38, -27.42, 6.48, and -10.99, -22.69, 4.50 in 1977 and 1976, respectively.



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