The Effect of Assembly and Transit Stressors on Plasma Fibrinogen Concentration of Beef Calves

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ABSTRACT

Plasma fibrinogen concentration was measured in beef calves at various points within the system presently used to assemble, market and transport calves from one production point to another in order to determine the effect of the stresses encountered. A short haul of 160 km immediately after weaning did not significantly elevate fibrinogen concentration above the pretransit values. Yearling steers transported 400 km and confined in unfamiliar surroundings for 15 h did have an elevated ($P < 0.01$) concentration of fibrinogen, but this increase was not significantly different from that of steers which were confined but not transported, thus confinement may be a significant portion of the stress associated with transit. The change in plasma fibrinogen concentration during assembly and transit was dependent upon the farm from which the calves originated. The magnitude of the change in fibrinogen concentration as a result of assembly and transit varied between the years studied. In one year pretransit assembly for ten days resulted in a higher fibrinogen concentration before and after transit than assembly for four days, but no difference was noted between the two groups in the second year. Bovine plasma fibrinogen concentration does increase in response to the stresses associated with assembly and transit. The stress of fasting and housing in unfamiliar surroundings also increase bovine plasma fibrinogen concentration and are present in the assembly and transit system. These two stresses may account for a majority of the stress associated with marketing and transit. The response of beef calves to the marketing and transit system varied between years.

Key words: Feeder calves, stress, fibrinogen, transit, shipping fever.

RÉSUMÉ

Cette expérience consistait à déterminer la teneur du plasma en fibrinogène, chez des veaux de boucherie, à diverses étapes du système présentement utilisé pour les rassembler, les commercer et les transporter d'un point de production à un autre. On voulait ainsi déterminer l'effet des stress qu'engendrent ces opérations. Un trajet de 160 km, immédiatement après le sevrage, n'éleva pas de façon significative la concentration plasmatique du fibrinogène au-dessus de celle d'avant le transport. Les bouvillons âgés d'un an, transportés sur une distance de 400 km et confinés dans un environnement étranger, durant 15 heures, affichèrent une concentration élevée du fibrinogène plasmatique ($P < 0,01$), mais cette élévation ne s'avéra pas sensiblement différente de celle des bouvillons qui furent confinés sans toutefois être transportés. Le rassemblement représenterait par conséquent une portion appréciable du stress relié au transport. Les variations de la concentration du fibrinogène plasmatique, durant le rassemblement et le transport, dépendaient de la ferme d'où provenaient les veaux. L'importance des variations de la concentration du fibrinogène plasmatique, consécutives au rassemblement et au transport, varia d'une année à l'autre. Par exemple, le rassemblement qui, une année, se prolongea dix jours, avant que s'effectue le transport, provoqua une élévation de la concentration du fibrinogène plasmatique, avant et après le transport, comparativement à un autre rassemblement qui ne dura que quatre jours; l'année suivante, un procédé similaire ne provoqua aucune différence. La concentration du fibrinogène plasmatique augmente chez les bovins qui subissent le stress inhérent à un rassemblement suivi d'un transport; le stress du jeûne et du séjour dans un environnement étranger augmente aussi la concentration de leur fibrinogène plasmatique et il accompagne le système actuel de rassemblement et de transport. Ces deux stress expliqueraient la majeure partie de celui qui est associé au commerce et au transport. La réaction des veaux de boucherie à l'endroit du système de commerce et de transport a varié, d'une année à l'autre.

Mots clés: veaux d'engraissement, stress, fibrinogène, transport, fièvre du transport.

INTRODUCTION

Respiratory disease is a major cause of mortality in beef calves recently transported from cow-calf farms to feedlots (1). Transportation is a severe stress and can predispose the calves to bovine respiratory disease (shipping fever) (2,3). Other contributing factors present within the marketing system are the stresses associated with weaning (4), changes in the environment (5) and alteration in the social structure (6,7). Stress is physiologically mediated by an increase in the activity of the adrenal gland, which increases the synthesis of cortisol. Studies using rabbits indicate that the magnitude

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and duration of activity of the adrenal gland is reflected in changes in plasma fibrinogen concentration (8). Thus plasma fibrinogen concentration changes may be an indicator of the magnitude and duration of stresses within the assembly and transit systems. The objective of this research was to determine the effect of weaning, pretransit assembly, pretransit management and transit on plasma fibrinogen concentration of beef calves.

MATERIALS AND METHODS

EXPERIMENT 1

One hundred and thirty nine crossbred steer calves, weighing an average of 200 kg, were monitored for changes in plasma fibrinogen concentration as the result of the stress imposed by transportation immediately after weaning. All calves were of a three breed cross resulting from the matings of cross-bred dams and purebred bulls. Dams and calves were maintained on native range from birth until weaning in the fall of each year. Calves were weaned at an average age of 205 d in October of 1976 (46 calves), August of 1977 (39 calves) and October of 1977 (54 calves). Calves in groups 1 and 3 were sired by Braham and Charolais bulls. Calves in group 2 were sired by Red Poll bulls.

Preshipment samples were collected shortly after the calves were separated from the dams, between 0800 and 1000 h and prior to being transported in livestock trailors towed by gasoline engine trucks from Stillwater, Oklahoma to El Reno, Oklahoma, a distance of 160 km. Postshipment samples were collected within two hours after arrival.

Four and a half milliliters of blood were collected by venipuncture, added to 0.5 mL of 3.8% sodium citrate solution, mixed and placed in ice until the plasma could be separated by centrifugation. The plasma was then removed, placed in snap-cap containers and stored at -10° C until analyzed. Fibrinogen concentration of the plasma was determined by measuring the changes in optical density during the formation of the clot after activation with thrombin (9). All fibrinogen analyses were conducted with a Lancer Fibrinogen Analyzer (Sherwood Medical Industries St. Louis, Missouri. Mention of a trade name proprietary product, or specific equipment does not constitute a guarantee or warranty by the U.S. Dept. of Agriculture and does not imply its approval to the exculsion of other products that may be suitable) and the results were expressed as g of fibrinogen per L of plasma.

Data were analyzed within each of the three shipment groups as a split plot in time (10). Breed of the sire was used as the main plots and breed of the dam as the subplots. Differences among shipment groups were then determined by using the "t-test" for unpaired observations (10,11).

EXPERIMENT 2

Plasma fibrinogen concentration changes, as the result of transit and fasting, were measured using 63 yearling steers averaging 282 kg. The steers had been purchased in November of 1978 from four different farms in Tennessee, transported to El Reno, Oklahoma and allowed to graze "Triumph" winter wheat pasture (Triticum aestivum L; IFN 2-05-182) for 152 days prior to the initiation of this experiment. On the day of transit, April 10, 1979 all calves were moved from wheat pasture to a drylot (0800 to 1130 h). Each steer was weighed and a blood sample was taken for fibrinogen analysis.

The original four farms of origin were used as blocks and steers were allotted to one of three treatment groups within each block. Control and fasted calves were deprived of feed and water from 1130 to 1400 h, while the fed group was allowed ad libitum access to a mixed ration containing 32% alfalfa pellets (IFN 1-00-063), 32% shelled corn (IFN 4-02-931), 32%, cottonseed hulls (IFN 1-01-399) and 4% soybean meal (IFN 5-04-604), which had been treated with 5 g of formaldehyde per kg of meal. At 1400 h all calves were weighed and the fasted and fed calves were loaded onto a single deck commercial livestock carrier, transported 400 km and returned to the original starting point at 1900 h. Control calves were not transported, but were fasted during this same period of time. At 1900 h on day 1 all calves were weighed and allowed to consume alfalfa hay (IFN 1-00-063) and water until 1000 h day 2 at which time a blood sample was taken for fibrinogen determination, 15 h after the end of transit period. Rectal temperature was also determined by an electronic thermometer prior to and immediately after transit.

Sample preparation and fibrinogen analysis were the same as previously described for experiment 1. The data were analyzed as a split plot in time with the four farms of origin being used as the main plots and the pretransit treatment groups used as the subplots. Differences among means were determined by least significant difference, if a significant F-value was present in the analysis of variance (10).

EXPERIMENT 3

One hundred and twenty calves, 60 in year 1 (1977) and 60 in year 2 (1978), were identified on four cow-calf farms each year in Tennessee, prior to weaning and movement from the farm of origin. Farm number 4 was the only farm common to both years. The average weight of the calves was 173 kg and 198 kg during year 1 and 2, respectively. During year 1, the calves were assembled at a commercial auction barn in Tennessee. Upon arrival at the auction barn, no feed or water was provided for the first 24 h and only 3.7 m^2 of pen space were allowed per calf. Following the initial 24 h fast, grass hay (IFN 1-03-438) and water were provided, as well as 7.4 m^2 of space per calf. This environment was maintained for 72 h before the calves were transported 1300 km to El Reno, Oklahoma. One half of the calves from each farm were assembled on November 21 and transported on November 25. The other half were assembled and transported two weeks later. Additional nonexperimental calves were comingled with the experimental calves in both loads to obtain the normal animal density associated with livestock carriers of the type (double deck, trailer capacity 100 animals) used in this experiment. During year 2 all animals were transported in one load. Upon arrival "Triumph" winter wheat pasture (Triticum aestivum; L; IFN 2-05-182) was provided during both years 1 and 2.

Plasma fibrinogen concentration was determined at the farm of origin, upon arrival at the auction barn, prior

to transit, 24 h after arrival in El Reno and at frequent intervals during the posttransit period. Sample collection and fibrinogen analysis were as previously described. Data were analyzed as a split plot over time within each of the two years. The farm of origin was the main plot and load was a replication within year 1 only. Differences among means were determined by the least significant difference method, if a significant F-value was present in the analysis of variance (10).

EXPERIMENT 4

Over a period of two years (1977 and 1978) a total of 114 calves were studied to determine the effects of the length of the pretransit assembly period on plasma fibrinogen changes. In each year calves were divided into two groups for assignment to either a four day or a ten day assembly period and one half of each assembly group received a 50% concentrate (HE) diet described by Cole *et al* (12), while the remaining calves received grass hay. The grass hay fed in 1977 was medium quality prairie hay (IFN 1-07-957) and the hay fed in 1978 was orchard grass (IFN 1-03-438).

Two loads of calves, 26 in load 1 and 28 in load 2, were purchased from an order buyer and used in year 1. The loads were transported one week apart in February 1977, 965 km by commercial livestock carrier, from Memphis, Tennessee to El Reno, Oklahoma. Nonexperimental animals were comingled with experimental calves to simulate the typical transit environment. During the second year of this experiment, 60 calves were purchased from four cow-calf farms in Tennessee as described in experiment 3, year 2. Within each of the four farms of origin, calves were randomly allotted to either the four or ten day assembly group and fed either hay or HE diet. All calves were moved as one load in November 1978, 1300 km by commercial livestock carrier, from Algood, Tennessee to El Reno, Oklahoma.

Blood samples were obtained 24 h before transit and 24 h after transit during both years, but at 10 and 20 d posttransit in year 1, and 7, 14 and 21 d posttransit in year 2. Blood samples were processed and fibrinogen concentration was determined as previously described. Data were analyzed within each year as a split plot over time; the main plot was load in year 1 and farm of origin in year 2. Subplots were the number of days assembled prior to transit, pretransit diet, posttransit management (year 1 only) and sampling period. Differences among means were determined by least significant difference, if a significant F-value occurred in the analysis of variance (10).

RESULTS

Plasma fibrinogen concentrations of crossbred calves prior to and after transit of 160 km are presented in Table I. Fibrinogen concentration was not affected ($P > 0.05$) by the stress of transit immediately after weaning within either of the three groups studied. Pretransit and posttransit fibrinogen concentrations were similar for calves in groups 1 and 2 although they were transported during different years. Calves in group 3 had a higher ($P < 0.05$) pretransit and posttransit fibrinogen concentration than calves in groups 1 or 2.

The breed of the dam had no effect on pretransit or posttransit fibrinogen concentration, but the number of animals per subplot was small. Brahman and Charolais bulls were each used to sire approximately one half of the calves in groups 1 and 3. Charolais-sired calves in group 1 had a greater ($P < 0.05$) increase of fibrinogen concentration during transit than Brahman calves. Fibrinogen levels of Charolais calves increased from 3.58 g/L to 3.76 g/L during transit or a 5.1% increase over pretransit values, while the Brahman calves only changed 0.3%, from 3.24 g/L to 3.25 g/L. Thus the breed of the calf can effect its response to stress. No differences were noted between the two sire breeds used in group 3. It was, therefore, concluded simply that transit of 160 km after weaning failed to elicit a significant increase in plasma fibrinogen of crossbred calves.

In experiment 2 the distance the calves were transported was increased from 160 km to 400 km and the posttransit blood samples were not collected until 15 h after transit in order to allow the physiological system time to respond. Fibrinogen concentrations

TABLE I. The Effect of Transit After Weaning on Plasma Fibrinogen Concentration in Beef Steers G/L

	Group 1	Group 2	Group 3
Before transit			
Mean	3.42[b]	3.46[b]	3.83[c]
SEM[a]	0.06	0.11	0.12
N	46	39	54
After transit			
Mean	3.53[b]	3.48[b]	3.86[c]
SEM	0.07	0.12	0.14
N	46	39	54

[a]Standard error of the mean
[b,c]Means in the same row with different superscripts are different ($P < 0.05$)

before or after transit were not significantly different among the three treatment groups, but the calves which were transported (fasted and fed) tended to have greater increases in fibrinogen concentration than nontransported calves. The changes in plasma fibrinogen concentration from pretransit to 15 h posttransit were dependent upon the farm of origin from which the steers were purchased 152 d earlier. As shown in Table II, fibrinogen concentration was different ($P < 0.01$) among calves from the four farms of origin prior to transit, but 15 h after transit no significant differences were noted among the calves from the four farms. Posttransit fibrinogen concentrations were higher ($P < 0.01$) than pretransit values, but calves from some farms had larger increases during this period than others.

Increases in fibrinogen concentration when animals are fasted could be the result of hemoconcentration. Since the fibrinogen concentration is expressed as g/L of plasma, as dehydration occurs the concentration of fibrinogen would increase without an increase in the absolute amount of fibrinogen. Packed cell volume (PCV) was determined at the same time as fibrinogen concentration during experiment 2. The three pretransit treatments had no effect on PCV values determined prior to or after transit, but posttransit values were higher ($P < 0.01$) than pretransit values.

The PCV values were used to adjust the original fibrinogen concentration from g per L of plasma to g per L of whole blood and are presented in Table II. The results are similar to

TABLE II. The Effects of Farm of Origin on Fibrinogen Concentration, Packed Cell Volume, Rectal Temperature and Weight Change in Yearling Steers

Item	Farm 1	Farm 2	Farm 3	Farm 4
No. of calves	16	16	14	17
Plasma fibrinogen, g/L				
Before transit	$3.04^{a} \pm 0.09$	$3.40^{ab} \pm 0.11$	$3.48^{ab} \pm 0.19$	$3.69^{b} \pm 0.09$
After transit	3.80 ± 0.11	3.97 ± 0.11	4.14 ± 0.19	4.03 ± 0.11
Packed cell volume, %				
Before transit	$41.9^{a} \pm 0.9$	$38.6^{b} \pm 0.7$	$43.2^{a} \pm 1.0$	$41.4^{ab} \pm 0.6$
After transit	$43.4^{ab} \pm 0.9$	$41.1^{a} \pm 0.7$	$45.7^{b} \pm 1.1$	$44.6^{ab} \pm 0.6$
Whole blood fibrinogen, g/L				
Before transit	$1.76^{a} \pm 0.06$	$2.08^{b} \pm 0.06$	$1.98^{ab} \pm 0.12$	$2.14^{b} \pm 0.05$
After transit	2.16 ± 0.08	2.33 ± 0.05	2.26 ± 0.12	2.22 ± 0.06
Rectal temperature, C				
Before transit	39.2 ± 0.16	39.3 ± 0.07	39.0 ± 0.04	39.2 ± 0.06
After transit	39.4 ± 0.09	39.4 ± 0.09	39.2 ± 0.06	39.2 ± 0.07
Weight lost during transit, %	3.10 ± 0.29	3.10 ± 0.27	3.17 ± 0.26	2.89 ± 0.16

[a,b]Means ± SEM in the same row with different superscripts are different ($P < 0.01$)

those obtained from the unadjusted values. These observations are in agreement with Chen *et al* (8) and Carlson *et al* (13). In their studies with rabbits, an increase in both fibrinogen concentration and PCV were noted when prostaglandins or ACTH were infused which was due to increased fibrinogen synthesis and not due to hemoconcentration.

Consumption of the pretransit diet by the fed group was very low, (0.8 kg/hd/d). As a result, little difference was anticipated between fast and fed treatment groups. Feeding of the pretransit diet did decrease ($P < 0.01$) the percent of pretransit weight lost during transit, 2.9% vs 3.9%, compared with fasting before transit. The weight lost by the calves in the fed group was not significantly different from the control steers (2.4%). The transit event also increased ($P < 0.01$) rectal temperature of the calves in both fast and fed groups, compared with those in the control group, but the changes in rectal temperature as a result of transit were dependent upon the farm of origin. All calves had an increased rectal temperature after transit except those from farm 4. The changes in rectal temperatures and the amount of weight lost during the 400 km transit event indicate that transportation was stressful.

The effects of the farm of origin on fibrinogen concentration as measured in experiment 3 are presented in Table III. During year 1 the fibrinogen concentration at the farm of origin prior to entering the marketing system ranged from 2.40 to 4.82 g/L. Calves from farm 3 had a higher ($P < 0.01$) fibrinogen concentration at this time than calves from the other three farms. Movement from the farm of origin to the assembly point resulted in an increase ($P < 0.01$) in plasma fibrinogen concentration for calves from farms 1 and 2 only. After an assembly period of four days, the fibrinogen concentration had increased in calves from all four farms, but these increases were not significantly different from those observed upon arrival at the auction barn. Fibrinogen concentrations following transit were not significantly different from those observed 24 h before transit. Fourteen weeks after arrival the plasma fibrinogen was different among the four farms of origin. The ranking of the farms at this time was different than that established before the calves were assembled. During year 1, the fibrinogen concentration of the calves from farms 3 and 4 did not significantly increase during assembly, but calves from farm 4 did have a progressive increase in plasma fibrinogen concentration from the initial identification on the farm of origin to three weeks posttransit. Thus it appears the fibrinogen synthesis control mechanism which responds to the various forms of stress encountered during assembly was dependent upon the farm of origin.

During year 1, one half of the calves from each of the four farms of origin were assembled and transported at two week intervals. The environmental temperatures at the assembly point during loads 1 and 2 were 14.7°C and 6.8°C, respectively. It was also observed that the changes in the fibrinogen concentration during assembly were more pronounced ($P < 0.01$) in load 1 than load 2.

No significant difference in plasma fibrinogen concentration due to the farm of origin, assembly or transit were detected during year 2 (Table III). There was, however, a trend for the fibrinogen concentration to

TABLE III. The Effects of Farm of Origin and Transit on Plasma Fibrinogen Concentration of Beef Steers (g/L)

	Year 1				Year 2			
	Farm 1	Farm 2	Farm 3	Farm 4	Farm 4	Farm 5	Farm 6	Farm 7
No. of calves	18	15	12	15	16	16	12	16
Sampling point:								
On the farm	$2.40^{ab} \pm 0.18$	$2.78^{b} \pm 0.08$	$4.82^{c} \pm 0.34$	$3.27^{b} \pm 0.24$	3.15 ± 0.13	3.15 ± 0.24	3.31 ± 0.22	3.39 ± 0.29
Arrival at the auction barn	$5.24^{b} \pm 0.34$	$3.90^{c} \pm 0.15$	$4.56^{bc} \pm 0.26$	$3.69^{c} \pm 0.16$	3.71 ± 0.10	3.93 ± 0.26	4.17 ± 0.68	3.30 ± 0.14
24 h pretransit	$5.30^{b} \pm 0.27$	$4.67^{bc} \pm 0.31$	$5.07^{bc} \pm 0.25$	$4.19^{c} \pm 0.17$	3.87 ± 0.11	3.42 ± 0.14	3.71 ± 0.29	3.56 ± 0.16
24 h posttransit	5.46 ± 0.32	4.52 ± 0.23	4.67 ± 0.22	4.31 ± 0.28	3.40 ± 0.19	3.51 ± 0.18	3.70 ± 0.32	4.03 ± 0.28
1 weeks posttransit					3.74 ± 0.32	3.24 ± 0.17	3.00 ± 0.22	4.56 ± 0.45
2 weeks posttransit					$3.91^{b} \pm 0.23$	$2.86^{c} \pm 0.13$	$2.94^{c} \pm 0.12$	$3.88^{a} \pm 0.32$
3 weeks posttransit	$3.85^{bc} \pm 0.12$	$3.29^{c} \pm 0.10$	$3.52^{c} \pm 0.10$	$4.47^{b} \pm 0.28$	3.64 ± 0.25	2.94 ± 0.14	2.78 ± 0.18	3.44 ± 0.35
14 weeks posttransit	$2.76^{b} \pm 0.08$	$2.40^{bc} \pm 0.10$	$2.21^{c} \pm 0.09$	$2.45^{bc} \pm 0.11$	3.68 ± 0.12	3.44 ± 0.11	3.85 ± 0.52	3.10 ± 0.15

[a]Mean ± standard error of the mean

[b,c]Means in the same row within the same year with different superscripts are different ($P < 0.01$)

increase during assembly and transit and to decrease during the posttransit period as noted in year 1. The farm of origin had no affect ($P > 0.05$) on the fibrinogen concentration at any sampling point, with the exception of two weeks posttransit. At this time calves from farms 4 and 7 had a higher fibrinogen concentration than calves from farms 5 and 6.

In order to determine the affect of the two different years on the changes in fibrinogen concentration, the data from farm 4 for year 1 and 2 were compared. There was a significant change in fibrinogen concentration of calves from farm 4 during year 1 from the initial sample taken on the farm to 24 h pretransit, but no significant increases in fibrinogen concentrations for calves from farm 4 were noted during year 2. Thus the calves from farms 5, 6 and 7 may therefore have shown an increase in fibrinogen concentration during assembly if they had been assembled and under the conditions found during year 1. One of the differences between years 1 and 2 was ambient temperature at the time of assembly. It was noted earlier that in year 1 the response to the events of that year were more pronounced for calves in load 1 assembled at a higher ambient temperature (14.7°C), than for calves in load 2 (6.8°C). The ambient temperature during the assembly period was higher for year 2 than load 1 year 1 (22.3 vs 14.7°C), so assembly temperature alone cannot explain the low response during year 2. El-Nouty *et al* (14) reported that the adrenal response to ACTH was not dependent upon the ambient temperature.

In experiment 4, four pretransit management systems were evaluated over a two year period by using 106 calves. Calves were assembled for either four days or ten days prior to transit and one half of each assembly group was fed either a hay or mixed diet during the assembly period. The response to pretransit management treatments were different between years. Pretransit diet had no affect within either year on the fibrinogen concentration at the various sampling points so only the effect of the length of the assembly period are shown in Table IV. During year 1, the calves which were assembled for ten days before transit had a higher ($P < 0.01$) fibrinogen concentration prior to and after transit than the four day group. Although both the four day and ten day groups had higher fibrinogen concentrations after transit, posttransit values were not significantly different from pretransit values. At ten days after transit, the ten day group had shown a dramatic decline ($P < 0.05$) in fibrinogen concentration from 6.68 g/L to 4.67 g/L. At 21 days after transit the fibrinogen concentration for the ten day group was still lower ($P < 0.05$) than pretransit and 24 h posttransit values, but not significantly different from those of the four day group. There were no significant differences among the sampling points for the four day group.

TABLE IV. The Effects of the Length of Assembly on Plasma Fibrinogen Before and After Transit (g/L)

	Year 1		Year 2	
Sampling point	4 d	10 d	4 d	10 d
No. of calves	26	28	30	30
24 hr pretransit	$4.62^{bc} \pm 0.25$	$6.00^{d} \pm 0.35$	$3.59^{c} \pm 0.11$	$3.68^{c} \pm 0.13$
24 hr posttransit	$5.42^{c} \pm 0.25$	$6.68^{d} \pm 0.36$	$3.69^{c} \pm 0.18$	$3.63^{c} \pm 0.15$
7 d posttransit	—	—	$3.93^{c} \pm 0.29$	$3.44^{c} \pm 0.20$
10 d posttransit	$5.50^{c} \pm 0.56$	$4.67^{d} \pm 0.53$	—	—
14 d posttransit	—	—	$3.48^{c} \pm 0.21$	$3.37^{c} \pm 0.18$
21 d posttransit	$5.16^{c} \pm 0.41$	$4.74^{c} \pm 0.18$	$3.37^{c} \pm 0.24$	$3.09^{c} \pm 0.11$

[a]The number of days calves were assembled prior to transit
[b]Mean ± standard error of the mean
[c,d]Means in the same row and within the same year with different superscripts are different.

During year 2, no significant differences were noted in fibrinogen concentration due to the length of the assembly period, the pretransit diets, the transit event or the posttransit period. The overall means for the four and the ten day groups were 3.62 g/L and 3.45 g/L respectively, and were lower than the values observed during year 1. The calves in year 1 had a higher morbidity and mortality rate than the calves in year 2. Six calves died of respiratory disease within three weeks after arrival in year 1, while there were no deaths in year 2. The effects of various inflammatory disease on fibrinogen concentration have been previously reported by McSherry *et al* (15) Lloyd *et al* (16) and Ek (17). Calves that died during the experiment were removed from the data set at all sampling points to prevent the inflation of fibrinogen concentration means due to large individual values as the result of inflammation and not stress. The four day group in year 1 contained four of the six calves that died, but the total number of deaths were few.

DISCUSSION

Gwazdauskas *et al* (4) and Crookshank *et al* (18) previously observed an increase in plasma cortisol concentration in calves as the result of weaning or transit, indicating that these events were stressful, but the change in plasma cortisol concentration is more rapid than the change in plasma fibrinogen concentration. Carlson *et al* (13) reported an initial delay of three hours for fibrinogen concentration to change in the plasma of the rabbit as the result of prostaglandin infusion. This was followed by a rapid increase in fibrinogen concentration for the next 17 h. After the second phase of increased fibrinogen synthesis, the subsequent decline in fibrinogen concentration took several days with a half-life of three to four days. If the beef calf fibrinogen response system is similar to that of the rabbit, the calves in experiment 1 would have just entered the phase of rapid increase in fibrinogen concentration, which would explain the absence of a significant increase in plasma fibrinogen concentration.

Observations of differences among calves from different farms may be due in part to the breed of the steers, since breed is confounded with the farm of origin. In experiment 2 the steers from farm 1 were beef and dairy crossbred steers, and the steers from farm 3 were Angus and Hereford cross. The steers from farm 2 and 4 were of the Hereford breed. The exact age of the steers from each farm were not known, but McSherry *et al* (15) reported no differ-

ences in fibrinogen concentration due to age or sex of the calf. Ages of the animals in this experiment were estimated to be five to nine months.

Reid and Mills (5) and Berman *et al* (19) have shown that sheep respond very quickly to psychological stressors, such as unfamiliar surroundings and confinement, compared with physical stressors. In experiment 2 the stress of transit, as measured by the change in fibrinogen concentration was not greater than confinement and fasting in an unfamiliar location. The stress of transportation and unfamiliar surroundings can increase free fatty acid concentration in the serum of beef calves (20) and long chain free fatty acids have been shown to increase fibrinogen synthesis (21). Thus, one of the mechanisms for increasing fibrinogen synthesis as the result of stress associated with fasting may relate to serum free fatty acid concentrations.

The magnitude of the fibrinogen response to stress encountered during assembly, transit and posttransit may be determined by variables imposed months in advance of movement from the farm of origin (22). Friend *et al* (23) noted that the previous management of dairy cows affected their response to the stress of decreasing space allowance. Berman *et al* (19) observed that sheep accustomed to handling did not respond to the stress of confinement, but sheep adapted to the range did respond to confinement as a stress. Similar observations were also noted by Reid and Mills (5). Thus, the previous management of the animals can have a tremendous impact on perception of and response to stress.

Stress was described by Wilson (24) as a load on the physiological system and the subsequent physiological response as the strain of the load. At the center of the physiological response is the adrenal gland which plays an important role in the general adaptation syndrome (GAS) detailed by Selye (25). Once the animal perceives the event as a stress, the activity of the adrenal gland is increased and more corticoids are synthesized to prepare the physiological system to meet the challenge of the forthcoming event. The increased adrenal activity can not be continued indefinitely. The physiological system must adapt to the stress and mitigate its effect or the stress must be removed from the environment. The differences noted in experiments 2 and 3 due to the farm of origin and years may reflect how previous experiences of the calves on each of the farms during each year have conditioned the physiological response of the calf to different stresses.

The magnitude and duration of the stressor determines how much of a load is imposed upon the physiological system. Using dairy cows as the experimental animal and the numbers of cows per unit of housing space as the stress, Friend *et al* (23) noted that the stress must be imposed for 48 h before the physiological system would respond by increasing the capability of the adrenal gland to synthesize corticoids. This agrees with the dynamics of the GAS (25). Phillips *et al* (26) reported that calves assembled for ten days before transit have less adrenal activity than calves assembled for four days and that feeding the mixed diet used in this experiment was an additional stress and decreased adrenal activity. It is apparent from the research using rabbits (14) that ACTH does have a stimulatory effect on fibrinogen synthesis as well as adrenal activity. The increase in fibrinogen concentration may be initiated by ACTH while another physiological control, such as prostaglandins, maintains the elevated fibrinogen concentration. When the adrenal gland becomes refractive to ACTH, as the result of chronic exposure to the stress, ACTH may have more effect on fibrinogen synthesis than on adrenal activity. This was evident in the ten day group in year 1 of experiment 4. Although adrenal activity had decreased during assembly, the transit event elicited a response in the ten day group, which was similar to that of the four day group. However, the ten day group could not sustain the elevated fibrinogen concentration. Chen *et al* (8) and Carlson *et al* (13) observed that an increase in fibrinogen concentration was due to an increase in the synthesis of fibrinogen, and not a decrease in catabolic rates. Thus the ten day group decreased its rate of fibrinogen synthesis. This group either may not have perceived the posttransit environment as a stress or could not physiologically maintain an increase in fibrinogen synthesis.

In summary, plasma fibrinogen concentration did change in response to the various stresses associated with the assembly and transit period of beef calves. A short transit period of two hours immediately after weaning is stressful, but no differences were noted in fibrinogen values when samples were collected immediately before and after transit probably because there is a delay between the imposition of a stress and the response of increased fibrinogen synthesis. Deprivation of feed and water followed by confinement in unfamiliar surroundings resulted in an increase in fibrinogen concentration. The addition of a transit event to confinement, fasting and unfamiliar surroundings did not further elevate the fibrinogen concentration, although other observations indicated that transit was stressful. The response of a calf to the various stresses encountered during assembly and transit was dependent upon the previous environment and management applied before assembly and transit. Inflammatory disease can also result in an increase in fibrinogen concentration, but fibrinogen concentrations during disease are higher than those reported in this paper. Thus it appears that a change in the fibrinogen concentration can indicate a physiological response to stress, but additional research is needed to determine the relationship between changes in fibrinogen concentration and the physiological response to stress in the bovine.

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REFERENCES

1. **MARTIN SW, MEEK AH, DAVIS DG, THOMPSON RG, JOHNSON JA, LOPEZ A, STEPHENS L, CURTIS RA, PRESCOTT JF, ROSENDAL S, SAVAN M, ZUBAIDY AJ, BOLTON MR.** Factors associated with mortality in feedlot cattle: The Bruce County beef cattle project. Can J Comp Med 1980; 44: 1-10.
2. **DVORAK M.** Adrenocortical activity of young calves in relation to transport and traumatic stress. Doc Veterinaria 1975; 8: 119-126.

3. **ZIPRIN RL, STEEL EG, PETERSEN HD, ELISSALDE MH, McCARTOR M.** Hematologic study of effects of levamisole on stressed cattle. Am J Vet Res 1980; 41: 1884-1885.
4. **GWAZDAUSKAS FC, GROSS WB, BIBB TL, McGILLARD ML.** Antibody titers and plasma glucocorticoid concentrations near weaning in steer and heifer calves. Can Vet J 1978; 19: 150-154.
5. **REID RL, MILLS SC.** Studies on the carbohydrate metabolism of sheep. XIV. The adrenal response to psychological stress. Aust J Agr Res 1962; 13: 282-295.
6. **BRAKEL WJ, LEIS RA.** Impact of social disorganization on behavior, milk yield and body weight of dairy cows. J Dairy Sci 1976; 59: 716-721.
7. **FRIEND TH, GWAZDAUSKAS FC, POLAN CE.** Change in adrenal response from free stall competition. J Dairy Sci 1979; 62: 768-771.
8. **CHEN Y, BRIESE FW, REEVE EB.** Relation of fibrinogen secretion to ACTH dose. Am J Physiol 1974; 227: 932-939.
9. **ELLIS BC, STRANKSY A.** A quick and accurate method for determination of fibrinogen in plasma. J Lab Clin Med 1961; 58: 477-488.
10. **STEEL RGD, TORRIE JT.** Principles and procedures of statistics. New York: McGraw-Hill Book Co., 1960.
11. **COCHRAN WG, COX GM.** Experimental design. 2nd ed. New York: John Wiley and Sons, Inc., 1957.
12. **COLE NA, McLAREN JB, IRWIN MR.** Influence of pretransit feeding regimen and posttransit B-vitamin supplementation on stressed feeder steers. J Anim Sci 1979; 49: 310-317.
13. **CARLSON TH, FRADL DC, LEONARD BD, WENTLAND SH, REEVE EB.** Fibrinogen synthesis stimulation by prostaglandin E and some other vasodilators. Am J Physiol 1977; 233: H1-H9.
14. **EL-NOUTY FD, ELBANNA IM, JOHNSON HD.** Effect of adrenocorticotropic hormone on plasma glucocorticoids and antidiuretic hormone of cattle exposed to 20 and 33C. J Dairy Sci 1978; 61: 189-196.
15. **McSHERRY BJ, HORNEY FD, deGROOT JJ.** Plasma fibrinogen levels in normal and sick cows. Can J Comp Med 1970; 34: 191-197.
16. **LLOYD LC, PIERCY DWT, BINGLEY JB.** Changes in fibrinogen levels, platelet counts, clotting times and fibrinolytic activity in relation to thrombosis in contagious bovine pleuropneumonia. J Comp Pathol 1975; 85: 583-595.
17. **EK N.** The quantitative determination of fibrinogen in normal bovine plasma and in cows with inflammatory conditions. Acta Vet Scand 1972; 13: 175-184.
18. **CROOKSHANK HR, ELISSALDE MH, WHITE RG, CLANTON DC, SMALLEY HE.** Effect of transportation and handling of calves upon blood serum composition. J Anim Sci 1979; 48: 430-435.
19. **BERMAN DG, JOHNSON DE, PHILLIPS RW, BARRY BP.** Physiological and urinary metabolite responses to cold shock and confinement of sheep. J Anim Sci 1980; 50: 713-722.
20. **REYNAERT R, MARCUS S, DEPAEPE M, PEETERS G.** Influences of stress, age and sex on serum growth hormone and free fatty acid levels in cattle. Horm Metab Res 1976; 8: 109-114.
21. **CARLSON TH, WENTLAND SH, LEONARD BD, RUDER MA, REEVE EB.** Effects of prostaglandin E_2, analogs, fatty acids, and indomethacin on fibrinogen level. Am J Physiol 1978; 235: H223-H230.
22. **SEAL US, HOSKINSON RL.** Metabolic indicators of habitat condition and capture stress in pronghorns. J Wildl Management 1978; 42: 755-763.
23. **FRIEND TH, POLAN CE, GWAZDAUSKAS FC, HEALD CW.** Adrenal glucocorticoid response to exogenous adrenocorticotropin mediated by density and social disruption in lactating cows. J Dairy Sci 1977; 60: 1958-1963.
24. **WILSON WO.** Evaluation of stressor agents in domestic animals. J Anim Sci 1971; 32: 578-583.
25. **SELYE H.** The general adaptation syndrome and the disease of adaption. J Clin Endocrinol 1936; 6: 117.
26. **PHILLIPS WA, WETTEMAN RP, HORN FP.** Influence of preshipment management on the adrenal response of beef calves to ACTH before and after transit. J Anim Sci 1982; 54: 697-703.