EFFECT OF CHLORPROMAZINE ON THE PERFORMANCE OF LACTATING HOLSTEIN COWS

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OF LACTATING HOLSTEIN COWS

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INTRODUCTION

During recent years, tranquilizers have been widely used in veterinary practice. Scheidy and McNally (46) reported that tranquilizer-treated animals usually remain quiet and co-operative during and after treatment. It was found that the tranquilizing drugs lessen stress and anxiety and greatly simplify the handling of many animals during clinical procedures.

Different tranquilizers act on various parts of the nervous system to produce general tranquility and reduce the response of the animals to disturbing stimuli. Since dairy cows are usually fed, milked and managed at a specific time day after day, they develop a more pronounced dependence on a particular pattern of life than do other livestock and are, therefore, sensitive to changes in their environment. They have a tendency to produce less milk when their routine is disturbed.

Little information is available concerning the effect of tranquilizers on lactation. Therefore, studies were conducted to determine the oral dosage of chlorpromazine, a common representative of the phenothiazine derivatives, required to produce tranquilization in lactating Holstein cows, and to evaluate the effects of feeding low levels of this tranquilizer on milk production under different environments, during a six-month period. Information on the yield of milk and fat of the treated cows exposed to naturally fluctuating cold weather was especially desired.

REVIEW OF LITERATURE

Classification of Tranquilizers. Tranquilizers may be divided into two groups according to the areas of the brain upon which they act (49). One group which includes the phenothiazine derivatives and the Rauwolfia alkaloids acts primarily upon the hypothalmus and reticular areas. The other group which includes substituted propanediol compounds acts mainly on the thalamus. Scheidy and McNally (46) grouped the tranquilizers according to type of product, i.e., natural or synthetic. The most common natural tranquilizer is an alkaloid derivative of Rauwolfia serpentina of which reserpine is a representative. The synthetic compounds are divided into the phenothiazine and the propanediol groups. Phenothiazine derivatives include chlorpromazine, mepazine, perphenazine and promazine while propanediol compounds include meprobamate and phenaglycocol. Welsh (53) grouped the tranquilizing drugs according to their chemical structure as follows:[1]

The phenothiazines

Chlorpromazine - - - - - -	Thorazine
Promazine - - - - - - - - -	Sparine
Triflupromazine - - - - -	Vesprin
Mepazine - - - - - - - - - -	Pacatal
Prochlorperazine - - - - -	Compazine
Perphenazine - - - - - - - -	Trilafon
Trimeprazine - - - - - - - -	Temaril
Trifluoperazine - - - - - -	Stelazine
Trifluomeprazine - - - - -	SKF5354F
Ethyl isobutrazine - - - -	Diquel

[1]The first column refers to the generic name and the second column is its corresponding trade name.

Rauwolfia alkaloids

Rauwolfia serpentina - - -	Raudixin
Rauwolfia vomitoria - - -	(No trade name)
Alseroxylon - - - - - - - -	Rauwiloid
Reserpine - - - - - - - - -	Serpasil
Rescinnamine - - - - - - - -	Moderil
Recanescine - - - - - - - -	Harmonyl

Substituted propanediols

Meprobamate - - - - - - - -	Miltown, Equanil
Phenoglycodol - - - - - - -	Ultran

Diphenylmethane derivatives

Benactyzine - - - - - - - -	Suavitil
Hydroxyzine - - - - - - - -	Atarax, Tran-Q
Tetrahydrozoline - - - - - -	PVD-1

Ureides and amides

Ectylurea - - - - - - - - -	Nostyn
Oxanamide - - - - - - - - -	Quiactin

Mode of Action of Tranquilizers. In order to determine the value of tranquilizers, it might be well to consider their pharmacological effects. Theories relating to the biochemical aspect of drug actions have to do with changes in the properties of nerve membrane, especially at the synaptic junctions(50). These changes in turn produce alterations in behavior of the individual receiving the agent. Some of these theories proposed by different investigators suggest that tranquilizers may exert their actions by interfering with the production, storage or utilization of high-energy phosphate compounds necessary in the resynthesis of acetylcholine after a nerve impulse where the acetylcholine is broken down by acetylcholinesterase. Another theory proposed by Himwich (19) was that chlorpromazine (a phenothiazine derivative) has side chains similar to that of both sympathin and serotonin and that it may attach itself to the same binding site as do these amines and so exert its tranquilizing activity. These drugs may also alter neural activity by deranging carbohydrate metabolism thus affecting neural glycolysis and oxidation or they may potentiate or antagonize the action of either normal or abnormal metabolites.

When stresses are imposed on an animal, it is thought that the adrenal-pituitary axis is involved. Tranquilization is held to reduce the intensity of the "alarm reaction" and to enable the animal to adjust adequately without going into a stage of hyperexcitement (50). Some current research is being directed toward elucidation of the action of tranquilizers on farm animals since it is not yet known exactly how these drugs produce their effects. Solubility, ability to change the physical state of protoplasm, interference with cellular oxidative processes, surface activity, membrane permeability, and changes in electrical potentials are some of the areas involved in proposed theories.

Possible Uses of Tranquilizers. On the basis that tranquilizers act on the lower brain centers to diminish anxiety and agitation (49), animals exposed to an adverse environment may maintain or even improve their performance when fed tranquilizers. In a review paper, Scheidy and McNally (46) noted conditions where tranquilizers may improve the performance of various species of animals. Some of these conditions include those which increase restlessness and possibly fear, such as might be encountered during shipping over long distances, fear encountered by first calf heifers when first introduced to the milking parlor, weaning stress of different species of animals, and crowding of animals in holding pens in the case of cows before milking. Other stresses would include feedlot adaptation of beef cattle, environmental effects such as extremes of temperatures and conditions where fighting and competition cause either damage or restlessness with resulting waste of energy.

Troughton et al. (51) recorded various uses of chlorpromazine in veterinary practice such as the calming of animals for minor teat surgery and trimming of hoofs. It was also pointed out that chlorpromazine is very useful as a premedicant to general and local anesthesia.

Results of Tranquilizer Experiments. Due to contradictions in the results obtained in different experiments and the large amount of variation among animals in their response to various tranquilizers, it appears that the use of these drugs as feed additives is presently unwarranted without further basic research. Food and Drug Administration statutes and actions also seem to indicate that tranquilizers will not be widely used in the future. The results obtained in experimentation under normal conditions of animal production for the various species are discussed separately as follows:

Swine. Three groups of researchers (3, 39, 42) noted that the addition of tranquilizers in swine rations did not improve the performance of the animals.

Hydroxyzine, in combination with either estrogenic or androgenic compounds, failed to improve or alter carcass characteristics of dry-lot-fed swine from weaning to 200 lb. (3). Pickett et al. (39) observed no improvement in the weight gains of Duroc pigs attributable to adding reserpine, *Rauwolfia vomitoria*, meprobamate, hydroxyzine or perphenazine to the ration. Pond (42) reported that the addition of different levels of reserpine, chlorpromazine, trifluoperazine and trifluomeprazine to growing-finishing rations had no significant effect on the rate of gain and feed utilization of pigs raised on dry-lot.

Beef Cattle. Many tranquilizers have been used either alone or in combination with a hormone or antibiotics to study the production characteristics such as daily gain, feed conversion, shrink and dressing percentage. Substantial evidence that tranquilizers increased production was obtained only in those experiments involving a tranquilizer and a hormone and/or an antibiotic.

Baird et al. (4), Kolari et al. (26, 27) and Pope et al. (43) fed hydroxyzine to fattening beef cattle and did not obtain beneficial effects on daily gain. Henrickson et al. (16) reported that beef calves injected with ethyl isobutrazine or trifluomeprazine (both of which are phenothiazine derivatives) did not gain more weight following weaning than untreated calves. They also observed that prochlorperazine-fed yearling steers did not have any advantage in daily gain over the control animals. Sherman et al. (47, 48) reported that hydroxyzine, reserpine and Rauwolfia vomitoria significantly improved the growth rate and feed efficiency of steers when administered orally. On the other hand, no increase in daily gain or feed efficiency of beef calves was obtained by Baird et al. (4) when hydroxyzine was fed together with diethylstilbestrol, or by Beeson et al. (6) who fed hydroxyzine or reserpine alone or in combination with chlortetracycline or oxytetracycline to stilbestrol-implanted beef calves. Beeson et al. (5) and Perry et al. (40) both found that steers implanted with stilbestrol and fed 2.5 mg. per day of hydroxyzine and oxytetracycline gained significantly more than those not fed the tranquilizer. Perry et al. (40) also found that other levels of hydroxyzine and other tranquilizers, i.e., reserpine, tribluomeprazine, and Rauwolfia, either alone or with oxytetracycline, but without stilbestrol, did not increase daily gain. Kock et al. (25) found inconsistent improvement in rate of gain of beef cattle fed mepazine and trifluomeprazine either alone or in conjunction with stilbestrol. Preston et al. (44) fed 5 mg. of hydroxyzine per day per animal to one member of each of four pairs of identical twin cattle. The animals were of beef and dairy origin and weighed about 900 lb. each when placed on experiment; the animals were removed from experiment and slaughtered when they were thought to be in prime condition. The rate of live-weight increase was higher and feed conversion ratio was lower for the hydroxyzine-fed animals in three out of four pairs but the effect was not statistically significant. There was no effect on the dressing percentage. The adrenal and thyroid functions were not affected as measured by the weights of these organs.

Luther et al. (30) injected steers with different levels of perphenazine and transported the animals to different distances and measured shrink and feed lot adaptation. They found that the live-weight of the control steers shrank significantly less ($P < .01$) than the tranquilizer-treated group and found no difference in weight gains between the two groups up to 14 days after shipment. On the other hand, Kercher (23) reported that ethyl isobutrazine-injected beef cattle had less shrinkage than controls but yield and carcass characteristics were not affected. Marion (35) injected hydroxyzine and tetrahydrozoline intramuscularly and reported less shrinkage of treated animals than controls. Hoerlein and Marsh (19) reported that newly weaned beef calves injected with chlorpromazine were less disturbed by weaning than untreated calves, and weight gains during the week following weaning were greater for the treated than for the untreated calves.

Sheep. The results obtained from experiments with tranquilizer-fed sheep are inconsistent. Several workers (12, 47) have reported very advantageous weight gains while others (1, 22, 41), feeding the same types of tranquilizers, were not able to show any significant effect on sheep production.

Perry *et al.* (41) and Andrews *et al.* (1) reported that reserpine and hydroxyzine did not increase the growth rate of lambs when fed at the rate of 0.25, 0.01, or 0.005 mg. per lb. of feed and that a level of 0.50 mg. per lb. of pelleted ration significantly reduced the growth rate. Also, Jordan and Hanke (22) were not able to show any effect on daily gain, feed consumption and feed efficiency when chlorpromazine, triflorperazine, trifluomeprazine and hydroxyzine were fed at different levels to lambs "full-fed" a fattening ration. Contrary to these reports, Hale *et al.* (12) obtained up to 29% increase in daily weight gain with hydroxyzine; Sherman *et al.* (47) reported a significant increase in weight gain with *Rauwolfia vomitoria* and hydroxyzine; and Hansard *et al.* (14) observed a marked increase in weight of wether lambs when trifluoperazine and hydroxyzine were fed.

Dairy Cattle. The few trials that have involved administration of tranquilizers to dairy cows have shown little or no increase in milk or butterfat production. Lassiter *et al.* (29) fed hydroxyzine at a level of 2.5, 5.0, 10, 30, and 50 mg. per day per head to dairy cows. They observed that the treated animals had no significant increase in milk production, butterfat test, body weight or feed consumption over the cows not fed hydroxyzine. Voelker and Fitzgerald (52) administered from 8 to 32 mg. of hydroxyzine per day per cow and observed that the treated cows did not have an improvement in milk production and butterfat test. Upon injecting Vetame[2] either intramuscularly or intravenously at a level of 0.5 to 1.0 mg. per kilogram of body weight to first calf heifers several days postpartum and to high producing Holstein cows, Jordan and Ward (21) observed that the higher level of this drug depressed the activity and appetite of the animals during the course of treatment. Milk production of the treated animals did not appear to be affected and the increase in total fat yield was insignificant. Nervous first-calf heifers responded well to milking routine after several treatments. Farmer and Schultz (10) fed chlorpromazine and perphenazine to dairy cows. They employed nine double-reversal trials, using six cows in each trial and found that the two drugs caused a small but significant increase in the amount of residual milk obtained by oxytocin injection, indicating some interference with normal milk let-down.

Side Effects of Tranquilizers. In order to use tranquilizers most effectively, the drugs should be able to produce the desired action with a minimum of undesirable side effects. Meites (36) reported that reserpine induced lactation in certain breeds of virgin rabbits. This same tranquilizer was reported by De Bias *et al.* (8) to lower the rectal temperature of rats. Voelker and Fitzgerald (52) noted that dairy calves injected with tetrahydozoline had side effects such as drop in rate of heart beat and respiration rate for several hours

[2]Product of Squibb and Sons, New York, N. Y.

after administration of the drug, while Lank and Kingrey (28) reported an increase in heart rate due to injection of chlorpromazine. Hoerlein and Marsh (19) observed that calves suffered incoordination of body and showed signs of intoxication when injected with a relatively high dosage of chlorpromazine.

Residues of Tranquilizers in Farm Animals. In order to use a tranquilizer for improving production of farm animals, there should be no residue of the drug in the product obtained from these animals. Henrickson *et al*. (17) reported no chlorpromazine in any beef tissues 72 hours after administration but residues were recovered from some vital organs of beef cattle slaughtered eight hours after injection, and also damaged tissues at the site of injection were found.

Stress and Dairy Cattle Production. Hancock (13) indicated that attempts to reduce labor costs have resulted in systems of management where stock are kept outside or in uninsulated shelter throughout the winter, even in regions where housing for the major part of the year was previously traditional. These changes in management may bring about a greater thermal stress on farm animals. Using constant-temperature experiments, Kibler and Brody (24) brought out the fact that decreasing the temperature from 50° to 9° F. decreased respiration rate from about 25 to 15 per minute in Holstein, and from 20 to 14 per minute in Jersey cows and caused a slight increase in pulse rate. The results obtained by the Missouri workers were comparable to those obtained by MacDonald and Bell (31), although the latter workers conducted their experiment under natural conditions where the daily minimum temperatures fluctuated between -5° and 38° F., and analysis of temperature data was in degree-hours. A degree-hour employs 50° F.

as an environmental ideal basal value for the dairy cow. For any one hour, when the mean temperature is less than 50° F. there are as many degree-hours as there are Farenheit degrees difference between the mean temperature for the hour and 50° F. An average daily temperature may be obtained simply by dividing total degree-hours per day by 24 and subtracting the result from 50° F. MacDonald and Bell (32, 33) observed that as temperatures decrease, i.e., degree-hours per day increased from about 100 to 1,200, the average consumption of water, total dry matter, hay and gross calories increased significantly. In a later paper, MacDonald and Bell (34) reported that the actual milk yield of cows was decreased significantly when the temperatures decreased below 25° F. The temperature effect on milk yield was curvilinear during days colder than 600 degree-hours per day. On the contrary, Heizer *et al.* (15) reported that Holstein cows showed no appreciable change in milk production under different ranges of temperatures but cows kept in housing where there was no insulation against cold weather consumed more hay, silage, concentrate and TDN and at the same time gained more weight than cows kept in insulated housing. When allowances were made for gain in weight, there was no difference between the herds in the amount of TDN required per pound of 4% fat-corrected milk. These differences between the two experiments may be due to the different length and severity of the cold weather since Ragsdale *et al.* (45) asserted that the stressful effects of temperatures are not only the result of the average, maximal, and minimal temperatures but also of the number of hours exposed to heating and cooling.

EXPERIMENTAL PROCEDURE

Level of Chlorpromazine Required to Produce Tranquilization. During three different 4-day periods five mature Holstein cows were fed graded levels of chlorpromazine to determine the amount of tranquilizer required to produce clinical signs of tranquilization (Table 1). Animals No. 4, 12, 22, 72 and 83 were fed 0.05, 0.10, 0.15, 0.20 and 0.25 g. of chlorpromazine respectively during the first 4-day period; the levels were then increased to 0.30, 0.35, 0.40, 0.45 and 0.5 g., and to 1.0, 2.0, 3.0, 4.0 and 5.0 g. during the second and third periods, respectively. Three days were allowed between each 4-day period to decrease possible carry-over effects from the previous treatment. In all periods, the cows were observed for any unusual behavior such as staggering or failure to exhibit normal reflexes.

Milk samples were collected from all cows during each period at approximately 8 hours after the last feeding of the tranquilizer to determine whether any chlorpromazine residues were present in the milk. Blood samples collected about 3 hours after the last administration of the drug during the last two periods were also assayed for chlorpromazine residues. The samples were drawn from the jugular vein into flasks containing 5 mg. of sodium citrate per milliliter of blood to prevent coagulation of the samples. During the last period, rumen samples were collected by means of stomach tube at approximately 3 hours after the last feeding of chlorpromazine from the two cows fed the higher levels of tranquilizer.

TABLE 1

Observations on Lactating Holstein Cows Fed Different Levels of Chlorpromazine

Treatment period	Cow No. 1	4	12	22	72	83	Visual tranquilization	Chlorpromazine residue in:[a] Milk	Blood	Rumen	Feces	Urine
	(g./day)											
Oct. 9-13	-	0.05	0.10	0.15	0.20	0.25	None	neg	neg	-	-	-
Oct. 16-20	-	0.30	0.35	0.40	0.45	0.50	None	neg	neg	-	-	-
Oct. 23-27	-	1.00	2.00	3.00	4.00	5.00	None	neg	neg	neg	-	-
Nov. 28[b]	9.0	-	-	4.5	-	-	Pronounced[c]	neg	neg	pos[d]	pos[e]	pos[f]

[a]Lower limits of assay was 0.5 p.p.m. for chlorpromazine and 1.0 p.p.m. for chlorpromazine sulfoxide.

[b]Amounts of tranquilizer indicated were fed as a single dose.

[c]Visual tranquilization lasted for more than 24 hours for both cows.

[d]Samples collected at 8 and 12 hours after administration from cow No. 1 contained .082 and .076 mg./100 g., respectively; none from cow No. 22.

[e]Sample collected at 20 hours after feeding of chlorpromazine from cow No. 1 contained 3.06 mg./100 g.; none from cow No. 22.

[f]Sample from cow No. 1 contained 7.9 mg./100 ml.; the urine sample was collected 10 hours after feeding of chlorpromazine. No sample was available from cow No. 22.

The method employed for the assay of chlorpromazine and chlorpromazine sulfoxide in biological fluid was that of Flanagan et al. (11). It was modified so that the "free" and the "bound" forms of the tranquilizer were extracted simultaneously instead of separately. In general, the procedure involves an ether extraction of an alkaline aliquot of the biological fluid to remove the chlorpromazine and chlorpromazine sulfoxide. They are re-extracted into acid and both compounds are then determined quantitatively using a Beckmann DU spectrophotometer.

In a further attempt to determine the level of chlorpromazine necessary to cause visual tranquilization, two mature Holstein cows, one weighing 1,152 lb. and the other 947 lb., were fed single doses of 4.5 and 9.0 g. of chlorpromazine, respectively. Blood samples were collected from the jugular vein every two hours during the first 12 hours and at 24 hours after administration of the drug. Rumen samples were collected by means of stomach tube and pump at 1, 4, 8, 12 and 24 hours after feeding of the tranquilizer. Feces were collected about 20 hours after the drug was administered while milk samples were taken at 7 and 19 hours after administration. A urine sample was collected from the cow fed the higher level of chlorpromazine about 10 hours after the drug was fed. All samples were analyzed for chlorpromazine and chlorpromazine sulfoxide. The animals were observed during the course of treatment for clinical evidence of tranquilization.

Balance Study With Holstein Calves. To obtain information about the excretion of chlorpromazine and its metabolites, each of two Holstein bull calves weighing 262 and 288 lb., respectively, were administered 1.0 g. of chlorpromazine by means of a balling gun. The calves were placed in metabolism cages where feces and urine were quantitatively collected twice daily for two weeks. Homogenous fecal and urine samples were obtained during each collection and analyses were made for chlorpromazine and chlorpromazine sulfoxide to determine the amount of tranquilizer residues that were excreted via the feces and urine. The animals were offered alfalfa hay ad libitum and water and grain were offered twice daily in the morning and afternoon. The calves were watched for clinical signs of tranquilization.

Feeding Low Levels of Chlorpromazine to Holstein Cows. In another phase of the study, an additional 24 Holstein cows were used to evaluate the effects of feeding low levels of chlorpromazine on milk production under different environmental conditions. The cows were at different stages of lactation, ranging from 2 to 12 weeks after freshening at the beginning of the 24-week trial (Table 2). Only three of the cows were over three years old and the remainder were near three and in their first lactation. The weight of the cows at the start of the experiment varied from 846 to 1,332 lb. each. The 24 cows were divided into four groups on the basis of time of freshening and the cows in each group were randomly allotted to six treatment groups according to a 2 X 3 factorial arrangement. The treatment groups were: (S_1 T_0), pasture with open shed and no tranquilizer; (S_1 T_1), pasture with open shed and 250 mg. of chlorpromazine per head per day; (S_1 T_2), pasture with open shed and 500 mg. of chlorpromazine per head per day; (S_2 T_0), pasture without shelter and no tranquilizer; (S_2 T_1), pasture without shelter and 250 mg. of chlorpromazine per head per day; and (S_2 T_2), pasture without shelter and 500 mg. of chlorpromazine per head per day.

The four pastures consisted of approximately 2.4 acres each. Each of the open shelters was 336 sq. ft. with the side facing south open

TABLE 2

Characteristics of the 24 Cows Fed Different Levels of Chlorpromazine

Cow No.	Age	Stage of lactation at start of experiment	Body weight Initial	Body weight Final	Grain fed during 24 weeks of experiment	Initial daily milk yield[a]	Group[b]
	(yr.)	(wk.)	(lb.)		(lb.)	(lb.)	
37	3.0	8	936	998	1294	30	S_1T_0
38	3.0	8	1162	1288	1493	34	"
42	3.0	5	1062	1092	1761	38	"
43	3.0	3	906	944	2004	33	"
25	2.5	12	1032	1112	1082	26	S_1T_1
28	3.0	6	1140	1226	1562	34	"
30	3.0	4	1104	1144	1730	42	"
32	6.0	2	1332	1334	2100	50	"
13	3.0	12	1036	1120	1294	31	S_1T_2
14	3.0	8	908	984	1082	25	"
18	3.5	4	1064	1232	1790	43	"
20	3.0	2	1034	1086	2357	39	"
39	3.0	6	985	1192	1082	25	S_2T_0
40	3.0	6	846	908	1493	34	"
41	3.0	5	1272	1380	1151	27	"
44	3.0	3	1152	1240	2061	42	"
26	5.0	8	1248	1432	2186	44	S_2T_1
27	3.0	6	938	1052	1332	35	"
29	3.0	5	1072	1128	1562	42	"
31	3.0	4	904	1128	1744	39	"
15	3.0	8	992	1118	1332	34	S_2T_2
16	3.0	6	930	1080	1017	26	"
17	3.0	5	1164	1194	1820	44	"
19	3.0	4	1062	1170	1310	31	"

[a]Average of 1 week pre-experimental production.

[b]S_1 Shelter.
S_2 No shelter.
T_0 No tranquilizer.
T_1 250 mg./cow/day.
T_2 500 mg./cow/day.

at all times. Since it was of interest to determine whether the cows provided shelter were occupying them to escape the effects of cold weather, the number of animals within the shelters was recorded four times each day at about 8 a. m., 12 noon, 5 p. m. and 3 a. m.

The cows were fed good-quality alfalfa hay and sorghum silage *ad libitum* in the pasture and within the shelters. Following a period of about 10 days of liberal grain feeding, the level of concentrates was established according to Morrison standard for cows not on pasture--Table VIII of Morrison's *Feeds and Feeding* (37). The concentrates used in the experiment were the regular herd ration of the University. It is composed of 800 lb. ground milo, 600 lb. ground oats, 600 lb. wheat bran, 100 lb. cottonseed meal and 21 lb. each of salt, bone meal and calcium carbonate supplement. Water was provided by means of heated waterers both in the pasture and within the shelters.

The daily amount of tranquilizer was mixed in cerelose, pre-packaged and fed daily in two equal portions by adding it to the grain at the time of feeding. Individual records were kept of the milk produced daily. The fat percentage of the milk from each cow was determined by Babcock tests each week on composite samples consisting of aliquots from two consecutive milkings. The cows were weighed at the start of the experiment and at 2-month intervals thereafter until the experiment was terminated.

The climate was evaluated by taking into account the temperature, wind velocity and humidity. The wind velocity was measured with cup-type Bendix-Friez totalizing anemometers, with the rotating elements 4 ft. above the ground. The instruments were placed in two of the pastures to get a representative measure of the wind velocity in the four pastures. The temperature and humidity data were obtained with four recording hygrothermographs located in the pastures and the shelters. The miles of wind travel between 8 a. m. of one day and 8 a. m. of the next day were divided by 24 to represent the average wind velocity. This was done in order that the data on wind velocity, temperature and shelter occupancy would coincide with respect to time of observation.

The temperature data were first read hourly from the continuous graphs, and temperatures between 30° and 60° F. were considered as the zone of "thermal neutrality" since Brody (7) indicated that this temperature interval is the zone within which no demands are made on the temperature-regulating mechanisms of European cattle. Degree-hours per day were calculated for the days when the temperature was either below or above the zone of thermal neutrality. No degree-hours were computed for the days on which the temperatures ranged from 30° to 60° F. Therefore, the measurement units of degree-hours were time and temperature below 30° F. and above 60° F. This measurement differs with the degree-hours of MacDonald and Bell (31) on the range of temperature considered as ideal for the animals. Since there is a different physiological effect on cows depending on the length of time the animals are exposed to cold or heat, the degree-hours above and below the thermal neutrality zone were evaluated separately.

RESULTS AND DISCUSSION

Level of Chlorpromazine Required to Produce Tranquilization. A summary of the effect of different levels of chlorpromazine on lactating Holstein cows is presented in Table 1. No chlorpromazine or chlorpromazine sulfoxide was recovered from the milk from cows treated with the drug regardless of the dose administered. No chlorpromazine was recovered from the rumen fluid at 1, 4 or 24 hours after administration, but the concentration in the rumen fluid of the cow fed 9.0 g. of the drug was 0.082 and 0.076 mg. of chlorpromazine per 100 g., respectively, at 8 and 12 hours after dosage. The incongruous results may be due to the method of sampling in that representative samples may not have been obtained by means of the stomach tube. There was a concentration of 3.06 mg. of chlorpromazine per 100 g. of feces from the cow fed the 9.0 g. of drug at 20 hours after dosage, but no residue was detected in the feces of the cow fed 4.5 g. of chlorpromazine. It is possible that no residue was detected in the feces of the second cow because the drug had not passed through the alimentary tract when the fecal sample was taken although both samples were collected 20 hours after the feeding of the tranquilizer. It must also be pointed out here that the technique of assay of chlorpromazine in feces is not very reliable. Quantitative recovery of a known amount of chlorpromazine purposely added to feces is variable (38).

Although urine from the cow fed the 9.0 g. of chlorpromazine contained 7.9 mg. of chlorpromazine per 100 ml., no detectable amount was found in the blood of any of the animals regardless of amount fed or time of sampling. No explanation can be given as to why chlorpromazine was detected in the urine but not in the blood. Dukes (9) reported the average urine excretion of the dairy cow as 14.2 kg. per day; if this figure is taken to be about 14,000 ml. of urine, the excretion of chlorpromazine via the kidney was about 12.4%. This amount is comparable to the results obtained by Henrickson *et al.* (17) although the above estimate was based on the assumption that the excretion of the residue was at a constant rate during the day the sample was taken and that there was no appreciable amount excreted thereafter.

When 4.5 and 9.0 g. of chlorpromazine per cow were fed as single doses, the treated cows became tranquilized. In contrast, no effect was apparent when a cow was fed 5.0 g. of the drug per day for four days when the daily amount of tranquilizer was administered in two equal portions about eight hours apart. The two cows that received the single doses of 9.0 and 4.5 g. each were observed to be tranquilized two hours after administration of the drug. The cow that was fed the larger amount of chlorpromazine was particularly sedate. This animal showed an absence of some common reflexes such as no reaction to an object waved immediately before its eyes and did not resist various procedures such as insertion of a mouth speculum for taking a rumen sample. Similarly, Troughton *et al.* (51) reported that chlorpromazine-treated animals were easier to handle during ordinary clinical procedures such as minor surgery, changing of bandages or trimming of hooves. Both cows in the present experiment had muscle tremors especially in the hind quarters after they were stanchioned for bleeding. These tremors persisted for as long as 20 minutes in most cases. The last observed tremors occurred 24 hours after the feeding of the tranquilizer. Tremors were likewise observed by Irwin (20) in the cat, dog, and monkey treated with chlorpromazine. At all times the two cows ate, ruminated, urinated and defecated normally. These observations are in accord with those of Scheidy and McNally (46) who reported that tranquilizer-treated animals responded normally to stimuli of hunger and thirst and the necessity for elimination.

The milk production of the two cows following the feeding of chlorpromazine decreased but the drop in production was not abnormally high for the cows were in their declining phase of lactation. The average milk production of the two cows three days before treatment was 45, 41 and 38 lb. per day and for the three days after treatment was 38, 34 and 39 lb. per day while the production during the day of the treatment was 31 lb. The average daily milk yield was 21.0 lb. for the week before treatment and 19.5 lb. during the week after the tranquilizer was fed.

Henrickson <u>et al</u>. (16) were not able to determine the precise dosage of chlorpromazine, ethyl isobutrazine or trifluomeprazine required to produce tranquility in beef calves. There was wide variation among animals in the degree of tranquilization obtained from a given injected dose. These workers reported that a range of 0.25 to 0.8 mg. of chlorpromazine per pound of body weight was required to produce tranquility, with the required dosage depending on the agressiveness of the calves. Scheidy and McNally (46) and Bailey (2) have reported different levels of administration of several tranquilizing drugs in order to maintain a "chemical restraint" during medical and surgical treatment of animals. The two cows that showed signs of tranquility in the present experiment

(Table 1) were both docile animals when treatment started. Even when this was kept in mind, the amounts needed to produce visual tranquilization were very high, i.e., 9.5 and 3.9 mg. per pound of body weight, respectively, when compared to the dosage recommended by Scheidy and McNally (46) to produce tranquilization in cats and dogs. This would suggest that different species as well as different animals of the same species react differently to a given dosage of tranquilizer and that it is difficult to determine a precise amount to get tranquility in a given animal without over-dosing. This is again proven by the fact that two Holstein male calves which were fed 3.8 and 3.5 mg. of chlorpromazine per pound of body weight, respectively, did not show signs of tranquility whereas only 3.9 mg. per pound of body weight was required to produce visual tranquilization in one cow.

Balance Study With Holstein Calves. In the balance study where quantitative collection of urine and feces was made to determine the pathways and the amount of excretion of chlorpromazine, the average excretion of chlorpromazine in urine by the two calves during the first 24 hours was 2.4% which is low compared to 12% reported by Henrickson et al. (16). A minute amount of residue was detected in the urine on the second day after treatment for both calves and none thereafter.

As already mentioned, the assay of chlorpromazine residues in feces is not reliable; 51.8% and 102.9% were recovered from the two calves, respectively. It is interesting to note that in both cases, the greatest amount recovered from the feces was during the sixth day after the feeding of the drug; subsequently, no particular pattern of recovery was evident to the fourteenth day. It is important in a study such as this to develop a more exact method of assaying chlorpromazine in feces, and to use a longer collection period to detect the material that may be excreted after the fourteenth day.

Feeding Low Levels of Chlorpromazine to Holstein Cows. There was no appreciable difference in production of the cows with and without shelter for the entire experiment expressed in terms of actual or 4% fat-corrected milk (Figure 1). During the periods of coldest weather, the temperature within the shelter was in almost all instances not as low as that in the pasture. Also, the initial production of the cows was not exceptionally high and this may have increased the degree of thermal stress due to cold weather on the animals by increasing the "comfort zone" temperature inasmuch as Brody (7) reported that the "comfort zone" temperature decreases for high producing cows. Nevertheless, the differences in temperature between the shelter and pasture had no significant effect on milk production (Table 3).

The periods of cold weather may not have been severe enough to cause discernable changes in milk production since many "thermo-neutral" days were dispersed within the cold periods which may have cancelled the effects of the cold weather. This last point is in agreement with the results obtained by MacDonald and Bell (32) who reported that the thermal-stress effects experienced by cows in response to temperature changes appeared to be dissipated within 24 hours, or overshadowed by more immediate effects of the environment the following day.

The 4% FCM production for the cows receiving 0, 250, and 500 mg. of chlorpromazine per day was 4524, 4752, and 4244 lb., respectively, while the body weight gain for the 24 weeks of the experiment was 90, 86, and 99 lb. for the respective groups (Table 4 and Figure 2). The

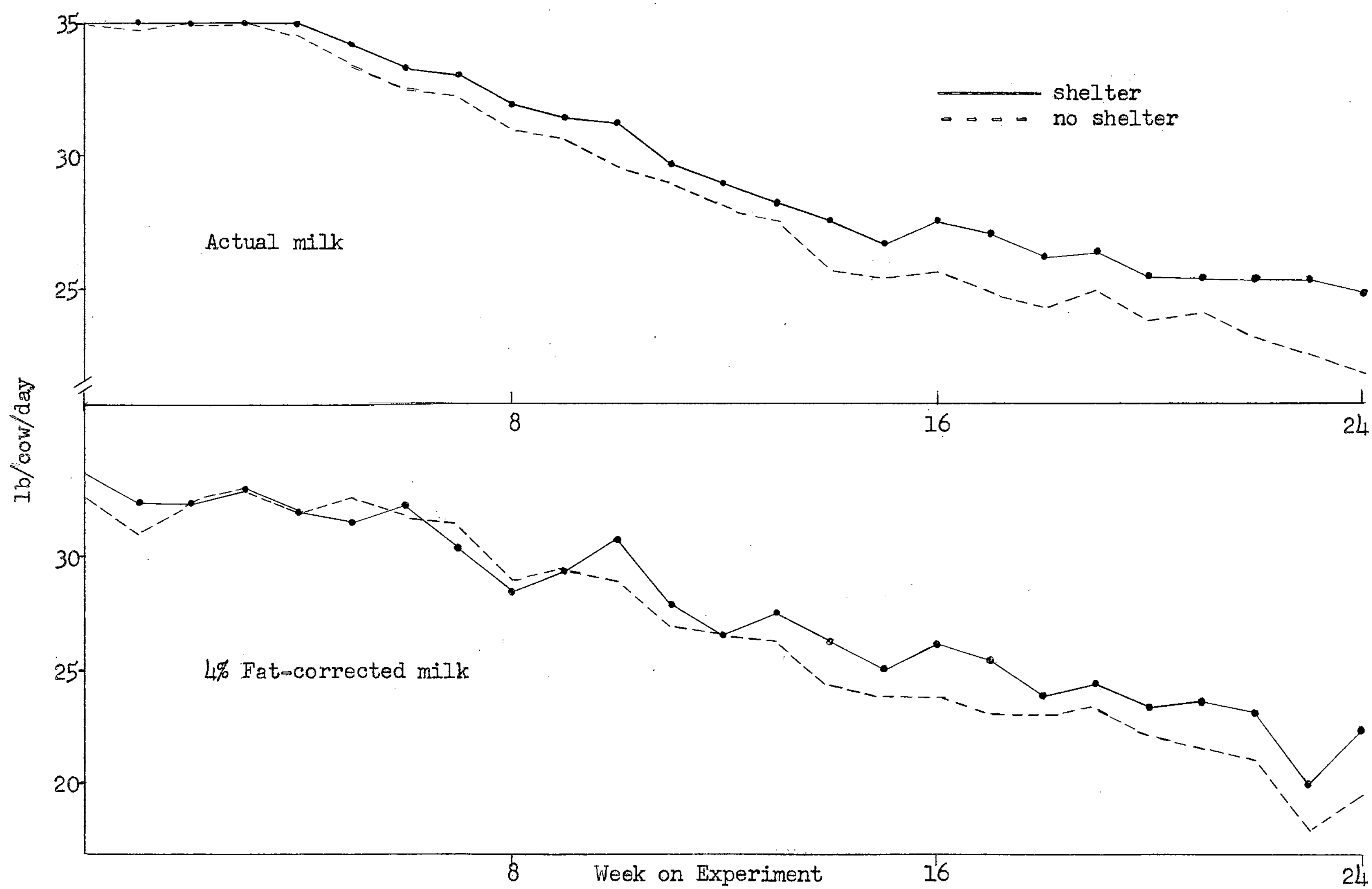

Figure 1. Production of Holstein Cows With and Without Shelter

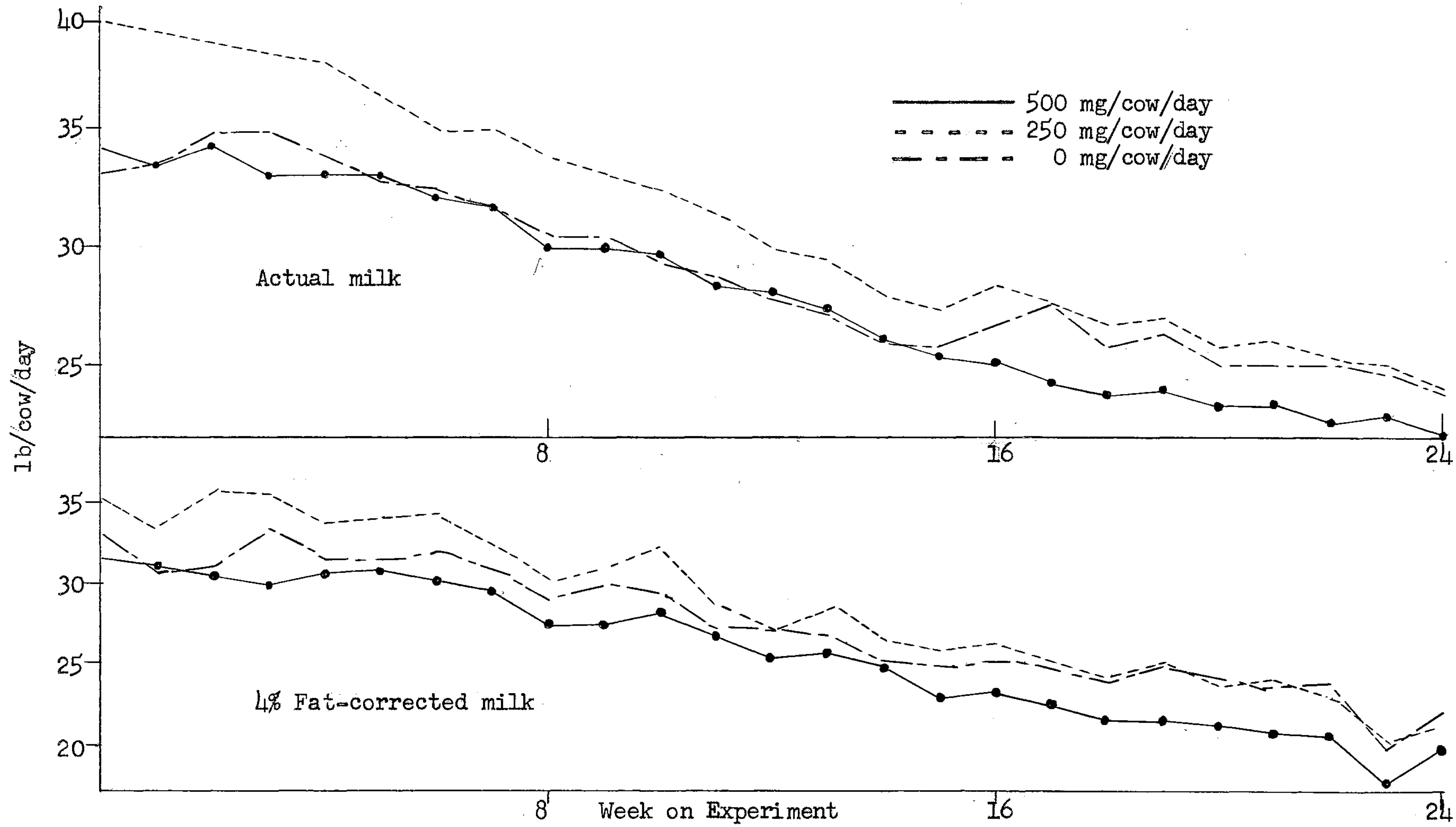

Figure 2. Production of Holstein Cows Fed Different Levels of Chlorpromazine

TABLE 3

Performance of Cows During the Months
When the Weather was Coldest

		Shelter			No shelter		
		Degree-hours		Average	Degree-hours		Average
	Wind	above	below	daily milk	above	below	daily milk
Date	velocity	60° F	30° F	production	60° F	30° F	production
	(mi./hr.)			(lb./cow)			(lb./cow)
12/27	2.6	0	0	30.7	0	0	30.2
12/28	11.0	0	0	31.3	11	0	31.2
12/29	11.3	0	26	31.4	0	16	30.9
12/30	6.4	0	76	31.8	0	55	30.8
12/31	5.4	0	259	31.6	0	269	29.1
1/1	4.1	0	41	32.7	0	44	31.3
1/2	14.0	0	304	31.7	0	398	31.1
1/3	9.1	0	704	32.9	0	770	30.8
1/4	2.2	0	525	31.4	0	530	28.7
1/5	11.2	0	86	31.5	0	92	29.6
1/6	12.1	0	0	30.8	0	0	29.9
1/7	10.9	1	0	31.2	0	0	30.0
1/8	6.4	0	25	31.6	0	53	29.4
1/9	1.2	0	42	30.1	0	125	28.8
1/10	7.2	0	2	30.3	0	0	29.2
1/11	3.7	0	0	30.2	0	0	29.7
1/12	6.0	26	0	31.5	12	0	30.2
1/13	8.3	61	0	29.0	37	0	27.6
1/14	5.3	0	0	28.5	0	1	29.3
1/15	9.3	0	111	29.8	0	174	29.0
1/16	3.2	0	21	29.0	0	95	28.0
1/17	4.3	0	0	26.8	0	11	27.4
1/18	11.2	4	0	29.3	0	0	28.6
1/19	9.0	0	0	29.9	0	0	30.3
1/20	13.4	0	160	28.9	0	196	28.9
1/21	6.4	0	340	30.3	0	452	27.7
1/22	5.0	0	67	27.2	0	117	26.2
1/23	5.1	0	0	28.7	0	3	27.9
1/24	10.1	0	0	29.1	0	0	30.1
1/25	7.4	54	0	29.2	31	0	28.8
1/26	9.2	0	6	28.8	0	21	27.8
1/27	4.2	0	0	27.7	0	1	26.5
1/28	10.9	0	0	28.0	0	0	27.0
1/29	9.7	0	30	27.9	0	74	26.2
1/30	7.1	0	41	27.5	0	86	27.1
1/31	8.7	0	127	27.5	0	164	25.2
2/1	9.4	0	172	28.3	0	251	25.0
2/2	4.5	0	56	29.5	0	145	26.7
2/3	4.6	0	32	27.5	0	80	25.0
2/4	9.6	0	11	27.5	0	30	26.6
2/5	3.9	0	70	27.0	0	149	25.6

TABLE 3 (continued)

Date	Wind velocity	Shelter: Degree-hours above 60° F	Shelter: Degree-hours below 30° F	Shelter: Average daily milk production	No shelter: Degree-hours above 60° F	No shelter: Degree-hours below 30° F	No shelter: Average daily milk production
	(mi./hr.)			(lb./cow)			(lb./cow)
2/6	10.1	0	1	26.3	0	1	25.2
2/7	7.6	17	0	28.1	4	0	25.3
2/8	4.3	0	0	28.3	0	0	27.5
2/9	9.2	0	5	26.1	0	17	24.8
2/10	5.7	0	58	26.9	0	117	25.9
2/11	6.4	0	0	24.9	0	6	23.7
1/12	8.1	0	0	26.4	0	0	24.3
2/13	5.5	4	0	26.4	0	0	25.1
2/14	5.4	0	3	27.2	0	27	25.5
2/15	6.4	0	0	26.6	0	0	24.2
2/16	10.7	83	0	30.0	73	0	27.4
2/17	12.2	0	2	27.6	0	7	24.9
2/18	8.7	0	66	28.3	0	103	26.0
2/19	5.6	0	50	28.2	0	121	26.3
2/20	4.2	0	7	26.2	0	37	25.7

TABLE 4

Performance of Holstein Cows Fed Chlorpromazine for 24 Weeks

Level of chlorpromazine[a]	Milk production		Body weight gain	Breeding efficiency
	4% FCM	actual		
(mg./cow/day)	(lb.)	(lb.)	(lb.)	(services/ conception)
0	4524	4806	+ 90	2.25
250	4752	5166	+ 86	3.62
500	4244	4663	+ 99	3.62

[a]Fed daily in two equal portions.

results of the analyses of variance on the data on 4% FCM during the entire experiment and the first 12 weeks of actual production are presented in Tables 5 and 6, respectively. The effects of shelter, tranquilizer, and shelter-tranquilizer interaction on milk production do not approach statistical significance ($P \gg 0.05$). Likewise, an analysis of covariance on the data representing the actual production of the cows during the 24 weeks revealed that the differences among treatment groups did not approach statistical significance at the 5% level of probability (Table 8). These results are in agreement with those of Lassiter et al. (29) who did not observe any beneficial effect from feeding graded levels of hydroxyzine to dairy cows. Also, Jordan and Ward (21) reported that Vetame-treated[1] animals did not produce more milk than control animals.

[1]Product of Squibb and Sons, New York, N. Y.

It is interesting to note that the two groups of tranquilizer-treated cows required 3.62 services per conception each compared to 2.25 for the group that received no tranquilizer. Although the information on the reproductive capacity of the tranquilizer-treated cows is limited, these data indicate that chlorpromazine may affect the breeding efficiency of dairy cows when fed over an extended period. More research in this area is needed in order to draw a definite conclusion.

The daily weather information obtained in the pastures and in the shelter is summarized in Table 9. This table includes data on shelter occupancy expressed as the average percentage of the number of animals that were in the shelters during four daily observations. Since silage and hay were provided in the sheds the animals may have been in them to eat rather than to escape the effects of the weather, though observations were made during parts of the day after sufficient time was allowed for the animals to have their fill of roughage.

The cows were observed to use the shelters even when the temperature was relatively high, i.e., when the number of degree-hours above 60° F. was high. This, of course, may have been due to the fact that the animals were in the shelters to drink water. There is better evidence though to support the converse; the animals used the shelters even more when the weather was cold, or when the number of degree-hours below 30° F. was relatively high. For example, on the days between Dec. 29 and Jan. 5 when the number of degree-hours was highest the animals were observed to be using the shelters (100% occupancy) on almost all observations.

The shelter provided some protection against cold especially during days when the wind velocity was low; for example, there was a difference of 89, 79, 65, 83 and 74 degree-hours below 30° F. between the shelter and the pasture temperatures on Dec. 15, Jan. 9, 16 and 22, and Feb. 2 and 5, respectively. Although no information concerning wind direction is available, it is reasonable to assume that there would be little or no difference in the shelter and the pasture temperature if the wind were blowing directly into the shelter or if the wind velocity were high. During days when the degree-hours above 60° F. was extremely high, the air temperature within the shelter was often higher than that in the pasture, especially when the wind velocity was low. This may have been due to the accumulation of heat in the shelter because of decreasing wind velocity and poor ventilation of the shelter. It is possible that the weather on Feb. 24, 25 and 26, March 1, 13 and 24, and April 2, 5 and 6 was such that the heat was accumulated in the shelter thus raising the temperature in the shelter. One way to combat thermal stress of animal thus is to provide all-sides-open loafing sheds for free circulation of wind during summer and one-side-open sheds during winter to minimize wind draft. However, on the basis of the data obtained from this experiment, provision of shelter or lack of it would have no marked influence on milk production.

SUMMARY

Studies were conducted to determine the oral dosage of chlorpromazine required to produce clinical evidence of tranquilization in lactating Holstein cows and to evaluate the effect of daily administration of low levels of the tranquilizer on milk production over a 6-month period during the winter of 1958-1959.

During three different 4-day periods five cows were fed in two equal portions each day graded levels of chlorpromazine as follows: 50, 100, 150, 200, 250 mg. per day; 300, 350, 400, 450, 500 mg. per day; 1, 2, 3, 4, 5 g. per day. None of the cows showed clinical evidence of tranquilization and none of the drug could be detected in the milk and blood when sampling was done at various times after the administration of the drug.

Two cows receiving single oral doses of 4.5 and 9.0 g. of chlorpromazine, respectively, showed various indications of tranquilization some of which persisted for as long as 24 hours. There was no detectable amount of tranquilizer in the milk and blood samples; however, tranquilizer residues were recovered from the urine, feces and rumen fluid.

Twenty-four cows were used to evaluate the effects of three levels of chlorpromazine on the milk production of cows subjected to different climatic environments. One-half of the cows were provided with shelter and pasture while the remainder had pasture only. The tranquilizer was fed daily in two equal portions at the following levels

per day: 0, 250, and 500 mg. Grain was allotted to the cows at the beginning of the experiment according to Morrison's standard and was reduced each month thereafter based on the average decline in production of all the cows. No appreciable differences were observed among treatment groups with respect to the production of actual or 4% fat-corrected milk during the 24 weeks of the experiment.

Wind velocity, temperature and humidity were collected on continuous recording graphs. The temperature data were converted to degree-hours using 30° to 60° F. as the basal, ideal temperature. Degree-hours varied between pasture and shelter depending to a great extent on the wind velocity at the time. There was a tendency for the degree-hours between the two environments to be equalized when wind velocity was high.

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A P P E N D I X

TABLE 5

Analysis of Variance on the 4% FCM Production of Holstein Cows

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Total	23	19,238,118		
Blocks	3	8,600,339		
Treatments	(5)	(1,442,779)		
Shelter (S)	1	273,921	273,921	.41
Tranquilizer (T)	2	1,000,609	555,304	.82
S x T	2	168,249	84,124	.14
Error	15	9,195,000	613,000	

TABLE 6

Analysis of Variance on the Actual Milk Production During the First Twelve Weeks of the Experiment

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Total	23	8,176,692		
Blocks	3	3,580,157		
Treatments	(5)	(509,941)		
Shelter (S)	1	23,688	23,688	.87
Tranquilizer (T)	2	435,529	217,764	.80
S x T	2	50,724	25,362	.93
Error	15	4,086,594	272,440	

TABLE 7

Average Daily Production of Holstein Cows Fed Three Levels of Chlorpromazine Under Two Different Environments[a,b]

Week	S_1 T_2		S_2 T_2		S_1 T_1		S_2 T_1		S_1 T_0		S_2 T_0	
	Act.[c]	FCM	Act.	FCM	Act.	FCM	Act.	FCM	Act.	FCM	Act.	FCM
						(lb/cow/day)						
Pre-exp.[d]	34	33	34	30	39	35	40	36	34	34	32	32
1	34	32	33	30	39	29	39	34	34	32	33	29
2	35	31	33	29	37	35	40	36	34	30	35	31
3	34	31	32	28	37	34	39	37	35	33	34	33
4	34	32	32	29	37	35	38	36	34	31	34	31
5	34	32	31	29	36	34	36	34	33	31	32	31
6	33	32	31	29	35	35	35	33	32	32	32	31
7	32	30	31	29	35	32	35	33	32	31	32	30
8	32	28	29	26	34	30	34	30	30	29	30	28
9	31	28	29	27	33	31	32	31	30	29	31	30
10	31	29	28	27	33	34	31	30	30	29	29	29
11	30	28	27	25	31	28	31	29	29	27	28	27
12	29	26	27	24	30	26	30	27	24	27	28	27
13	29	26	26	25	29	29	29	27	27	27	27	26
14	27	26	25	24	29	27	27	26	26	26	26	24
15	27	23	24	23	28	27	26	24	25	25	26	24
16	27	25	23	21	30	29	27	25	27	25	27	25
17	27	25	22	20	29	27	26	24	26	25	26	25

TABLE 7 (continued)

Week	S_1 T_2 Act.[c]	FCM	S_2 T_2 Act.	FCM	S_1 T_1 Act.	FCM	S_2 T_1 Act.	FCM	S_1 T_0 Act.	FCM	S_2 T_0 Act.	FCM
	(lb/cow/day)											
18	25	24	22	20	28	24	26	24	26	24	26	25
19	24	23	22	20	28	26	26	24	26	25	26	25
20	25	22	22	19	27	25	24	22	25	23	26	24
21	25	23	22	19	27	25	25	22	25	23	26	23
22	25	22	21	18	27	24	24	21	25	23	25	23
23	25	19	21	16	27	21	23	19	25	21	24	19
24	25	22	20	17	26	22	22	19	24	22	24	21

[a]Each treatment group composed of 4 cows.

[b]Treatments:
- S_1 T_2, shelter and 500 mg/cow/day
- S_2 T_2, no shelter and 500 mg/cow/day
- S_1 T_1, shelter and 250 mg/cow/day
- S_2 T_1, no shelter and 250 mg/cow/day
- S_1 T_0, shelter and no tranquilizer
- S_2 T_0, no shelter and no tranquilizer

[c]Actual production.

[d]Pre-experimental.

TABLE 8

Analysis of Covariance on the Actual Production of Holstein Cows During 24 Weeks

Source of variation	df	E_{x^2}	E_{xy}	E_{y^2}	df	Ed_{yx^2}	MS	F
					Deviations from Regression			
Blocks	3	17,331	391,357	10,890,489				
Treatments	5	9,326	90,149	1,602,614				
Error (E)	15	29,564	410,439	13,418,494	14	7,720,342	551,453	
Treatments + E	20	38,890	500,588	15,021,108	19	8,577,592		
	For test of adjusted means				5	857,250	171,450	.31
Comparisons								
Tranquilizers (T)	2	8,729	88,126	1,075,832				
Shelter(S)	1	10	1,737	282,969				
T x S	2	587	286	243,813				
Sum	5	9,326	90,149	1,602,614				
Error	15	29,564	410,439	13,418,494	14	7,720,342	551,453	
T + E	17	38,293	498,565	14,494,326	16	8,003,139		
	For testing adjusted mean difference for tranquilizer.				2	282,792	141,398	.26
S + E	16	29,574	412,176	13,701,463	15	7,956,922		
	For testing adjusted mean difference for shelter				1	236,580	236,580	.43

TABLE 9

Daily Weather Information and Shelter Occupancy

Date	Average wind velocity (mi./hr.)	Average shelter deg.-hr. above 60° F	Average shelter deg.-hr. below 30° F	Occupancy (%)	Average pasture deg.-hr. above 60° F	Average pasture deg.-hr. below 30° F
11/1	4.3	3	0	41.7[a]	0	0
11/2	3.9	89	0	0[a]	79	0
11/3	1.3	98	0	100[a]	99	0
11/4	8.5	83	0	100[a]	140	0
11/5	6.2	1	0	100[a]	2	0
11/6	2.2	3	0	91.7[a]	5	0
11/7	10.5	29	0	62.5[a]	63	0
11/8	4.9	14	0	66.7[b]	18	0
11/9	5.1	85	0	66.7[b]	93	0
11/10	7.9	66	0	70.8[b]	95	0
11/11	6.4	111	0	66.7[b]	130	0
11/12	5.9	100	0	79.2[b]	146	0
11/13	4.1	173	0	87.5[b]	221	0
11/14	5.8	66	0	91.7[b]	100	0
11/15	9.5	129	0	41.7[b]	215	0
11/16	11.4	241	0	95.8[b]	311	0
11/17	11.8	11	0	58.3[b]	14	0
11/18	3.9	0	0	50.0[b]	0	0
11/19	2.7	26	0	66.7[b]	34	0
11/20	0	46	0	58.3[b]	40	0
11/21	0	43	0	100[a]	40	0
11/22	0	39	0	100[a]	40	0
11/23	6.5	87	0	66.7[b]	103	0
11/24	6.1	0	0	70.8[b]	0	0
11/25	11.9	22	12	54.2[b]	20	9
11/26	8.2	0	1	66.7[b]	0	0
11/27	7.7	0	40	100[c]	0	53
11/28	4.4	0	14	85.4	0	15
11/29	3.6	0	0	66.7	0	0
11/30	6.6	0	0	64.6	0	0
12/1	1.2	0	0	52.1	0	0
12/2	5.11	0	0	33.3	0	0
12/3	4.1	31	0	29.2	18	0
12/4	5.2	37	6	75.0	29	6
12/5	9.0	0	15	70.8	0	9
12/6	4.3	0	28	75.0	0	34

[a]1 observation.

[b]2 observations.

[c]3 observations.

TABLE 9 (continued)

Date	Average wind velocity (mi./hr.)	Average shelter deg.-hr. above 60° F	Average shelter deg.-hr. below 30° F	Occupancy (%)	Average pasture deg.-hr. above 60° F	Average pasture deg.-hr. below 30° F
12/7	7.1	0	1	62.5	0	0
12/8	10.6	0	112	75.0	0	100
12/9	6.2	0	120	52.1	0	101
12/10	1.5	0	64	39.6	0	46
12/11	7.6	0	50	97.9	0	46
12/12	9.2	0	313	100.0	0	322
12/13	3.9	0	227	95.8	0	216
12/14	3.7	0	205	93.8	0	210
12/15	2.7	0	36	89.6	0	101
12/16	4.8	0	0	66.7	0	4
12/17	2.1	4	0	66.7	0	16
12/18	4.8	6	0	41.7	0	0
12/19	7.7	12	28	50.0	0	58
12/20	3.2	0	0	41.7[b]	0	18
12/21	3.3	3	0	27.1	0	0
12/22	8.0	29	0	56.3	24	0
12/23	7.6	0	11	64.6	0	10
12/24	1.2	0	17	47.9	0	17
12/25	10.5	0	0	68.7	0	0
12/26	6.1	0	0	62.5	0	0
12/27	2.6	0	0	39.6	0	0
12/28	11.0	0	0	66.7	11	0
12/29	11.3	0	26	100.0	0	16
12/30	6.4	0	76	100.0	0	55
12/31	5.4	0	259	100.0	0	269
1/1	4.1	0	41	100.0	0	44
1/2	14.0	0	304	100.0	0	398
1/3	9.1	0	701	100.0	0	770
1/4	2.2	0	525	81.3	0	530
1/5	11.2	0	86	100.0	0	92
1/6	12.1	0	0	89.6	0	0
1/7	10.9	1	0	89.6	0	0
1/8	6.4	0	25	50.0	0	53
1/9	1.2	0	42	66.7	0	125
1/10	7.2	0	2	62.5	0	0
1/11	3.7	0	0	47.9	0	0
1/12	6.0	26	0	43.8	12	0
1/13	8.3	61	0	52.1	37	0
1/14	5.3	0	0	100.0	0	1
1/15	9.3	0	111	83.3	0	174
1/16	3.2	0	21	50.0	0	95
1/17	4.3	0	0	70.1	0	11
1/18	11.2	4	0	54.2	0	0

[b] 2 observations.

TABLE 9 (continued)

Date	Average wind velocity	Average shelter deg.-hr. above 60° F	Average shelter deg.-hr. below 30° F	Occupancy	Average pasture deg.-hr. above 60° F	Average pasture deg.-hr. below 30° F
	(mi./hr.)			(%)		
1/19	9.0	0	0	100.0	0	0
1/20	13.4	0	160	72.9	0	196
1/21	6.4	0	340	62.5	0	452
1/22	5.0	0	67	58.3	0	117
1/23	5.1	0	0	58.3	0	3
1/24	10.5	0	0	60.4	0	0
1/25	7.4	54	0	62.5	31	0
1/26	9.2	0	6	85.4	0	21
1/27	4.1	0	0	25.0	0	1
1/28	10.9	0	0	56.3	0	0
1/29	9.7	0	30	75.0	0	74
1/30	7.1	0	41	85.4	0	86
1/31	8.7	0	127	100.0	0	164
2/1	9.4	0	172	95.0	0	251
2/2	4.5	0	56	54.2	0	145
2/3	4.6	0	32	25.0	0	80
2/4	9.6	0	11	83.3	0	30
2/5	3.9	0	70	37.5	0	149
2/6	10.1	0	1	50.0	0	1
2/7	7.6	17	0	52.1	4	0
2/8	4.3	0	0	72.9	0	0
2/9	9.2	0	5	91.7	0	17
2/10	5.7	0	58	60.4	0	117
2/11	6.4	0	0	91.7	0	6
2/12	8.1	0	0	45.8	0	0
2/13	5.5	4	0	68.8	0	0
2/14	5.4	0	3	58.3	0	27
2/15	6.4	0	0	58.3	0	0
2/16	10.7	83	0	52.1	73	0
2/17	12.2	0	2	93.8	0	7
2/18	8.7	0	66	43.8	0	103
2/19	5.6	0	50	47.9	0	121
2/20	4.2	0	7	75.0	0	37
2/21	9.2	0	0	68.8	0	0
2/22	10.0	0	0	52.1	0	0
2/23	5.2	1	0	41.7	0	2
2/24	4.2	15	0	22.9	0	0
2/25	2.4	49	0	47.9	7	0
2/26	3.2	72	0	54.2	28	0
2/27	7.2	8	0	35.4	0	0
2/28	6.7	0	0	70.8	0	2
3/1	4.8	25	0	52.1	2	0
3/2	9.6	1	0	64.6	2	0
3/3	9.1	9	0	68.8	0	0
3/4	12.2	2	0	68.8	0	1
3/5	11.7	0	4	68.8	0	36

TABLE 9 (continued)

Date	Average wind velocity	Average shelter deg.-hr. above 60° F	Average shelter deg.-hr. below 30° F	Occupancy	Average pasture deg.-hr. above 60° F	Average pasture deg.-hr. below 30° F
	(mi./hr.)			(%)		
3/6	4.2	0	5	52.1	0	43
3/7	8.3	3	0	37.5	0	0
3/8	6.7	11	0	45.8	0	0
3/9	8.3	72	0	43.8	56	0
3/10	12.4	41	0	20.8	16	0
3/11	7.7	0	0	39.1	0	1
3/12	6.0	20	0	29.2	2	0
3/13	10.1	233	0	43.8	91	0
3/14	17.3	80	0	72.9	54	2
3/15	5.6	0	0	50.0	0	2
3/16	6.1	14	0	68.8	1	0
3/17	4.0	90	0	22.9	47	0
3/18	13.4	225	0	33.3	94	0
3/19	14.8	86	0	56.3	58	0
3/20	15.0	0	0	97.9	0	0
3/21	6.8	0	1	45.8	0	23
3/22	7.1	22	0	41.7	11	0
3/23	14.9	166	0	50.0	113	0
3/24	12.3	303	0	45.8	235	0
3/25	12.5	44	0	75.0	34	0
3/26	15.1	0	0	83.3	0	0
3/27	6.5	0	0	22.9	0	0
3/28	2.7	0	0	37.5	0	0
3/29	7.1	0	0	50.0	0	0
3/30	4.8	130	0	25.0	86	0
3/31	13.9	171	0	52.1	148	0
4/1	8.2	50	0	33.3	22	0
4/2	12.8	276	0	22.9	259	0
4/3	7.2	55	0	16.7	13	0
4/4	9.7	151	0	0[c]	102	0
4/5	5.9	309	0	8.3	248	0
4/6	10.4	378	0	4.2	328	0
4/7	13.8	123	0	97.9	95	0
4/8	8.1	0	0	39.6	0	0
4/9	7.7	0	0	58.3	0	0
4/10	6.8	0	0	14.6	0	0
4/11	6.9	7	0	16.7	0	0
4/12	8.8	0	0	27.1	0	0
4/13	3.3	2	0	6.3	0	0
4/14	10.2	57	0	33.3	44	0
4/15	14.3	43	0	18.6	29	0
4/16	13.6	232	0	56.3	108	0
4/17	-	180	0	12.5	152	0

[c]3 observations.

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