BLOOD EOSINOPHILS OF DAIRY COWS DURING THE PARTURIENT PERIOD

by

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Thesis submitted to the Faculty of the Graduate School
of the University of Maryland in partial
fulfillment of the requirements for the
degree of Doctor of Philosophy

1953

APPROVAL SHEET

M. Franklin Ellmore, Ph.D., 1954

Title of Thesis: Blood Eosinophils of Dairy Cows During the Parturient Period

Thesis and Abstract approved: J C Shaw
Professor in charge of thesis

Date Jan 8, 1954

ACKNOWLEDGEMENTS

The author wishes to express his gratitude to Dr. Joseph C. Shaw, Professor of Dairy Husbandry, for his aid in planning and conducting these experiments, and for his assistance in the preparation of this thesis. Further acknowledgement is made to Dr. John W. Pou, Professor and Head of the Dairy Department, for his support of this work, and to Mr. M. H. Fohrman, Head, Division of Dairy Cattle Breeding, Feeding and Management Investigations, USDA, and to Mr. R. E. McDowell, also of this Division, for their cooperation in making the animals available for these experiments. The author also wishes to express his gratitude to Mr. Anthony C. Chung for his assistance in the laboratory.

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INTRODUCTION

> "Cannon has suggested a new physiological term -- homeostasis -- to describe the regulation and adjustment of vital functions so that a steady state exists not only in the blood but also in other bodily mechanisms."
>
> -- Amberson and Smith: OUTLINE OF PHYSIOLOGY (1)

According to Selye (20) abnormal environmental changes result in what he calls the "Alarm Reaction". Any change, even though slight, elicits a response and promotes efforts to resist the change. Attempts of the organism to compensate for stress of greater magnitude and/or duration, he calls the "General Adaptation Syndrome".

The defense mechanism is the result of the cooperative activity of all the body functions. The endocrine glands with their stimulating and inhibiting actions, play a key role in this compensating system. The pituitary gland acts as coordinator for the endocrine system. It is known to secrete tropic hormones which stimulate the activity of other glands. Increased activity of the pituitary gland is initiated by both humoral and nervous stimuli, which arise as the result of stress.

Of particular interest here is the fact that as part of the defense mechanism, the adrenocorticotropic hormone (ACTH) of the anterior pituitary gland stimulates the adrenal cortex to produce more of the cortical steroid hormones. These hormones in turn aid in protecting the organism against stress. One result of this increased production of cortical steroids is an altered blood picture. The changes in the total leucocyte count and in the proportion of the various leucocyte fractions are characteristic of the stress reaction.

These facts have been employed by Shaw and Coworkers (29) (30) at this station in their studies of ketosis in dairy cows. This is a metabolic disease of dairy cows which has been reported by Shaw et al (28) (12) to be an anterior pituitary adreno-cortical insufficiency. Shaw et al (29) (30) have shown that the level of circulating eosinophils is altered during attacks of ketosis. and they have demonstrated the value of the eosinophil count in diagnosing this disease.

Presumably the ketotic condition develops as a result of the inability of these cows to adequately compensate for the stress of high milk production imposed upon the stress of parturition and possibly other stresses. It was deemed desirable to study the eosinophil levels of very high producing cows during the prepartum and postpartum periods in order to establish normal trends and values for this period during which the incidence of ketosis is highest.

Workers at the U. S. D. A. Research Center, Beltsville, Maryland in their studies on the heat tolerance of dairy animals employ the stress of high environmental temperature for a period of six hours. Observations currently consist of changes in body temperature, changes in respiration rate and changes in respiratory volume. It was felt that the changes in the eosinophil level might provide a precise measure of the physiological response to this type of stress. For this study eosinophil counts were made prior to and at two hour intervals during the period of increased environmental temperature.

REVIEW OF LITERATURE

Selye (22) has written that exposure to stressor agents elicits an alarm reaction as the first manifestations of stress. This alarm reaction is characterized by a series of adaptive changes which occur as a means of defense or resistance against these stressor agents. In the event that the imposed stress is greater than the animal's ability to compensate for it, then a last line defense is set up which he calls the General Adaptation Syndrome.

Selye states (23), "The alarm reaction is not necessarily a pathologic phenomen. In the case of mild exposure to stress, there is no shock in the ordinary sense of the word. Slight hyperglycemia, tachycardia and leucocytosis may be the only signs of alarm." In the case of the generan adaptation syndrome, regardless of cause, certain changes are invariably noted. Among these are the involution of the thymico-lymphatic apparatus, the appearance of gastro-intestinal ulcers and the enlargement of the adrenal cortex, with it's discharge of hormones, lipids and ascorbic acid (21).

The stressor agents are classified as specific or non specific, depending upon their effect on the animal. Specific agents are those whose effect is directed toward a single target or relatively small group of cells. Stress elicited by specific stressor agents may or may not be drastic, depending upon the importance of the target organ to the life processes of the organism. Non specific agents are systemic in their effect.

According to Selye, Virchow (24) was the first to point out that blood poison corresponded to leucocytocis, and Israel recognized that this was not a disease in itself, but the result of disease. (24) By the end of the last century it was generally accepted that most types of leucocytosis are of a non specific nature. It has also been recognized that some abnormalities of the blood count are highly specific for certain diseases. As a result the differential blood count has become an important diagnostic tool in modern medicine.

It has been shown that the white cell count is normally different in different vascular territories of the body and that these differences may be more pronounced as the result of diverse injuries. (24) This indicates that a rise or fall in the level of circulating leucocytes is not necessarily indicative of an altered production or destruction of these cells. It would appear then that the diagnostic value of the white blood cell count is greatest when it is used in conjunction with other diagnostic tests.

Marlow and Selye (11) showed that such diverse alarming stimuli as adrenaline, formaldehyde, cold, trauma or forced exercise, cause essentially similar changes in the white cell count (mouse and rat). They noted that the white cell count increased as the result of an increase in the member of neutrophils during the alarm reaction. At the same time there was a relative decrease in the number of lymphocytes. They observed that alarm stimuli strong enough to cause death, resulted in leucopenia. They (11) also observed that under stress of this kind the eosinophils decrease almost to the diminishing point, but reappear later in greater numbers when the neutrophils return to normal.

Randolph and Rollins (19) showed that this eosinophenia is a constant sign of alarm reaction in man and that it is probably mediated through the discharge of ACTH and glucocorticeids. This clinical observation has been developed into a diagnostic test for the integrity of the pituitary and adrenal cortex (32).

In various allergic conditions eosinophilia is rather characteristic and sometimes attains extremely high levels. Marked fluctuations, however, have been seen to occur in the eosinophil and white blood cell count during experimental shock produced by various proteins, anaphylaxis, histamine and other drugs (25). In acute allergic attacks in man as well as in severe anaphylactic shock in animals eosinopenia tends to develop (33). On the other hand pronounced eosinophilia has been produced in mice by feeding them rat muscle infected with Trichina Spiralis (31).

Urbach and Cottleib state (33), "It is now generally accepted that the eosinophil cells participate in the defensw process of the human body, especially in conditions of hypersensitiveness." Selye (26) points out that it is well to remember that diametrically opposed reactions may be produced by the same agent under different experimental conditions. He therefore concludes that the eosinopenia of the alarm reaction may be related to the eosinophilia of parasitic infestations and allergic conditions. Gradwohl (7) states that the same processes which in moderate degree may produce eosinophilia, in greater degree cause either hypereosinophilia or aneosinophilia.

The functional significance of the eosinophilia of parasitic infestations is not known, but Godlowski (6) found that anaphylactogenic protein could be detected in eosinophils, but not in other leucocytes. According to Best and Taylor (2), eosinophils are not markedly motile and are not phagocytic. They do migrate to the site of infection (14), probably as the result of chemotaxis.

Normal eosinophil values fluctuate over quite a wide range and vary considerably between individuals within the species. Kracke (16) states that there are many causes of classic familial hereditary eosinophilia in individuals otherwise quite normal. It would be reasonable to expect that there might be fairly wide differences between different breeds of cattle and between different individuals within the breed.

According to Dimock and Thompson (3) the eosinophils constitute 13.15% of the white blood cells in cows, with an absolute count ranging from 171 to 1,855 per cu.mm. Dukes (4) lists 5% as the average eosinophils in cows. This range in values may be due to individual or breed differences and suggests caution in using eosinophil counts diagnostically without reasonably accurate normal values for the individual. Its greatest value would seem to lie in the correct interpretation of changes over a period of time. This is borne out by Gradwohl (9) who points out the significance of changes in eosinophil levels as follows:

"Marked decrease of eosinophils accompanied by rising leucocytes, indicates an <u>aggravated</u> condition. Total disappearance of eosinophils with simultaneous marked lymphocytopenia is to be regarded as an unfavorable condition. Constant presence of eosinophils, especially if it parallels hyperleucocytoses, means a <u>favorable</u> condition. Decreasing low white count, or leucopenia, with varying neutrophilia and beginning shift to the left, lymphocytopenia, and eosinophilia, means an absolute <u>fatal prognosis</u>."

The changes in the eosinophils of animals subjected to heat has not been studied. However, Hoagland (13) has subjected normal and psychotic patients to heat and high humidity. Normal patients responded with a drop in the lymphocytes. He states that these manifestations are probably the first stage of the adaptation syndrome, which involves adreno-cortical hypersecretion as the result of pituitary stimulation following stress. The failure of the psychotic patients to respond may have been due to a failure in the adrenal cortex or to a failure in the pituitary secretion.

Thorn (32) has shown that the level of circulating eosinophils is controlled by the corticosteroids. Therefore it is reasonable to assume that the changes in the eosinophil level of animals subjected to the stress of heat should be indicative of the resistance to the stress and might be useful as an additional measure of heat tolerance.

EXPERIMENTAL PROCEDURE

Eosinophil Levels in High Producing Cows

The cows used in this study were selected from the experimental breeding herd of purebred Holsteins at the Agricultural Research Center of the U. S. Department of Agriculture, Beltsville, Maryland. The feeding and management in this herd is designed to standardize, as nearly as possible, all enviornmental factors.

Alfalfa hay, U. S. Grade number 1, was fed ad libitum while the cows were confined in the maternity stalls. This was supplemented with 6 pounds per day per cow of a concentrate mixture made up as follows: 800 pounds yellow corn; 400 pounds oats; 500 pounds wheat bran; 400 pounds linseed oil meal and 20 pounds salt.

Three days after calving the cows were moved into individual box stalls in the test barn. All cows were milked twice per day by hand. U. S. number 1 alfalfa hay and corn silage were weighed in twice per day to each cow. The amounts offered were slightly in excess of consumption, so that maximum roughage consumption was assured. The actual consumption was approximately 1½ pounds and 3 pounds of hay and silage respectively per 100 pounds of body weight. The roughage was supplemented with the following concentrate mixture: 300 pounds oats; 300 pounds linseed oil meal; 100 pounds corn gluten meal; 400 pounds yellow corn; 200 pounds wheat bran; 200 pounds beet pulp and 16 pounds salt. The amounts of this supplement fed per day were based on Morrison's Feeding Standards (18).

All available cows calving between June 5, 1952 and August 12, 1952 were used in this study except first calf heifers. The experimental period for each cow began when she was placed in the maternity barn, which was one to two weeks prior to calving. Blood samples were collected from the jugular vein at this time and at semi-weekly intervals through the eighth week postpartum. Whenever possible, a blood sample was collected on the day of parturition.

Samples of approximately 25 milliliters of blood were drawn into plastic centrifuge tubes containing heparin. These tubes were rolled between the hands to insure complete mixing, after which, 3 or 4 milliliters of the blood were poured into small silicated tubes. These small samples were immediately cooled and placed in an ice chest for transportation to the laboratory. It was from those chilled samples that the total leucocyte counts and the eosinophil counts were made. Sodium fluoride and thymol were added to the blood remaining in the plastic tubes, and these samples were used for the blood glucose determinations. These determinations were made by the method of Shaffer, Hartmann and Somogyi (15).

The procedure followed in making the total leucocyte counts was one initiated by Malassez (8). A method described by Friedman (10) was used in making the eosinophil count. A special stain which is specific for eosinophils is the essential feature of this method.

All computations relative to the nutrient intake were based on records which were available in this herd. These records include: daily amounts of the various feeds fed, weigh back figures on uneaten feed, daily milk weights, monthly body weights and monthly butterfat tests. The average daily milk production and the average daily feed consumption were calculated for each week during the experiment. The daily T. D. N. requirements were calculated from Morrison's Standards (18) by using 100 percent of the higher recommendations.

The percent of the T. D. N. requirements actually consumed was derived by use of the following formula:

$$\frac{.107\ (CF - WB_1) + .071\ (HF - WB_2) + .0238\ (SF - WB_3)}{\text{Pounds of T.D.N. required per day}}$$

where:

.107, .071 and .0238 are factors which were derived by dividing the percent of T.D.N. in the particular feedstuff by 7

CF equals the pounds of concentrate fed per week

HF equals the pounds of hay fed per week

SF equals the pounds of silage fed per week

WB equals the pounds of weighback of each kind of feed per week

Eosinophil Levels of Cows Subjected to the Stress of Heat

The cows used in this study were selected from the purebred Jersey herd and from the Jersey-Sindhi crossbreds at Beltsville. These cows had completed at least one lactation. They were in various stages of lactation, ranging from 30 days postpartum to 30 days prepartum. All cows had been exposed to the heat chamber at least once as dry cows prior to this study. Blood samples were collected in small silicated tubes containing heparin, in the manner already described. The analytical procedure was the same except that total leucocytes were not counted and blood glucose determinations were not made.

The animals were handled in the same manner during this study as in the routine heat chamber studies. The animals were placed in the heat chamber at 5:30 A.M. immediately after the morning milking. They were allowed to remain quiet and to become adjusted to the surroundings until 7:00 A.M. Initial body temperatures, respiration rates, blood samples and other pertinent data were collected at this time. These observations were used as the norms, and subsequent deviations were compared to these norms. At the completion of these initial observations, the heat was turned on and reached 105 degrees F. by 8:30 A.M. This temperature was maintained with a relative humidity of 60 percent for the next six hours. Body temperatures, respiration rates and the general condition of the individual animals were recorded each hour, starting one hour after the chamber temperature had reached 105 degrees F. In addition to the blood sample drawn at 7:00 A.M. blood samples were taken at two hour intervals during the heat period and at two hours after the end of the heat period.

In the routine heat chamber studies at Beltsville, the mean body temperature (based on the trapesoidal mean) and the average rise in body temperature are calculated. The average rise in body temperature is used in arriving at a measure or rating of the animal's resistance to the stress of heat. In the long time studies, the reaction of the cow during the dry period is used as the basis for assigning a heat resistance rating to her as an individual. A dry cow with an average temperature rise of from 0 to 1 degree F. is given a rating of 1. This is interpreted as meaning that she has shown very little reaction to the stress or has compensated for the imposed stress. An average temperature rise of from 1 to 2 degrees F. is given a rating of 2. An average temperature rise of 2 or more degrees F. is given a rating of 3. The above system is modified in the case of lactating animals in order to compensate for the effect of lactation. In this case one degree of temperature is discounted when assigning the ratings.

The animals used in this study were selected on the basis of their reaction during previous exposures as dry cows.

RESULTS

Observed Changes in High Producing Cows

In this study the eosinophil and the total leucocyte counts were made and blood glucose was determined from the blood of 12 high producing dairy cows at semi-weekly intervals from one week prepartum to eight weeks postpartum. Average milk production was recorded and the percent of the T.D.N. requirements actually consumed was calculated.

A 12 cow average was made of each period and is presented graphically in figure 1. Tables I, II, III and IV contain the individual observations from which Figure 1 was prepared. Table V contains the total leucocytes and the averages for each period for all cows.

To aid in the interpretation of the results which are presented in Figure 1, it is convenient to divide the experimental period into three parts as follows:

1. The prepartum period
2. The first week postpartum
3. From the first to the eighth week postpartum

During the prepartum period the eosinophil values fell quite rapidly from an average of 1110 per cu. mm. of blood one week prepartum to an average of 665 on the day of calving. Blood glucose determinations were not made during the early part of the study, however blood glucose determinations were made on four of the cows on the day of perturition. The 4 cow average at this time reached a relatively high value of 69.7 mg. per 100 ml. of blood. The T.D.N. requirements for this period were not calculated as roughage was fed ad libitum during the dry period. It was assumed that all cows were consuming at least 100 percent of their requirements during this period.

The eosinophil values increased from 665 per cu. mm. of blood to 811 during the first half week following calving and then fell to 574 by the end of the first week. Blood glucose decreased to a low of 41.3 mg. per 100 ml. of blood during the first half week and then tended to remain at a fairly constant level during the remainder of the experimental period. During this week the average T.D.N. consumption was 84 percent of the requirements.

In the first four weeks following the first week postpartum, the eosinophil level rose to 1401 per cu. mm. of blood, a value which was greater than the prepartum value of 1110. From the fifth week to the end of the experiment, a slight decrease occurred. During the same period the blood glucose was maintained at a fairly constant level. The cows were able to consume approximately 100 percent of their requirements by the end of the fourth week postpartum, and consumed slightly over 100 percent through the eighth week. Average milk production reached a peak of 67 pounds per cow per day at the end of the fourth week, after which it tended to level off.

Figures 2 through 13 are graphic presentations of the observations on the individual cows. These charts show the changes in the eosinophil level, blood glucose level and changes in the percent of the T.D.N. requirements consumed. The data from which these charts were prepared are included in the appendix, Tables VI through XVII.

It can be seen that marked changes often occurred in the eosinophil levels of the individual cows. Figure 1a shows the fiducial limits of these values. There was not only a wide variation between individuals, but also a rather wide variation between samples from individual cows. At the same time variations in blood glucose and in the percent of T.D.N. consumed showed only normal individual variations from the 12 cow average. Examples of the eosinophil changes may be seen in Figures 4, 5, 7, 10, 11 and 12.

Two of the cows maintained consistently lower eosinophil levels throughout the experiment, without showing any marked fluctuations. Here again, blood glucose and the percent of the T.D.N. requirements consumed showed only normal variations from the 12 cow average. This is shown in Figures 8 and 13.

One cow, Figure 10, maintained a relatively high eosinophil level throughout the experiment. No abnormalities were observed in the blood glucose picture or in the percent of the T.D.N. requirements consumed.

The remaining three cows (Figures 2, 3 and 6) exhibited fluctuations in the eosinophil level, but the changes were not of as great a magnitude as those seen in some of the other cows. These cows also showed no abnormal variations in the blood glucose values or in the percent of T.D.N. requirements consumed.

FIGURE 1

Average Eosinophils per cu. mm. of Blood and average Blood Glucose (mg. %) of 12 High Producing Cows

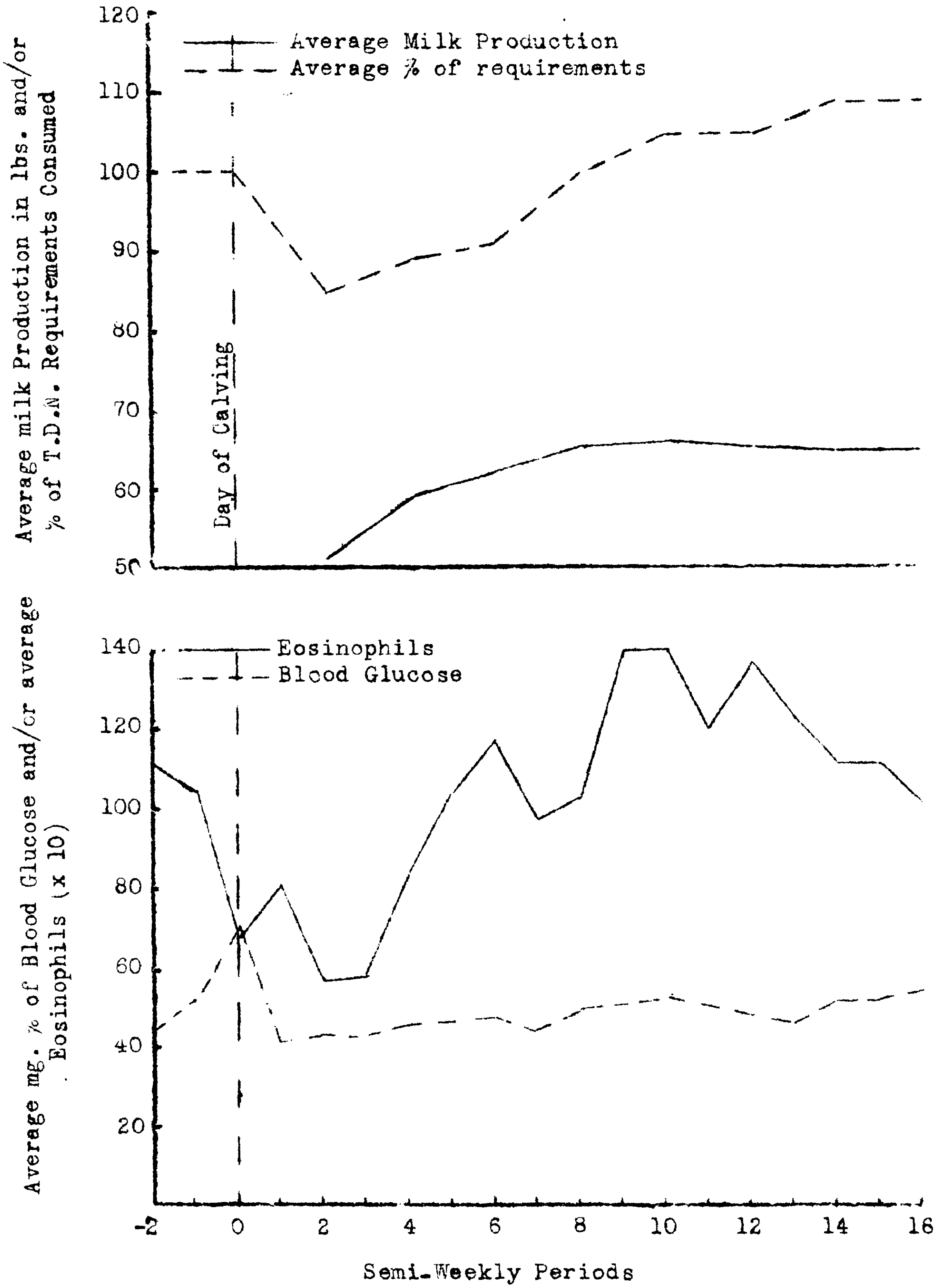


FIGURE 1-a

Average Eosinophils per cu. mm. of Blood of 12 High Producing Cows. Shaded Area Indicates Fiducial Limits

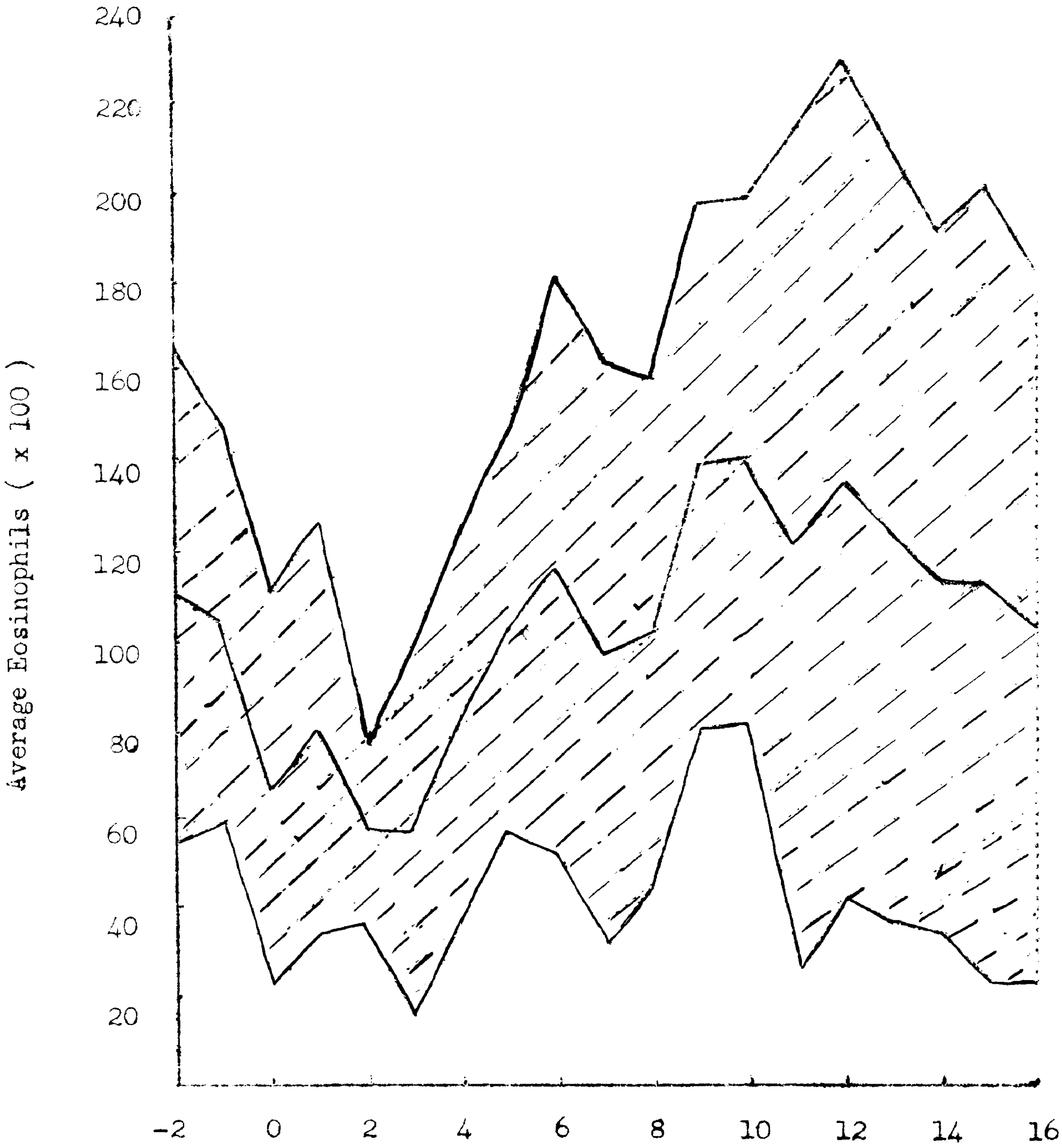


FIGURE 2

Eosinophils per cu. mm. of Blood, Blood Glucose (mg. %) and Percent of T.D.N. Requirements Consumed by Cow No. 2842

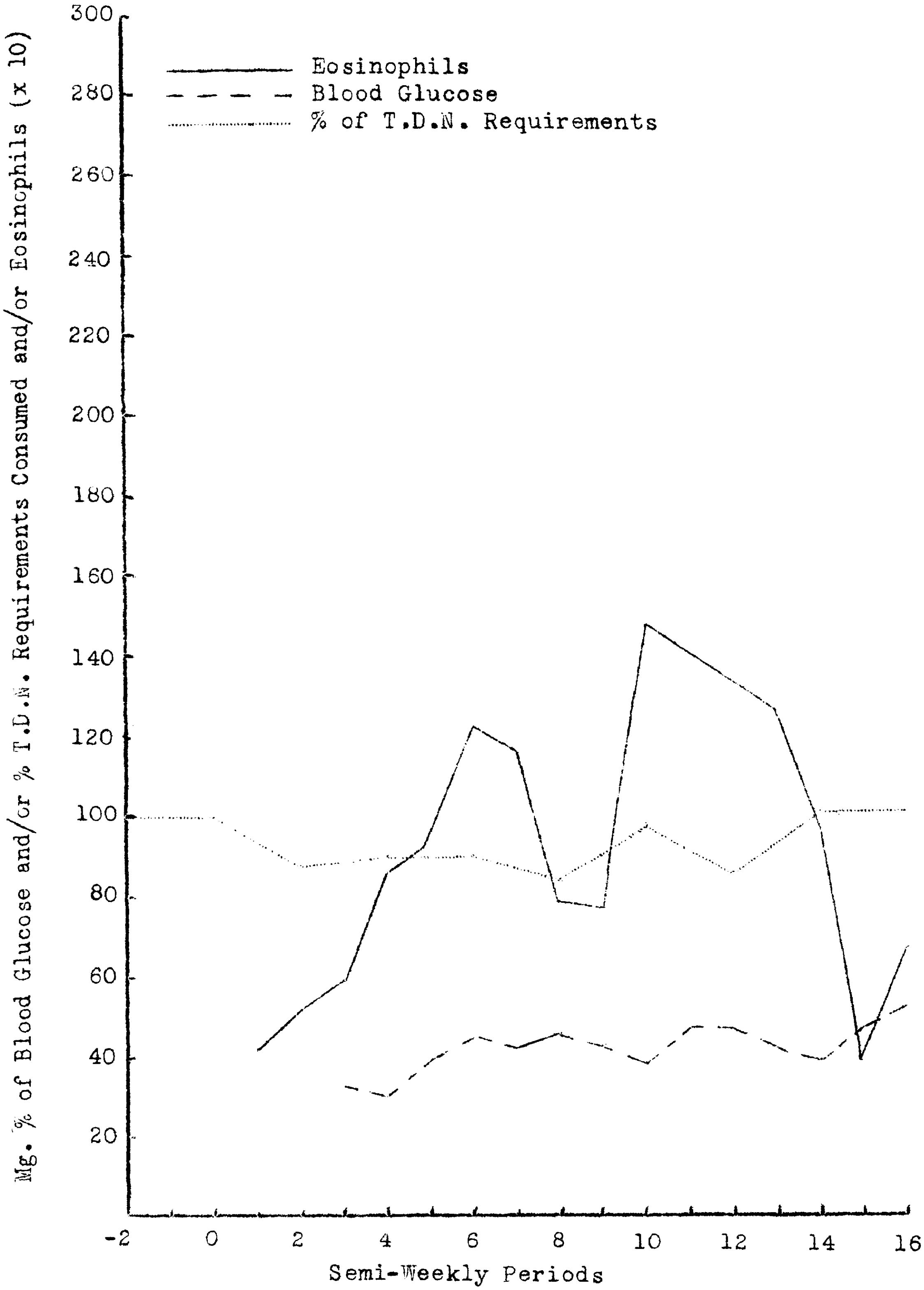


FIGURE 3

Eosinophils per cu. mm. of Blood, Blood Glucose (mg. %) and Percent T.D.N. Requirements Consumed by Cow No. 2838

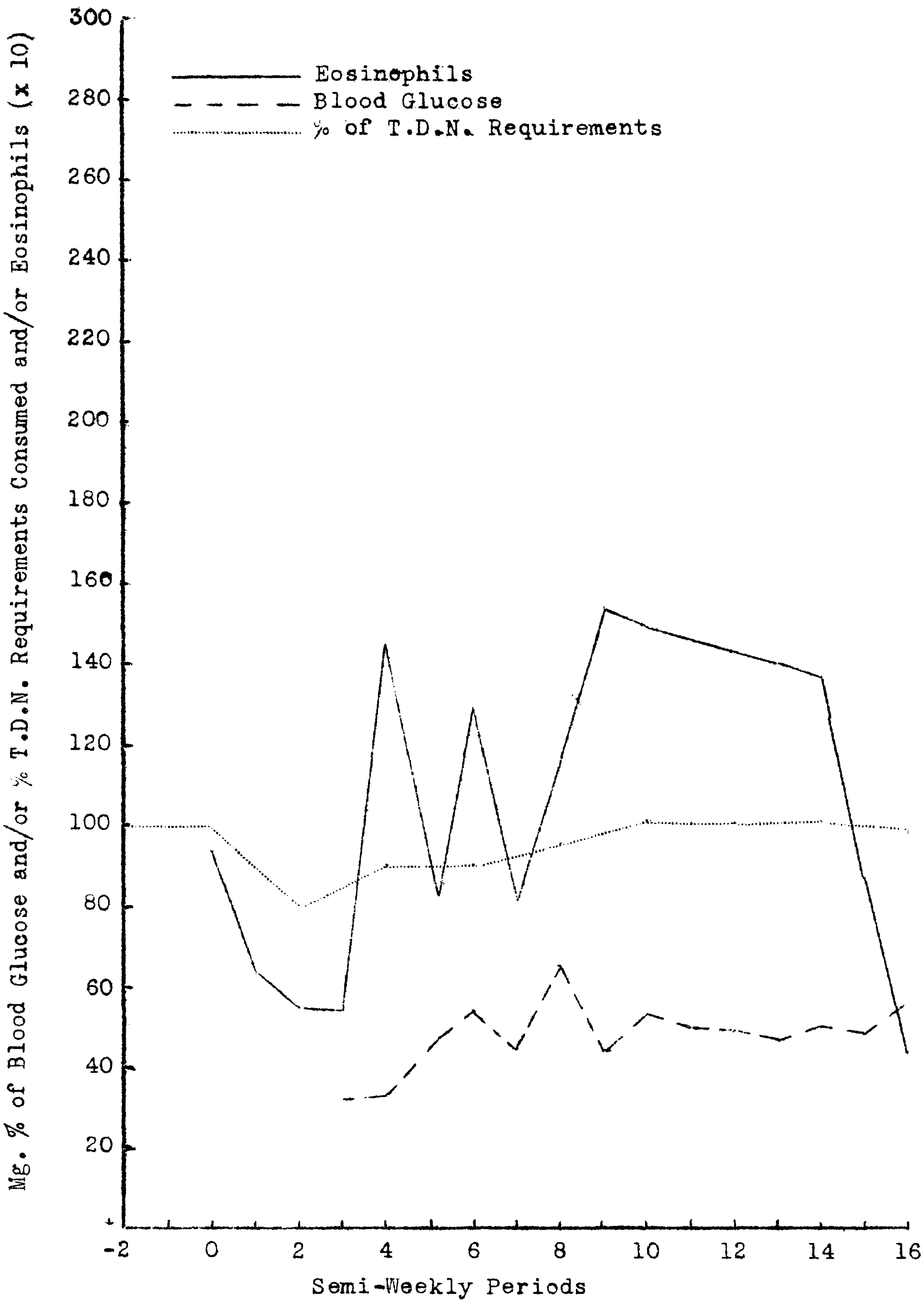


FIGURE 4

Eosinophils per cu. mm. of Blood, Blood Glucose (mg. %) and Percent of T.D.N. Requirements consumed by Cow No. 2426

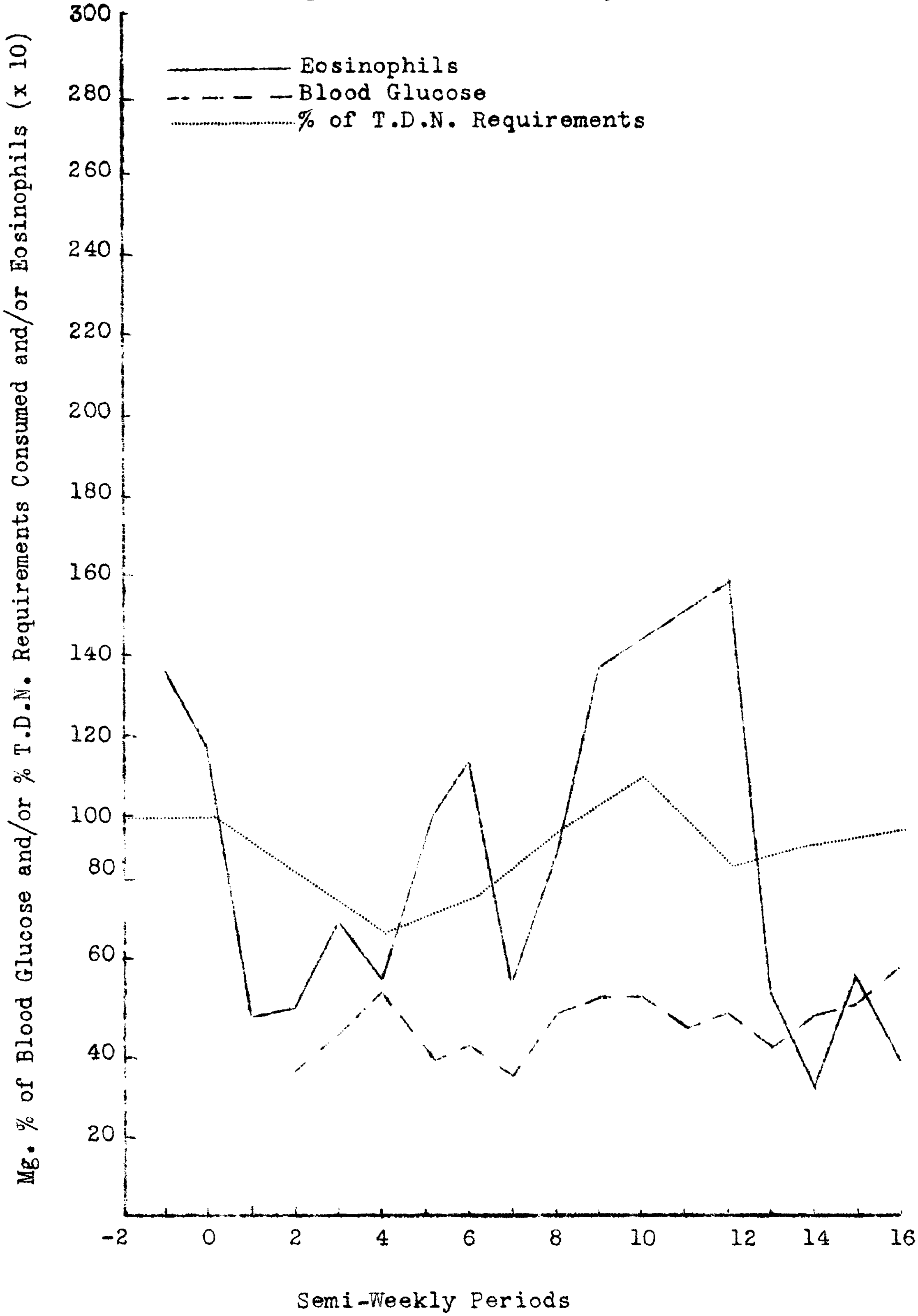


FIGURE 5

Eosinophils per cu. mm. of Blood, Blood Glucose (mg. %) and Percent of T.D.N. Requirements consumed by Cow No. 2414

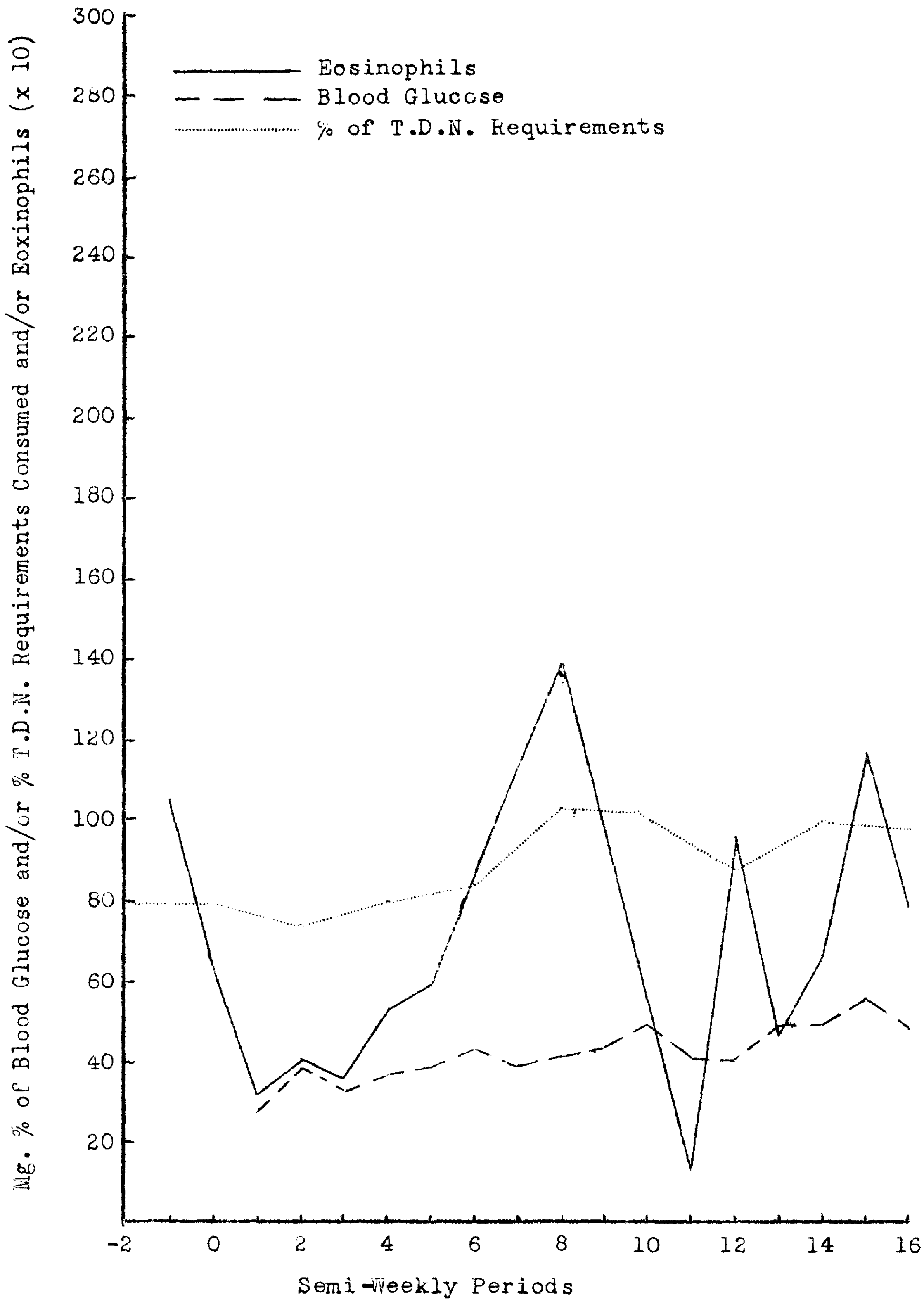


FIGURE 6

Eosinophils per cu. mm. of Blood, Blood Glucose (mg. %) and Percent of T.D.N. Requirements Consumed by Cow 2823

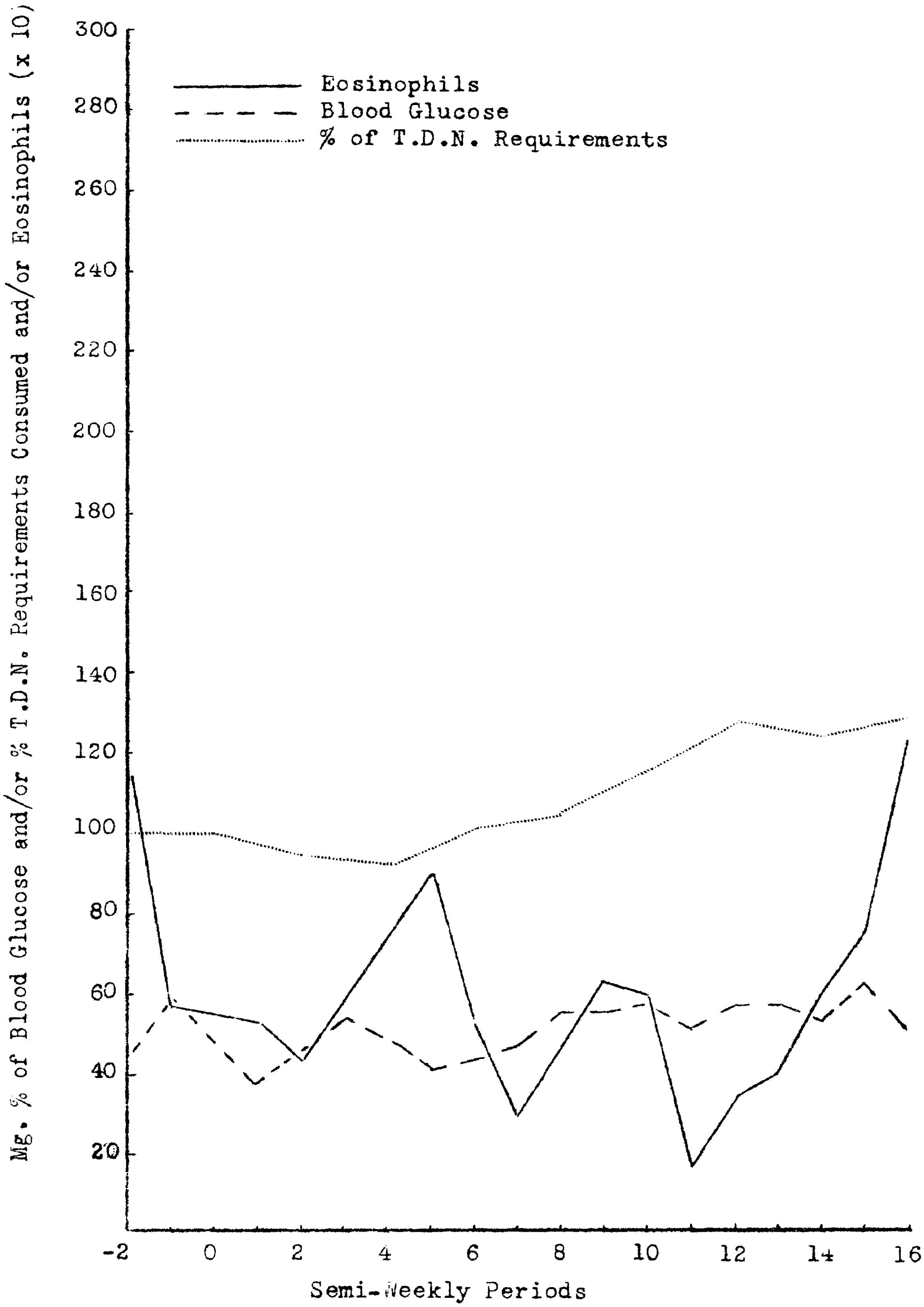


FIGURE 7

Eosinophils per cu. mm. of Blood, Blood Glucose (mg. %) and Percent of T.D.N. Requirements Consumed by Cow No. 2452

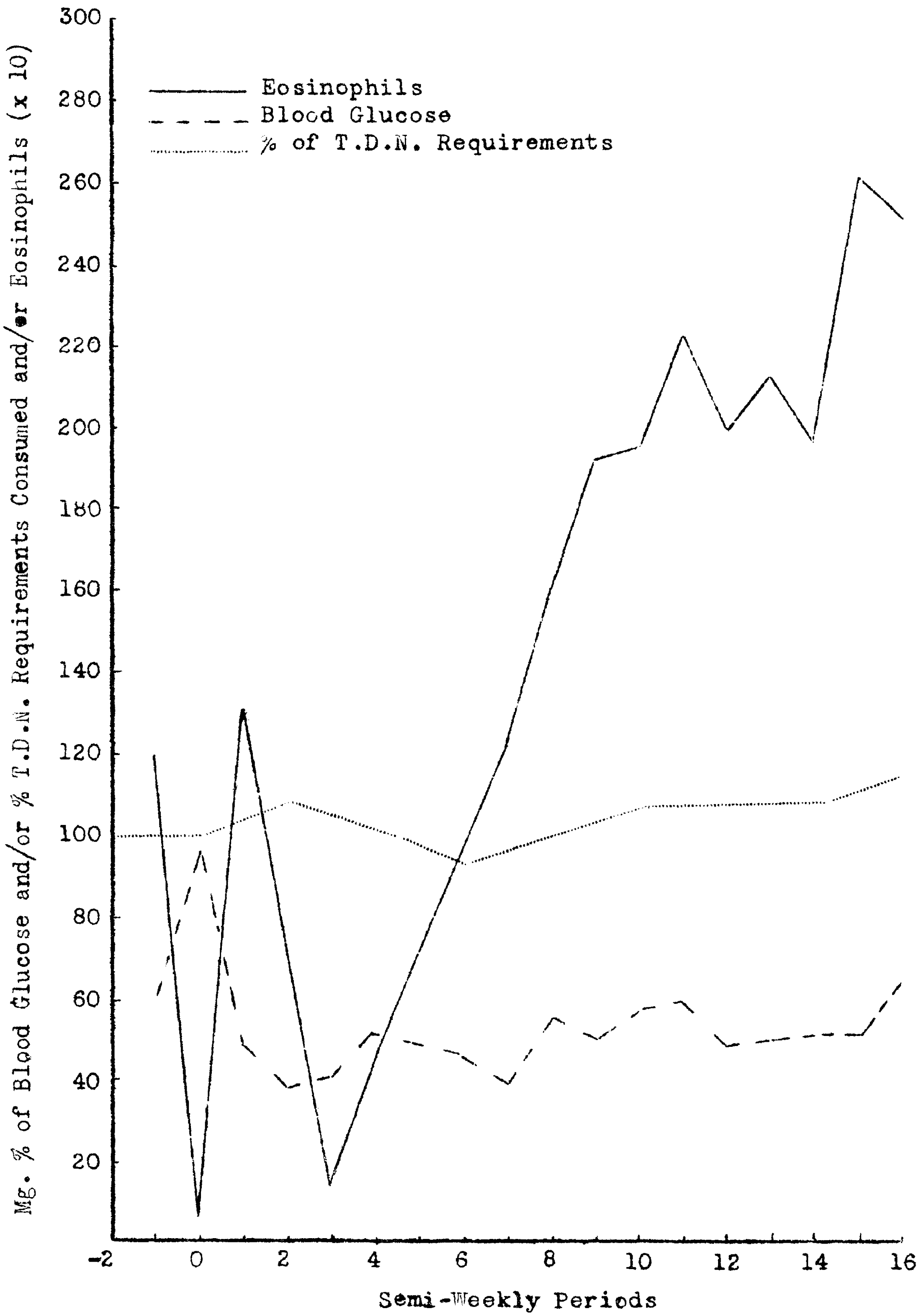


FIGURE 8

Eosinophils per cu. mm. of Blood, Blood Glucose (mg.%) and Percent of T.D.N. Requirements consumed by Cow No 2476

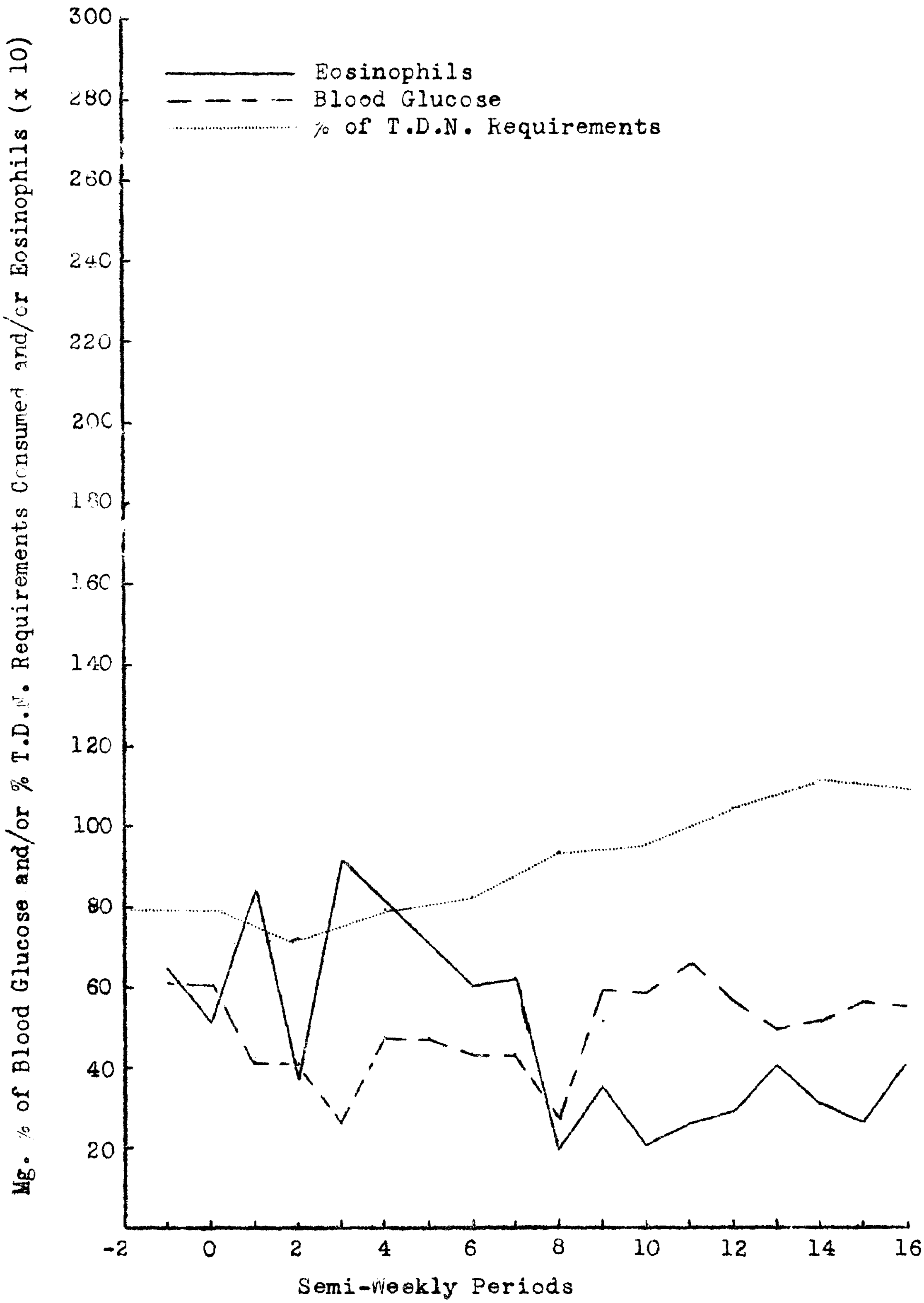


FIGURE 9

Eosinophils per cu. mm. of Blood, Blood Glucose (mg. %) and Percent of T.D.N. Requirements Consumed by Cow No. 2485

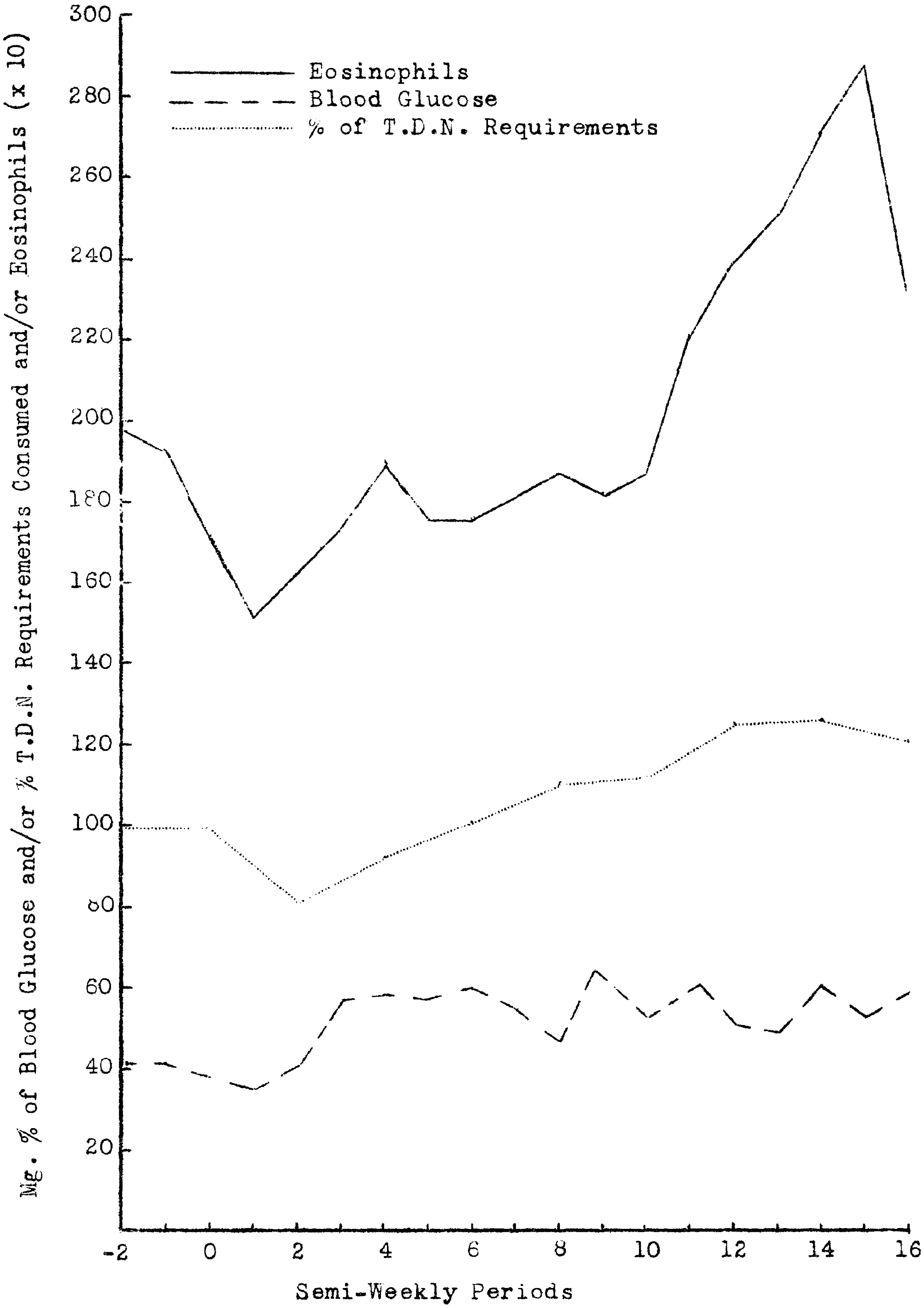


FIGURE 10

Eosinophils per cu. mm. of Blood, Blood Glucose (mg.%) and Percent of T.D.N. Requirements consumed by Cow 2470

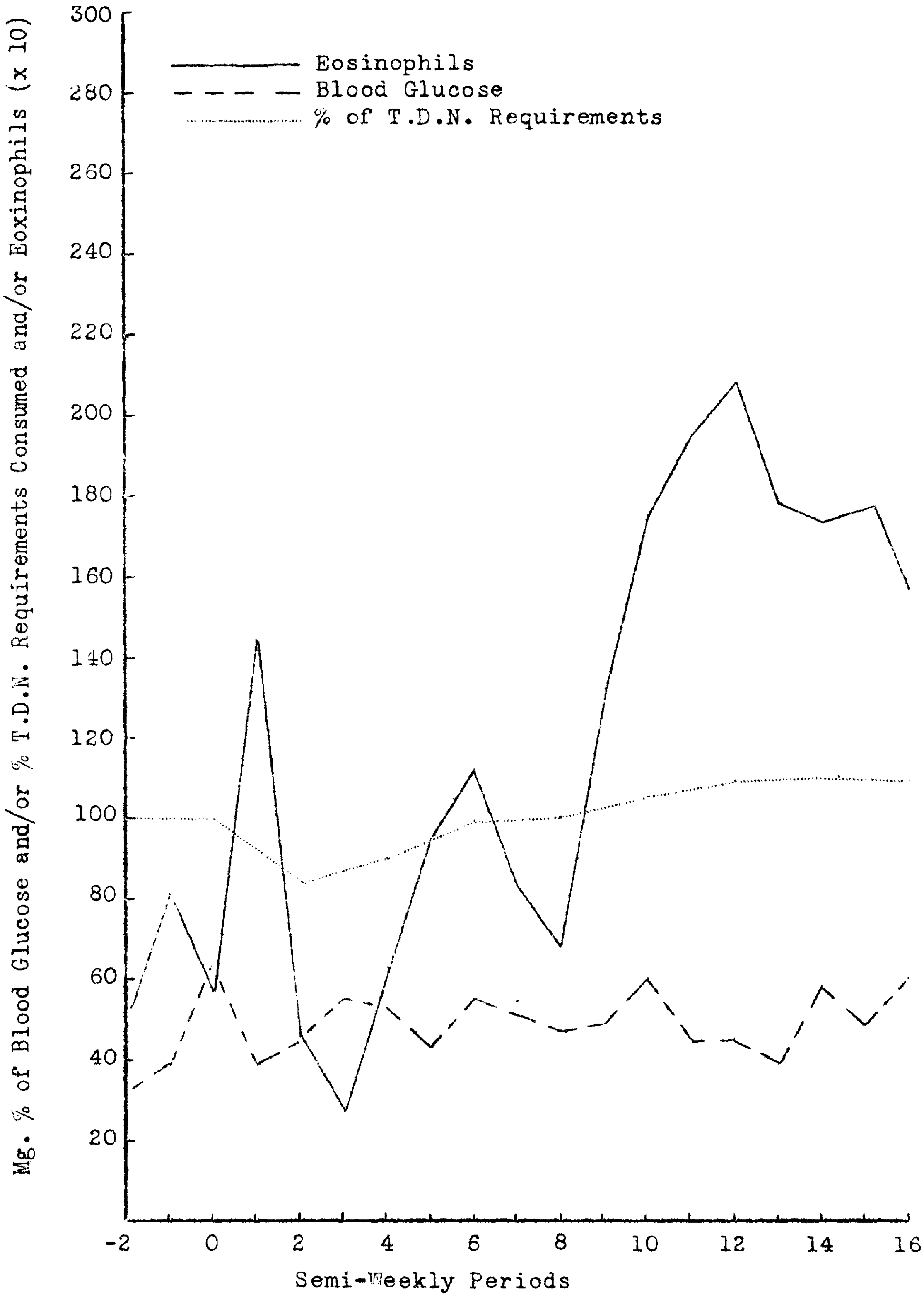


FIGURE 11

Eosinophils per cu. mm. of Blood, Blood Glucose (mg. %) and Percent of T.D.N. Requirements by Cow No. 2446

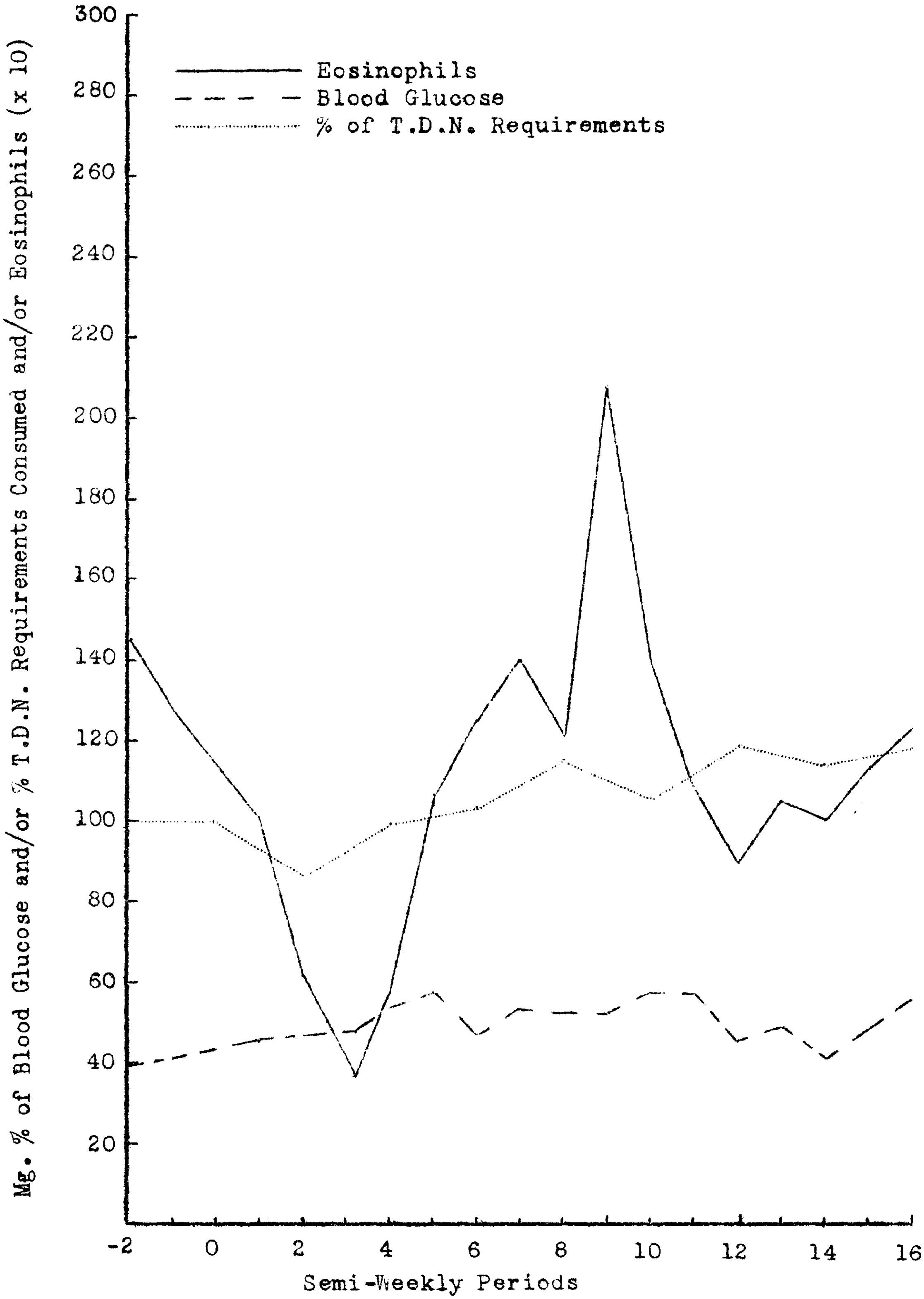


FIGURE 12

Eosinophils per cu. mm. of Blood, Blood Glucose (mg. %) and Percent of T.D.N. Requirements consumed by Cow No. 2037

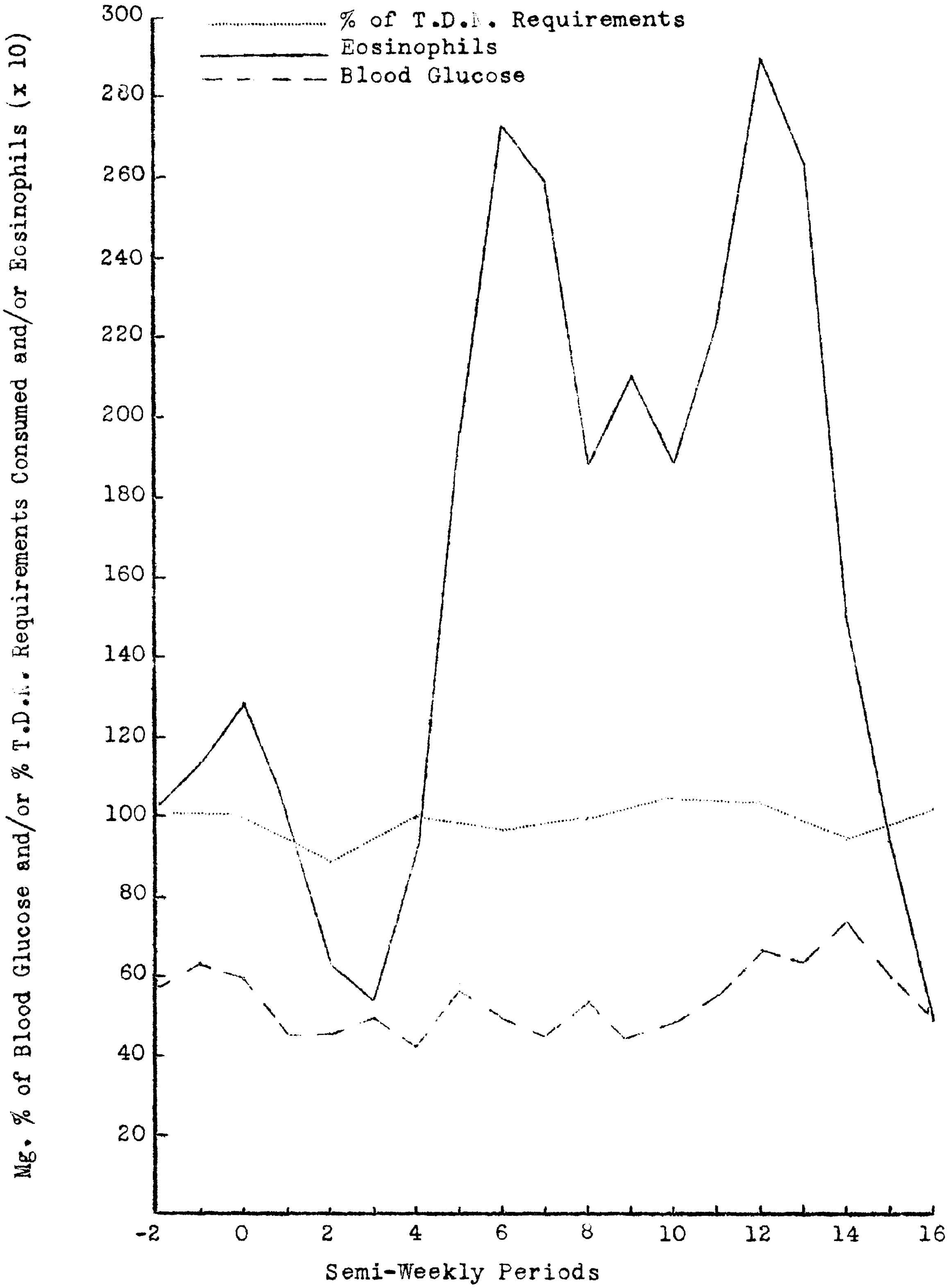


FIGURE 13

Eosinophils per cu. mm. of Blood, Blood Glucose (mg. %) and Percent of T.D.N. Requirements consumed by Cow No. 2406

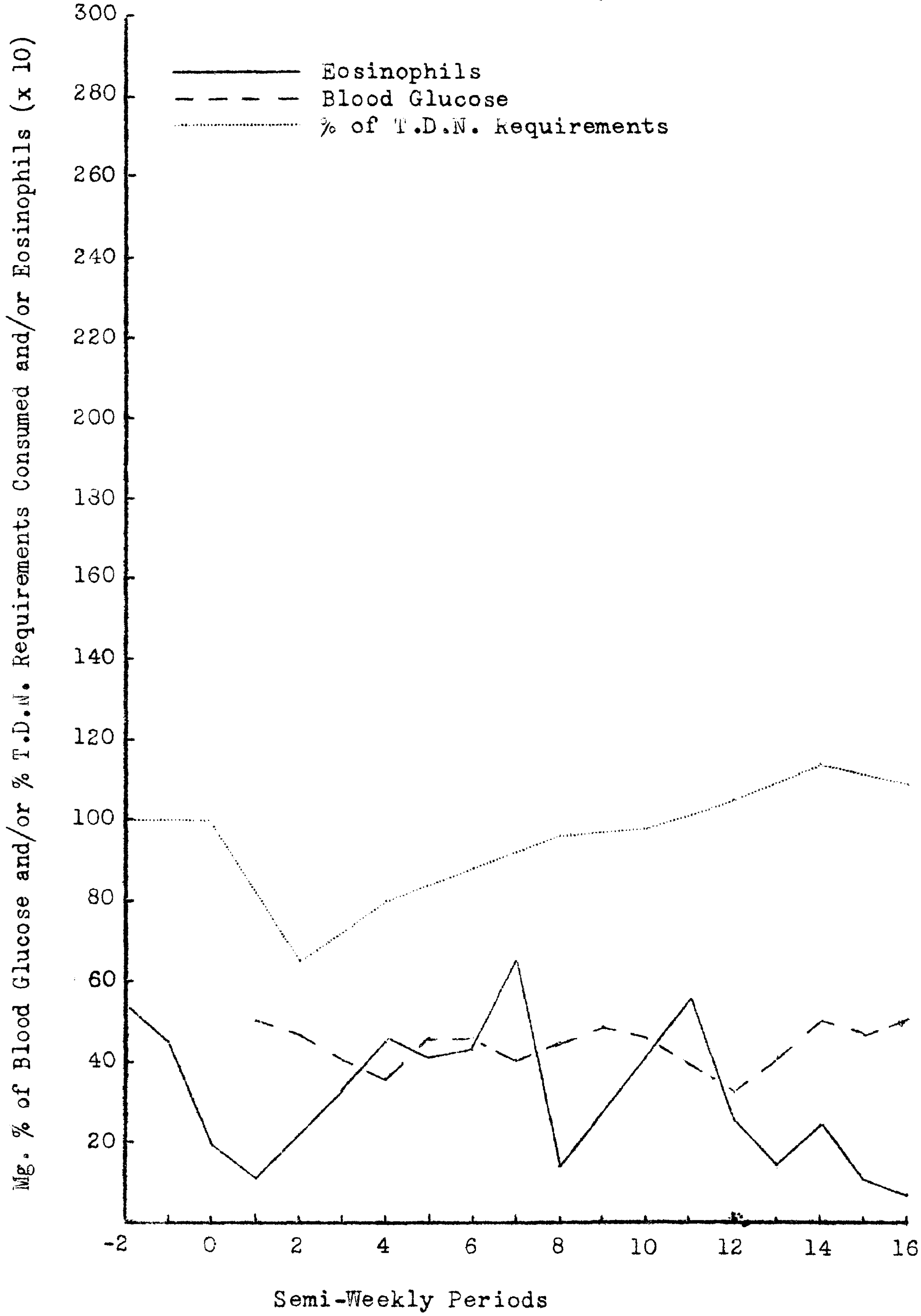


TABLE I

Eosinophils per cu. mm. in the Blood of Normal High Producing Cows Immediately Prepartum and Postpartum at Semi-Weekly Periods.

Semi-Weekly Periods	Cow Numbers												
	2842	2838	2426	2414	2823	2452	2476	2485	2470	2446	2037	2406	Av.
2	—	—	—	—	1138	—	—	1965	538	1454	1031	533	1110
1	—	—	1365	1054	572	1199	644	1926	810	1282	1138	455	1045
0*	—	899	1166	633	—	61	510	—	577	—	1282	189	665
1	422	633	500	322	533	1315	847	1515	1443	1010	1075	111	811
2	533	555	522	405	433	655	372	1110	461	616	663	—	574
3	599	544	744	366	—	128	910	1726	278	377	544	361	578
4	860	1443	594	511	—	477	—	1900	633	572	921	455	837
5	916	821	1005	594	899	—	—	1750	956	1061	1965	416	1038
6	1227	1287	1121	871	505	—	599	1750	1127	1250	2730	427	1172
7	1143	810	588	101	289	1227	622	1500	834	1400	2590	655	979
8	783	1166	899	1399	466	1626	200	1865	688	1215	1887	144	1029
9	777	1504	1376	—	625	1993	350	1821	1325	2086	2100	—	1396
10	1476	1487	—	—	594	1948	217	1865	1750	1390	1885	—	1401
11	—	—	—	136	161	2225	261	2215	1950	1090	2238	561	1204
12	—	—	1587	960	339	1990	289	2390	2086	900	2890	261	1369
13	1260	1404	555	465	400	2138	400	2508	1787	1055	2637	150	1230
14	966	1365	322	677	599	1950	305	2750	1750	1000	1525	250	1122
15	389	827	594	1165	755	2650	267	2875	1776	1138	937	111	1124
16	677	444	394	790	1225	2575	405	2325	1565	1227	483	77	1016

TABLE II

Blood Glucose. Mg. per 100 ml. of Blood of Normal High Producing Cows Immediately Prepartum and Postpartum at Semi-Weekly Periods

	2842	2838	2426	2414	2823	2452	2476	2485	2470	2446	2037	2406
2	—	—	—	—	44.2	—	—	40.3	33.8	39.3	57.5	—
1	—	—	—	—	58.3	60.1	61.6	41.3	38.8	41.3	63.3	—
0	—	—	—	—	—	96.2	60.0	—	63.3	—	59.3	—
1	—	—	—	27.8	38.3	48.4	40.8	34.5	39.8	45.0	45.0	52.0
2	—	—	35.9	39.8	44.3	39.5	40.0	41.3	45.5	46.8	46.3	46.3
3	33.8	31.2	45.0	33.0	52.0	41.3	26.8	56.3	55.0	47.5	48.8	40.8
4	30.7	33.8	56.4	36.7	49.5	52.0	47.0	58.3	53.5	53.3	42.0	36.4
5	39.5	44.7	38.5	38.5	41.3	49.5	46.3	56.8	43.8	56.3	56.3	45.5
6	44.5	50.2	42.9	43.3	43.8	46.3	43.8	60.0	55.0	46.8	48.8	45.3
7	42.2	44.2	34.6	38.8	45.5	39.0	43.8	55.0	51.3	53.8	44.5	41.3
8	46.0	64.2	49.5	41.8	54.8	55.0	31.0	46.3	47.8	52.5	53.8	45.5
9	43.3	43.8	54.3	43.3	54.5	50.5	59.3	64.5	48.8	52.0	44.3	48.3
10	39.3	53.8	54.5	48.5	61.0	57.5	58.0	53.8	60.0	57.5	48.3	46.0
11	47.0	50.8	47.0	41.0	41.0	51.3	58.8	65.0	61.3	45.0	57.5	54.5
12	46.8	48.5	51.3	40.3	57.5	48.0	56.8	51.3	45.5	45.5	65.5	33.8
13	42.3	46.3	41.8	48.3	55.3	50.0	49.0	48.8	39.3	48.3	62.5	41.3
14	38.8	50.0	49.0	49.5	52.8	50.8	51.3	61.0	58.3	40.5	72.5	50.5
15	46.3	48.3	53.5	56.0	62.0	50.8	56.3	53.3	48.3	48.7	58.8	47.0
16	52.5	56.0	62.5	48.3	50.0	63.8	55.8	59.5	60.5	55.8	50.0	49.0

TABLE III

Average Daily Milk Production in Pounds of Twelve High Producing Cows During the First Eight Weeks Postpartum

	2842	2838	2426	2414	2823	2452	2476	2485	2470	2446	2037	2406	Av.
1	53.3	50.4	58.1	52.5	44.5	38.5	50.7	46.8	58.4	45.3	67.6	51.1	51.4
2	58.7	50.5	66.6	62.6	55.1	47.8	57.8	53.8	66.5	53.3	75.3	64.7	59.4
3	66.0	53.8	60.4	65.5	55.4	54.7	59.2	55.8	69.4	59.2	79.2	65.9	62.0
4	65.1	57.9	69.0	68.6	58.3	53.3	64.4	55.6	74.9	61.9	85.3	72.5	65.6
5	68.2	57.8	71.5	69.8	59.1	57.2	64.0	57.0	72.2	65.7	85.8	75.4	67.0
6	66.1	56.9	66.9	65.9	51.5	60.1	63.8	56.1	74.3	63.4	86.7	73.1	65.4
7	61.0	57.7	69.4	66.0	54.6	58.1	65.6	53.6	77.8	65.5	89.1	64.0	65.2
8	62.9	57.6	71.2	66.6	55.8	59.3	67.1	53.0	75.5	63.0	88.4	63.3	65.3

TABLE IV

Percent of T. D. N. Requirements Consumed by Twelve High Producing Cows Immediately Prepartum and Postpartum

	2842	2838	2426	2414	2823	2452	2476	2485	2470	2446	2037	2406	Av.
0*	100	100	100	100	100	100	100	100	100	100	100	100	100
1	88	80	85	74	94	108	72	81	84	86	88	65	84
2	89	90	71	80	92	102	79	92	90	99	99	80	89
3	88	90	79	84	101	93	82	104	99	103	96	88	92
4	84	95	95	103	104	100	93	110	100	115	99	96	100
5	97	103	110	102	115	107	95	112	105	106	104	98	105
6	86	101	88	88	127	108	104	125	109	119	103	105	105
7	101	102	93	100	124	108	111	126	110	114	94	114	108
8	101	98	95	98	128	114	109	121	109	118	101	109	108

*Week of calving

TABLE V

Total Leucocytes per cu. mm. in the Blood of Normal High Producing Cows Immediately Prepartum and Postpartum at Semi-Weekly Periods (X 10)

	2842	2838	2426	2414	2823	2452	2476	2485	2470	2446	2037	2406	Av.
2	—	—	—	—	645	—	—	1555	1068	778	1575	410	1005
1	—	—	985	895	1080	1183	633	1383	918	703	1055	630	947
0*	—	1415	1120	620	—	225	268	—	983	—	723	845	775
1	695	630	865	715	688	748	805	1370	1379	515	738	535	807
2	610	720	485	525	868	558	788	1315	1283	593	633	—	762
3	760	815	590	723	—	558	825	1398	1185	370	680	858	797
4	753	656	665	775	—	675	—	1253	1068	540	950	1028	836
5	840	720	858	690	985	—	—	1355	894	600	1095	468	851
6	728	993	513	705	928	—	540	1055	933	618	1140	555	792
7	652	670	830	685	745	795	783	1363	815	475	878	658	779
8	520	675	655	858	985	1015	610	1128	918	680	896	625	797
9	715	890	1058	—	880	818	945	1313	948	915	1130	—	916
10	800	860	—	—	1125	1150	795	1128	1058	593	1108	—	957
11	—	—	—	595	698	1233	848	1223	898	813	1255	778	927
12	—	—	1000	880	943	1238	740	1193	1108	490	1128	588	931
13	943	990	448	790	1348	1363	940	1364	1008	640	1125	578	961
14	803	923	490	724	1303	1203	888	1235	795	608	900	700	881
15	668	783	680	930	1088	1350	730	890	1003	725	1020	775	887
16	695	553	663	668	875	1180	1100	1300	890	930	855	870	882

*Week of calving

Observed Changes in Cows Subjected to Heat Stress

The cows which were subjected to high temperature exhibited a rather wide range in the absolute eosinophil values. This was true even in the normal or pretreatment values which varied from a low of 439 eosinophils per cu. mm. of blood, to a high of 3,408. Because of this variability, it was decided to express the eosinophil values for each observation in terms of percent change from the normal. This procedure facilitated the comparison of the results obtained.

The changes in body temperature and the changes which were observed in the blood eosinophils during the course of this experiment are presented graphically in Figures 14, 15, 16 and 17 for the 16 cows that were used. The data from which these charts were prepared are presented in Tables XVIII through XXXIII in the appendix.

An attempt is made to determine if the observed changes in the eosinophil levels might be used as a measure of adaptation or resistance to the stress of moist heat.

Cow number 2272 (Figure 14) had the highest body temperature of any of the 16 cows studied. The body temperature increased from a normal value of 100.7 degrees F. to 108 degrees F. during the six hour period. This was an increase of 7.3 degrees, with an average temperature rise of 5.23 degrees F. At the same time there was a drop of 72 percent in the eosinophil level of the blood by the end of the six hour period. Additional evidence that the animal was under great stress was shown by an excessive salivation and by an increase in the respiration rate. The respiration increased from a normal rate of 68 per minute to 160 per minute, which was observed after the animals had been in the heat chamber for four hours. By the end of the six hour period the rate of breathing had slowed somewhat.

Cows number Sx-46 and 2696 (Figure 14) had the lowest rise in body temperature of any of the sixteen cows studied. Sx-46 had a normal temperature of 101.5 degrees F. This had increased to 102.5 by the third hour after which it decreased to 102.2 degrees by the end of the six hour period. Her average temperature rise was .75 degrees F. In no other cow was the maximum body temperature reached as soon as the third hour. Respiration rate increased from a normal of 28 per minute to 162 by the third hour, and then decreased to 152. This was a three year old, dry cow that had been exposed to the heat on one previous occasion, also as a dry cow, at which time her average temperature rise was .83 degrees F. Cow number 2696, a two year, nine month old, dry cow, had a normal body temperature of 101.7 degrees F. This animal had a 1.1 degree rise in body temperature which was reached by the fifth hour. She had an average temperature rise of .70 degrees F. The initial respiration rate was 28 and it increased to 168 by the fourth hour. Both of these animals showed a decrease in the eosinophil level by the end of the second hour of the heat period, followed by an increase to the fourth hour. At this time the values were above the normal level. The eosinophil values of cow number Sx-46 maintained this level until the end of the experimental period, whereas in cow number 2696 the eosinophil values decreased to the sixth hour. Two hours after the end of the six hour heat period, the eosinophil level of cow number 2696 had increased to a higher than normal level. It is possible that cow number Sx-46 reacted to the stress, but was unable to resist the effects and to maintain this resistance for the remainder of the period. Cow number 2696 may have reacted to the stress, started to resist, but was unable to maintain the resistance. She appeared to adapt easily after the stress was discontinued.

The remaining twelve cows all showed a similar trend in body temperature. The maximum temperatures of these twelve cows were intermediate between those of the four cows mentioned above. With the exception of cow number Sx-44 (Figure 16) whose maximum body temperature was reached by the fourth hour, all body temperatures reached the maximum by the fifth or sixth hour. The respiration rates of these twelve cows increased to maximum levels sometime before the end of the six hour period. This varied with the individual cow. Cow number 2678 (Figure 15) reached this maximum by the second hour. The maximum body temperature of the remainder of these cows was reached sometime between the second and fifth hour of the six hour period. In all cases there was a decrease in the respiration rate by the end of the six hour period.

The eosinophil changes were variable in all of the sixteen cows during the course of this experiment, but these changes seem to fall in one of four general patterns.

1. Cows number 2272 and 2669 (Figure 14), Sx-9 and Sx-43 (Figure 16) and Sx-11 and Sx-42 (Figure 17) showed a more or less steady decline in the eosinophil values throughout the six hour heat period.

2. Cows number Sx-46 and 2696 (Figure 14), 2675 (Figure 16), and Sx-6 (Figure 17) showed a maximum drop in eosinophil levels at the second hour, with a subsequent rise.

3. Cows number Sx-2, 2694 and 2643 (Figure 15) and Sx-44 (Figure 16) showed a maximum increase in eosinophil levels at the second hour, with a subsequent fall.

4. Cows number 2678 (Figure 15) and Sx-1 (Figure 17) showed relatively little change in the eosinophil level throughout the experimental period.

Table V-a has been prepared in order to show that in this particular study, the eosinophil pattern per se does not offer a precise measure of the animal's ability to adapt itself to the stress of moist heat. It can be seen from the table that the heat resistance rating, based on the average temperature rise, is quite consistent for the individual cow regardless of stage of lactation. It can also be seen that the average eosinophil values, based on a trapezoidal mean, are not consistent with the heat resistance ratings. It is possible that if a series of two or more eosinophil values were obtained on the dry cow, a normal pattern for that individual might be established. If so, deviations from this normal might be useful as a tool to measure the effects of heat stress.

TABLE V-a

Base Data for Evaluating the Heat Resistance on 16 Cows Subjected to the Stress of Moist Heat.
(Temperatures are expressed as degrees F., eosinophils as number per cu. mm. of blood).

Cow No.	Months in milk	Norm body T.	Mean body T.	Average body T. rise	Rating	Average eosinophil value
2272	dry	100.3	103.85	3.82	3	
	1	100.7	105.90	5.23	3	280
2243	dry	100.9	103.62	2.72	3	
	4	101.0	104.07	3.07	3	1446
2269	dry	101.0	103.00	2.00	3	
	3	100.9	105.22	4.32	3	2891
2675	dry	100.8	102.48	1.68	2	
	dry	100.9	102.41	1.51	2	1514
2678	dry	100.7	102.38	1.68	2	
	10	102.1	104.88	2.78	2	3076
2694	dry	101.4	102.75	1.35	2	
	dry	101.3	102.55	1.25	2	848
2696	dry	101.8	102.33	.53	1	
	dry	101.7	102.47	.70	1	1427
Sx-1	dry	101.3	101.83	.53	1	
	1	101.1	103.18	2.08	2	1339
Sx-2	dry	100.9	101.88	.98	1	
	2	100.7	101.93	1.23	1	552
Sx-6	dry	100.9	101.88	.98	1	
	2	100.7	101.93	1.23	1	1515
Sx-9	dry	100.9	101.82	.92	1	
	1	101.0	103.13	2.13	2	785
Sx11	dry	101.1	102.17	1.07	2	
	1	102.1	104.27	2.17	2	563
Sx42	dry	101.6	101.55	.95	1	
	4	101.6	103.22	1.62	1	1214
Sx43	dry	101.4	102.38	.98	1	
	5	101.4	102.68	1.28	1	429
Sx44	dry	100.9	101.70	.80	1	
	3	101.4	102.61	1.27	1	1129
Sx46	dry	101.0	101.83	.83	1	
	dry	101.3	102.05	.75	1	389

Note: The first line for each cow shows the temperature observations on animal during the dry period prior to the present study. The second line shows data collected during the eosinophil study.

FIGURE 14

% Change in Eosinophils from Normal and Body Temperature of Cows 2272, Sx-6, 2669 and 2696 during 6hr. period in heat chamber

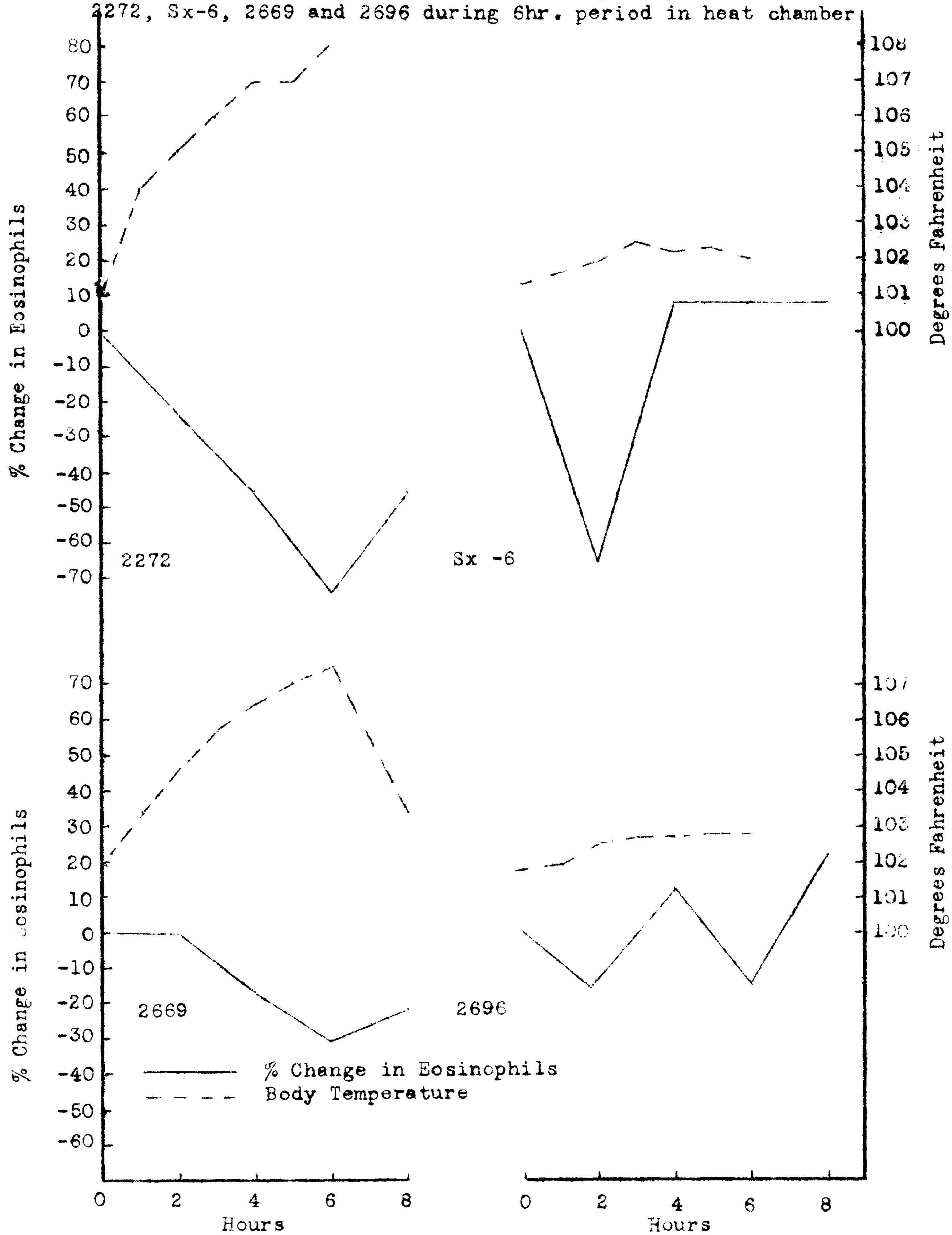
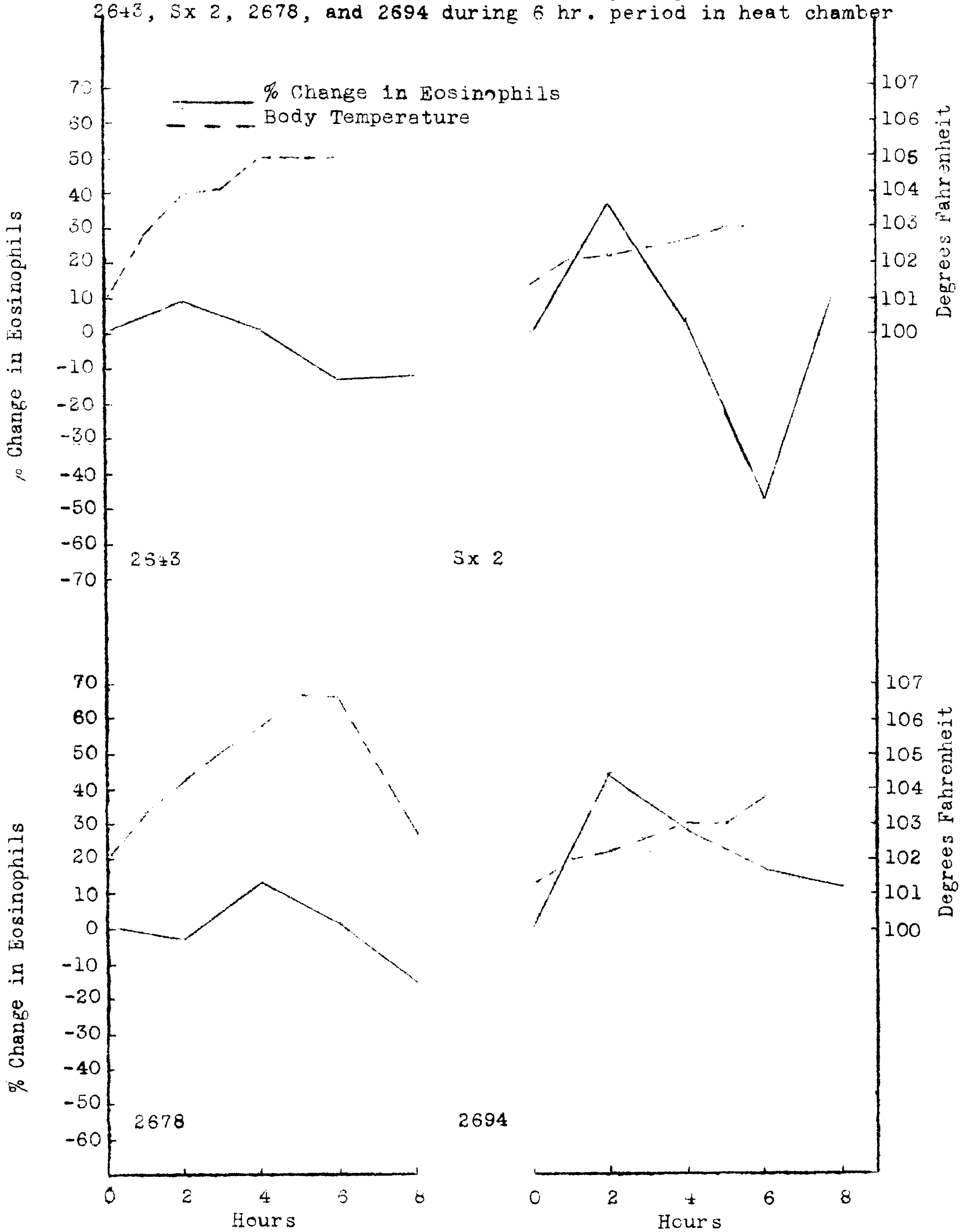


FIGURE 15

% Change in Eosinophils from Normal and Body Temperature of Cows 2643, Sx 2, 2678, and 2694 during 6 hr. period in heat chamber



DISCUSSION

The data reported indicate that the stress of parturition has a depressing effect upon the eosinophil level in the blood of the dairy cow. An eosinopenia was observed in all of the cows included in this study at the time of parturition. The fact that all cows responded in a similar manner indicates that parturition is a major stressor agent. The parturient eosinopenia observed in this study confirms the work of Gill (5).

The onset of lactation may be a secondary stressor agent which is imposed upon the cow before she has completely recovered from the stress of parturition. It is possible that the increase in the metabolic rate due to lactation stimulates the pituitary adreno-cortical system which in turn exerts a suppressing effect on the eosinophil level. The variations which occurred between cows is probably due to the ability of the individual animal to resist or to adapt to the stress. Unknown factors may also contribute to this individual variability.

It has been suggested by Shaw et al (27) that the rise in blood glucose at the time of parturition may be due to a rapid mobilization of glucose or to a rapid breakdown of lactose as a result of excitement. Dairy cows typically have this hyperglycemia at time of calving regardless of the degree of visible excitation. A hyperglycemia and eosinopenia similar to that which was observed in this study at the time of parturition can be produced by the injection of ACTH. This suggests that the hyperglycemia accompanying parturition may be mediated at least in part by the discharge of ACTH and glucocorticoids.

It has been shown by Leffel (17) that hypoglycemia was a characteristic feature in the blood of cows that were fasted following calving. He also observed that in cows, whose T. D. N. consumption following calving did not fall below 70% of requirements, the blood glucose values tended to remain at normal levels following the parturient hypoglycemia. The results of this study confirm the work of Leffel. The blood glucose levels of the cows in this study remained relatively high following calving. On the average these cows were able to consume not less than 84 percent of their T. D. N. requirements during and after the first week postpartum.

Changes were observed in the eosinophil levels in the blood of cows which were subjected to the stress of heat. In general an eosinopenia occurred, but the variations between cows were too great to establish precise conclusions as to the value of the eosinophil count as a measure of reaction to heat stress. Change in body temperature during the six hour period of heat is currently being used as a measure of heat tolerance. The data reported in this study indicate, only generally, that those animals having the lowest heat tolerance also show the greatest drop in eosinophil levels. On the other hand, those animals that have the highest heat tolerance seem to show the least drop in eosinophil levels. There was no correlation between temperature rise and eosinophil levels, in the cows whose temperature rise is intermediate.

It has been shown that the cortical steriods influence the eosinophil level of the blood. However, there is no assurance that other factors are not also responsible. Therefore, it cannot be assumed that all fluctuations in the eosinophil values are indications of adrenal activity. It has been pointed out (24) that the white cell count is normally different in different vascular territories of the body. Therefore, the technician cannot be absolutely sure that every blood sample will yield representative results. Selye (26) and Gradwohl (7) have pointed out that the same stressor agents may produce diametrically opposed reactions under different experimental conditions. Therefore, some variations in the observed eosinophil levels may be due to conditions within the animal body at the time of sampling.

In view of the results obtained in this study, it appears that the diagnostic value of the eosinophil count is greatest when it is used as a supplement to other diagnostic methods.

CONCLUSIONS

On the basis of the changes in the blood eosinophils, it appears that the stress of parturition in the dairy cow is a primary stress which elicits marked adrenal cortex activity. A decrease in blood eosinophils occurred during the parturient period of all cows studied.

The onset of lactation in the dairy cow appears to constitute a secondary stress which is imposed upon the animal before complete recovery from the stress of parturition takes place. In general the eosinophils increased gradually after the first few days postpartum, although the variations were large.

Postparturient hypoglycemia was absent in normal cows who's T.D.N. intake did not fall below 80 percent of requirements.

The hyperglycemia at time of parturition may be associated with the increased pituitary-adreno-cortical activity apparent at this time.

The eosinophil count is not a reliable measure of heat tolerance.

The greatest value of the eosinophil count is realized when it is used in connection with other diagnostic methods.

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APPENDIX

TABLE VI

Experimental Data on Cow No. 2842

Fresh 6-5-52

Date	Eosino-phils per cu. mm.	Leuko-cytes per cu. mm.	Blood Glucose mg. per 100 ml.	Average daily milk production in pounds	% of T.D.N. re-quirements consumed
6-10-52	422	6950	—	—	—
6-12-52	522	6100	—	53.3	88
6-16-52	599	7600	33.8	—	—
6-19-52	860	7525	30.7	58.7	89
6-23-52	916	8400	39.5	—	—
6-26-52	1227	7275	44.5	66.0	88
6-30-52	1143	6523	42.2	—	—
7- 3-52	783	5200	46.0	65.1	84
7- 7-52	777	7150	43.3	—	—
7-10-52	1476	8000	39.3	68.2	97
7-14-52	—	—	47.0	—	—
7-17-52	—	—	46.8	61.1	86
7-21-52	1260	9425	42.3	—	—
7-24-52	966	8025	38.8	61.0	96
7-28-52	389	6675	43.3	—	—
7-31-52	677	6950	52.5	62.9	101
8- 4-52	985	4888	52.5	—	—
8- 7-52	775	7200	58.8	61.6	101
8-11-52	940	9175	46.0	—	—

Butterfat Tests: 6-30-52, 2.79%; 7-28-52, 3.57%

TABLE VII

Experimental Data on Cow No. 2838

Fresh 6-6-52

Date	Eosino-phils per cu. mm.	Leuko-cytes per cu. mm.	Blood Glucose mg. per 100 ml.	Average daily milk production in pounds	% of T.D.N. requirements consumed
6- 6-52	899	14150	—	—	100
6-10-52	633	6300	—	—	—
6-12-52	555	7200	—	50.4	80
6-16-52	544	8150	31.2	—	—
6-19-52	1443	6560	33.8	50.5	90
6-23-52	821	7200	44.7	—	—
6-26-52	1287	9925	50.2	53.8	90
6-30-52	810	6700	44.2	—	—
7- 3-52	1666	6750	64.2	57.9	95
7- 7-52	1504	8900	43.8	—	—
7-10-52	1487	8600	53.8	57.8	103
7-14-52	—	—	50.8	—	—
7-17-52	—	—	48.5	56.9	101
7-21-52	1404	9900	46.3	—	—
7-24-52	1365	9225	50.0	57.7	102
7-28-52	827	7825	48.3	—	—
7-31-52	444	5525	56.0	57.6	98
8- 4-52	666	7000	56.3	—	—
8- 7-52	1288	12550	58.5	56.0	103
8-11-52	1240	11725	51.3	—	—

Butterfat Tests: 6-30-52, 2.97%; 7-28-52, 3.42%

TABLE VIII

Experimental Data on Cow No. 2426

Fresh 6-10-52

Date	Eosino-phils per cu. mm.	Leuko-cytes per cu. mm.	Blood Glucose mg. per 100 ml.	Average daily milk production in pounds	% of T.D.N. re-quirements consumed
6- 6-52	1365	9850	—	—	100
6-10-52	1166	11200	—	—	—
6-12-52	500	8650	—	—	100
6-16-52	522	4850	35.9	—	—
6-19-52	744	5900	45.0	58.1	85
6-23-52	594	6650	56.4	—	—
6-26-52	1005	8575	38.5	66.6	71
6-30-52	1121	5125	42.9	—	—
7- 3-52	588	8300	34.6	60.4	79
7- 7-52	899	6550	49.5	—	—
7-10-52	1376	10575	54.3	69.0	95
7-14-52	—	—	54.5	—	—
7-17-52	—	—	47.0	71.5	110
7-21-52	1587	10000	51.3	—	—
7-24-52	555	4475	41.8	66.9	88
7-28-52	322	4900	49.0	—	—
7-31-52	594	6800	53.5	69.4	93
8- 4-52	394	6630	62.5	—	—
8- 7-52	522	6400	63.3	71.2	95

Butterfat Tests: 6-30-52, 4.43%; 7-28-52, 3.54%

TABLE IX

Experimental Data on Cow No. 2414

Fresh 6-12-52

Date	Eosinophils per cu. mm.	Leukocytes per cu. mm.	Blood Glucose mg. per 100 ml.	Average daily milk production in pounds	% of T.D.N. requirements consumed.
6-10-52	1054	8950	—	—	—
6-12-52	633	6200	—	—	—
6-16-52	322	7150	27.8	—	—
6-19-52	405	5250	39.8	52.5	74
6-23-52	366	7225	33.0	—	—
6-26-52	511	7750	37.7	62.6	80
6-30-52	594	6900	38.5	—	—
7- 3-52	871	7050	43.3	65.5	84
7- 7-52	101	6850	38.8	—	—
7-10-52	1399	8575	41.8	68.6	103
7-14-52	—	—	43.3	—	—
7-17-52	—	—	48.5	69.8	102
7-21-52	135	5950	41.0	—	—
7-24-52	960	8800	40.3	65.9	88
7-28-52	465	7900	48.3	—	—
7-31-52	677	7240	49.5	66.0	100
8- 4-52	1165	9300	56.0	—	—
8- 7-52	790	6675	48.3	66.6	98
8-11-52	230	6875	53.8	—	—
8-14-52	500	6850	56.5	65.8	105

Butterfat Tests: 6-30-52, 3.98%; 7-28-52, 3.33%

TABLE X

Experimental Data on Cow No. 2823

Fresh 7-4-52

Date	Eosino-phils per cu. mm.	Leuko-cytes per cu. mm.	Blood Glucose mg. per 100 ml.	Average daily milk production in pounds	% of T.D.N. re-quirements consumed
6-19-52	516	5373	50.2	—	100
6-23-52	1188	7475	46.0	—	—
6-26-52	72	2650	46.3	—	100
6-30-52	1138	6450	44.2	—	—
7- 3-52	576	10800	58.3	—	100
7- 7-52	533	6875	38.3	—	—
7-10-52	433	8675	44.3	44.5	94
7-14-52	—	—	52.0	—	—
7-17-52	—	—	49.5	55.1	92
7-21-52	899	9850	41.3	—	—
7-24-52	505	9275	43.8	55.4	101
7-28-52	289	7450	45.5	—	—
7-31-52	466	9850	54.8	58.3	104
8- 4-52	625	8800	54.5	—	—
8- 7-52	594	11250	61.0	59.1	115
8-11-52	161	6975	51.3	—	—
8-14-52	339	9425	57.5	51.5	127
8-18-52	400	13475	55.3	—	—
8-21-52	599	13025	52.8	54.6	124
8-25-52	755	10875	62.0	—	—
8-28-52	1225	8750	50.0	55.8	128

Butterfat Tests: 7-28-52, 3.33%; 8-25-52, 3.20%

TABLE XI

Experimental Data on Cow No. 2452

Fresh 6-27-52

Date	Eosinophils per cu. mm.	Leukocytes per cu. mm.	Blood Glucose mg. per 100 ml.	Average daily milk production in pounds	% of T.D.N. requirements consumed
6-26-52	1199	11825	60.1	—	—
6-27-52	61	2250	96.2	—	100
6-30-52	1315	7475	48.4	—	—
7- 3-52	655	5575	39.5	38.5	108
7- 7-52	128	5575	41.3	—	—
7-10-52	477	6750	41.3	47.8	102
7-14-52	—	—	52.0	—	—
7-17-52	—	—	49.5	54.9	93
7-21-52	1227	7950	46.3	—	—
7-24-52	1626	10150	39.0	53.3	100
7-28-52	1993	8175	55.0	—	—
7-31-52	1948	11500	50.5	57.2	107
8- 4-52	2225	12325	57.5	—	—
8- 7-52	1990	12375	58.8	60.1	108
8-11-52	2138	13625	48.0	—	—
8-14-52	1950	12025	50.0	58.1	108
8-18-52	2650	13500	50.8	—	—
8-21-52	2575	11800	50.0	59.3	114
8-25-52	2440	10150	50.8	—	—
8-28-52	1875	11625	63.8	60.3	115

Butterfat Tests: 7-7-52, 3.0%; 8-25-52, 3.2%

TABLE XII

Experimental Data on Cow No. 2476

Date	Eosinophils per cu. mm.	Leukocytes per cu. mm.	Blood Glucose mg. per 100 ml.	Average daily milk production in pounds	% of T.D.N. requirements consumed
6-30-52	644	6325	61.6	—	100
7- 1-52	510	2675	60.0	—	—
7- 3-52	647	8050	40.8	—	100
7- 7-52	372	7875	40.0	—	—
7-10-52	910	8250	26.8	50.7	72
7-14-52	—	—	47.0	—	—
7-17-52	—	—	46.3	57.8	79
7-21-52	599	5400	43.8	—	—
7-24-52	622	7825	43.8	59.2	82
7-28-52	200	6100	31.0	—	—
7-31-52	350	9450	59.3	64.4	93
8- 4-52	217	7950	58.0	—	—
8- 7-52	261	8475	65.0	64.0	95
8-11-52	289	7400	56.8	—	—
8-14-52	400	9400	49.0	63.8	104
8-18-52	305	8875	51.3	—	—
8-21-52	267	7300	56.3	65.6	111
8-25-52	405	11000	55.8	—	—
8-28-52	294	8600	55.0	67.1	109

Butterfat Tests: 7-28-52, 4.01%; 8-25-52, 3.70%

TABLE XIII

Experimental Data on Cow No. 2485

Fresh 7-25-52

Date	Eosinophils per cu. mm.	Leukocytes per cu. mm.	Blood Glucose mg. per 100 ml.	Average daily milk production in pounds	% of T.D.N. requirements consumed
7-10-52	1571	14000	48.8	—	—
7-14-52	—	—	54.5	—	—
7-17-52	—	—	50.8	—	—
7-21-52	1965	15550	40.3	—	—
7-24-52	1926	13825	41.3	—	—
7-28-52	1515	13700	34.5	—	—
7-31-52	1110	13150	41.3	46.8	81
8- 4-52	1726	13975	56.3	—	—
8- 7-52	1900	12525	58.3	53.8	96
8-11-52	1750	13550	56.8	—	—
8-14-52	1750	10550	60.0	55.8	104
8-18-52	1500	13625	55.0	—	—
8-21-52	1865	11275	46.3	55.6	110
8-25-52	1821	13125	64.5	—	—
8-28-52	1865	11275	53.8	57.0	112
9- 1-52	2215	12225	61.3	—	—
9- 4-52	2390	11925	51.3	56.1	125
9- 8-52	2508	13640	48.8	—	—
9-11-52	2750	12350	61.0	53.6	126
9-15-52	2875	8900	53.3	—	—
9-18-52	2325	13000	59.5	53.0	121

Butterfat Tests: 8-25-52, 3.60%

TABLE XIV

Experimental Data on Cow No. 2470

Fresh 7-25-52

Date	Eosinophils per cu. mm.	Leukocytes per cu. mm.	Blood Glucose mg. per 100 ml.	Average daily milk production in pounds	% of T.D.N. requirements consumed
7-21-52	538	10675	33.8	—	—
7-24-52	810	9175	38.8	—	—
7-28-52	577	9825	63.3	—	—
7-31-52	1443	13785	39.8	—	—
8- 4-52	461	12825	45.5	—	—
8- 7-52	278	11850	55.0	58.4	84
8-11-52	633	10675	53.5	—	—
8-14-52	956	8938	43.8	66.5	90
8-18-52	1126	9325	55.0	—	—
8-21-52	834	8150	51.3	69.4	99
8-25-52	688	9175	47.8	—	—
8-28-52	1325	9475	48.8	74.9	100
9- 1-52	1750	10575	60.0	—	—
9- 4-52	1950	8975	45.0	72.2	105
9- 8-52	2086	11080	45.5	—	—
9-11-52	1787	10075	39.3	74.3	109
9-15-52	1750	7950	58.3	—	—
9-18-52	1776	10025	48.3	77.8	110
9-22-52	1565	8900	60.5	—	—
9-25-52	—	—	—	75.5	109

Butterfat Tests: 8-25-52, 3.40%

TABLE XV

Experimental Data on Cow No. 2446

Fresh 7-27-52

Date	Eosino-phils per cu. mm.	Leuko-cytes per cu. mm.	Blood Glucose mg. per 100 ml.	Average daily milk production in pounds	% of T.D.N. requirements consumed
7-21-52	1454	7775	39.3	—	—
7-24-52	1282	7025	41.3	—	100
7-28-52	1010	5150	45.0	—	—
7-31-52	616	5925	46.8	45.3	86
8- 4-52	377	3700	47.5	—	—
8- 7-52	572	5400	53.3	53.3	99
8-11-52	1061	6000	56.3	—	—
8-14-52	1250	6175	46.8	59.2	103
8-18-52	1400	4750	53.8	—	—
8-21-52	1215	6800	52.5	61.9	115
8-25-52	2086	9150	52.0	—	—
8-28-52	1390	5925	57.5	65.7	106
9- 1-52	1090	8125	57.5	—	—
9- 4-52	900	4900	45.5	63.4	119
9- 8-52	1055	6400	48.3	—	—
9-11-52	1000	6075	40.5	65.5	114
9-15-52	1138	7250	48.7	—	—
9-18-52	1227	9300	55.8	63.0	118

Butterfat Tests: 8-25-52,

TABLE XVI

Experimental Data on Cow No. 2037

Fresh 8-12-52

Date	Eosinophils per cu. mm.	Leukocytes per cu. mm.	Blood Glucose mg. per 100 ml.	Average daily milk production in pounds	% of T.D.N. requirements consumed
8- 7-52	1031	15750	57.5	—	—
8-11-52	1138	10550	63.3	—	—
8-12-52	1282	7225	59.3	—	—
8-14-52	1075	7375	45.0	—	—
8-18-52	663	6325	46.3	—	—
8-21-52	544	6800	48.8	67.6	88
8-25-52	921	9500	42.0	—	—
8-28-52	1965	10950	56.3	75.3	99
9- 1-52	2730	11400	48.8	—	—
9- 4-52	2590	8775	44.5	79.2	96
9- 8-52	1887	8960	53.8	—	—
9-11-52	2100	11300	44.3	85.3	99
9-15-52	1885	11075	48.3	—	—
9-18-52	2238	12550	54.5	85.8	104
9-22-52	2890	11275	65.5	—	—
9-25-52	2337	11250	62.5	86.7	103
9-29-52	1523	9000	72.5	—	—
10-2-52	937	10200	58.8	89.1	94
10-6-52	483	8550	50.0	—	—
10-9-52	—	—	—	88.4	101

Butterfat Tests: 8-25-52, 3.1%

TABLE XVII

Experimental Data on Cow No. 2406

Fresh 6-15-52

Date	Eosino-phils per cu. mm.	Leuko-cytes per cu. mm.	Blood Glucose mg. per 100 ml.	Average daily milk production in pounds	% of T.D.N. re-quirements consumed
6-10-52	534	4100	—	—	—
6-12-52	455	6300	—	—	—
6-15-52	189	8450	—	—	—
6-16-52	111	5350	52.0	—	—
6-19-52	—	—	46.3	51.1	65
6-23-52	361	8575	40.8	—	—
6-26-52	455	10275	36.4	64.7	80
6-30-52	416	4675	45.5	—	—
7- 3-52	427	5550	45.3	65.9	88
7- 7-52	655	6575	41.3	—	—
7-10-52	144	6250	45.5	72.5	96
7-14-52	—	—	48.3	—	—
7-17-52	—	—	46.0	75.4	98
7-21-52	561	7775	38.8	—	—
7-24-52	261	5875	33.8	73.1	105
7-28-52	150	5775	41.3	—	—
7-31-52	250	7000	50.5	64.0	114
8- 4-52	111	7750	47.0	—	—
8- 7-52	77	8700	49.0	63.3	109

Butterfat Tests: 6-30-52, 3.46%; 7-28-52, 3.08%

TABLE XVIII

Experimental Data on Cow No. 2272

Recorded 9-10-52*

Time	Eosinophils per cu. mm.	% change in Eosinophils from initial	Body Temperature Degrees F.	Respiration per min.
7:30	480	—	100.7	68
9:30	—	—	104.4	132
10:30	372	-22	105.5	144
11:30	—	—	106.6	140
12:30	261	-46	107.3	160
13:30	—	—	107.6	156
14:30	133	-72	108.0	148
16:30	228	-52	—	—

*30 Days Postpartum. Average daily production - 49.6 lbs. 4% F. C. M.

TABLE XIX

Experimental Data on Cow No. 2643

Recorded 9-16-52*

Time	Eosinophils per cu. mm.	% change in Eosinophils from initial	Body Temperature Degrees F.	Respiration per min.
7:30	1465	—	101.0	40
9:30	—	—	102.8	124
10:30	1590	+ 9	103.9	140
11:30	—	—	104.1	152
12:30	1540	+ 5	105.0	128
13:30	—	—	105.0	136
14:30	1275	-13	105.0	124
16:30	1290	-12	—	—

*120 Days Postpartum. Average daily production - 32.0 lbs. 4% F. C. M.

TABLE XX

Experimental Data on Cow No. 2669

Recorded 8-27-52*

Time	Eosinophils per cu. mm.	% change in Eosinophils from initial	Body Temperature Degrees F.	Respiration per min.
7:30	3408	—	100.9	44
9:30	—	—	103.4	148
10:30	3390	- 1	104.6	160
11:30	—	—	105.7	160
12:30	2815	-17	106.4	164
13:30	—	—	107.0	160
14:30	2350	-31	107.5	160
16:30	2610	-23	103.1	—

*60 Days Postpartum. Average daily production 41 lbs. 4% F. C. M.

TABLE XXI

Experimental Data on Cow No. 2675

Recorded 9-5-52*

Time	Eosinophils per cu. mm.	% change in Eosinophils from initial	Body Temperature Degrees F.	Respiration per min.
7:30	1465	—	100.9	32
9:30	—	—	101.7	120
10:30	1040	-29	102.3	120
11:30	—	—	103.0	140
12:30	1898	+30	103.6	132
13:30	—	—	103.8	132
14:30	1438	- 2	104.0	132
16:30	1690	+15	—	—

*Dry

TABLE XXII

Experimental Data on Cow No. 2678

Recorded 8-27-52*

Time	Eosino-phils per cu. mm.	% change in Eosino-phils from initial	Body Temperature Degrees F.	Res-piration per min.
7:30	3047	—	102.1	60
9:30	—	—	103.2	168
10:30	2965	- 3	104.2	172
11:30	—	—	105.1	172
12:30	3450	+13	105.8	168
13:30	—	—	106.7	160
14:30	3090	+ 1	106.6	156
16:30	2550	-16	102.7	—

*306 Days Postpartum. Average daily production 33 lbs. 4% F. C. M.

TABLE XXIII

Experimental Data on Cow No. 2694

Recorded 9-5-52*

Time	Eosino-phils per cu. mm.	% change in Eosino-phils from initial	Body Temperature Degrees F.	Res-piration per min.
7:30	684	—	101.3	28
9:30	—	—	102.0	136
10:30	990	+44	102.2	144
11:30	—	—	102.6	156
12:30	875	+28	103.0	164
13:30	—	—	103.0	172
14:30	800	+17	103.8	160
16:30	766	+12	—	—

*Dry

TABLE XXIV

Experimental Data on Cow No. 2696

Recorded 9-10-52*

Time	Eosinophils per cu. mm.	% change in Eosinophils from initial	Body Temperature Degrees F.	Respiration per min.
7:30	1454	—	101.7	28
9:30	—	—	101.9	128
10:30	1225	-16	102.5	120
11:30	—	—	102.7	128
12:30	1627	+12	102.7	128
13:30	—	—	102.8	124
14:30	1239	-15	102.8	112
16:30	1775	+22	—	—

*Dry

TABLE XXV

Experimental Data on Cow No. SX-1

Recorded 9-5-52*

Time	Eosinophils per cu. mm.	% change in Eosinophils from initial	Body Temperature Degrees F.	Respiration per min.
7:30	1565	—	101.1	28
9:30	—	—	102.3	140
10:30	1325	-15	102.8	136
11:30	—	—	103.2	152
12:30	1450	- 7	103.3	168
13:30	—	—	103.8	168
14:30	1110	-29	104.4	140
16:30	1375	-12	—	—

*30 Days Postpartum. Average daily production 46.4 lbs. 4% F. C. M.

TABLE XXVI

Experimental Data on Cow No. SX-2

Recorded 9-18-52*

Time	Eosinophils per cu. mm.	% change in Eosinophils from initial	Body Temperature Degrees F.	Respiration per min.
7:30	555	—	101.4	32
9:30	—	—	101.9	118
10:30	760	+37	102.2	114
11:30	—	—	102.4	140
12:30	577	+ 4	102.6	152
13:30	—	—	103.0	136
14:30	286	-48	103.0	144
16:30	611	+10	—	—

*60 Days Postpartum. Average daily production 38.4 lbs. 4% F. C. M.

TABLE XXVII

Experimental Data on Cow No. SX-6

Recorded 9-10-52*

Time	Eosinophils per cu. mm.	% change in Eosinophils from initial	Body Temperature Degrees F.	Respiration per min.
7:30	1776	—	100.8	28
9:30	—	—	101.8	132
10:30	1240	-30	101.9	128
11:30	—	—	102.4	136
12:30	1450	-18	102.6	148
13:30	—	—	102.9	156
14:30	1675	- 6	102.9	140
16:30	1615	- 9	—	—

*30 Days Postpartum. Average daily production 30.1 lbs. 4% F. C. M.

TABLE XXVIII

Experimental Data on Cow No. SX-9

Recorded 9-5-52*

Time	Eosinophils per cu. mm.	% change in Eosinophils from initial	Body Temperature Degrees F.	Respiration per min.
7:30	1082	—	101.0	40
9:30	—	—	102.4	128
10:30	865	-20	102.9	132
11:30	—	—	103.2	136
12:30	716	-34	103.7	152
13:30	—	—	104.1	156
14:50	663	-39	104.1	152
16:50	705	-35	—	—

*30 Days Postpartum. Average daily production 44.2 lbs. 4% F. C. M.

TABLE XXIX

Experimental Data on Cow No. SX-11

Recorded 8-27-52*

Time	Eosinophils per cu. mm.	% change in Eosinophils from initial	Body Temperature Degrees F.	Respiration per min.
7:30	863	—	102.1	32
9:30	—	—	103.2	164
10:30	550	-36	104.2	172
11:30	—	—	104.7	156
12:30	475	-45	104.6	176
13:30	—	—	105.0	172
14:30	494	-43	105.8	160
16:30	605	-30	—	—

*30 Days Postpartum. Average daily production 48 lbs. 4% F. C. M.

TABLE XXX

Experimental Data on Cow No. SX-42

Recorded 8-27-52

Time	Eosino-phils per cu. mm.	% change in Eosino-phils from initial	Body Temperature Degrees F.	Res-piration per min.
7:30	1317	—	101.6	32
9:30	—	—	102.4	156
10:30	1315	—	102.9	172
11:30	—	—	103.2	168
12:30	1190	-10	103.8	172
13:30	—	—	104.0	172
14:30	1075	-22	104.0	160
16:30	1240	- 6	—	—

*120 Days Postpartum. Average daily production 18 lbs. 4% F. C. M.

TABLE XXXI

Experimental Data on Cow No. SX-43

Recorded 9-10-52*

Time	Eosino-phils per cu. mm.	% change in Eosino-phils from initial	Body Temperature Degrees F.	Res-piration per min.
7:30	622	—	101.4	32
9:30	—	—	102.2	124
10:30	483	-22	102.4	164
11:30	—	—	102.9	160
12:30	472	-24	103.0	168
13:30	—	—	103.2	160
14:30	215	-65	103.3	148
16:30	466	-25	—	—

*180 Days Postpartum. Average daily production 30.9 lbs. F. C. M.

TABLE XXXII

Experimental Data on Cow No. SX-44

Recorded 9-18-52*

Time	Eosinophils per cu. mm.	% change in Eosinophils from initial	Body Temperature Degrees F.	Respiration per min.
7:30	1293	—	101.4	44
9:30	—	—	102.4	164
10:30	1350	+ 4	102.6	168
11:30	—	—	102.8	168
12:30	1010	-22	103.1	172
13:30	—	—	102.9	144
14:30	1010	-22	103.0	160
16:30	999	-23	—	—

*90 Days Postpartum. Average daily production 25.1 lbs. 4% F. C. M.

TABLE XXXIII

Experimental Data on Cow No. SX-46

Recorded 9-18-52*

Time	Eosinophils per cu. mm.	% change in Eosinophils from initial	Body Temperature Degrees F.	Respiration per min.
7:30	439	—	101.3	28
9:30	—	—	101.7	124
10:30	150	-66	101.9	144
11:30	—	—	102.5	168
12:30	478	-18	102.2	156
13:30	—	—	102.3	152
14:30	472	+ 8	102.2	136
16:30	472	+ 8	—	—

*Dry

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