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RELATION OF *Mineral Content of* Summer Milk *to Mineral Content of* Pasture Herbage

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THE RELATION OF THE MINERAL CONTENT OF SUMMER MILK TO THE MINERAL CONTENT OF THE PASTURE HERBAGE

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From the nutritional standpoint the mineral fraction of milk is recognized as being extremely important (9). Certain minerals in milk are known to be influenced by dietary means. Roughage is the primary source of minerals, especially the trace elements, in the ration of dairy cattle. Although considerable information exists regarding the mineral content of both milk and forage crops, comparatively few attempts have been made to correlate the content of the various mineral elements in the milk with the content of these mineral elements in the feed consumed.

Spectrographic analysis of milk and feed ash offers an excellent method for determining the content of many of the elements concurrently on numerous samples (1), (3), (4), (5), (8), (9), (10).

This report is concerned with the results of spectrographic mineral analyses of milk ash correlated with similar analyses of the ash from pastures on which the milk was produced.

EXPERIMENTAL PROCEDURE

During the pasture seasons of 1945, 1946 and 1947, three groups of Jersey cows were used in the pasture experiments (6). In each pasture period one group (A) was pastured on permanent bluegrass without supplemental hay and another group (B) ate the same pasture plus supplemental hay, fed **ad libitum** in the barn during the time the cows were being milked. A third group (C) was pastured on various legume mixtures without supplemental hay. The bluegrass pastures were well fertilized and contained varying amounts of white clover, depending on the season and weather conditions.

Each year in April, just before the cows were turned out to pasture, a sample of milk was collected from the individual cows of each pasture group. Subsequently, during each pasture period throughout the pasture season, individual milk samples were collected and composited according to morning and evening production and pooled for each group for spectrographic analysis. Sampling was done as near to the middle of the pasture period as could be anticipated.

The pooled milk samples were then dried, ashed in a muffle at approximately 1000° F., ground to a fine powder and placed in clean test tubes until analyzed.

About four days prior to the milk sampling date, a "plucked" sample of pasture herbage was taken from the various pasture plots on which the cows were grazing. These samples were dried, then ashed in a muffle at approximately 1000° F., ground to a fine powder, and placed in clean test tubes until analyzed. Information concerning the length of the pasture periods, cow groups, number of cows in the groups, description of the pastures, date of milk sampling and date of pasture sampling is indicated in Figures 1 to 13, and the accompanying legend.

Ten milligrams of each sample of the milk and pasture ashes were thoroughly mixed and ground with ninety milligrams of lithium fluoride. Lithium fluoride was used to dilute the ash samples and served as a buffer and internal standard which was then used to calculate the lithium ratios of the various elements (2), (7).

Duplicate spectrograms were made of each sample on Eastman 33 plates using a Bausch and Lomb medium quartz spectrograph. The carbon electrodes were purified before using by boiling with aqua regia then thoroughly washed until all the acids were removed.

The source of excitation was a 2200 volt, 2.2 ampere electric arc which was kept at constant voltage during the three 20 second exposures.

Additional ash lithi-um fluoride mixture was added to the electrode between each exposure.

With all factors, dilution and mixing, exposure time, developing time, voltage, amperage, plates, and development time and temperature, kept constant, the mineral content of the ash was assumed to be the only variable. Hence any differences in line intensity of the elements were due to differences in concentrations.

The line intensities were measured on a ARL Dietart densitometer with a constant power source to keep fluctuations to a minimum. The element lithium ratios, determined by dividing the line intensity of each element by the line intensity of lithium in each spectrogram are plotted for each pasture period during three years as shown in Figures 1 to 13.

The wavelength of the lithium reference line used to obtain the element/lithium ratios was 2741.3 Å and for the following elements: boron 2497.73 Å; phosphorus 2536.4 Å; manganese 2593.7 Å; magnesium 2779.9 Å; silicon 2881.6 Å; iron 3020.65 Å; aluminum 3092.7 Å; calcium 3158.9 Å; copper 3274.0 Å; silver 3280.7 Å; sodium 3302.3 Å; zinc 3345.0 Å; and potassium 4044.2 Å.

Element/lithium ratios shown in Figures 1 to 13, give a semiquantitative measure of the relative concentration of the elements studied during the various periods.

Qualitative examination of spectrograms of the undiluted ash of milk revealed the presence of the following additional elements in addition to those elements listed above; molybdenum, chromium, titanium, barium and strontium. In the examination of the undiluted ash pasture samples the following elements were also found; molybdenum, chromium, tin, titanium, barium and strontium.

In an attempt to measure quantitatively the amounts of the various elements present in milk and pasture ashes a synthetic ash was prepared, which approximated as closely as possible the composition of milk and pasture ash. The synthetic standard contained the following elements in the amounts indicated; sodium 52.7 mg., potassium 201.7 mg., phosphorus 108.9 mg., magnesium 12.8 mg., calcium 166.4 mg., copper 1.5 mg., zinc 30.0 mg., manganese 4.0 mg., aluminum 50.0 mg., silicon 10.0 mg., boron 6.0 mg., silver 10.0 mg., and iron 0.43 mg. The synthetic standard was treated in the same manner as the milk and pasture ashes.

At least three spectrograms of the synthetic standard were placed on each plate for the year 1945. The average line intensities of the elements served as a standard for comparison with the milk and pasture ash samples. Thus in Figures 1 to 13, for the year 1945, the amounts of the elements in both milk and pasture ash expressed as mg/gm as well as the element lithium ratios are given.

RESULTS AND DISCUSSION

Examination of the data shown in Figures 1 to 13 shows the seasonal trends in the relative concentrations of the various elements in both pastures and in the milk produced by the cows grazing the different pastures. The supplemental feeding and variations in herbage of the pastures is indicated in the legends for each figure.

The following general statements concerning the variations in the concentration of the various elements, throughout the season, during the different years, and pertaining to the relationship between pasture and milk seem justified. Detailed information can be best obtained by reference to the charts.

Calcium: There were no consistent seasonal trends in milk calcium nor did there appear to be a close correlation between milk calcium and the calcium content of the pasture herbage. The calcium content of the pastures increased somewhat as the season advanced, however the calcium content of the legume mixtures was higher than bluegrass only during 1945. It appeared that calcium was low in both milk and pasture during 1947 as compared with 1945 and 1946.

Phosphorus: There were no consistent seasonal trends in milk phosphorus nor did there appear to be a close correlation between milk phosphorus and the phosphorus content of the pasture herbage.

The phosphorus content of pastures remained fairly constant throughout the three seasons, however druing the 1945 and 1946 seasons the phosphorus content of the bluegrass pastures was higher than the legume pastures, this is especially true of the 1945 season.

It appeared that phosphorus was lower in milk in 1947 as compared to the other seasons, whereas the phosphorus content of the herbage appeared to be much higher in 1946 than in the other years.

Magnesium: There were no consistent seasonal trends in milk magnesium nor does there seem to be much correlation between milk magnesium content and the magnesium content of the herbage. The milk magnesium appears to be lower in 1947 than in the other years.

The magnesium content of the pastures increased somewhat during the pasture seasons and the pastures during 1945 appear to have a somewhat greater amount of magnesium. In the 1945 season the legume pastures contained a somewhat greater amount of magnesium, whereas the reverse was true in 1946. There were no apparent differences between the bluegrass and legume magnesium contents during the 1947 season.

Sodium: There were no consistent seasonal trends in milk sodium, nor did there appear to be a close correlation between milk sodium and the sodium content of the pasture herbage.

The sodium content of both pastures in 1945 showed an increase as the season progressed, with no consistent difference between the sodium content of the bluegrass and legume pastures. There appeared to be an increase in sodium in the legume pastures during July for the 1946 season compared to bluegrass followed by a sharp decline during August. This same effect is noted in the 1947 season except that the increase began in June and the decline in July and August was not so pronounced.

Potassium: There were no consistent seasonal trends in milk potassium although there seemed to be more fluctuation in the 1945 pasture season than in the other years, with the milk from the legume pasture cows being somewhat consistently lower in potassium than the other groups. There seemed to be some correlation between milk potassium and the potassium content of the pasture herbage in 1946.

Milk potassium was consistently lower in the 1947 season than in the other two years.

There was little difference in potassium content of the ash between the bluegrass and legume pastures in 1946 and 1947; whereas the bluegrass pastures seem to contain more potassium than the legume mixture in 1945. Also during this season there was greater variation than in the other years.

Iron: There were no seasonal trends in milk iron during the 1946 and 1947 seasons. In the 1945 season the milk iron increased markedly after the first of June then declined rapidly to July 15 and remained at a constant level the remainder of the season.

There was no correlation between milk iron and the iron in the pasture herbage.

The iron content of the pastures increased as the 1945 season progressed and after the middle of June the bluegrass pastures contained more iron in the pasture ash than did the legume pastures. During the 1946 and 1947 seasons, except for a few individual samples the iron content of the ashes of the bluegrass and the legume pasture were quite similar.

Some of the marked individual differences between the milk samples on the one hand and the pasture samples on the other, may have been due to contamination in the muffling procedure.

Aluminum: There were no significant seasonal trends in milk aluminum during the three years, nor did there seem to be any correlation between the milk aluminum and the aluminum in the pasture herbage.

During the month of May in 1945 the aluminum in milk ash declined and then in June increased beyond its original level then remained fairly constant the remainder of the season.

The 1946 season showed a marked increase in milk aluminum for the group of cows being grazed on the legume pastures during the months of June and early July, thereafter it was identical to the other groups.

The eratic differences in milk aluminum for 1947 are not considered significant and may be due to contamination.

The aluminum content of the pasture ashes for 1945 declined during mid-summer and then increased markedly during September. In general the bluegrass pastures seemed to contain more aluminum than did the legume pastures.

In the 1946 pasture season the legume pastures appeared to contain more aluminum in their ash during May and June than did bluegrass.

During the 1947 pasture season no marked differences in the aluminum content of the ash of bluegrass and legume pastures could be determined.

Copper: There were no seasonal trends in milk copper although there were some fluctuations during each of the three years. No marked differences between the groups were found.

There was no correlation between milk copper and the copper content of the pasture herbage.

The legume pasture ashes throughout most of each of the three years appeared to contain more copper than did the bluegrass pasture ash.

Zinc: There were no seasonal trends in milk zinc during the three years although there appeared to be a greater amount of zinc in the 1945 milk ashes than in the other years.

During May 1945 the milk zinc content declined then increased during June, and again declined in July and remained constant for the remainder of the year.

In the 1946 and 1947 seasons there were individual fluctuations between the groups in their milk zinc contents.

There was no correlation between milk zinc and the zinc content of the pasture herbage.

The pasture zinc ashes were alike during the 1946 and 1947 pasture seasons with a slightly greater zinc content in the legume ashes than in the bluegrass ashes.

Greater fluctuation in the pasture zinc ashes occurred during the 1945 season than in the other two years particularly until mid-July and in mid-September. Throughout most of this season the legume pastures contained more zinc than did the bluegrass ashes.

Silver: No measurable amounts of silver in either milk or pasture ashes for 1946 and 1947 could be determined.

In 1945 there was no significant seasonal trend in milk silver. The milk ash varied greatly in its silver content, however, there was no correlation between milk silver and silver in the pasture herbage. The silver content of the pasture ashes was similar throughout most of the year except during August when the legume pasture ashes were definitely higher than the bluegrass pasture.

Boron: At the dilutions used boron could not be determined in the milk ash nor could it be determined for the 1947 season in pasture ash. There was no seasonal trend in 1945 and 1946, however in 1945 in May and October there appeared to be a greater amount present than at any other part of the season. In 1946 the content varied with a definite increase the latter part of July.

Manganese: No milk ash manganese could be determined for the three years. In the pasture ashes of 1945, manganese varied greatly. There appeared to be a greater amount present during September than any other part of the season.

There was a slight downward trend in pasture manganese during 1946 with a peak around the latter part of June. There appeared to be a somewhat greater amount of manganese in the legume pasture ashes. The manganese in the pasture ashes of 1947 followed the same general trend as in 1946 except that a definite increase occurred the latter part of June and the early part of July.

Silicon: The silicon content of neither the milk and pasture ashes was measured since the ashing of the samples was carried out in fused quartz dishes which was a known source of possible contamination.

After examining all the data it was apparent that, while there were definite trends during the season for certain of the elements in pasture ash there was little correlation between these changes and the concentration in the milk ash. Milk ash tended to be more constant and subject to less fluctuation than the pasture ash. Where temporary marked fluctuations in the milk and pasture ash did occur they were presumed to be due to variations in rainfall, weather conditions, fertilization, supplemental feed, drinking water, and possible other unrecognized factors. Some of the seasonal trends in milk ash may have been due to the effects of advancing lactation, inasmuch as the cows were all in relatively the same stage of lactation at the beginning of the pasture season.

Marked differences in the relative concentration of certain of the elements were noted between years which cannot be readily accounted for.

SUMMARY

Milk and pasture ashes obtained during three years 1945, 1946, and 1947 were analyzed spectrograpically. Lithium fluoride was used to dilute the ash samples and served as a buffer internal standard which was used to calculate the lithium ratios of the various elements.

Three groups of cows were studied each year. Two groups were pastured on bluegrass, one group with and one group without supplemental hay and another group on legume grass mixtures without supplemental hay.

Qualitative analysis of the pure milk ashes showed the presence of the following elements; boron, phosphorus, manganese, magnesium, silicon, iron, aluminum, calcium, copper, silver, sodium, zinc, potassium, molybdenum, chromium, titanium, barium and strontium. In the examination of the pasture ashes all of the minerals found in milk ash plus tin were found.

In the semiquantitative estimation of milk and pasture ashes several of the elements could not be determined spectrograpically, those were; molybdenum, chromium, tin, titanium, barium and strontium.

As measured by the element lithium ratios of the ashes there appeared to be little or no correlation between milk ash elements and those of the pasture herbage.

Some trends during the season for certain of the elements in pasture ash were noted, however milk ash tended to be more constant than

did the pasture ash. Marked differences in the relative concentration of certain of the elements were noted between years.

Where temporary marked fluctuations in the milk and pasture ashes did occur they were presumed to be due to variations in rainfall, weather conditions, fertilization, supplemental feed, drinking water, stage of lactation and possible other unrecognized factors.

Figure 1

Milk

——— Group A
······· Group B
—·—·— Group C

Pasture

━━━ Group A-B
— — — Group C

LEGEND—Figures 2—13

The relation of the mineral content of summer milk to the mineral content of the pasture herbage.

1945. Groups A and B were pastured on bluegrass during periods 1, 2, 3, 4, 5, 6, 7, 8, 9, and 12; on orchard grass in period 10; and on alfalfa-timothy in period 11. Group C was pastured on bluegrass during periods 1, 2, 12; on alfalfa-timothy in periods 3, 4, 6, 7, 8, and 9; on orchard grass in period 5; and on alfalfa-bromegrass in periods 10 and 11. Number of cows per group was 5.

1946. Groups A and B were pastured on bluegrass during periods 1, 3, 5 and 7; on a legume mixture consisting of alfalfa with timothy, bromegrass and Ladino clover in periods 2, 4, and 6; and on orchard grass in period 8. Group C was pastured on bluegrass in period 1; on the above legume mixture during periods 2, 4, and 6; on alfalfa bromegrass and Ladino clover in periods 3, 5, and 7; and on alfalfa-timothy in period 8. Number of cows per group was 6.

1947. Groups A and B were pastured on bluegrass during periods 1, 3, 5, 7 and 9; and on a legume mixture consisting of alfalfa, bromegrass, Ladino clover and timothy in periods 2, 4, 6, and 8. Group C was pastured on bluegrass during periods 1 and 9; on the above legume mixture in periods 2, 4, 6, and 8; and on a legume mixture of alfalfa, bromegrass and Ladino clover in periods 3, 5, and 7. Number of cows per group was 7.

Figure 2 **Calcium**

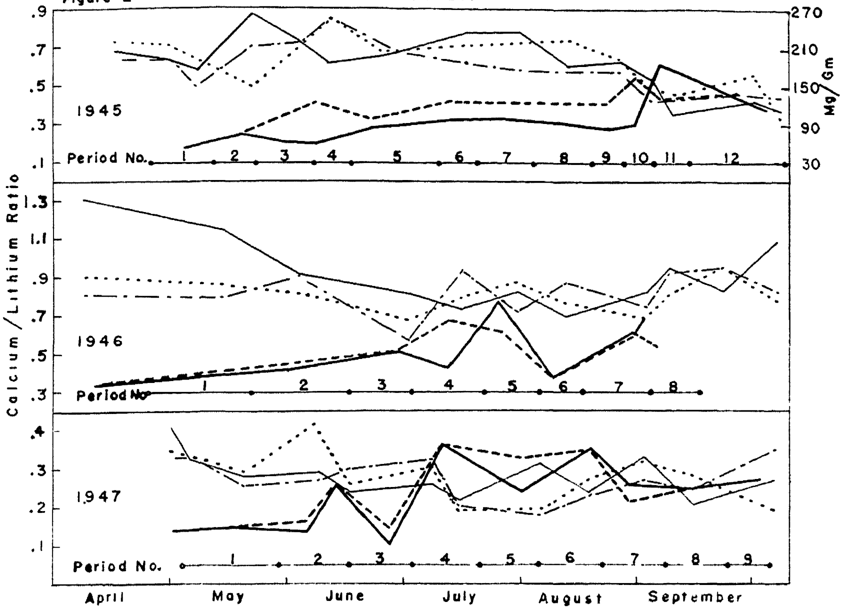


Figure 3 **Phosphorus**

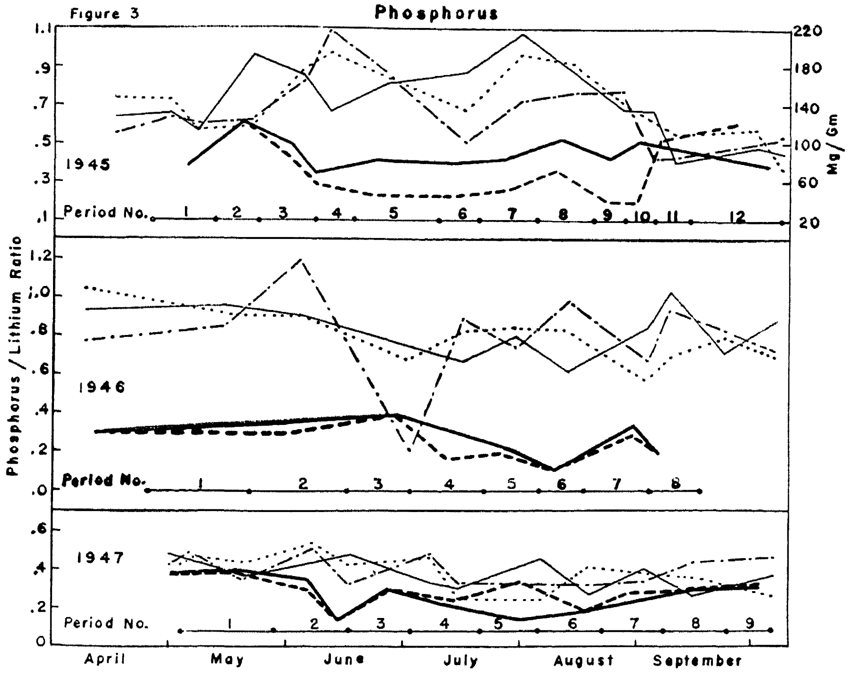


Figure 4 **Magnesium**

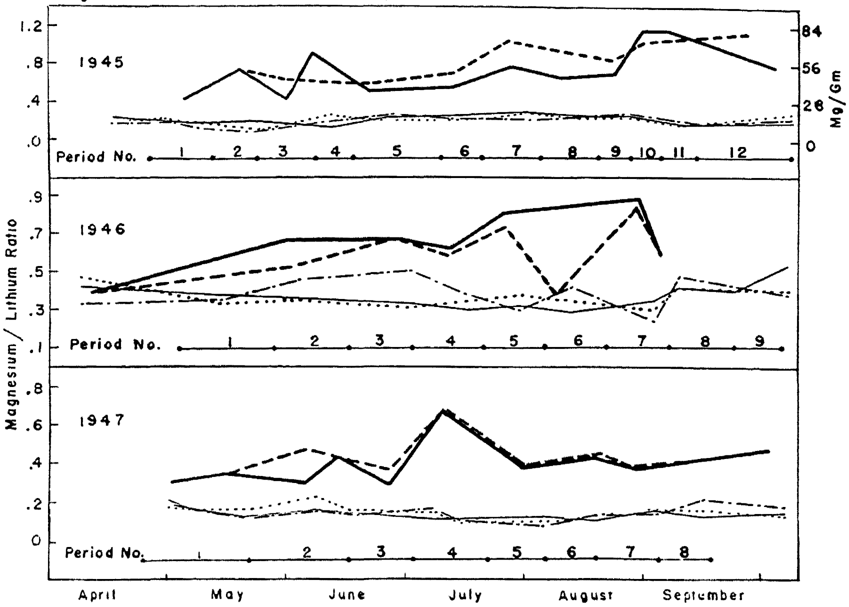


Figure 5 **Sodium**

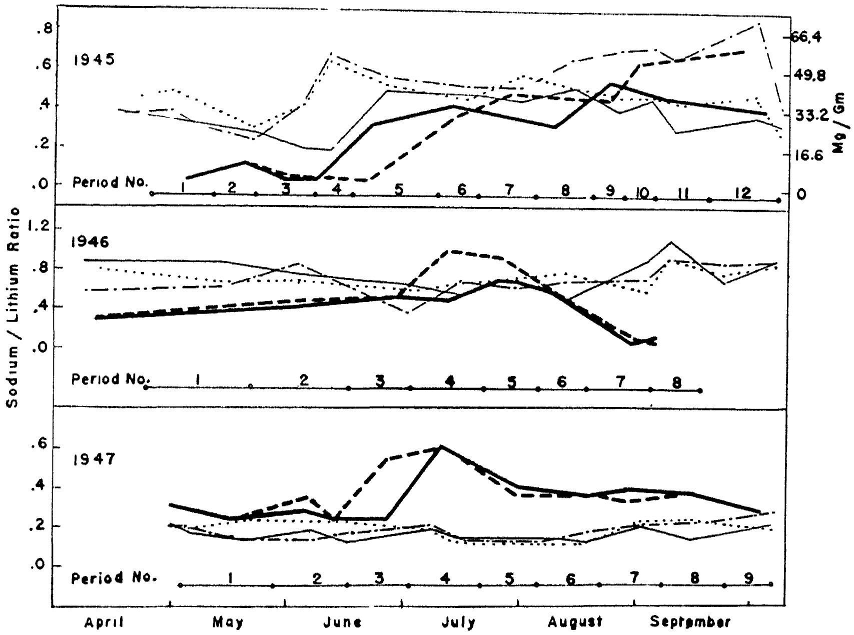


Figure 6 **Potassium**

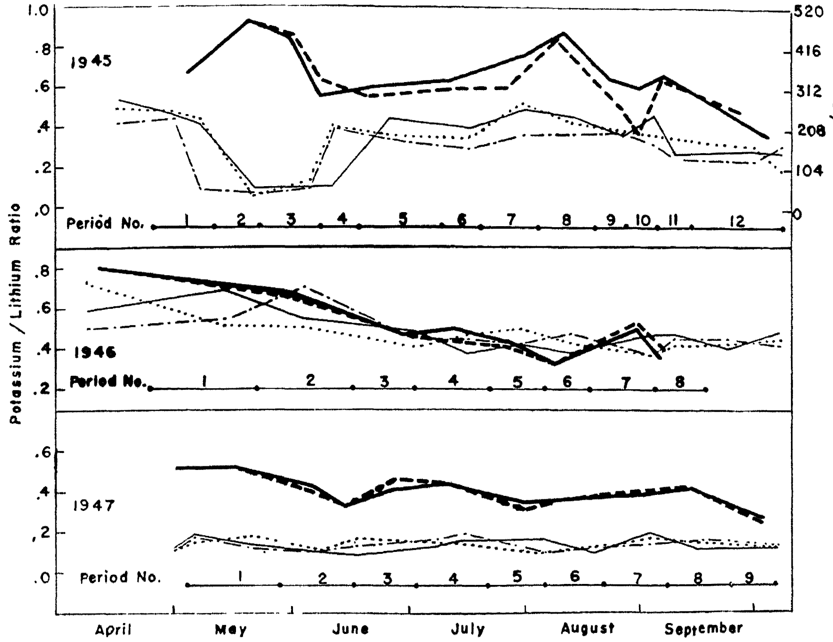


Figure 8 **Aluminum**

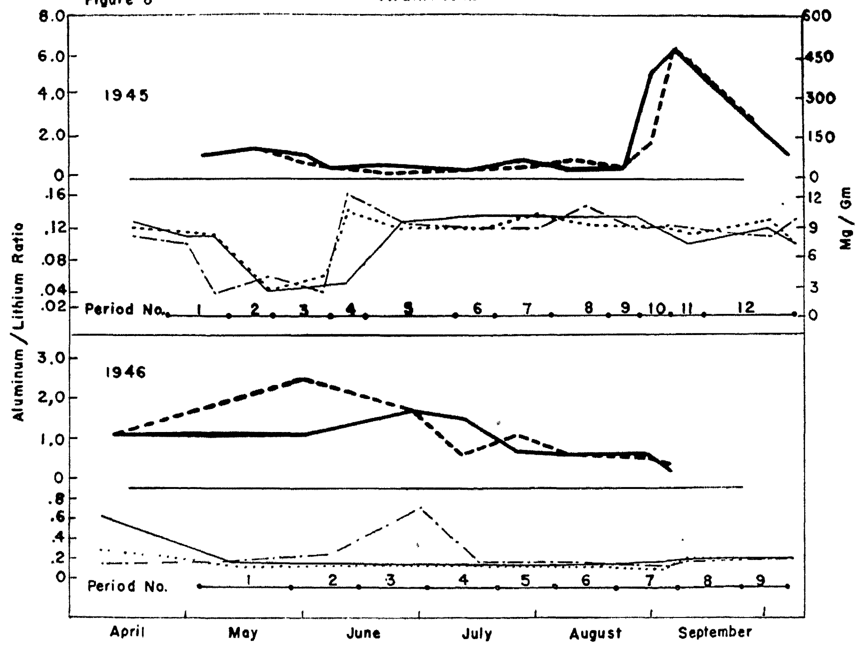


Figure 7

Iron

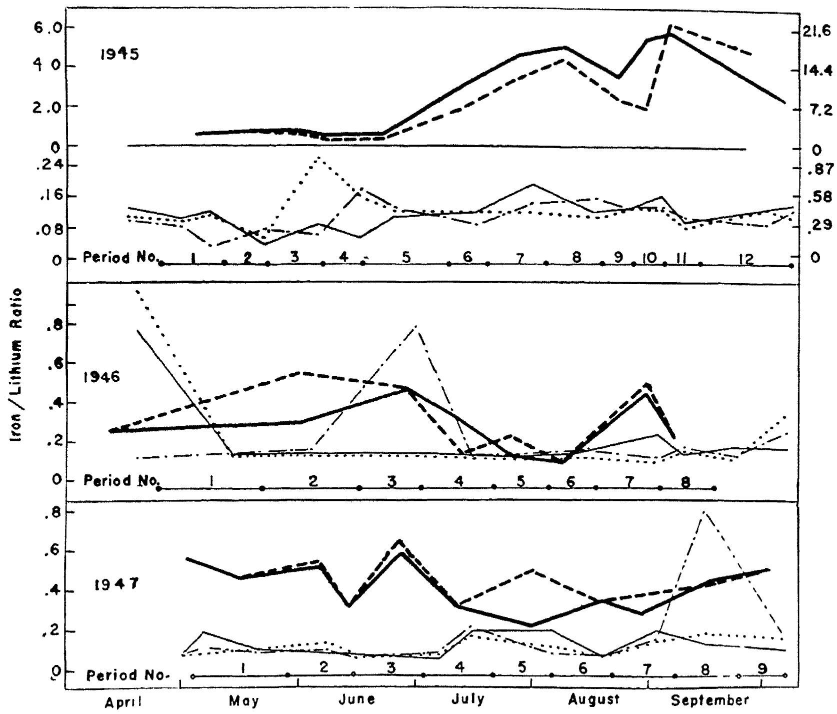
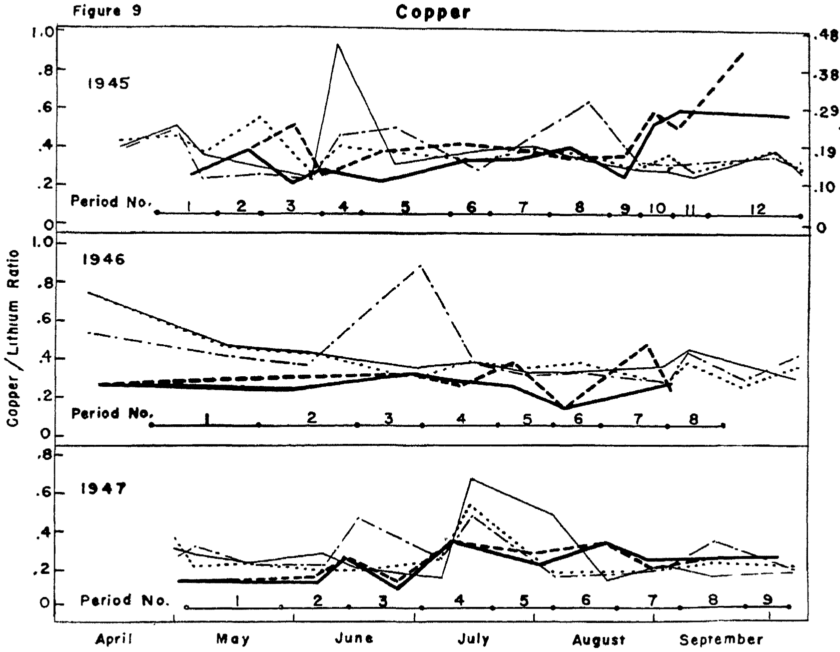


Figure 9

Copper



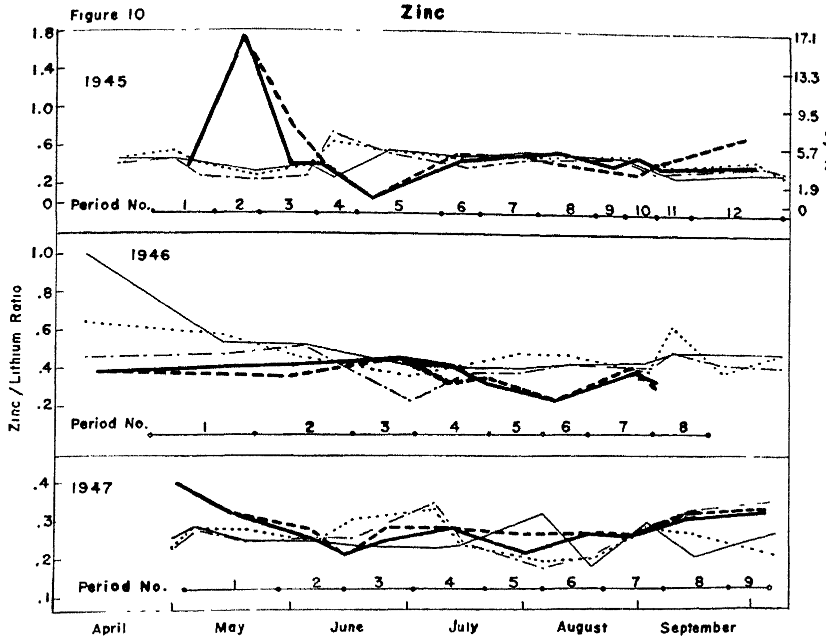


Figure 10
Zinc
1945
1946
1947
Zinc / Lithium Ratio
Mg / Gm
Period No.
April
May
June
July
August
September

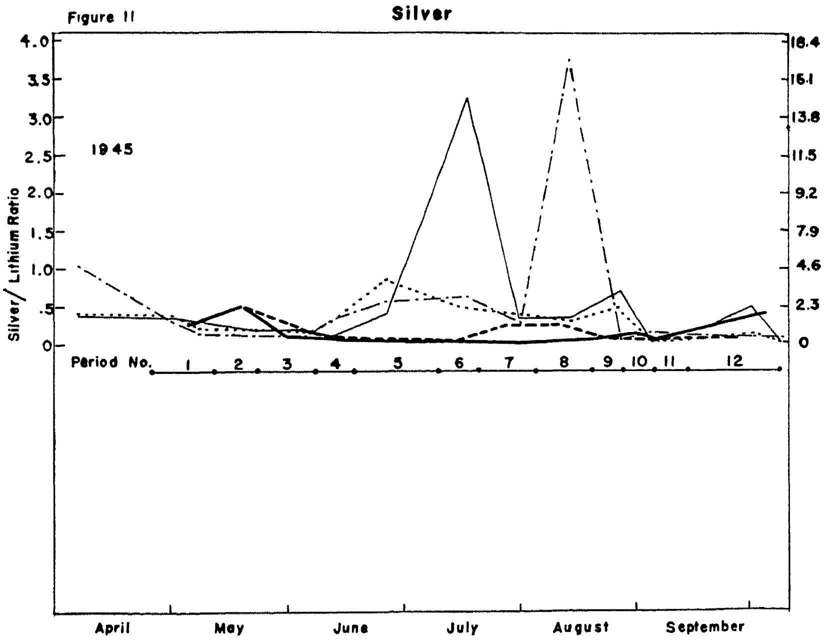


Figure 11
Silver
1945
Silver / Lithium Ratio
Mg / Gm
Period No.
April
May
June
July
August
September

Figure 12 **Boron**

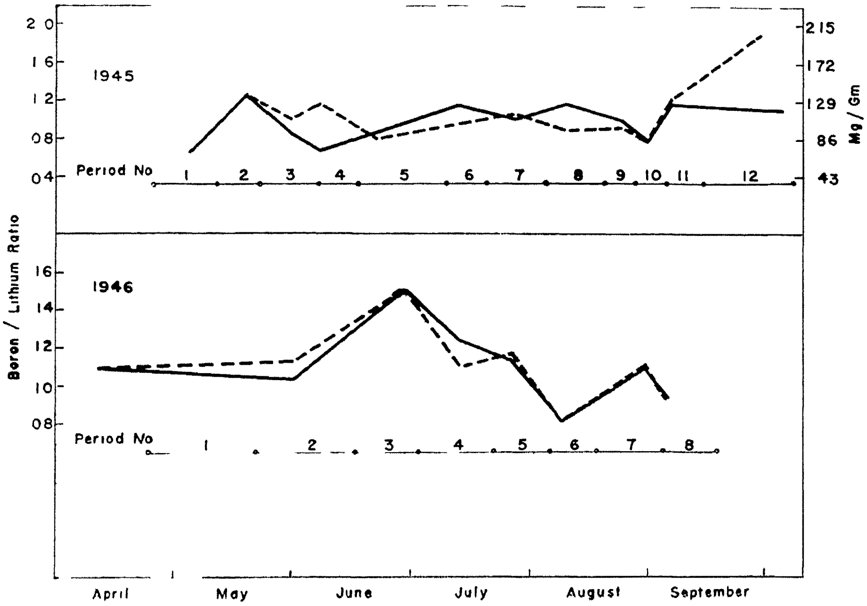


Figure 13 **Manganese**