THESIS

on

PRACTICAL METHODS TO CONTROL ANEMIA IN SUCKLING PIGS

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OBJECT

The object of this study is to develop a practical method of preventing nutritional anemia in young suckling pigs confined within the farrowing house for several weeks after farrowing.

PROBLEM

When pigs are confined indoors from farrowing time until they are three or four weeks old, a disease known as anemia will develop.

This disease is one of the greatest single causes of loss to the swine industry, because of the greatly reduced pig crop, retarded growth, and reduced yield.

Anemia is strictly a nutritional disease, the result of the lack in the sow's milk, of certain metallic salts which are essential for blood formation. Where it is necessary to keep late fall and early spring pigs indoors for several weeks because of unfavorable climatic conditions, it is important to supplement the pigs' diet in some way with these metallic salts.

That anemia in young pigs is of a nutritional origin and responds to the treatment of available iron and copper salts from various sources, has been explained by many experimental workers but there remains yet a controversy between some of these workers as to the most practical source and method of administration of these materials. It becomes, therefore, the purpose of this paper to suggest some sources and methods of administering these materials.

Symptoms of Nutritional Anemia

Usually the first symptoms exhibited by anemic pigs are lack of vigor and pale mucous membrane. The pigs may at first be in good condition and yet be severely anemic. Sudden deaths are common among anemic pigs that are plump and in good flesh. As the disease develops, the hair coat becomes rough and the skin wrinkled. The pigs finally become thin and weak. In the prolonged cases diarrhoea, flu, pneumonia, and other complications usually develop.

REVIEW OF LITERATURE

Aston (1) in 1911 reported a condition known as "bush sickness" common to cattle, sheep, goats, and swine in a certain locality of New Zealand, which is probably the earliest record of anemia in livestock. He states, "It (bush sickness) is not a disease in the proper sense of the term, but a physiological condition resulting either from a feed supply wanting or deficient in some essential nutrient, which therefore, results practically in starvation."

This investigation goes on to show that animals restricted to this area for a period over eight months lose their appetite, have a rough hair coat, gradually loose weight, and eventually die. Greater mortality is noticed among young animals.

Sheep and cattle are permitted to graze on the deficient range area for approximately six to eight months. At the end of this time they are moved into heavier soil areas, where they make rapid recovery and restore their supply of mineral elements, which are lacking on the deficient range. After a mineral reserve is built up, the same animals are grazed again on the deficient area for another six months period. Thus the deficient range is utilized. Aston also states, "Blood counts show conclusively that anemia is always present in animals suffering from bush sickness."

Later Aston (2) found that cattle dosed with double citrate of iron and ammonium soon overcame "bush sickness." Also that molasses was very effective in curing this condition. When phosphates were applied to the pastures, it improved the quality and quantity of the forage, and lengthened the period during which the stock could be kept on the pasture without a change to other districts or other treatment.

McGowan (3) is recognized by many experimental workers as being the first to produce anemia in pigs under laboratory conditions. He encountered anemia in pigs when he attempted to keep them on concrete floors, and believed it to be due to a deficiency of iron in the ration.

In a later report McGowan and his coworkers (4) claimed they were successful in preventing anemia in young pigs by adding iron oxide to the sow's ration. This is contrary to the results of the more recent work at other experiment stations.

Doyle, Mathews and Whiting (5) in 1924 began a study of the pathologic conditions found in young pigs when they were deprived of certain vitamins. At the outset of this study anemia was encountered. The pigs were kept on a concrete floor in a well lighted hog house. Vitamins were supplied to the sow's and pig's rations by the addition of cod-liver oil, yeast, and orange juice. Pigs receiving this treatment developed anemia as readily as pigs receiving only a basal ration, thus proving rather definitely that some factor other than the lack of vitamins was responsible for anemia.

Later iron was added (5) to the rations of the sows and pigs but had no apparent effect in keeping the pigs from becoming anemic.

Hart, Steenbock and Elvehjem (6) began a study of rabbits on a whole milk diet. In a short time they found a reduction in the erythrocytes to three to four million per cubic millimeter while the hemoglobin showed to be only fifty to sixty percent normal. They realized this condition to be a nutritional deficiency, probably iron. Inorganic iron as ferric oxide was added but apparently had no value in correcting the condition, but when fresh cabbage or alcoholic extracts of cabbage or yellow corn were added the rabbits began to gain in weight and to overcome the anemic condition. From these results it was concluded that inorganic iron is utilized for hemoglobin production only when supplemented by certain organic substances. All vitamins except E were ruled out.

Hart and his coworkers (7) realizing that milk is very low in iron, began a series of experiments attempting to increase the iron content of goat's milk by supplementing their ration with the substances effective in curing anemia in rabbits. Neither iron alone, in the form of sulfate or oxide, or the same supplemented with green feeds, showed any increase in the iron content of the milk, and rabbits fed this milk developed anemia the same as those fed milk from animals receiving a basal ration alone. Cows were fed different kinds of green feed, as alfalfa hay and timothy hay, rich in iron, and in neither case did the milk prove richer in iron than milk from cows fed a basal ration low in iron. From these findings the investigators concluded that the amount of iron in the milk of each specie is fairly constant and cannot be changed by adding iron or substances containing large amounts of iron to the diet.

The Wisconsin workers (8), thinking that vitamin E might have some supplementive action to iron, began another series of experiments, supplementing iron oxide with green feeds as lettuce, cabbage, and other green feeds containing large amounts of vitamin E. These were all effective in preventing or curing anemia. Vitamin E, however, was soon ruled out, as they found that the ash of these feeds was just as effective as the green feeds themselves. From this the workers thought that the unknown supplementing factor might be inorganic in nature instead of organic. Ash of cabbage, beef liver, spleen, marrow, and yellow corn was similarly prepared and proved to be effective in preventing anemia when fed as a supplement to inorganic iron. A qualitative analysis of these materials showed that iron was present in varying amounts.

That vitamin E has no effect on the hemoglobin regeneration was also shown by Anderegg and Nelson (9) with their reproduction problems. In these experiments they noticed some improvement in fertility when fresh celery tops were fed, but the hemoglobin remained low. The increase in fertility was due to the addition of vitamin E, but because of no increase in iron the hemoglobin remained low.

After the report from the Wisconsin Station that iron oxide alone did not correct or prevent anemia but was effective only when accompanied by iron-free organic substance, Mitchell and Schmidt (10) did not think that a single compound such as ferric oxide should be taken as a representative of all inorganic compounds, so they began a study on the availability of iron from various sources. Young rats were put on a certified milk ration at the age of six weeks. All materials were handled in glass dishes and all other precautions were taken to prevent the animal from getting even a trace of iron from other sources. The milk ration was supplemented with both organic and inorganic substances from varying sources. The amount of supplements added to the ration was calculated so that each animal received an allowance of .04 mg of iron per day. The sources of organic iron containing supplements were meats, spinach, egg yolk, molasses, and dates. The inorganic sources were ferric chloride, ferric ammonium citrate, ferrous carbonate and iron oxide. All of the organic sources showed some effect in curing anemia, while molasses and meats were very effective. Of the organic supplements tested, ferric chloride and ferric ammonium citrate proved to be very good while ferric oxide and ferrous carbonate were very poor. From these findings Mitchell and Schmidt state, "Our observations are suggestive of a new line of differentiation between available and unavailable sources of iron; namely, soluble versus insoluble, rather than organic versus inorganic." In considering further the question of relative availability of iron in various soluble and insoluble salts, Mitchell and Schmidt found that the ordinary soluble ferrous sulfate was effective without other supplements, but when purified was ineffective in curing anemia in rats.

Hart and his Associates (11) found that there was no increase in the hemoglobin when inorganic iron salts such as chloride, sulfate, acetate, citrate, and phosphate, when purified and fed at the rate of .5 mg of iron per day to rats rendered anemic. But again, the ash from lettuce, beef, and yellow corn, and the acid extracts from the same materials, when fed at the rate of .5 mg of iron per rat per day, were all very effective in curing anemia. These workers concluded that iron salts; ash of lettuce, beef, and yellow corn; and the acid extracts of lettuce, beef, and corn contained other substances necessary in curing anemia. They state, "These results are quite uniform and show that no one of these five inorganic salts of iron stands out from the other and that all completely fail to increase materially the hemoglobin of the blood." Further conclusions are stated: "It appeared to us that the results of all these data which we have presented could best be explained by assuming that in addition to iron, the ash and extracts of the ashes of corn, lettuce, and beef liver contained some other substance, or substances vitally concerned in the building of hemoglobin. What this substance was we did not know but that it was inorganic in nature was definite."

Hart and his associates (12) next step was to determine the nature of this inorganic substance. Their first experiment was with an individual rat on a diet of whole milk supplemented with 0.25 mg. daily of copper as copper sulfate, plus 0.5 mg of iron as ferric chloride. The anemic rat responded to this treatment very quickly. Instead of the rat loosing weight it began to gain immediately and the hemoglobin was restored to normal in only a few days. Experiments with varying quantities of copper showed that only a trace, 0.01 mg, and 0.5 mg of iron fed daily, would prevent anemia in rats.

Shortly after Wisconsin reported that copper in some form essential for the utilization of iron in hemoglobin formation, the Kentucky Station (13) reported similar results in the use of copper as a supplement to iron in hemoglobin regeneration in anemic rats.

Elvehjem and Lindow (14) made an examination of different methods for the determination of copper in biochemical materials, the most promising being a modification of the Biazzo colorimetric. By this method they were able with a high degree of occuracy, to detect as small an amount as 0.02 mg of copper. Analyses of ten samples of different iron salts by this new method indicated that only two were found to be copper free. Out of a total of 160 samples of common food materials tested, copper was found present in amounts ranging from 0.1 to 44.1 mg per kilogram. Fresh calf liver was the highest. Beef liver was somewhat lower, 21.5 mg, and hog liver still lower, 6.5 mg per kilogram. Omitting liver and oysters, the foods tested, arranged in descending order of copper content, are as follows: nuts, dried legumes, cereals, dried fruits, poultry, fish, animal tissues, green legumes, roots, leafy vegetables, fresh fruits, and non-leafy vegetables.

Peterson and Elvehjem (15) made iron analyses of about 150 samples of common food materials. These figures show a wide range, from 0.00015 percent for lemon juice to 0.0192 percent for parsley. Arranged in descending order of iron content, the various groups of food stuff rank as follows: Dried legumes, green leafy vegetables, dried fruits, nuts, cereals, poultry, green legumes, roots and tubers, nuts, leafy vegetables, fish and fruits.

Comparing the analyses made by Elvehjem and Lindow for copper distribution with similar analyses made by Peterson and Elvehjem for iron in common food materials, the relative distribution of iron and copper is shown to be different.

The Kansas investigators (16) continuing their anemia studies, supplemented the whole milk diet of three groups of rats with 0.1 mg of manganese, 0.05 mg of copper, and 0.5 mg of iron, respectively. All of the rats became anemic in a short time. At the fifth week the copper and manganese was replaced with 0.5 mg of daily of iron. The rats receiving iron were continued on the same diet. Immediately the hemoglobin in the first two groups began to rise while the third group receiving iron became more anemic.

Blard, Myers, and Shipley, (17) working with rats, found that traces of nickel, cobalt, and germanium added to iron brought about regeneration of hemoglobin.

Attempts (18) to increase the copper content of of alfalfa hay, silage, and a grain mixture gave negative results, as had iron previously. Results obtained by analyses of samples of cow's milk collected from several herds in different states show only a slight variation in the copper content.

Titus and Cruse (19) reported that they found manganese to be effective as a supplement to iron in curing anemia in rabbits on a whole milk diet. Later they reported (20) similar results with manganese as a supplement to iron in hemoglobin regneration in rats. The Wisconsin observations on the use of copper as a supplement to iron in curing anemia, were confirmed. They also found that rats receiving both copper and manganese as a supplement to iron showed a greater response than when only copper was used as a supplement.

Mitchell and Miller (21) made a study of the effect of inorganic factors on hemoglobin regeneration of anemic rats on a whole milk diet. They found that when a water-soluble extract of spinach was fed in amount to supply 0.5 mg. of iron per day the response was faster than when iron and copper was fed. They later (22) reported that a quantitative analyses of the spinach extract that was so effective in curing anemia in rats on a whole milk diet showed the presence of copper, antimony, tin, iron, aluminum, zinc, manganese, stratium, sodium, potassium, calcium, magnesium, and phosphorous. From these analyses they suggested that a group of substances rather than a single substance was essential as a supplement to iron for hemoglobin production.

At this time the question as to copper being specific as a supplement to iron in hemoglobin development was quite confusing.

The Wisconsin workers, (23) attempting to throw more light on the importance of copper as a supplement to iron in the production of hemoglobin, extended their work to other elements. Pure salts of several elements were tested separately and in various combinations for their effect as a supplement to iron for curing anemia in rats on a whole milk diet. Of all the various salts tested only one (arsenic produced a slight but a temporary effect) showed any effect. From these findings the opinion was that the favorable results reported for other elements than copper were due to traces of copper being present.

Hart and his associates, having definitely shown that nutritional anemia brought on in rabbits and rats by feeding only cow's whole milk is due to a lack of iron and copper in the milk, extended their work to pigs. In this study (24) they found that when iron in the form of commercial iron sulfate was put in a solution and given orally at the rate of 25 mg of iron per day to anemic pigs, the hemoglobin of the blood increased very rapidly and in two weeks reached the normal level. Copper in the form of copper sulfate added to the iron sulfate solution at the rate of 5 mg of copper per day, did not correct the anemic condition any more quickly than did the iron sulfate alone. They state, "The addition of copper along with the iron is not so important in the case of pigs because only a very small amount is needed, and such minute quantities are probably obtained from the impure iron salts used."

Iron oxide fed in capsules to anemic pigs was not effective in correcting the anemic condition.

These investigators also found that iron sulfate and copper sulfate fed to sows during the entire gestation and lactation period did not prevent anemia in the pigs.

The Wisconsin workers also found that pigs farrowed on pasture or put out on pasture soon after farrowing, when the ground was not frozen, did not become anemic. From these results they state, "When little pigs run out of doors in warm weather they apparently pick up enough iron and copper from the soil to give them the needed protection."

Following the Wisconsin discovery that the essential elements needed to prevent anemia in pigs kept inside were of iron and copper salts to dry feed, which was kept available to the pigs at all times during the experiment. This method proved to have no value in preventing anemia in pigs.

Another method tested was to apply a paste of iron and copper salts to the sow's udders two or three times daily. This treatment was started shortly after farrowing and was found to be effective in preventing anemia in the pigs during the entire experiment. This work was confirmed by the Cornell Station (26) and others. Iron sulfate fed in this manner, without the copper, also protected the pigs against anemia. Also, applying the iron salts to the sow's udders once daily was found to be effective.

Exercise will not Protect Pigs Against Nutritional Anemia

That exercise will not prevent anemia in young pigs was thoroughly demonstrated by Hamilton, Carroll and Hunt (27). Ten pigs were confined in a close pen and ten were exercised twice daily for four weeks. The pigs were exercised by driving them over a large floored run-way. Both groups developed anemia and two in each group died.

Light has no value in Correcting Anemia in Pigs

In the Indiana Study (28) on the effect of vitamins on preventing anemia in pigs, the investigators had an opportunity to compare the prevalence of anemia in pigs kept inside with the prevalence of anemia in pigs kept on the outside. All the light was shut out from the pigs kept inside. The pigs on the outside ran on a concrete floor with no covering whatsoever. Each group of pigs received cod-liver oil daily and one group kept on the inside and one group kept on the outside received orange juice in addition to the cod-liver oil. The pigs all become anemic regardless of their treatment, showing conclusively that sunlight will not prevent anemia in pigs.

One year later Doyle, Mathews, and Whiting (28) demonstrated very conclusively that irradiation with the mercury vapor quartz lamp would not prevent anemia in pigs. In this experiment nine sows were fed 2.7 grams of iron lactate per sow daily throughout the gestation period and after farrowing. These sows were irradiated daily for 15 minutes during the entire length of the experiment. The pigs were also irradiated daily. Supplying the iron lactate to the ration and irradiation did not prevent anemia in the pigs.

A study of the effect of light on preventing anemia in pigs was also made by Hart and his associates (29) at the Wisconsin Station. They found that light, either sunlight or ultraviolet from a quartz mercury lamp, had no influence on the prevalence of anemia in pigs. This confirmed the Illinois findings.

Soil Fortifies Pigs against Nutritional Anemia

That nutritional anemia is not prevalent in pigs that are permitted to run outside on the ground, on pasture or in a lot, has been recognized by many experiment stations. That a small amount of soil put in the pen, where pigs are not permitted to run out, will fortify them against sutritional anemia, has only been recognized within the last few months. A short report (30) from the Purdue station shows that blue-grass sod or rich soil without the sod, kept in the pen where pigs are confined after birth, will give full protection against anemia.

MATERIALS AND METHODS

In this experiment six different litters of pigs were used. The sows were put in the farrowing pen two or three days before farrowing. Within twenty-four hours after farrowing all the pigs were weighed and marked. Two or three pigs were selected from each litter.

These were taken as representative of the litter to be tested. When the litter was divided into groups two or three pigs were tested in each group. The hemoglobin determination of the pigs tested was made the second day after birth and every seventh day until the experiment terminated.

The pigs remained in the pen with the sow and had the privilege of eating with her at all times.

The hemoglobin of the blood of the pigs tested was made by the Newcomer method. The blood was taken from the pig's ear in duplicate samples. Litter No. 1 was considered as a check litter. The pigs were allowed to run in the pen with the sow without any treatment. As the experiment progressed it became evident, not only from the hemoglobin determination but from the appearance of the animals, that pigs kept under these conditions became severely anemic at from three to four weeks of age. To confirm previous work indicating that the lack of iron and copper in the pig's diet was the cause of the anemia, certain anemic pigs of this group were dosed daily with a solution containing iron and copper salts. The pigs that received the iron and copper salts all lived and made a gradual recovery from the anemic condition, while three of the five pigs that received nothing in addition to the sow's milk, died. The other two remained anemic throughout the experiment. That the effect of soil might be determined in the prevention of nutritional anemia, litter No. 2 was given access to silt loam soil in an adjacent pen. This method proved to be very effective in protecting the pigs against anemia. Another probable simple method of preventing nutritional anemia in young pigs was tried with litter No. 3. The pigs were given free access to iron oxide (Venetian Red). This form of iron was used because it is cheap and can be obtained at almost any paint shop. Creighton and McGowan reported that iron oxide fed to the sow prevented anemia in pigs. Hart and his associates fed iron oxide and found that it would neither cure nor prevent anemia in the pigs. The results of this experiment at this station support Hart's work.

The most practicable method that was recommended by other experiment stations was the applying of iron salts to the udders of the sow from farrowing time until the pigs began to eat enough feed to get the required amount of minerals. In order to test this method litter No. 4 was treated in a similar manner. It is seen, in table No. 2, that the hemoglobin content of the blood of these pigs dropped only slightly and that all the pigs tested made a gain in weight each week. Although this method of preventing nutritional anemia in young pigs is effective it was not found to be as practical as the method where soil is put in the pen.

Since it was found that silt loam soil was so effective in preventing anemia in the pigs of litter No. 2, a further study was made with litter No. 5 and No. 6 to determine the effect different types of soil might have in preventing nutritional anemia in suckling pigs. Litter No. 5 was given access to rich bottom sand and litter No. 6 was given access to red hill clay soil. It will be noticed, from the results obtained from these litters and from litter No. 2, that each type of soil gave full protection to the pigs against nutritional anemia. The results of the different methods tested for the prevention of anemia in young pigs is shown in Table No. 2.

Litter No. One

Litter No. 1 was 11 Poland China pigs farrowed Nov. 1, 1932. These pigs were confined inside, on concrete, from birth until they were 12 weeks of age. At birth the hemoglobin determination showed an average of 9 grams of hemoglobin to 100 cc of blood. The hemoglobin determination at the end of the first week showed that the hemoglobin was down to an average of 6 grams of hemoglobin to 100 cc of blood. The hemoglobin continued to drop and at the end of the fourth week it was down to 3.2 grams to 100 cc of blood. At this time all the pigs were very pale about the nose. The skin was wrinkled, the hair-coat was rough, and there was very little increase in weight. In fact, two of the pigs failed to make any gain.

Beginning the fifth week the pigs were divided in three groups, three pigs in each of the first and second groups, and five in the third group. Group one, pigs No. 155, 157 and 158, were each day given orally 5 cc of a solution of water containing 25 mg of iron in the form of iron sulfate and 5 mg of copper in the form of copper sulfate. The second group, pigs No. 159, 160 and 161, were given every other day 10 cc of the same iron and copper salts solution that was given daily to group one. The third group received nothing in addition to the sow's milk. The hemoglobin of each group is shown in charts 1, 2 and 3, respectively. At the end of the first week after beginning to give the iron salts, the hemoglobin in the blood of the pigs that were dosed increased, while the hemoglobin in the blood of the pigs in the third group remained low and some of them began to loose weight. Three pigs in group III died. Pig No. 156 died the seventh week, pig No. 162 died the ninth week, and pig No. 165 died the tenth week. The other two pigs of this group lived throughout the experiment but remained in a very poor condition and weighed about one-half as much as the pigs that received the iron salts. The pigs that got the iron and copper salts all lived and the hemoglobin of the blood was up to normal by the eleventh week. The pigs receiving the iron and copper salts daily made a little faster gain in hemoglobin and weight than the pigs receiving the same salts every other day, but as this experiment includes only three pigs in each group, the difference in the rate of gain was not great enough to be significant. The results of this experiment is shown in Table No. 1.

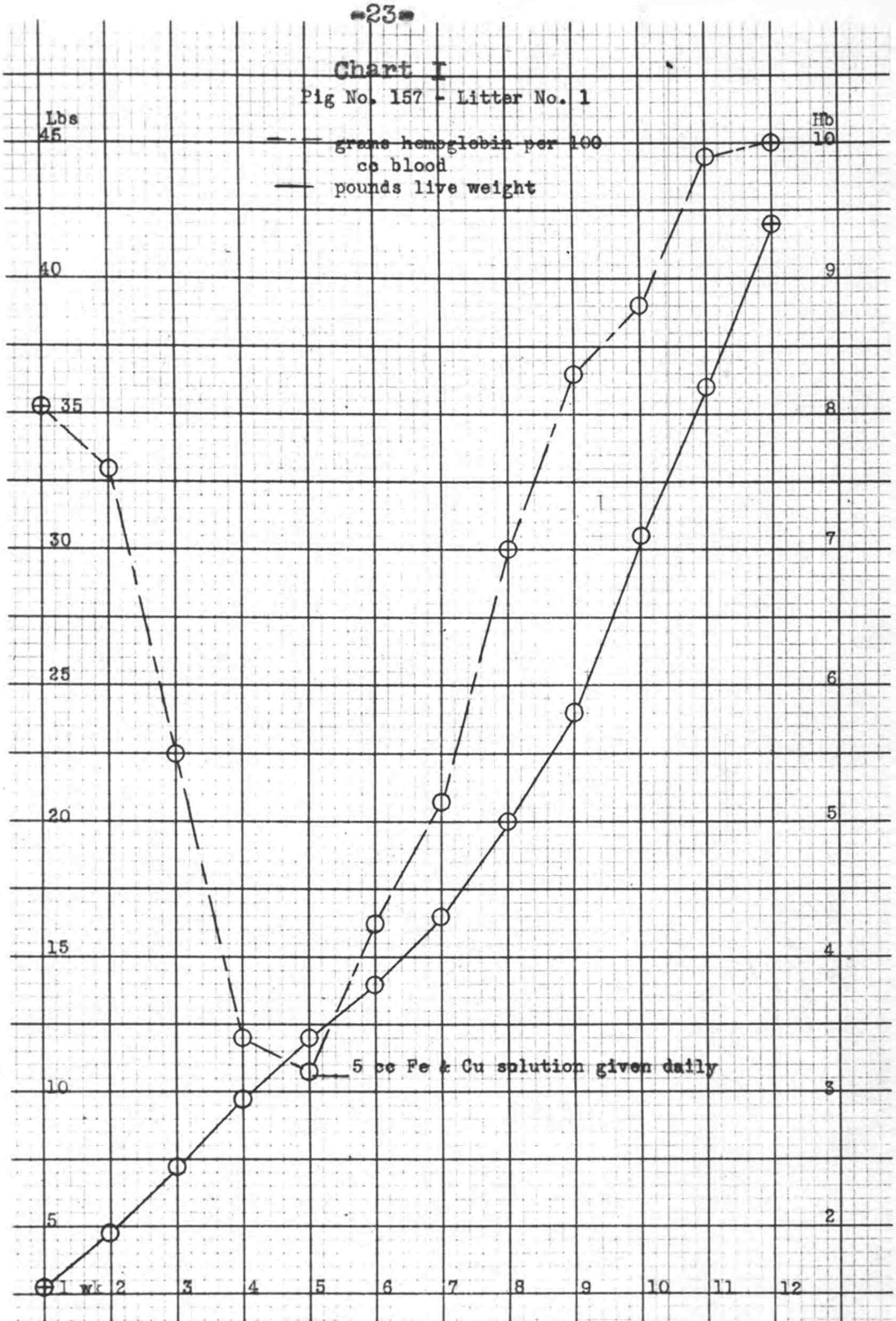


Chart I
Pig No. 157 - Litter No. 1
Lbs
Hb
grams hemoglobin per 100 cc blood
pounds live weight
5 cc Fe & Cu solution given daily
45
40
35
30
25
20
15
10
5
10
9
8
7
6
5
4
3
2
1 wk 2 3 4 5 6 7 8 9 10 11 12

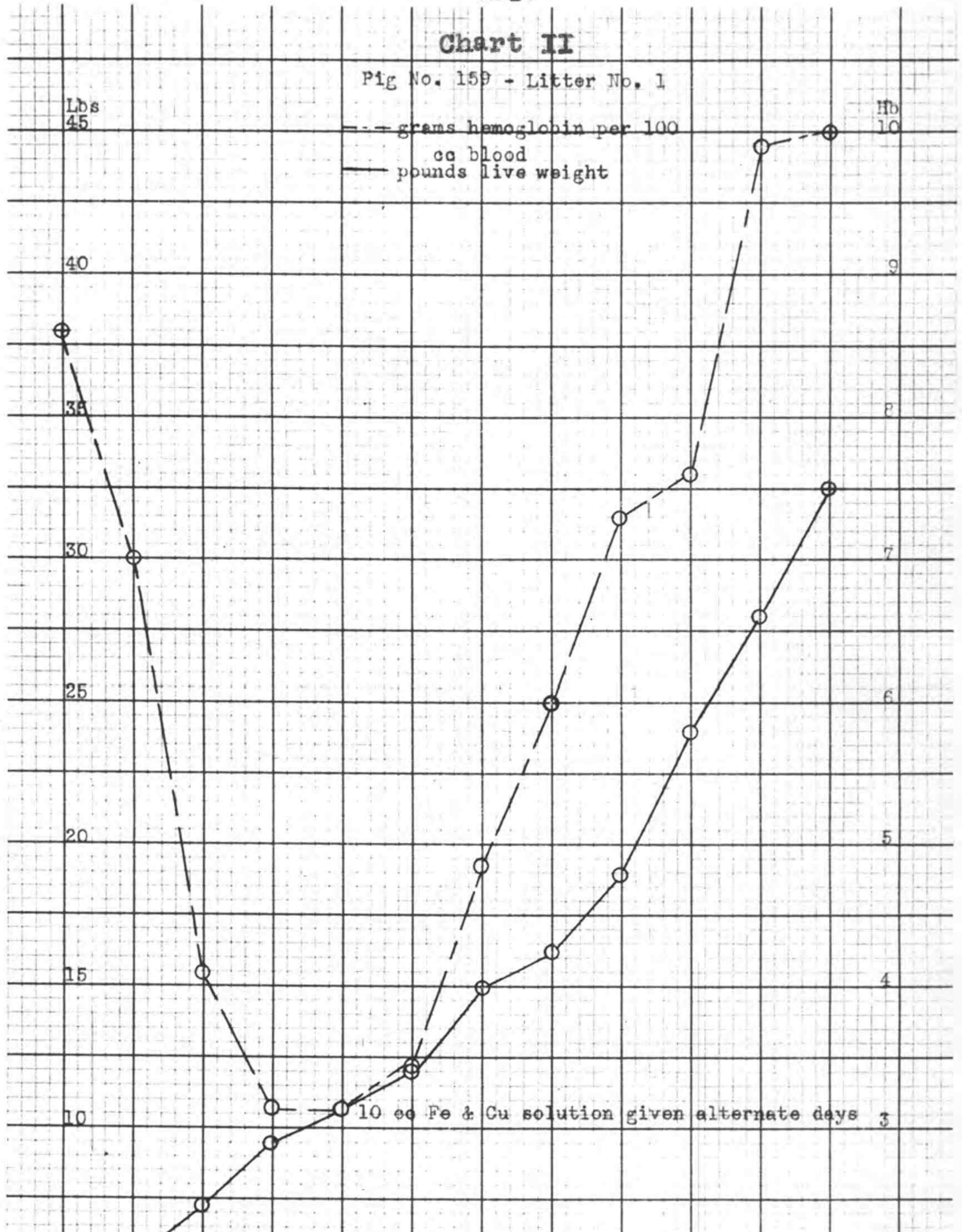


Chart II
Pig No. 159 - Litter No. 1
Lbs
45
40
35
30
25
20
15
10
5
Hb
10
9
8
7
6
5
4
3
2
grams hemoglobin per 100 cc blood
pounds live weight
10 cc Fe & Cu solution given alternate days
1 wk
2
3
4
5
6
7
8
9
10
11
12

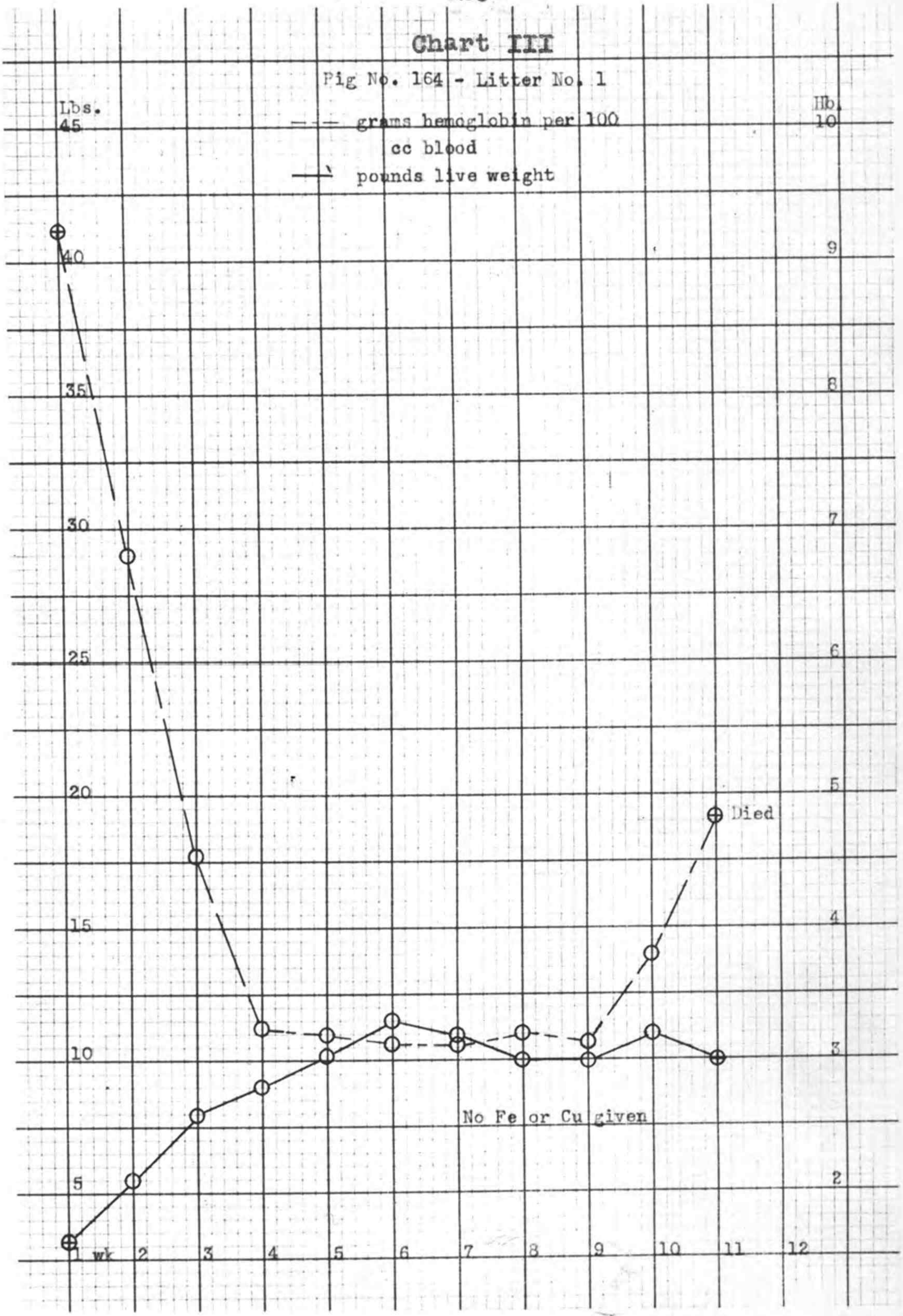


Chart III
Pig No. 164 - Litter No. 1
Lbs.
Hb.
grams hemoglobin per 100
cc blood
pounds live weight
45
40
35
30
25
20
15
10
5
10
9
8
7
6
5
4
3
2
Died
No Fe or Cu given
1 wk
2
3
4
5
6
7
8
9
10
11
12

Table No. 1.

Treatment of Anemic Pigs with Iron and Copper

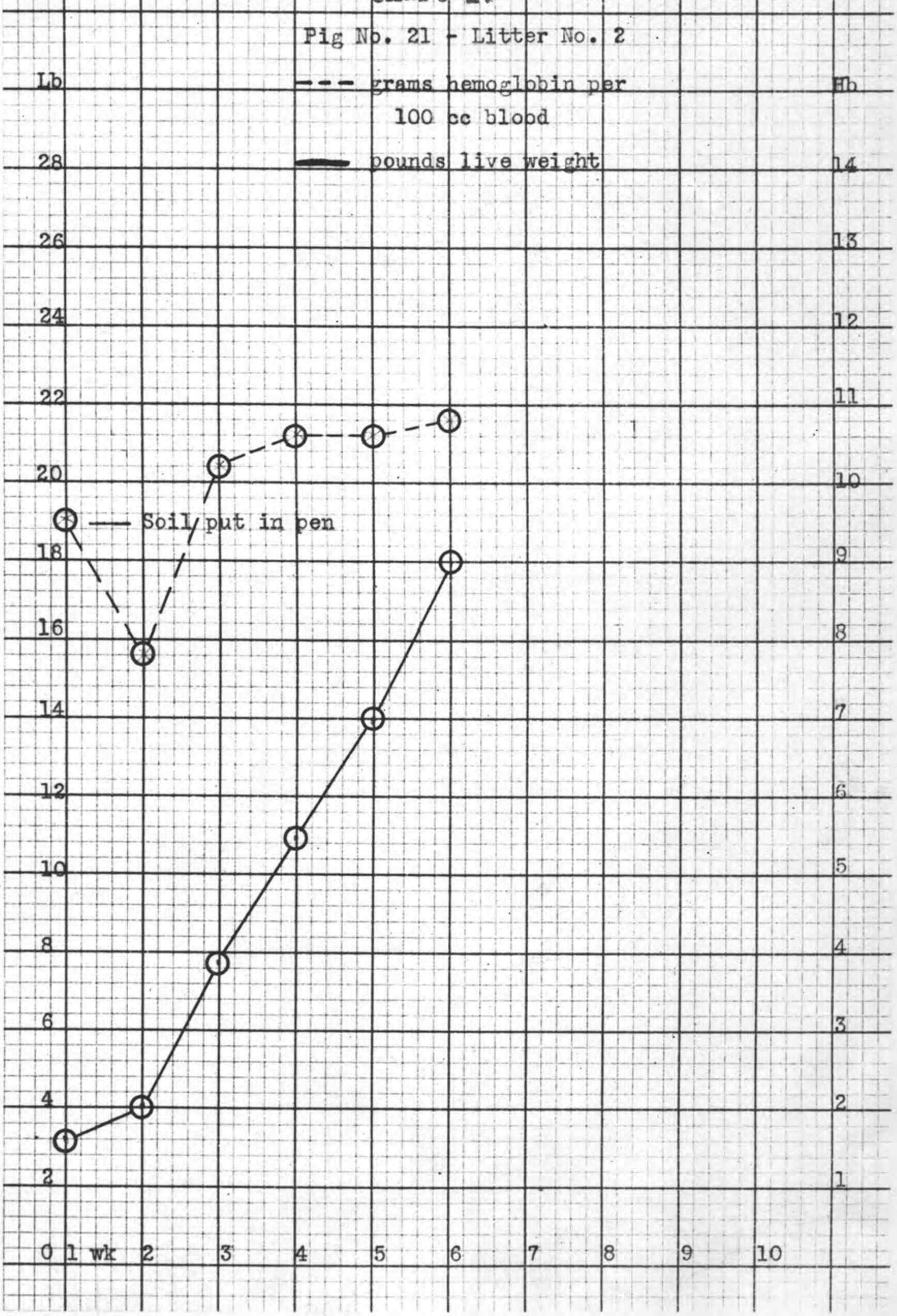
	Age in weeks	Ave. weight lb.	oz.	Ave. gain per week lb.	oz.	Ave. Hemo-globin	Methods
Litter No. 1 11 pigs	Birth	2	12	-	-	8.3	No treatment
	1	4	15	2	3	7.1	
	2	7	0	2	1	4.9	
	3	8	13	1	13	3.5	
	4	10	13	2	0	3.2	
Group No. 1 Pigs 155, 157, 158	5	13	0	2	2	4.0	Iron plus copper daily
	6	15	3	2	3	6.1	
	7	18	3	3	0	7.6	
	8	21	11	3	8	8.4	
	9	26	11	5	0	9.8	
	10	32	5	5	10	9.4	
	11	38	13	6	8	10.0	
Group No. 2 Pigs 159, 160, 161	5	10	11	1	6	3.5	Iron plus copper every other day
	6	13	3	2	8	5.6	
	7	14	3	1	0	6.9	
	8	15	5	1	2	7.9	
	9	19	5	4	0	8.0	
	10	22	0	2	11	9.1	
	11	24	13	2	13	9.2	
Group No. 3 Pigs 156, 162, 163, 164, 165	5	12	8	0	14	3.2	No treatment
	6	13	6	0	14	3.3	
	7*	13	0	-0	6	3.1	
	8⊖	13	8	0	4	3.2	
	9✲	15	2	1	10	3.8	
	10	15	11	1	0	4.0	
	11	22	8	4	0	7.0	

* Pig No. 156 died
⊖ Pig No. 162 died
✲ Pig No. 163 died

Litter No. Two

Litter No. 2 consisted of seven Berkshire pigs farrowed March 5, 1932. This litter was handled by the same method as litter No. 1 with the exception that two pens were given over to this litter. A creep was put across the door between the two pens. This shut the sow off in one pen but permitted the pigs to run at liberty in either pen. The third day after the pigs were farrowed, soil which was classified as silt loam was put into the pen to which the pigs only had access. It was noticed that the little pigs began to root in the dirt in three or four days after farrowing. There were seven pigs in this litter and the hemoglobin determination was made of two pigs which were taken as a representative of the group. The hemoglobin in the blood of this group presented entirely a different picture from that of litter No. 1. There was a slight decrease in the hemoglobin the first week, but was back up to 10 grams to 100 cc of blood, which is considered normal, at the end of the second week. All the pigs made good gains in weight and none showed any signs of anemia.

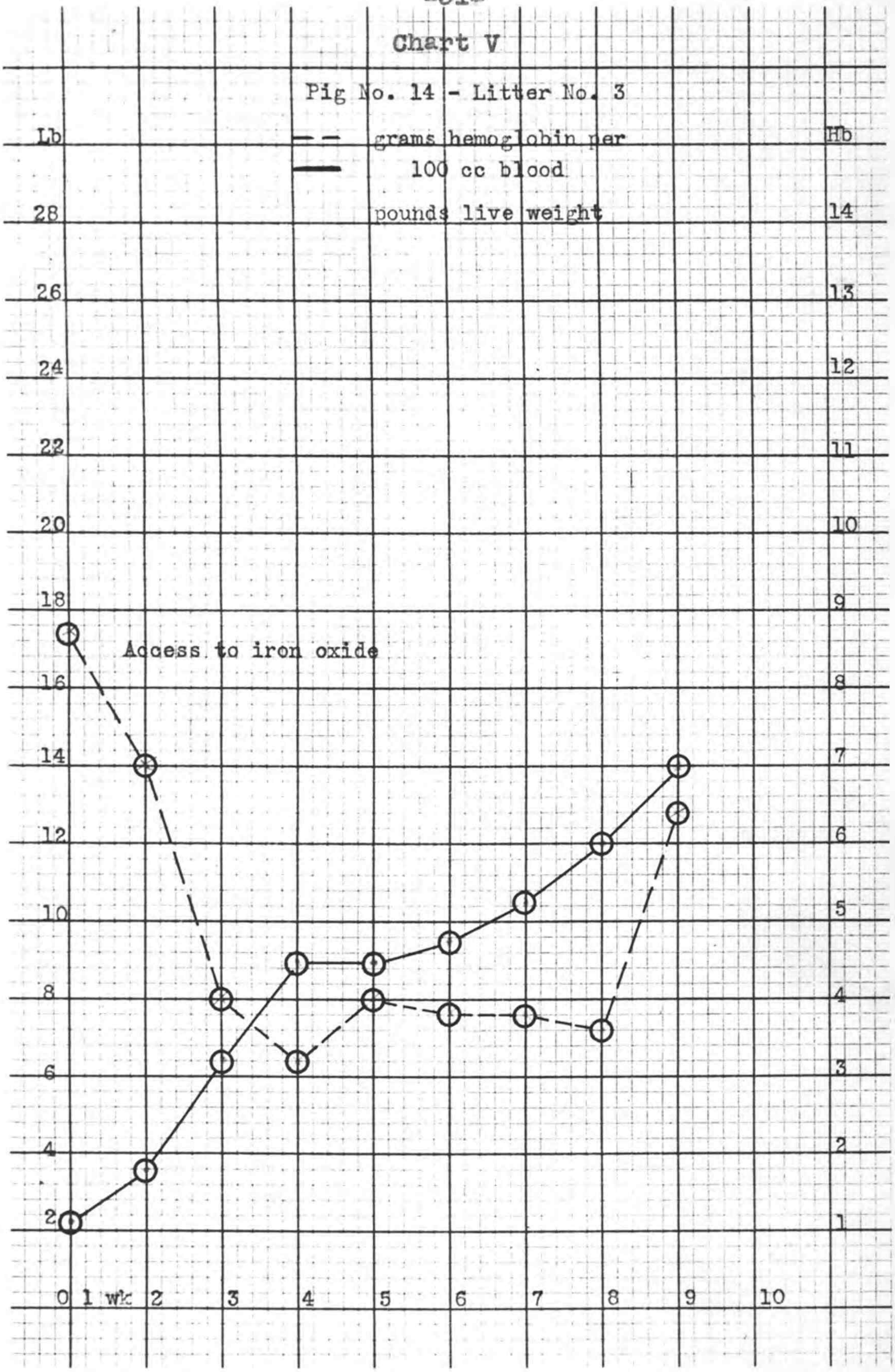
Chart IV


Pig No. 21 - Litter No. 2
Lb
Hb
--- grams hemoglobin per 100 cc blood
pounds live weight
Soil put in pen
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
14
13
12
11
10
9
8
7
6
5
4
3
2
1
1 wk
2
3
4
5
6
7
8
9
10

Litter No. Three

Litter No. 3 was given free access to a mineral mixture consisting of equal parts of bone meal, salt, and iron oxide. Each week the hemoglobin readings showed a decrease. The fourth week all the pigs showed symptoms of anemia and none of the three pigs tested made any gain for that week. No improvement was shown in any of the pigs at the end of the fifth week, which indicated that this method of controling anemia was ineffective. Thinking that the failure of the iron oxide to prevent nutritional anemia might be due to the lack of copper, a small amount of copper sulfate was added to the mineral mixture and at this time the pigs were divided in two groups. Group one, pigs No. 6 and 14, was continued on the mineral mixture which had the copper added. These pigs were separated from the other pigs and sow and put in a pen about two hours each day, where they had free access to the mineral mixture. The second group, pigs No. 2 and 5, were separated about two hours each day and put in a pen where they could have a box of silt loam soil to play in. The pigs that were permitted to play in the soil made a gradual recovery from the anemic condition and were back to a normal condition within three weeks after they were given access to the soil two hours each day. The results obtained from group one, in which the pigs were continued on the mineral mixture, showed that the addition of copper did not increase the effectiveness of the iron oxide in curing anemia in this experiment. Charts No. 5 and 6 indicate the amount of hemoglobin found in a typical pig of each group of this litter.

Chart V


Pig No. 14 - Litter No. 3
grams hemoglobin per 100 cc blood
pounds live weight
Lb
Hb
28
26
24
22
20
18
16
14
12
10
8
6
4
2
14
13
12
11
10
9
8
7
6
5
4
3
2
1
Access to iron oxide
0
1 wk
2
3
4
5
6
7
8
9
10

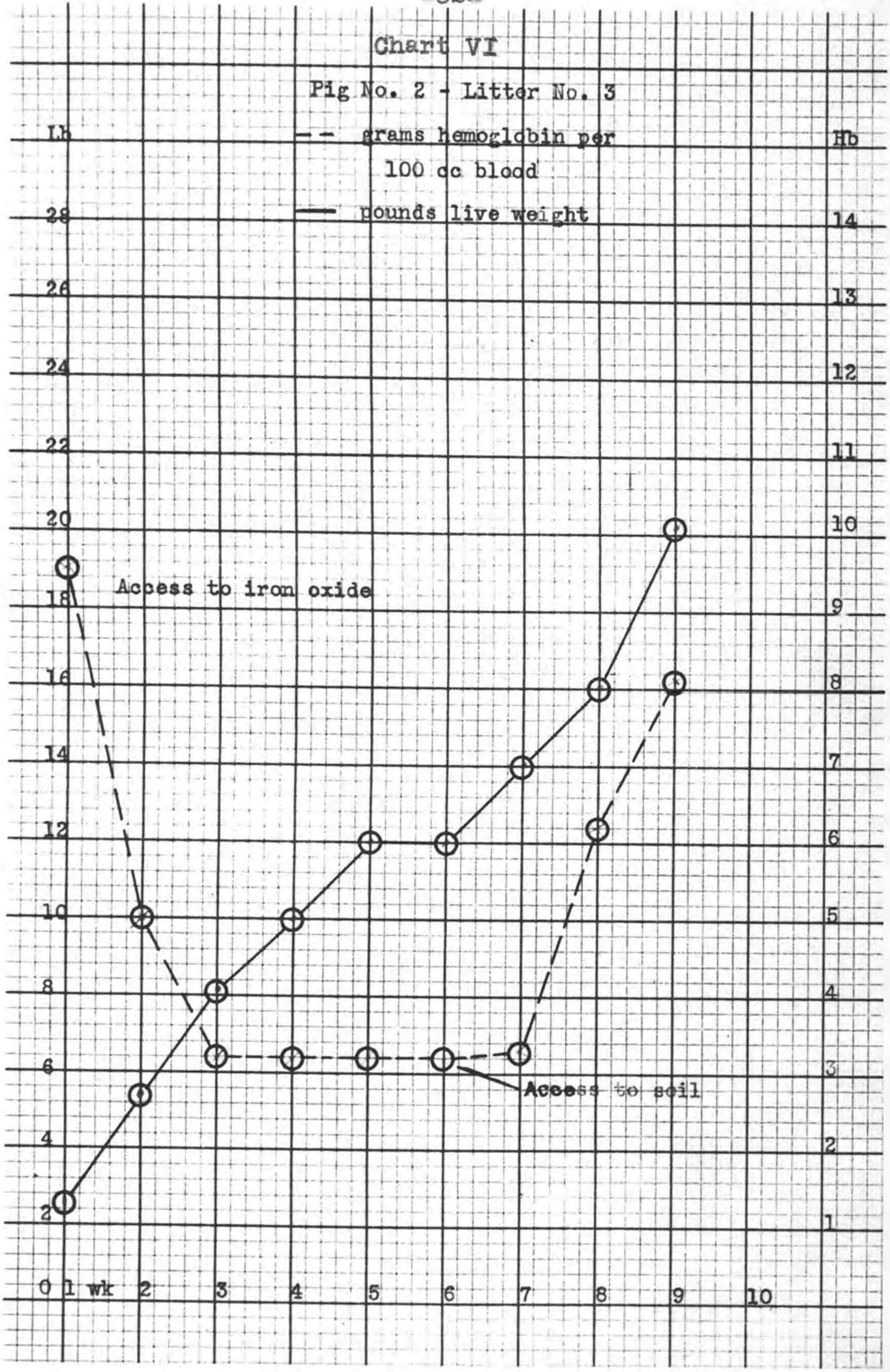


Chart VI
Pig No. 2 - Litter No. 3
-- grams hemoglobin per 100 cc blood
— pounds live weight
Lb
Hb
Access to iron oxide
Access to soil
0 1 wk 2 3 4 5 6 7 8 9 10
28 26 24 22 20 18 16 14 12 10 8 6 4 2
14 13 12 11 10 9 8 7 6 5 4 3 2 1

Litter No. Four

To test the practicability of painting iron salts on the sow's udders to prevent nutritional anemia in the pigs, a method which has been recommended at other stations as being the most practicable, litter No. 4 was treated in this manner. Cod-liver oil containing iron sulfate was applied with a paint brush to the sow's udders each day from birth until the pigs were seven weeks of age. Chart No. 7 shows the hemoglobin determinations made of a typical pig in this litter. This method protected the pigs against anemia but apparently was not as effective as the method where the pigs were permitted to play in the soil. All the pigs in this litter remained in good condition and made good gains in weight throughout the experiment.

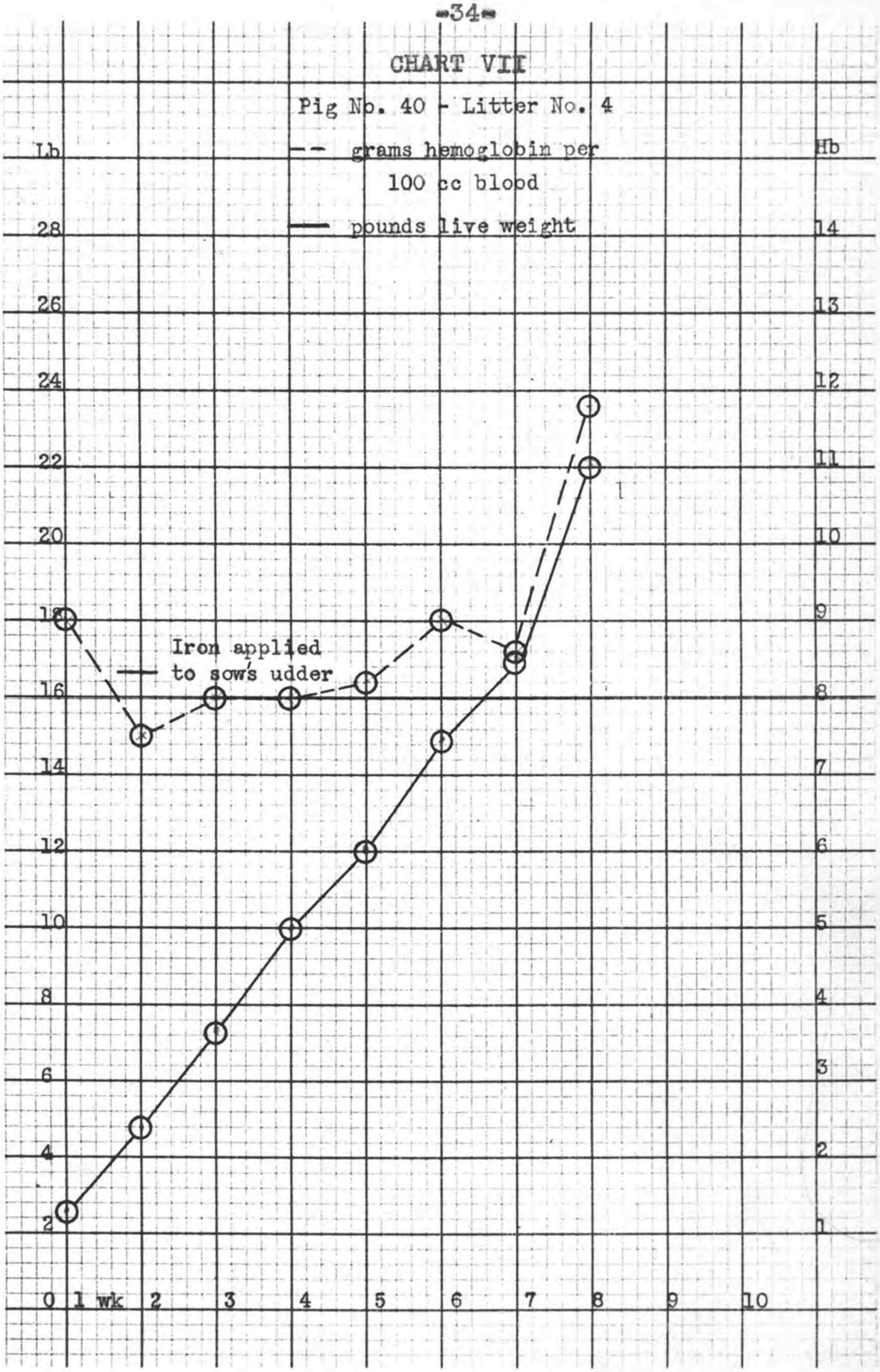


CHART VII
Pig No. 40 - Litter No. 4
-- grams hemoglobin per 100 cc blood
— pounds live weight
Lb
Hb
28
26
24
22
20
18
16
14
12
10
8
6
4
2
14
13
12
11
10
9
8
7
6
5
4
3
2
1
Iron applied to sow's udder
0 1 wk 2 3 4 5 6 7 8 9 10

Litters No. Five and Six

Litters No. 5 and 6 were Berkshires. Litter No. 5 was farrowed April 13 and litter No. 6 was farrowed April 15, 1932. There were ten pigs in each litter, all uniform in size. A creep was constructed in one corner of each pen and a box of rich medium sandy soil was put in the creep for the pigs of litter No. 5 to play in. Likewise a heavy clay soil was put in the other pen for the pigs in litter No. 6. The hemoglobin determination for a typical pig in litter No. 5 is shown in chart No. 8 and the hemoglobin determination for a typical pig in litter No. 6 is shown in Chart No. 9. It is noticed from the charts that there is practically no difference in the variation of the hemoglobin or weight of these pigs. Each of these two types of soil gave full protection to the pigs against anemia, as did silt loam.

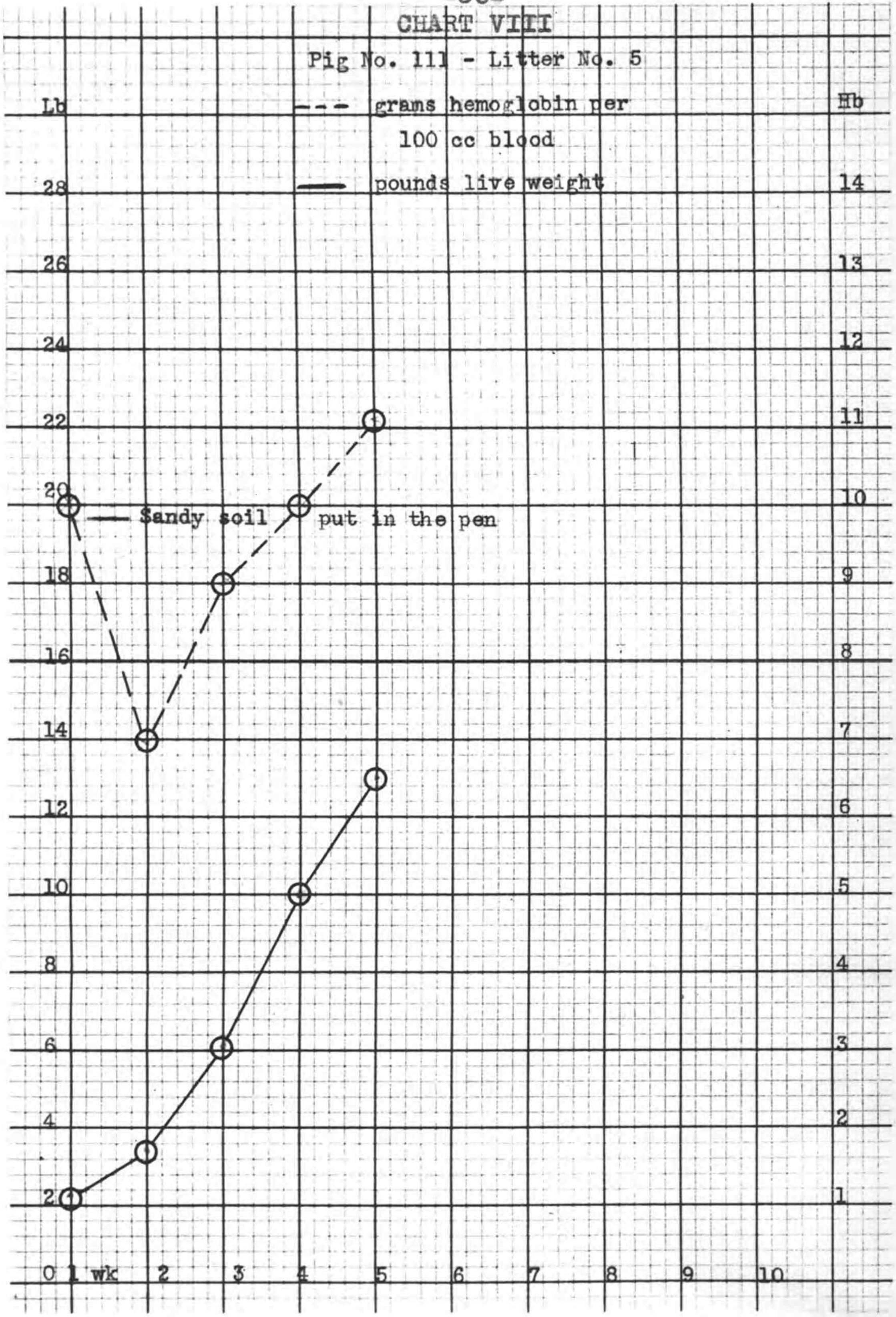


CHART VIII
Pig No. 111 - Litter No. 5
Lb
Hb
grams hemoglobin per 100 cc blood
pounds live weight
Sandy soil put in the pen
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
1 wk
2
3
4
5
6
7
8
9
10
14
13
12
11
10
9
8
7
6
5
4
3
2
1

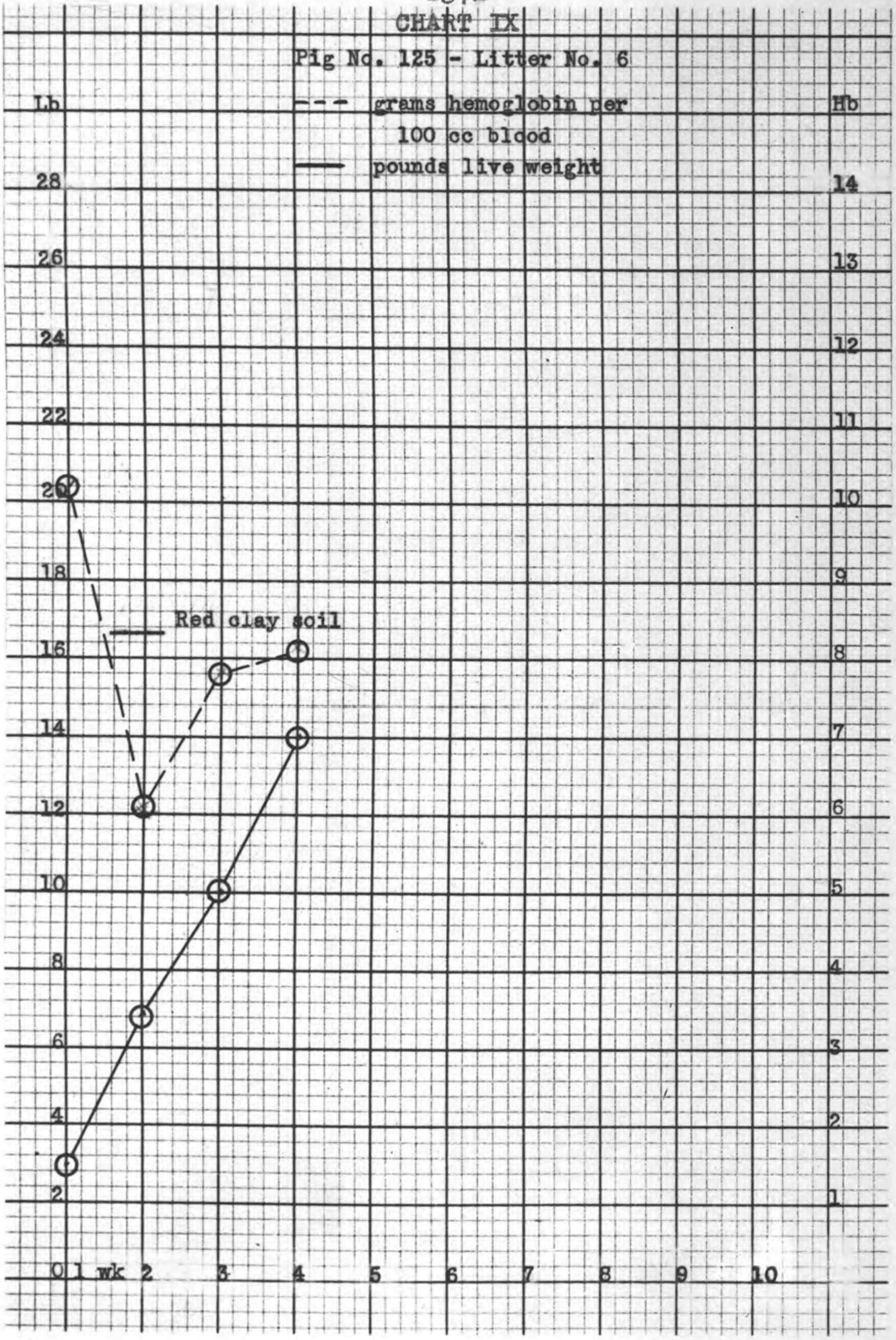


CHART IX
Pig No. 125 - Litter No. 6
grams hemoglobin per 100 cc blood
pounds live weight
Lb
Hb
28
26
24
22
20
18
16
14
12
10
8
6
4
2
14
13
12
11
10
9
8
7
6
5
4
3
2
1
Red clay soil
0
1 wk
2
3
4
5
6
7
8
9
10

Table No. 2

DIFFERENT METHODS TESTED

	Age in weeks	Ave. weight lb.	Ave. weight oz.	Ave. gain per week lb.	Ave. gain per week oz.	Ave. Hemoglobin	Methods
Litter No. 3 Pigs 2, 5, 6, 14	Birth	2	8	-	-	8.9	Iron oxide
	1	4	14	2	6	6.0	
	2	7	10	2	12	3.7	
	3	9	11	2	1	3.1	
	4	10	13	1	2	3.7	
	5	11	3	0	6	3.5	
Group No. 1 Pigs 6 and 14	6	10	4	1	0	3.4	Iron oxide plus copper
	7	13	0	2	12	3.6	
	8	15	0	2	0	6.4	
Group No. 2 Pigs 2 and 5	6	14	4	2	4	3.3	Silt loam soil put in pen
	7	16	12	2	8	7.1	
	8	22	0	5	4	8.5	
Litter No. 2 Pigs 16 and 21	Birth	2	10	-	-	9.4	Silt loam soil put in pen
	1	4	8	1	14	7.5	
	2	8	6	3	14	10.0	
	3	11	7	3	1	10.5	
	4	14	4	2	13	10.4	
	5	18	0	4	0	10.8	
Litter No. 4 Pigs 40 and 45	Birth	2	8	-	-	9.5	Iron sulfate applied to sow's udders
	1	4	14	2	6	7.5	
	2	7	9	2	11	7.6	
	3	10	8	2	15	7.5	
	4	12	8	2	0	7.9	
	5	15	4	2	12	8.6	
	6	17	8	2	4	8.3	
	7	22	8	5	0	11.6	
Litter No. 5 Pigs 111 and 112	Birth	2	10	-	-	10.2	Sandy soil put in pen
	1	3	15	1	5	7.0	
	2	6	1	2	2	8.5	
	3	9	12	3	11	9.9	
	4	12	8	2	12	10.5	
Litter No. 6 Pigs 118 and 125	Birth	2	15	-	-	10.3	Red clay soil put in pen
	1	6	13	3	14	6.2	
	2	9	8	2	11	7.7	
	3	14	0	4	8	8.2	

SUMMARY AND CONCLUSIONS

Nutritional anemia is common among suckling pigs when kept off the ground, and is recognized as being responsible for a large percentage of losses among small pigs.

The cause of nutritional anemia is the lack of certain metallic (iron and copper) salts necessary for hemoglobin production.

Pigs rendered anemic responded markedly to oral treatment with an equeous solution of iron sulphate and copper sulphate.

A mixture of cod-liver oil and iron sulphate painted daily on the sow's udders gave sufficient protection against anemia.

Access to a mineral mixture consisting of equal parts of bone meal, salt, and iron oxide did not prevent anemia.

The results at the Oregon Experiment Station showed that the most practical method of preventing nutritional anemia was to put soil in the farrowing pens so the pigs would have access to it. Several types of soil (Amity silt, sandy loam, and red hill clay) were tested and all proved to be satisfactory for this purpose.

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