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Supplementary Value of Various Feed- stuffs in Brood Sow Rations

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ABSTRACT

Data were presented in a previous publication which indicated that the concentrates most commonly used in swine rations are partially inadequate for brood sows, and the purpose of this report is to present more direct evidence on this point. The basal rations were made up of various combinations of corn, tankage, linseed oil meal, and alfalfa meal. When brood sows were limited to rations of this type there was evidence of partial nutritional inadequacy, especially in the suckling pigs. The symptoms of malnutrition included diarrhoea, lameness, scanty hair, scaly skins, a high mortality rate, and abnormal gait or muscular incoordination. The symptoms were very much less severe, or were eliminated entirely, when the basal ration was supplemented with certain combinations of feedstuffs. The supplements were not tested individually, but combinations including wheat germ, dried skim milk, large amounts of dried yeast, and a commercial liver meal, brought about great improvement. When a specially prepared liver meal was included the ration seemed to be entirely adequate. Alfalfa meal and wheat middlings likewise improved the basal rations, though at the levels tested neither was completely effective. Of the feedstuffs that are commercially important, fresh forage or pasture is the only one investigated that seems to be completely effective. In all probability the basal rations are deficient in one or more vitamins that are essential for swine. These data are interpreted as confirming our hypothesis that many of the rations in common use are inadequate for swine.

A number of miscellaneous observations were made, which were not confirmed by repetition. When fresh carrots were included the basal ration was not improved. The first marked examples of muscular incoordination were observed in the litter of a sow that received 8 lbs. of fresh skim milk daily. No evidence could be obtained of even a partial iodine deficiency. When excessive amounts (3 per cent) of cod liver oil were included in the basal ration the result was disastrous. Every pig died within the first week. The addition of cod liver oil to rations that were more nearly complete had little or no effect.

Supplementary Value of Various Feed-stuffs in Brood Sow Rations

A. G. HOGAN AND S. R. JOHNSON*

Observations extending over a period of years have convinced us that the adequacy of the rations of brood sows is a major problem in swine production. Our data on the performance of sows while receiving the standard basal ration, which is probably superior to those often supplied in practice, were described in a previous publication (1).† Additional data have been published, chiefly in preliminary reports (2-10). The frequency with which abnormalities occurred in new born pigs suggested that a large percentage of them was actually sick at birth. Their inferior response during the suckling stage, and the high mortality rate, indicated that the milk of their dams was of poor quality, presumably because of a deficiency of vitamins. In an attempt to determine whether this explanation was correct the basal diet was fortified with a wide variety of feed-stuffs. The purpose of this bulletin is to describe the data obtained, and to provide additional evidence that many of the failures of brood sows are the result of consuming rations which are inadequate. Typical illustrations are shown in Figures 1, 2, and 3. The experimental procedure was described in one of the earlier publications (1). It should be added that usually all animals received the control ration until approximately the beginning of the stage of gestation. It was the custom to change to the experimental rations at that time.

I. MISCELLANEOUS VITAMIN CARRIERS

It had been suggested at various times that it may not be possible for a sow to rear a normal litter under the restricted conditions we have imposed, so in an attempt to answer that question supplements that are effective vitamin carriers, but which are not ordinarily used, were incorporated in some of the rations. If any of these supplements were successful it was hoped that they might also give some useful suggestion as to the nature of the deficiency of the basal rations. The variable constituents were wheat middlings, alfalfa meal, wheat germ, dried skim milk, dried yeast, and liver meal. In the years 1930-31 and 1932-33 the liver meal was obtained from one of the

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†Numerals refer to "Bibliography", page 20.

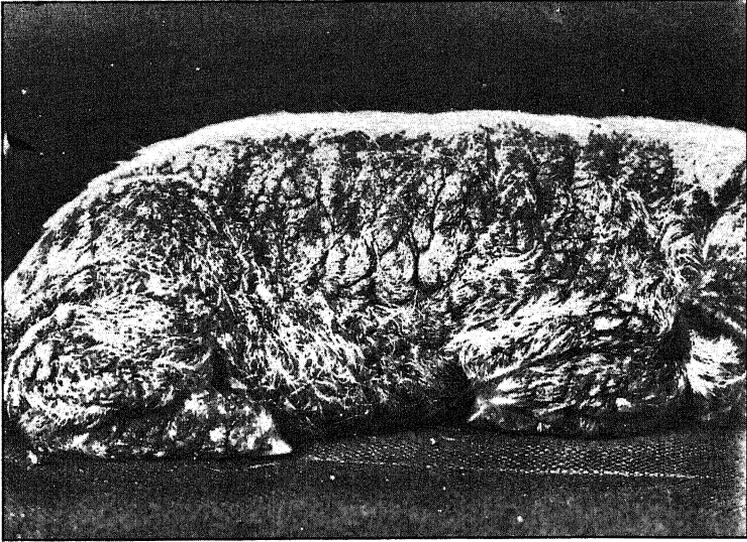


Fig. 1.—Dam of this pig received the basal ration. Lesions of this degree of severity are rare.

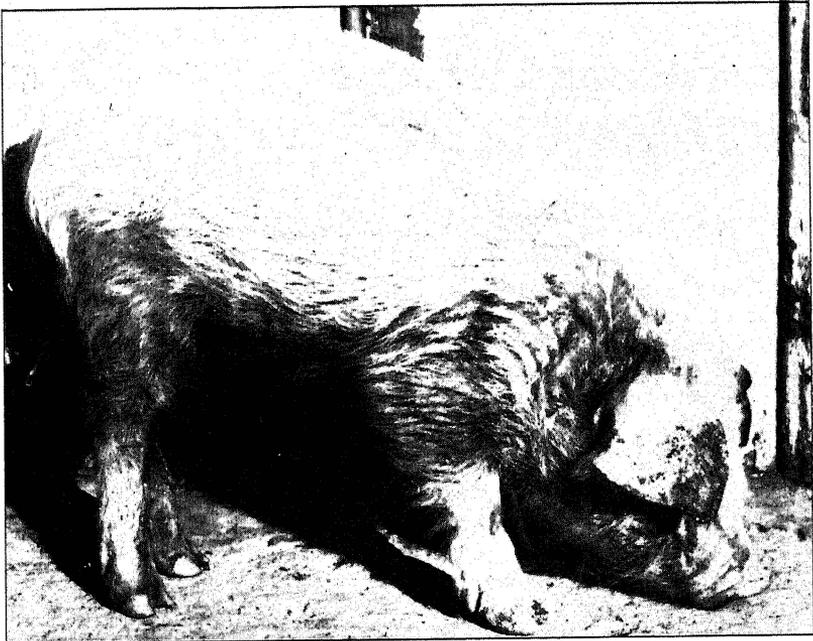


Fig. 2.—Dam of this pig received the basal ration. In some seasons a characteristic heavy brown exudate appears in approximately 25 per cent of the pigs.

large packing companies¹. In 1931-32 this product² was prepared especially for our use. The rations are described in Table 1, and the weights of the animals and their feed intakes are summarized in Tables 2, 3, and 4. The farrowing and weaning records are summarized in Table 5.

TABLE 1. COMPOSITION OF RATIONS CONTAINING MISCELLANEOUS VITAMIN CARRIERS

Constituent	Ration No.				
	80 ¹	53	63	72	116 ²
Corn	77	37	33	42	
Wheat shorts			20	20	
Liver meal		10	10	10	
Alfalfa meal	5	15	25	25	15
Cod liver oil	1	1	1	1	3
Mineral mixture	2	2	1	2	2.5
Wheat germ		25			10
Dried skim milk		10	10		10
Tankage	10				5
Ground wheat					42.5
Dried yeast					12
Linseed oil meal	5				

¹ Example of a typical basal ration.

² This ration is also described in Section 4.

TABLE 2.--WEIGHT AND FEED RECORDS PRECEDING GESTATION

Ration No.	Duration days	Weight		Avg. daily Ration lbs.
		Initial lbs.	Final lbs.	
53	128	106	232	5.1
63	159	54	210	4.7
72	169	33	211	4.1
116	173	38	219	4.0

No attempt was made to estimate separately the potency of the various supplements to the basal rations, but there can be no doubt that collectively they were quite active. Such evidence

¹Swift and Co., Chicago, Ill.

²Generously supplied by Dr. David Klein of the Wilson Laboratories.

TABLE 3.--WEIGHT AND FEED RECORDS DURING GESTATION

Ration No.	Duration days	Weight		Avg. daily Ration lbs.
		Initial lbs.	Final lbs.	
53	114	232	404	7.8
63	115.5	210	353	7.2
72	114.5	214	396	7.9
116	116	219	389	6.1

TABLE 4.--WEIGHT AND FEED RECORDS DURING LACTATION

Ration No.	Sow No.	Duration days	Weight		Avg. daily Ration lbs.
			Initial lbs.	Final lbs.	
53	163	56	392	382	11.8
	30	"	368	309	12.2
	119	"	368	332	11.8
	94	"	414	296	10.2
63	33	Pigs were given to Sow 5 when 5 days old			
	9	56	308	274	12.7
	10	"	322	272	12.1
	5	"	348	342	8.0
72	16	"	351	300	15.3
	7	"	361	247	11.4
	3	"	362	301	10.8
	1	"	369	317	14.6
116	37	"	329	300	10.5
	54	"	360	305	13.2
	79	"	367	366	10.8
	66	"	355	360	8.8
	5	"	369	365	7.6

as was obtained indicated that the liver meal obtained from the Wilson Laboratories was especially effective. The mortality was zero, and the weaning weights at 8 weeks averaged 33.1 lbs., which is unusually high for first litters. However, the data on this product were not entirely satisfactory from the experimental standpoint. Thus as previously explained 2 of the sows on the ration used as a control (1) lost their entire litters. These

TABLE 5. RECORD OF PIGS AT FARROWING AND AT WEANING

Ration No.	Sow No.	Litters born				Litters weaned	
		Live pigs		Dead pigs		No. of pigs	Avg. wt. lbs.
		No.	Avg. wt. lbs.	No.	Avg. wt. lbs.		
Farrowed 1931							
	163	8	2.2			4	30.9
	30	10	3.0			8	29.4
53	119	6	2.4			5	35.6
	94	11	2.5			10	25.0
Farrowed 1932							
	33	3	2.9			31	36.7
	10	8	2.9			8	32.1
63	9	8	2.7			8	32.4
	5	1	2.7	3	mummies	1	35.6
Farrowed 1933							
	3	10	2.2	1	0.7	5	31.6
	54	11	2.2			9	24.7
72	7	12	2.4			11	24.6
	16	10	2.2			9	28.2
	37	5	2.6			4	39.8
	1	10	2.7			8	31.5
Farrowed 1936							
	79	8	2.5	1	2.2	7	30.7
116	66	6	3.0	1	2.3	3	34.1
	5	3	2.5	1	2.0	3	29.4

¹Pigs with sow 5 after 5th day.

losses make it difficult to evaluate the improvement due to modification of the ration, but even if these two sows are discarded from the averages there is still a very considerable difference between the control and experimental groups. The latter have very much higher weaning weights. If all four control sows are considered in the comparison there is also a very large difference in the mortality rate. One other disturbing experimental condition was the small number of pigs per litter in the experimental group, but there is every reason to believe the ration had no influence on the size of the litters.

The other rations of this series were probably less adequate and need not be discussed individually. The averages of the farrowing and weaning records of the control and experimental sows are shown in Table 6.

Notes on litters: As judged by current standards the rations described in this section were satisfactory. The weaning weights were normal and the mortality rate was not excessive. However, the observations in 3 years out of 4 indicated that the rations were slightly inadequate, as a few of the pigs exhibited the abnormalities described in an earlier publication (1, page 11). These included unexplained deaths within a week after birth, diarrhoea, and a mild exudate. Practically all of the survivors though were

healthy and thrifty when weaned. The exceptional ration was No. 63, which contained specially prepared liver meal. The litters of the sows which received this ration were entirely normal.

TABLE 6. AVERAGES OF FARROWING AND WEANING RECORDS

Ration No.	No. of Sows	Litters born				Litters weaned		Mortality per cent
		Alive		Dead		No. of pigs	Avg. wt. lbs.	
		No.	Avg. wt. lbs.	No.	Avg. wt. lbs.			
1931								
51(basal)	4	7	2.3	0.3	1.8	5	21.4	28.6
53(special)	4	8.8	2.6	0	---	6.8	29.0	22.7
1932								
61(basal)	2	8	2.4	0	---	8	25.7	0(or 50) ¹
63(special)	4	5	2.8	0	---	5	33.1	0
1933								
70(basal) ²	5	9.6	2.3	0.8	1.5	4.4	24.5	54.2
72(special)	6	9.7	2.4	0.2	0.7	7.7	28.6	20.6
1935								
113(basal)	9	8.9	2.7	0	---	2.7	21.2	69.7
116(special)	3	5.7	2.7	1	2.2	4.3	31.2	24.6

¹Two sows lost their litters, presumably because of a cold wave.

²The usual basal ration was not used this season. Ration 70 is described in Table 7.



Fig. 3.—Dam of this pig received the basal ration. The spots are made up of a brown exudate which ultimately disappears.

It is not practical commercially to use some of the supplements which these special rations contained, but they demonstrate that the rations of the sows described in the preceding publication (1) were inadequate, and were responsible for the failures to rear satisfactory litters.

II. RATION IS IMPROVED BY WHEAT MIDLINGS OR BY LARGE QUANTITIES OF ALFALFA MEAL

After it had been shown that the basal ration could be greatly improved by including in it certain supplements which are highly regarded as vitamin carriers, it was decided to investigate those supplements that are commercially available. Rations were therefore formulated, as described in Table 7, which contained varying proportions of wheat middlings, wheat bran, and alfalfa meal. The weights of the animals and their feed intakes are summarized in Tables 8, 9, and 10.

TABLE 7.--COMPOSITION OF RATIONS CONTAINING WHEAT BY-PRODUCTS

Constituent	Ration No.				
	70	82	91	92	93
Corn	62	51.6	58	56	37
Tankage	5	5	8	8	5
Linseed oil meal	10	5	6	3	5
Alfalfa meal		5	25	5	25
Cod liver oil	1	1	1	1	1
Mineral mixture	2	2.4	2	2	2
Wheat bran	10	10		5	5
Shorts	10	20		20	20

TABLE 8.--WEIGHT AND FEED RECORDS PRECEDING GESTATION

Ration No.	Duration days	Weight		Avg. daily Ration lbs.
		Initial lbs.	Final lbs.	
70	170	36	221	4.6
.91	174	38	218	5.6
92	190	30	209	4.3
93	180	35	211	5.4

In the spring of 1933 a different phase of this problem was being studied, and a basal ration was used, No. 70, which contained 10 per cent of wheat middlings and 10 per cent of wheat bran. If both weaning weight and mortality rate are considered

TABLE 9.--WEIGHT AND FEED RECORDS DURING GESTATION

Ration No.	Duration days	Weight		Avg. daily Ration lbs.
		Initial lbs.	Final lbs.	
70	114	221	402	6.9
82	115	305	494	6.9
91	115	218	394	7.0
92	115	209	415	7.1
93	116	211	389	7.2

TABLE 10.--WEIGHT AND FEED RECORDS DURING LACTATION

Ration No.	Sow No.	Duration days	Weight		Avg. daily Ration lbs.
			Initial lbs.	Final lbs.	
70	9	56	356	317	11.5
	8	"	377	280	7.6
	10	"	394	272	10.4
	5	"	361	287	11.5
	13	"	345	258	10.8
	15	"	357	319	11.3
82	3	"	438	408	11.3
	37	"	399	382	9.2
	159	"	349	310	10.1
91	135	"	391	283	8.8
	124	"	350	405	10.1
	95	"	346	405	8.4
	93	"	338	243	10.7
	104	"	385	288	13.1
92	126	"	356	325	10.8
	187	"	370	340	10.7
	155	"	430	364	6.2
93	100	"	357	260	7.4
	134	"	345	294	10.5
	181	"	344	300	12.3
	153	"	355	301	11.8
	184	"	367	287	11.6
	94	"	320	245	9.8
	108	"	327	285	8.1

this ration was notably better than any ration used previously which did not contain the wheat by-products. This observation was followed up that fall on a very small scale, as only 2 sows were available for the fortified ration. It contained 20 per

cent of wheat middlings, 10 per cent of wheat bran, and 5 per cent of alfalfa meal. Apparently the inclusion of these constituents improved the ration, for the pigs of this group had somewhat higher weaning weights, and a lower mortality rate, than did the controls.

In the spring of 1934 both wheat middlings and alfalfa meal were studied, alone and in combination. It will be noted that the inclusion either of 20 per cent wheat middlings, or of 25 per cent of alfalfa meal, was about equally effective in improving the ration. Either one reduced the mortality and increased the weaning weight. When these two feedstuffs were combined the mortality was not much reduced, but there was a considerable increase in weaning weight. When compared with the basal group it will be seen that these sows reared over

TABLE 11. RECORD OF PIGS AT FARROWING AND AT WEANING

Ration No.	Sow No.	Litters born		Litters weaned		No. of pigs	Avg. wt. lbs.
		No.	Avg.wt. lbs.	No.	Avg.wt. lbs.		
Farrowed 1933S							
	13	12	2.0			8	25.2
	15	7	2.1			5	32.6
70	9	12	2.5			7	24.6
	5	10	3.2			8	23.1
	10	10	2.6			8	26.9
	8	9	3.1			6	27.1
Farrowed 1933F							
82	3	6	2.7			6	29.4
	37	9	2.6			4	25.4
Farrowed 1934							
	124	5	2.7			2	27.1
	95	3	2.4	3 mummies		1	21.0
91	93	12	2.5			10	28.8
	104	9	2.9			9	27.7
	126	9	2.4			9	19.3
Farrowed 1934							
	159	8	2.9	1	2.4	8	21.9
	135	7	2.9			7	34.3
92	187	7	2.7	1	1.7	5	27.1
	155	10	2.4	1	1.8	6	14.6
	100	7	3.1	2	2.4	6	27.6
Farrowed 1934							
	134	10	2.1			8	33.2
	181	10	2.6	1 mummy		10	27.9
93	153	9	2.5			7	34.4
	184	8	2.6			7	35.3
	94	11	2.1			8	27.2
	108	9	2.8			8	18.1

twice as large a percentage of the pigs born as did those on the basal ration. Moreover the average weight of the pigs weaned by them was 26 per cent higher. Of the 27 sows observed none lost an entire litter though 2 of them reared only 1 living pig. Another evidence of improvement was a lower degree of variability, which is in sharp contrast to our experience with the basal rations. In the series now under discussion there was less variability between groups, between sows in the same group, and within litters of the same sows. The farrowing and weaning records are shown in Table 11. The averages of these records for both the control and experimental groups are shown in Table 12.

TABLE 12. AVERAGES OF FARROWING AND WEANING RECORDS WITH WHEAT MIDDINGS AND ALFALFA AS SUBSTITUTES FOR CORN

Ration No.	No. of Sows	Litters born				Litters weaned		Mortality per cent
		Alive		Dead		No. of pigs	Avg. wt. lbs.	
		No.	Avg. wt. lbs.	No.	Avg. wt. lbs.			
1933								
80 (basal)	5	9.6	2.3	0.8	1.5	4.4	24.5	54.2
82 (wheat by-products)	2	7.5	2.6	0	---	5	27.8	33.3
1934								
90 (basal)	6	7.7	2.4	0	---	3	21.5	60.9
91 (alfalfa)	5	7.6	2.6	0	---	6.2	25.4	18.4
92 (wheat by-products)	5	7.8	2.8	1	2.1	6.4	25.1	18.0
93 (alfalfa + wheat by-products)	6	9.5	2.4	0	---	8	29.1	15.8

Notes on litters: The performance of these pigs was inferior to that of those described in Section I. Though the mortality rate was not significantly higher, diarrhoea and skin lesions were more severe, and the weaning weights were lower. The higher degree of variability, within and between litters, is additional evidence of inferiority.

Whatever may be the defects of the corn-tankage ration, it is clear that they are partly repaired by either wheat middlings or by larger quantities of alfalfa meal. The combination of the two is probably more effective than either alone, but it is not entirely adequate.

III. GREEN FORAGE AS A SUPPLEMENT TO RATIONS OF CONCENTRATES

Under practical conditions one would expect that pasture, or green forage, would overcome the deficiencies of corn and the protein supplements in general use, and an attempt was made to demonstrate its effectiveness. On various occasions therefore sows were supplied with green feed, as a supplement to the

basal ration. The basal rations are described in Table 13, and the weights of the animals and their feed intakes are summarized in Tables 14, 15, and 16. The farrowing and weaning records are summarized in Tables 21 and 22.

TABLE 13.--COMPOSITION OF RATIONS CONSUMED WHEN GREEN FORAGE WAS SUPPLIED

Constituent	Ration No.			
	51	61	71	80, 129
Yellow corn	75	72	62	77
Tankage		5	5	10
Linseed oil meal	10	10	10	5
Alfalfa meal	5	5		5
Wheat bran	5	5	10	
Wheat shorts			10	
Dried Buttermilk	2			
Cod liver oil	1	1	1	1
Mineral mixture ¹	2	2	2	2 ²

¹Common salt, ground limestone, and steamed bone meal in equal parts were the chief ingredients. There were minor variations in some rations which are not described as they apparently had no significance.

²These rations were identical except for minor differences in the mineral mixture.

TABLE 14.--WEIGHTS AND DRY FEED CONSUMPTION PRECEDING GESTATION

Ration No.	Duration days	Weight		Avg. daily Ration lbs.
		Initial lbs.	Final lbs.	
51, pasture	120	94	219	5.0
61, with forage	162	67	215	4.3
71, with forage	175	33	221	4.2

TABLE 15. WEIGHTS, AND DRY FEED CONSUMPTION DURING GESTATION

Ration No.	Duration days	Weight		Avg. daily Ration lbs.
		Initial lbs.	Final lbs.	
51, pasture	113.5	219	378	6.7
61, with forage	116	215	359	5.8
71, " "	113.7	221	398	6.7
80, " "	113.3	288	499	6.4
129, " "	113	338	492	5.7

TABLE 16. WEIGHTS, AND DRY FEED CONSUMPTION DURING LACTATION

Ration No.	Sow No.	Duration days	Weight		Avg. daily Ration lbs.
			Initial lbs.	Final lbs.	
51, pasture	151	25	365	326	5.3
	5	56	344	201	12.5
	149	"	347	237	10.4
	4	"	304	378	13.6
61, with forage	31	Sow killed all but one pig. It was given to No. 63			
	6	56	340	320	7.9
	63	"	329	328	10.2
71, with forage	19	"	349	297	8.3
	33	"	371	249	9.5
	6	"	349	215	8.9
	18	"	397	293	10.1
	17	"	391	308	10.2
80, with forage	13	"	414	366	11.7
	33	"	464	419	7.1
	6	"	449	340	8.2
	18	"	520	406	9.5
	17	"	422	408	10.9
129, with forage	19	"	450	396	8.9
	48	"	456	446	8.2
	66	"	437	372	12.5

In 1931 the sows were taken to a bluegrass pasture at approximately the farrowing date, and left there until their litters were weaned.

There were 4 of these sows and they farrowed an average of 8 live pigs and 1 dead pig per litter. The mortality was zero, and the average weaning weight was 27.9 lbs. These weaning weights were a little low, but they would probably have been higher, if the pasture had been more abundant and if the sows had been given access to it during the stage of gestation. The pigs were entirely normal in every way, with clean, healthy skins; and no abnormalities. The improvement due to the provision of pasture was clearly marked.

In the following years it was decided to subject the sows on green feed to precisely the same experimental conditions as those on the basal ration, so the green feed was cut fresh daily and brought to the sows. The amounts and kind of forage in 1932, and the periods when it was supplied, are shown in Table 17.

There were three of these sows, and unfortunately they farrowed only a small number of living pigs, an average of 4.3. In addition they farrowed an average of 0.3 dead pigs per litter, in various stages of development. One of these sows farrowed

TABLE 17.--AMOUNTS OF FORAGE SUPPLIED AT VARIOUS STAGES
(1931-'32)

Sow No.		6	31	63
Growth	Days	82	92	89
	Alfalfa, lbs.	9	9	9
	Soybeans, lbs.	13.9	13.9	13.9
	Rye, lbs.	76.8	88.8	83.8
	Average daily consumption of fresh forage, lbs.	1.2	1.2	1.2
Gestation	Days	116	115	117
	Rye, lbs.	131.4	140.7	125.4
	Average daily consumption of fresh forage, lbs.	1.1	1.2	1.1
	Days	56		56
Lactation	Rye, lbs.	80.5		62.5
	Alfalfa, lbs.	69.0		93.0
	Average daily consumption of fresh forage, lbs.	2.7		2.8
	Total forage, lbs.	380.6	252.4	387.6

only 3 pigs and refused to accept them. She killed two and the third was transferred to another sow on the same ration. This third pig provided an excellent example of variability. It weighed 41.8 lbs. when weaned, while its 5 foster litter mates had an average weight of only 18.6 lbs. In all probability the 5 were suffering at birth from some nutritional deficiency which the one had escaped. In the entire group only 13 live pigs were farrowed, and 10 were reared, giving a mortality of 23.1 per cent. If the 2 pigs killed by the mother are not counted the mortality was 9.1 per cent. The average weaning weight was 26.2 lbs.

Reference to Table 22 shows that at weaning the pigs from the control and forage groups had practically the same weight, but that the mortality in the control group was excessively high. During gestation the sows received daily a little over 1 lb. of fresh forage, and during lactation they received a little less than 3 lbs. Presumably this amount was enough to improve the quality of the milk, though the degree of improvement is uncertain. It seems fairly certain though that the amount of forage was insufficient to sustain a milk flow of normal quantity.

Additional data on the value of green forage as a supplement was obtained in the spring of 1933. As in the previous year the forage was cut daily and brought to the sows in inside pens.

The amounts and kind of forage, and the periods when it was supplied, are shown in Table 18.

TABLE 18.--AMOUNTS OF FORAGE SUPPLIED AT VARIOUS STAGES
(1932-'33)

Sow No.		6	11	17	18	19	33
Growth	Days	97	85	102	107	94	100
	Alfalfa, lbs.	8	8	8	8	8	8
	Oats+clover, lbs.	48.5	48.5	48.5	48.5	48.5	48.5
	Rye, lbs.	52.0	34.0	62.5	52.0	62.5	62.5
	Miscellaneous "	2.5	0.5	2.5	2.5	0.5	2.5
	Average daily consumption of fresh forage, lbs.	1.1	1.1	1.2	1.0	1.3	1.2
Gestation	Days	114	113	113	116	116	116
	Bluegrass, lbs.	49.0	49.0	65.8	64.0	65.8	64.8
	Rye, lbs.	51.0	54.0	68.5	84.5	55.8	70.5
	Average daily consumption of fresh forage, lbs.	0.9	0.9	1.2	1.3	1.1	1.2
Lactation	Days	56		56	56	56	56
	Rye, lbs.	295.5		356	416	262	343
	Average daily consumption of fresh forage, lbs.	5.3		6.4	7.4	4.7	6.1
Total forage		506.5	203.0	611.8	675.5	505.0	599.8

The weaning weights of the pigs that received the fresh forage were satisfactory, but as in the preceding year the weaning weights of the control group were higher than was expected. For that reason the difference between the weaning weights of the control and experimental groups was less than had been expected. As shown in Table 12 the basal ration contained 10 per cent of both wheat bran and wheat middlings, and presumably this was enough to partly conceal the deficiencies of the other constituents. The sows that received the fresh forage farrowed an average of 8.7 living pigs per litter and weaned 7.6, or 87.4 per cent. The average weaning weight was 29.4 lbs. The sows on the basal ration farrowed 10 pigs per litter, and weaned 7, or 70 per cent. The average weaning weight was 26.2 lbs.

Reference to Table 18 shows that the daily allowance of fresh forage during lactation varied from 4.7 to 7.4 lbs., considerably more than was supplied in the preceding year. Presumably this explains the somewhat higher weaning weights.

This comparison was repeated in the fall, but the basal ration was more typical of the ones commonly used in practice,

and contained no wheat by-products at all. Again the green forage was cut daily and carried to the sows. The amounts and kind of forage, and the periods when it was supplied are shown in Table 19.

TABLE 19.--AMOUNTS OF FORAGE SUPPLIED AT VARIOUS STAGES
(FALL 1933)

Sow No.		6	13	17	18	19	33
Growth	Days	28			23		27
	Sudan grass, lbs.	111			123		146
	Average daily consumption of fresh forage, lbs.	4.0			5.4		5.4
Gestation	Days	113	115	113	116	112	117
	Sudan grass, lbs.	92	68	203	116	203	96
	Soybeans, lbs.	309	302	332	345	315	323
	Alfalfa, lbs.	75		24	88		82
	Rye, lbs.	61.5			118.5		61
	Average daily consumption of fresh forage, lbs.	4.8	3.2	5.0	5.8	4.6	4.8
Lactation	Days	56	56	56	56	56	56
	Soybeans, lbs.		43			14	
	Alfalfa, lbs.		98.	62		50	
	Rye or wheat, lbs.	362	234	322	512	173.5	425
	Average daily consumption of fresh forage, lbs.	6.5	6.7	6.9	9.1	4.2	7.6
	Total forage, lbs.	1010.5	745.0	943.0	1302.5	755.5	1133.0

TABLE 20.--AMOUNTS OF FORAGE SUPPLIED AT VARIOUS STAGES
(FALL 1935)

		Sow No.	
		48	66
Preceding Parturition	Days	24	19
	Cowpeas, lbs.	104	103
	Average daily consumption of fresh forage, lbs.	4.3	5.4
Lactation	Days	56	56
	Cowpeas, lbs.	10	59
	Barley, lbs.	205	511
	Bluegrass, lbs.	39	45
	Average daily consumption of fresh forage, lbs.	4.5	11.0
	Total forage	358.0	718.0

on one day consumed 18 lbs. Her pigs had satisfactory weaning weights, and they were exceptionally thrifty in appearance. She farrowed 10 living pigs and weaned 7, or 70 per cent, with an average weaning weight of 34.3 lbs. The diseased sow farrowed 12 and weaned 4, or 33.3 per cent, with an average weaning weight of 21.7 lbs. The sows on the basal diet farrowed an average of 11 living pigs, and weaned 5.2 or 47.3 per cent with an average weaning weight of 25.0 lbs. The highest average weight of any litter was 27.9 lbs. and the lowest was 9.2 lbs.

TABLE 22. GREEN FORAGE AS A SUPPLEMENT TO THE BASAL RATION

Ration	No. of Sows	Litters born				Litters weaned		Mortality per cent
		Alive		Dead		No. of pigs	Avg. wt. lbs.	
		No.	Avg. wt. lbs.	No.	Avg. wt. lbs.			
1931								
51(basal)	4	7	2.3	0.3	1.8	5	21.4	28.6
51(pasture)	4	8	2.9	1.0	2.6	8	27.9	0.0
1932S								
61(basal)	4	10	2.4			4	25.7	60.0
61(forage)	3	4.3	2.4	0.3	0.4	3.3	26.2	23.2
1933S								
71(basal)	6	10	2.6			7	26.2	30.0
71(forage)	6	8.7	2.6	0.3	1.2	7.6	29.4	12.6
1933F								
80(basal)	5	9.6	2.3	0.8	1.5	4.4	24.5	54.2
80(forage)	6	8.8	2.6	0.5	1.4	5.8	29.8	34.1
1935F								
129(basal)	7	11.0	2.7	0.6	2.4	5.2	25.0	52.7
129(forage)	1 ¹	10.0	2.5			7.0	34.3	30.0

¹Sow 66 only.

Additional data are required for an exact valuation of the properties of green forage, but it is believed that the chief value of the 1935 trial was to give an indication of the amount of green feed required to give optimum results. Thus Sow 66 received an average daily allowance of 5.3 lbs. of the green forage for the 19 days preceding farrowing, and of 10.4 lbs. during lactation. This means that the total ration of this sow probably contained over 10 per cent of nutrients derived from the green forage. The records of the individual sows are shown in Table 21. The averages of the farrowing and litter records with appropriate controls are shown in Table 22.

It seems fairly certain that the concentrates commonly supplied to swine are inadequate for brood sows, and that the deficiencies can be overcome by the provision of an adequate amount of a suitable fresh forage.

Notes on litters: The mortality rate was higher than it was among the litters described in Section I, and the weaning weights were about the same. In other respects the pigs described in this Section were superior. It is our opinion that if high quality forage had been available for longer periods, and in greater abundance at times, these pigs would have done still better.

IV: MISCELLANEOUS OBSERVATIONS

During the years these observations were under way a number of the rations tried gave unexpectedly disastrous results, though in most cases there was no satisfactory explanation. These feeding trials have not been repeated, as usually any one of these rations was supplied to only a few sows, but nevertheless the data seem worthy of record. The rations are described in Table 23. The weights of the animals and their feed intakes are summarized in Tables 24, 25, and 26.

TABLE 23. COMPOSITION OF MISCELLANEOUS RATIONS

Constituents	Ration No.						
	62	113	114	115	116 ¹	118	119
Yellow corn	53	77.2	75.2	36.6		38.6	
Tankage	5	10.0	10.0	6.0	5	6	5
Linseed oil meal	10	5.0	5.0	3.0		3	
Alfalfa meal	25	5.0	5.0	25.0	15	25	15
Cod liver oil	1	1.0	3.0	3.0	3	1	1
Mineral mixture	1	1.8	1.8	1.4	2.5	1.4	2.5
Wheat bran	5			5.0		5	
Wheat shorts				20.0		20	
Wheat						42.5	44.5
Dried yeast						12.0	12.0
Wheat germ						10.0	10.0
Dried skimmilk						10.0	10.0

¹This ration is also described in Section I.

TABLE 24.--WEIGHT AND FEED RECORDS PRECEDING GESTATION

Ration- No.	Duration days	Weight		Avg. daily Ration lbs.
		Initial lbs.	Final lbs.	
51, basal + carrots	121	97	225	5.1
62, alfalfa + skimmilk	178	56	232	5.0
114, basal, 3 o/o cod liver oil	176	36	230	4.4
115, alfalfa, wheat shorts, 3 o/o cod liver oil	173	44	220	4.1
116, special ration 3 o/o cod liver oil	169	41	219	4.0

TABLE 25.--WEIGHTS, AND DRY FEED CONSUMPTION DURING GESTATION

Ration No.	Duration days	Weight		Avg. daily Ration lbs.
		Initial lbs.	Final lbs.	
51,basal+carrots	113.5	218	378	6.7
62,alfalfa+skimmilk	115	232	362	7.0
114,basal,3 o/o cod liver oil	114.5	230	411	6.1
115,alfalfa,wheat shorts, 3 o/o cod liver oil	113.4	218	394	6.8
116,special ration 3 o/o cod liver oil	115.7	219	389	6.1

TABLE 26. WEIGHTS, AND DRY FEED CONSUMPTION DURING LACTATION

Ration No.	Sow No.	Duration days	Weight		Avg. daily Ration lbs.
			Initial lbs.	Final lbs.	
51,basal+carrots	40	9	380	360	8.0
	108	2	337	337	
	148	56	288	316	
	188	7	400	388	
62,alfalfa + skimmilk	4	56	331	334	6.4
	18	0			
	60	56	338	285	7.0
114,3 o/o cod liver oil	11	7	372	340	
	18	7	402	380	
	34	1	353	350	
	35	3	397	383	
	39	6	354	331	
	46	4	389	378	
115,alfalfa,wheat shorts,3 o/o cod liver oil	47	56	359	271	11.0
	48	"	360	347	7.6
	76	"	366	318	10.6
	78	"	346	254	9.4
116,special ration 3 o/o cod liver oil	5	"	369	365	7.6
	66	"	355	360	8.8
	79	"	367	366	10.8

1. Substitution of Carrots for Cereal Grass.

In the winter and spring of 1930-31, a group of 4 sows received some form of "fresh" feed in addition to the basal ration, No. 51. These were started on green rye forage, but this had to be discontinued 23 days later because of unfavorable

weather conditions. Carrots are highly regarded by livestock men, both for horses and sheep, so it was decided to use them as a supplement instead of the green rye. The amount and kind of supplements and the periods when they were supplied, are shown in Table 27. The farrowing and weaning records of the sows are compared in Table 28 with those of the sows that received the basal ration only.

TABLE 27.--SUMMARY OF DATA ON ALLOWANCE OF
"FRESH" FEED

Sow No.	108	188	148	40
Breeding date	11-22-30	11-38-30	12-2-30	12-9-30
Farrowing date	3-15-31	3-20-31	3-27-31	3-29-31
(days)	23	23	23	23
Green rye (
(Avg.allowance,lbs.	1.1	1.1	1.1	1.1
Carrots,stage of gestation				
Avg. daily allowance, lbs.	4.0	4.0	4.0	4.0
Carrots,stage of lactation				
Avg. daily allowance,lbs.			3.7	

TABLE 28. FARROWING AND WEANING RECORDS OF SOWS ON BASAL
RATION AND ON BASAL RATION + CARROTS

Ration No.	Sow No.	Litters born		Litters weaned		Mortality per cent
		Alive No.	Dead No.	No. of pigs	Avg. wt. lbs.	
	148	7			3	15.4
51, basal	40	10			0	
+ carrots	108	9			0	
	188	9			0	
	Avg.	8.8	2.3		0.8	15.4
51, basal	Avg.	7	2.3	0.3	1.8	21.4
						28.6

Notes on litters: The various abnormalities were as severe as they were in the groups on the basal rations, described previously (1).

No satisfactory explanation is available but the group which received carrots failed decisively. Three of the 4 sows lost their entire litters within 8 days after farrowing. The fourth sow reared 3 pigs out of a total of 7 born alive. The mortality in this litter was higher than in any of the three litters on the basal ration that survived, and the weaning weight was lower.

As to the cause of the failure of the sows that received carrots one can only speculate. There is no evidence that the carrots were actually toxic, but they were very unpalatable to the sows, and were refused entirely if any feed selection was possible. In order to insure that they were consumed they were ground and mixed intimately with the evening feed. It may be of some significance that according to Goldberger and Wheeler (11) carrots are practically devoid of antipellagric activity.

2. First Cases of Incoordination or Paralysis.

In the year 1931-32 3 sows received a ration which contained 25 per cent of alfalfa meal, and in addition fresh skim-milk. The average daily allowance during gestation, as calculated from Table 29, varied from 3.1 to 7.8 lbs. It had been supposed that the supplement of skimmilk would insure a high degree of success but strangely enough these sows had the poorest record of any groups then under observation, though it is impossible to assign any specific cause for the failures. The ration employed, No. 62, is described in Table 23. Ration 61 (1) was the control at that time. The record of concentrates consumed is shown in Tables 24, 25, and 26, and the farrowing and weaning records of the sows are shown in Table 30.

TABLE 29.--RECORD OF MILK CONSUMPTION

Sow No.	Milk consumed during gestation		Milk consumed during lactation	
	Days	Avg. daily allowance lbs.	Days	Avg. daily allowance lbs.
18	47	8	(Farrowed 2 dead pigs)	
4	54	8	56	8
60	112	8	56	8

TABLE 30. RECORD OF PIGS AT FARROWING AND AT WEANING

Ration No.	Sow No.	Litters born				Litters weaned	
		Alive		Dead		No. of pigs	Avg. wt. lbs.
		No.	Avg.wt. lbs.	No.	Avg.wt. lbs.		
Farrowed 1932							
62 + skimmilk	18			2	2.2	0	
	4	3	2.3	4	2.1	2	26.3
	60	11	2.3	2	1.6	8	15.8
61,basal	Avg.	7	2.3	2.7	2.0	5	17.9
	Avg.	10	2.4			4	25.7

Any extended discussion seems unnecessary, but the litter of Sow 60 deserves some description. This sow received 8 lbs. of milk daily throughout the period of gestation, and farrowed a litter of 11 living and 2 dead pigs on May 19, 1932. Eight pigs were weaned, with an average weight of 15.8 lbs.

Notes on litter of Sow 60

- 5-19-32. 5 of the pigs had abnormally red areas on the neck and head.
 5-22 Pig 4M overlaid, killed.
 5-29 All pigs have diarrhoea, sow is off feed.
 6-9 Pigs scour less, feed consumption of sow increased.
 6-30 All pigs scour intermittently, never free from diarrhoea. The ears of most of the pigs are scabby. Pig 5M has lost control completely of all 4 legs. Pig 7M shows first symptoms of paralysis.
 7-1 Pig 8M shows marked degree of paralysis. Pig 7M shows a slight decrease.
 7-6 Pig 5M died, paralyzed and severe diarrhoea. At autopsy general infection just under the skin, probably secondary. Muscles atrophied. Bones and joints were normal. Pig 8M was killed for examination, veterinarian found nothing abnormal. Pig 7M unchanged, slightly affected.
 7-10 Pigs 3F and 7M unchanged.
 7-12 Pig 3F much worse, uses front legs only.
 7-13 Pig 7M worse. Pig 1M shows slight signs of paralysis.
 7-14 Pigs weaned.
 7-26 Pig 3F died, weighed 5.4 lbs. Rear quarters much atrophied.

The remaining pigs were retained, on a variety of rations, and ultimately they started to grow at a normal rate. A photograph of an affected pig is reproduced in Fig. 4.

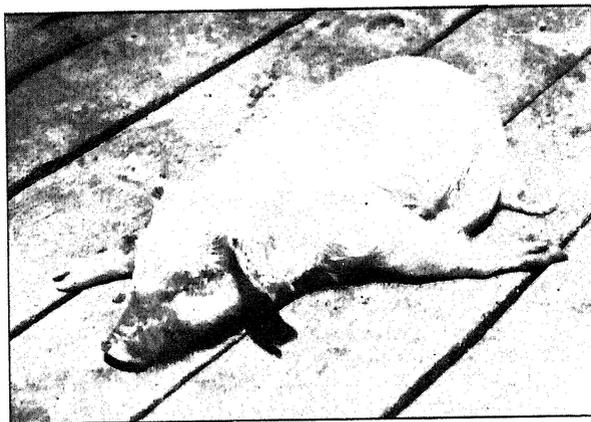


Fig. 4.—Typical example of muscular incoordination.

We have no definite suggestion as to why this group was so much inferior to the others, though we have assumed that the abnormalities, as well as the slow growth rate of the pigs, were correlated with the decreased consumption of dry feeds. If the assumption is correct then skimmilk must be even more deficient in the agent required for protection than was the basal ration itself. These same symptoms of incoordination and paralysis have been observed subsequently, and it seems certain that the condition is a deficiency disease. Eveleth and Biester (12) produced experimentally a type of incoordination which was

probably identical with that we encountered at this time. The dams of the pigs described by Eveleth and Biester received a ration which contained 20 per cent of skimmilk powder, and skimmilk is evidently not a potent source of the factor which prevents paralysis.

3. Feeding Excessive Amounts of Cod Liver Oil.

As was mentioned before a considerable number of pigs developed a peculiar type of paralysis, and an abnormal gait described as "goose" step. A very slightly similar abnormality has been ascribed by Hughes, Aubel, and Lienhardt (13) to a deficiency of vitamin A.

The rations the sows consumed in this experiment contained yellow corn, alfalfa meal, and 1 per cent of cod liver oil, so it seemed very doubtful that the symptoms observed were due to a lack of vitamin A. However, in an attempt to secure additional data on that point, the amount of cod liver oil (prepared for animal feeding) in some of the rations was greatly increased in the year 1934-35. The basal ration, No. 113, contained 1 per cent as usual. This was compared with Ration 114 which was very similar except it contained 3 per cent. Ration 115 contained a larger per cent of alfalfa meal and of wheat middlings. Ration 116 contained wheat instead of corn, also a number of other constituents designed to increase the amount of vitamins; both of these rations likewise contained 3 per cent of cod liver oil. These rations are described more completely in Table 23. The record of feed consumed is shown in Tables 24, 25, and 26.

The results obtained with the basal ration were similar to those obtained in previous years. Nine sows farrowed a total of 80 pigs, all of which were alive. Three of these sows lost their entire litters before they were weaned. One sow farrowed only 2 pigs and one died the first day so the remaining pigs were given to another sow. These 5 sows reared from 2 to 9 pigs per litter, and the average weaning weight of these was 21.2 lbs., at 8 weeks. The mortality was high and characteristic pathological symptoms appeared. The pigs were quite plump for a few days and then gradually became thinner. At about the time the decline in thrift was observed there would be signs of leg weakness which gradually, or rapidly, became more pronounced. The stride would be lengthened, accompanied by an undulating gait. The entire body would become limp, and the muscles of the loin and hind quarters would apparently atrophy. Death followed quickly after this condition developed, and often occurred before the symptoms became pronounced. In practically every case it was found at post mortem examination that the liver was about twice the normal size, very light in

color, tender, and friable. Blood blisters would appear at the surface as the result of a slight scratch, and hemorrhage from visceral blood vessel was frequently the immediate cause of death. The kidneys were somewhat enlarged also. Histological examination revealed globular fat deposits in both liver and kidney cells.

Although the basal ration was unusually unsatisfactory during this trial, the experimental ration, No. 114, was even more unsuitable. Sow 4 of this group will be discussed separately, but there were 7 other sows which received Ration 114. One striking feature was the large number of embryos that had died in a comparatively early stage of development. The pigs which were alive at birth seemed quite normal and healthy, but when a day or two old it became evident that they were sick. Since this ration differed from No. 113 only in the percentage of cod liver oil it was taken for granted that cod liver oil is toxic to swine if supplied in excessive amounts. This oil is toxic to guinea pigs, rabbits, sheep, and goats (14), and Nicolaus (15) reports that cod liver oil has some toxicity for suckling pigs. A review by Woodman (16) describes toxic liver degeneration in suckling pigs that were supplied with cod liver oil. After it became apparent that the first two sows that farrowed on this ration would lose their litters they were changed to Ration 113. Two sows did not farrow until nearly 4 weeks after the change was made, but even then they were unable to rear their litters, and none of the pigs survived over 7 days.

As was mentioned before one of the sows on Ration 114 is to be described separately. No. 4 of this group went off feed in January, and in a short time consumed practically no feed at all. She also became very lame. It was believed that her poor condition was the result of an unsatisfactory ration, and as it seemed certain that she would die unless some change was made, she was given a small quantity of skimmilk and transferred to Ration 116. A brief summary of her subsequent history is shown below.

Notes on Sow 4

- 12-5-34 Bred.
- 1-13-35 Very inactive.
- 1-26 Consumes very little feed, losing weight, does not get up without help.
- 1-30 Left hind leg seems useless.
- 2-2-to 3-5. From 4 to 10 lbs. skimmilk was supplied daily. Improvement not spectacular, but made some gain in weight, and use of left hind leg improved.
- 2-18 Changed to Ration 116.
- 4-3 Farrowed 2 live pigs, 1 small dead pig, and 4 small mummies. Another mummy was expelled the next day, and still another 6 days later.
- 4-9 Left thigh seems to be atrophying.

5-29 The pigs farrowed alive were weaned, with an average weight of 46.8 lbs. The pigs seemed thrifty, but there were a few bumps, and a few tiny, scabby skin lesions under the flank.

It will be observed then that Sow 4 was changed to Ration 116 on the 75th day of the period of gestation, and farrowed 44 days later. Only 2 pigs were farrowed alive, and in addition there were 7 dead pigs in all, in various stages of decomposition. When her record is compared with the others in this group it would seem that the ration change was made about as late as possible and still permit any pigs to be reared. When these sows were taken off Ration 114 all the others that received excessive amounts of cod liver oil were likewise changed to rations that contained only 1 per cent of cod liver oil.

There were 9 sows on Ration 115, which contained 25 per cent of alfalfa meal, 20 per cent of wheat middlings, and 3 per cent of cod liver oil. Most of these sows had farrowed before the ration was changed but apparently they were much more resistant to excessive amounts of cod liver oil than were the sows on Ration 114. There were relatively few mortalities in the first week, and the peak was reached in the second week. Following that time the mortalities declined as usual. One sow farrowed 6 living pigs and one partly resorbed embryo at full

TABLE 31.--SCHEDULE OF RATION CHANGES

Sow No.	Date of ration change	Date farrowed	Notes

Changed from Ration 114 to Ration 113			
11	----	3-15-'35	All dead at 7 days
18	3-19-'35	3-18-'35	All dead at 7 days
34	3-22-'35	4-2-'35	All dead at 2 days
35	3-22-'35	4-1-'35	All dead at 3 days
39	----	3-15-'35	All dead at 6 days
46	3-22-'35	4-18-'35	All dead at 4 days
58	3-22-'35	4-17-'35	Carried litter 138 days, dead for some time

Changed from Ration 114 to Ration 116			
4	2-18-'35	4-3-'35	Weaned 2

Changed from Ration 115 to Ration 118			
3	3-26-'35	3-22-'35	Weaned none
10	3-26-'35	3-19-'35	Weaned 2
47	3-26-'35	3-29-'35	Weaned 3
48	3-26-'35	3-25-'35	Weaned 2
64	3-26-'35	4-9-'35	Weaned none
74	3-26-'35	3-26-'35	Weaned 1
76	3-26-'35	3-28-'35	Weaned 9
77	----	2-18-'35	Aborted
78	3-26-'35	3-26-'35	Weaned 10

Changed from Ration 116 to Ration 119			
5	3-26-'35	4-1-'35	Weaned 3
66	3-26-'35	3-17-'35	Weaned 3
79	3-26-'35	4-1-'35	Weaned 7

TABLE 32.--RECORD OF PIGS AT FARROWING AND AT WEANING

Ration No.	Sow No.	Litters born						Litters weaned		Mortality per cent	Notes
		Live Pigs		Dead pigs				No.	Avg. wt. lbs.		
		No.	Avg. wt. lbs.	Full term		Mummies					
				No.	Avg. wt. lbs.	No.	Avg. wt. lbs.				
113 ¹	basal	Avg.	8.9	2.7				2.7	21.2	69.7	
		34	1	1.0			9	0.5	0		dead at 1 day
		18	6	2.8	1	2.6			0		all dead 7 days
		39	13	2.5					0		" " 6 "
114		35	5	2.4			2	0.6	0		" " 3 "
		11	9	2.7					0		" " 7 "
		46	13	2.2					0		" " 4 "
		58	0				4	1.2	0		Farrowed 138th day
		Avg.	6.7	2.4	0.14	2.6	2.1	0.7	0		100.0
		48	6	2.4	2	2.1	4	0.5	2	10.6	
		76	11	2.9	1	1.6			9	22.0	
		47	3	2.6			2	0.4	3	12.6	
115		74	8	2.2	1	1.2			1	11.5	
		78	11	2.8					10	23.7	
		64	6	2.6			4	0.7	0		all dead at 39 days
		10	10	2.4					2	8.0	
		3	6	2.4			2	0.4	0		all dead at 15 days
		Avg.	7.6	2.6	0.5	1.8	1.5	0.5	3.4	19.3	55.7
		77					8				aborted at 2/3 term
		79	8	2.5	1	2.2	2	0.8	7	30.7	
116		66	6	3.0	1	2.3	2	0.5	3	34.1	
		5	3	2.5	1	2.0			3	29.4	
		Avg.	5.7	2.7	1	2.2	1.3	0.7	4.3	31.2	23.5
116		4	2	2.6			6	0.9	2	46.8	

¹Mo. Agr. Exp. Sta. Res. Bul. No. 321 (1940)

term. One of these died on the 10th day. This sow refused to eat, and secreted little milk so her pigs were given to another sow of the same group, but none survived. In all 61 living and 4 dead pigs were farrowed, and 27 were weaned, with an average weight of 19.3 lbs.

It seems evident then that either the alfalfa meal, or the wheat middlings, or both, are effective in overcoming the toxicity of cod liver oil.

There were 3 sows on Ration 116, which had been formulated in the hope that it would provide optimum nutrition, and our experience with it was about the same as with Ration 115. In fact the mortalities in the first 2 weeks were unusually low. These sows farrowed 17 living and 3 dead pigs, and reared 13 with an average weaning weight of 31.2 lbs. at 8 weeks.

A summary of the ration changes, and of the farrowing and weaning records, appears in Tables 31 and 32.

Doyle, Mathews, and Whiting (17) supplied brood sows with a ration which contained 3 per cent of cod liver oil, with no evident ill effects. Their Ration 5 differed from our Ration 114

chiefly in containing a large percentage of wheat by-products, and is somewhat similar to our Ration 115.

The first question that arises is, was the 100 per cent mortality in the first week of the group on Ration 114 due to the excessive intake of cod liver oil. The evidence indicates that this was the case, as the first week mortality in the basal group was less than one third of that in the group on Ration 114. A complete summary of the distribution of mortalities with age is shown in Table 33. The sows originally on Ration 114 lost all their pigs within the first week. The highest mortality in the first week in any other group was 28.7 per cent. Additional evidence is seen in the behavior of the pigs, as shown in selected notes on the litters of sows that were originally on Ration 114.

TABLE 33. DISTRIBUTION WITH AGE OF MORTALITIES OF SUCKLING PIGS IN COD LIVER OIL GROUPS

Ration No.	No. of pigs	Per cent that died by weekly periods								Total Mortality
		1	2	3	4	5	6	7	8	
113	80	28.7	15.0	11.2	7.5	1.3	1.3	2.5	2.5	30.0
114	47	100.0								100.0
115	61	4.9	23.0	13.1	8.2		4.9	1.6		44.3
116	17	5.9	11.8					5.9		23.6

Sow 18. Farrowed 3-18. Pigs normal

- 3-19. Change to Ration 115.
 3-20. Pig 3F overlaid. Normal, stomach filled with milk.
 3-21. Pigs look abnormal; stiff, squeal easily, do not nurse much. Sow's udder hardened, though still secreting milk. Pigs stop nursing before milk secretion declines.
 3-22. Pig 7M cold and stiff, almost dead, scouring. Killed for examination. Considerable milk in stomach, liver very light in color. The other pigs have rough coats, nurse little, their backs are rigid. Pigs shiver though barn is warm. Two of them have a tendency to get in the water trough and drink (probably due to diarrhoea).
 3-24. Sow still does not eat. The remaining pigs very weak. 2 P. M., Pig 1F dead, stomach contains very little milk, intestines red, nothing else of note.
 3-25. Pig 4M has diarrhoea, overlaid. No milk in stomach. 6:00 P. M. Pig 5F overlaid.

Sow 35. Farrowed 4-1. Pigs normal.

- 4-3. Pigs appear normal 6:00 A. M.
 4:00 P. M. all are sick, lie on backs and claw the air. 63F and 64F
 4-4. Pigs 61F and 65F dead. Pigs 60F, 63F died 4-4. Stomachs and intestines of all contain milk, organs normal. No apparent cause of death. dead. Stomachs contain milk, organs normal.

The notes on the other litters, with minor variations are practically the same. It was the opinion at the time, and it still

seems to be correct, that the milk of sows which received large amounts of cod liver oil was actually toxic to the pigs, or it was seriously deficient in some essential nutrient, possibly a vitamin. This shipment of cod liver oil may have been inferior in some way, but there was no direct evidence that it was unusual in any respect.

The next question is, why were the sows on Rations 115 and 116 more resistant to excessive cod liver oil than those on Ration 114. We believe the explanation is that the resistance of sows on an inadequate ration is less than of sows on a more adequate ration. For example unpublished observations on rabbits have shown very clearly that cod liver oil is toxic to these animals when they receive an inferior ration, and relatively harmless when the ration is made more adequate.

4. Feeding Iodine to Brood Sows.

Missouri lies outside the goiter belt and as would be expected we never observed symptoms in either the sows or their litters that could be identified with a deficiency of iodine. It is well known though that iodine is deficient in certain areas, both in the United States and abroad (18), so it seemed worth while to investigate the possibility that our results had been complicated with a mild deficiency of this element. It did not seem necessary to set up a special feeding trial for this purpose, so the sows under observation in the spring of 1931 were used for this study. Half of the animals in each of three groups, or six sows in all, received a supplement of potassium iodine, and the others served as controls. The iodine was supplied continuously during the stage of lactation. The number of days it was supplied during the stage of gestation is indicated below.

Sow No.	Days	Sow No.	Days
3	64	151	40
30	43	158	36
149	45	163	47

There was some doubt as to the correct dosage of iodine so we chose the amount used by S. Weiser and A. Zaitschek (19), 125 mg. daily per sow. These authors reported that this supplement brought about a vast improvement in the lactation record of sows and some of their more important observations are summarized in Table 34.

This summary would seem to show clearly that the basal ration of Weiser and Zaitschek was deficient in iodine, but there were differences in the experimental conditions of the control and experimental groups that make the interpretation less certain. However that may be there is little doubt that if needed at all 125 mg. daily per sow should be enough. On the other

TABLE 34. SUMMARY FROM REPORT OF
WEISER AND ZAITSCHEK (19)

	Control	Iodine Supplement
No. of sows	17	23
No. of pigs	152	210
Weaned, per cent	42.10	82.85
Weaning weight at 10 weeks, lbs.	28.97	40.79

hand it seems improbable that this amount was large enough to be toxic. According to Orr, Crichton, and Middleton (20) a pig can tolerate a daily dosage of 5 grams of iodine over a period of 116 days. The weights of the animals were not reported. Our results are shown in Table 35.

TABLE 35. POTASSIUM IODIDE FOR BROOD SOWS

Ration No.	Sow No.	No. of pigs		Avg. weight at weaning	Mortality per cent
		Born alive	Weaned		
51	155	8	5	23.6	
	183	10	10	19.5	
51 + KI	3	2	0		
	158	8	5		
51 + pasture	4	6	6	19.6	
	5	7	7	33.3	
51 + pas- ture + KI	149	10	10	31.0	
	151	9	9	24.1	
53	94	11	10	25.0	
	119	6	5	35.6	
53 + KI	30	10	8	29.4	
	163	8	4	30.9	
Basal	Avg.	8	7.2	25.7	10.4
Basal + KI	Avg.	7.8	6.0	27.8	23.4

Inspection of Table 35 shows that the average weight at weaning of the pigs in the iodine group was slightly higher than that of the controls, but the difference was not significant. It also shows that the sows that did not receive potassium iodine

weaned more pigs per litter than did those that received this mineral supplement. This difference also is not significant. It may be concluded then that under the experimental procedure we followed the feeding of iodine had little or no effect on the performance of the sows. Certainly an iodine deficiency was not the determining factor in the failures we encountered.

DISCUSSION AND SUMMARY

Although great stress is laid on the rate of mortality in various groups slight differences have no great significance when small numbers of sows are compared. It is the experience of all swine growers that even under the most favorable circumstances sows are exceedingly variable in the care they give their litters. Some step on their pigs or overlay them, and make no attempt to avoid accidents. Others are careful in the extreme and seldom or never injure their young. Minor variations in weaning weights are also without significance unless large numbers are available, due to the great variability in the capacity of sows to secrete milk. One will secrete a liberal amount, another will fail almost entirely, even though they are similar in breeding, and in conformation, and the ration and environment are ideal.

It seems certain from the data presented that the commonly used concentrates, if they comprise the entire ration, fail to supply in adequate amount all of the nutrients required by brood sows. The basal ration was superior to those in common use, but if sows were denied access to any supplementary feeds their litters were inferior. The mortality rate was high, especially in the first week of life, and subsequently other abnormalities developed. If certain supplementary feedstuffs were included, as described in Section I, most of these symptoms of failure were eliminated. Wheat germ, dried skimmilk, liver meal, and dried yeast if supplied in a sufficiently large quantity, all seemed to have unique nutritional properties. Unfortunately the cost of this latter group of feedstuffs probably makes it impractical to use them in commercial swine feeding. They were used in this instance to demonstrate that the failures encountered with the basal rations were not due to the environment, but were actually due to nutritional deficiencies. According to our present knowledge the deficiencies must have been in the vitamin content. Of the more readily available commercial feedstuffs, liberal supplies of alfalfa meal and of wheat shorts were helpful, but they failed to make the ration entirely adequate.

Of the feedstuffs that are of practical importance fresh forage, or pasture, is the only one investigated that seems to be

completely effective. Our data do not show precisely what quantity of forage is required, and undoubtedly this amount varies with the length of time it is provided. Large amounts at the beginning of the lactation period are partially effective in overcoming an earlier deficiency. One may conclude that fresh forage is not a concentrated source of the effective agent, and that liberal amounts are required to maintain sows in a state of optimum nutrition.

Ellis and Madsen (21) studied the relation of nutrition to locomotor incoordination. The pigs were 10-12 weeks of age at the beginning of the experimental period, which lasted from 12 to 24 weeks. They report that "The identity of the lameness-and-nerve-degeneration-preventive factor is still obscure. Evidently it is not present in large quantities in the usual swine feeds.—Liver, skimmilk, whey, rice bran, and corn-gluten meal are among the feeds tested that possessed considerable value yet at the levels fed were not effective in all animals." One lot of pigs received 1 lb. daily of green forage, but this supplement was only slightly effective in preventing incoordination. The abnormality these authors were studying is probably different from the one we found to be most troublesome in suckling pigs, and it could not be expected that our observations would agree with theirs in all respects. Dried liver was found to be highly effective, but it was fed in much larger quantities than the amounts used by Ellis and Madsen. In our experience cereal grass was effective if supplied in large amounts. Skimmilk was not highly effective, but on a dry matter basis it was supplied at a comparatively low level.

During the course of these investigations a number of miscellaneous observations were made that seem worthy of record. An attempt was made to substitute carrots for fresh leafy forage, but the substitution was entirely ineffective. In fact the performance of the sows which received carrots was inferior to that of those which did not. It is not supposed that the carrots were toxic, but presumably they supplied less of the needed nutrients than did the dry feed which they displaced.

In the earlier years of these studies skimmilk was added to Ration 62 in the expectation that the combination would at least closely approach nutritional completeness. Surprisingly enough, the result indicated that this combination was inferior to the basal ration then in use. Marked examples of muscular incoordination were noted in one litter, in addition to other evidence of nutritional inadequacy. Only 3 sows received this ration, but the observations are confirmed by the experience of Eveleth and Biester with dried skimmilk. Previous experience when whole milk was supplied to other animals, leads one to

expect that whole milk would have improved the ration of these sows. It may be that the nutritional value of milk fat is not completely understood.

A deficiency of vitamin A was suggested as the cause of some of the nutritional failures reported, therefore the amount was greatly increased during one trial. Three per cent of cod liver oil was included in the rations, but apparently this increase was unfortunate. The mortality rate was 100 per cent in the group that received the basal ration fortified with 3 per cent of cod liver oil. When this amount of cod liver oil was added to rations that were nutritionally more complete the injurious effects were reduced, or possibly eliminated entirely. This agrees with our unpublished observations on rabbits. In our experience the toxicity of cod liver oil for rabbits is completely nullified by alpha-tocopherol.

Some slight attention was given to the possibility that a deficiency of iodine may have contributed to the failures, but the evidence obtained indicated that this is not the correct explanation.

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