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M. F. MILLER, *Director*

Inadequacy of the Concentrates Commonly Used in Swine Feeding

A. G. Hogan and S. R. Johnson

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ABSTRACT

The purpose of this report is to present data demonstrating the inadequacy of the commonly used concentrates, for brood sows, and to describe the abnormalities that appeared in suckling pigs. The rations were made up chiefly of corn, tankage, linseed oil meal, and alfalfa meal. The sows were constantly restricted to pens with concrete floors, and never received fresh forage. The response of the sows indicated that the ration was partially inadequate. Their consumption of feed was subnormal. Other less frequent evidence of malnutrition was lameness, scanty hair, scaly skins, and unsteadiness when standing or walking.

The response of the pigs was highly variable, as some litters were almost normal, but most of them developed characteristic abnormalities. These included skin lesions, muscular weakness and incoordination, diarrhoea, and collapse followed by death. On post mortem examination fatty livers, fatty kidneys, and hemorrhage were frequently observed. The mortality rate was excessive. It is believed these abnormalities are explained by the inadequacy of the ration their mothers received.

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Inadequacy of the Concentrates Commonly Used in Swine Feeding

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

Extensive data concerning the mortality among suckling pigs are not available but Thomsen and Richards (1)† have assembled statistics which indicate that in the Cornbelt approximately 5.5 pigs per litter is the average number saved. These authors did not estimate the average number of live pigs per litter at birth, but the average for the sows to be described in this report was 9.0. If this is the approximate number for the state at large one may assume that under typical farm conditions the mortality during the suckling stage is about 40 per cent. Deakin and Fraser (2) reported that at the Dominion Experimental Farms (Canada) the average number of pigs per litter was 12, and the mortality during the first 3 weeks was 29.2. One may conclude that the mortalities may be reduced by more careful attention but the rate is high even with skilled supervision.

In seeking the cause of these losses a number of investigators have considered the possibility that it is due to an inadequate supply of minerals. It is well known that lactating animals require a large amount of these substances, especially calcium and phosphorus, and there is abundant evidence that a deficiency of these elements in the rations of brood sows will end in disaster. If the deficiency is serious, abnormalities will develop before the stage of gestation is complete, but a mild deficiency will not become evident until the period of lactation. Our experience (3) in investigating the mineral requirements of brood sows demonstrated that mineral deficiencies may occur under special conditions but convinced us that in practice a deficiency of the more obvious minerals is not likely to be of extreme importance.

Another suggestion that has received serious consideration is the possibility that swine rations may be deficient in vitamin A. A number of investigators have shown that a deficiency of this factor will disturb the normal course of gestation and lactation in brood sows. Other reports, however, show that the deficiencies may be more complicated than was at first supposed and the addition of vitamin A to the negative control rations uniformly failed to make

*Now with the Department of Animal Industry, College of Agriculture, University of Arkansas, Fayetteville, Arkansas.

†Numerals refer to "Bibliography," page 20.

them adequate. Hughes, Aibel, and Lienhardt (4) observed that sows collapse on a basal ration of white corn 87, tankage 10, and bone ash 3. A combination of 95 parts of the basal ration and 5 parts of commercial alfalfa meal was superior to the basal ration alone, but was not entirely adequate. Some of the sows developed abnormalities similar to those observed in the group that consumed the basal ration, but these symptoms were much delayed. Living pigs were farrowed when the sows received a mixture of 95 parts of the basal ration and 5 parts of butter fat, but the pigs died during the first 2 days. On a mixture of 90 parts of the basal ration and 10 parts of high quality alfalfa leaf meal the sows farrowed normal pigs, but the mortality was high during the suckling stage. It would be strange indeed if 10 per cent of high quality alfalfa meal did not supply an adequate amount of vitamin A, and in all probability the ration was also deficient in other vitamins.

In an attempt to discover the nature of the deficiencies of their earlier rations Aibel, Hughes, and Lienhardt (5) included wheat germ in one mixture. This addition probably improved the ration but the mortality rate among the suckling pigs was still excessive. The weaning weights were not reported, but there was other evidence that the rations were inadequate. Special emphasis should be placed on the development of two abnormalities. The incidence of diarrhoea was high and lesions of the alimentary tract were discovered on post mortem examination. These consisted of a marked enteritis, and inflammation of the stomach with ulcerations in the glandular portion.

There are available two field reports that are worthy of mention in connection with the reports of vitamin A deficiency. Biester and Murray (6) report observations on posterior paralysis in young pigs, while suckling or after weaning. "It was reported that in some cases the pigs from certain sows were affected while others were not. The pigs were usually in good flesh. Some were completely down behind, dragging their hind legs, others were able to walk with difficulty. Many showed a stiffened gait, stilted, walking on the toes or knuckling over, while in others only a trace of incoordination could be detected when closely observed. The affected pigs appeared highly nervous. As a rule the appetite remains good in the affected individual. In one instance a pig which was blind and showing incoordination of all legs had a good appetite, eating as long as it could find its feed or when helped." The affected pigs were kept in dry lot or on scanty pasture. The condition was reported as pre-

vented or alleviated by fresh pasture or alfalfa and was diagnosed as a lack of vitamin A.

A similar condition is described by Doyle (7). Approximately 20 shots in a herd of 300 were affected and the disease occurred in the summer with a ration of corn and tankage while on bluegrass pasture. The condition of the pasture is not described, but to fit any recognized hypothesis one must assume that the pasture was scanty, and in the dry woody state characteristic of bluegrass in July and August.

There is no doubt that vitamin A is essential for swine but under practical conditions it is doubtful that a deficiency of this nutrient has any major responsibility for the losses that occur. Our earlier rations (8) usually contained 2 per cent of cod liver oil, and though there was considerable evidence of malnutrition there were no signs of a vitamin A deficiency. During our early investigations we were primarily concerned with mineral requirements, but some of the observations indicated that the rations were inadequate in other respects. The suckling pigs were undersized, unthrifty, and a brown exudate covered irregular areas. In a few cases mild lesions of the skin developed. Sows on similar rations were transferred to a bluegrass plot about the time of farrowing and their litters were much superior. Their pigs were 18 per cent heavier at weaning, and possibly still more important, they had every appearance of health and thrift. Two of these sows were taken to the pasture approximately 3 weeks after farrowing, the other two were taken out shortly before farrowing. It was supposed at the time that these sows had been placed on pasture too late to obtain the maximum response, and later work has supported that view. This very limited experience with pasture suggested that green forage supplies some essential nutrient in larger amounts than do the concentrates. This interpretation finds some support in a paper by Fishwick (9) who reported that the provision of grass runs improves the health of suckling pigs. They did have mild cases of scours, but the attacks never lasted over 2 days. They began eating the creep feed when about 1 month old, and had good appetites. Pigs reared indoors seemed in average condition until they were a month old, but they deteriorated in appearance during the second month, as they acquired dirty skins and harsh coats. They also had more severe cases of scours lasting from 3 to 7 days and several developed a depraved appetite between 6 and 8 weeks of age. They began eating the creep feed between 5 and 6 weeks, but had poor appetites, and

were subnormal in weight. In one comparison the outdoor pigs weighed 23.7 lbs. at 6 weeks, those reared indoors weighed 18.3 lbs.

In a later report Fishwick (10) states that a few healthy pigs are killed by carelessness of the mother during the first 24 hours after farrowing. Most of the losses, however, are due to the fact that the pigs are subnormal and make little effort to escape. A high mortality among young pigs indicates disease, or faulty feeding and management. High quality pasture for the sows, until 2 or 3 weeks before farrowing, reduced these losses.

Fishwick also states that every litter observed has scoured at some time or other during the suckling stage, but there were few cases that did not clear up without treatment if the pigs had access to grass. This disorder was most troublesome when the pigs were confined to pens. In these cases the most effective treatment was to turn the sow and litter out on grass for 2 or 3 hours every day until they had recovered. Usually 3 days was long enough.

One of the points emphasized by Fishwick has also been discussed by King (11) who states that the mortality among young pigs shortly after farrowing is from 20 to 25 per cent in purebred breeding herds. The losses are considerably higher in farmers' herds. King observed that many pigs will die that have not been injured by their dams, in spite of an ample food supply. In his opinion many pigs even of careful mothers may be overlaid because they are too weak and sluggish to protect themselves. He ascribes this condition to the poor quality of the milk the pigs consume, or to their inability to assimilate it.

Dunlop (12) has reported an investigation parallel in many respects to those of Fishwick. According to Dunlop fresh liver contains an appetite-stimulating or physin factor. Pigs were divided into three groups at weaning. One group received 4 oz. per head daily of raw liver, the second 4 oz. of fresh young grass, the third group received no supplementary feeding.

The pigs which received the raw liver gained 35 per cent more than the controls. Those which received the green grass gained 5 per cent more than the controls, but the difference was of doubtful significance. According to Dunlop, liver contains large amounts of the growth-accelerating (or appetite-stimulating) factor, and fresh green grass contains relatively small amounts. In the main our experience agrees with that of Dunlop. Grass is effective, but it does not contain the sought for factor in high concentration.

EXPERIMENTAL

Object

During our earlier studies (3, 8) of the nutritional requirements of brood sows it was observed that many of the litters were subnormal in weight and thrift. In the later studies, the object was (1) to study in greater detail the adequacy for swine of the commonly used concentrates; (2) to learn more of the nature of the abnormalities that appeared in the suckling pigs.

Our observations on swine which received the basal ration are described in this report. The effectiveness of various feedstuffs in overcoming the deficiencies of the basal ration will be described in a separate bulletin.

Purebred Hampshires were used in the years 1930-32. Since then purebred Chester Whites have been used exclusively. The pigs retained for study were farrowed in the spring, and usually they were started on experimental rations at weights of 30 to 35 lbs. They were all quartered in one large barn, and this was divided into pens 8 by 11 feet. Each inside pen is connected with an outside pen 8 feet square, to which the sows had access when the weather was suitable. The floor of the barn and outside pens is surfaced with concrete. The animals were fed twice daily, and water was available practically all the time. Shortly before the sows were expected to farrow they were removed to individual pens, carefully washed with soap and water, and provided with shavings or wheat straw for bedding.

It has also been our practice during the last 4 years to have an attendant in the barn constantly during the farrowing season, in an effort to keep the mortalities due to accident down to a minimum. This practice has been helpful though it was not entirely effective.

When the pigs were three weeks old the ration of the dam was placed in a creep to which the pigs had access at all times. If the ration of the dam was partially inadequate and the pigs were unthrifty, they consumed very little of the creep feed. However, if the ration was satisfactory and the pigs grew normally they usually consumed very considerable quantities after the 5th week. The amount consumed also depended on the dam's flow of milk for when the secretion was liberal less creep feed was consumed than when the secretion was scanty. The pigs were weaned at 8 weeks of age, or earlier if the sows failed to secrete milk that long. Most of the sows were discarded after their first litter but a considerable number were retained for a second litter.

It was realized that there is considerable variability among animals, and there is probably an equal degree of variability in the

vitamin content of the commercial feeding stuffs. For that reason largely it was decided to use only a small number of sows at any one time in a study of the nutritional properties of a feedingstuff, and then repeat the trial in subsequent seasons until a suitable number of animals had been observed. It was hoped that in this way all extremes of variability in the feedingstuffs would appear, and that a truer assay of their nutritional properties would be possible.

We will mention also that in order to conserve space many of the minor details have been omitted. For example a wide variety of mineral mixtures has been used, with varying proportions of calcium and phosphorus. Since these variations apparently were of no significance whatever, many of the details have been omitted. We are convinced though that these omissions involve no sacrifice of essential accuracy.

TABLE 1.—COMPOSITION OF BASAL RATIONS

Constituent	Ration Number					
	51	61	80, 90 129 ^a	113	136	151
corn	75	72	77	77.2	67	78
tankage	..	5	10	10.0	5	10
linseed oil meal	10	10	5	5.0	5	5
alfalfa meal	5	5	5	5.0	5	5
cod liver oil	1	1	1	1.0	1	5 ^b
mineral mixture ^c	2	2	2	1.8	2	2
wheat bran	5	5	..	..	..	..
dried buttermilk	2	..	..	..	..	..
dried skim milk	..	..	..	..	15	..

^aThese three rations were the same except for minor differences in the mineral mixture.

^bEach sow received separately 3 cc. of Haliver oil per week supplied by Mead Johnson and Co. According to the manufacturers this amount of oil contained 175,000 I. U. of vitamin A.

^cIn an attempt to improve the adequacy of the ration various mixtures were tried but it was immaterial which was used. The one most used recently contains, in per cent of the ration, common salt 0.82, ground limestone 0.60, bone meal 0.55, ferrous sulphate 0.03.

TABLE 2.—WEIGHT AND FEED RECORDS PRECEDING GESTATION

Group	Ration No.	Duration days	Weight		Avg. Daily Ration lbs.
			Initial lbs.	Final lbs.	
1931	51	127	111	231	5.1
1932	61	157	67	228	4.5
1934S	90	199	37	228	4.0
1935S	113	171	35	219	3.8
1937S	151	188	30	202	3.4

TABLE 3.—WEIGHT AND FEED RECORDS DURING GESTATION

Group	Ration No.	Duration days	Weight		Avg. Daily Ration lbs.
			Initial lbs.	Final lbs.	
1931	51	115	231	404	7.7
1932	61	115	228	386	6.2
1933F	80	115	295	488	6.1
1934	90	115	228	436	7.0
1935S	113	113	219	412	6.2
1935F	129	112	357	496	5.9
1936F	151	113	368	523	5.7
1937S	151	115	230	443	7.3

The composition of the rations used is shown in Table 1, and the weights of the animals and their feed intakes are summarized in Tables 2, 3, and 4. The more important features of the farrowing and weaning records are shown in Tables 5 and 6.

TABLE 4.—WEIGHT AND FEED RECORDS DURING LACTATION

Sow No.	Ration No.	Duration days	Weight		Avg. Daily Ration lbs.
			Initial lbs.	Final lbs.	
1931	51				
3		1	372	372	
155		56	337	235	6.3
158		56	404	363	8.5
183		56	388	274	10.1
1932	61				
1		56	359	295	13.4
7		Pigs killed by cold wave			
8		56	369	319	10.9
13		Pigs killed by cold wave			
1933F	80				
1		56	438	446	10.7
10		56	449	434	8.6
15		56	424	402	12.1
16		56	454	442	11.6
54		56	524	432	9.2
1934S	90				
3		56	389	324	8.0
6		56	442	366	5.9
8		35	456	438	6.0
50		12	382	370	3.7
91		24	389	370	6.2
186		56	385	387	7.9
1935S	113				
1		56	375	319	12.5
13		56	414	413	8.4
15		56	370	320	10.2
16		18	391	360	3.8
31		56	334	346	7.7
38		56	343	373	7.0
44		1	388	378	1.0
56		7	352	310	1.7
68		24	400	353	5.8
1935F	129				
1		56	473	483	12.3
5		56	471	486	7.4
15		56	402	403	7.1
31		20	470	456	3.1
38		56	415	332	9.2
47		34	434	440	8.1
68		56	469	446	10.3
1936F	151				
3		0	Pigs farrowed dead, not included in average		
15		56	515	513	11.0
31		56	539	494	9.1
40		56	400	389	10.5
77		56	444	363	5.7
85		56	398	307	5.9
1937S	151				
18		56	390	323	13.5
41		56	367	302	13.0
43		56	446	344	13.2

TABLE 5.—RECORD OF PIGS AT FARROWING AND AT WEANING

Ration No.	Sow No.	Litters Born				Litters Weaned		Notes
		Live Pigs		Dead Pigs		No. of Pigs	Avg. Wt. lbs.	
		No.	Avg. Wt. lbs.	No.	Avg. Wt. lbs.			
Farrowed 1931								
51	3	2	1.9	1	1.8	0	...	Dead 2nd day
	155	8	2.3	..	..	5	23.6	.....
	158	8	2.3	..	..	5	22.8	.....
	183	10	2.4	..	..	10	19.5	.....
	Avg.	7	2.3	1	1.8	5	21.4	71.4 per cent weaned
Farrowed 1932								
61	1	8	2.8	..	..	8	29.0	.....
	7	13	2.3	..	..	0	...	Died in 48 hrs., cold wave
	8	8	2.7	..	..	8	22.4	.....
	13	11	2.2	..	..	0	...	Died in 48 hrs., cold wave
	Avg.	10	2.4	..	..	4	...	100 per cent weaned
Farrowed 1933F								
80	1	3	3.0	..	..	3	33.9	.....
	10	13	2.0	2	1.4	1	14.1	.....
	15	12	2.4	1	1.8	6	25.4	.....
	16	7	2.5	..	..	5	26.3	.....
	54	13	2.1	1	1.3	7	19.8	.....
	Avg.	9.0	2.3	0.8	1.5	4.4	24.5	45.8 per cent weaned
Farrowed 1934S								
90	3	6	2.4	..	..	6	25.9	.....
	6	10	2.3	..	..	7	14.3	.....
	8	8	2.4	..	..	0	...	All dead in 49 days
	50	7	1.8	..	..	0	...	All dead in 27 days
	91	10	2.4	..	..	0	...	All dead in 24 days
	186	5	2.6	..	..	5	26.4	.....
	Avg.	7.7	2.4	..	..	3	21.5	39.1 per cent weaned
Farrowed 1935S								
113	1	12	2.7	..	..	9	21.1	.....
	13	9	2.2	..	..	3	13.8	.....
	15	8	2.9	..	..	7	23.5	.....
	16	5	3.4	..	..	0	...	All dead at 18 days
	31	13	2.3	..	..	2	24.6	.....
	38	11	2.6	..	..	2	22.5	.....
	44	2	3.2	..	..	1	19.8	Pig transferred to Sow 15 at 1 day
	56	10	3.1	..	..	0	...	All dead at 7 days
	68	10	2.8	..	..	0	...	All dead at 25 days
	Avg.	8.9	2.7	..	..	2.7	21.2	30.3 per cent weaned
Farrowed 1935F								
129	1	12	3.0	..	..	8	25.2	.....
	5	8	2.9	1	1.8	1	9.2	.....
	15	8	2.2	..	..	2	21.8	.....
	31	11	2.7	..	..	0	...	All dead in 19 days
	38	13	2.8	..	..	8	27.9	.....
	47	14	2.5	..	..	0	...	All dead in 36 days
	68	11	2.7	3	2.5	7	24.8	.....
	Avg.	11	2.7	0.6	2.4	5.2	25.0	47.3 per cent weaned
Farrowed 1936F								
151	3	0	..	1	2.8	0	...	.....
	15	11	3.2	1	3.0	8	15.9	.....
	31	11	2.7	6	2.3	5	30.3	.....
	40	10	2.8	2	2.3	6	24.3	.....
	77	12	2.8	0	..	8	14.1	.....
	85	7	3.3	3	2.4	6	18.4	.....
	Avg.	8.5	2.9	2.2	2.4	5.5	19.6	64.7 per cent weaned
Farrowed 1937								
151	18	9	2.4	2	2.1	9	26.5	.....
	41	10	3.0	..	..	10	27.8	.....
	43	8	3.7	..	..	8	32.5	.....
	Avg.	9	3.0	0.7	2.1	9	28.7	100 per cent weaned

TABLE 6.—SUMMARY OF FARROWING AND WEANING RECORDS

Total litters farrowed	44
Per cent of litters that survived 8 weeks	72.7
Average number of live pigs farrowed per litter	9.0
Average weight of live pigs farrowed, lbs.	2.6
Average number of dead pigs farrowed per litter	0.5
Average weight of dead pigs farrowed, lbs.	2.1
Per cent of pigs born alive that survived 8 weeks	47.0
Average weight of pigs at weaning	23.1
Minimum weight at weaning, lbs.	8.8
Maximum weight at weaning, lbs.	42.0

Example of notes taken on a typical litter during an unfavorable season.

Litter of Sow 31

- 3-11-35 Farrowed. Live pigs 13. 1 very strong, 12 strong.
 Pig 3M died shortly after birth. Lungs collapsed, never
 breathed. Weighed 2.4 lbs.
 Pig 8F, dead, overlaid. Weighed 1.9 lbs.
- 3-13-35 Pig 1F died. Had made little effort to nurse. Died of
 starvation. Weighed 1.1 lbs.
- 3-16-35 All pigs have moderate diarrhoea.
 Pigs 3F, 9F, squeal intermittently.
 Pig 5M dead, killed accidentally by sow.
- 3-18-35 All pigs have severe diarrhoea, unthrifty. Eyes watery,
 black exudate around eyes.
 Pig 6M dead, overlaid.
- 3-19-35 Pig 7F dead, overlaid. Weighed 2.0 lbs.
 Pig 9F dead, overlaid. Weighed 1.6 lbs.
- 3-24-35 Pigs still have marked diarrhoea, but are in better condi-
 tion, appear plump.
- 3-28-35 Pig 9M recovered from diarrhoea.
 All pigs weak in hind quarters.
- 3-29-35 Pig 1M recovered from diarrhoea.
- 3-31-35 Pig 1M plump, getting rough-haired. Walks with undulat-
 ing snake-like gait.
- 4- 1-35 Pigs 1M, 3F, 4M, 5F, 7M have diarrhoea.
- 4- 2-35 Pigs 1M, 5F, 7M have weak legs and backs.
- 4- 4-35 Pig 1M drags hind legs, died in afternoon. Enormous liver
 and kidneys. Pig weighed 6.4 lbs.
- 4- 5-35 Pigs 3F, 5F, 7M severe diarrhoea.
 Pigs 4M, 9M recovered from diarrhoea. Entire litter has
 dark exudate around eyes.
 Pig 5F died in afternoon. Enormous, light colored liver
 and kidneys. Pig weighed 4.5 lbs.
- 4- 7-35 Pig 3F severe diarrhoea, but plump and active.
 Pig 7M died. Liver large and friable, light colored areas,
 but less marked than others. Weighed 5.4 lbs.

- 4-18-35 Only Pig 3F has diarrhoea. All pigs have definite signs of leg weakness.
- 4-19-35 Pig 3F dead. Cause uncertain. Weighed 8.2 lbs.
 Pig 9M plump but unsteady on hind legs; toes double back, legs crooked.
 Pig 4M is only slightly affected.
- 5- 6-35 Pigs weaned, 2. Neither has diarrhoea, both sleek and thrifty.
 Pig 9M has crooked legs, wabby gait.

Tables 5 and 6 show that the performance of the sows was unsatisfactory, and it has been assumed that the failures observed were due to malnutrition. The first evidence on this point is the rate of gain of the gilts during the stages of growth and gestation, and the amount of feed consumed. During the stage of growth the gilts were supplied practically all the feed they would consume, and yet it will be observed that the average daily gain was only about 1 lb. There were sporadic examples of gilts that would not even maintain that rate of gain and it was necessary to modify their rations at times in order to induce them to consume more feed. This difficulty was especially acute among the gilts that farrowed in the spring of 1935. During the preceding summer it had been necessary to supply each gilt with 2 lbs. daily of skim milk over a period of 4 weeks, in order to induce them to consume enough to gain at a satisfactory rate. This made an average daily skim milk consumption of 0.5 lb. for the entire growth period. Seven of these same sows were retained for fall litters, and during the stage of lactation some of the sows refused for several days at a time to consume any feed at all. It seemed almost certain that these animals, and their litters, would all be lost unless the ration was improved, therefore they were given supplementary feedstuffs. The changes made are summarized below:

Sow 1.	12 lbs. skim milk, during	3 days.
Sow 15.	108 " " " "	14 "
Sow 31.	27 " " " "	6 "
Sow 38.	30 " " " "	4 "
Sow 68.	Received a mixture of 80 parts of Ration 129, and 20 parts of dried yeast, for 6 days. The feed intake rose but declined again 12 days later. She then received 24 lbs. skim milk during 4 days.	

It soon became evident that the supplementary feeding described above was not sufficient to prevent complete failure, and one week after the last sow farrowed, the ration of all sows was changed to

No. 136 which contains 15 per cent of dried skim milk. Even with this change the mortality was over 50 per cent, though the average weaning weight, 25.0 lbs., was higher than had been commonly observed in previous seasons.

The reductions in feed intake were most pronounced in the fall of 1935, but reference to Table 4 shows that the feed consumption of nearly all sows during lactation was unsatisfactory. According to current feeding standards these sows should have consumed approximately 12.5 lbs. of feed daily. There were 38 sows under observation sufficiently long to include them in a comparison and it will be observed that only 7 had an average that high. The average daily consumption of these 38 sows is 8.8 lbs., or about two-thirds of the amount recommended. The low feed consumption would certainly reduce the flow of milk, and this alone would account in large measure for the poor performance of the sows during lactation.

The response of the sows indicates that they were in some manner improperly nourished, and this indication is supported by the response of the pigs. Of all pigs born alive 47.0 per cent were weaned and the average weaning weight was 23.1 lbs., or about 80 per cent of the normal weight. This low weight is partly, if not entirely, due to an insufficient quantity of milk. It will also be observed that the mortality among the pigs was very high. Of 43 litters that were born alive 11, or over 25 per cent, failed to have even 1 pig alive at 8 weeks. This mortality rate also could be explained by an insufficient milk supply.

In order to show more clearly the importance of a satisfactory feed intake, some of the more significant records have been assembled in Table 7. The sows are arranged in order according to their average feed consumption during an 8 week lactation period, beginning with the one that consumed the least. Since there are numerous other variables the data are not entirely consistent, but the trend is very clear. As a rule a low feed intake by the sow is associated with litters that contain a small number of pigs at weaning, with low average weaning weights, and with low weights of the entire litter at weaning. Not one sow attained even moderate success unless her feed consumption approached that of accepted feeding standards.

The inadequacy of the basal ration is also shown by the notes taken while different groups were under observation. These are too voluminous to publish in full, so the records of one sow which farrowed in the spring of 1935 were selected as an example. These notes are reproduced immediately following Table 6, omitting the less significant items.

TABLE 7.—RELATION OF WEIGHT OF LITTER AT WEANING TO FEED CONSUMPTION AND CHANGE IN WEIGHT OF SOW DURING LACTATION

Group	Sow Record			Litter Record		
	No. of Sow	Daily Feed Consumption lbs.	Change in Wt. lbs.	No. of Pigs	Avg. Weaning Weight lbs.	Total Wt. of Litter lbs.
36F	77	5.7	- 81	8	14.1	112.8
34	6	5.9	- 76	7	14.3	100.4
36F	85	5.9	- 91	6	18.4	110.4
31	155	6.3	-102	5	23.6	118.2
35S	38	7.0	+ 30	2	22.5	45.0
35F	15	7.1	+ 1	2	21.8	164.3
35F	5	7.4	+ 15	1	9.2	9.2
35S	31	7.7	+ 12	2	24.6	49.2
34	186	7.9	+ 2	5	26.4	132.0
34	3	8.0	- 65	6	25.9	155.2
35S	13	8.4	- 1	3	13.8	41.3
31	158	8.5	- 41	5	22.8	114.1
33	10	8.6	- 15	1	14.1	14.1
36F	31	9.1	- 45	5	30.3	151.5
33	54	9.2	- 92	7	19.8	138.6
35F	38	9.2	- 83	8	27.9	223.2
31	183	10.1	-114	10	19.5	195.0
35S	15	10.2	- 50	7	23.5	164.3
35F	68	10.3	- 23	7	24.8	173.6
36F	40	10.5	- 11	6	24.3	145.8
33	1	10.7	+ 8	3	33.9	101.7
32	8	10.9	- 50	8	22.4	179.3
36	15	11.0	- 2	8	15.9	127.2
33	16	11.6	- 12	5	26.3	131.5
33	15	12.1	- 22	6	25.4	152.4
35F	1	12.3	+ 10	8	25.2	201.6
35S	1	12.5	- 56	9	21.1	189.1
37	41	13.0	- 65	10	27.8	278.0
32	43	13.2	-102	8	32.5	260.0
32	1	13.4	- 64	8	29.0	232.0
37	18	13.5	- 67	9	26.5	238.5

Various other symptoms among the sows were observed occasionally, but they are difficult to describe in any quantitative manner. Of the 44 sows reported, 8 were markedly lame at some time or other. When the lameness was most severe the pigs were least thrifty, and when it was inconsequential the pigs did well. Proof is lacking, but it is regarded as probable that the lameness was one of the consequences of malnutrition. Other occasional symptoms were thin hair, and a scaly skin. There were also occasional intervals when some of the sows would be unsteady on their feet, and sway as they walked.

The low weaning weights of the pigs could be accounted for by an insufficient supply of milk, but an examination of the suckling pigs makes it extremely probable that the milk was also inadequate in quality. A variety of abnormalities has been observed including:

1. Skin lesions, such as an exudate, scabs, and raw areas.
2. A form of muscular failure. In the early stages the pigs often have a very peculiar gait, and at each step throw the hind legs almost up to the body line. This is commonly called "goosestep," or "jake leg." Whether or not this condition is observed, the next stage is a characteristic paralysis. Control of the legs is lost, the pigs are un-

able to stand, and apparently the muscles of the loin and thigh atrophy. It is assumed that the peculiar gait and the paralysis have the same origin, but this may not be the case. Either condition may occur, independently of the other.

Scattered reports of this condition have appeared in the literature, and it has been assumed that it is due to a lack of vitamin A. In view of our experience this did not seem plausible, because our ration contained three good sources of vitamin A, yellow corn, alfalfa meal, and cod liver oil.

3. Diarrhoea. This is the most common symptom and may appear at any time during the suckling stage, but it usually becomes less severe after the pigs begin consuming significant amounts of dry feed.

4. Sudden collapse. If the pigs die within a few days after birth they seldom show any characteristic symptom until a few hours before death. Casual observation would often indicate that the pigs were healthy and doing well, but a few hours later one or more might be found lying limp and almost lifeless, usually unable to stand. Within 5 or 6 hours the pig would be practically dead. With very few exceptions post mortem examination would show enlarged livers, light colored and sometimes almost white, and very friable. The kidneys also were large and light colored, usually spotted with pin-point hemorrhages.

Beginning in the fall of 1935 a record sheet was kept for each individual pig, in such a form that the data could be assembled in a quantitative manner. The notes beginning at that time are assembled in Tables 8, 9, and 10.

The cause of the deaths is shown in Table 8. Sickness accounted for 35 per cent of the deaths in the fall of 1935, and for 50 per cent in the fall of 1936. The high rate of sickness, and the early age at which death occurred both indicate that the pigs were improperly nourished, due to the poor quality of the milk they received.

It will also be noted that the death rate due to accident was very high. These "accidents" usually mean the pigs were overlaid by the mother. An attendant was in the barn almost continuously to keep this from happening but though his presence was helpful it was not entirely effective. In most cases the pigs would not squeal and apparently made no effort to escape. It seems certain that most of these pigs were too sick to resist, and that the deaths were really due to sickness. Since this was not definitely established, however, these losses were all listed as accidental. Between 10 and 15 per cent of the pigs starved to death, and a few were too weak to nurse.

TABLE 8.—CAUSES OF DEATH IN SUCKLING PIGS

Ration	Sow	Sickness				Accident			Starvation		Too Weak to Nurse	
		No. Pigs Farrowed Alive	No. of Mortalities	Avg. Age at Death, Days	Per cent of Mortalities	Avg. Age Days	Per cent of Mortalities	Avg. Age, Days	Per cent of Mortalities	Avg. Age, Days	Per cent of Mortalities	Avg. Age, Days
Fall, 1935	1	12	4	8.0	75.0	9	25.0	5.0	...	...	...	...
	5	8	7	18.4	14.3	29	57.1	20.8	14.3	13	14.3	4
	15	8	6	12.5	66.7	6.3	33.3	25.0	...	...	...	...
	31	11	11	7.0	36.4	13.3	63.6	3.4	...	...	...	...
	38	13	5	11.8	40.0	5.5	60.0	16.0	...	...	...	...
	47	14	14	12.7	21.4	9.3	28.6	6.0	50.0	18	...	...
	68	11	4	17.0	25.0	26.0	75.0	14.0	...	...	...	...
	Avg.	11	7.4	12.1	35.3	11.1	35.3	11.1	15.7	17.4	2.0	4
Fall, 1936	3	Farrowed 1 dead pig		...	...	...	...	...	...	...	...	...
	15	11	3	6.0	66.7	8.5	33.3	1.0	...	...	...	...
	31	11	6	6.5	50.0	8.3	33.3	1.5	16.7	11	...	...
	40	10	4	3.0	25.0	2.0	75.0	3.3	...	...	...	...
	77	12	4	8.8	50.0	7.0	25.0	19.0	25.0	2	...	...
	85	7	1	17.0	100.0	17.0	...	...	...	...	...	...
	Avg.	10.2	3.6	6.7	50.0	8.3	38.9	4.7	11.1	6.5	...	...
Spring, 1937	18	9	0	...	...	...	...	...	...	...	...	...
	41	10	0	...	...	...	...	...	...	...	...	...
	43	8	0	...	...	...	...	...	...	...	...	...
		Avg.	9	0	...	...	...	...	...	...	...	...
	Total	155	69	...	...	...	...	...	...	...	...	...
	Avg.	10.3	4.6	10.7	39.1	10.2	44.9	10.0	14.5	15.2	1.5	4

TABLE 9.—ABNORMALITIES AMONG LIVING PIGS

Ration	Sow	Diarrhoea			Skin Lesions			Abnormal Gait			Severity
		Per cent of Pig-Days	Per cent of Pigs	Age When Observed	Per cent of Pig-Days	Per cent ¹ of Pigs	Age When Observed	Per cent of Pig-Days	Per cent ² of Pigs	Age When Observed	
Fall, 1935	1	52.9	100.0	1-24	4.6	33.3	10-18	41.0	88.9	25-51	1.38
	5	67.0	100.0	2-21	8.1	16.6	19-35	41.1	100.0	21-47	2.33
	15	55.1	100.0	2-16	22.5	32.3	25-46	36.9	100.0	29-50	2.67
	31	79.2	54.5	1-10	10.0	25.0	11-18	...	...	...	...
	38	56.4	92.3	2-36	13.8	100.0	23-41	11.6	55.5	44-56	1.00
	47	82.6	100.0	1-12	2.2	11.1	14-18	8.4	40.0	20-30	1.50
	68	55.9	90.9	1-37	0.3	40.0	15-18	23.3	70.0	40-56	1.00
	Avg.	59.4	90.9	1.5-23.0	8.3	38.2	18.6-31.2	20.4	64.3	33.2-53.0	1.52
Fall, 1936	3	Farrowed 1 dead pig		...	...	...	...	...	...	...	...
	15	43.8	81.8	10-51	...	...	...	27.5	88.9	25-50	1.00
	31	36.4	72.7	1-29	...	...	...	48.9	100.0	20-54	1.00
	40	0.6	14.3	2-3	...	...	...	38.2	85.7	26-51	1.00
	77	34.9	100.0	5-38	...	...	...	38.2	88.9	32-56	1.00
	85	11.1	100.0	3-31	...	...	...	34.6	100.0	18-44	1.00
	Avg.	27.0	70.6	4.9-37.0	...	...	...	36.7	89.5	24.7-51.0	1.00
Spring, 1937	18	8.9	77.8	26-48	13.9	88.9	46-55	27.6	88.9	27-51	1.12
	41	36.6	100.0	7-40	1.8	20.0	55-56	43.8	100.0	30-56	1.00
	43	5.4	75.0	22-30	27.9	87.5	33-51	46.4	87.5	16-50	1.43
		Avg.	18.1	85.2	14.2-34.3	11.0	63.0	42.1-53.5	36.2	92.6	25.1-53.0	1.16
	Avg. of the three groups	36.7	83.2	5.1-30.0	6.1	30.4	29.1-41.3	31.3	80.4	27.5-51.9	1.21

¹These percentages are based on the number of pigs alive at 7 days.

²These percentages are based on the number of pigs alive at 14 days.

TABLE 10.—POST MORTEM OBSERVATIONS

Ration	Sow	No. Pigs Farrowed Alive	No. of Fatalities	Fatty Livers		Fatty Kidneys		Hemorrhages ¹	
				Per cent of Fatalities	Avg. Age at Death, Days	Per cent of Fatalities	Avg. Age at Death, Days	Per cent of Fatalities	Avg. Age at Death, Days
129	1	12	4	25.0	21	25.0	21	...	...
Fall, 1935	5	8	7	14.3	13	14.3	29	14.3	10.0
	15	8	6	16.0	10	...	...	66.7	14.5
	31	11	11	27.3	10.7	9.1	18	36.4	6.0
	38	13	5	...	...	...	...	60.0	5.7
	47	14	14	35.7	21.4	28.6	26	7.1	13.0
	68	11	4	...	...	...	...	...	...
	Avg.	11	7.3	21.6	17.0	13.7	24.6	25.5	9.4
151	3	Farrowed 1 dead pig		...	...	...	...	Mild, diagnosis uncertain	
Fall, 1936	15	11	3	66.7	8.5	33.3	2	...	...
	31	11	6	50.0	8.3	33.3	6.5	...	...
	40	10	4	...	...	25.0	8	...	...
	77	12	4	25.0	19	25.0	19	...	...
	85	7	1	...	...	...	...	...	...
		Avg.	8.5	3	33.3	10.2	27.7	8.2	...
165	18	9	0	...	...	...	...	...	...
Spring, 1937	41	10	0	...	...	...	...	...	...
	43	8	0	...	...	...	...	...	...
		Avg.	27	..	...	...	...	...	...
	Total Avg.	9.7	4.3	24.6	14.5	17.4	17.8	25.5	9.4

¹92.3 per cent of hemorrhages were petechiae on kidneys.
7.7 per cent of hemorrhages were abdominal,

Table 9 shows that from 70 to 90 per cent of the pigs had diarrhoea at some time or other. The percentage of time this condition occurred varied from 18 to almost 60. The seriousness of this condition is emphasized by the fact that both the incidence and the length of time it occurred are closely correlated with the mortality rate.

In the fall of 1935, 38 per cent of the pigs had some type of skin lesion. In the fall of 1936 there were practically none, and in the spring of 1937, 63 per cent of the pigs were affected. Practically all of these cases were mild.

The incidence of abnormal gait was high all three seasons. Most of these cases were mild and usually the pigs recovered when they began consuming solid feed. There can be little doubt that this abnormality is due to malnutrition, and that the milk of the sows was deficient in some essential vitamin.

The severity of the abnormal gait is indicated by the numbers 1 to 4:

- (1) a slight abnormality, just noticeable.
- (2) the condition is marked, but not severe.
- (3) the pig has some difficulty in moving about.
- (4) the pig is almost, or entirely, helpless.

The index for a litter is the average of the individual index numbers.

The post mortem findings are summarized in Table 10. The percentage of fatty livers was 21.6 in the fall of 1935, and 33 in the fall of 1936. The per cent of fatty kidneys was 13.7 in the fall of 1935, and 27.7 in the fall of 1936. In the fall of 1935, 25.5 per cent of the dead pigs were diagnosed as hemorrhagic. In the fall of 1936 these cases were mild, and were omitted because of uncertainty as to the diagnosis.

In connection with the mortality rate it seemed of interest to determine at what stage of the suckling period the deaths occurred, and our calculations appear in Table 11. Almost half the total mortalities occur in the first week. The mortality rate was much lower in the 2nd, 3rd, and 4th weeks, and then continued at a still lower rate from the 5th to the 8th week. Our interpretation is that many of the pigs were subnormal at birth, and in addition the milk of these sows was deficient both in quantity and quality. Only the strongest pigs, and those that received more than their share of milk, were able to survive.

TABLE 11.—DISTRIBUTION WITH AGE OF MORTALITIES OF SUCKLING PIGS IN BASAL GROUPS

No. of Sows	No. of Pigs	Per cent that Died by Weekly Periods								Total Mortality
		1	2	3	4	5	6	7	8	
43	397	21.8	7.9	6.7	5.1	1.6	2.1	0.8	1.0	47.0

Aside from the gross failures themselves the most striking feature of the data reported is their great variability. It is usually observed though that when a ration is on the borderline between adequacy and inadequacy that the variability in response is at a maximum. Our experience is in complete accord with this observation. The greatest extremes in response may be encountered even though the rations are made up according to the same formula and have the same chemical analysis. Some of the variability is no doubt due to individual differences in the animals, and in all probability part is due to obscure differences in the nutritional properties of the feeding stuffs themselves, possibly in their vitamin content. An example of these wide differences in response is shown in Table 12.

TABLE 12.—EXAMPLES OF VARIABILITY ON SIMILAR BASAL RATIONS

Group	Live Pigs per Litter		
	Number Farrowed	Weaned, per cent	Weight at Weaning
Spring 1935, Ration 113	8.9	30.3	21.2
Fall 1935, Ration 129	11.0	47.3	25.0
Fall 1936, Ration 151	8.5	64.7	19.6
Spring 1937, Ration 151	9.0	100.0	28.7

On paper the rations were practically identical, but there were wide extremes in the rate of mortality and in weaning weight. As an example of variability within litters it may be mentioned that the weight of the heaviest pig at weaning was 42 lbs. This pig had a litter mate that weighed 11.5 lbs.

SUMMARY

Brood sows were supplied with rations made up exclusively of the concentrates commonly used in swine feeding. The weaning weights of their litters were subnormal and the mortality rate was excessively high.

Other less frequent symptoms in the sows of a nutritional deficiency were lameness, scanty hair, scaly skins, and a swaying movement either when walking or standing still.

The feed consumption of the sows, before and after farrowing, was usually too low. The sows that ate the most were more suc-

successful in rearing their litters and their pigs developed fewer abnormalities.

The abnormalities observed in the pigs included (1) skin lesions, (2) muscular incoordination and weakness, (3) diarrhoea, (4) collapse. Post mortem examination revealed (5) fatty livers, (6) fatty kidneys, (7) hemorrhagic areas.

The mortality rate among the pigs was highest in the first week. Almost 90 per cent of all mortalities occurred in the first 4 weeks.

The performance of the pigs in different seasons is highly variable.

It is concluded that the concentrates commonly used in swine feeding are partially inadequate as the sole ration of brood sows.

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