July 27, 1965

To the Graduate Council:

I am submitting herewith a thesis written by John Larry Black entitled "Factors Affecting Baby Pig Mortality." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

Harold J. Smith
Major Professor

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FACTORS AFFECTING BABY PIG MORTALITY

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

---

by

John Larry Black

August 1965

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John Larry Black

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TABLE OF CONTENTS

CHAPTER		PAGE
I.	INTRODUCTION	1
II.	REVIEW OF LITERATURE	3
	Stillbirths	3
	Age of dam	6
	Breed	7
	Size of litter	7
	Birth weight	8
	Sex	9
	Preweaning Mortality	9
	Age of dam	13
	Breed	14
	Season	15
	Litter size	17
	Birth weight	19
	Sex	19
	Preweaning Losses During Various Periods from Birth to Weaning	20
III.	EXPERIMENTAL PROCEDURE	23
	Source of Data	23
	Experimental Animals	24
	Herd Management	24

CHAPTER PAGE

Feeds and Rations 26

Methods and Analysis. 27

IV. RESULTS AND DISCUSSION. 29

Stillbirths 29

Season. 29

Age of dam. 29

Breed 32

Size of litter. 34

Birth weight. 34

Preweaning Mortality. 34

Season. 35

Age of dam. 38

Breed 41

Litter size 44

Birth weight. 44

Sex 45

Preweaning Losses During Various Periods from Birth to Weaning 46

Season. 50

Age of dam. 50

Breed 54

V. SUMMARY AND CONCLUSIONS 59

LITERATURE CITED. 61

LIST OF TABLES

TABLE		PAGE
I.	The Incidence of Stillborn Pigs Reported at Various Locations, 1920 to 1965.	4
II.	The Incidence of Preweaning Mortality at Various Locations, 1925 to 1965.	10
III.	Summary of Stillbirths and Certain Other Litter Traits by Season of Birth in the Ames Plantation Swine Herd, 1961 to 1964	30
IV.	Summary of Stillbirths and Certain Other Litter Traits by Age of Dam in the Ames Plantation Swine Herd, 1961 to 1964	31
V.	Summary of Stillbirths and Certain Other Litter Traits by Breed of Dam and Breed of Pigs in the Ames Plantation Swine Herd, 1961 to 1964	33
VI.	Summary of Preweaning Losses and Certain Other Litter Traits by Season of Birth in the Ames Plantation Swine Herd 1961 to 1964	36
VII.	Summary of Preweaning Losses and Certain Other Litter Traits by Age of Dam in the Ames Plantation Swine Herd, 1961 to 1964.	39

TABLE PAGE

VIII. Summary of Preweaning Losses and Certain Other Litter Traits by Breed of Dam and Breed of Pigs in the Ames Plantation Swine Herd, 1961 to 1964. 42

IX. Summary of Preweaning Losses During Various Periods from Birth to Weaning and Certain Other Litter Traits by Season of Birth in the Ames Plantation Swine Herd, 1961 to 1964 47

X. Summary of Preweaning Losses During Various Periods from Birth to Weaning and Certain Other Litter Traits by Age of Dam in the Ames Plantation Swine Herd, 1961 to 1964 . . 51

XI. Summary of Preweaning Losses During Various Periods from Birth to Weaning and Certain Other Litter Traits by Breed of Dam and Breed of Pigs in the Ames Plantation Swine Herd, 1961 to 1964 55

CHAPTER I

INTRODUCTION

At the time of the first United States census in 1840, the corn growing areas of Tennessee, Kentucky and Ohio were important centers of hog production (Ensminger, 1960). Tennessee is still in the top one-fourth of the states in both value and numbers of swine, and Tennessee swine producers realize a gross income of 75 million dollars annually from swine (Robinson and Houston, 1958).

In view of the importance of the swine industry in Tennessee, it should be realized that profit from any swine enterprise is determined to a great extent by the efficiency of production. Management is an important influence in the efficiency of production, especially management of the sow herd and management at farrowing time. Other factors of production are important and should not be overlooked, but every pig born represents a sizeable investment, and conversely, every pig lost represents a sizeable loss. These losses tend to be taken as a matter of course by many swine producers, but the financial loss remains a fact.

Many papers have been written examining these losses under various conditions, but none recently which dealt specifically with Tennessee conditions. With this in mind, the objective of this study was to examine some of the factors affecting baby pig mortality. More specifically, the problem was threefold: (1) to determine the percentage

of stillborn pigs in a herd of swine and some of the factors that influence this percentage; (2) to examine the mortality rate of the pigs from birth to weaning and factors that influence this; and (3) to determine the ages at which the death losses occur.

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CHAPTER II

REVIEW OF LITERATURE

I. STILLBIRTHS

There is general agreement in the literature (Squires, Dickerson and Mayer, 1952; Rathnasabapathy, Lasley and Mayer, 1956; and Lerner, Mayer and Lasley, 1957) that the majority of the prenatal deaths occur during the early stages of gestation. Even though this is true, the incidence of embryonic mortality in the later states of gestation, as reflected by stillbirths, has been reported extensively. Table I summarizes the incidence of stillbirths reported in the literature at various locations under various conditions over a period of 45 years, 1920 to 1965.

There is a wide range in the percentage of stillborn pigs reported. Braude, Clarke and Mitchell (1954) reported an incidence of 2.0 per cent, but their examination dealt only with gilt litters. In a more extensive survey, which included sows and gilts, Snedecor (1947) found a stillbirth rate of 2.5 per cent. The highest percentage of stillbirths found, 10.6, was reported by Jordao (1946), but this survey was conducted in Brazil and included several native breeds. Carmichael and Rice (1920) also reported a high incidence, 10.5 per cent, but this included only litters that had a larger number of pigs born than the average of all those examined. Most of the percentages of stillborn

TABLE I

THE INCIDENCE OF STILLBORN PIGS REPORTED AT VARIOUS LOCATIONS, 1920 TO 1965

Source	Year	Number of litters	Number of pigs	Per cent stillborn	Comments
Carmichael and Rice	1920	720	5,840	10.5	litters larger than 8.1 pigs
				7.7	litters smaller than 8.1 pigs
Severson	1925	393	3,779	3.6	1909-1924; North Dakota Ag. Exp. Sta.
McPhee and Zeller	1934	1,121	8,991	5.5	259 litters had at least 1 stillborn pig
Asdell and Willman	1941	--	--	6.6	1930-1935; Cornell Univ. swine herd
Stewart	1945	749	--	3.5	gilts, 12 months old, 19.2 per cent inbred; pigs 25.5 per cent inbred
Jordao	1946	644	--	10.6	1936-1944; Brazil
Snedecor	1947	--	16,507	2.5	177 survey farms in Iowa; 14 per cent of total deaths were stillbirths
Braude, Clarke and Mitchell	1954	109	1,120	2.0	gilts; per cent is on litter average of live pigs born
		378	4,765	6.8	sows; per cent is on litter average of live pigs born
		487	5,885	5.9	sows and gilts; per cent is on litter average of live pigs born
Hutchinson *et al.*	1954	220	2,116	5.2	4 breeds; Univ. of Ill. swine herd
Gracey	1955	--	--	4.9	random 1 per cent sample of swine population of Northern Ireland
Saunders	1958	371	4,394	4.8	0.4 to 12.9 per cent variation in herds

TABLE I (continued)

Source	Year	Number of litters	Number of pigs	Per cent stillborn	Comments
Vet. Investigation Service	1959	2,581	28,400	6.0	1956-1958; England and Wales
Pond *et al.*	1960	162	1,454	6.3	Berkshire only
		138	1,310	3.3	Chester White only
		251	2,926	8.2	Yorkshire only
		551	5,690	7.6	3 breeds; 1946-1957; Cornell Univ. swine herd
Godbey and Godley	1961	--	659	5.9	
Kernkamp	1965	5,263	48,564	5.6	

pigs reported in the literature were between 4 and 8 per cent (Table I, page 4). The two largest surveys, reported by the Veterinary Investigation Service (1959) and Kernkamp (1965), which together included 76,964 pigs, had 5.6 and 6.0 per cent stillborn pigs, respectively.

A number of factors influence the incidence of stillborn pigs. Some of the more important of these are age of dam, breeding of the dam and of the litter, size of the litter and the season in which the litter was born. Other factors, such as birth weight and sex of the pig may not enter a cause and effect relation with stillbirth, but may be correlated with the percentage of stillbirths.

Age of dam. There is general agreement that older sows farrow more dead pigs than do younger sows or gilts.

Carmichael and Rice (1920) stated that older sows farrowed a greater percentage of dead or immature pigs than did younger sows. Of the 5,778 pigs involved in their study, 8.1 per cent farrowed by sows 1 to 2.5 years old were dead or immature and 12.3 per cent of those farrowed by sows 3 years of age and over were dead or immature.

Robison (1948), in a study involving a limited number of pigs, found that gilts about 1 year of age and sows 1.5 years old had fewer stillborn pigs than did older sows.

Braude, Clarke and Mitchell (1954) reported that 109 gilt litters had a mean of 0.2 dead pigs per litter, while 378 sow litters had a mean of 0.8 dead pigs per litter.

In a recent, extensive survey, Kernkamp (1965) found that the 3,601 first gestation litters surveyed had only 4.5 per cent stillborn, or 1,453 of the 31,852 pigs born. In 963 second gestation litters, he found 5.8 per cent stillborn, or 554 of 9,431 pigs; and, in 430 third gestation litters the percentage stillborn increased to 8.4, or 376 of 4,350 pigs. Although fewer litters of fourth through eighth gestation periods were included, the percentage stillborn pigs increased from 9.5 per cent to 24.0 per cent, respectively.

Breed. The literature contains extensive reports that inbreeding increases the percentage of stillbirths, but as no inbred animals were used in this study, it was beyond the scope of this work to review these reports.

There are less extensive reports on the effects of purebreeding and crossbreeding on the incidence of stillbirths in swine. According to Lush, Shearer and Culbertson (1939), however, the percentages of stillborn pigs in 108 litters at the Iowa Agricultural Experiment Station was smaller among crossbreds than among purebreds.

Size of litter. The size of the litter exerts considerable influence on the percentage of stillborn pigs.

In an early study, Carmichael and Rice (1920) found there was a tendency for larger litters to contain a larger proportion of dead or immature pigs than smaller litters. In 720 litters they found that litters larger than the average litter size, 8.1 pigs, contained 10.5 per cent stillborn pigs, but those smaller than the average only contained 7.7 per cent.

McPhee and Zeller (1934) reported that very large and very small litters contained a higher percentage of stillbirths than did litters of medium size.

An extensive survey conducted by the Veterinary Investigation Service (1959) showed that in 523 litters of eight pigs or less the percentage of stillbirths was 5.98. There was a decrease in stillbirths in 588 litters of 9 to 10 pigs to 4.09 per cent. In 629 litters of 11 to 12 pigs and 468 litters of 13 to 14 pigs, the percentage of stillbirths was 4.8 and 5.8, respectively. The 373 litters containing 14 or more pigs had the greatest per cent of stillbirths, 9.6 per cent.

Asdell and Willman (1941) and Pond *et al.* (1960) agreed that generally as the size of the litter increased the incidence of stillborn pigs also increased.

Birth weight. Carmichael and Rice (1920) found, in a study of 720 litters with a total of 5,840 pigs, that the stillborn pigs weighed less, 2.17 pounds, than the average, 2.55 pounds.

Asdell and Willman (1941) reported an average birth weight of 2.1 pounds for stillborn pigs as compared with 2.6 pounds for the live pigs born in the Cornell University herd over a 5-year period.

Pond *et al.* (1960) found a lower birth weight average for stillborn pigs than for live pigs of three breeds. The three breeds--Berkshire, Chester White and Yorkshire--had birth weight averages for the live pigs of 2.92, 2.66 and 2.44 pounds, respectively, while the stillborn pigs of the three breeds averaged 2.48, 1.74 and 2.12 pounds, respectively.

Fredeen and Plank (1963) observed that of the pigs in their study that weighed less than 1.4 pounds, 41.9 per cent of them were stillborn, while only 11.1 per cent of the pigs weighing 1.5 to 1.9 pounds at birth were stillborn. Of the total of 1,146 pigs that weighed over 2.0 pounds at birth, only 79, or 6.89 per cent, were born dead.

Numerous workers agreed that stillborn pigs generally weigh less than live pigs farrowed in the same litter. McPhee and Zeller (1934), however, found that the stillborn pigs in the 1,121 litters included in their study were significantly heavier in weight than the pigs born alive. They found no difference in the mean birth weight of live pigs farrowed in litters containing stillbirths and that of litters containing only live pigs. The birth weights of the stillborn pigs were more variable than those of the live pigs in their study.

Sex. There are few reports in the literature on the relation of sex to stillbirths. In one study, however, no sex differences were found in the proportions of stillborn pigs (Asdell and Willman, 1941).

II. PREWEANING MORTALITY

Preweaning mortality rates are reported extensively in the literature. Table II presents a summary of these data over a period of about 40 years, 1925 to 1965.

There is variation in the incidence of preweaning mortality reported in the literature. In two extensive studies the percentage of preweaning mortality was less than 20 per cent. Gracey (1955) reported

TABLE II

THE INCIDENCE OF PREWEANING MORTALITY AT VARIOUS LOCATIONS, 1925 TO 1965

Source	Year	Number of litters	Number of pigs	Per cent mortality	Comments
Severson	1925	393	3,779	30.2	N. Dakota Agr. Exp. Sta.; 1909-1924 5 breeds
Anon., Veterinary Medicine	1930	--	--	35.8	spring only; Iowa, Ind. and Ill.
		--	--	24.2	fall only; Iowa, Ind. and Ill.
Aubel, Hughes and Leinhardt	1932	--	--	35.0	
Kernkamp	1943	--	27,023	29.2	RSB lab[a] data 1938-1942, inclusive; total 6 stations
		--	5,238	35.4	RSB lab data 1938-1942, inclusive; Station A
		--	7,390	33.6	RSB lab data 1938-1942, inclusive; Station B
		--	3,199	27.8	RSB lab data 1938-1942, inclusive; Station C
		--	1,345	23.6	RSB lab data 1940-1942, inclusive; Station D
		--	7,561	20.7	RSB lab data 1938-1942, inclusive; Station E
		--	2,290	33.5	RSB lab data 1938-1942, inclusive; Station F
		--	2,335	33.6	Minn. Station several years prior to 1943
Snedecor	1947	--	16,507	18.3	177 survey farms in Iowa, July 1946 to June 1947

TABLE II (continued)

Source	Year	Number of litters	Number of pigs	Per cent mortality	Comments
Winters, Cummings and Stewart	1947	745	5,562	29.7	gilt litters only; per cent mortality is of pigs born alive
Braude, Clarke and Mitchell	1954	487	--	29.5	1934-1950; sows and gilts
		109	--	23.0	1934-1950; gilts only
		378	--	31.0	1934-1950; sows only
Gonzalez-Chapel and Carlo	1954	382	3,841	35.7	Puerto Rico; purebred and crossbred pigs included
Hutchinson *et al.*	1954	220	2,116	31.0	Univ. of Ill. swine herd
Gracey	1955	1,231	13,635	18.2	random 1 per cent sample of swine population of Northern Ireland
Veterinary Investigation Service	1959	2,581	28,400	20.5	England and Wales; 1956-1958
Pomeroy	1960a	2,411	--	26.5	4 breeds
Godbey and Godley	1961	--	659	34.5	
Fredeen and Plank	1963	135	1,276	28.1	gilts only; Canada
Kernkamp	1965	5,263	48,564	20.5	per cent mortality is of live pigs

[a]Regional Swine Breeding Laboratory.

from a survey of 1 per cent of the swine population of Northern Ireland that 18.2 per cent of the pigs born never reached weaning age. Snedecor (1947), in an earlier study involving 16,507 pigs, found a preweaning mortality rate of 18.3 per cent. The two largest studies reported had a preweaning mortality rate only slightly higher than these. The Veterinary Investigation Service (1959) reported that of the 28,400 pigs they surveyed, only 20.5 per cent were lost before weaning. In another recent survey, Kernkamp (1965) found a preweaning mortality rate in 48,564 pigs that agreed with the 20.5 per cent found by the Veterinary Investigation Service (1959) in England. Earlier, however, Kernkamp (1943) reported a preweaning mortality rate of 29.2 per cent in a study involving 27,023 pigs at six locations of the Regional Swine Breeding Laboratory.

The highest rates reported were by Veterinary Medicine (1930) and Gonzalez-Chapel and Carlo (1954). An anonymous report in Veterinary Medicine (1930) showed that 35.8 per cent of the pigs included in their survey did not reach weaning age, but this survey was only in the spring season in three states. In a study of 3,841 pigs in Puerto Rico, Gonzalez-Chapel and Carlo (1954) observed that 35.7 per cent of these pigs died prior to weaning.

Although the preweaning mortality rates were about equally distributed throughout the range of reported rates, most of the surveys involving a large number of pigs, with the exception of that of Kernkamp (1943), were about 20 per cent.

Just as in the incidence of stillbirths, there are several factors which influence the preweaning mortality. Age of the dam,

breeding of the pigs and of the dam, season of birth, litter size, birth weight and sex may all influence the number of pigs lost prior to weaning.

Age of dam. Olbrycht (1943) stated that there was a regular increase in the size of the litter raised up to and including the fourth litter, but that there was a gradual decline in the number of pigs raised per litter after that. There was a general consensus (Carmichael and Rice, 1920; Keith, 1930; Morris and Johnson, 1932; Hetzer, Lambert and Zeller, 1940; Korkman, 1947), however, that there was an increase in the number of pigs born up to this age and this may account for the increase in the number raised rather than some change in the mortality rate directly due to age of the dam.

Korkman (1947) stated that for equal numbers of pigs born in each litter, the mortality will increase steadily with the litter order, or that is, age of dam.

Robison (1948) found that sows 1.5 to 3.5 years of age saved more pigs per litter than younger or older sows.

Braude, Clarke and Mitchell (1954) found that gilts lost only 23.0 per cent of their pigs before weaning, but sows lost 31.0 per cent.

In a Puerto Rican study, litters from sows 16 to 23 months of age had lower preweaning mortality rates than those from older sows (Gonzalez-Chapel and Carlo, 1954). In this same study, second litters were found to be more vigorous than succeeding litters. Gracey (1955), who was in agreement with this, observed that the lowest losses occurred in the second and third litters.

Pomeroy (1960a) reported that pig mortality increased with increasing litter order. In his study he found that in first and second litters the preweaning mortality was 27.4 and 25.6 per cent, respectively, and there was a gradual increase up to litters of eight pigs or more, which had 32.5 per cent mortality.

In a recent, extensive survey, Kernkamp (1965) reported a slight variation in mortality rate in respect to age of dam. In his study the preweaning mortality rate in the first gestation litters was 21.4 per cent and there was a drop to 16.8 per cent in the second gestation litters. There was then a gradual increase in mortality to 23.9 per cent in the sixth gestation litters. The mortality rates for the seventh and eighth gestation litters dropped to 12.5 and 12.0 per cent, respectively. Only a few litters were in the seventh and eighth gestation groups, however, and these may not have been representative.

Breed. Crossbred pigs have been reported as superior to purebred pigs in their ability to survive. Lush, Shearer and Culbertson (1939) reported that crossbred pigs were more vigorous at birth than purebred as demonstrated by their ability to survive to weaning age.

In the same year, Roberts and Carroll (1939) used a double mating system to produce purebred and crossbred pigs in the same litter. They also found that crossbred pigs were stronger at birth and that they had fewer deaths prior to vaccination. Gonzalez-Chapel and Carlo (1954) agreed with these early workers.

Robison (1948) found that purebred pigs farrowed from gilts averaged 9.4 live pigs per litter, but only 6.9 were weaned; the preweaning mortality rate was 2.5 pigs per litter, or 26.6 per cent. If the pigs were crossbred and from purebred dams, 7.9 pigs was the average live litter size and 6.8 of these were weaned; the average loss was 1.1 pigs, or 13.9 per cent of those born alive. The preweaning mortality was even less if the pigs and the dam were crossbred. Of the 8.0 pigs born alive on the average, 7.3 were weaned. Only 0.7 pigs, or 8.75 per cent, of the live pigs born in this group were lost before weaning. Although the sows in this study farrowed larger litters, the trends were the same. Purebred litters, on the average, lost 3.8 pigs, or 35.85 per cent, prior to weanings; 3.0 pigs, or 30.47 per cent, were lost from crossbred litters from purebred dams; but only 2.6 pigs, or 28.88 per cent, from crossbred litters out of crossbred dams were lost.

Cox (1960) stated that survival in swine is adversely influenced by inbreeding, and, conversely, shows heterosis from crossbreeding. In his study involving seven breeds, forty-two crosses and some 5,000 pigs, the crossbred males showed a higher mortality rate at birth and during the first three days than did the purebred males. The females followed this pattern also. However, overall mortality from births to weaning was greater in the purebreds.

Season. There is controversy over the effects of season on preweaning mortality.

The fact that season of farrowing exerts considerable influence over survival rate to about 6 weeks was discussed by Menzies-Kitchen (1937). He reported that about one pig more per litter survived in the summer than in the winter. A Scandanavian worker, Korkman (1947), and two Puerto Rican workers, Gonzalez-Chapel and Carlo (1954) agreed that summer or late spring born pigs have lower mortality rates than the pigs born in other seasons.

Braude, Clarke and Mitchell (1954) reported that preweaning mortality was higher for sows and gilts, 35.9 and 32.5 per cent, respectively, in the winter season than the losses in sows and gilts, 26.7 and 19.4 per cent, respectively, in the summer season.

In a study of 17,015 pigs which had births almost equally distributed over all 12 months, Pomeroy (1960a) found that from April to August the per cent preweaning mortality by months ranged from a low of 23.1 per cent in August to a high of 26.1 per cent in May. During the months of September through March, the range was 25.8 per cent in September to a high of 35.9 per cent in December. Pomeroy (1960b), in a later study, also found that the mortality was higher in the winter months.

Other workers have failed to substantiate these reports and have found lower preweaning mortality rates during the fall.

A study made by the Departments of Agriculture of Indiana, Iowa and Illinois (Veterinary Medicine, 1930) showed that 35.8 per cent of the pigs farrowed in the spring were lost before weaning, but only 24.2 per cent of the pigs farrowed in the fall were lost.

Asdell and Willman (1941), in a study of the Cornell University swine herd records over a 5-year period, found that spring farrowed litters had nearly twice the mortality of the fall farrowed litters.

After examining the pig mortality statistics of the Regional Swine Breeding Laboratories from 1938 to 1942, inclusive, Kernkamp (1943) reported that of the 18,483 pigs farrowed in the spring, 5,639, or 30.5 per cent were dead by 56 days of age. Only 2,238, or 26.2 per cent, of the 8,540 pigs born in the fall at these same stations were lost prior to weaning.

Bowman, Bowland and Fredeen (1961) found that the average number of pigs weaned in the fall litters exceeded those of spring litters by about 0.78 pig in a Yorkshire herd over a 20-year period.

Litter size. In an early study, Severson (1925) reported that sows which farrowed from 4 to 6 pigs lost 45 per cent; in litters of 7 to 9 pigs, 34 per cent were lost; and in litters of 10 to 12 pigs, only 33 per cent died. In the very large litters of 13 to 17 pigs, slightly more, 37 per cent, were lost.

Menzies-Kitchen (1937) stated there appeared to be little advantage in producing litters of more than 12 pigs since any additional number will be more than off-set by an increased death rate.

Olbrycht (1943) found that even though the number of pigs raised per litter increased with the number born, the number of deaths also increased with increasing litter size at birth.

Later, Winters, Cummings and Stewart (1947) commented that an increase in the size of the litter at birth reduces the chance for survival, but that the effects are small.

Gonzalez-Chapel and Carlo (1954), in close agreement with Menzies-Kitchen (1937), said that litters of 12 or more pigs had higher mortality than smaller litters.

A British worker, Gracey (1955), agreed that the per cent preweaning mortality increased with the size of the litter.

Pomeroy (1960a) found that there was 22.6 per cent preweaning mortality in litters of less than 6 pigs and 21.6 per cent in litters of 6 to 7 pigs; from litters of 8 to 9, 10 to 11 and 12 to 13 pigs the mortality was 22.2 per cent, 23.4 per cent and 26.7 per cent, respectively. There was a sharp increase to 41.3 per cent mortality in litters of 14 to 15 and a further increase to 47.1 per cent mortality in litters of over 15 pigs. In a later study, Pomeroy (1960b) reported that there was a significant difference in the mortality rates of pigs from litters ranging in size from 5 to 15 pigs and that the highest rates occurred outside of this range.

The Veterinary Investigation Service (1959) found an increase in mortality as litter size increased. In litters with 8 pigs or less, the preweaning mortality was 15.2 per cent, but it increased to 17.6 per cent as litter size increased to 9 to 10 pigs per litter and further increased to 17.9 per cent as the litter size rose to 11 to 12 pigs. There was an additional increase to 22.2 per cent as the number born in the litter increased to 13 to 14 pigs. The mortality rate of litters of

over 14 pigs, 30.5 per cent, was more than twice that of litters of 8 pigs or less, 15.2 per cent.

Godbey and Godley (1961) agreed with the general consensus that the size of the litter at birth had a significant effect on the number of pigs raised per litter.

Birth weight. Winters, Cummings and Stewart (1947) concluded from their studies that the average birth weight of the litter had the greatest effect on the survival of the pigs in that litter.

In a study of 1,368 pigs in which 658 died prior to weaning, Pomeroy (1960b) reported that 83.0 per cent, or 106 pigs, of those weighing less than 900 grams at birth died prior to weaning. Of the pigs weighing from 900 to 1,399 grams at birth, 33.8 per cent, or 417 pigs, died before weaning, while only 18.5 per cent, or 135, of those weighing over 1,400 grams at birth were lost.

Fredeen and Plank (1963) found that of the pigs in their study, 1,276 pigs from 135 gilt litters, 96.8 per cent of those weighing less than 1.4 pounds at birth died before 21 days of age. With increasing birth weight up to about 3.4 pounds, there was a decrease in the mortality to 16.5 per cent of those weighing between 3.0 and 3.4 pounds. Above this weight there was little change in the mortality rate.

Sex. There is no general agreement as to whether sex influences the mortality of pigs prior to weaning.

Carmichael and Rice (1920) found that of 5,657 sexed pigs, 51.9 per cent were male and 48.1 per cent were female, but there was a

greater predominance of male deaths (56.0 per cent were males) over females.

Cox (1960), in agreement with Carmichael and Rice (1920), stated that the mortality rate in both crossbred and purebred females was lower than those of males of comparable breeding. He also stated that the difference in male and female mortality was over twice as large in the purebreds as it was in the crossbreds.

Other workers (Asdell and Willman, 1941; Braude, Clarke and Mitchell, 1954; and Pomeroy, 1960b) found no significant differences in the mortality as far as sex was concerned.

III. PREWEANING LOSSES DURING VARIOUS PERIODS FROM BIRTH TO WEANING

At best, difficulty exists in comparing the reports of the age at which preweaning losses occur since the various authors reported the deaths at different time intervals. There were reports in which the death losses were given on a daily basis, but the accuracy of this might be questioned since some pigs may be dead for all practical purposes and still remain alive for several more days. Other reports were more conservative and gave the losses on a per week basis or on a 14-day basis.

Also, some losses were given as a percentage of the pigs born while others were given as a percentage of the total losses. In addition, the reports were from various locations, involved various breeds and were under different management regimes.

At any rate, there was general agreement that the majority of the losses occurred in the early part of neonatal life and a large number of these within 2 or 3 days of birth.

Severson (1925) reported in his survey that of the pigs that were lost, 68.9 per cent died the first week, 9.2 per cent the second week, 5.9, 4.1, 3.5 per cent for the next 3 weeks, respectively, and only about 0.9 per cent of the total losses occurred during the 3 weeks immediately prior to weaning.

Two groups of pigs were discussed by Kernkamp (1943). In the first group of 2,335 pigs, 800 were lost. Of these, 34 per cent were lost during the first week of life and 64 per cent from the second week of age to weaning at 8 weeks. In the second group, 46 per cent of the deaths occurred the first week after birth, 35 per cent the second, 16 per cent the third and only 3 per cent the remainder of their lives.

Hutchinson et al. (1954) examined the data from 2,116 pigs in 220 litters at the University of Illinois. They found that 174, or 26 per cent, of the 657 deaths occurred on the first day; 86 deaths, or 13 per cent occurred the second day; 60, or 9 per cent, of the deaths were on the third day; and only 36, or 5 per cent, on the fourth day.

In an extensive survey, the Veterinary Investigation Serivce (1959) found that 15.34 per cent, or 1,716 of the total 28,400 pigs born, died during the first week of their life. This was 80 per cent of the total losses. During the second and third weeks after parturition, 2.50 per cent, or 710 pigs, were lost, while only 1.97 per cent, or 562 pigs, died during the fourth to the eighth week.

Pomeroy (1960b) found that of the 647 that died out of a total of 1,368 pigs, 533, or 82.4 per cent, died during the first week. Nearly one-half of all deaths, 302, or 46.7 per cent, occurred the first day. During the period from 8 to 56 days, only 114 deaths, or 17.6 per cent, occurred; the losses were small and about the same number of pigs died in the periods of 8 to 14 days, 15 to 28 days and 29 to 56 days.

Cox (1960) observed a drop in mortality for about 2 days after birth and then a rise after this period. He explained that apparently the pig has sufficient nutrients to carry him from birth to about 2 days, at which time the reserves are depleted and mortality rises.

Godbey and Godley (1961) reported that of the 659 pigs included in their study, 15.78 per cent died during the first 3 days of life, 2.89 per cent died from the fourth to the seventh day of age and only 9.82 per cent died after they reached 7 days of age.

Edwards (1963) agreed with the other workers that most deaths occur one or two at a time within a few days of farrowing.

In a recent, extensive survey involving 48,564 pigs from 5,263 litters, Kernkamp (1965) reported that 11.5 per cent, or 5,262 pigs, died during the first week of life and there was a decrease in the death rate during the following 3 weeks to 3.3 per cent, 1.7 per cent and 1.3 per cent. In the second month after parturition, the percentage of the pigs born that died was 0.9 per cent, 0.7 per cent, 0.5 per cent and 0.6 per cent for the fifth through the eighth week, respectively.

CHAPTER III

EXPERIMENTAL PROCEDURE

I. SOURCE OF DATA

The data for this study were taken from the records of an extended swine breeding project at Ames Plantation, Grand Junction, Tennessee. The project is being conducted by the University of Tennessee Animal Husbandry-Veterinary Science Department, Knoxville, Tennessee. These data included records from seven farrowing seasons beginning with the spring of 1961, and continuing through the spring of 1964.

Data were obtained for the following litter traits: litter size at birth (including pigs alive and stillborn), birth weight of the pigs, number of males and females born, stillbirths (only those that were fully developed and died in late stages of gestation), sex and weight of the stillborn pigs, pigs dying 0-14 days of age (excluding stillbirths) and their sex, pigs dying 15-28 days of age and their sex, pigs dying 29 days of age to weaning and their sex, pigs dying birth to weaning (including stillborn pigs and pigs viable at birth) and their sex, and the number of pigs at weaning and their sex. In addition, the age of dam, breed of pigs and dams and season of birth were recorded.

II. EXPERIMENTAL ANIMALS

The animals used in this study consisted of litters of purebred Hampshires and Durocs and various two- and three-breed repeat and rotational crosses. Purebred Hampshire (H), Duroc (D), Landrace (L) and Yorkshire (Y) boars were used in the various crosses. The breeding of the pigs represented in the data analyzed included purebred Hampshire, purebred Duroc, HxD, DxH, LxH, LxD, YxH, YxD, LxHD, YxHD, HxYD, DxYH, HxLD, DxLH and various two- and three-breed rotational crosses. About 15 litters of purebred Hampshires and Durocs each and 6 litters in each of the crossbred groups were produced each season for a total of approximately 100 to 120 litters.

III. HERD MANAGEMENT

A central farrowing house with farrowing stalls was used to farrow the sows. Sows were bred to farrow at 2-week intervals with about one-third of the sows farrowing each 2 weeks. This practice allowed the house to be steam cleaned and disinfected before each group of sows farrowed.

The sows were bred for two litters a year. The spring farrowing season began about April 1 and the fall season about October 1. The approximate farrowing dates were obtained by daily checks for sows in estrus since the sows were all pasture bred. Gilts in the herd were bred to farrow initially at 10 to 14 months of age.

When the sows were brought to the farrowing house, they were washed, using soap and a disinfectant, and wormed with piperazine. They were allowed out of their farrowing crate twice daily for feed and water both pre- and post-parturition.

The sow vaccination program included a yearly vaccination for erysipelas, cholera and leptospirosis. Twice yearly a brucellosis test was run. In addition to worming at farrowing, the sows were wormed twice more each year and rung as needed to prevent excessive rooting in the pasture lots.

The boars were managed in a similar manner to the sows as far as vaccination and general management were concerned.

At birth the pigs were ear notched for identification, weighed to the nearest 0.1 pound, injected with 3 cc. of swine erysipelas anti-serum, had their needle teeth clipped and their umbilical cords dipped in tincture of iodine.

At 3 to 5 days of age the pigs were injected with an iron compound to prevent anemia, and at 7 to 10 days of age, sows and their litters were moved to pasture lots consisting of about four acres each. About eight sows and their litters were placed in each lot. Portable houses were used in these lots to provide shelter and shade.

At 4 weeks of age the male pigs were castrated, with the exception of the purebred males which were being considered as possible future herd sires.

When the litters were about 8 weeks of age, the sows were taken from the lots and the pigs weaned.

Health problems encountered were recorded. Atrophic Rhinitis was considered a serious health problem in the herd during part of the period included in the study, but there was no evidence to indicate that it was more prevelant in any one breed or group than in another.

IV. FEEDS AND RATIONS

The sows were fed ground ear corn and a protein supplement, the composition depending on the condition of the pastures. On "good" pasture, the sows were fed a supplement consisting of a mixture of 100 pounds of tankage and 100 pounds of soybean oil meal. If the pastures were classed as "poor," 100 pounds of alfalfa leaf meal was added to the mixture.

Between weaning and rebreeding, the sows were fed daily 2 to 5 pounds of ground ear corn and 0.5 to 1 pound of supplement, depending on the pasture condition and age and condition of the sow. At breeding time the sows were flushed by increasing the ground ear corn about 2 pounds and the supplement 0.5 to 1 pound. This level was maintained for about a month after breeding and then the ration was reduced to prevent the sows from becoming excessively fat.

Three or 4 weeks prior to farrowing, the supplement was increased to 1.5 to 2 pounds and the corn was also increased. When the sows farrowed, they received a small amount of corn and the supplement containing the alfalfa leaf meal. After being placed on pasture, this was increased to a full feed and maintained until weaning of the pigs.

Boars received the same ration as sows and were fed in a manner to keep them in a thrifty condition at all times.

The pastures consisted of Ladino clover, alfalfa and orchardgrass for the spring litters and oats and Crimson clover for fall litters.

V. METHODS AND ANALYSIS

The litter traits were recorded along with each litter classification as to year, season of birth, breed of sire, breed of dam and age of dam. From these data the grand means and their standard errors were determined.

The means were also determined on the basis of season of birth, age of dam and breed. The season of birth means were determined by averaging the litter traits of all litters farrowed in the fall and then of all litters farrowed in the spring. The age-of-dam classifications consisted of five classifications: 1.0, 1.5, 2.0, 2.5 and 3 years of age and older. The ages were approximations since the sows born in one season and farrowing in the same season a year later were classed 1.0 year of age and the other groups were determined in the same manner. All sows at least 3 years of age were classed as 3 years and older. The means for this classification were obtained by averaging the traits for all litters from the age-of-dam groups on the basis of each of the five groups separately. The breed classifications were Hampshires, Durocs, Purebreds (the average of the Hampshires and Durocs), Purebred dams with crossbred pigs (Hampshire or Duroc sows bred to a boar other than their own respective breed) and Crossbred sows with crossbred pigs (crossbred

sows bred to any of the purebred males). The means of each of these breed groups were determined by averaging the traits of all litters classed in that particular group for each of the groups, respectively.

Selected means of the season of birth, age of dam and breed classifications were tested for statistical significance using a multiple range test originated by Duncan (1955) and modified by Kramer (1957) for use with means of groups of unequal numbers.

No attempt was made to adjust any of the means in a group for age of dam, season of birth or any other factor which may have been influencial.

CHAPTER IV

RESULTS AND DISCUSSION

I. STILLBIRTHS

Of the 7,873 pigs born, 6.40 per cent, or 504 pigs were stillborn (Table III). This generally agrees with the percentages for stillbirths in swine reported in the literature (Table I, page 4). However, in these data there was variation in the per cent stillborn when computed on a seasonal, age of dam and breed basis.

Season. Although an extensive examination of the literature revealed no reports on the effect of season on stillbirths, this study showed that there was a significantly higher number of stillborn pigs in litters born in the fall season than in the spring season ($P < .01$) (Table III).

Age of dam. The variation in the per cent stillborn pigs was more evident on this basis than on any other. In the five age of dam groups included, the per cent stillborn pigs ranged from a low of 3.99 per cent in the 1.5-year-old sows to a high of 15.09 per cent in the sows 3 years of age and older (Table IV). The 3 years and over age group had significantly more stillborn pigs per litter than the 1.5-year-old group ($P < .01$) and significantly more than the other three age groups ($P < .05$). Although the 2.5-year-old sows had significantly less

TABLE III

SUMMARY OF STILLBIRTHS AND CERTAIN OTHER LITTER TRAITS BY SEASON OF BIRTH IN THE AMES PLANTATION SWINE HERD, 1961 TO 1964

Season of birth	No. of litters	No. of pigs born	Avg. no. pigs per litter	Avg. birth weight[a] (lb.)	No.		Stillborn pigs						
							Total no.	%	No. per litter[b]	Males		Females	
					Males	Females				No.	%	No.	%
Spring	468	4,781	10.22	3.05	2,436	2,345	278	5.81	0.59	143	2.99	135	2.82
Fall	321	3,092	9.91	2.91	1,620	1,472	226	7.31	0.72	130	4.20	96	3.11
Total	780	7,873	10.09	3.00	4,056	3,817	504	6.40	0.65	273	3.47	231	2.93

[a]Spring > Fall ($P < .01$).

[b]Spring > Fall ($P < .05$).

TABLE IV

SUMMARY OF STILLBIRTHS AND CERTAIN OTHER LITTER TRAITS BY AGE OF DAM IN THE AMES PLANTATION SWINE HERD, 1961 TO 1964

Age of dam	No. of litters	No. of pigs born	Avg. no. pigs per litter[a]	Avg. birth weight[b] (lb.)	No.		Stillborn pigs						
							Total		No. per litter[c]	Males		Females	
					Males	Females	no.	%		No.	%	No.	%
1.0	393	3,465	8.82	2.85	1,764	1,701	167	4.82	0.43	90	2.60	77	2.22
1.5	167	1,730	10.36	3.10	887	843	69	3.99	0.41	35	2.02	34	1.97
2.0	107	1,276	11.93	3.19	687	589	81	6.35	0.76	48	3.76	33	2.59
2.5	48	562	11.71	3.06	297	265	56	9.96	1.17	26	4.63	30	5.34
3 and over	79	928	11.75	3.14	465	463	140	15.09	1.77	73	7.87	67	7.22

[a]Age of dam 2.0, 2.5 and 3 and over > Age of dam 1.0 and 1.5 ($P < .01$).

[b]Age of dam 1.5, 2.0, 2.5 and 3 and over > Age of dam 1.0 ($P < .01$).

[c]Age of dam 3 and over > Age of dam 2.5 ($P < .01$), Age of dam 3 and over > Age of dam 1.0, 1.5 and 2.0 ($P < .05$), Age of dam 2.5 > Age of dam 2.0 ($P < .05$), Age of dam 2.5 > Age of dam 1.0 and 1.5 ($P < .01$), Age of dam 2.0 > Age of dam 1.0 and 1.5 ($P < .01$).

stillborn pigs than the older sows ($P < .05$), they had a significantly greater number than sows 1.0 and 1.5 years of age ($P < .01$) and 2.0 years of age ($P < .05$).

The 2.0-year-old sows had fewer stillbirths per litter than the two sow groups of older age, but significantly more than the two sow groups of younger age, 1.0 and 1.5 years ($P < .01$). No difference was found in the 1.0- and 1.5-year-old sow groups (Table IV, page 31). These results agree with the conclusions of other workers that older sows tend to farrow more stillborn pigs (Carmichael and Rice, 1920; Robison, 1948; Braude, Clarke and Mitchell, 1954; and Kernkamp, 1965).

Breed. It has been reported in the literature (Lush, Shearer and Culbertson, 1939) that purebreds have a higher per cent stillborn pigs than crossbreds. The results of this study substantiate this report.

The two pure breeds included in this study, Hampshire and Duroc, had 9.94 and 10.48 per cent stillborn pigs, respectively (Table V). The combined average for the purebreds of 1.07 stillborn pigs per litter (10.22 per cent), was significantly more than the number of stillbirths for litters of either crossbred pigs from crossbred dams or crossbred pigs from purebred dams (Hampshire and Duroc) of 0.42 and 0.53 pigs per litter, respectively ($P < .01$).

No significant difference was found between the Hampshires, Durocs and the average of the purebreds (Hampshire + Duroc) or between the crossbred pigs from purebred dams and crossbred pigs from crossbred dams with respect to stillbirths.

TABLE V

SUMMARY OF STILLBIRTHS AND CERTAIN OTHER LITTER TRAITS BY BREED OF DAM AND BREED OF PIGS IN THE AMES PLANTATION SWINE HERD, 1961 TO 1964

Breed	No. of litters	No. of pigs born	Avg. no. pigs per litter[a]	Avg. birth weight (lb.)	No.		Stillborn pigs						
							Total no.	%	No. per litter[b]	Males		Females	
					Males	Females				No.	%	No.	%
Hampshire	113	1,157	10.24	2.96	580	577	115	9.94	1.02	60	5.19	55	4.75
Duroc	117	1,259	10.76	2.97	627	632	132	10.48	1.13	69	5.48	63	5.00
Purebred (H + D)	230	2,416	10.50	2.96	1,207	1,209	247	10.22	1.07	129	5.34	118	4.88
Purebred dams-Crossbred pigs	227	2,119	9.34	2.98	1,132	987	121	5.71	0.53	80	3.78	41	1.93
Crossbred dams-Crossbred pigs	323	3,338	10.33	3.03	1,717	1,621	136	4.07	0.42	74	2.21	62	1.86

[a]Hampshires, Durocs, Purebreds (H + D), Crossbred dams-crossbred pigs > Purebred dams-crossbred pigs ($P < .01$).

[b]Hampshires, Durocs, Purebreds (H + D)> Purebred dams-crossbred pigs and Crossbred dams-crossbred pigs ($P < .01$).

Size of litter. There were significant differences in average litter size at birth among the various age-of-dam groups. Sows 2.0, 2.5 and 3 years of age and older farrowed significantly larger litters than the younger sows ($P < .01$) (Table IV, page 31). Sows 2.0, 2.5 and 3 years of age and older also had a significantly higher number of stillbirths per litter ($P < .01$).

On a breed basis, however, no trends were evident since four of the breed groups were not significantly different in litter size, but were significantly different in the number of stillborn pigs per litter (Table V, page 33). The purebred groups, which had the highest stillbirth rates, were not significantly different in litter size from the breed group which had the lowest stillbirth rate, the crossbred litters from crossbred dams. Although statistical significance was absent, there was a trend for the groups with the larger litters to have more pigs born dead than those with smaller litters.

Generally, as the litter size increased the number of stillbirths per litter also increased. This substantiates the reports of Carmichael and Rice (1920), McPhee and Zeller (1934), Asdell and Willman (1941), the Veterinary Investigation Service (1959) and Pond et al. (1960).

Birth weight. The pigs included in this study had an average birth weight of 3.00 pounds calculated as the average of the litter averages. The average birth weight of the stillborn pigs calculated on the average weight of the stillborn pigs in the 279 litters which contained stillborn pigs was 2.20 pounds. The average birth weight

exceeded the birth weight of the stillborn pigs by 0.8 pound.

These data support the work of Carmichael and Rice (1920), Asdell and Willman (1941), Pond et al. (1960) and Fredeen and Plank (1963) who found that the birth weights of stillborn pigs averaged considerably less than the average of the pigs in their studies. While these data agree with the data of numerous workers that stillborn pigs generally weigh less than the average, McPhee and Zeller (1934) found that stillborn pigs were significantly heavier in weight than those born alive.

II. PREWEANING MORTALITY

Of the 7,873 pigs included in this study, 1,783, or 22.65 per cent, did not reach weaning age (Table VI). This overall percentage is in general agreement with the data reported by the Veterinary Investigation Service (1959) and Kernkamp (1965), 20.5 per cent preweaning mortality, and several of the less extensive surveys (Table II, page 10). There was considerable variation in mortality rates when determined and compared on a seasonal, age of dam and breed basis.

Season. Of the 4,781 pigs farrowed in the spring, 951 or 19.89 per cent of them died before reaching weaning age. Of the 3,092 fall farrowed pigs, 832 or 26.91 per cent were lost prior to weaning (Table VI). The fall farrowed pigs had a significantly higher preweaning death rate than spring farrowed pigs ($P < .01$). Because spring farrowed litters had a significantly higher number of pigs born, 10.22 compared with 9.91 for fall litters, and a significantly lower mortality rate,

TABLE VI

SUMMARY OF PREWEANING LOSSES AND CERTAIN OTHER LITTER TRAITS
BY SEASON OF BIRTH IN THE AMES PLANTATION SWINE HERD
1961 TO 1964

Season of birth	No. of litters	No. of pigs born	Avg. no. pigs per litter	Avg. birth weight[a] (lb.)	No.		Pigs dying birth to weaning				
							Total no.	%	No. per litter[b]	Per cent	
					Males	Females				Males	Females
Spring	468	4,781	10.22	3.05	2,436	2,345	951	19.89	2.03	10.58	9.31
Fall	321	3,092	9.91	2.91	1,620	1,472	832	26.91	2.67	14.52	12.39
Total	780	7,873	10.09	3.00	4,056	3,817	1,783	22.65	2.29	12.13	10.52

TABLE VI (continued)

Season of birth	Pigs at weaning								
				Males			Females		
	Total no.	%	No. pigs per litter[c]	Total no.	%	No. pigs per litter	Total no.	%	No. pigs per litter
Spring	3,830	80.11	8.18	1,930	40.37	4.12	1,900	39.74	4.06
Fall	2,260	73.09	7.24	1,171	37.87	3.75	1,089	35.22	3.49
Total	6,090	77.35	7.81	3,101	39.39	3.98	2,989	37.96	3.83

[a]Spring > Fall ($P < .01$).

[b]Fall > Spring ($P < .01$).

[c]Spring > Fall ($P < .01$).

2.30 pigs per litter as compared with 2.67 pigs per litter for fall litters, they had a higher number of pigs at weaning ($P < .01$).

This substantiates the work of Menzies-Kitchen (1937), Korkman (1947), Gonzalez-Chapel and Carlo (1954), Braude, Clarke and Mitchell (1954) and Pomeroy (1960a, 1960b) who reported that spring litters have lower mortality rates than fall litters. These data failed to agree with that of other workers, however, (Veterinary Medicine, 1930; Asdell and Willman, 1941; Kernkamp, 1943; Bowman, Bowland and Fredeen, 1961) who found that fall litters had a lower mortality rate than spring litters.

Age of dam. Including stillbirths, the sows 1.0-year-old lost 19.48 per cent of their pigs, while the oldest sows, those 3 years of age and over, lost 35.99 per cent (Table VII). The sows in the latter group had a significantly higher mortality rate in their pigs than the youngest sows and the other three groups, 1.5, 2.0 and 2.5 years ($P < .01$). In addition, the sows 2.0 and 2.5 years of age lost significantly more of their pigs prior to weaning than did the younger sows ($P < .01$).

Even though the youngest sows lost a lower percentage of their pigs before weaning, and conversely, raised a higher percentage, they still had fewer pigs at weaning than the other age groups. Therefore, it is misleading to examine only the percentage lost or raised.

The results of this study agree with previous research that preweaning losses increase with increasing age of dam from about the second litter (Olbrycht, 1943; Korkman, 1947; Braude, Clarke and

TABLE VII

SUMMARY OF PREWEANING LOSSES AND CERTAIN OTHER LITTER TRAITS BY AGE OF DAM IN THE AMES PLANTATION SWINE HERD, 1961 TO 1964

Age of dam	No. of Litters	No. of pigs born	Avg. no. pigs per litter[a]	Avg. birth weight[b] (lb.)	No.		Pigs dying birth to weaning				
							Total no.	%	No. per litter[c]	Per cent	
					Males	Females				Males	Females
1.0	393	3,465	8.82	2.85	1,764	1,701	675	19.48	1.72	10.48	9.00
1.5	167	1,730	10.36	3.10	887	843	348	20.12	2.08	10.00	10.12
2.0	107	1,276	11.93	3.19	687	589	308	24.14	2.88	14.26	9.88
2.5	48	562	11.71	3.06	297	265	153	27.22	3.19	14.94	12.28
3 and over	79	928	11.75	3.14	465	463	334	35.99	4.23	18.32	17.67

TABLE VII (continued)

	Pigs at weaning								
				Males			Females		
Age of dam	Total no.	%	No. pigs per litter[d]	Total no.	%	No. pigs per litter	Total no.	%	No. pigs per litter
1.0	2,788	80.46	7.09	1,401	40.43	3.57	1,387	40.03	3.52
1.5	1,382	79.88	8.28	713	41.21	4.27	669	38.67	4.01
2.0	968	75.86	9.05	565	44.28	4.72	403	31.58	4.33
2.5	409	72.78	8.52	213	37.90	4.44	196	34.88	4.08
3 and over	594	64.00	7.52	295	31.78	3.74	299	32.22	3.78

[a]Age of dam 2.0, 2.5 and 3 and over > Age of dam 1.0 and 1.5 ($P < .01$).

[b]Age of dam 1.5, 2.0, 2.5 and 3 and over > Age of dam 1.0 ($P < .01$).

[c]Age of dam 3 and over > Age of dam 1.0, 1.5, 2.0 and 2.5 ($P < .01$), Age of dam 2.0 and 2.5 > Age of dam 1.0 and 1.5 ($P < .01$).

[d]Age of dam 2.0 > Age of dam 1.5 ($P < .05$), Age of dam 2.0 > Age of dam 1.0 and 3 and over ($P < .01$), Age of dam 2.5 > Age of dam 3 and over ($P < .05$), Age of dam 1.5 > Age of dam 1.0 ($P < .01$), Age of dam 2.5 > Age of dam 1.0 ($P < .01$), Age of dam 1.5 > Age of dam 3 and over ($P < .05$).

Mitchell, 1954; Gracey, 1955; Pomeroy, 1960a). They are not in agreement, however, with the conclusion of most of these workers that there is a drop in mortality rate of pigs from age of dam 1.0 to 1.5 years.

Breed. Table VIII summarizes the preweaning losses on a breed basis. There was considerable variation in the mortality rates on this basis. Purebred Hampshires lost 34.09 per cent of their pigs, while the mortality rate among crossbred pigs from crossbred dams was 18.54 per cent.

The two purebred groups, Hampshires and Durocs, and the average of the two had mortality rates of 34.05, 27.16 and 30.46 per cent, respectively. None of the differences among these three groups were significant.

The crossbred pigs from purebred dams and the crossbred pigs from crossbred dams had preweaning mortality rates of 20.20 and 18.54 per cent, respectively, but the difference was not significant.

Crossbred pigs, both from crossbred and purebred dams, had significantly lower mortality rates prior to weaning than did either Hampshires or Durocs ($P < .01$). The fact the crossbreds have a greater ability to survive to weaning than purebreds has been reported in the literature by several workers (Lush, Shearer and Culbertson, 1939; Roberts and Carroll, 1939; Robison, 1948; and Gonzalez-Chapel and Carlo, 1954).

TABLE VIII

SUMMARY OF PREWEANING LOSSES AND CERTAIN OTHER LITTER TRAITS BY BREED OF DAM AND BREED OF PIGS IN THE AMES PLANTATION SWINE HERD, 1961 TO 1964

Breed	No. of litters	No. of pigs born	Avg. no. pigs per litter[a]	Avg. birth weight (lb.)	No.		Pigs dying birth to weaning				
							Total no.	%	No. per litter[b]	Per cent	
					Males	Females				Males	Females
Hampshire	113	1,157	10.24	2.96	580	577	394	34.05	3.49	18.15	15.90
Duroc	117	1,259	10.76	2.97	627	632	342	27.16	2.92	13.90	13.26
Purebred (H + D)	230	2,416	10.50	2.96	1,207	1,209	736	30.46	3.20	15.95	14.51
Purebred dams-Crossbred pigs	227	2,119	9.34	2.98	1,132	987	428	20.20	1.89	11.66	8.52
Crossbred dams-Crossbred pigs	323	3,338	10.33	3.03	1,717	1,621	619	18.54	1.92	9.73	8.81

TABLE VIII (continued)

Breed	Pigs at weaning								
				Males			Females		
	Total no.	%	No. pigs per litter[c]	Total no.	%	No. pigs per litter	Total no.	%	No. pigs per litter
Hampshire	763	65.95	6.75	370	31.98	3.27	393	33.97	3.48
Duroc	917	72.84	7.84	452	35.91	3.86	465	36.93	3.98
Purebred (H + D)	1,680	69.54	7.30	822	34.02	3.58	858	35.52	3.72
Purebred dams-Crossbred pigs	1,691	79.80	7.45	885	41.76	3.90	806	38.04	3.55
Crossbred dams-Crossbred pigs	2,719	81.46	8.42	1,392	41.70	4.32	1,327	39.76	4.10

[a]Hampshires, Durocs, Purebreds (H + D), Crossbred dams-crossbred pigs > Purebred dams-crossbred pigs ($P < .01$).

[b]Hampshires, Durocs, Purebreds (H + D) > Purebred dams-crossbred pigs and Crossbred dams-crossbred pigs ($P < .01$).

[c]Crossbred dams-crossbred pigs > Durocs ($P < .05$), Crossbred dams-crossbred pigs > Hampshires, Purebreds (H + D), Purebred dams-crossbred pigs ($P < .01$), Durocs > Hampshires ($P < .01$), Purebreds (H + D) and Purebred dams-crossbred pigs > Hampshires ($P < .05$).

Litter size. On an age of dam basis, sows 1.0 and 1.5 years old which had the smallest litter sizes at birth also had the lowest mortality rates, 19.48 and 20.12 per cent, respectively. Sows 2.0, 2.5 and 3 years of age and over which had larger litters at birth had higher pig mortality rates, 24.14, 27.22 and 35.99 per cent, respectively (Table VII, page 39).

On a breed basis, there was no trend toward larger litters having a higher preweaning mortality in the purehreds (Hampshire + Duroc) and the Hampshires and Durocs, but there were no significant differences in the litter sizes (Table VIII, page 42). Crossbred pigs from crossbred dams and crossbred pigs from purebred dams had significantly less mortality per litter than did the purebreds (Hampshire + Duroc) or the Hampshires or Durocs, but only the crossbred litters from purebred dams were significantly smaller in litter size.

Although spring farrowed litters were slightly larger, the difference in the average litter size for the two seasons was not significant. Mortality in fall farrowed litters was significantly greater, however, than in spring farrowed litters (19.89 vs. 26.91 per cent; $P < .01$). Difficulty exists, however, in making comparisons and definite statements on the basis of season of birth, breed or age of dam unless the comparisons or statements are directly about these groups since they are biased in the direction of the group basis.

Birth weight. Spring farrowed pigs had significantly higher birth weights and a significantly lower mortality rate to weaning than

fall farrowed pigs ($P < .01$) (Table VI, page 36). These data agree with the conclusions of other workers that pigs with higher birth weights have lower mortality rates (Winters, Cummings and Stewart, 1947; Pomeroy, 1960b; and Fredeen and Plank, 1963).

Sex. Of the total pigs born, 4,056 or 51.52 per cent were males (Table VI, page 36). Only a few more males than females died before weaning in accordance with the original predominance of males. These data are in agreement with those of Asdell and Willman (1941), Braude, Clarke and Mitchell (1954) and Pomeroy (1960b).

Differences were noted on a breed basis, however, as far as sex and mortality were concerned (Table VIII, page 42). At birth, the purebred litters contained 50.00 per cent males, crossbred litters from purebred dams contained 53.50 per cent males and the crossbred litters from crossbred dams contained 51.44 per cent males. At weaning, the crossbred litters from purebred dams and the crossbred litters from crossbred dams had slightly lower percentages of males, 52.33 and 51.19 per cent, respectively, as compared with 53.50 and 51.44 per cent at birth. However, the per cent purebred males was also lower at weaning (50.00 per cent) than at birth (48.83 per cent). The sex losses are shown as a per cent of the total pigs born in Table VI, page 36. These data agree with those of Carmichael and Rice (1920) and Cox (1960) which showed a greater predominance of male deaths in both crossbreds and purebreds. Cox (1960) also found that the difference in male and female mortality was twice as large in purebreds as in crossbreds.

III. PREWEANING LOSSES DURING VARIOUS PERIODS FROM BIRTH TO WEANING

Table IX presents a summary of the pig losses that occurred during various periods from birth to weaning on a season of birth and total basis.

Of the 7,873 pigs born, 845 or 10.73 per cent died during the first 14 days of their life. These losses and those stillborn (1,349 pigs) were 17.13 per cent of the total number born and 75.65 per cent of the total losses.

An additional 227 pigs, or 2.88 per cent of the total born, died from the 15th through the 28th day of their life. This accounted for 12.73 per cent of the total lost from birth to weaning.

In the second month post-parturition, 207 more pigs were lost. This was 2.63 per cent of the total pigs born and 11.61 per cent of the total pigs lost.

These findings support the work of Severson (1925) who found that 78.1 per cent of the pigs he examined died in the first 14 days of their life and another 10.00 per cent in the period from 15 to 28 days of life. They are also in harmony with those of Kernkamp (1943) who reported that 81.0 per cent of the death losses in pigs occurred in the first 2 weeks of life. In addition, these data agree with the conclusions of other workers that the majority of the death losses occur in the early part of life even though many of the reports of death losses were based on time periods other than those used in this study.

TABLE IX

SUMMARY OF PREWEANING LOSSES DURING VARIOUS PERIODS FROM BIRTH TO WEANING AND CERTAIN OTHER LITTER TRAITS BY SEASON OF BIRTH IN THE AMES PLANTATION SWINE HERD, 1961 TO 1964

Season of birth	No. of litters	No. of pigs born	Avg. no. pigs per litter	Avg. birth weight[a] (lb.)	No.		Stillborn pigs						
							Total no.	%	No. per litter[b]	Males		Females	
					Males	Females				No.	%	No.	%
Spring	468	4,781	10.22	3.05	2,436	2,345	278	5.81	0.59	143	2.99	135	2.82
Fall	312	3,092	9.91	2.91	1,620	1,472	226	7.31	0.72	130	4.20	96	3.11
Total	780	7,873	10.09	3.00	4,056	3,817	504	6.40	0.65	273	3.47	231	2.93

TABLE IX (continued)

Season of birth	Pigs dying 0-14 days of age					Pigs dying 15-28 days of age					Pigs dying 29 days-weaning		
	Total no.	%	No. per litter[b]	Per cent Males	Per cent Females	Total no.	%	No. per litter	Per cent Males	Per cent Females	Total no.	%	No. per litter
Spring	469	9.81	1.00	5.27	4.54	122	2.55	0.26	1.38	1.17	82	1.72	0.18
Fall	376	12.16	1.21	5.89	6.27	105	3.40	0.34	2.04	1.36	125	4.04	0.40
Total	845	10.73	1.08	5.51	5.22	227	2.88	0.29	1.64	1.24	207	2.63	0.27

TABLE IX (continued)

Season of birth	Pigs dying 29 days-weaning: Per cent Males	Pigs dying 29 days-weaning: Per cent Females	Pigs dying birth-weaning: Total no.	Pigs dying birth-weaning: %	Pigs dying birth-weaning: No. per litter[c]	Pigs dying birth-weaning: Per cent Males	Pigs dying birth-weaning: Per cent Females	Pigs at weaning: Total no.	Pigs at weaning: %	Pigs at weaning: No. per litter[a]	Pigs at weaning: Males No.	Pigs at weaning: Males %	Pigs at weaning: Females No.	Pigs at weaning: Females %
Spring	0.94	0.78	951	19.89	2.03	10.58	9.31	3,830	80.11	8.18	1,930	40.37	1,900	39.74
Fall	2.39	1.65	832	26.91	2.67	14.52	12.39	2,260	73.09	7.24	1,171	37.87	1,089	35.22
Total	1.51	1.12	1,783	22.65	2.27	12.13	10.52	6,090	77.35	7.81	3,101	39.39	2,989	37.96

[a]Spring > Fall ($P < .01$).

[b]Spring > Fall ($P < .05$).

[c]Fall > Spring ($P < .01$).

Season. Although a significant difference between seasons (fall > spring; $P < .01$) was observed in the number of pigs per litter lost prior to weaning, the trends were similar for both spring and fall (Table IX, page 47) in respect to periods during which the losses occurred. Of the 4,781 pigs farrowed in the spring, 9.81 per cent or 469 pigs, died within 14 days of birth, while 12.16 per cent or 376 of the 3,092 fall farrowed pigs were lost during the same period. During the period from 15 to 28 days after birth, the death losses in spring farrowed litters were 2.55 per cent, or 122 of 4,781 pigs farrowed, and 3.40 per cent or 105 of the 3,092 pigs in fall farrowed litters. In the month prior to weaning at about 56 days of age, the mortality of pigs in fall litters was higher (4.04 per cent) than in the spring farrowed litters (1.72 per cent).

Age of dam. When the ages at which the preweaning losses occurred were examined on an age of dam basis, the data showed that the oldest sows, those 3 years of age and older, lost a larger number of their pigs than did the youngest sows, those 1.0 year old, in the 2 weeks immediately post-parturition ($P < .01$; Table X). The oldest sows also lost more pigs than the other age groups in this same period ($P < .01$). In addition, the sows 2.0 years old lost significantly more pigs than those 0.5 year younger or older ($P < .05$). With the exception of the sows 2.0 years of age, there was a trend toward greater death losses of pigs with increasing age of the sow during the period from birth to 14 days of age.

TABLE X

SUMMARY OF PREWEANING LOSSES DURING VARIOUS PERIODS FROM BIRTH TO WEANING AND CERTAIN OTHER LITTER TRAITS BY AGE OF DAM IN THE AMES PLANTATION SWINE HERD, 1961 TO 1964

Age of dam	No. of litters	No. of pigs born	Avg. no. pigs per litter[a]	Avg. birth weight[b] (lb.)	No.		Stillborn pigs						
							Total no.	%	No. per litter[c]	Males		Females	
					Males	Females				No.	%	No.	%
1.0	393	3,465	8.82	2.85	1,764	1,701	167	4.82	0.43	90	2.60	77	2.22
1.5	167	1,730	10.36	3.10	887	843	69	3.99	0.41	35	2.02	34	1.97
2.0	107	1,276	11.93	3.19	687	589	81	6.35	0.76	48	3.76	33	2.59
2.5	48	562	11.71	3.06	297	265	56	9.96	1.17	26	4.63	30	5.34
3 and over	79	928	11.75	3.14	465	463	140	15.09	1.77	73	7.87	67	7.22

TABLE X (continued)

Age of dam	Pigs dying 0-14 days of age					Pigs dying 15-28 days of age					Pigs dying 29 days-weaning		
	Total no.	%	No. per litter[d]	Per cent Males	Per cent Females	Total no.	%	No. per litter	Per cent Males	Per cent Females	Total no.	%	No. per litter[e]
1.0	261	7.53	0.66	3.98	3.55	104	3.00	0.27	1.67	1.33	137	3.95	0.35
1.5	201	11.62	1.20	5.49	6.13	42	2.43	0.25	1.50	0.93	36	2.08	0.22
2.0	171	13.40	1.60	8.07	5.33	38	2.98	0.36	1.33	1.65	18	1.41	0.17
2.5	70	12.46	1.46	7.12	5.34	18	3.20	0.38	1.78	1.42	9	1.60	0.19
3 and over	159	17.13	2.01	8.08	9.05	23	2.48	0.29	1.51	0.97	12	1.29	0.15

TABLE X (continued)

Age of dam	Pigs daying 29 days-weaning		Pigs dying birth-weaning					Pigs at weaning						
	Per cent		Total		No. per	Per cent		Total		No. per	Males		Females	
	Males	Females	no.	%	litter[f]	Males	Females	no.	%	litter[g]	No.	%	No.	%
1.0	2.25	1.70	675	19.48	1.72	10.48	9.00	2,788	80.46	7.09	1,401	40.43	1,387	40.03
1.5	1.04	1.04	348	20.12	2.08	10.00	10.12	1,382	79.88	8.28	713	41.21	669	38.67
2.0	0.86	0.55	308	24.14	2.88	14.26	9.88	968	75.86	9.05	565	44.28	403	31.58
2.5	1.42	0.18	153	27.22	3.19	14.94	12.28	409	72.78	8.52	213	37.90	196	34.88
3 and over	0.86	0.43	334	35.99	4.23	18.32	17.67	594	64.00	7.52	295	31.78	299	32.22

[a]Age of dam 2.0, 2.5 and 3 and over > Age of dam 1.0 and 1.5 ($P < .01$).

[b]Age of dam 1.5, 2.0, 2.5 and 3 and over > Age of dam 1.0 ($P < .01$).

[c]Age of dam 3 and over > Age of dam 2.5 ($P < .01$), Age of dam 2.5 > Age of dam 1.0, 1.5 ($P < .01$), Age of dam 2.0 > Age of dam 1.0 and 1.5 ($P < .01$), Age of dam 3 and over > Age of dam 1.0, 1.5, 2.0 ($P < .05$), Age of dam 2.5 > Age of dam 2.0 ($P < .05$).

[d]Age of dam 3 and over > Age of dam 1.0, 1.5, 2.0 and 2.5 ($P < .01$), Age of dam 2.0 > Age of dam 1.5, 2.5 ($P < .05$), Age of dam 2.0 > Age of dam 1.0 ($P < .01$), Age of dam 1.5, 2.5 > Age of dam 1.0 ($P < .01$).

[e]Age of dam 1.0 > Age of dam 2.0 and 3 and over ($P < .05$).

[f]Age of dam 3 and over > Age of dam 1.0, 1.5, 2.0 and 2.5 ($P < .01$), Age of dam 2.0 and 2.5 > Age of dam 1.0, 1.5 ($P < .01$).

[g]Age of dam 2.0 > Age of dam 1.5 ($P<.05$), Age of dam 2.0 > Age of dam 1.0 and 3 and over ($P < .01$), Age of dam 2.5 > Age of dam 3 and over ($P < .05$), Age of dam 2.5 > Age of dam 1.0 ($P < .01$), Age of dam 1.5 > Age of dam 3 and over ($P < .05$), Age of dam 1.5 > Age of dam 1.0 ($P < .01$).

No definite trends were noted in the period from 15 to 28 days of age in respect to death losses in pigs as related to age of dam. The sows 1.0 year old had the lowest death losses in their pigs in the 14-day period immediately after birth, but had the second highest loss, 3.00 per cent or 0.27 pigs per litter, in the period from 15 to 28 days after birth. The oldest sows (3 years of age and older) had the second lowest death losses in their litters in this time period, but had the highest losses in the previous period. The differences were not statistically significant, however.

In the 28-day period immediately prior to weaning, the sows 3 years of age and older lost the least number of pigs per litter, 0.15, while the youngest sows (1.0 year old) lost the greatest number of pigs per litter, 0.35. The sows 1.5, 2.0 and 2.5 years old lost 0.22, 0.17 and 0.19 pigs per litter, respectively, during this period. Differences between sows 1.0 year of age and those 2.0 and 3 years of age and over were statistically significant.

On the basis of the total pigs lost, the number of pigs lost per litter increased with age of dam. Sows 3 years of age and over lost significantly more pigs per litter than those in the younger groups, and the sows 2.0 and 2.5 years of age lost significantly more pigs than the sows 1.0 and 1.5 years of age ($P < .01$) (Table X, page 51).

Breed. Table XI summarizes the death losses which occurred during various periods on the basis of breed.

TABLE XI

SUMMARY OF PREWEANING LOSSES DURING VARIOUS PERIODS FROM BIRTH TO WEANING AND CERTAIN OTHER LITTER TRAITS BY BREED OF DAM AND BREED OF PIGS IN THE AMES PLANTATION SWINE HERD, 1961 TO 1964

Breed	No. of litters	No. of pigs born	Avg. no. pigs per litter[a]	Avg. birth weight (lb.)	No.		Stillborn pigs						
							Total no.	%	No. per litter[b]	Males		Females	
					Males	Females				No.	%	No.	%
Hampshire	113	1,157	10.24	2.96	580	577	115	9.94	1.02	60	5.19	55	4.75
Duroc	117	1,259	10.76	2.97	627	632	132	10.48	1.13	69	5.48	63	5.00
Purebred (H + D)	230	2,416	10.50	2.96	1,207	1,209	247	10.22	1.07	129	5.34	118	4.88
Purebred dams-Crossbred pigs	227	2,119	9.34	2.98	1,132	987	121	5.71	0.53	80	3.78	41	1.93
Crossbred dams-Crossbred pigs	323	3,338	10.33	3.03	1,717	1,621	136	4.07	0.42	74	2.21	62	1.86

TABLE XI (continued)

Breed	Pigs dying 0-14 days of age					Pigs dying 15-28 days of age					Pigs dying 29 days weaning		
	Total no.	%	No. per litter[c]	Per cent Males	Per cent Females	Total no.	%	No. per litter[d]	Per cent Males	Per cent Females	Total no.	%	No. per litter[e]
Hampshire	178	15.38	1.58	7.60	7.78	57	4.93	0.50	3.11	1.82	44	3.80	0.39
Duroc	153	12.15	1.31	6.11	6.04	24	1.91	0.21	0.88	1.03	33	2.62	0.28
Purebred (H + D)	331	13.70	1.44	6.83	6.87	81	3.55	0.35	1.95	1.40	77	3.19	0.33
Purebred dams-Crossbred pigs	183	8.64	0.81	4.39	4.25	66	3.11	0.29	1.79	1.32	58	2.74	0.26
Crossbred dams-Crossbred pigs	331	9.22	1.02	5.12	4.80	80	2.40	0.25	1.35	1.05	72	2.16	0.22

TABLE XI (continued)

Breed	Pigs dying 29 days-weaning: Per cent Males	Pigs dying 29 days-weaning: Per cent Females	Pigs dying birth-weaning: Total no.	Pigs dying birth-weaning: %	Pigs dying birth-weaning: No. per litter[f]	Pigs dying birth-weaning: Per cent Males	Pigs dying birth-weaning: Per cent Females	Pigs at weaning: Total no.	Pigs at weaning: %	Pigs at weaning: No. per litter[g]	Pigs at weaning: Males No.	Pigs at weaning: Males %	Pigs at weaning: Females No.	Pigs at weaning: Females %
Hampshire	2.25	1.55	394	34.05	3.49	18.15	15.90	763	65.95	6.75	370	31.98	393	33.97
Duroc	1.74	0.88	342	27.16	2.92	13.90	13.26	917	72.84	7.84	452	35.91	465	36.93
Purebred (H + D)	1.99	1.20	736	30.46	3.20	15.95	14.51	1,680	69.54	7.30	822	34.02	858	35.52
Purebred dams-Crossbred pigs	1.70	1.04	428	20.20	1.89	11.66	8.54	1,691	79.80	7.45	885	41.76	806	38.04
Crossbred dams-Crossbred pigs	1.05	1.11	619	18.54	1.92	9.73	8.81	2,719	81.46	8.42	1,392	41.70	1,327	39.76

[a]Hampshires, Durocs, Purebreds (H + D), Crossbred dams-crossbred pigs > Purebred dams-crossbred pigs ($P < .01$).

[b]Hampshires, Durocs, Purebreds (H + D)> Purebred dams-crossbred pigs, Crossbred dams-crossbred pigs ($P < .01$).

[c]Hampshires, Purebreds (H + D) > Purebred dams-crossbred pigs, Crossbred dams-crossbred pigs ($P < .01$), Durocs > Purebred dams-crossbred pigs ($P < .05$).

[d]Hampshires > Purebred dams-crossbred pigs, Purebreds (H + D) ($P < .05$), Hampshires > Durocs, Crossbred dams-crossbred pigs ($P < .01$).

[e]Hampshires > Crossbred dams-crossbred pigs ($P < .05$).

[f]Hampshires, Durocs, Purebreds (H + D) > Purebred dams-crossbred pigs, Crossbred dams-crossbred pigs ($P < .01$).

[g]Crossbred dams-crossbred pigs > Durocs ($P < .05$), Crossbred dams-crossbred pigs > Hampshire, Purebreds (H + D), Purebred dams-crossbred pigs ($P < .01$), Durocs > Hampshires ($P < .01$), Purebreds (H + D), Purebred dams-crossbred pigs > Hampshires ($P < .05$).

During the first 14 days of life, the mortality in purebred pigs (Hampshire + Duroc) was greater than the mortality in crossbred pigs, regardless of whether their dam was purebred or crossbred ($P < .01$). From 15 to 28 days of age, purebred pig losses per litter were greater than the losses of the crossbred pigs from purebred dams and crossbred pigs from crossbred dams, but the differences were not significant.

In the month preceding weaning, the trend was the same. More purebred pigs per litter were lost than the crossbred pigs from either crossbred or purebred dams. Only the Hampshire lost significantly more pigs per litter than the crossbred pigs from crossbred dams and the other differences were not significant.

As previously noted, by the time of weaning both Hampshires, Durocs and these two as a group had lost significantly more pigs per litter than the crossbred pigs from crossbred dams and purebred dams ($P < .01$).

CHAPTER V

SUMMARY AND CONCLUSIONS

This study was conducted to determine the percentage of stillbirths, the preweaning mortality rate from birth to weaning and some factors which influence these in a herd of swine. The data were taken from the records of an extended swine breeding project at Ames Plantation and included seven farrowing seasons, beginning with the spring of 1961, and continuing through the spring of 1964.

Of the 7,873 pigs born during the period included in the study, 6.40 per cent were stillborn. There was a significantly higher number of stillbirths in the fall farrowed litters than the spring farrowed litters ($P < .01$). Sows 3 years of age and older had significantly more stillborn pigs than sows 1.0, 1.5, 2.0 and 2.5 years of age ($P < .05$). Sows 2.5 years of age had more stillbirths than the three younger sow groups ($P < .05$). Sows 1.0 and 1.5 years of age did not differ significantly in the number of stillbirths per litter. Crossbred litters from either crossbred or purebred dams had significantly less stillbirths than the Hampshires, Durocs or their average ($P < .01$). As the litter size increased, the percentage of stillbirths also increased on an age of dam basis. The stillborn pigs averaged less in weight at birth than the average of all pigs born.

The preweaning mortality rate was 22.65 per cent for all pigs born. Pig losses in fall litters were 26.91 per cent and this was

significantly greater than the mortality rate of 19.89 per cent in the spring litters. There was an increase in mortality rate with age of dam. Preweaning losses in Hampshires and Durocs were greater than the losses in crossbred pigs from either crossbred dams or purebred dams. Spring farrowed litters had higher average pig birth weights and lower mortality rates than fall litters ($P < .01$). On the basis of the total number of pigs, there was no great sex difference in mortality rates, but the males had a greater predominance of deaths than the original predominance of males over females in all breed groups.

Of the 7,873 pigs born, 6.40 per cent were stillborn, 10.73 per cent died during 0-14 days of age, 2.88 per cent died from 15-28 days of age and 2.63 per cent died from 29 days of age to weaning. The pig losses during the various periods from birth to weaning computed on a season of birth, age of dam and breed basis were similar to those observed on the total pig basis.

LITERATURE CITED

LITERATURE CITED

Anon. 1930. Survey: Dept. of Agr. in Indiana, Iowa, and Illinois. Vet. Med. 25:178.

Asdell, S. A. and J. P. Willman. 1941. The causes of stillbirth in swine and an attempt to control it. J. Agr. Res. 63:345.

Aubel, C. E., J. S. Hughes and H. F. Leinhardt. 1932. A study of mortality among young pigs--the influence of wheat-germ meal on the reproduction and suckling of pigs. Kansas Agr. Exp. Sta. Tech. Bul. 31.

Bowman, G. H., J. P. Bowland and H. T. Fredeen. 1961. An appraisal of certain sources of environmental variation in the productivity of Yorkshire sows. Can. J. Animal Sci. 41:220.

Braude, R., P. M. Clarke and K. G. Mitchell. 1954. Analysis of the breeding records of a herd of pigs. J. Agr. Sci. 45:19.

Carmichael, W. J. and John B. Rice. 1920. Variations in farrow: with special reference to the birth weight of pigs. Ill. Agr. Exp. Sta. Bul. 226.

Cox, D. F. 1960. The relation between sex and survival in swine. J. Heredity 51:284.

Duncan, D. B. 1955. Multiple range and multiple F tests. Biometrics 11:1.

Edwards, B. L. 1963. Starvation in new-born pigs. J. of Ministry of Agr., Fisheries and Food 70:220.

Ensminger, M. E. 1960. Animal Science (4th ed.). The Interstate Printers and Publishers, Inc., Danville, Illinois.

Fredeen, H. T. and R. N. Plank. 1963. Litter size and pre- and post-weaning performance in swine. Can. J. Animal Sci. 43:135.

Godbey, E. G. and W. C. Godley. 1961. Effects of inbreeding and other factors and weights, measurements and mortality of pigs. S. C. Agr. Exp. Sta. Tech. Bul. 1004.

Gonzalez-Chapel, A. and Ismal Carlo. 1954. Control of factors increasing preweaning mortality in swine in Puerto Rice. J. Agr. Univ. Puerto Rico 38:205.

Gracey, J. F. 1955. Survey of pig losses. Vet. Rec. 67:984.

Hetzer, H. O., W. V. Lambert and J. H. Zeller. 1940. Influence of inbreeding and other factors on litter size in Chester White swine. U. S. D. A. Circ. 570.

Hutchinson, H. D., S. W. Terrill, C. C. Morrill, H. W. Norton, R. J. Meade, A. H. Jensen and D. E. Becker. 1954. Causes of baby pig mortality. J. Animal Sci. 13:1023. (Abstr.)

Jordao, L. P. 1946. Leitoes nati-mortos. Bol. Soc. Paulista Med. Vet. 7:204 (cited in Biol. Abstr. 24:30448).

Keith, T. B. 1930. Relation of size of swine litters to age of dam and to size of succeeding litters. J. Agr. Res. 41:593.

Kernkamp, H. C. H. 1943. Pig mortality. Report of the 47th Annual Meeting U. S. Livestock Sanitary Assn., 1943:87.

Kernkamp, H. C. H. 1965. Birth and death statistics on pigs of pre-weaning age. J. Am. Vet. Med. Assn. 146:337.

Korkman, Nils. 1947. Causes of variation in the size and weight of litters from sows. Acta Agr. Suecana 2:253.

Kramer, Clyde Y. 1957. Extension of multiple range tests to group correlated adjusted means. Biometrics 13:13.

Lerner, Elmer H., D. T. Mayer and John F. Lasley. 1957. Early embryonic mortality in strain crossed gilts. Mo. Agr. Exp. Sta. Res. Bul. 629.

Lush, J. L., P. S. Shearer and C. C. Culbertson. 1939. Crossbreeding hogs for pork production. Iowa Agr. Exp. Sta. Bul. 380.

McPhee, Hugh C. and John H. Zeller. 1934. The stillborn pig. J. Am. Vet. Med. Assn. 85:224.

Menzies-Kitchen, A. W. 1937. Fertility, mortality and growth rate in pigs. J. Agr. Sci. 27:611.

Morris, H. P. and Don W. Johnson. 1932. Effects of nutrition and heredity upon litter size in swine and rats. J. Agr. Res. 44:511.

Olbrycht, T. M. 1943. The statistical basis of selection in animal husbandry. II. Studies on life performance of brood sows: the judging of brood sows by their number of offspring born and reared in the earliest litters. J. Agr. Sci. 33:74.

Pomeroy, R. W. 1960a. Infertility and neonatal mortality in the sow. I. Lifetime performance and reasons for disposal of sows. J. Agr. Sci. 54:1.

Pomeroy, R. W. 1960b. Infertility and neonatal mortality in the sow. III. Neonatal mortality and fetal development. J. Agr. Sci. 54:31.

Pond, W. G., S. J. Roberts, J. A. Dunn and J. P. Willman. 1960. Late embryonic mortality and stillbirths in three breeds of swine. J. Animal Sci. 19:881.

Rathnasabapathy, V., J. F. Lasley and D. T. Mayer. 1956. Genetic and environmental factors affecting litter size in swine. Mo. Agr. Exp. Sta. Res. Bul. 615.

Roberts, E. and W. E. Carroll. 1939. A study of hybrid vigor in a cross between Poland China and Duroc Jersey swine. J. Agr. Res. 59:847.

Robinson, John S. and Joe W. Houston. 1958. More money from hogs. Tenn. Agr. Ext. Service Publication 391.

Robison, W. L. 1948. Crossbreeding for the production of market hogs. Ohio Agr. Exp. Sta. Bul. 675.

Saunders, C. N. 1958. Abortion and stillbirths in pigs--an analysis of 67 outbreaks. Vet. Rec. 70:965.

Severson, Albert. 1925. Prolificacy of sows and mortality of pigs. Proceedings of American Society of Animal Production Annual Meeting 1925:60.

Snedecor, George W. 1947. An experiment in the collection of morbidity and mortality data on farm animals. Report of the 51st Annual Meeting U. S. Livestock Sanitary Assn., 1947:218.

Squires, C. D., G. E. Dickerson and D. T. Mayer. 1952. Influence of inbreeding, age and growth rate of sows on sexual maturity, rate of ovulation, fertilization and embryonic survival. Mo. Agr. Exp. Sta. Res. Bul. 494.

Stewart, H. A. 1945. An appraisal of factors affecting prolificacy in swine. J. Animal Sci. 4:250.

Veterinary Investigation Service, Ministry of Agr., Fisheries and Food. 1959. A survey of the incidence and causes of mortality in pigs. I. Sow survey. Vet. Rec. 71:777.

Winters, L. M., J. N. Cummings and H. A. Stewart. 1947. A study of factors affecting survival from birth to weaning and total weaning weight of the litter in swine. J. Animal Sci. 6:288.