THE EFFECTS OF PASTURE VS. CONFINEMENT REARING ON REPRODUCTIVE PERFORMANCE OF GILTS

by

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INTRODUCTION

Extensive investigations have been conducted to determine the effects of confinement on growing-finishing swine, but very little work has been done to evaluate the effects of lifetime confinement on reproductive performance. With an increasing number of swine producers maintaining their brood sows and boars in complete confinement in order to more efficiently utilize their resources, there are a number of problems which may arise that could offset these gains. Among these problems are the already present detrimental foot and leg conditions brought on by concrete floors and delayed onset of estrus observed in gilts while in confinement. Other factors which may affect a confinement breeding operation are age at puberty, longevity, breeding and rebreeding problems, litter size, and subsequent reproductive performance of offspring.

Although there have been reports of producers maintaining their breeding stock in confinement with much success (Watkins, 1968), there has been little designed research to investigate this procedure under controlled experimental conditions. It therefore seemed desirable to find what effects such a procedure might have on the reproductive performances of gilts reared in confinement.

REVIEW OF LITERATURE

Puberty

Wiggins et al. (1950) found that season of birth has an effect on sexual development in gilts. They found that a highly significant percentage of fall farrowed gilts reached puberty at an earlier age than did spring farrowed gilts. Robertson (1951) reported that gilts farrowed later in the spring farrowing season tended to reach puberty at an earlier age. He also reported that the age at puberty for pasture reared gilts ranged from 167 to 250 days with a mean of 201 days. The weight at puberty had a mean of 195 lb. Wise et al. (1953) found that date of birth in the farrowing season was not associated with age at puberty. Sorensen (1961) reported that the average age at puberty of gilts reared on pasture was about 210 days.

Hafez (1963) related that social environment, living space, associates, and stressors may affect puberty or the onset of the sexual season. Goode et al. (1965) reported that the average age at puberty in low and high energy groups was 290±48 days, which they recognized as somewhat higher than most other authors had reported.

In recent work dealing with confinement rearing of gilts, the authors have not reported any ages at puberty. Miller and Cutright (1966) and England (1968) have only reported that the first estrus was delayed somewhat in gilts reared in confinement.

Reproductive Performance

Wingert and Nelson (1964) reported a study of the reproductive performance of swine on pasture vs. concrete using 88 gilt and 92 sow farrowings. They found that the pasture group had a higher average conception rate (87.1% vs. 83.6%) and a slightly lower average litter size born alive (11.59 vs. 11.77). The average preweaning mortality markedly favored the pasture group with 15.70% while the concrete group had 19.53%.

Miller and Cutright (1966) ran three trials with sows and gilts in complete confinement or in a semi-confinement building. The semi-confinement building was arranged so that each sow or gilt had the same amount of floor space inside as the complete confinement gilts (25 sq. ft.), plus an additional 50 sq. ft. runway outside. No conclusions were drawn from the first trial as the numbers involved were too small. However, in the second trial there were significant differences in favor of the complete confinement group regarding number of pigs per litter (13 vs. 10), and pigs weaned per litter (10 vs. 8). As would be expected, the semi-confinement group had a significantly higher average birth weight (2.95 vs. 2.62). There were no differences in the third trial. There were also significant differences between the numbers of gilts and sows mating in complete confinement and semi-confinement in the second and third trials. Only 18 of 29 in the complete confinement group were bred while 24 of 27 in the semi-confinement group were bred. They also observed that gilts did not mate well while in confinement. Estrus was checked for 23 days with only 16 of 44 gilts exhibiting estrus and mating. Symptoms of estrus were evident but they would not stand. Once a confinement gilt had a litter she would breed again in confinement just as easily as the semi-confinement gilts. Other observations on unsound feet and legs showed no differences due to treatment.

Turner (1966) stated that some animals exhibit a quiet heat. These animals may show all the anatomical and physiological alterations of typical estrus, including ovulation, but sexual receptivity is lacking. It may be that such animals are not producing enough estrogen or there is an imbalance of estrogen and progesterone inhibiting psychological heat.

MacNair (1967), reporting on work done in England, observed that in confinement, foot injuries and inability to reproduce appeared to be no more of a problem than in any other large sow unit. MacNair was working with sows tethered with a collar. He believes that this type of operation could be a management aid to increased reproductive efficiency. Jensen (1968), in an experiment using trio littermates, tethering one, placing the second in a small group in close confinement in the same building, and placing the third in an outside lot, arrived at the same conclusion. There were no significant differences among treatments insofar as conception rates, ovulation rates and number of live embryos at 20 days are concerned. There is a trend toward larger numbers of live embryos per gilt from the outside gilt; however, none of these gilts were carried through gestation.

England (1968) also maintains that swine in confinement will reproduce just as well as those in pastures or drylots. Confined sows come in heat regularly, breed and conceive normally, and farrow litters of the usual number. Confined gilts, however, show some delay or failure in coming into heat for the first breeding. In agreement with other authors, he found that after gilts were bred and farrowed one time, they had a normal reproductive pattern. Of 68 gilts, 12% failed to come in heat and another 10% was slow to come in heat.

Ulberg *et al*. (1951) and Baker *et al*. (1953) stated that the alteration of only one hormone (progesterone) will inhibit estrus, increase the incidence of cysts, and cause lower fertility at the first post-treatment estrus. Self and Grummer (1958) found that as weaning age of the litter increases from 1 to 56 days of age, a progressively shorter period of time is required for sows to exhibit estrus following weaning of their litters. Likewise, weaning earlier than 56 days of age resulted in decreased efficiency of sow reproduction. They observed that it took an average of 9.4, 6.25, and 4.0 days to return to heat for 10, 21, and 56-day weanings, respectively. They also found a complete cystic condition in 2 of 10 sows whose pigs were weaned at 10 days of age. They postulated that this indicated an improper hormone output or balance.

Blood Analysis

Coffin (1947), Miller (1960), Benjamin (1961), and Schalm (1965) state that inflammatory diseases, tissue destruction, hypercholesterolemia, and pregnancy will increase sedimentation rate. According to Coffin (1947) blood sedimentation is caused by rouleaux formation. Coffin also states that during pregnancy there is an increase in sedimentation rate after the first trimester with a return to normal values the first few weeks after delivery. Other factors which the above authors state will increase sedimentation rate are decreased number of red blood cells and reduced amounts of anticoagulant. Factors which may decrease sedimentation rate are an increased number of red blood cells, an increase in the time between bleeding and performing the test, and large amounts of anticoagulant. Miller (1960) relates that in uncomplicated hypertension and nutritional deficiency states, sedimentation rate may not be altered. Benjamin (1961) states that the type of anticoagulant used will not affect sedimentation rate.

Benjamin (1961) gives a normal value of 0 to 6 mm. over a 30 minute time period for the sedimentation rate in normal, mature swine. Schalm (1965) however, states that much higher values can be anticipated in normal swine. He gives average values of 26, 7, 20, 21, and 35 mm. per 30 minutes for the non-pregnant; pregnant 3 to 8 weeks, pregnant 2.5 to 3.5 months, 2 weeks or less before parturition, and 15 to 49 days post partum sow, respectively.

Miller (1960) and Benjamin (1961) state that the hematocrit is one of the most accurate and simple methods for the detection of anemia and is a good index of circulating hemoglobin. Benjamin (1961) and Schalm (1965) give an average value of 42% for the normal, mature, sow. Schalm's average hematocrit values for the same time periods are discussed above for sedimentation rates were 38, 33, 42, 40, and 32%, respectively. Both of the above mentioned authors (Benjamin and Schalm) were using the Wintrobe method. Kornegay (1967) found that daily and twice daily blood sampling of weanling pigs decreased packed cell volume (PCV). He found that neither handling nor puncture of the vena cava without removal of blood had any effect on PCV. He also stated that the depleted erythrocyte volume could take days or even weeks to be replaced. Guyton (1966) states that an increase in mineralocorticoid (corticosterone) secretion will increase blood volume, thereby lowering the hematocrit.

Kleiner (1951) and Benjamin (1961) state that excitement, pain, and other emotional distrubances will tend to raise blood glucose level. Miller (1960), and Benjamin (1961) state that overactivity of the adrenal cortex and the anterior pituitary may also result in hyperglycemia. Other factors which Benjamin (1961) states will elevate blood glucose are: elevated cholesterol, some acute infections, cold stress, and epinephrine. Guyton (1966) states that the mechanism by which epinephrine operates is so powerful that it can raise blood glucose concentrations by 15 mg. percent each minute.

Work dealing with blood corticosterone levels as an estimator of stress has been limited. However, Colmano et al. (1967) have conducted several experiments using chickens and pigs in which they defined stress physiologically as the determinant of ACTH production detectable as blood plasma corticosterone measurable fluorometrically. In one of the control experiments chickens that were injected with ACTH reacted as if they had been stressed. With each degree of stress shown, the blood plasma level of corticosterone increased. However, in birds that were challanged with E. coli and became sick, the corticosterone levels were lower than in the well birds. In another experiment in which there was a control group (C), a moved group (M), which was moved about within a resident (R) group, and an isolated (I) group, the I group appeared to be the least stressed (19.10 μg. % corticosterone). In this case the C group had 23.49 μg. % while the M and R groups were about the same with 26.40 and 26.44 μg. %, respectively. Pigs, which were miniature or normal and aged 7 to 10 weeks were fed 15 to 30 grams of clay pigeon powder for 10 to 14 days, or had endotoxin by a continuous dripping through the ear vein over a 28 hour period. The clay pigeon powder which causes severe centro lobular necrosis of the liver gives a stressful situation. The results clearly showed that the clay pigeon acted as a stressor, as there was a continuous increase in corticosterone levels following the increase in level of poisoning. The same result was observed in the pigs which were administered the endotoxin.

As a restatement of Selye's (1961) nonspecific resistance, Guyton (1966) states that trauma of almost any type, intense heat or cold, injection of necrotizing substances beneath the skin, and restraining of any animal so that he cannot move, are types of stress that stimulate adrenocortical secretion. The latest and most comprehensive study of stress was made by Yates (1967). His description of the physiological control of adrenal cortical hormone secretion is quite complex and involves more than the present study entails. However, for a complete review of the stress mechanisms, one should review his work.

OBJECTIVES

The primary objective of this experiment is to compare the effects of rearing and maintaining gilts in confinement or on pasture on their subsequent reproductive performance. The influence of these two environments will be evaluated in terms of (1) age at puberty, (2) incidence of breeding and rebreeding problems and (3) litter size and weight at birth and weaning.

Differences in blood glucose, plasma corticosterone, blood hematocrit and sedimentation rate values will be investigated, as physiological indicators of stress.

MATERIALS AND METHODS

Animal Management

The experimental animals were 26 Yorkshire x Hampshire gilts. In August of 1966 12 of these gilts were allotted at 56 days of age to two treatment groups according to litters. One group was placed in a large open lot and the other confined on concrete in an open shed. The other 14 gilts were farrowed in August and September, 1966 and allotted at 56 days of age to the same two treatments. The groups confined on concrete in the open shed remained there until farrowing their first litter. After weaning their litters, the sows were placed on a concrete slotted floor in an enclosed building. The open lot groups remained in the same lots throughout the experiment.

All gilts were self-fed a 16% protein ration until they weighed approximately 150 lb. and limited-fed a 15% protein ration thereafter to control growth. The open lot groups were fed 5 lb./day in separate stalls on a concrete platform located near their lot while the confined groups were fed 4 lb./day in their pen. The difference in feed allotment was to keep both groups growing at the same rate. All gilts were flushed one week prior to the breeding season with one extra pound each. The composition of the basal ration is shown in Table I.

Puberty, Breedings, and Litter Data

The gilts were checked daily for estrus to evaluate the effect of rearing environment on puberty. Age at puberty was calculated from the day each gilt was first observed to be in heat.

TABLE I. COMPOSITION OF BASAL SWINE RATION

Ingredient	Pounds
Corn	1567
Soybean meal (45%)	366
Defluorinated phosphate	40
Limestone	6
Vitamin B_{12} supplement	1
Vitamin premix[a]	10
Zinc Sulfate	100 gm.
Salt	10
	2000

[a]Contains (per 10 lb.) 2 gm. riboflavin, 8 gm. d-pantothenic acid, 20 gm. niacin, 300 gm. choline chloride, 40 mg. vitamin B_{12}, 3,000,000 IU vitamin A, 1,150,000 IU vitamin D, and 10 gm. santoquin.

Breeding was started around the first of February, 1966 for group I and about the first of May for group II. All gilts had been in heat several times before they were bred. The gilts were handmated to a purebred Hampshire boar and double-bred whenever possible. Rebreeding of group II gilts was done on the first heat after weaning of their litters. Group I gilts were held back and bred with group II although a record was kept on the length of time from weaning to first estrus.

All pertinent litter data were recorded for each gilt. These factors included number of pigs born dead or alive, birth weight, number of pigs weaned, weaning weight, and general observations on the condition of the gilts and litters while in the farrowing stall. All litters were weaned at 28 days of age and placed in the nursery. The sows were returned to their respective environments.

Bleeding and Blood Analysis

Blood samples were taken via the anterior vena cava from each gilt eight different times during the reproductive cycle. These were: (1) breeding, (2) 30 days gestation, (3) 60 days gestation, (4) 90 days gestation, (5) 48 hours confinement, (6) 14 days lactation, (7) 21 days lactation, and (8) 2 days postweaning.

The animals were restrained in a squeeze chute and then secured by a snare around the nose. With the head held securely in an upward position, the blood was taken with a 14 gauge needle attached to a 30 cc heparinized syringe. The puncture was made midway between the point of the shoulder and the tip of the sternum. The drawn blood was then placed in heparinized blood collection tubes and inverted slowly several times to mix. Care was taken throughout the entire collection procedure to prevent as much hemolysis as possible.

Determinations of sedimentation rate, hematocrit, and whole blood glucose were made within an hour after each sample was taken. Winthrobe sedimentation tubes were used to determine sedimentation rates and hematocrits were estimated by centrifuging in a Wintrobe hematocrit tube for 30 minutes at 3000 R.P.M. The Nelson-Somogyi (Somogyi, 1945) method was used to estimate whole blood glucose. The remaining blood was centrifuged and the plasma portion removed and frozen for later estimation of corticosterone. Plasma corticosterone determinations were made by a method described by Guillemin (1959) and modified by Colmano (1967).

Statistical Analysis

The number of days to puberty and number of days from weaning of the litter to first estrus for all groups and treatments was analyzed by the analysis of variance (Li, 1964). All litter data; pigs per litter, average birth weight, number of pigs weaned, and average weaning weight, were tested by least squares analysis (Harvey, 1960). Simple and multiple correlations were calculated on all blood data, and then the same data were analyzed by the least squares method for treatment, period, and group effects.

RESULTS

Age at Puberty

The differences in age at puberty due to treatment were not significant; however, there was a trend in both groups toward pasture reared gilts reaching puberty earlier (Table II). The pasture treated gilts (I-P and II-P), reached puberty 12.5 days earlier than the confinement treated gilts in group I and 17.4 days earlier than those in group II. The difference when the same treatments from each group were combined was 15.1 days. Estimated weights at puberty are also shown in Table II. For group I confinement and pasture and group II confinement and pasture mean body weights were 216, 218, 222, and 203 lb., respectively.

Reproductive Performance

There was one gilt in group I-C and one in group II-C that were mated, but did not conceive. The cause of sterility is unknown. They did not cycle for almost three months after they were bred and no evidence of abortion was noted. When they did cycle, they were rebred and farrowed. There were two gilts in group II-C that did not breed. One of these gilts had cystic ovaries and the other had an abnormal reproductive tract. Upon autopsy, the latter gilt appeared to have a hymen-like structure blocking the vagina, precluding normal mating.

A least squares analysis was conducted on all litter data obtained from two farrowings. The overall averages were found in Table III and the mean squares are found in Table IV. There were no significant differences in average pigs per litter although the trend was toward

TABLE II. GILT AGE AND WEIGHT AT PUBERTY

Treatment Groups[1]											
Group I-C			Group I-P			Group II-C			Group II-P		
Gilt no.[2]	Age, days	Wt. (lb.)	Gilt no.	Age, days	Wt. (lb.)	Gilt no.	Age, days	Wt. (lb.)	Gilt no.	Age, days	Wt. (lb.)
1235	248	230	1234	178	176	1302	217	213	1304	212	221
1236	212	217	1238	245	240	1303	223	175	1305	218	213
1237	246	229	1276	230	220	1295	250	280	1296	199	183
1233	251	242	1200	173	166	1326	260	238	1297	268	217
1208	252	184	1204	257	252	1329	214	189	1327	192	198
1207	206	194	1206	251	254	1346	208	210	1328	198	187
						1374	251	248	1376	215	202
Av.	235.8	216.0		223.3	218.0		231.9	221.9		214.5	203.0

[1]Treatments designated by C = confinement and P = pasture.

[2]Littermate gilts will have the same first three digets in their number.

TABLE III. LITTER DATA FOR THE PASTURE AND CONFINEMENT TREATMENTS IN GROUPS I AND II FOR TWO CONSECUTIVE FARROWINGS

	Av. pigs/ litter	Av. birth weight	No. weaned	Av. wean. wt.
1st Farrow[a]	9.68	2.77	6.79	15.98
2nd Farrow[a]	9.08	3.06*	6.52	16.64
Group I[b]	9.98	2.80	6.84	16.21
Group II[b]	8.53	3.03	6.47	16.38
Pasture[c]	9.50	2.92	7.25	17.24*
Confinement[c]	9.06	2.86	6.81	15.34

* $P<.05$

[a]Over both groups and both treatments.

[b]Over both farrowings and both treatments.

[c]Over both farrowings and both groups.

TABLE IV. LEAST SQUARES ANALYSIS OF LITTER DATA

Source	D.F.	Av. pigs per litter	Av. birth wt.	Number weaned	Av. weaning wt.
Farrowing	1	1.11	0.739*	4.08	3.93
Group	1	18.27	0.447	5.29	0.402
Treatment	1	3.95	0.020	1.10	30.66*
F x G	1	2.62	0.004	0.497	23.76
F x T	1	1.01	0.064	0.416	13.93
G x T	1	5.66	0.186	4.08	3.08
F x G x T	1	23.38	0.014	23.43*	18.59
Error	30	6.71	0.122	5.02	5.79

* $P<.05$

larger numbers in the pasture treatments. An average over all pasture and confinement treatments at both farrowings showed that the pasture groups farrowed 0.44 more pigs per litter (8.50 vs. 9.06). There was a significant farrowing effect on average birth weight. Over both treatments the average birth weight for the first farrowing was 2.77 lb. and 3.06 lb. per pig for the second farrowing. Over both farrowings, the pasture and confinement treatments farrowed pigs with an average birth weight of 2.92 and 2.86 lb., respectively. There was a significant farrowing x groups x treatment interaction on number of pigs weaned, but this would be almost impossible to explain biologically. There were no other significant effects on number of pigs weaned but once again, the trend was toward larger numbers in the pasture treatments. The pasture treated gilts weaned an average of 7.25 pigs per litter while the confinement gilts weaned 6.81 pigs per litter. The average preweaning mortality was 23.68% and 24.84% for pasture and confinement, respectively. There was a significant treatment effect on average weaning weight. The pasture and confinement treatments weaned pigs averaging 17.24 and 15.34 lb., respectively, at 28 days of age. The farrowing effect on average weaning weight was not significant, but the trend was toward higher weights as the second farrowing (15.98 vs. 16.64 lb.).

<u>Postweaning Performance</u>

Two gilts in group I-P died postweaning due to a fractured femur. Two gilts in group I-C were lost from the study; one was removed due to a fractured femur and the other gilt never returned to estrus. Upon post-mortem examination of the gilts that were lost from the fractured femurs, it was found that blood levels of calcium and phosphorus were in the low end of the normal range.

An analysis of variance showed that group I-P took a significantly shorter period of time to return to estrus after weaning of the first litter than did group I-C. This difference was due primarily to two gilts in group I-C that took 174 and 141 days, respectively, to return to heat. In group II, there was a trend toward shorter periods in the pasture treatment (5.25 vs. 12.25 days).

There were no significant differences found after the second litter was weaned. In fact, in group I, the pasture reared sows took one day longer than the confinement sows, but in group II, the confinement sows took 1.5 days longer than the pasture reared sows to return to heat. The average number of days for each group and treatment at both farrowings to return to estrus is shown in Table V.

Blood Analysis

The least squares analysis, as shown in Table VI, revealed several significant treatment and period effects among the four blood components analyzed. The averages at each period are shown in Tables VII and VIII.

There were significant treatment and period effects on blood glucose. The combined levels for the pasture and confined treatments from the two groups (I and II) for each period are shown in Figure 1. For the most part, the pasture reared gilts exhibited higher blood glucose levels. They averaged 43.43 mg.% from breeding to two days post-weaning while the confined gilts averaged 39.80 mg.% for the same time period. The pasture gilts had higher levels at breeding (Period 1)

TABLE V. NUMBER OF DAYS FROM WEANING TO ESTRUS
(FIRST AND SECOND FARROWING)

	Treatment groups			
	I-P[a]	I-C[b]	II-P[a]	II-C[b]
		First Farrowing		
No. gilts	3	4	7	4
Av. no. days	5.0	84.5*	5.24	12.25
		Second Farrowing		
No. gilts	3	3	6	3
Av. no. days	6.67	5.67	4.50	6.0

* $P<.01$ (possibly due to cystic condition of two of the animals).

[a]P = pasture.

[b]C = confinement.

TABLE VI. LEAST SQUARES ANALYSIS OF BLOOD DATA

Source	Blood Glucose D.F.	Blood Glucose M.S.	Hematocrit D.F.	Hematocrit M.S.	Sedimentation Rate D.F.	Sedimentation Rate M.S.	Corticosterone D.F.	Corticosterone M.S.
Treatment	1	333.83*	1	278.01*	1	4193.4*	1	285.92*
Group	1	47.57	1	27.90	1	86.32	1	170.45*
Period	7	340.11*	7	46.35*	7	427.02	5	129.68*
T x G	1	187.11	1	29.73	1	231.68	1	45.29
T x P	7	49.99	7	7.38	7	144.35	5	15.20
P x G	7	83.77	7	45.10*	7	134.15	5	14.44
P x G x 7	7	81.56	7	14.53	7	154.64	5	0.73
Error	112	72.07	112	11.17	112	131.82	84	12.18

* $P<.05$

TABLE VII. AVERAGE BLOOD GLUCOSE, HEMATOCRIT AND SEDIMENTATION RATES AT EACH SAMPLING PERIOD[1]

Sampling period and treatment	Blood glucose (mg%)	Hematocrit (%)	Sedimentation rate (mm/60 min.)
(1) Breeding			
Pasture	47.1	42.6	26.6
Confinement	39.5	45.4	14.4
(2) 30 days gestation			
Pasture	37.6	44.6	19.7
Confinement	36.9	49.5	7.8
(3) 60 days gestation			
Pasture	38.8	44.3	23.8
Confinement	35.0	46.9	14.4
(4) 90 days gestation			
Pasture	37.3	44.1	29.6
Confinement	39.5	46.8	14.0
(5) 48 hours confinement			
Pasture	52.1	40.3	21.4
Confinement	42.8	43.5	16.8
(6) 14 days lactation			
Pasture	49.7	42.8	27.1
Confinement	44.3	44.8	6.1
(7) 21 days lactation			
Pasture	43.7	43.7	19.5
Confinement	39.0	45.1	10.3
(8) 2 days post weaning			
Pasture	41.1	44.1	39.2
Confinement	41.4	49.6	19.4

[1]Values for groups I and II were pooled for glucose, hematocrit and sedimentation rate.

TABLE VIII. BLOOD PLASMA CORTICOSTERONE LEVELS (μg.%) FOR PASTURE (P) AND CONFINEMENT (C) AND BOTH GROUPS (I&II) AT EACH SAMPLING PERIOD

Period	Pasture	Confinement	Group I	Group II
(1) Breeding	22.5	19.7	18.94	23.24
(2) 30 days gestation	20.9	17.2	17.74	22.03
(3) 60 days gestation	20.6	19.5	18.31	21.82
(4) *90 days gestation				
(5) 48 hours confinement	21.1	17.1	19.28	18.88
(6) 14 days lactation	26.9	22.5	24.04	25.24
(7) *21 days lactation				
(8) 2 days post weaning	29.2	22.6	24.46	27.36

*No determinations made.

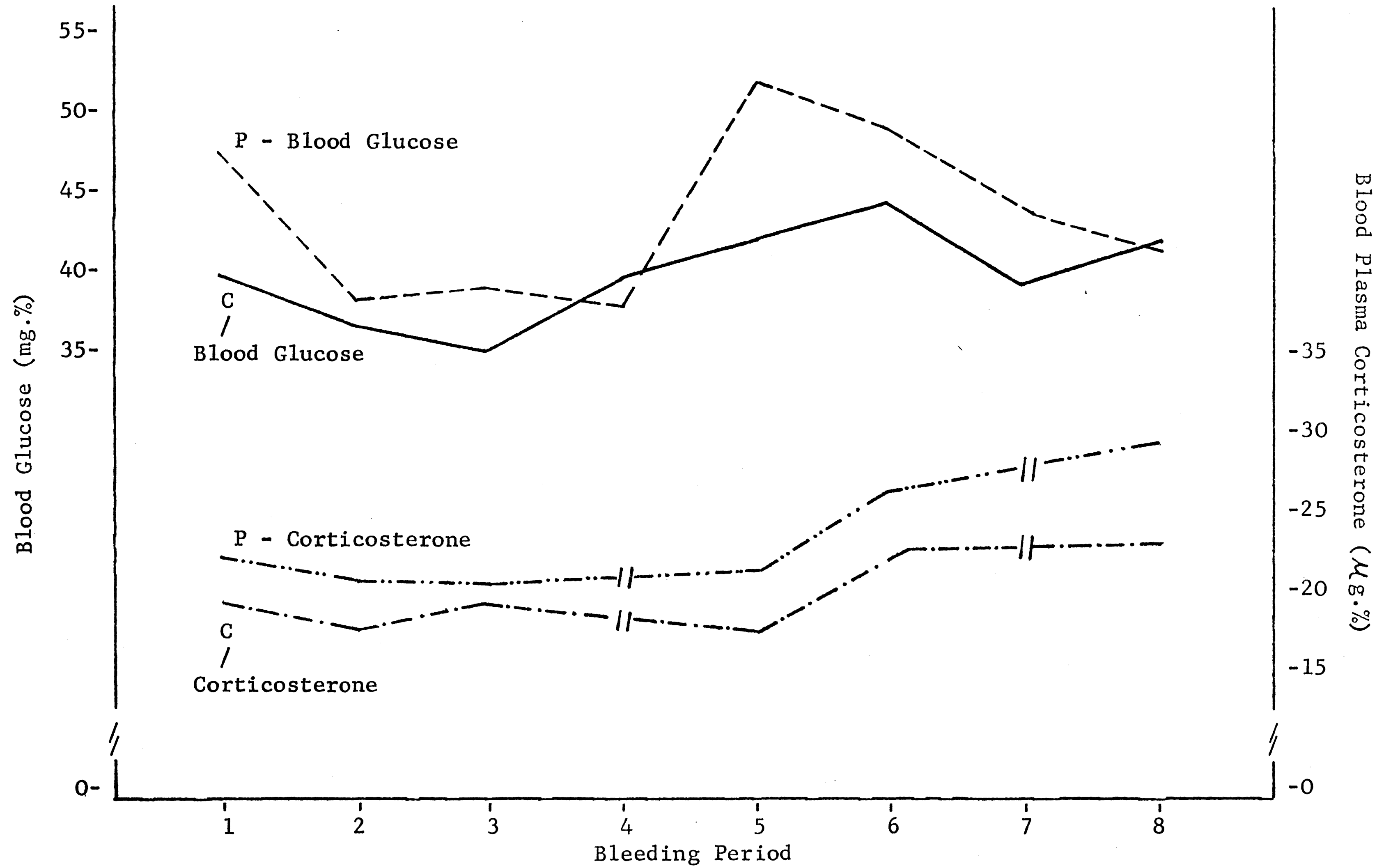

FIGURE 1. Blood Glucose and Corticosterone Levels in the Pasture (P) and Confinement (C) Treatments

but dropped to about the same levels as the confined gilts from 30 days (Period 2) to 90 days gestation (Period 3). Then from 90 days gestation to 48 hours before parturition (Period 5) the levels in the pasture reared gilts rose considerably and reached a peak of 52.1 mg.%. At that point, they started decreasing and continued decreasing until they reached about the same level as the confined gilts. The confined gilts decreased from breeding to 60 days gestation (Period 3) and then rose again to reach a peak of 44.3 mg.% at 14 days lactation (Period 6) but still remained below the pasture gilts. The levels decreased again, but not as much as the pasture reared gilts.

There were also significant treatment and period effects on hematocrit level, plus a period x group interaction. As seen in Figure 2, the hematocrit values of the confined gilts were consistently higher than those of the pasture reared gilts throughout the bleeding period. Both treatments exhibit a rise at 30 days gestation (Period 2), then decrease to reach a low point at 48 hours before parturition (Period 5), and then continually rise throughout lactation (Period 6 and 7) to two days post weaning (Period 8). The overall average was 46.5% and 43.0% for the confinement and pasture reared gilts, respectively. The interaction between period and group is shown in Figure 3. Both groups show a driving oscillation but they oscillate in opposite directions, accounting for the interaction. However, both groups have essentially the same PCV at breeding and two days postweaning. This gives an indication on the possible causes of the least squares analysis interaction.

Figure 2 also shows a significant treatment effect on sedimentation rate. Over the whole bleeding period, the pasture gilts

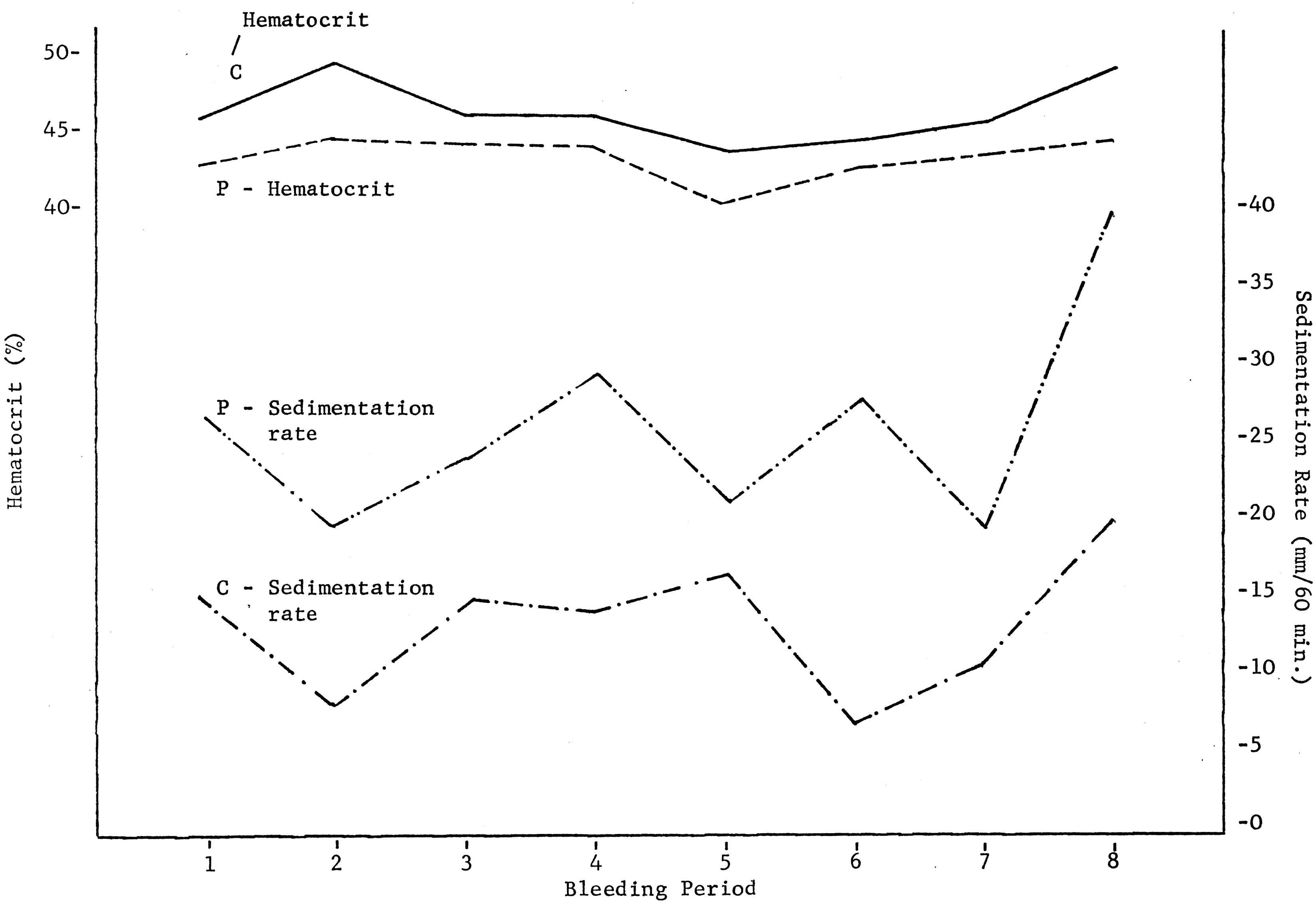

FIGURE 2. Hematocrit and Sedimentation Rate in the Pasture (P) and Confinement (C) Treatments

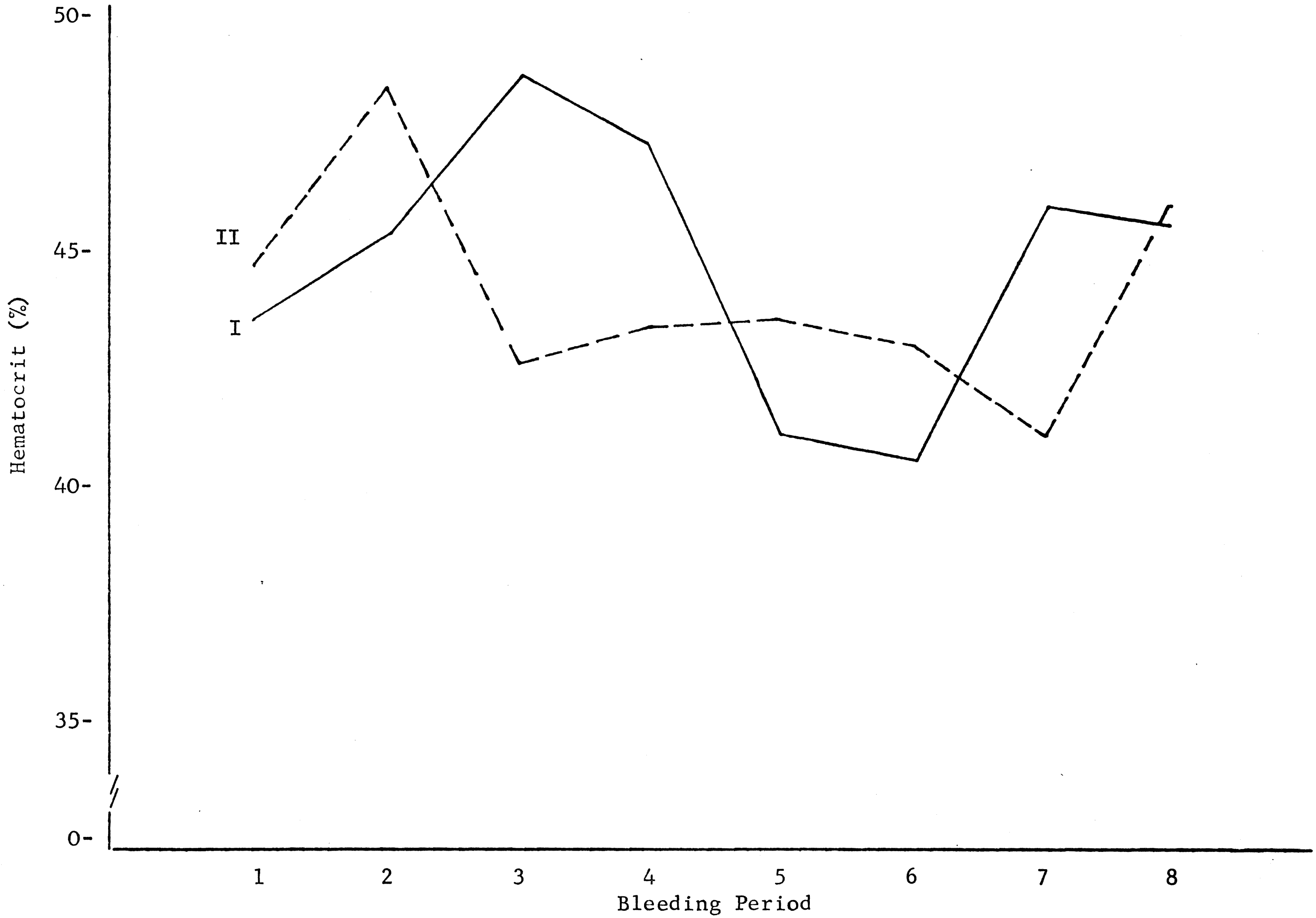

FIGURE 3. Period x Group Interaction on Hematocrit

averaged 25 mm. and the confined gilts averaged 13 mm. (sed. rate/60 min.). Both treatments decreased after breeding but then exhibited a general increase from 30 days gestation (Period 1) until 48 hours before parturition (Period 5). After parturition there did not appear to be much relationship between the two treatments, but the pasture treated gilts were always higher at each respective period.

There were significant treatment, group, and period effects on corticosterone levels. The pasture group exhibited higher levels from breeding (Period 1) to two days postweaning (Period 8). Both treatment levels remained fairly constant from breeding (Period 1) to 48 hours before parturition (Period 5). From then until 14 days lactation (Period 6) there was a fairly sharp rise and another slight increase at two days postweaning. In figure 4 are shown the corticosterone levels for groups I and II. At every point except 48 hours before parturition (Period 5) group II had higher levels. Overall, the two groups exhibited the same pattern as shown in Figure 1 for the two treatments (P and C).

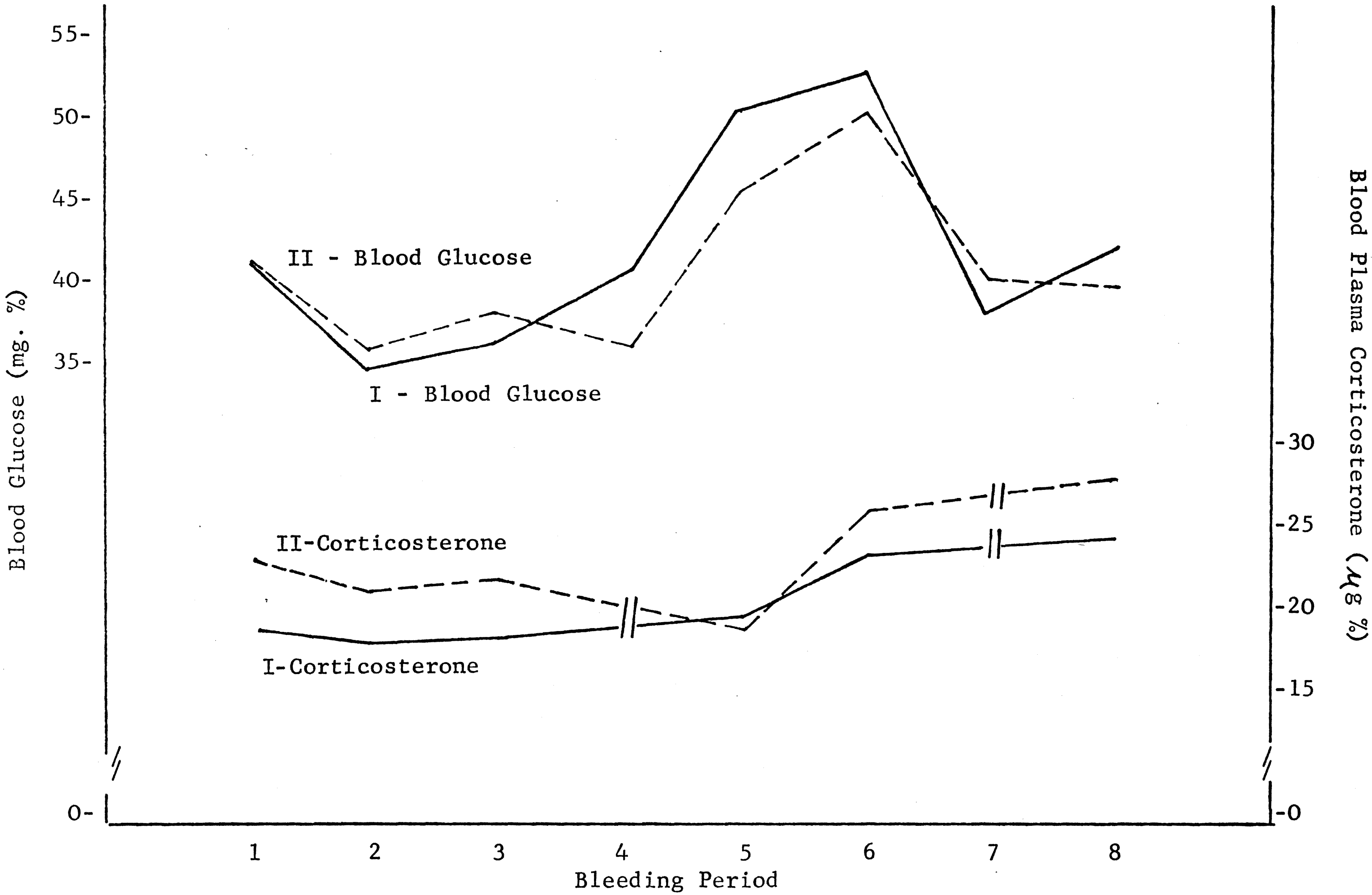

FIGURE 4. Blood Glucose and Corticosterone Levels for Group I and Group II

DISCUSSION

Age at Puberty

This report does not completely agree with Wiggins *et al.* (1950) and Robertson (1951) who found that fall farrowed gilts reach puberty at an earlier age. Although there was a trend toward the group II gilts, which were farrowed in August, reaching puberty earlier than the May farrowed group I gilts, the difference was not significant. Also, there is a great amount of variation within each treatment and the numbers within each treatment should be much larger in order to make such a determination possible.

Robertson (1951) reported that the average age of pasture reared gilts was 201 days and the average weight was 195 lb. The present experimental findings indicated the age and weight to be slightly higher with 218.5 days and 210 lb., respectively. The age at puberty is closer to the 210 days reported by Sorensen (1961) but far below the 200±48 days reported by Goode *et al.* (1965).

Miller and Cutright (1966) and England (1968) reported that the first estrus was delayed somewhat in gilts reared in confinement. Although in the present study the overall difference of 15 days between the two treatments was not significant, the trend agrees with the findings of the previously mentioned authors. The possibility exists that some of the gilts may have ovulated but not shown psychological heat. If this happened, then this would account for the confined gilts taking longer to reach puberty since the gilts were determined to be in estrus only if they exhibited visual signs of heat. Hafez

(1963) has reported that social environment, living space, associates, and other stressors may effect puberty or the onset of sexual season. The present experiment may entail all of these, so it would be impossible to pinpoint any one particular factor that would cause a delay in puberty or the suppression of visual or psychological signs of estrus.

Reproductive Performance

The two gilts that were thought to be pregnant for almost three months were considered to have a cystic ovary condition. Although this could not be proven defimitely in the present study, Nalbandov (1964) states that pigs with such cysts have very irregular estrus cycles, with prolonged anestrus periods leading to a mistaken diagnosis of pregnancy. The gilt, which a later autopsy showed to have an abnormal reproductive tract due to an anatomical defect, could not be attributed to treatment.

The litter results found in this experiment are, for the most part, in agreement with Weingert and Nelson (1964), Miller and Cutright (1966), MacNair (1967), England (1968) and Jensen (1968), who found the confined gilts to produce just as large a litter as pasture reared gilts. Miller and Cutright (1966) found a significant difference in favor of the complete confinement group while other authors did not. There was a trend toward larger litters (.44 pigs/litter) in the pasture treated gilts in the present experiment, but the difference was not significant.

Litters from pasture reared gilts also had slightly higher birth weights. This was not expected since an increase in litter size usually decreases average birth weight. Other authors have reported lower average birth weights from larger litters. Wingert and Nelson (1964) and Miller and Cutright observed that litters from confinement reared gilts had the larger birth weights, but the pasture reared gilts had the larger litters.

Miller and Cutright (1966) observed that confined gilts weaned two more pigs per litter even though they farrowed three more pigs per litter. They had an average postweaning mortality of 23.1% for the confinement reared gilts and 20.0% for the gilts reared in semi-confinement. The average preweaning mortality in the present study was 24.8% and 23.7%, respectively, for the litters of the confinement and pasture reared gilts. Wingert and Nelson (1964) observed the same trend although the percentages were lower than those obtained by Miller and Cutright or those obtained in the present study.

Besides the previously described higher birth weights, the significantly higher average weaning weight in the pasture treatment were also not expected since the pasture reared gilts weaned more pigs. Even on the basis of average birth weights, this would not be expected since there was only an average difference of 0.06 lb. at birth and almost 2 lb. at weaning. The only report on weaning weight was made by Wingert and Nelson (1964). They reported heavier weights from the pasture groups and they also weaned larger litters with heavier average birth weights.

Postweaning Performance

The three sows lost postweaning from fractured femurs due to a calcium and phosphorus deficiency interfere with any attempt to critically evaluate the treatment effects on postweaning performance. However, out of the remaining gilts, some significant differences were found. After the first farrowing, the confined sows took longer to return to heat than the pasture sows. This is in disagreement with Miller and Cutright (1966) and England (1968) who found that once a confinement gilt was bred and farrowed one time, she had a normal reproductive pattern. The return to a normal pattern did not occur in the present experiment until after farrowing of the second litter. It took the sows an average of 5.7 days to return to estrus which compares favorably with the results obtained by Self and Grummer (1958). They found that weaning pigs at an early age increased the incidence of cystic ovaries. The sows in the present study had their litters weaned at 28 days with no apparent detrimental effect on the pasture treatments, so it is probably unlikely that weaning age would have a very pronounced effect on the confinement treatments. Ulberg *et al.* (1951) and Baker (1953) found that the alteration of only one hormone could inhibit estrus, increase the incidence of cysts, and cause lowered fertility at the first post-treatment estrus. Here again it is possible that the sows were ovulating but not showing visual signs of estrus. In some cases it is possible to induce standing heat in a sow or gilt by placing them with a boar. However, with two gilts in group II-C, this was not the case. They were placed with the boar every day for about a month and would not mate. Approximately one month later, they spontaneously returned to estrus. Another gilt, which was not included in the postweaning data, never returned to heat. With the data at hand, it can only be assumed that these gilts developed a cystic condition in part due to confinement on a concrete floor.

Blood Analysis

There have been many reports on factors that would affect blood glucose levels. Kleiner (1951) and Benjamin (1961) state that excitement, pain and other emotional disturbances will tend to raise blood glucose levels. Miller (1960) and Benjamin (1961) state that overactivity of the adrenal cortex may also result in hyperglycemia. Colmano et al. (1967) did not relate blood glucose levels to the corticosterone levels they found, but they clearly demonstrated that stress would increase the corticosterone levels. However, Colmano (1968) found a definite correlation between glucose and corticosterone levels in blood plasma of fetuses and weanling pigs. Knowing the function of the glucocorticoids, the fact that all the animals in the present experiment were on the same ration, and the fact that corticosterone possesses about 50% glucocorticoid as well as a 15% mineralocorticoid activity, several assumptions can be made. First of all it should be noted that the blood glucose levels and the corticosterone levels were found to be higher in the pasture treatment than in the confinement treatment. This would indicate that the adrenal cortices of the pasture reared gilts were more active in response to stress, having an increased blood glucose level at sampling time. Guyton (1966) states the glucocorticoid secretion is increased during pregnancy, presumably to provide more glucose to nourish the fetus. The levels of corticosterone observed in the present experiment do not show such an increase, probably because one would have to measure cortisol and corticosterone to get the complete picture, or possibly because the homeostatic mechanisms are strong enough to maintain equilibrium. However, the levels of blood glucose do increase during the later part of pregnancy in both the pasture and confinement treatments. Care should be taken in interpreting the values obtained for blood glucose and corticosterone levels and only view them from a relative standpoint. The blood glucose levels are in the low end of a normal range of a 40 to 100 mg.% and the corticosterone levels, while consistent with the levels found using the same method, have been known to vary with the individual conducting the determination and the method used. The low glucose levels might be due to the fact that the animals were bled in the morning before feeding. This possible effect was uniform across treatments however, since all gilts were bled at the same time of day.

According to the blood glucose and corticosterone levels in the pasture reared gilts, the pasture reared gilts were definitely stressed more than the confined gilts. However, there was apparently not only no adverse effect but maybe a beneficial one involved by this mild stress since the pasture reared gilts farrowed larger litters which weighed more and also weaned more and heavier pigs. One hypothesis to explain this could be that the increase in glucocorticoid activity, which presumably raised blood glucose, was responsible for an increase in fetal nutrition. This could in turn increase embryonic survival and weight which would show up as larger litters with larger average birth weights. If this occurs, then increased numbers weaned at heavier weights would be expected. There has been a great number of published articles stating that high energy diets decrease embryonic survival, and in this experiment only average weaning weight had a significant treatment effect so that another hypothesis would be needed to explain it. Here again the increase in blood glucose during lactation may account for this effect. Guyton (1966) has stated that in humans, 100 grams of lactose, which must be derived from glucose, are lost from the mother each day. With an increase in blood glucose levels, it may very well be that the sow is capable of supplying other nutrients needed to increase milk production. By way of deduction, an increase in milk production should increase weaning weight.

The hematocrit values obtained in this experiment were very close to those obtained by Schalm (1965). However, the packed cell volume (PCV) increased after parturition while Schalm (1965) says it will probably decrease. Observations in the present study showed a decrease immediately before parturition (Period 5) with a continuous increase thereafter. The average PCV values of all bleeding periods observed were 46.5 and 43.0%, respectively, for the confined and pasture reared gilts. Benjamin (1961) and Schalm (1965) give an average value of 42.0% for the normal, mature sow. The pattern observed in Figure 2 is apparently normal from breeding through 48 hours parturition. The increasing sedimentation rates during pregnancy back up this observation since sedimentation rates are inversely related to hematocrit. Kornegay

(1967) found that daily and twice daily blood sampling of weanling pigs decreased the PCV values. Frequency of bleeding is probably not a significant factor in the present study since the readings obtained were normal or slightly above. The percentage of the total blood volume taken in sampling was small and the bleedings were further enough apart to permit the red blood cell (RBC) population to be replenished. Also, during lactation when the three bleedings were two, two, and one week apart, respectively, and the average hematocrit values actually increased, indicating a rebuilding of the RBC supply. Here again, the corticosterone blood plasma levels reflect the cortical hyperactivity which may be then responsible for the difference in PCV levels between the two treatments. Figure 5 illustrates graphically the relationships between PCV and corticosterone levels. Guyton (1966) states that an increase in mineralocorticoid secretion will increase blood volume thereby decreasing the hematocrit. Although the inverse relationship at each period was not detectable, it was evident between treatments, as shown in Figure 2.

The sedimentation rates followed an expected pattern throughout pregnancy; however, after parturition it was difficult to define whether the values returned to what should be considered a normal value, since the two treatments reacted in different ways. The average values for all 8 bleeding periods (25 mm./hr. for pasture and 13 mm./hr. for confinement) were higher than the 0-6 mm. range given by Benjamin (1961), but Schalm (1965) states that much higher rates can be expected in normal swine. As was pointed out earlier, sedimentation rate is related to hematocrit, so it would appear that the difference noted between the two treatments may again be due to the same stressing effects characterizing the adrenal hyperactivity and which are reflected by the corticosterone levels in blood plasma.

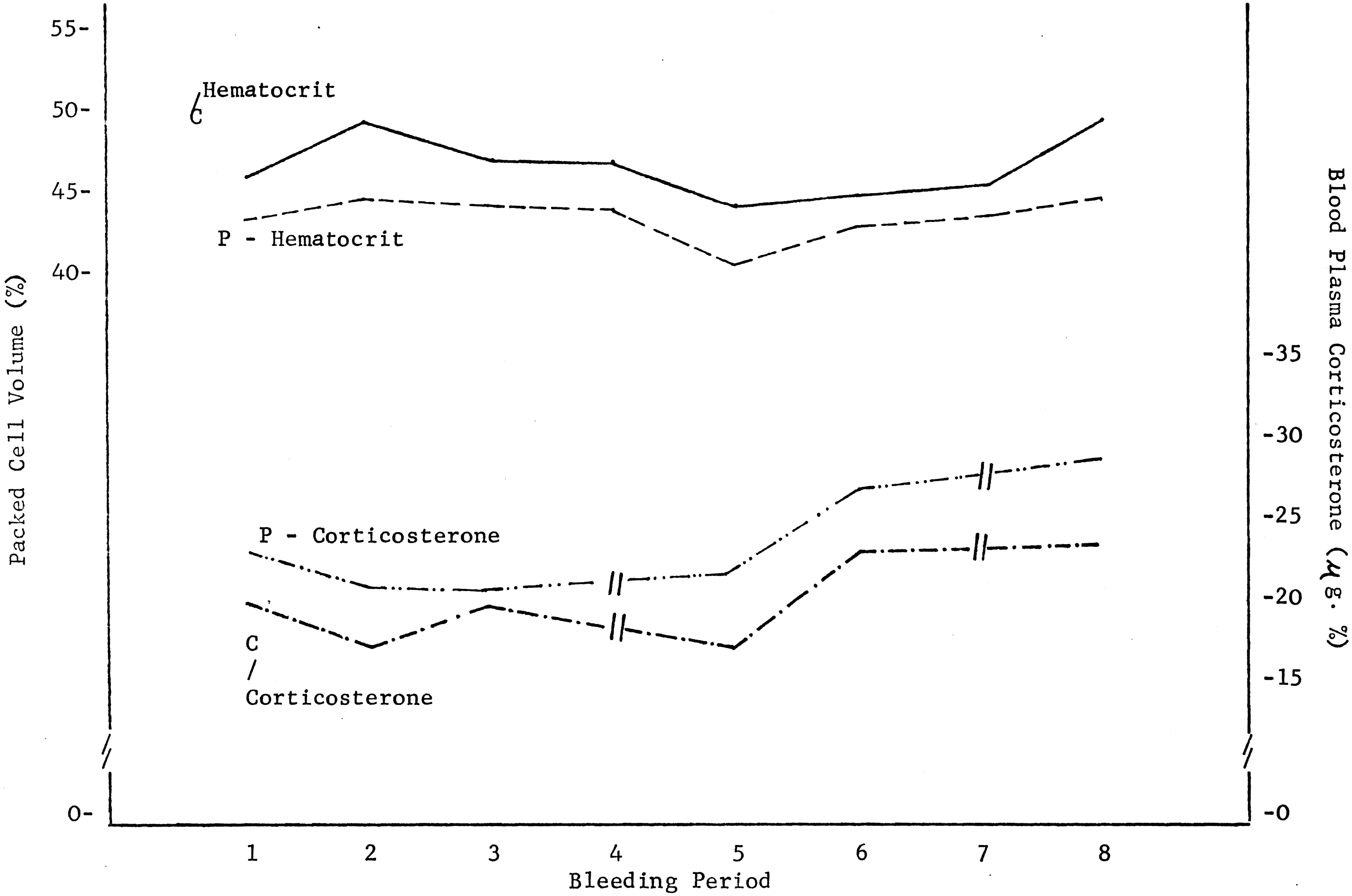

FIGURE 5. Hematocrit and Corticosterone Levels in the Pasture (P) and Confinement (C) Treatments

SUMMARY

The differences in age at puberty due to treatment were not significant although the pasture gilts reached puberty 15.1 days earlier than the confined gilts. The least squares analysis conducted on the litter data showed a significant farrowing effect on average birth weight. The birth weights of pigs at the second farrowing were heavier. The pasture gilts weaned heavier pigs than the confined gilts. Although there was no significant difference, the pasture reared gilts farrowed more pigs (9.50 vs. 9.06) with heavier average birth weights (2.92 vs. 2.86 lb.). They also weaned more pigs (7.25 vs. 6.81) with significantly heavier weaning weights (17.24 vs. 15.34 lb.).

An analysis of variance showed that group I-P (pasture) took a significantly shorter period of time to return to estrus after weaning of the first litter than did group I-C (confinement). The same trend was observed in group II. No differences were observed after weaning of the second litter.

There was a significant treatment effect on blood glucose, hematocrit, sedimentation rate, and corticosterone; and a significant period effect on all but sedimentation rate. There was also a significant group effect on corticosterone and a period x group interaction on hematocrit. The pasture treatments appear to be the most highly stressed since they had the higher levels of corticosterone. The blood glucose levels and sedimentation rates were also higher in the pasture treatments while the hematocrits were lower; the differences apparently

due to the difference seen in corticosterone levels. The sedimentation rates and hematocrit values appeared to be normal. The blood glucose levels were in the low end of the normal range.

With a greater number of experimental animals, the trends noted in the present experiment may become significant. Even though not all differences were significant, the trends indicate that the pasture reared gilts may out-perform confinement reared gilts.

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THE EFFECTS OF PASTURE VS. CONFINEMENT REARING ON

REPRODUCTIVE PERFORMANCE OF GILTS

by

Frank B. Masincupp

Abstract

Twenty-six Yorkshire x Hampshire gilts were allotted to two treatments, pasture and confinement (P and C), in two groups (I and II), at 56 days of age. They were limited fed after 150 lb. to keep both treatments growing at about the same rate. The ages at puberty were 236, 223, 232, and 215 days, respectively, for group I-C, I-P, II-C, and II-P. There were no differences in weights at puberty, but the confined gilts in group II tended to be heavier. Over two farrowings, the pasture treated gilts farrowed more pigs (9.50 vs. 9.06) with heavier birth weights (2.92 vs. 2.86 lb.) and weaned more pigs at 28 days (7.25 vs. 6.81) with significantly higher weaning weights (17.24 vs. 15.34 lb.). There was a significant treatment effect on blood glucose, hematocrit, sedimentation rate and corticosterone; and a significant period effect on all but sedimentation rate. There was also a significant group effect on corticosterone and a period x group interaction on hematocrit. Higher values were observed for corticosterone, blood glucose, and sedimentation rate, and lower values for hematocrit in the pasture treatment. The data indicate that the pasture treatments are more highly stressed but they also out-perform confinement reared gilts.