RELATIONSHIPS OF BIRTH ORDER AND NURSING ORDER OF PIGS TO PREWEANING GROWTH AND OTHER PARAMETERS

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ABSTRACT

RELATIONSHIPS OF BIRTH ORDER AND NURSING ORDER OF PIGS TO PREWEANING GROWTH AND OTHER PARAMETERS

By

Chuan L. Ai

Two trials involving 37 sows and their litters were conducted to examine (1) the relationship of birth order and nursing order, (2) the relationship of birth order and nursing order to preweaning growth, (3) the relationship of birth order and nursing order to blood parameters at 24 hours and 2 weeks of age and the relationship of these parameters to preweaning growth, and (4) the relationship of teat order to milk production and the relationship of milk production and pig growth.

As a result of many observations and analytical measures the following conclusions can be reached.

1. There was no significant relationship between birth order and sex, nursing order of pigs, birth weight or preweaning gain of pigs.

2. There was a significant positive relationship between birth order and several blood parameters at 24 hours of age including hemoglobin (r=0.34),

hematocrit (r=0.27) and per cent serum non-immune globulins (r=0.23) and a significant negative relationship between birth order and 24-hour (r=-.21) and 2-week (r=-.29) values of per cent serum γ-globulin.

3. Birth weight was significantly related to subsequent weekly preweaning weights at one week (r=0.39), two weeks (r=0.27), three weeks (r=0.20) and four weeks (r=0.23) but was not significantly related to nursing order in either trial 1 (r=-.02) or trial 2 (r=0.05).

4. Nursing order was firmly established within the first few days of life. Switching of teats in a horizontal or diagonal direction frequently occurred when the sow alternated the side on which she lay to nurse the pigs. The first-born pig usually fixed to either the most anterior or the most posterior teat. The second pig born either settled on the teat adjacent to the first-born pig or at the other extreme end of the udder. There was no definite pattern of teat order of pigs born later in the litter except the last-born pig which also fixed to a teat at one end of the udder.

5. Although not statistically significant there was a positive relationship between the concentration of serum γ-globulin at 24 hours (antibody protein obtained from colostrum) and preweaning body weight gain (r=0.12).

6. There was a highly significant correlation between five-week milk intake and five-week gain (r=0.78). The regression equation of five-week weight gain on five-week milk intake was $Y=1.44 + .214X$ where Y=five-weeks gain in weight and X=five-week milk intake. Pigs gained 214 grams in weight for each kilogram of milk consumed.

7. Birth weight was significantly related to subsequent milk intake over a five-week lactation (r=0.42) and to five-week gain (r=0.48).

8. The two anterior teats on either side tended to supply the most milk and thus there was a significant negative relationship between teat order and milk yield (r=-.27).

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I. INTRODUCTION

Many researchers and swine producers have observed that newborn pigs develop a preference for particular teats during the first few hours although they may change teats during the first two days and then nurse the same teat or teats until weaning. This arrangement of pigs at the udder is termed the nursing order.

Since different teats of the same sow may yield different quantities and/or qualities of milk, the choice of teat may greatly influence the early growth of pigs. This evokes a number of questions. What are the factors which influence the choice of nipple and subsequent orientation to that teat? What are the effects of nursing order upon preweaning growth and development? Are there any effects of early fighting upon later dominance structure? What is the ability of a pig to claim and maintain possession of a particular teat? What are the effects of birth order and nursing order upon blood parameters such as hemoglobin concentration, hematocrit or serum proteins?

This study, while not of sufficient scope to answer all of these questions, provides observations of (1) birth order related to nursing order during the first 4 weeks of lactation, (2) the relationship of birth order and nursing order to preweaning growth, (3) the relationship of birth order and nursing order to hematological parameters of hemoglobin concentration, hematocrit and serum proteins and the relationship of these parameters to preweaning growth and (4) the relationship of teat milk production to preweaning growth.

II. REVIEW OF LITERATURE

Suckling Behavior

It is often asserted that during the suckling period each member of a litter has its own teat, i.e., suckles regularly at a particular nipple. This suckling preference is not without practical interest, for it means that some pigs in a litter obtain very much less milk than others since different gland sections of the udder may secrete very different quantities. Several researchers cited by Donald (1937b) have made reference to this phenomenon. Donald (1937b) evaluated the nursing orders of five litters after the fourth day of age. Following numerous observations, he concluded that the chief factors influencing the number of departures from the normal distribution during suckling appears to be the number of pigs in the litter, the suckling behavior of the sow and the uniformity in the udder. There was much evidence to support the hypothesis that each piglet in the litter prefers to nurse on a particular teat. Most "errors" in teat choice were made by piglets nursing from teats in the middle of the udder, while piglets at either end were rarely found out of position. Data taken when the sow was lying on her right side indicate that most errors were horizontal in nature.

The fixation on an individual teat and the establishment of the social hierarchy occur simultaneously (Van Loen and Molenaar, 1967). When there are fewer piglets than teats the posterior teats remain unemployed. With some exceptions (England et al., 1961) piglets which are heavier at birth tend to appropriate the anterior teats (Allen and Lasley, 1958; McBride et al., 1965). Even when litters are experimentally homogenized with respect to bodyweight, the correlation between birthweight, teat order and subsequent growth persists (Lodge and Pratt, 1963).

Hafez and Signoret (1969) observed that piglets which change their preference for a particular nipple during the early part of the suckling period attempt to move anteriorly. Occasionally, one piglet is left to suckle the two rear most teats when all others are occupied. In addition, pectoral teats are in a region which is safer for the pig than those teats near the dam's hind legs. Piglets suckling anteriorly are less apt to be moved if the sow should rise. Donald (1937b) and Gill and Thomson (1956) also noted that piglets appear to prefer the more anterior teats over the others. Donald (1937b) observed that in the first day or two after parturition the desire of the piglets to suckle on anterior teats was stronger than the desire to retain one particular teat. McMeekan (1943) observed two cases where piglets suckling the two inguinal teats were especially heavy at weaning. A piglet which suckles two teats usually divides its attention quite unequally between the two.

Donald (1937b) described that the chief means of recognizing teat location is by an appreciation of the conformation of the sow's udder as a whole. Unpaired or unequal size of udder sections help in this recognition. McBride (1963) suggests that a sense of smell and thereby recognition of neighboring piglets as well as sight of the udder may be important in teat recognition. He observed a nose-rubbing behavior which did not seem to be associated with the normal massaging to obtain more milk and he assumed this to be some type of "marking" behavior. As a result of the marking procedure or some olfactory cue the piglets were able to identify teats hidden under the sow. However, when Donald (1937b) coated sow udders with mud or a scented substance the positions of the piglets was unchanged.

Hafez and Signoret (1969) described that the sow selects a definite place in the pen where she lies down for nursing. She is induced to assume the appropriate position when the piglets first massage the udder. Sows usually spend an equal amount of time on the right and left sides while nursing and favor the standing position more frequently later in the lactation. Sows do not turn over during a single nursing period. Some sows always lie on one particular side and others favor standing position while nursing. Feral and phacochoerus pigs frequently nurse in a standing position (Frädrich, 1965).

Gill and Thomson (1956) mentioned that although sows followed different behavior patterns, they lay approximately equal time on either side. Piglets could not massage the udder so forcefully when the sow adopted a standing position at nursing time and those sows which favored this position produced a correspondingly lower total yield than those which favored the lying position.

Nursing Interval

Shepperd (1929), Schneider (1934), Donald (1937a), Wells *et al*. (1940), Niwa *et al*. (1951), Smith (1952), Berge and Indrebo (1953), Braude (1954), Barber *et al*. (1955), Hafez and Signoret (1969) and Mahan *et al*. (1971) have studied nursing frequency of pigs. Hartman *et al*. (1962) observed that the nursing interval varied from 60 to 90 minutes with the majority being near 60 minutes. He noted no significant difference in nursing interval between day and night nursings. Hafez and Signoret (1969) and Mahan *et al*. (1971), however, observed a shorter interval between nursing during the day than at night.

Niwa et al. (1951) and Mahan et al. (1971) noted that the frequency of nursing declines through the lactation. Frequent suckling increases the sow's milk yield. Sows nursed at 1-hour intervals produced about one-third more milk than those nursed at 2-hour intervals (Barber et al., 1955). The suckling rhythm of feral swine in zoological gardens is similar to that of domestic breeds, but in the wild nursing occurs less frequently (Frädrich, 1965).

The nursing frequency of neonatal pigs is very irregular immediately after parturition, but soon a regular schedule is established (Smith and Hutchings, 1952). In general, the interval between nursing does not increase as laction progresses, particularly through the first 5 weeks postpartum. Salmon-Legagneur (1956) found that the mean interval between nursings during the first week of lactation was 67 minutes, and at 7 to 8 weeks the interval was 74 minutes. These results conflict with Wells et al. (1940) who found approximately 1-hr. intervals during early lactation and 2- to 3-hr. intervals at 8 weeks. Such differences can be explained in part by the work of Lenkeit and Gütte (1957) who found that the number of nursings was influenced by the milk production of the sow. Thus, as milk production declines, which is common in late lactation, the nursing frequency decreases, Mahan et al. (1971) found that the variance of cumulative quantities of milk decreased as the duration of milk production estimations increased. The 4-hr. variance was significantly ($P<.02$) larger (Snedecor and Cochran, 1967) than of periods of 8-, 12- or 16-hr. duration. An additional 10% decrease in the variance was indicated for periods longer than 8 hours.

Phases of Suckling

Three phases of suckling may be recognized (Hafez and Signoret, 1969). The first phase is a touching phase. During this phase the pigs in the litter touch the sows teats making the sow lie down. As soon as the sow takes the nursing position the young touch the udder very vigorously for about one minute. The duration of this touching or nosing increases steadily from birth to weaning (Hafez and Signoret, 1969). Barber et al. (1955) suggest that the secretion of neurohypophysial hormones in response to this stimulus is delayed as lactation advances.

The second phase is a milking phase. The touching phase stops abruptly, the young become quieter and draw back their ears. The sow's vocal sounds change from slow and low tones to quick and heavier sounds. The pigs rapidly consume the milk which is let down at this time. This period of milk let-down averages less than 30 seconds (Niwa et al., 1951; Barber et al., 1955). Whittlestone (1953) found little variation in the duration of milk flow among Berkshire sows when a standard dose of oxytocin was used.

The third phase is a quiet phase. The milk let-down phase also stops abruptly but the pigs continue to nurse. Pigs generally continue nursing the teat for another 2 or 3 minutes after milk let-down has stopped but it may last for 15 minutes before the pigs give up the notion that there is more milk available and they go and lie in the creep area. During this post let-down period the sow is also quiet, making low and soft tones.

Gill and Thomson (1956) assert that milk ejection is a reflex process which is most probably stimulated through the massage of the udder by the complete litter. Nursing then follows a consistent behavior pattern which can be divided into three parts, initial massage, milk ejection and final massage. The final massage phase occurs after milk has stopped flowing and the massage rhythm is slower than that of the initial massage. During early lactation nursing ends when the piglets fall asleep at the udder. Later, the sow often brings nursing to a halt by turning over on her udder or walking away. Sows with tender teats do not allow the piglets to massage the udder after milk let-down ceases. During the first 4 to 5 weeks of lactation, once the piglets have satisfied their hunger, they fall asleep cuddling to the sow for warmth. Older piglets will first suckle the sow and then eat supplementary feed before resting (Allen et al., 1959).

Suckling Behavior of Other Species

Tsai (1931) found that young rats most frequently suckled the fourth pair of nipples. He suggested that with regard to the nursing attitude of the dam this pair was the most accessible.

In sheep it was stated by Brown (1961), Brown (1964) and Spedding (1965) that after about the fourth week of life each twin usually sucks from (is fixed on) a particular side of the ewe's udder, although evidence has been put forward (Ewbank, 1964) that in the early stages of lactation, all the ewes allowed one out of a twin pair to suckle without the other being present. From the 3rd to 5th week onwards most of the ewes showed at times, a behavior pattern in which the ewe would call the lambs and one would arrive at her side before the other. She would not then allow the first lamb to suck until the second was present. It appeared that twins, on the average, suckled more frequently than singles during the first 4 weeks of lactation. By the 5th week the suckling rate was about the same, and after the 5th week the rate of suckling tended to be approximately equal for both twins and singles. About two-thirds of the pairs appeared by the 10th week to have a definite preference as to which side of the ewe's udder a particular lamb would suckle while the other third used the sides in a much more random manner.

Milk Production

The gain made by suckling pigs during the first few weeks presumably depends on the milk-producing ability of the sow.

Several attempts have been made to measure the amount of milk produced by sows during lactation. This has been done by keeping the pigs away from the sow except at nursing time and then weighing the pigs before and after nursing. Henry and Woll (1897) were the earliest men to measure the milk production of the lactating sow with the weight difference before and after suckling being attributed to the milk produced by the sow. Numerous researchers have used this method to measure sow milk yield. Hughes and Hart (1935) reported the average production of 79 sows suckling an average of 7.9 pigs to be 413 pounds of milk during a 8-week lactation. Bonsma and Oosthuizen (1935) reported 367 pounds as the average 8-week production of 25 sows during 52 lactations, in which each suckled an average of 6.7 pigs.

Stage of Lactation

Milk production varies in the sow during various periods of lactation. Henry and Woll (1897) reported that milk yield was small immediately after parturition but gradually increased with a maximum flow being reached about the fourth week of lactation. Most workers agree that the peak in milk production is reached at the third or fourth week with a gradual decline thereafter (Hughes and Hart, 1935) (Greenslade, 1952), (Smith, 1959b) (Kovacs, 1954) and (Lalevic, 1953). Individual sows vary in the time required to reach a peak in milk production. Some sows maintain an optimum level until the eighth week of lactation once they reach their peak.

This fact fits very well with the needs of the pigs. During the later part of the suckling period the pigs need less milk because they are large enough to obtain most of their required nutrients from a supplemental creep ration or by eating some of the feed fed to the sows. But during their first few weeks of life the pigs would be almost entirely dependent upon milk for their nutrients (Greenslade, 1952).

The average milk supply increased up to the 23rd day of lactation, then it decreased slowly and from the 40th day on there was a rapid decline (Onderscheka, 1970).

Age

With regard to the different age of sow or number of litters which she has farrowed upon milk yield, Allen and Lasley (1958) found that milk yield increases up to the third litter and possibly to the fifth or sixth. Milk yield was not observed in the same sows, however, for more than three consecutive litters.

Litter Size

In general, milk production increases as the number of pigs nursing increases, although the milk available for each pig decreases. Many investigators have observed that the amount of milk which a sow produces is dependent upon the number of pigs she suckles (Schmidt and Lauprecht, 1926; Hughes and Hart, 1935; Wells, Beeson and Brady, 1940; Smith, 1952; Kovacs, 1954; Allen and Lasley, 1960). Berge and Indrebo (1953) reported that the average daily milk production of sows with small litters was 8.4 pounds whereas in sows with litters of 12 pigs it was 21.9 pounds. The average of 1.76 to 2.65 pounds of milk per pig per day was recorded with the pigs from the smaller litters receiving the larger amounts. Lalevic (1953) reported that the production of sows suckling six pigs was 295.3 pounds of milk while in those suckling fewer pigs it was 280.0 pounds during the entire lactation period. He found a positive correlation between number of pigs per litter and the amount of milk produced by the sow. Allen and Lasley (1958) observed that the number of functional mammae was significantly correlated with the number of pigs in the litter at weaning in all of the breeds and crosses.

Position of Teats

Studies of individual teat yields in the sow have resulted in some interesting observations. Donald (1937b) and Barber *et al.* (1955) found that the milk yield was the highest in the foremost pair of teats and decreased progressively in posterior pairs. Wohlbier (1928) found that the amount of milk coming from different teats varied widely. He found that this variation was due largely to the constitution of the pigs with the most vigorous pigs obtaining the most milk. The most vigorous pigs, he felt, evacuated the teat more completely, thus providing a favorable stimulus to the productive capacity of the gland. Weak pigs were unable to empty the teat and therefore, gave little stimulus to production. After a few days, the teats occupied by the vigorous pigs were clearly recognized. In those teats not suckled, the milk production soon ceased.

Gill and Thomson (1956) reported that among 64 piglets in 8 litters, 39 (61%) which suckled the 3 pairs of anterior teats got 83.8 per cent more milk than the 25 (39%), which suckled the posterior 3 or 4 pairs of teats.

Onderscheka (1970) found that anterior teats appeared to produce the most milk while the posterior teats came next. Central teats were less abundant in milk and were left to weaker pigs.

Breed

Breed difference in milk-producing ability of sows has been indicated by some investigators. Allen et al. (1959) determined the milk production of sows of inbred Landrace, Poland, and Duroc breeds, and Landrace X Poland crossbreds by weighing the pigs before and after nursing.

Average milk production for a 6-week lactation period was 306 pounds for Landrace, 266 pounds for Polands, 236 pounds for Durocs, and 300 pounds for Landrace X Poland crossbreds.

Growth

The weight gains made by pigs are, of course, greatly dependent upon the amount of milk produced by the sow. Donald (1937b) found that the rate of gain is closely associated with the amount of milk obtained. Zeller, Johnson and Craft (1937) stated that a sow's performance beyond the number of pigs farrowed may be thought of as a combination of a progeny test of the sow and a measure of her direct nutritional influence on her litter. Berge and Indrebo (1953) observed that the weight gain during the first three to four weeks was chiefly determined by the milk yield of the sow and that improved fertility in sows must be accompanied by a higher milk production or an earlier use of supplementary feed if the weight gains are to be maintained.

Barber *et al*. (1955) also noted a close positive relation between milk intake and live-weight gain during the first three weeks of the lactation, but supplementary food was available during that time. A correlation coefficient of .98 was found between milk consumption and growth rate up to 19 days of age by Gill and Thomson (1955). Hartman and Pond (1960) also found a high positive correlation (.77) between growth rate and milk intake.

The weight gain for the first four weeks of lactation for each 10 pounds of milk was calculated for 32 litters by Hempel (1928) and was found to average 3.29 pounds with a variation between litters ranging from 2.42 to 5.48 pounds. This marked range in difference in litter requirements for each pound of gain was thought to be due more to the influence of environmental factors than to differences in the composition of the milk of the sows.

Lodge and McDonald (1959) reported that of the total variation in 3-week weight within litters 39% was associated with variation in birth weight, 67% with variation in milk consumption to 3 weeks, and 80% with these two factors combined. Of the total variation in 8-week weight within litters, 30% was associated with variation in birth weight, 25% with variation in milk consumption to 8 weeks and 42% with these two factors combined. Lodge and McDonald (1959) also reported that 45% of the variation in 8-week weight was associated with variation in 3-week weight.

An apparent correlation between the total milk yield and the total time spent massaging by piglets at each nursing was found by Gill and Thomson (1956). They determined milk yield and time spent massaging the udder before and after milk ejection. Further proof of this correlation was provided by a sow that lay on her left side during more than 97% of her nursings. The lower row of teats was somewhat restricted as to its being massaged because it was less accessible than the upper row. Since this sow constantly lay on her left side, the left row of teats was essentially a restricted massage treatment. The result was that the piglets on the right side consumed an average of 46.0 kilograms of milk per piglet during the lactation while those on the left side averaged only 27.8 kilograms. Data from another sow with similar habits showed the same tendency.

Milk Composition

Milk composition varies by breed, feeding and management, lactation number, stage of lactation, age of the sow, season of the year, and the dose of hormone used to stimulate milk ejection (Barber *et al*., 1955) and even in the same sow the milk of different teats may vary in composition, especially in fat content. Smith (1952) reported fat values of 9 and 15 per cent in two teats, simultaneously milked from the same sow.

Willett and Maruyama (1946) compared the fat content of milk during early and advanced stages in lactation from sows fed on three different rations containing varying levels of garbage. They observed that the fat content of milk increased with increased fat intake and also with advance of lactation. They noted a great variation in fat content of milk with the sows receiving the highest garbage ration, where the fat content was highest but not a constant daily level.

Bowland et al. (1949) milked sows at parturition, the third day, the end of the first week and each subsequent week throughout the 8-week lactation period. They observed that after an initial rise the fat content decreased appreciably as lactation advanced. They considered that it was difficult to establish a trend for total solids, but that a low point appeared to be reached about the third week of lactation after which the total solids increased slightly. In the case of solids not fat there was a tendency to rise after the third week. Protein showed a decline until the third week after which it gradually rose. After an initial rise from the colostral stage the lactose was more or less constant over the whole lactation. The ash showed a very definite rise from about 0.7% in the first milk to between 1.2% and 1.3% in the eighth week milk.

Dawn (1954) reported analyses through sixty-eight lactations of forty-four sows. He found that the protein content decreases until about the middle of the third week and then rises steadily as lactation proceeds. The lactose remains steady until about this same stage and then falls slightly over the rest of the lactation. Apart from a stationary stage during the third week, the ash content rises steadily over the whole lactation. The third week seems to be a critical time for several of the major constituents because during this week there is a change in the direction of their trends. This does not coincide with the stage of maximum production, but appears some one or two weeks earlier.

III. MATERIALS AND METHODS

The subjects of the study were 37 sows and their litters from the November, 1971 and March, 1972 farrowings of the Michigan State University swine herd. Sows and litters were housed in the central farrowing facility at the Michigan State University swine farm. This facility consists of a 96 feet by 24 feet wing off the main barn with large thermopane windows on the southern exposure. The building is fully insulated. Two thermostatically-controlled space heaters provide heat for this room. Three thermostatically-controlled exhaust fans and baffled, uniformly-spread inlet air provides draft-free ventilation. Farrowing crates are arranged in two rows in the facility on either side of a 6-feet aisleway. On one side of the aisleway there are 17 units (6.5' long by 5' wide) with the farrowing crate running the length in the center and an 18-inch wide creep area on either side. The floor on this side is solid concrete and these units are cleaned and bedded daily with soft wood shavings. There are 15 units on the other side of the aisleway and the pens are

6-feet wide allowing a 24-inch wide creep area on either side of the farrowing crate. The floor on this side is slotted with concrete slats under some of the units and aluminum slats under others. No bedding is used in these pens, however, a 3 feet by 2 feet piece of indoor-outdoor carpeting is placed on the slats in one of the creep areas and a heat lamp is suspended 2 feet above this pad. This provided heat to the pigs from above and insulation to prevent heat loss to the floor below. A heat lamp was also similarly hung over one of the bedded creep areas in units on the other side of the aisle. Room temperature was maintained at about 80°F.

Each unit provided a feed container directly in front of the sow with an automatic waterer directly beside the feed container. Sows were fed twice daily (8:00 A.M. and 4:00 P.M.) a 16% protein, corn-soybean meal ration fortified with minerals and vitamins. The daily feed of the sows varied with the number of pigs nursed and amounted to about 6 pounds plus 2/3 pound per pig nursed. The average daily feed during lactation was about 12 pounds.

The pigs were ear notched for permanent identification during the first day of life. Needle teeth were clipped also at this time and tails were docked. A single 100 mg. injection of iron in the form of iron dextran was administered intramuscularly at one to three days of age.

IV. EXPERIMENTAL PROCEDURE

Trial 1

Eleven sows were moved into the farrowing house on about the 110th day of gestation. These consisted of 9 Yorkshire x Hampshire crossbred sows, one Hampshire sow and one Yorkshire sow. Average weight of these sows as they entered the farrowing house was 437 pounds.

Constant attention was given to sows when it became apparent by let-down of the udder and ejectability of milk from the teats that parturition was imminent. As the piglets were born they were wiped dry, weighed and ear-notched for identification by birth order. Birth weight, sex and time of birth were recorded. When suckling began, teat order was recorded. After the entire litter was born nursing order was recorded twice daily (morning and evening) until one week of age and then recorded once daily until four weeks of age.

In addition to birth weight, weights of pigs at one day, one week, two weeks, three weeks and four weeks of age were recorded.

Blood samples were taken from the anterior vena cava of all pigs at one day and two weeks of age for determinations of hemoglobin concentration, hematocrit, total serum protein concentration and electrophoretic fractionation of serum proteins. Hemoglobin concentration was assayed by the cyanmethemoglobin method of Crosby et al. (1954) using a Coleman Junior II spectrophotometer. Hematocrit was determined by the micro method (McGovern et al., 1955). Blood samples were centrifuged for 5 minutes at 10,000 rpm in an International "Hemacrit" centrifuge and read on an International micro-capillary reader.

Blood taken for serum was allowed to clot in centrifuge tubes and serum separation was achieved by centrifuging for 10 minutes at 3000 g in an International Company Model V centrifuge. Serum was then harvested by aspiration, placed in vials and stored at -20 C until thawed just prior to total protein and electrophoretic determinations. Total serum protein was determined by the method of Miller (1959) and optical density was read on a Coleman Junior II Spectrophotometer. Electrophoretic separation was accomplished by the agar gel on film leader method of Leop and Lucile (1962). Densitometer scanning was performed on a Beckman, Model RB Analytrol for quantitation of the electrophoretic fractions.

Trial 2

Twenty-six sows which farrowed in March, 1972 were used in this study, including 13 Hampshires and 13 Yorkshires. Milk production of these 26 sows was estimated by the method of Mahan et al. (1971). This consisted of placing the pigs with the sow at hourly intervals for an 8-hour period on one day each week and accurately weighing pigs just prior to and immediately after each nursing. The difference in weight of the pig before and after nursing was attributed to milk consumption. Nursing order was observed and recorded each week in order to assign milk yield to each teat nursed. When pigs nursed two teats or when nursing pattern was altered as the sow alternated sides, this was also noted and recorded. All of these measurements and observations were recorded weekly during a 5-week lactation.

V. RESULTS AND DISCUSSION

Trial 1

The relationship between the birth order and nursing order of the nine crossbred, one Hampshire and one Yorkshire litter is shown in Table 1. There is no particular side the sow lies on during parturition. Some prefer the left side, while others prefer the right side. Most sows remain on one side throughout the entire farrowing, while others get up after farrowing has started and may lie on the other side to finish. The length between the first-born and the last-born is quite a range (Table 1a). From these 11 sows the range was from 19 minutes to 5 hours and 30 minutes, with most of them around 2 hours. The time of day when they farrow is quite different also, with some during the day-time and some at night. Five out of 11 farrowed at mid-day, with the rest in the evening or morning or midnight. As might be expected, there was a positive correlation of litter size and duration of parturition (r=0.20).

With regard to the relation between the birth order and nursing order, from Table 1 we can see quite

TABLE 1.--Birth Order Related to Nursing Order During the First Four Weeks of Lactation.

	Teat Position, Front to Rear											
Sow	1	2	3	4	5	6	7	8	9	10	11	
Breed	XB	XB	XB	XB	XB	H	XB	XB	XB	Y	XB	
Side Born	R	R	L	L	R	L	L	S	RL	R	L	Total
Birth Order												
1	L1	R6	R2	X	R6	X	R1	R1	R7	L6	L1	9
2	L6	L1	L3	R6	L1	R6	X	R4	R6	L2	R2	10
3	L5	R3	L4	R5	R4	X	R4	L1	L6	X	R3	9
4	R6	R4	R5	L3	L2	L2	R2	X	X	L1	R4	9
5	X	X	R3	L1	L6	L7	L1	R2	RL3	X	L2	8
6	R4	L2	L1	R7	R2			L3	RL2	R1	L1	9
7	L2	X	L2	X	X			L5	RL1	X	R6	5
8	L4	R2	R4	R3	L3			R3		R3	L3	8
9	L3	R1	L5	R2	X			R6		X	R5	6
10	R1	R5	X	L5	R3					L7		5
11	R5		R1	R4	R5					X		4
12	R7		R3	R1	R1					L4		5
13	R2		X							R2		2
14	R7		L6									2

Key: S=Stand or lie down both sides; XB=Hampshire x Yorkshire cross breed; H=Hampshire; Y=Yorkshire; X=died; L=left side; R=right side; Side born=sow parturition position.

TABLE 1A.--Time of Farrowing and Duration of Parturition.

Litter	Breed	Number of Pigs	Farrowing	Duration of Parturition (minutes)
1	XB	14	9:40 P.M.	162
2	XB	10	5:20 A.M.	98
3	XB	14	11:55 A.M.	95
4	XB	12	1:20 P.M.	132
5	XB	12	8:10 P.M.	95
6	H	5	1:30 A.M.	76
7	XB	8	10:35 A.M.	19
8	XB	9	8:58 A.M.	317
9	XB	7	2:30 P.M.	110
10	Y	14	4:43 P.M.	163
11	XB	10	10:30 A.M.	90
	Average	10.46		123.4

clearly that the first-born piglet usually nurses the first teat or the last teat (8 out of 9 surviving first-born), as did the last-born piglet (8 out of 11). Usually, when the first-born piglet took the first teat, the last-born piglet took the last teat; but if the first-born piglet took the last teat, then the last-born piglet took the first teat. The second-born piglet generally suckled the teat next to the first-born piglet, or suckled the teat farthest away from the first-born piglet (6 out of 9). The third-born piglet may follow the second, the fourth may follow the third, etc. but there did not seem to be any certain pattern. Ordinarily, when the piglet was born, as soon as he touched the ground, the first thing which he tried to do was to stand up and look for teats, starting from the last teat and going forward, trying different ones until he found the most suitable teat to his liking.

The reason for fixing upon a certain teat is unknown, but some of the researchers have offered opinions on this matter. Hafez, Sumption and Jakway (1962) stated that neither the physical nor the behavioral characteristics of the new-born piglet are correlated with their ultimate teat position. However, Hafez and Signoret (1969) reported that teat fixation and the establishment of a social hierarchy occur simultaneously. On the other hand, McBride (1963) said that teats seemed to be recognized by sight, smell and the recognition of neighbors, and he thought that the teat order and the social order are not directly related. They are probably both dependent upon such competitive factors as body size and aggressiveness. If the correlation between teat size and birth weight reflects any advantage in the teat order, then this would tend also to give social advantage to pigs with these qualities since social position and weaning weight contribute to subsequent growth (McBride et al., 1965). Concerning birth weight and teat position, Wyeth and McBride (1964) found a regression equation of teat position on birth weight which was $y=4.0-0.44x$, where y is the teat used and x is the birth weight. The regression coefficient of -0.44 had a standard error of 0.19 ($p<.05$).

The relation between birth order and piglet weight data are presented in Table 2. There was an extremely low correlation between birth order and birth weight in this study ($r=0.01$). There was a nonsignificant negative relationship between birth order and post-natal, pre-weaning gain ($r=-.09$).

The correlations between the birth weight and one week weight, two weeks weight, three weeks weight, and four weeks weight are all statistically significant ($r=0.39$, 0.27, 0.20, and 0.23 respectively). These correlation coefficients are somewhat lower than that found by Hartsock (1970), in which birth weight was positively

TABLE 2.--Piglets Weight-Related Birth Order.

Order of Birth	Growth									
	Birth Wt. (kg)	No.*	1-week Wt. (kg)	No.*	2-week Wt. (kg)	No.*	3-week Wt. (kg)	No.*	4-week Wt. (kg)	No.*	4-week Gain (kg)
1	1.25	10	2.29	9	3.51	8	5.21	8	6.45	8	5.30
2	1.24	10	2.62	9	3.75	9	5.29	9	6.73	9	5.44
3	1.17	10	2.42	8	3.57	8	5.15	8	6.63	8	5.45
4	1.13	10	2,01	8	2.78	8	5.13	8	5.59	8	4.43
5	1.20	10	2.53	8	3.50	7	5.08	7	6.81	7	5.5
6	1.27	9	2.38	8	3.40	8	4.86	8	6.28	8	5.07
7	1.15	9	2.48	4	3.78	4	5.55	4	7.0	4	5.68
8	1.24	8	2.49	7	3.35	7	4.69	7	6.32	7	5.03
9	1.23	7	2.67	5	3.95	5	5.72	5	7.28	5	5.99
10	1.21	6	2.40	5	3.35	5	4.75	5	6.21	5	5.03
11	1.24	5	2.51	4	3.58	4	5.09	4	6.45	4	5.22
12	1.24	5	2.49	5	3.27	5	4.63	5	5.98	5	4.32
13	1.21	3	2,67	2	3.7	2	5.25	2	6.72	2	4.45
14	1.17	3	1.97	2	2.35	2	3.3	2	4.31	2	3.18

*Number of piglets.

correlated with 21-day weight (r=.57) and with 21-day gain (r=.43).

England and Rose (1963) found that the correlation between birth weight and weaning weight in swine was relatively high (r=.43). In 1964, Keeler and England reported that piglets heavier at birth gained faster to 7 kilograms body weight than piglets of lighter birth weight. However, a follow-up study by Keeler and England (1964), in which piglets averaging about 3.9 kilograms were removed from their mothers and full-fed milk replacer for 17 days, revealed no significant differences between lower birth weight piglets and higher birth weight piglets with respect to average daily intake, average daily gains, or efficiency of feed utilization.

Veum et al. (1967) stated that pig weight gains were highly repeatable by week with an average correlation of 0.64, which differed significantly from zero ($p<0.05$). The within-sow correlations show a significant positive correlation between birth weight and pig weight gain for each week.

McBride et al. (1965) stated that about 19% of the variation in 8-week weight was determined by difference in birth weight.

The relationship of birth order and 24-hour and two-week hemoglobin and hematocrit values is presented in Tables 3, 4, 5, and 6. There was a significant positive

TABLE 3.--Birth Order Related to Twenty-Four Hour Hemoglobin Values.

	Hemoglobin, g/100 ml.										
Breed Sows	1 XB	2 XB	3 XB	4 XB	5 XB	6 H	7 XB	8 XB	9 XB	10 Y	11 XB
Birth Order 1	10.23	6.9	9.15	8.56	8.83	X	8.0	8.87	8.62	3.94	3.94
2	9.98	6.4	7.07	8.81	7.50	7.5	6.55	8.04	9.95	6.63	8.5
3	9.6	8.56	7.4	8.36	9.37	5.43	8.29	9.08	7.79	X	11.06
4	9.1	7.98	9.98	10.43	8.45	7.21	8.87	X	X	4.1	6.84
5	8.69	8.06	8.98	9.19	9.66	7.5	X	8.62	7.79	2.74	9.16
6	8.77	7.98	9.81	11.27	7.83		8.41	7.83	8.66	9.53	7.67
7	9.81	X	8.81	X	7.50			8.83	7.25	X	15.21
8	8.6	6.98	8.73	9.69	8.87			10.03		8.66	9.99
9	10.48	9.98	9.29	10.43	8.08			7.42		X	11.35
10	10.48	8.15	11.14	10.27	7.62					8.99	
11	9.06		8.81	9.39	8.91					X	
12	10.39		10.48	9.19	11.52					9.24	
13	11.35		X							10.9	
14	9.35		4.57							X	

TABLE 4.--Birth Order Related to Twenty-Four Hour Hematocrit Values.

	Hematocrit, %											
	Breed Sows	1 XB	2 XB	3 XB	4 XB	5 XB	6 H	7 XB	8 XB	9 XB	10 Y	11 XB
Birth Order	1	31.4	23.1	26.8	26.3	25.2	X	26.2	27.2	27.2	11.8	8.3
	2	32.6	21.2	21.1	29.2	21.8	23.0	20.6	25.0	32.1	18.7	24.4
	3	29.8	27.4	23.7	37.1	29.3	18.0	29.8	27.2	23.9	X	28.9
	4	28.1	24.9	31.0	33.8	24.2	26.2	29.8	X	X	12.0	18.5
	5	27.1	22.4	27.3	29.2	29.8	23.0	X	25.5	24.0	8.4	21.2
	6	26.5	24.7	29.2	34.2	22.7		28.8	23.3	29.5	29.2	23.6
	7	32.1	X	25.8	X	21.8			27.5	25.0	X	23.2
	8	27.0	21.1	25.7	31.6	25.6			31.1		25.1	27.5
	9	32.9	31.2	27.3	28.6	22.9			26.0		X	24.0
	10	32.2	25.3	30.1	28.0	22.7					27.9	
	11	29.6		28.6	31.2	26.8					X	
	12	31.2		31.5	27.1	33.5					31.0	
	13	34.6		X							32.6	
	14	28.6		12.6							X	

TABLE 5.--Birth Order Related to Two-Week Hemoglobin Values.

		Hemoglobin, g/100 ml.									
	Breed Sows	1 XB	2 XB	3 XB	4 XB	5 XB	6 H	7 XB	8 XB	9 XB	10 Y
Birth Order	1	10.69	9.16	10.28	X	10.77	X	9.95	9.78	10.77	9.22
	2	9.57	3.90	6.38	8.7	6.63	6.22	X	4.89	5.72	5.38
	3	4.64	10.24	8.83	11.69	9.49	X	9.99	9.74	11.11	X
	4	8.33	5.14	7.79	8.04	7.17	10.57	5.47	X	X	X
	5	X	X	8.66	10.98	9.86		8.83	9.16	9.66	X
	6	X	4.52	7.63	9.57	6.55			5.06	4.48	5.34
	7	10.73	X	10.36	X	X			10.82		X
	8	9.49	3.36	6.42	6.3	5.76			5.3		4.71
	9	10.11	9.49	10.03	9.49	X			9.82		X
	10	7.13	4.64	X	7.46	7.71					4.09
	11	3.03		10.73	10.36	10.36					
	12	8.04		7.50	5.64	10.36					
	13	11.15		X							
	14	8.87		6.63							

TABLE 6.--Birth Order Related to Two-Week Hematocrit Values.

		Hematocrit, %									
	Breed Sows	1 XB	2 XB	3 XB	4 XB	5 XB	6 H	7 XB	8 XB	9 XB	10 Y
Birth Order	1	33.8	31.2	32.0	X	34.7	X	31.9	31.1	36.2	28.8
	2	30.6	13.7	20.3	27.0	21.4	22.2	X	15.8	19.8	13.8
	3	15.7	32.9	29.5	36.0	32.5	X	33.8	31.8	39.2	X
	4	27.8	16.6	24.2	25.1	22.8	32.4	18.7	X	X	X
	5	X	X	29.1	36.2	30.9		31.2	28.3	32.2	X
	6	X	14.8	24.4	31.1	19.8			18.3	19.4	16.3
	7	34.4	X	33.7	X	X			34.8		X
	8	29.3	11.7	20.1	21.0	18.5			17.8		18.4
	9	32.5	30.0	32.2	34.2	X			34.1		X
	10	24.3	16.1	X	25.2	23.3					14.6
	11	11.6		33.8	34.1	34.7					
	12	26.2		24.2	17.1	32.3					
	13	25.3		X							
	14	25.7		23.0							

relationship between birth order and 24-hour values of hemoglobin (r=0.34) and hematocrit (r=0.27). This relationship might be expected, since the earlier born pigs would have access to the first colostrum and for a longer period of time than pigs which were born later in the litter. Having obtained more colostrum, the earlier born pigs should transfer the proteins obtained from this colostrum to their blood plasma, thus increasing the plasma volume due to the increased osmotic pressure and lowering the concentration of cellular components in the blood (Miller et al., 1961b).

There was a non-significant negative relationship between birth order and two-week hemoglobin (r=-.10) and hematocrit (r=-.14) values. Since birth order was non-significantly negatively related to two-week gain (r=-.11), any relationship which may exist between birth order and post-natal hemoglobin and hematocrit values could be expected to be positive rather than negative.

Veum et al. (1967) found a correlation coefficient between birth weight and hemoglobin at 12 days post partum of 0.34, but the correlation of hemoglobin and weight gain at specific intervals through 24 days post partum were very low (average r=.08). In the study of Veum et al. (1967) pigs were not given iron treatment or creep feed but likely picked up iron from the sow's feces (Veum et al., 1965). Dimov (1964) reported data which indicate an inverse relationship between hemoglobin and weight at weaning. Many researchers have noted this inverse relationship between pre-weaning gain and hemoglobin concentration (Miller *et al*., 1961b) when there was equal iron intake. In the present study, each pig received a single 100 mg. intramuscular injection of iron, in the form of iron dextran, at 3 days of age and an inverse relationship between post partum gain and hemoglobin values would have been expected. Since blood hemoglobin and hematocrit values are highly correlated (Miller *et al*., 1961b), whatever relationships exist between hemoglobin and other parameters would be expected to be similar to that of hematocrit and the same parameters.

The influence of birth order upon 24-hour values of total serum protein may be obtained from the data presented in Table 7. While the correlation coefficient ($r=-.13$) was not statistically significant, it did approach significance ($p<.10$). This negative relationship between birth order and 24-hour total serum protein value is that which should be expected, since the 24-hour value of total serum protein is largely dependent upon the protein obtained from colostrum (Miller *et al*., 1961a), and early born pigs in the litter are likely to consume more colostrum. Twenty-four-hour value of serum protein (Table 7) and two-week value of total serum protein (Table 8) were selected as parameters, since the former

TABLE 7.--Birth Order Related to Twenty-Four Hour Total Serum Protein.

		Total Serum Protein, mg/ml										
	Breed Sows	1 XB	2 XB	3 XB	4 XB	5 XB	6 H	7 XB	8 XB	9 XB	10 Y	11 XB
Birth Order	1	64.71	85.58	97.96	81.97	84.00	85.01	91.61	74.61	72.83	67.25	73.09
	2	66.95	92.12	88.06	70.04	79.18	77.4	87.55	89.52	72.07	92.94	79.18
	3	63.19	78.16	97.96	76.39	88.82	74.10	104.38	85.48	69.03	-----	80.70
	4	56.43	92.88	106.33	62.68	82.48	77.4	94.15	-----	-----	51.30	96.69
	5	60.14	89.07	92.34	79.01	70.80	57.10	105.17	64.96	58.74	27.21	94.91
	6	43.14	81.83	105.62	53.55	84.25		87.3	84.0	85.52	96.96	100.75
	7	65.41	-----	97.76	-----	57.35			71.82	84.65	-----	113.94
	8	38.07	74.10	101.76	72.09	80.19			69.28		95.16	85.52
	9	35.40	71.31	86.28	69.28	87.55			83.35		-----	97.70
	10	31.91	93.90	108.87	45.43	67.25					83.74	
	11	60.02		98.46	45.43	91.61					-----	
	12	47.74		105.53	77.21	82.48					91.02	
	13	35.37		------							69.03	
	14	54.91		76.89								

TABLE 8.--Birth Order Related to Two-Weeks Total Serum Protein.

		Total Serum Protein, mg/ml									
	Breed / Sows	1 XB	2 XB	3 XB	4 XB	5 XB	6 H	7 XB	8 XB	9 XB	10 Y
Birth Order	1	49.23	61.31	96.43	-----	67.50	-----	70.28	53.29	58.62	45.68
	2	51.52	72.32	67.98	55.32	71.31	79.52	-----	66.74	-----	57.86
	3	52.02	68.49	72.83	62.82	66.68	-----	66.23	58.88	63.95	-----
	4	52.68	66.69	67.25	55.32	75.44	68.23	64.46	-----	-----	60.40
	5	-----	-----	73.09	62.94	64.71	77.98	70.54	64.71	62.68	-----
	6	51.24	76.44	-----	49.49	62.17			60.14	56.08	75.62
	7	49.99	-----	-----	-----	-----			52.02	78.53	-----
	8	46.75	83.93	71.82	59.64	68.52			-----		74.39
	9	41.62	68.52	66.94	56.89	-----			65.41		-----
	10	52.78	79.81	-----	55.32	63.44					74.36
	11	44.16		68.77	54.07	62.0					-----
	12	52.27		79.01	57.86	61.16					62.17
	13	50.50		-----							
	14			59.0							

value could serve as an indicator of the quantity of colostrum consumed and the latter value could serve as an indicator of metabolic rate. The correlation of birth order and two-week serum protein values (r=-.12) is of the same order as that between birth order and 24-hour serum protein values (r=-.13) and would indicate that there is no significant influence of birth order on post partum metabolic rate.

Included in tables 9, 10, 11, 12, 13 and 14 are relationships of birth order and 24-hour or two-week values of serum γ-globulin, non-immune globulins and albumin. At 24 hours of age the pig has the highest level of γ-globulin that he will ever have (Miller et al., 1961a). This is almost exclusively due to antibody protein obtained from colostrum. Percentage of total serum protein which was immune protein (γ-globulin) in the current study was generally higher than that observed by Miller et al. (1961a), indicating that the pigs in the present study, in general, obtained good nursings of colostrum. As with serum total protein, so also there is a negative relationship of 24-hour γ-globulin and birth order (r=-.21), and this is statistically significant ($p<.05$). This leaves little doubt that the first-born pigs obtain significantly greater quantities of antibody protein from colostrum than those pigs born later in the litter. One might expect this to be most pronounced in

TABLE 9.--Birth Order Related to Twenty-Four Hour Serum γ-Globulin.

		Serum γ-Globulin, %									
	Breed Sows	1 XB	2 XB	3 XB	4 XB	5 XB	6 H	7 XB	8 XB	9 XB	10 Y	11 XB
Birth Order	1	50	66.2	65.9	73.1	57.3	62.0	70.2	58.6	81	60.5	73.5
	2	63.2	69.3	67.0	54.2	58.6	57.5	74.4	50.7	56.2	57.1	59.6
	3	63.3	61	66.8	54.2	60.9	71.4	65.3	51.6	60	----	68.1
	4	61.2	68.6	69.9	49.6	62.9	51.1	65.5	----	----	45.7	65.4
	5	68.1	68.6	69.9	59	53.4	59.4	62.8	59	59	31.7	46.7
	6	40	62.1	66.7	44.4	66.2		58.7	57.6	54.5	75	69.2
	7	45.6	----	69.9	----	50.6			50	62.8	----	74.5
	8	----	63.9	----	48.9	59.3			49.2		67.2	66.1
	9	29.1	72.9	68.5	59	65			57.7		----	63.3
	10	59.3	66.3	62.9	36.3	64					81.8	
	11	50.5		64.1	36	61.2					----	
	12	41.8		64.9	60.8	52.4					59.6	
	13	44.4		----							56.1	
	14	53.1		65.3								

TABLE 9A.--Total Serum γ-Globulin.

		Total Serum γ-Globulin, mg/ml									
	Breed Sows	1 XB	2 XB	3 XB	4 XB	5 XB	6 H	7 XB	8 XB	9 XB	10 Y
Birth Order	1	32.36	56.65	64.56	59.92	48.13	52.71	64.31	43.72	58.99	40.69
	2	42.31	63.84	59.0	37.96	46.4	44.51	65.14	45.39	40.50	53.07
	3	40	47.68	65.44	41.4	54.09	52.91	68.16	44.11	41.42	-----
	4	34.54	63.72	74.32	52.74	51.88	39.55	61.67	-----		23.44
	5	40.96	61.1	64.55	46.62	37.81	33.92	66.05	38.33	34.66	8.63
	6	17.26	50.82	70.45	23.78	55.77		51.25	48.38	46.61	72.72
	7	29.83	-----	69.03	-----	29.02			35.91	53.16	-----
	8	-----	47.35	-----	35.25	47.55			34.09		63.95
	9	10.3	51.99	59.1	40.88	56.91			48.09		-----
	10	18.92	62.26	68.48	16.49	43.04					68.50
	11	30.31		63.11	16.35	56.07					-----
	12	19.96		71.09	66.59	43.22					54.25
	13	15.7		-----							38.73
	14	29.16		50.21							

TABLE 10.--Birth Order Related to Twenty-Four Hour Serum Albumin

		Serum Albumin, %										
	Sow	1	2	3	4	5	6	7	8	9	10	11
	Breed	XB	XB	XB	XB	XB	H	XB	XB	XB	Y	XB
Birth Order	1	9.3	9.7	8.5	9.1	12.6	12.7	9.7	9.4	8.9	10.1	14.3
	2	9.2	9.2	7.9	6.9	11.2	12.8	11.6	11.3	21.9	7.5	10.8
	3	8.2	10.4	8.8	11.9	12	19.1	15.3	8.6	14.6	----	13.2
	4	16.3	8.6	8	11.3	11.3	19.8	10.3	----	----	10.1	17.6
	5	6.9	9.8	9.8	11	21.1	17.9	11.6	11	10.3	22	9.6
	6	11.4	9.8	11.9	10	11.8		9.4	7.6	11.6	6.8	6.9
	7	8.8	----	8.6	----	12.4			11.3	9.2	----	9.4
	8	----	10.7	----	8	12.1			16.9		8.6	10.1
	9	14	12.9	8.4	8.4	8.3			13.5		----	10.7
	10	22.2	7.9	10.5	13.7	12					8.2	
	11	14		10.5	18	11.2					----	
	12	12.1		10	8.4	11.9					8.8	
	13	20		----							11.4	
	14	9.2		7.3								

TABLE 11.--Birth Order Related to Twenty-Four Hour Serum Non-Immune Globulins.

	Serum Non-Immune Globulins, %										
Sow Breed	1 XB	2 XB	3 XB	4 XB	5 XB	6 H	7 XB	8 XB	9 XB	10 Y	11 XB
Birth Order 1	40.7	24.1	25.6	17.7	30.2	25.4	20.2	32	10.1	29.4	12.3
2	27.6	21.5	25.1	39.2	30.3	29.8	14	38.1	21.9	35.4	29.5
3	28.6	28.7	24.4	33.9	27.2	9.5	19.4	39.8	25.5	----	18.8
4	22.5	22.9	22.1	39.1	25.8	29.1	24.3	----	----	44.2	17
5	25	21.6	20.3	30.1	25.5	22.6	25.6	30.1	30.7	46.3	43.7
6	48.6	28.1	21.5	45.6	22.1		27.7	34.5	34.2	18.2	23.9
7	45.6	----	21.5	----	37.1			38.7	28.1	----	16.0
8	----	25.4	----	43.1	28.6			33.9		24.1	23.8
9	57	14.0	23.1	32.6	26.7			28.9		----	26.1
10	18.5	25.7	26.6	50	24					10	
11	35.5		25.5	46	27.7					----	
12	46.2		25.1	30.8	35.7					31.6	
13	35.6		----							32.5	----
14	37.8		27.4								

TABLE 12.--Birth Order Related to Two-Weeks Serum γ-Globulin.

		Serum γ-Globulin, %									
	Breed Sows	1 XB	2 XB	3 XB	4 XB	5 XB	6 H	7 XB	8 XB	9 XB	10 Y
Birth Order	1	14.3	27.8	----	----	20.2	----	21.1	22.6	16.8	17.5
	2	19.1	11.3	13.6	24	13.9	15.9	----	11.8	12.7	14.7
	3	21.2	19	27.3	15.8	10.8	----	22.2	22.2	12.5	----
	4	13.2	21.9	18.9	14.6	17.0	26.6	16.6	----	----	13.8
	5	----	----	20.7	22	25.3	14.9	18.6	14.4	13.1	----
	6	7.1	14.7	16.9	25.2	18.9		16.2	16.2	16.1	16.7
	7	15	----	22.9	----	----			15.3	11.5	----
	8	11.0	14.6	23.2	12.2	20.6			18.6		23.5
	9	8.3	18.9	24.6	18.4	----			12.9		----
	10	3.7	13.5	----	9.4	13.1					14.5
	11	10.7		18.1	14.3	14.4					----
	12	6.6		18.3	15.1	16.4					16.5
	13	10.3		----							19.5
	14	----		14.9							

TABLE 13.--Birth Order Related to Two-Weeks Serum Albumin.

		Serum Albumin, %*									
	Breed Sows	1 XB	2 XB	3 XB	4 XB	5 XB	6 H	7 XB	8 XB	9 XB	10 Y
Birth Order	1	54.5	46.5	X	X	52.4	X	43.8	46.8	48	54.4
	2	47.6	48.3	51.2	39.1	57	43	X	46.6	47.6	50
	3	37.7	62	30.7	54.4	56.7	X	35.8	35.8	52.5	X
	4	48.8	45.3	42.1	53.1	38.8	45.7	52.3	X	X	51.7
	5	X	X	36.2	49.5	40.9	45.3	54.6	46.5	54.6	X
	6	44.7	41.7	50	41.8	56.8		40.5	40.5	41.2	43
	7	34.0	X	51.7	X	X			54.1	55.1	X
	8	51.4	45.3	35.9	46.0	50.7			38.6		36.8
	9	58.3	52.8	48.4	46.8	X			57.7		X
	10	54.5	48	X	54.7	48.9					52.6
	11	54.1		52.6	60.4	65.6					X
	12	40.4		39.4	47.1	49.2					52.8
	13	57.4		X							51.8
	14			49.6							

*Albumin per cent in serum protein.

TABLE 14.--Birth Order Related to Two-Weeks Other Serum Non-Immune Globulins.

		Serum Non-Immune Globulins, %									
	Breed Sows	1 XB	2 XB	3 XB	4 XB	5 XB	6 H	7 XB	8 XB	9 XB	10 Y
Birth Order	1	31.3	25.7	----	----	27.4	----	35.1	30.7	35	28.1
	2	33.3	40.4	35.2	36.9	29.1	41.1	----	41.6	39.7	35
	3	41.2	19	42.1	29.8	32.5	----	42	42	35	----
	4	38	32.8	39.0	32.3	44.2	27.7	31.1	----	----	34.5
	5	----	----	43.1	28.4	33.8	39.9	26.8	39.1	32.3	----
	6	48.2	43.6	33.1	33	24.3		43.3	43.3	42.8	42.3
	7	51	----	25.4	----	----			30.6	33.5	----
	8	37.6	40.2	40.9	41.9	28.8			42.8		39.7
	9	33.3	28.3	27.1	34.9	----			29.4		----
	10	41.8	38.5	----	36.0	38.1					33
	11	35.3		29.3	25.3	20					----
	12	53		42.3	37.8	34.4					30.7
	13	32.4		----							28.7
	14			35.5							

large litters in which the duration of parturition was extended; however, inspection of the data (tables 9 and 9a) does not appear to verify this.

Serum albumin (Table 10) is low at birth and is not increased during the first 24 hours because there is little or no albumin in colostrum (Miller et al., 1961a). Actual percentage of total serum protein which is albumin is generally 10% or less at 24 hours of age (Table 10) and there was no influence of birth order on this measure (r=.02).

At birth the non-immune globulins comprise about 75% of the total serum proteins (15% β-globulins and 60% α-globulins, Miller et al., 1961a), but as a percentage of total serum protein, these non-immune globulins diminish to less than 40% at 24 hours of age (Table 11). There was a positive significant relationship between birth order and percentage of non-immune globulins at 24 hours (r=0.23). There is, no doubt, a strong negative relation between percentage of serum γ-globulin and percentage of serum non-immune globulins at this age.

At two weeks of age only one of the electrophoretic fractions was significantly related to birth order and this was serum γ-globulin (r=-.29). Serum non-immune globulins were no longer significantly related to birth order (r=0.05), but the relation between birth order and serum albumin had increased to near significance (r=0.18).

The serum γ-globulin relationship with birth order (r=-.29) probably reflects a continued influence of the relationship which existed at 24 hours (r=-.21), since γ-globulin is not being actively synthesized to any extent by the pig during this period and is being metabolized at this age at a rate in which the half-life is 9 days (Miller et al., 1961a). On the other hand, serum albumin is actively synthesized by the pig during this period (Miller et al., 1961a). Many of the proteins which transport essential metal ions in serum are contained in the non-immune globulin fraction (Fruton and Simmonds, 1953).

There are indeed large and rapid changes occurring in the first 24 hours of life which, no doubt, greatly influence the physiology of the neonatal pig. Rook et al. (1951), Rutqvist et al. (1958), Foster et al. (1950), Nordbring and Olsson (1957) and Miller et al. (1961a) all found none or very small amounts of γ-globulin in the pig at birth. Olsson (1959) found large amounts of antibodies or immune proteins were absorbed during the first 12 hours of life. Speer et al. (1959) demonstrated that the absorption of ingested antibodies by the pig occurs only within the first 24 hours after birth with absorption rate diminishing exponentially from birth. Miller et al. (1962) verified this. Lecce and Morgan (1962) and Lecce, Morgan and Matrone (1964) showed that some dietary component is responsible for the closure of the gut to absorption of protein. No doubt there are factors other than diet which influence the amount of immune proteins which are absorbed prior to gut closure (Ullrey, Long and Miller, 1965), but the data presented in the present study indicate that the pig born first in the litter has an advantage in this regard over those born later in the litter. Presumably, a higher level of antibody protein present in the circulation of the post natal pig should be beneficial to his performance in an environment which is not pathogen-free. In the present study, the correlation of serum γ-globulin (mg/ml) obtained from colostrum (24-hour value) with subsequent four-week, pre-weaning gain (r=.12) indicated a positive, if not a strong, beneficial effect. The fact that these pigs were free from any clinical manifestation of disease during the study may preclude the possibility that there might be a stronger positive relationship between these two parameters under conditions of greater pathogenicity.

Trial 2

A comparison of milk intake and pig growth was made in this study and detailed data, including birth weight, 5-week weight, 5-week gain and 5-week milk intake of 174 individual pigs are presented in Table 15. There is a very high correlation, as should be expected, between 5-week gain and 5-week milk intake (r=0.78). This relationship would, no doubt, have been even closer had not

TABLE 15.--The Relationship of Milk Production to Pig Growth.

Birth Wt. (kg)	5th Weeks Wt. (kg)	Gain Wt. (kg)	Total 5-Week Milk Intake (kg)
1.0	8.99	7.99	28.18
1.32	9.16	7.84	27.99
1.32	9.10	7.78	29.4
1.41	9.12	7.71	25.94
1.04	8.05	7.01	28.39
1.23	10.18	8.95	32.66
1.36	5.94	4.58	17.72
1.27	8.43	7.16	27.99
1.09	11.01	9.92	27.91
1.0	8.14	7.14	27.20
1.23	9.05	7.82	30.77
1.23	6.26	5.03	21.80
1.32	5.73	4.41	14.22
.82	7.53	6.71	24.11
1.23	8.62	7.39	26.36
1	7.86	6.86	29.42
1.27	9.06	7.79	28.71
1.23	8.71	7.48	32.93
1.45	9.5	8.05	32.70
1.27	8.18	6.91	24.84
1.32	8.16	6.84	27.22
1.27	8.87	7.60	26.82
1.14	6.58	5.45	21.44
1.27	10.23	8.96	23.75
1.09	9.52	8.43	35.27
.77	9.27	8.50	31.61
1.73	8.29	6.56	23.52
1.91	11.98	10.07	34.06
1.68	11.38	9.7	46.73
1.95	12.94	10.99	42.0
1.77	10.54	8.77	32.03
1.91	12.86	10.95	42.53
1.68	10.2	8.52	33.64
1.59	9.85	8.26	35.04
1.36	6.65	5.29	23.80
1.23	7.01	5.78	20.97
1.23	6.55	5.32	22.58
1.14	5.48	4.35	15.96
1.50	9.90	8.40	26.81
1.41	10.20	8.70	32.73
1.27	9.05	7.78	26.46
.95	8.76	7.81	24.85
.91	8.99	8.08	23.63
1.04	7.47	6.43	23.94

TABLE 15.--Continued.

Birth Wt. (kg)	5th Weeks Wt. (kg)	Gain Wt. (kg)	Total 5-Week Milk Intake (kg)
.95	7.83	6.88	23.73
1.27	9.19	7.92	27.09
1.09	10.40	9.31	29.16
1.0	9.21	2.21	24.71
.86	8.45	7.59	23.03
1.14	9.25	8.12	21.84
.95	8.64	7.70	20.79
1.23	9.50	8.27	21.04
1.59	10.54	8.95	33.01
1.32	8.96	7.64	28.29
1.54	9.64	8.10	32.21
1.50	8.25	6.75	24.47
1.41	8.90	7.49	27.64
1.36	9.10	7.74	27.89
1.27	7.53	6.26	29.34
1.41	9.33	7.92	35.62
1.27	9.72	8.45	32.66
1.41	8.0	6.59	24.49
1.32	8.89	7.57	32.68
1.23	8.67	7.44	26.04
1.23	6.34	5.11	20.22
1.73	10.88	9.16	31.48
1.68	10.78	9.10	29.38
1.14	7.03	5.9	19.71
1.09	5.0	3.91	16.28
.86	6.10	5.24	18.20
1.09	7.37	6.28	24.89
1.04	6.95	5.91	26.25
.82	5.13	4.31	15.26
1.0	6.73	5.73	24.43
.86	5.71	4.85	24.05
1.59	8.74	7.15	27.67
1.36	8.93	7.57	28.91
1.27	8.05	6.78	30.21
1.32	9.07	7.75	32.34
1.27	9.55	8.87	32.82
1.54	6.45	4.91	16.58
1.36	9.8	8.44	32.79
1.45	10.76	9.31	34.43
1.27	10.18	8.91	32.79
1.18	6.15	4.97	30.30
1.23	10.66	9.43	37.02
1.41	6.71	5.30	17.72
1.18	8.90	7.72	22.92
1.09	10.26	9.17	40.13

TABLE 15.--Continued.

Birth Wt. (kg)	5th Weeks Wt. (kg)	Gain Wt. (kg)	Total 5-Week Milk Intake (kg)
1.77	11.0	9.23	34.55
1.63	7.58	5.94	18.98
1.59	10.70	9.11	33.65
1.32	7.05	5.73	23.73
1.23	6.92	5.69	24.39
1.59	8.29	6.70	27.12
1.23	11.26	10.03	32.49
1.00	9.34	8.34	29.30
1.00	8.18	7.18	31.82
0.73	5.24	4.51	22.67
0.82	6.76	5.94	23.31
0.82	7.45	6.63	24.29
1.18	8.09	6.91	26.27
0.95	6.05	5.10	19.40
1.54	10.48	8.94	27.25
1.36	11.96	10.60	29.42
1.14	8.20	7.07	22.92
0.73	7.86	7.13	23.06
1.45	10.54	9.09	26.90
1.27	8.22	6.95	20.97
1.14	10.30	9.17	28.45
1.04	9.39	8.35	22.03
1.04	7.24	6.17	19.84
1.23	5.76	4.26	16.28
1.41	8.98	7.75	32.95
1.41	5.90	4.49	18.90
1.27	6.86	5.59	19.45
1.59	9.84	8.25	30.66
1.41	9.79	8.38	29.04
1.32	8.93	7.61	33.32
1.36	8.86	7.50	29.46
1.41	8.75	7.34	29.73
1.54	8.62	7.08	33.86
1.36	7.92	6.56	28.54
1.23	7.21	5.98	24.81
1.27	8.05	6.78	29.96
1.18	8.22	7.04	21.07
1.13	8.31	7.18	30.48
1.04	7.86	6.82	29.80
1.36	5.17	3.81	18.72
1.59	6.31	4.72	20.30
1.63	5.55	3.92	20.09
1.59	5.50	3.91	19.98
1.32	4.94	3.62	19.17

TABLE 15.--Continued.

Birth Wt. (kg)	5th Weeks Wt. (kg)	Gain Wt. (kg)	Total 5-Week Milk Intake (kg)
1.32	3.19	1.87	13.37
1.41	7.90	6.49	23.63
1.95	10.32	8.37	30.03
1.95	9.37	7.42	26.46
1.82	7.60	5.54	19.98
1.54	11.40	9.90	37.59
1.45	10.14	8.69	29.48
0.91	7.26	6.35	24.57
1.0	7.97	6.97	27.09
1.18	6.44	5.26	17.23
1.41	9.33	7.92	25.34
1.23	9.03	7.80	19.06
0.82	6.27	5.45	19.43
1.45	10.08	8.63	23.07
1.45	9.27	7.82	23.46
1.36	8.51	7.15	22.14
1.36	8.90	7.54	25.19
1.45	10.42	8.97	33.74
1.45	10.22	8.77	32.46
1.36	9.29	7.93	30.29
1.27	10.74	9.47	33.54
1.54	7.64	6.10	31.28
1.59	8.43	6.84	28.13
1.36	7.97	6.61	29.25
1.45	8.09	6.64	32.14
1.36	8.35	6.99	29.27
1.23	6.54	5.31	26.25
1.14	5.30	4.37	22.65
1.14	8.08	6.95	34.44
0.95	5.76	4.81	23.79
1.63	11.76	10.13	37.50
1.36	8.56	7.20	24.33
0.91	7.29	6.38	24.73
0.91	9.11	8.20	24.87
1.45	10.94	9.49	33.27
1.95	12.66	10.71	43.62
1.73	11.12	9.40	37.14
1.59	10.32	8.73	31.82
1.91	11.42	9.51	36.19
1.73	10.14	8.42	35.31
1.63	11.04	9.41	33.92

creep ration been available, since Lodge and McDonald (1959) have shown that a large portion of the variation in weaning weight between litters is due to variation in creep feed eaten.

Hartman et al. (1962) related weekly milk intake to weekly pig weights and from the first through the sixth week of lactation obtained the following correlation coefficients: first week 0.08, second week 0.59 ($p<.01$), third week 0.62 ($p<.01$), fourth week 0.84 ($p<.01$), fifth week 0.54 ($p<.01$). Although the correlation coefficients for the second through the sixth week were all highly significant, no explanation was apparent for the high value during the fourth week of lactation.

Two other highly significant correlations of parameters in Table 15 are that between birth weight and 5-week milk intake ($r=0.42$) and that between birth weight and 5-week weight ($r=0.48$). The positive correlation of birth weight and milk intake suggests that the larger pigs obtain more milk because they are better competitors and that when two pigs fight for the same teat the heavier pig wins out and drinks until satisfied with the lighter pig obtaining the remaining milk, or, what is more likely, the heavier pig obtains the choicer teat and the lighter pig must accept a poorer milking teat. The other possibility is that the larger pig provides greater stimulation to whatever teat he is nursing and thus stimulates more milk flow. Donald (1937a) observed that the largest pigs generally obtained the most milk. McBride (1965) said that heavy pigs at birth have a double advantage in that they reach greater weights independently of teat position and, in addition, tend to occupy the more favorable teats. Hartsock (1970) observed that pigs which are heavier at birth win a greater percentage of their fights and can, therefore, choose and defend the more productive teats. Hartman et al. (1962) noted that it appeared that the larger pigs, assumed to be more vigorous, emptied their mammary glands more completely when nursing and thus stimulated greater milk production. Thus, it is evident that several factors function to enable the high correlation of birth weight and milk intake (r=0.420) and result in the still higher correlation of birth weight and weaning weight (r=0.480).

Data are presented in Table 16 which relate teat order to milk production. Included are data from 120 pigs which were stable nursers, that is, they consistently nursed the same teat no matter what the nursing position of the sow and they nursed that one teat only. The anterior teats, left or right, were the most often preferred stable teats. The second, third, fourth or sixth teats were about equally stably occupied, while the fifth and seventh teats were least often stably occupied. Some of the sows, of course, did not have seventh teats and this

TABLE 16.--The Relationship of Teat Order to Milk Production.

Teat Order	Number of Pigs	5-Week Milk Yield Per Pig Nursed (kg)	5-Week Average Weight of Pigs (kg)
Left			
1	14	29.88	8.97
2	10	25.86	7.82
3	8	25.04	7.54
4	10	27.30	8.18
5	3	27.69	9.01
6	11	23.71	7.58
7	3	32.27	11.19
Right			
1	17	29.99	8.77
2	9	31.60	9.26
3	10	28.62	8.22
4	8	23.26	7.30
5	7	26.86	8.67
6	7	24.38	8.23
7	3	25.02	8.52

at least partially accounts for the low stability on this teat. It should be pointed out that most of the teat switching occurred as a result of the sow's nursing position. Frequently when the sow reversed the side on which she lay during nursing, some pigs would alternate teats with their counterparts directly on the other side or would exchange teats in a diagonal arrangement with another pig. Rarely did this exchange involve a longitudinal displacement of more than one teat. Occasionally a pig would nurse two teats at each nursing, and this pig was invariably a heavy pig. In one case, in a large litter, one teat became non-functional and two pigs alternated on this teat. Depending on the side on which the sow lay, the pig left with this teat most often was barely able to maintain his weight until he started consuming creep feed.

Donald (1937b) found that the pigs at either end of the udder are rarely found out of position, which is well-illustrated by a litter Donald (1937b) studied. Most of the errors were committed by numbers 4 and 6, which significantly were on the lower row of teats as the sow regularly nursed on one side, with other pigs being forced into secondary errors. In all litters the pigs centrally placed were most often at fault, suggesting that it is more difficult to find a correct position in the middle than at the ends of the udder.

Average 5-week milk production of each teat indicated that the anterior two teats (right plus left) had the greatest production, with teat seven next and teat six had the lowest production. Donald (1937b), Barber et al. (1955) and Gill and Thomson (1956) found that anterior teats usually have higher milk yields than the most posterior teats. However, Hartman et al. (1962) found that there was no significant difference in milk yield between milk glands located on the left or right side.

Smith (1952), in a summary of data from various experiments, found an indication of significant breed differences in the amount of milk produced by sows. Oloffson and Larsson (1950) and Donald (1937a) found that shorter suckling intervals have resulted in greater milk production. Allen and Lasley (1960) found that the milk yield was significantly correlated with the size of the litter suckled. A positive correlation was also found between the amount of milk produced by the sow and the amount of creep feed consumed.

There appears to be no significant pattern of teat order influencing 5-week pig weight. Heaviest average 5-week weight was that of the three pigs nursing the left hind teat, but this number of pigs is too small to place any significance in it. McBride et al. (1965) described the regression of 3-week weight on birth weight and teat position gave a squared multiple correlation of 0.40. He found, as expected, a positive relation of 3-week weight and birth weight ($r=0.55$ and $b=2.79$) while there was a negative relation of 3-week weight and teat position ($r=-.39$ and $b=0.48$). The negative regression on teat position showed that anterior teats gave an advantage in growth, presumably through a more abundant milk supply. He found that only 5% of the 8-week weight was determined by the effect of teat order.

VI. CONCLUSIONS

Under the experimental conditions employed, the following conclusions may be made from the correlations presented in Table 17 and from recorded observations.

1. There was no significant relationship between birth order and sex, nursing order of pigs, birth weight or pre-weaning gain of pigs.

2. There was a significant positive relationship between birth order and several blood parameters at 24 hours of age, including hemoglobin (r=0.34), hematocrit (r=0.27) and percentage of serum non-immune globulins (r=0.230) and a significant negative relationship between birth order and percentage serum γ-globulin at 24 hours (r=-.210) and at 2 weeks (r=-.29).

3. Birth weight was significantly related to subsequent weekly pre-weaning weights at one week (r=0.39), two weeks (r=0.27), three weeks (r=0.20) and four weeks (r=0.23), but was not significantly

TABLE 17.--Simple Correlation Coefficients

Comparisons	Number	Correlation Coefficient	Significance
Trial I			
Birth order vs.			
Sex (male=1, female=2)	115	0.03	N.S.
Nursing order	91	0.04	N.S.
Birth weight	115	0.01	N.S.
Four-week gain	81	- .09	N.S.
24-hour hemoglobin	100	0.34	<.05
24-hour hematocrit	100	0.27	<.05
2-week hemoglobin	76	- .10	N.S.
2-week hematocrit	76	- .14	N.S.
24-hour total serum protein	102	- .13	N.S.
2-week total serum protein	76	- .12	N.S.
24-hour % serum γ-globulin	100	- .21	<.05
24-hour % serum albumin	100	- .02	N.S.
24-hour % non-immune globulins	100	0.23	<.05
2-week % serum γ-globulin	81	- .29	<.05
2-week % serum albumin	81	0.18	N.S.
2-week % non-immune globulins	81	0.05	N.S.
Birth weight vs.			
1-week weight	84	0.39	<.01
2-week weight	82	0.27	<.05
3-week weight	82	0.20	<.05
4-week weight	82	0.23	<.05
Nursing order	91	- .02	N.S.
24-hour serum γ-globulin vs. 4-week gain	80	0.12	N.S.
Nursing order vs. 4-week gain	81	- .22	<.05
Trial II			
Birth weight vs. milk intake	174	0.42	<.01
Birth weight vs. 5-week gain	174	0.48	<.01
Milk intake vs. 5-week gain	174	0.78	<.01
Birth weight vs. nursing order	121	0.05	N.S.
Nursing order vs. milk intake	121	- .27	<.05

related to nursing order in either Trial 1 (r=.02) or Trial 2 (r=0.05).

4. Nursing order was firmly established within the first few days of life. Switching of teats in a horizontal or diagonal direction frequently occurred when the sow alternated the side on which she lay to nurse the pigs. The first-born pig usually fixed to either the most anterior or the most posterior teat. The second pig born either settled on the teat adjacent to the first-born pig or at the other extreme end of the udder. There was no definite pattern of teat order of pigs born later in the litter except the last-born pig which also fixed to a teat at one end of the udder.

5. Although not statistically significant, there was a positive relationship between the concentration of serum γ-globulin at 24 hours (antibody protein obtained from colostrum) and pre-weaning body weight gain (r=0.12).

6. There was a highly significant correlation between five-week milk intake and five-week gain (r=0.78). The regression equation of five-week weight gain on five-week milk intake was $Y=1.44 + .214X$, where

Y=five-week gain in weight and X=five-week milk intake. Pigs gained 214 grams in weight for each kilogram of milk consumed.

7. Birth weight was significantly related to subsequent milk intake over a five-week lactation (r=0.42) and to five-week gain (r=0.48).

8. The two anterior teats on either side tended to supply the most milk and thus there was a significant negative relationship between teat order and milk yield (r=-.27).

9. Factors studied and their influence on weaning weight of pigs are graphically presented in Figure 1.

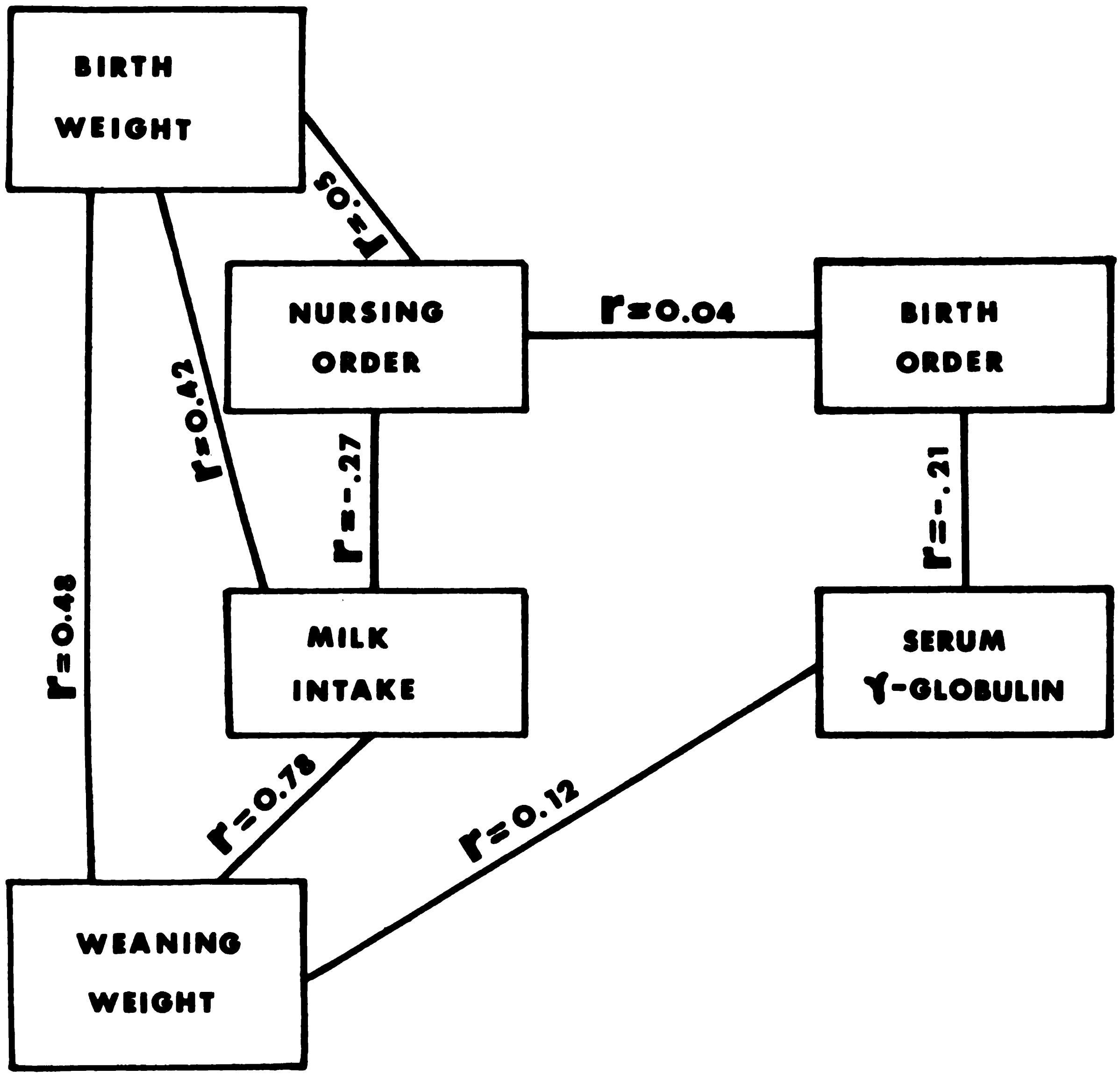

Figure 1.--Factors influencing weaning weight.

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