HERD DIFFERENCES IN THE EXPRESSION OF FATAL DIARRHEA IN ARTIFICIALLY REARED PIGLETS WEANED AFTER 12 HOURS VS. 36 HOURS OF NURSING

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Summary

TWO farrowing and three weaning systems involving two swine herds were studied to determine whether passively acquired humoral immunity would protect neonatal piglets reared in an automatic feeding device. The two farrowing systems were isolation-farrowed and farm-farrowed. The three weaning systems were: no nursing; 12-hr. nursing and 36-hr. nursing. The source of piglets were two herds: Herd A, with a high level of sanitation, and Herd X with a low level of sanitation. Piglets that were isolation-farrowed, colostrum-free and isolation-farrowed with 12 or 36 hr. of nursing from Herd A and Herd X had excellent growth rates and all survived. Piglets in Herd A, farm-farrowed and weaned after 12 or 36 hr. of nursing from Herd A and Herd X had excellent growth rates and all survived. However, those piglets from Herd X that nursed 12 hr., as compared to littermates nursing 36 hr., vomited and had diarrhea within 24 hr. after being placed in the automatic feeding device. Forty percent of those piglets died within 48 to 72 hr. of weaning. Humoral immunity as measured by total serum proteins, optical density of trichloroacetic acid precipitate and relative percent $\beta_{2-\gamma}$ globulin was normal for all nursing piglets, regardless of farrowing or weaning procedures. Antibacterial therapy did not affect the course of this disease.

Introduction

Healthy, vigorous, pathogen-free piglets can be reared artificially without resorting to surgery (hysterectomy or Caesarean section) coupled with specialized housing and management procedures (sterile individual isolators, filtered sterile air, sterile milk, mask and gowns) (Young and Underdahl, 1953; Betts, Lamont and Littlewort, 1960; Schneider and Sarrett, 1966; Coalson et al., 1973). To do this, piglets are caught at the moment of birth and removed to and individually caged in an automatic feeding device which is isolated from the contamination of other swine (Perry and Lecce, 1968; Lecce, 1969). These colostrum-free piglets by 2 weeks of age have outgained naturally suckled piglets and death losses are practically nil—as opposed to the 20 to 30% losses experienced in conventional rearing.

These immunologically virgin, fast growing animals are valuable to experimentalists such as nutritionists, pathologists, immunologists, physiologists and the like (Bustad and McClellan, 1966). At a more pragmatic level, because piglets reared in this manner are free of the external and internal parasites that normally plague pigs (Lecce, 1960; Lecce, Matrone and Morgan, 1961; Lecce, 1969; Lecce, 1972a), they afford one an opportunity to renew a badly contaminated herd with clean stock.

Deaths in the suckling litter occur mainly in the first 2 days of life (Krider and Carroll, 1971). Thus, if one desires to rear piglets artificially in an environment contaminated by swine, it is important to determine the minimum nursing time necessary to rear them. Initial inquiry into this question using neonatal piglets in controlled nursing experiments revealed that adequate humoral immunoglobulin levels ($>25\%$ $\beta_{2-\gamma}$ globulin) are acquired after a 1- to 2-hr. nursing opportunity (Coalson and Lecce, 1973). The purpose of the research reported herein was to determine

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* Autosow.
whether this humoral immunity, acquired via sow's colostrum, was enough to protect piglets reared artificially with an automatic feeding device.

**Materials and Methods**

**Source of Piglets.** Piglets were supplied from two different farms, hereafter referred to as Herd A and Herd X.

Herd A was a closed herd assembled from clean breeding stock. The physical arrangement of the facilities lent themselves to sanitation; i.e., little or no fecal build-up and excellent ventilation that discouraged the accumulation of foul air. There had been no major outbreak of disease since the herd was in existence (6 years).

Herd X was quite the opposite. The herd was open. Foul air and feces accumulated and often there were outbreaks of severe diarrhea in nursing and freshly weaned piglets.

**System of Farrowing.** Three different management procedures were used for farrowing and nursing: isolation-farrowed, colostrum-free; isolation-farrowed, 12- or 36-hr. nursing; and farm-farrowed, 12- or 36-hr. nursing.

**Isolation-Farrowed, Colostrum-Free.** Sows were brought to the laboratory approximately 4 days prior to farrowing. Both the sows and the farrowing area were washed frequently; i.e., no feces accumulated. Piglets were caught as they emerged from the birth canal and placed in a box until farrowing was completed. Then, all piglets were taken to the automatic feeding device that was located in a converted poultry house some miles away.

These piglets served as controls in that we expected the performance of nursing piglets to equal or exceed that of the colostrum-free piglets. Thirty-one piglets from three sows from Herd X were used in this experiment which lasted 2 weeks.

**Isolation-Farrowed, 12 or 36-hr. Nursing.** Sows and piglets were handled as above until farrowing was completed. Then all piglets were placed with their dam simultaneously to insure equal nursing opportunity (Coalson and Lecce, 1973). One-half of each litter was weaned after 12 hr. of nursing opportunity and the remaining one-half was weaned after 36 hours.

At the completion of the assigned nursing interval, piglets were placed in the automatic feeding device for 2 weeks. Piglets from Herd A and Herd X were not mixed. The automatic feeding device and the poultry house were fumigated before using piglets from the other herd. But, piglets from the same herd were introduced as they were farrowed. Thus, piglets ranging from 2 days to 2 weeks of age were reared together. Twenty-two piglets from two sows came from Herd A and 48 piglets from five sows came from Herd X.

**Farm-Farrowed, 12- or 36-hr. Nursing.** Sows were farrowed either at Farm A or Farm X. Piglets were caught at farrowing and handled similarly to those above (isolation-farrowed, 12- or 36-hr. nursing). Generally, the litters were split so that one-half were allowed 12 hr. of nursing opportunity and the others were allowed 36 hr. of nursing opportunity. Some litters from Herd X were split into thirds and in this case, one-third nursed 12 hr., one-third nursed 36 hr. and one-third nursed continuously. Twenty-two piglets from two litters were used in Herd A and 55 piglets from seven litters were used in Herd X.

At the end of the 2-week experimental period, 25 of the piglets coming from Herd X were removed from the automatic feeding de-

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**Figure 1.** View of service alleyway showing individual feeding pans in vertical wash position. Wash carriage at extreme end with fully extended washing hoses. Feeding pans are washed with warm chlorinated detergent after each hourly feeding.
Figure 2. Linear arrangement of cages, of which one-half are shown, the other one-half of the cages are separated by a service alleyway. Each pig is fed hourly a volume of diet dependent on his body weight. Pigs shown above range from 8 to 14 days of age.

vice and fed as a group a commercial weaning ration until 4 weeks of age. At this time they were moved back into the herd as a group and managed conventionally throughout the growing and finishing phases.

Automatic Feeding Device and Diet. This machine, containing individually caged piglets, is designed to dispense, aseptically, small volumes of liquid diet according to the weight of each piglet on an hourly schedule. Since the diet reservoir is refrigerated, bacterial growth in the diet is minimal (<10,000/ml). The feeding pans (figure 1) are washed under pressure after each feeding with warm chlorinated detergent; thus, they are maintained practically sterile. This machine differs from an earlier model (Lecce, 1969) mainly in that the arrangement of the cages is linear (Lecce, 1972a) rather than circular (figure 2). The diet consists of spray dried non-fat milk solids plus the addition of cod liver oil, corn oil, peanut oil and minerals. Each liter of the diet contained 180 g (spray-dried) non fat dried milk, 20 g corn oil, 20 g peanut oil, 2 g cod liver oil, 4.1 mg CuSO₄·5H₂O, 62 mg FeSO₄·7H₂O and 8 mg ZnO. The total solids of the diet were made up to 20%; 28% of which was protein, 42% lactose, 22% fat and 8% minerals. The feeding program of an earlier model of this machine and the diets have been described in detail (Lecce, 1969).

Measurements. Piglets were bled from the anterior vena cava within 48 hr. of delivery to the automatic feeding device. The serum samples were analyzed by gel electrophoresis for concentrations of immunoglobulin (β₂-γ globulin), total serum proteins and optical density of trichloroacetic acid precipitate (O.D. of T.C.A.). Piglets were weighed every 2 days for 14 days (8 days in one experiment). Details of analytical techniques are published (Lecce and Matrone, 1960; Lecce, 1971). Piglets at birth have an average serum protein value of 3.0 g/100 ml with no more than 3% of the serum protein in the β₂-γ globulins fraction; O.D. of T.C.A. is less than 0.02. All
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these measurements increase rapidly when piglets nurse.

Therapy. One-half of the piglets showing diarrhea were randomly selected for treatment for a period of 3 days. The remaining half were not treated. Blood samples were obtained prior to treatment and cultured aerobically on blood agar plates for the presence of bacteria (Schaub and Foley, 1952).

Results

Isolation-Farrowed, Colostrum-Free: Herd X. The performance of these piglets using the new feeding device (Lecce, 1972a) and housing was approximately the same as that reported previously for a similar facility and device (Lecce, 1969); namely, piglets more than tripled their birth weight by 2 weeks of age. The average cumulative 14-day weight gain was 2.76 kg which included one piglet that weighed 0.34 kg at birth and 1.60 kg at 14 days (figure 3).

Isolation-Farrowed, 12- or 36-hr. Nursing: Herd A. Piglets from this herd farrowed at the laboratory grew at about the same rate whether they nursed 12 or 36 hours. Both groups more than tripled their birth weight. The average cumulative 14-day weight gain was 3.45 kg for piglets nursing 12 hr. and 3.20 kg for piglets nursing 36 hr. (figure 4). This weight gain was slightly, but not significantly, greater than the colostrum-free controls.

Serum protein measurements for the piglets nursing 12 hr. revealed an average total protein of 5.1 g/100 ml, O.D. of T.C.A. of 0.39 and relative percent $\beta_2\gamma$ globulin of 43. For piglets nursing 36 hr., these measurements were 5.2 g/100 ml total protein, 0.46 O.D. of

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6 Chloramphenical, E. I. Lilly, 15 mg/kg, intramuscularly, daily for 3 days. Furacin, Eaton, Inc., 2 ml/kg, orally, daily for 3 days.
T.C.A. and 38% $\beta_{2-\gamma}$ globulin (figure 5). There were no significant differences between the two groups and the measurements indicated that both groups had adequate amounts of circulating immunoglobulin.

**Herd X.** Piglets from this herd farrowed at the laboratory grew at about the same rate whether they nursed 12 hr. or 36 hr. and at the same rate as piglets from Herd A. The average cumulative weight gain was 3.15 kg for piglets nursing 12 hr. and 3.05 kg for piglets nursing 36 hr. (figure 6). Piglets that nursed 12 hr. had 5.3 g/100 ml total protein, 0.45 O.D. of T.C.A. precipitate and 37% $\beta_{2-\gamma}$ globulin. For piglets nursing 36 hr., these measurements were 5.4 g/100 ml total protein, 0.43 O.D. of T.C.A. precipitate and 34% $\beta_{2-\gamma}$ globulin. Again, there was no significant difference between the two groups. Both had adequate amounts of circulating immunoglobulin (figure 7).

**Farm-Farrowed, 12- or 36-hr. Nursing: Herd A.** Piglets from this herd farrowed and nursed on the farm, grew at about the same rate whether they nursed for 12 or 36 hours. After 8 days in the automatic feeding device, when the experiment was terminated, both groups had more than doubled their birth weights. Piglets nursing 12 hr. had an average cumulative weight gain of 1.78 kg and piglets that nursed 36 hr. had weight gains of 1.95 kg (figure 8). Piglets that nursed 12 hr. had 5.6 g/100 ml total protein, 0.40 O.D. of T.C.A. precipitate and 38% $\beta_{2-\gamma}$ globulin. For piglets nursing 36 hr., average total proteins were 5.94 g/100 ml, O.D. of T.C.A. precipitate was 0.50, and percent $\beta_{2-\gamma}$ globulin was 38 (figure 5). These measurements indicate that both groups had adequate amounts of circulating immunoglobulin and were not different from each other in that respect.

The performance of these piglets was no different than that for the piglets farrowed in isolation.

**Herd X.** There was a marked difference in performance between the piglets nursing 12 hr. and 36 hr. when they were farrowed and
nursed on this farm. About 18 to 24 hr. after the piglets that nursed their dam for 12 hr. were placed in the automatic feeding device, they vomited and diarrhea began shortly thereafter. Thirty-six to 72 hr. after the onset of diarrhea, 40% of these dehydrated piglets died. Piglets continued to eat up to the time of death. Bacteria were not isolated from the blood of sick piglets or the liver of freshly dead piglets. Post mortem examinations of freshly dead piglets or piglets killed in extremis revealed few abnormalities, except for extreme dehydration, large casein curd in the stomach and enteritis (small intestines appeared thin walled, transparent and were distended with watery fluid). Histological sections of the intestine showed some areas with clipped villi and other areas with normal villi.

Antibacterial therapy did not alter the course of this disease. Piglets that survived started making adequate weight gains around 8 days of age.

Some of the pigs within litters which nursed 36 hr. experienced diarrhea lasting about 12 hr. but none lost weight and all survived. Similar results were observed in littersmates remaining with their dam. The cumulative weight gain for the surviving piglets that nursed 12 hr. was 1.25 kg and 2.85 kg for those that nursed 36 hr. (figure 9).

In the piglets nursing 12 hr., total proteins were 5.4 g/100 ml, O.D. of T.C.A. precipitate was 0.50 and percent β2-globulin was 35. For piglets nursing 36 hr., total proteins, O.D. of T.C.A. precipitate and percent β2-globulin were 5.8 g/100 ml, 0.56 and 34, respectively. Both groups had high levels of circulating immunoglobulin and they were neither different from each other nor different from the piglets farrowed at the laboratory (figure 7).

Reintroduction of Piglets into Herd.

Twenty-five piglets from Herd X that were farm-farrowed were reintroduced into the herd without incident at 4 weeks of age. These piglets weighed more than their littermates that were in the herd continuously and were sold for slaughter when averaging 104 kg at 160 days of age.

Discussion

Results reported here show again that large amounts of immunoglobulin are required by piglets from their dams after relatively short nursing opportunities (Lecce, 1971; Coalson and Lecce, 1973). In all cases, whether sows were farrowed at the farm or in the laboratory, 12 hr. of nursing was equal to 36 hr. of nursing with respect to the absorption of immunoglobulins into the circulatory system. Thus, these two different groups of piglets were passively protected to about the same level.

Our results show further that these piglets were equal in performance when they were farrowed in a relatively sanitary environment (isolation farrowing at our laboratory or farrowing at the well managed Herd A). However, contrary results were obtained when piglets were farrowed in the less desirable environment of Herd X. Under these circumstances a catastrophic diarrhea developed in piglets nursing 12 hr. while littermates nursing 36 hr. remained mainly asymptomatic. Both groups had equal circulating immunoglobulin, but the intestinal epithelium in the piglets nursing for 36 hr. was exposed to immunoglobulin longer than the piglets nursing 12 hours.

We propose that the pathogenesis and pathology of the disease is mainly in the intestine. Therefore, moderation of the infection must occur in the intestine. This would require a continuous bathing of the intestine by inhibiting immunoglobulin and would be independent of circulatory immunoglobulin. This kind of local protection has been implicated for transmissible gastroenteritis of swine (Haelterman, 1965; Hooper and Haelterman, 1966), swine colibacillosis (Kohler and Bohl, 1966; Rejnek et al., 1968; Wilson and Svendsen, 1971) and human polio viruses (Kenny, Boesman and
Michaels, 1967; Warren et al., 1964; Gonzaga, Warren and Robbins, 1963; Sabin and Fieldsteel, 1962). Others attempting to rear piglets artificially have also reported diarrhea with high death losses in the piglet less than 4 days old (Bustad, Ham and Cunha, 1948; Catron et al., 1953; Bellis, 1957; Owen et al., 1961; Owen and Bell, 1964; White et al., 1969). One wonders if there is a common etiological agent.

Our results show further that piglets more than 2 days of age do not need to nurse the sow's mammary secretions (immunoglobulin) to resist this disease. Piglets by this time may be producing a local gut immunity (IgA) (Porter and Allen, 1970) and/or a maturation leading to resistance has occurred (intestinal epithelium, Lecce, 1972b). In this connection, we have been able to reproduce this syndrome with bacteria-free filtered extracts (0.45 μ) of diseased intestinal epithelium in colostrum-free piglets 2 days old or younger (Lecce, Coalson and Mock, 1972).

In conclusion, our results demonstrate that it is possible to rear piglets artificially in environments contaminated by other swine provided piglets are farrowed in a reasonably sanitary environment; i.e., no accumulation of feces and stale air. Moving sows out of the general herd into clean farrowing facilities seems to be adequate. Our farrowing facility housed 4 sows; feces was washed into a drain twice a day and the air changed 10 times per hour. Under these circumstances piglets need to nurse no longer than 12 hr. (perhaps even shorter) for excellent performance. These piglets then, shifted to conventional diets and regimes, can be reintroduced into the main herd. Piglets reared in this manner, thus far, have been free, by gross inspection, of atrophic rhinitis, enzootic pneumonia, and external and internal parasites when moved back to the main herd.

Schemes devoted to weaning piglets at birth or soon thereafter, offer potential for increasing the number of pigs produced per sow per year. For example, non-nursing sows can be bred about 12 days after parturition (Baker et al., 1953; Coalson and Ulberg, 1972); thus, it could be possible for sows to produce about three litters a year instead of the conventional two. Since the number of piglets reared per litter would no longer be dependent on the milking propensities of the sow or the number of milking teats, physiologists and geneticists would feel encouraged to manipulate the sow towards producing large numbers of piglets per litter. Low death losses in the artificially reared would also increase number of pigs per sow per year.

Literature Cited

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