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A longitudinal study of natural infection of piglets with *Streptococcus suis* types 1 and 2

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SUMMARY

Streptococcus suis types 1 and 2 were detected in nasal swabs taken from five litters of piglets sampled twice weekly from birth. The two types had been detected in all pigs by the time they were 38 and 25 days old respectively with mean ages of first detectable infection being 13·5 and 8·5 days. The prevalence of infection was not affected by housing conditions or the population density of pigs. Piglets originating from a sow with vaginal swabs positive for *S. suis* type 2 were infected earlier than piglets from non-vaginal carriers. It is concluded that infection of piglets with *S. suis* type 2 may occur during the birth process.

INTRODUCTION

Streptococcus suis types 1 and 2 have been isolated from most pig-rearing countries of the world. These organisms are responsible for meningitic, arthritic, and septicaemic conditions, however the reported losses and clinical signs vary from country to country [1, 2]. Both organisms are carried within the palatine tonsils and nasal cavities of apparently normal pigs and have also been isolated from numerous other body tissues [3].

Although many workers have performed cross-sectional studies investigating the prevalence of infection of pigs with *S. suis* at one particular instance in time, there have been few studies following the infection in individual pigs over a period of time. The present study was designed to investigate the spread of infection in five litters of pigs reared in a piggery under conventional conditions.

MATERIALS AND METHODS

Sows

Four pregnant sows and one gilt were selected from a herd on the basis that they were due to farrow within a 3-day period. This herd of 60 sows had previously been demonstrated to contain pigs infected with *S. suis* types 1 and 2. The selected sows were transferred to the farrowing house 5 days prior to the expected farrowing date. Three sows and the gilt were housed in one farrowing room whilst the

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remaining sow was housed in another room with three other sows which had already farrowed. All farrowing pens had previously been hosed out and disinfected with an alkaline disinfectant (Multikleen, KW Products Ltd, Auckland, New Zealand). Vaginal and nasal swabs had been collected fortnightly from the four sows during a 6-month period prior to this farrowing. Further nasal and vaginal swabs were collected from the sows in the 4 weeks following farrowing.

Piglets

Each piglet was identified with a consecutively numbered ear tag. Nasal swabs were collected within 24 h of birth and thereafter twice weekly for the first 8 weeks of life. E.N.T. swabs (Medical Wire and Equipment Ltd, Corsham, Wiltshire, England) were used for sampling piglets younger than 4 weeks of age and the larger Hospiswabs (Medical Wire and Equipment Ltd, Corsham, Wiltshire, England) were used for older pigs. Swabs were inserted approximately 1 cm into the nasal chamber and rotated on the mucosa.

The pigs under study were managed in a similar manner to other pigs in the herd except for the extra handling required for the collection of samples.

When the piglets were 26 days old, 21 were randomly selected and weaned into individual cages and housed in a building over 2 km from the piggery. The remaining unweaned piglets were cross-fostered onto three sows whilst the other sows were dried off.

At the age of 5 weeks, six of the individually housed pigs and four unweaned piglets were killed and autopsied. Swabs were collected from the nasal cavities, heart blood and meninges, and samples of tissue were taken from the brain, tonsil, liver, kidney, and female reproductive tract. Swabs were taken aseptically from these tissues in the laboratory.

The surviving piglets were weaned at 5·5 weeks of age and transferred into the normal weaning house of the piggery. After 3 weeks in isolation, the early weaned pigs were also transferred to the same weaning room.

Environmental isolation of S. suis

Swabs of feed, feed troughs, water, floors, and dust were collected from all accommodation areas during the experiment. In the farrowing shed, feed troughs were of steel construction and incorporated a nipple drinker. They were made of plastic in the isolation pens and steel in the conventional weaner house.

Handling of swabs

All swabs were returned to the laboratory within 1 h of collection and used to inoculate 5% sheep blood agar plates. Plates were incubated aerobically overnight at 37 °C. An indirect fluorescent antibody test (IFAT) for both *S. suis* types 1 and 2 was then performed on a smear of the bacterial growth as described by Robertson [3, 4] and Robertson and Blackmore [5].

RESULTS

The reproductive history of the sows and the isolation of *S. suis* from nasal and vaginal swabs pre and post farrowing are listed in Table 1. *Streptococcus suis* types 1 and 2 were recovered from nasal swabs of all sows both before and after

Table 1. *The reproductive history and detection of* S. suis *in sows used in the cohort study*

Sow identification	Parity	Number of piglets born in cohort	Pre-farrowing *S. suis* type 1* Nasal (%)	Pre-farrowing *S. suis* type 1* Vaginal (%)	Pre-farrowing *S. suis* type 2* Nasal (%)	Pre-farrowing *S. suis* type 2* Vaginal (%)
A	2	11†	4/12 (33)	0/12 (0)	6/12 (50)	4/12 (33)
B	7	11	2/12 (17)	0/12 (0)	8/12 (67)	0/12 (0)
C	3	9	4/12 (33)	0/12 (0)	6/12 (50)	0/12 (0)
D	1	9	—	—	—	—
E	5	13‡	4/12 (33)	0/12 (0)	4/12 (33)	0/12 (0)

Sow identification	Parity	Number of piglets born in cohort	Post-farrowing *S. suis* type 1* Nasal (%)	Post-farrowing *S. suis* type 1* Vaginal (%)	Post-farrowing *S. suis* type 2* Nasal (%)	Post-farrowing *S. suis* type 2* Vaginal (%)
A	2	11†	3/8 (38)	2/8 (25)	4/8 (50)	3/8 (38)
B	7	11	2/8 (25)	0/8 (0)	3/8 (38)	0/8 (0)
C	3	9	3/8 (38)	0/8 (0)	3/8 (38)	3/8 (38)
D	1	9	2/8 (25)	0/8 (0)	2/8 (25)	0/8 (0)
E	5	13‡	4/8 (50)	0/8 (0)	3/8 (38)	0/8 (0)

* Number of swabs from which *S. suis* was detected in the previous 6 months.
† One pig died at 2 weeks with no autopsy performed.
— Not sampled.
‡ Only five of the piglets were included in cohort study.

farrowing. The percentage of swabs positive at any one sampling time ranged from 17–50 % for *S. suis* type 1, and 25–67 % for *S. suis* type 2. During the prefarrowing sampling period, *S. suis* type 2 was detected in 4 of 12 vaginal swabs from sow A. Subsequently, after farrowing, vaginal swabs from sow A were found to contain *S. suis* type 1 while vaginal swabs from both sows A and C contained *S. suis* type 2.

The detection of *S. suis* type 1 in nasal swabs collected from the five litters is recorded in Table 2. *S. suis* type 1 was not detected in any nasal swabs, on the first day of sampling (1-day old). However by the age of 4 days, *S. suis* type 1 had been detected in piglets from four litters (B, C, D and E). The first infected piglet from sow A was detected at the age of 7 days. All piglets from litter D were identified as being infected with *S. suis* type 1 by the age of 17 days, litters A and E by 21 days, litter B by 25 days and finally litter C by 38 days.

Streptococcus suis type 1 was not detected in nasal swabs collected from two

Table 2. *Isolation of* S. suis *type 1 from the cohort piglets*

Sow		Age in days: 1	4	7	10	14	17	21	25	28	32	38	42	46	49	52	56
A*	Swabs	0/11	0/11	1/11	6/11	4/11	4/11	4/10†	3/10	4/10	4/10	1/8	3/8	3/8	2/8	3/8	4/8
B	Swabs	0/11	2/11	5/11	5/11	5/11	7/11	6/11	5/11†	5/11	3/11	3/8	4/8	2/8	2/7	2/7	4/7
C	Swabs	0/9	1/9	0/9	3/9	1/9	5/9	4/9	2/9	2/9	3/9	1/6†	1/6	2/6	2/6	2/6	3/6
D	Swabs	0/9	2/9	3/9	6/9	5/9	7/9†	4/9	4/9	3/9	3/9	2/7	5/7	2/7	2/7	3/7	3/7
E	Swabs	0/5	1/5	0/5	0/5	1/5	2/5	5/5†	2/5	1/5	2/5	0/5	1/5	1/5	1/5	3/5	2/5

† Age when all piglets had at least one positive nasal swab.
* Sow with a post-farrowing infection of *S. suis* type 1.

Table 3. *Isolation of* S. suis *type 2 from the cohort piglets*

Sow		Age in days: 1	4	7	10	14	17	21	25	28	32	38	42	46	49	52	56
A*	Swabs	0/11	3/11	3/11	2/11†	3/11	3/11	3/10	7/10	3/10	7/10	4/8	3/8	3/8	2/8	7/8	3/8
B	Swabs	0/11	1/11	2/11	3/11	3/11	5/11	5/11	5/11†	3/11	7/11	5/8	5/8	3/8	4/7	3/7	3/7
C‡	Swabs	3/9	6/9	4/9†	5/9	8/9	3/9	4/9	7/9	5/9	5/9	5/6	1/6	3/6	2/6	4/6	2/6
D	Swabs	0/9	5/9	5/9	6/9†	6/9	4/9	6/9	3/9	4/9	4/9	2/7	1/7	4/7	2/7	3/7	3/7
E	Swabs	0/5	1/5	1/5	2/5	4/5†	3/5	3/5	5/5	2/5	2/5	2/5	3/5	2/5	2/5	3/5	2/5

† Age when all piglets had at least one positive nasal swab.
* Sow with pre and post-farrowing infection of *S. suis* type 2.
‡ Sow with post-farrowing infection of *S. suis* type 2.

piglets prior to transferring them to the isolated cages. Subsequently the organism was detected 2 and 12 days after weaning/isolation at 28 and 38 days of age respectively.

In Table 3 the proportion of swabs positive on the IFAT for *S. suis* type 2 is shown for the litters. Three 1-day-day-old piglets from sow C, which had a *S. suis* type 2 vaginal infection, had nasal swabs containing *S. suis* type 2. No other piglets were infected on the first day of sampling, although by the age of 4 days some piglets from all litters were infected. The nasal swabs from all piglets were positive for *S. suis* type 2 by the time the piglets were 26 days old. All the piglets from sows C and A were infected with *S. suis* type 2 by the age of 7 and 10 days respectively while the remaining three litters were all infected by 14, 21 and 25 days.

During the period of isolation (21 days), 30 and 45% of nasal swabs collected from the isolated pigs were positive for *S. suis* types 1 and 2 respectively. The comparable results for the conventionally reared pigs were 34 and 48%. There were no significant differences between these rates ($P > 0{\cdot}5$ for *S. suis* type 1 and $P > 0{\cdot}7$ for *S. suis* type 2).

The mean age of the first detectable infection with *S. suis* type 1 for all piglets was 13·5 days (S.D. = 7·5) and 8·9 days (S.D. = 6·2) for *S. suis* type 2. These means were significantly different ($P < 0{\cdot}01$).

When the ten 5-week-old pigs were autopsied, *S. suis* type 2 was isolated from the kidney and liver of one pig and from the heart blood and female reproductive tract of another. Both pigs were from the traditionally reared, unweaned group and had appeared healthy. *Streptococcus suis* type 1 was only detected in tonsillar and nasal swabs (40 and 20% of ten swabs respectively). *Streptococcus suis* type 2 was detected in 70% of the ten tonsillar swabs and 50% of the ten nasal swabs including the two pigs which had the organism isolated from other body organs.

During the investigation, one weaned pig died. Pathological changes included congested meninges and parenchymatous organs and a severe purulent peritonitis and pleuritis. Coliforms, *Proteus* spp. and a few haemolytic streptococci were cultured from the liver and from peritoneal and meningeal swabs. Smears of the bacterial growth from the meningeal swab, liver and tonsil were also positive for *S. suis* type 2, while *S. suis* type 1 was detected only in the tonsil. The primary cause of death was believed to have been associated with peritonitis associated with a perforated rectum.

Environmental isolation

Table 4 displays the proportion of environmental swabs positive for *S. suis* types 1 and 2. *Streptococcus suis* was detected most frequently from the feed-troughs of the weaner house with 7% positive for *S. suis* type 1 and 14% for *S. suis* type 2. The organisms were also isolated from the feed troughs of the individually housed pigs (5 and 8% respectively). Both *S. suis* types 1 and 2 were also detected more frequently in swabs taken from the floor of conventionally weaned pigs than from the floor of individually housed pigs. *Streptococcus suis* type 2 was detected from two sow feed troughs (7%) and *S. suis* type 1 from one (3%). Swabs taken from the floors after all pigs had been removed and the pens had been washed were negative for both *S. suis* types 1 and 2.

Table 4. *Isolation of* S. suis *types 1 and 2 from the environment*

Collection site	Number of swabs	Number positive for *S. suis* type 1 (%)	Number positive for *S. suis* type 2 (%)
Sow troughs, farrowing shed	30	1 (3)	2 (7)
Farrowing pen, mesh floor	40	1 (3)	3 (8)
Slatted floor of individually housed rigs	20	1 (5)	1 (5)
Feed troughs of individually housed pigs	63	3 (5)	5 (8)
Solid floor, weaning house	14	0 (0)	1 (7)
Slatted floor, weaning house	14	1 (7)	1 (7)
Feed troughs, weaning house	14	1 (7)	2 (14)
Dust, weaning house	10	0 (0)	0 (0)

DISCUSSION

In the present investigation, all piglets became infected with *S. suis* type 2 earlier than with *S. suis* type 1 (25 days versus 38 days). However, as the IFAT and other microbiological tests require a minimum number of organisms to be present before a positive result is obtained, it is probable that the actual age of infection is younger than that recorded here. These results are in contrast to the typical clinical picture, where disease from *S. suis* type 1 occurs predominantly in sucking piglets, whilst disease from *S. suis* type 2 occurs in older weaners and growers.

The piglets from sows with vaginal infection of *S. suis* type 2 became infected earlier than piglets from sows without infection and it is possible they became infected during the birth process [6]. Robertson and Blackmore [2] believed that hysterectomy derived pigs were produced free from infection with *S. suis*. Similarly neonatal sepsis of humans with group B streptococci, which arises from a vaginal infection, can be prevented by caesarean delivery [7].

Although *S. suis* type 1 was not detected in vaginal swabs collected prior to farrowing, one sow had positive swabs after farrowing. Unlike the sow with persistent vaginal infection of *S. suis* type 2, the offspring of this sow did not become infected with *S. suis* type 1 earlier than other litters from non-vaginal carriers. These findings would indicate that the infection of pigs with *S. suis* types 1 and 2 may occur by different mechanisms and that vaginal infection with *S. suis* type 1 does not play an important role in the epidemiology of the infection.

Windsor [8] believed that infected sows spread *S. suis* to their susceptible non-infected piglets. He considered that once infection with both *S. suis* types 1 and 2 was present in a litter, there was rapid spread of the organisms throughout the herd after the infected litter was weaned. However, this investigation indicates that, in an infected herd, the majority of piglets born to infected sows are infected prior to weaning. The rapid spread of infection within a litter is probably

associated with the frequent nose-to-nose contact that occurs both between sows and suckling piglets and between piglets [9].

As was demonstrated by Robertson and Blackmore [2], *S. suis* type 2 can be isolated from tissues other than the palatine tonsils of apparently healthy pigs. *Streptococcus suis* type 2 was detected in the blood and female reproductive tract of one weaner pig and the liver and kidney of another, possibly as a consequence of a haematogenous spread of infection. The detection of *S. suis* type 2 in the female reproductive tract is at variance with earlier findings where *S. suis* type 2 was not detected from vaginal or uterine swabs of pigs smaller than bacon weight [2]. It would appear that if the present infection of the reproductive tract was of haematogenous origin it occurs only rarely, otherwise younger pigs, such as porkers, would have been found to be infected at the time of slaughter. It is also possible that infection could have been of ascending nature, originating from external contamination or from naso-vulval contact.

Streptococcus suis types 1 and 2 were readily detected in the environment of the piggery. The higher rate of detection of *S. suis* from the environment of the conventional weaner house was probably associated with the greater number of pigs housed in this building and hence presumably a larger number of organisms being shed. The type of housing had, however, little effect on the prevalence of infection. This supports the belief that pigs carrying the organism in their tonsils play the most important role in the epidemiology of the infection. However, the high prevalence of the organism within the environment may indicate that it might be possible to introduce infection into a previously free herd by contaminated fomites. This may account for the findings of Lamont and co-workers [10] and Robertson and Blackmore [2] who demonstrated infection in hysterectomy derived SPF herds.

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