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Transmission of pathogens via transportation vehicles

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With the recent outbreaks of Foot and Mouth Disease (FMD) and Classical Swine Fever (CSF) in Europe and the United Kingdom, the news media has heightened our awareness of disease transmission. Realizing how rapidly these diseases spread and that $1.2 billion in pork export sales are at risk, the swine industry must restrict pathogen transmission at all production levels. Our focus in this presentation will be on transportation.

Because of the increasing movement of pigs in multisite production, the economics of finishing pigs in the Midwest, plus location of the US packing industry, the chances of transmission of respiratory or enteric organisms have increased. As A. Mateos Poumian stated, "All trucks, trailers, and other vehicles used for transporting animals, animal products, products, feed, offal, and contaminated equipment are a potential risk in the spread of disease" (Poumain 1995). In the CSF outbreak of 1997 in the Netherlands, unsanitary vehicles were believed to have been responsible for 24% of the cases. This outbreak was responsible for the slaughter of 10 million pigs and was estimated to cost $3.2 million US dollars (Waddilove 2001).

Although viruses do not replicate outside the host they can be maintained and transported to susceptible hosts (Pirtle 1991). Approximate survival times and potential airborne spread for many viruses are shown in **Table 1**. In general, viruses survive long periods if frozen, fairly long in damp overcast cold weather, but only short periods in hot sunny dry weather (http://www.thepigsite.com 2001).

The vectors that facilitate transmission of organisms through pig movements are feces, water, and surface contamination. Owing to the difficulty in proving aerosol transmission, we will focus on the first three vectors.

Experimental data demonstrated survival times for pseudorabies virus suspended in saliva, nasal-washing, or glucose control fluids kept moist at 25°C. Maximum survival times required to achieve 99.99% inactivation are set down in **Table 2.**

Beran (1991) reported PRV was 99% inactivated at 22°C within 20 minutes when it was placed under UV light in a thin liquid layer. When it was dried on glass or gelatin it could not be recovered at either 22°C or 37°C.

PRRSV does not survive long on most fomites, but was shown to remain viable in city water for 11 days and in well water 9 days.

Orthomyxoviridae, infuenza A, and influenza B have been shown to survive on hard surfaces for 24–48 hours.

FMD virus has been recovered from cattle stalls 14 days after cattle removal, from urine after 39 days, and from soil after 28 days in the autumn and after 3 days in the summer.

Swine vesicular disease virus was isolated from feces after 28 days (Pirtle 1991).

TGE has been shown to be very stable in a frozen state. No detectible drop in titer was found at –20°C for 6–18 months. After drying 10 days the virus was no longer infective (Saif 1999).

With the increasing importance of food safety and the implementation of HACCP in the packing industry, bacterial contamination from every step in the pork chain is being identified. Pre-harvest HACCP programs and identity preservation are becoming part of the pork quality program. The European Union now requires all member states to initiate monitoring programs for Salmonella in pigs (Kaesbohrer 1999).

In the Netherlands about 66% of all farms are more or less permanently infected; 5–30% of the animals may still excrete *Salmonella spp.* at the end of the finishing period. This percentage may double during transport and lairage (Berends 1996).

Hurd (2001) was able to demonstrate that pigs became infected within 2–3 hours after exposure to *Salmonella typhimurium* in feces. After 6 hours all of the exposed pigs tested positive in at least one tissue sample test. *Salmonella choleraesuis* survival in feces was examined after storage in a wet and a dry form. In the wet form the organism was recovered after three months; in the dry form it was recovered after 13 months (Gray 2001). After taking 549 swabs from both feed and trucks, Fedorka-Cray (1997) was able to isolate Salmonella from 5 of 22 feed trucks (22.7%). Three trucks had positive swabs for a recovery rate of 13.6%, while 23.5% of the feed samples were positive. However, positive swabs and feed samples

Table 1. Approximate survival times of pig viruses outside the pig and their potential for airborne transmission

	approximate survival time in favorable conditions	airborne spread up to
diseases caused by viruses		
African swine fever	18 months	N
Aujeszky's disease (pseudorabies)	14 days	4000m
Influenza	a few days	T
Foot-and-mouth disease	8 weeks	300km
Parvovirus	2–6 months	N
PRRS	4 days	4000m
SVD	3 months	N
Swine fever, hog cholera	2 months	N
TGE	3 weeks	N
diseases caused by bacteria/mycoplasma		
Actinobacillus pleuropneumonia (APP)	2 weeks	T
Anthrax	indefinitely	N
Brucellosis	3 weeks	N
Cystitis (*E. suis*)	7 days	N
E. coli scour	6 months	N
Enzootic pneumonia	3 days	2000m
Erysipelas	up to 8 weeks	N
Greasy pig disease (*Staphylococcus*)	3 weeks	N
Mastitis (*Klebsiella*)	4 weeks	N
Rhinitis—pasteurella	7 days	T
Salmonella	6 months	10m
Streptcoccal meningitis	5 days	10m
Swine dysentery	8 weeks	N
Tuberculosis	2–3 years	10m
Arthritis (*Mycoplasma hyosynoviae*)	2 days?	10m

N=Not known to occur
T=Thought to occur but not proven

only matched in two trucks. None of the trucks had been used to haul livestock within the past 30 days.

Fussing (1998), in a retrospective epidemiological investigation of APP transmission in SPF herds in Denmark, reported nine cases became infected within two weeks of a pig vehicle transporting from the farm. Transmission via the vehicles was indicated in six of these cases after further investigation revealed that the same vehicle had transported pigs from a positive herd earlier in the day.

Table 2. Maximum pseudorabies survival time required to achieve 99.99% inactivation (source: Pirtle 1991)

control fluid (no fomite)	58 days
steel	18 days
rubber	7 days
plastic	8 days
denim cloth	<1 day
swine feces	2 days
straw bedding	2 days
sawdust bedding	2 days
well water	7 days
chlorinated water	2 days
urine from swine	14 days

Dee and Cory conducted an experiment in 1993 that demonstrated *Streptococcus suis* would survive on truck tires up to 11 miles at speeds averaging 75 mph (Dee 1993).

In 1998 Kajkowski reported a study on the efficacy of washing and sanitizing pig trailers between loads at the Hatfield Packing plant in Hatfield, Pennsylvania. In this study they sampled bedding materials and trailer floors for *E. coli* and Salmonella. Of the 30 bedding samples, 100% were positive for *E. coli* and 80% positive for Salmonella. The recovery incidence of Salmonella was 100% in the spring and fall, 88% in the summer, and 50% during the winter months. **Table 4** shows the results of bedding sampling.

Of the 32 trailers sampled before washing, 78% were positive in at least one pen. After washing and sanitizing (see **Table 5**), 97.3% of the 188 pens sampled had undetectable levels.

In this Hatfield study, the after washing samples were taken before the trailer had dried and before any bedding was applied. Based on the Beran (1991) study, I would surmise that if the trailer had been allowed to dry the swab results would have been better. From this study we can see the benefits of washing and disinfection.

Several sources have shown the decrease in bacterial counts from washing and disinfection. In an article written by John Gadd in 1999 he showed the effects in bacterial counts after pigs were removed, after washing, and after hot wash and detergent (**Table 6**).

Temperature of the liquids used in cleaning and disinfection as well as the surface temperature of the material being cleaned are factors in the effectiveness of the cleaning process. Optimal temperature for the water is 40°C (104°F) and for the surface to be cleaned, 20°C (68°F). Colder surfaces require higher concentrations of active

Table 3. Recovery of PRRSV from liquid fomites (expressed in terms of cell culture infective dose 50%/ml)

	Day of Sampling										
Fomite	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
City water	2×10^4	1.8×10^4	1.5×10^4	1.8×10^3	1.6×10^3	1.3×10^3	1.0×10^3	1.0×10^3	0.2×10^3	1.6×10^2	1.4×10^2	0.2×10^2
Well water	2×10^4	1.6×10^4	1.4×10^4	1.5×10^3	1.3×10^3	1.0×10^3	0.8×10^3	0.5×10^3	1.6×10^3	1.3×10^2	NR	NR
Saline G solution	1.8×10^4	1.6×10^4	1.2×10^4	2.2×10^3	1.6×10^3	1.0×10^3	1.8×10^3	NR	NR	NR	NR	NR
PBSS	1.2×10^4	1.0×1^4	1.6×10^3	1.4×10^3	1.2×10^3	NR	NR	NR	NR	NR	NR	NR
Swine saliva	1.4×10^3	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Swine urine	2.4×10^3	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Fecal slurry	3.6×10^3	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

NR=No virus recovered

Saline G solution = NaCl, 0.137M; KCl, 0.005M; NaH_2PO_4, 0.0018M; KH_2PO_4, 0.001M; $Mg50_4$, $7H_20$, 0.006M; $CaC1_2$, $2H_20$

PBSS=phosphate-buffered saline solution

(source: Pirtle 1996)

Table 4. Effect of season of the year on levels of *E. coli* and Salmonella in composite bedding samples from trailers.

Season	# of bedding samples tested	*E. coli*[a] # positive	*E. coli*[a] Range	*E. coli*[a] Mean[c]	Salmonella[b] # positive	Salmonella[b] Range	Salmonella[b] Mean[c]
Spring	5	5	2.9–8.4	5.3±0.9	5	1–110	22.8±43.6
Summer	8	8	5.4–8.1	6.9±0.6	7	1–110	26.1±37.6
Fall	7	7	5.1–6.9	6.3±0.4	7	1–>110	54.4±50.3
Winter	10	10	<1–6.3	4.8±1.5	5	1–110	34.8±41.0

[a] log cfu/g

[b] MPN/g; detectability, 1 MPN/g

[c] Overall no significant effect of season or distance traveled, $P>.05$

Table 5. Effect of season on recovery levels of Salmonella and *E. coli* from the floors of trailers.

			Salmonella[a]						*E. coli*[b]					
			Before washing			After washing[c]			Before washing			After washing[c]		
Season	T	P	+P	Range	Mean	+P	Range	Mean	+P	Range	Mean	+P	Range	Mean
Spring	5	30	8	1–21	8.3±6.6	2	1–21	11.0±10.0	28	< 1–4.4	2.4±1.0	5	<1–3.4	2.5±0.8
Summer	10	56	27	1–>110	11.2±28.1	1	2	2±0	56	<1–5.7	4.2±1.1	10	<1–3.7	1.4±1.0
Fall	7	42	26	1–>110	37.2±48.9	2	1–>110	55.5±54.5	42	<1–5.3	3.8±1.1	10	<1–1.5	1.3±0.3
Winter	10	60	17	1–24	2.9±5.6	–[d]	–	–	55	<1–4.6	2.6±1.0	9	<1–1.3	1.0±0.4
Total	32	188	78			5			181			34		

T=trailers tested (n)

P=pens tested (n)

+P=positive pens (n)

[a] MPN/cm^2; detectabiity, 1 MPN/cm^2

[b] Log cfu/cm^2

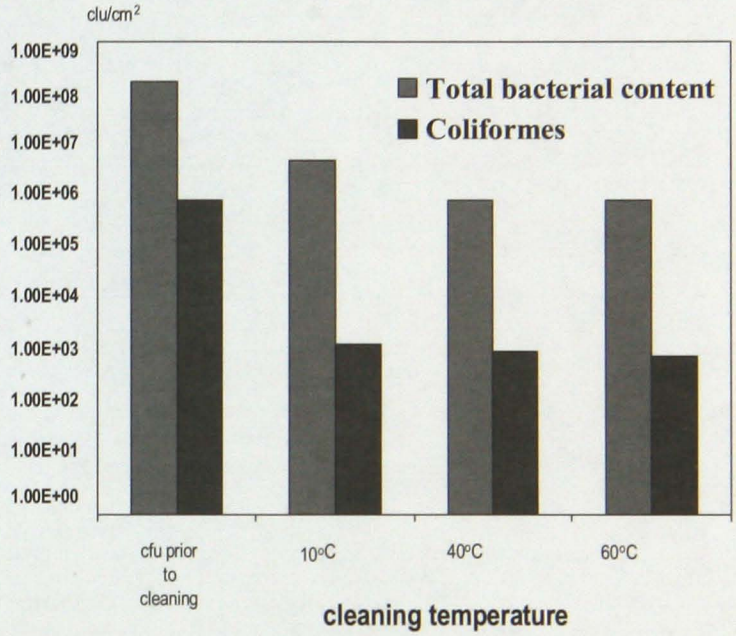
[c] After washing levels were significantly lower ($P<.5$) than before washing levels

[d] Negative for Salmonella (<1 MPN/cm^2)

Table 6. Why just pressure washing isn't sufficient (source: Antec 1999).

State of house	Viable bacteria/sq. cm
immediately after pigs out	50,000,000
after plain washing	20,000,000
hot wash and heavy detergent	100,000
target before disinfection	1,000

Fig. 1 The influence of water temperature in the cleaning of a concrete floor under field conditions, as demonstrated by the reduction in total bacterial counts



substances or longer contact times with the disinfectants (Bohm 1998). Using hot water to clean is more effective as demonstrated in **Figure 1**.

The purpose of this presentation was to provide you with information on the ability of viruses and bacteria to survive in livestock trailers. Along with that data, additional information was provided to demonstrate the importance of cleaning, water temperature, and disinfection. In order to provide a quality pork product and maintain herd health status, it is essential that all equipment used to transport animals be washed, disinfected, and allowed time to dry.

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