A retrospective analysis of Salmonella isolation trends from pigs in Great Britain since 1994, with special reference to monophasic S. Typhimurium and antimicrobial resistance trends

D. Mueller-Doblies,*
K. Speed, R. H. Davies

Bacteriology Department, Animal Health and Veterinary Laboratories Agency Weybridge
Woodham Lane, New Haw, Addlestone, Surrey, KT15 3NB, United Kingdom

**corresponding author : doris.mueller-doblies@ahvla.gsi.gov.uk*

Abstract

The numbers of Salmonella reports from pigs in Great Britain have reduced considerably since the mid- 1990s, when up to 384 positive epidemiological group reports (incidents) per year were recorded, and numbers have been relatively stable since 2003 with less than 200 incidents reported per year. S. Typhimurium has been the most common serovar throughout the study period (between 58 and 75% of incidents). S. Derby, which was the second most common serovar for many years, has shown a downward trend since 2007, accounting only for 5% of incidents in 2009. At the same time, monophasic strains of S. Typhimurium have been on the rise since 2006. S. 4,5,12:i:- went from 0% in 2005 up to 6.2% of incidents in 2009, whereas S. 4,12:i:-, after showing a small peak in 1997, has also increased since 2007 and accounted for 1.2% of incidents in 2009. Throughout the 1990s, the most commonly seen phage type among S. Typhimurium isolates was DT104, but numbers declined sharply from 1998 onwards. Since 2002, U288 has been the most commonly seen phagetype in S. Typhimurium with up to 67.7% of all S. Typhimurium incidents being U288. DT193 has been increasing since 2003, with up to 41.5% of S. Typhimurium incidents in 2008. At the same time as the number of DT193 incidents in S. Typhimurium increased, an increase in the number of monophasic strains of S. Typhimurium occurred, with the majority of those isolates being DT193.

The percentage of S. Typhimurium isolates from pigs showing resistance to six or more antimicrobials has increased from 19.7% in 1995 to 47.6% in 2009, with a peak of 76.8% in 2007. Resistance of S. Typhimurium to compound sulphonamides, ampicillin, streptomycin and chloramphenicol increased considerably between 2002 and 2007, while resistance to tetracycline has been at a high level since the beginning of the study period. The most common resistance pattern observed in S. 4,5,12:i:- (ampicillin, streptomycin, compound sulphonamides, tetracycline) was seen in 72.7% of isolates in 2009. In species other than pigs, S. 4,5,12:i:- has, so far, shown a significant increase in cattle only, and the first isolates from poultry were only reported in 2010.

Introduction

Human salmonellosis is one of the most common foodborne diseases in the UK, and contaminated pork may be an important source of infection for humans. It has been estimated in various European countries that 10–20% of all cases of salmonellosis in humans are related to the consumption of pork (Borch et al., 1996; Berends et al., 1998; Steinbach & Hartung, 1999; EFSA, 2010).

Pigs can be infected by several Salmonella serovars but symptoms are rarely seen, making infection difficult to recognize, thus risking the spread of infection to the rest of the herd and causing Salmonella to enter the food chain.

The majority of Salmonella serovars are biphasic and express two distinctive **f**agellar phases but some isolates do not express either phase 1 or phase 2 **f**agella and are therefore classed as monophasic. In recent years, such monophasic strains of S. Typhimurium (namely S. 4,5,12:i:- and S. 4,12:i:-) have been observed in several animal species including pigs.

Material and Methods

The Salmonella Unit at The Animal Health and Veterinary Laboratories Agency is the Salmonella Reference Laboratory for Veterinary Salmonellosis in the UK. The data for this study period was sourced from Salmonella surveillance data from Great Britain from 1994 to 2009.

Characterisation of the Salmonella isolates in this study was done by serotyping according to the White-Kauffmann-LeMi-

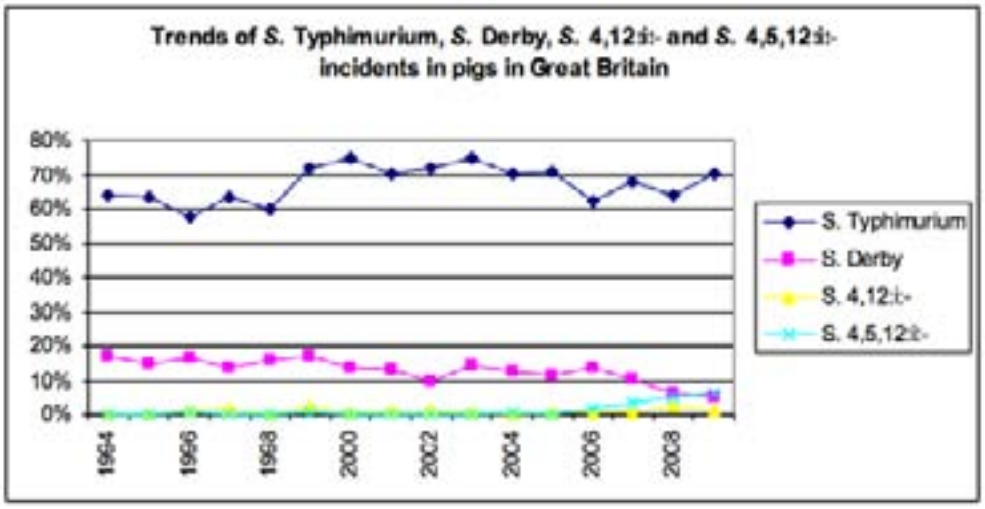
nor scheme. Phagetyping of S. Typhimurium was carried out using the HPA, Colindale Bacteriophage updated Anderson typing designations for S. Typhimurium, and Antimicrobial Resistance was determined using a disc diffusion technique on Oxoid "Isosensitest" agar.

Results

Salmonella incidents:

The numbers of Salmonella reports from pigs in Great Britain have reduced considerably since the mid- 1990s, when up to 384 positive epidemiological group reports (incidents) per year were recorded, and numbers have been relatively stable since 2003 with less than 200 incidents reported per year. S. Typhimurium has been the most common serovar throughout the study period (between 58 and 75% of incidents). S. Derby, which used to be the second most common serovar for many years, has shown a downward trend since 2007, accounting only for 5% of incidents in 2009. At the same time, monophasic strains of S. Typhimurium have been on the rise since 2006. S. 4,5,12:i:- went from 0% in 2003 up to 6.2% of incidents in 2009, whereas S. 4,12:i:-, after showing a small peak in 1997, has also increased since 2007 and accounted for 1.2% of incidents in 2009. Fig. 1 shows trends of S. Typhimurium, S. Derby, S. 4,5,12:i:- and S. 4,12:i:- incidents in pigs in Great Britain between 1994 and 2009.

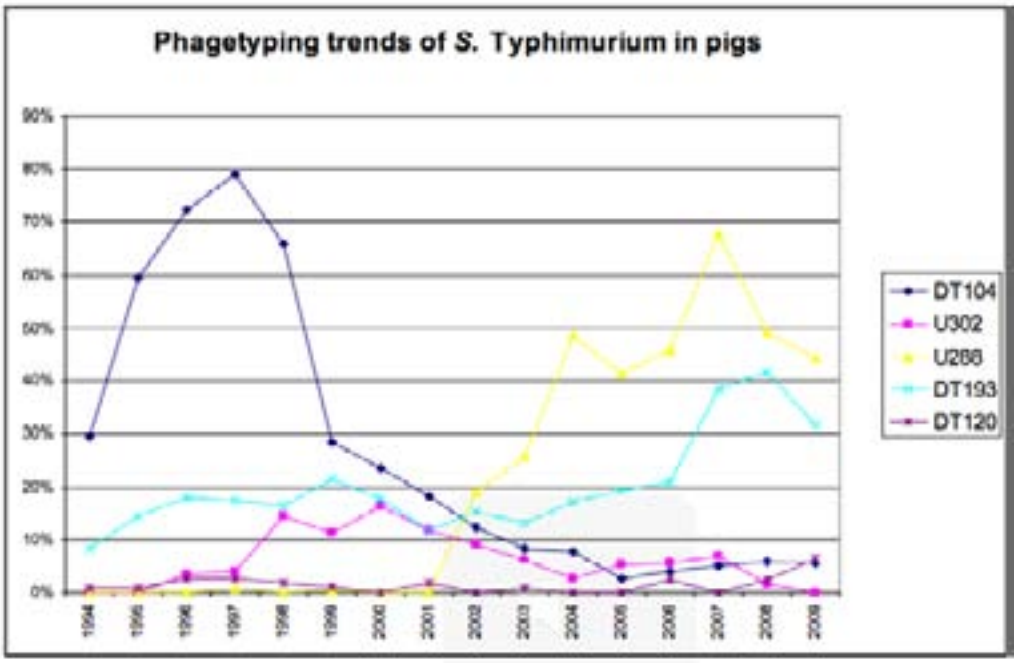
Fig. 1:



Phagetyping trends:

There has been a significant shift in the phage types associated with S. Typhimurium in pigs during the period 1994 to 2009. In the mid to late 1990's, the predominating phagetype was DT104, peaking at 79% of S. Typhimurium incidents in 1997 and then decreasing sharply to 28.5% in 1999 and has declined further to 5.6% of S. Typhimurium incidents in 2009. Phagetype U288 was first seen in 1997, and numbers rose sharply since 2002. U288 has been the predominant phagetype since 2002, peaking at 67.7% of S. Typhimurium incidents in 2007. Since 2008, numbers have declined, with 44.4% of S. Typhimurium incidents in 2009 being U288. Fig. 2 shows phagetyping trends (in terms of the proportion of S. Typhimurium incidents represented by each phage type) of S. Typhimurium in pigs between 1994 and 2009. At the same time as the number of DT193 incidents in S. Typhimurium increased, an increase in monophasic strains of S. Typhimurium could be observed, which predominantly belong to DT193, with 73% of S. 4,5,12:i:- incidents being DT193 in 2009 (data not shown).

Fig. 2:



Resistance trends:

Resistance of S. Typhimurium to compound sulphonamides, ampicillin, streptomycin and chloramphenicol increased considerably between 2002 and 2007, whereas resistance to tetracycline has been at a high level since the beginning of the study period. Fig. 3 shows resistance trends in S. Typhimurium over the study period. The percentage of S. Typhimurium isolates from pigs showing resistance to six or more antimicrobials has increased from 19.7% in 1995 to 47.6% in 2009, with a peak of 76.8% in 2007 (fig. 4).

The most common resistance pattern observed in S. 4,5,12:i:- (ampicillin, streptomycin, compound sulphonamides, tetracycline) was seen in 72.7% of isolates in 2009.

In species other than pigs, S. 4,5,12:i:- has, so far, shown a significant increase in cattle only, and the first isolates from poultry were reported in 2010.

Fig. 3:

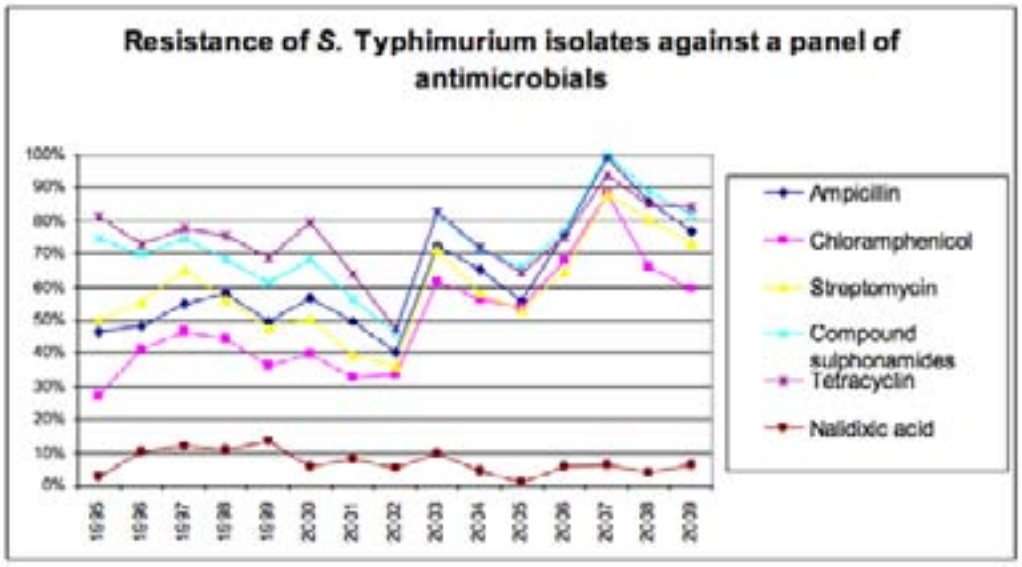
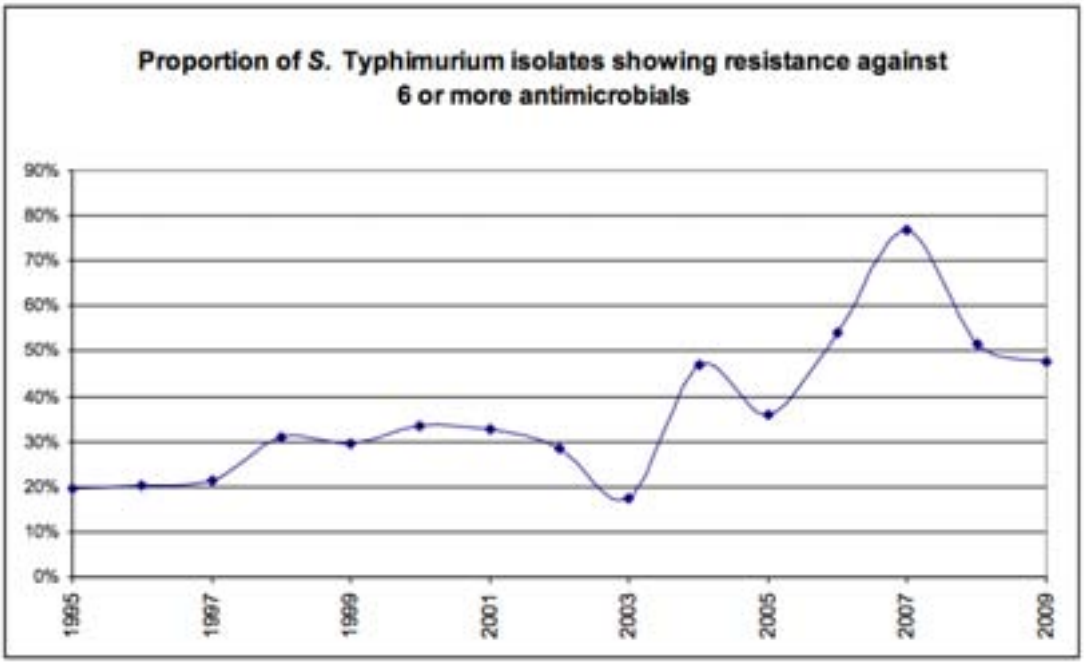


Fig. 4:



Discussion.

It is not unusual for certain Salmonella serovars or phage types to rise and fall over time and be replaced by other strains, which is shown here for pigs in Great Britain. In some cases, this is a slow process (as in the case of S. Derby in pigs), but it can become epidemic in nature, as shown by S. Typhimurium DT104. However, the emergence of multi-resistant S. Typhimurium DT104 was not confined to one species, and was seen across a wide range of animal species and humans. In England and Wales, infections in humans with S. Typhimurium DT104 went from ~200 in 1990 to >4000 in 1996 (Threlfall et al., 1998), followed by a significant decline to 2090 cases in 1998 (Threlfall et al., 1999). The situation in pigs shows a comparable trend, whereas the proportion of S. Typhimurium DT104 in cattle remained at a fairly high level since the early 1990s and only started to decline in 2007 (VLA, 2009). This is likely to be related to the higher rate of development and dissemination of new phage types in the pig industry. The reason for the fall in specific resistances and resistance to six or more antimicrobials is unclear, but the former is likely to be largely related to the emergence of S. Typhimurium and mST DT193 strains with tetracycline resistance only and the latter due to the predominance of the tetra-resistant phenotype (ASSuT) amongst such strains. The occurrence of mST S.4,12:i;- in the late 1990s is interesting as this corresponds with reports of the emergence of mST in Spain. Unfortunately, no further typing was carried out on these strains and they have not been retained.

Conclusion

Large scale pig production has traditionally been associated with the cyclical occurrence of high levels of S. Typhimurium and antimicrobial resistance. The direct relevance of this to public health is uncertain but the simultaneous occurrence of mST DT193 in pigs and humans in many countries suggests that the porcine source is important. The reason for the rapid emergence of mST DT193 across Europe since 2007 is unclear, but the organism must have some fitness advantage in competition with existing strains. The most likely explanation is limited 'herd immunity' in the early stages of national and international dissemination as the virulence of mST in pigs appears to be comparable with other S. Typhimurium strains. The role of the pig industry as a source of S. Typhimurium contamination of the environment, animal feed and poultry **f**ocks should also not be under-estimated.

References

Berends, B. R., Van Knapen, F., Mossel, D. A., Burt, S. A., and Snijders, J. M. (1998). Impact on human health of Salmonella spp. on pork in The Netherlands and the anticipated effects of some currently proposed control strategies. Int J Food Microbiol 44, 219-29.

Borch, E., Nesbakken, T., and Christensen, H. (1996). Hazard identification in swine slaughter with respect to foodborne bacteria. Int J Food Microbiol 30, 9-25.

EFSA (2010). Scientific Opinion on a Quantitative Microbiological Risk Assessment of Salmonella in slaughter and breeder pigs . EFSA Journal 8, 1547 [80 pp.].

Steinbach, G. and Hartung, M. (1999). [Attempt to estimate the share of human Salmonella infections, which are attributable to Salmonella originating from swine]. Berl Munch Tierarztl Wochenschr 112, 296-300.

Threlfall, E. J., Ward, L. R., Frost, J. A., Cheasty, T., and Willshaw, G. A. (1999). The emergence and spread of antibiotic resistance in food-borne bacteria in the United Kingdom. APUA Newsletter 7, 1-7.

Threlfall, E. J., Ward, L. R., and Rowe, B. (1998). Multiresistant Salmonella typhimurium DT 104 and salmonella bacteraemia. Lancet 352, 287-8.

VLA (2009). "Salmonella in livestock production in GB 2008".