SVARM 2011

Swedish Veterinary Antimicrobial Resistance Monitoring

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Swedish Veterinary Antimicrobial Resistance Monitoring - SVARM

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Content

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Preface

THE INTRODUCTION of antimicrobials some 70 years ago was a true paradigm shift with immense impact on the possibility to treat infectious diseases in human medicine. Soon antimicrobials were introduced also in animal health care and not the least, these drugs came into use in the breeding of animals for food production.

Unfortunately use and misuse of antimicrobials for humans and animals have diminished the usefulness of the miracle drugs by selecting for antimicrobial resistance. The impact of resistance is vast and goes beyond therapeutic failures in single cases. Virtually the foundation of human healthcare as perceived today is being undermined by emergence of resistance. Likewise, modern companion animal healthcare relies on access to effective therapy of infectious diseases as does food production based on breeding of production animals. Not surprisingly emergence of antimicrobial resistance is often described as one of the greatest current global threats and challenges to man.

To recapture the usefulness of antimicrobials for treatment of man and animals, joint actions on several levels are needed. This is generally recognized and was recently addressed by the European Commission in its "Action plan against the rising threats from antimicrobial resistance" released in November 2011 (COM 2011 748). The plan acknowledges a holistic approach comprising actions in several different sectors such as medicine, veterinary medicine, animal husbandry, agriculture, environment and trade.

Among the 12 urgently needed key actions described in the plan is research and development of new antimicrobials to replace drugs that have become obsolete by emerging resistance. This is easily understood but the plan goes further and proposes actions in several other fields. Among these are measures to prevent infectious diseases in man and animals and measures to promote and ascertain prudent use of antimicrobials in human and veterinary medicine. Surveillance of antimicrobial use and of resistance in human as well as veterinary medicine are also among the key actions proposed. Also it is emphasised that harmonisation of monitoring is vital because it increases the usefulness for risk assessment and management of the data generated.

It is in this context the reports from SWEDRES and SVARM should be perceived. To be effective, relevant actions against resistance must be based on sound knowledge of the current situation and of trends over time. For more than a decade the reports have yearly documented the national situation with regard to antimicrobial use and prevalence of resistance. The data generated so far, and in the future, is urgently needed as guidance for actions and initiatives to mitigate antimicrobial resistance as well as for designing strategies on a national level.

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Guidance for readers

Cut-off values for resistance

In SVARM, isolates of indicator bacteria and zoonotic bacteria are classified as susceptible or resistant by epidemiological cut-off values (ECOFF) issued by European Committee on Antimicrobial Susceptibility Testing (EUCAST) and available online at www.eucast.org. Also, animal pathogens are classified by ECOFFs when such values are available and suitable for the concentration range tested. Cut-off values used are given in Appendix 4.

ECOFFs classify isolates with acquired reduced susceptibility as non-wild type, in SVARM called "resistant". This classification is relevant for monitoring purposes, but it should be understood that "resistance" does not always imply clinical resistance.

Since the first report from SVARM, some cut-off values for resistance have been changed. To facilitate comparisons when retrospect data are presented in SVARM 2011, levels of resistance have been recalculated using current cut-off values if not otherwise stated.

Indicator bacteria

In SVARM, *Escherichia coli*, *Enterococcus faecalis* and *Enterococcus faecium* serve as indicators for presence of antimicrobial resistance in the enteric flora of healthy animals and in the flora contaminating retail meat. The prevalence of acquired resistance in such commensal bacteria indicates the magnitude of the selective pressure from use of antimicrobials in an animal population. Most bacteria of the enteric flora are unlikely to cause disease, but they can be reservoirs for resistance genes that can spread to bacteria that cause infections in animals or humans. Prevalence of resistance in bacteria contaminating meat indicates the magnitude of the potential human exposure to such reservoirs in food producing animals.

Presentation of MIC distributions

Susceptibility data are presented as distributions of MICs in tables of a uniform design as below. Distributions are given as percentages of isolates tested. In the tables, white fields denote range of dilutions tested for each substance and vertical bold lines indicate cut-off values used to define resistance.

The percentage of isolates with a certain MIC of an antimicrobial is given in the corresponding white field. For MICs above the range tested of an antimicrobial (>X mg/L) the percentage is given in the field closest to the range, i.e. in the first shaded field to the right of the tested range. For MICs equal to or lower than the lowest concentration tested for an antimicrobial (≤Y mg/L) the percentage is given as the lowest tested concentration, i.e. in the first white field of the tested range.

Multiresistance

The term "multiresistance" is used in SVARM with a meaning as proposed by Schwarz et al. (2010). Briefly, isolates with phenotypically identified acquired resistance to three or more antimicrobial classes are deemed multiresistant. This implies for example that resistance to ciprofloxacin, enrofloxacin and nalidixic acid represents resistance to one class of antimicrobials.

Antimicrobial abbreviations

Am	ampicillin	Fu	fusidic acid
Ba	bacitracin	Gm	gentamicin
Ce	ceftiofur	Km	kanamycin
Ci	ciprofloxacin	Na	narasin
Cl	clindamycin	Nal	nalidixic acid
Cm	chloramphenicol	Ox	oxacillin
Col	colistin	Pc	penicillin
Ct	cephalothin	Sm	streptomycin
Ctx	cefotaxime	Su	sulphonamide
Ef	enrofloxacin	Tc	tetracycline
Em	erythromycin	Tm	trimethoprim
Fox	cefoxitin	Va	vancomycin.
Ff	florfenicol	Vi	virginiamycin

Other abbreviations

ESBL	extended spectrum beta-lactamase
MRSA	meticillin resistant *Staphylococcus aureus*
MRSP	meticillin resistant *Staphylococcus pseudintermedius*
MIC	minimum inhibitory concentration
VRE	vancomycin resistant enterococci

Example of a table with distributions of MICs:

Antimicrobial	Resistance (%)	Distribution (%) of MICs (mg/L)											
		≤0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	>64
Ciprofloxacin	21	21.0	52.0	6.0			1.0			20.0			
Erythromycin	0				93.0	4.0	3.0						
Tetracycline	2		75.0	22.0	1.0			1.0	1.0				

Summary

THE 2011 REPORT FROM SVARM shows that the situation regarding antimicrobial resistance in bacteria from animals remains favourable from an international perspective. However, the importance of continuous monitoring as a tool to discover appearance of new types of resistance and to identify trends is again manifested. In SVARM 2011, transferable resistance to third generation cephalosporins (ESBL) in *Escherichia coli* from pigs in Sweden is reported for the first time as is the first isolation of methicillin resistant *Staphylococcus aureus* from dairy cows.

These examples illustrate a dynamic and gradually deteriorating situation. They are also examples of the complex and multifactorial background to emergence and spread of antimicrobial resistance. To guide actions to counteract resistance, it is important to fully understand the interaction of the factors involved. This is also important for assessment of the risks for animal and human health as a consequence of resistance in bacteria from animals.

However, of key importance for emergence as well as for spread of resistance is the selection pressure exerted by use of antimicrobials. The stable or declining use of antimicrobials for animals in Sweden reported in SVARM 2011 is therefore encouraging and signifies that activities to promote "prudent use" in veterinary medicine are successful. From an international perspective the level of antimicrobial use for animals in Sweden is outstandingly low.

The total amount of antimicrobials used for animals was 12 606 kg in 2011. When data were expressed as mg active substance per 'population correction unit' (PCU; estimated kg live-weight of the populations of food producing animals), the sales in 2011 were 15.4 mg/PCU which is 26% lower than in 2007 and more than 50% lower than in 1992. Decreases are seen for all antimicrobial classes and for all major animal species. Sales of products for group medication are only about 10% of the total sales.

Salmonella is rare in Swedish animals and most incidents involve susceptible isolates. In 2011, 72% of the isolates were susceptible to all antimicrobials tested. Only four of 43 isolates from food producing animals and three of 28 isolates from companion animals and wildlife were multiresistant. Resistance to third generation cephalosporins was not observed. Only one incident involved multiresistant *S.* Typhimurium DT 104 but multiresistant monophasic *Salmonella* subspecies I, O 4,5,12:i- was found in one incident in cattle and also in a dog. There are no indications of increased occurrence of resistance, but in view of the public health consequences vigilance towards resistant *Salmonella* in food-producing animals is warranted.

In pigs, all isolates of ***Campylobacter coli*** were susceptible to erythromycin but a large proportion was resistant to quinolones (37%). This is in agreement with previous findings and probably caused by use of quinolones (enrofloxacin) in sows and piglets.

Methicillin resistant *Staphylococcus aureus* (MRSA) in animals is notifiable to the Board of Agriculture. In 2011, MRSA was confirmed in one cat, two horses and in four milk samples from dairy cows. Since first reported in 2006 and until the end of 2011, MRSA has been isolated from 18 dogs, 5 cats, 17 horses, 4 dairy cows and in one sample from pigs. The four isolates from cows were of *spa*-types t524 and t9111 and were the first findings of MRSA from cattle in Sweden. They were also the first isolations of MRSA with the divergent *mecA* homologue, $mecA_{LGA251}$ from Swedish animals. Most isolates from horses and the isolate from pig were of *spa*-type t011 and belonged to the livestock associated CC398. This type is common in several animal species in other countries but rare among humans in Sweden. In contrast, most isolates from dogs and cats were of *spa*-types that are common among MRSA from humans in Sweden. Since there is a zoonotic aspect to MRSA in animals, the situation should be closely monitored and measures to hinder spread, such as improved biosecurity and infection control, is of utmost importance.

Resistance in indicator bacteria (*Escherichia coli* and *Enterococcus* spp.) from the intestinal flora of healthy animals, are believed to reflect the antimicrobial selective pressure in an animal population. At slaughter, intestinal bacteria can contaminate carcasses and subsequently be passed along the food chain. Resistance in indicator bacteria on food can therefore be used to assess exposure of humans to resistant bacteria from food animals.

In an international perspective, resistance in indicator bacteria from pigs and pig meat was low and at similar levels as in previous years. However, resistance to ampicillin, trimethoprim or sulphonamides in *E. coli* from pigs has gradually increased since monitoring started in 2000. These three antimicrobials are commonly used in pig production and the increase is probably due to direct selection. Co-selection probably enhances selection since these three resistance traits are common in multiresistant isolates.

By screening of samples from pigs with sensitive selective cultures, *E. coli* with ESBL resistance was found in 1.6% of the samples. This is the first finding of ESBL resistance in *E. coli* from pigs in Sweden. Notably, use of cephalosporins in pigs is insignificant in Sweden. In broilers, selective culture confirmed previous findings of *E. coli* with ESBL or AmpC

resistance in intestinal content in a large proportion of birds. These findings cannot be explained by antimicrobial use in broiler production in Sweden and preliminary findings indicate introduction and spread from imported breeding stock.

The overall resistance situation in **pathogenic bacteria from food-producing animals** in Sweden is favourable. Resistance was most common in isolates of *E. coli* from pigs and calves where resistance to ampicillin, streptomycin, tetracycline or trimethoprim-sulphonamides was not unusual. Forty percent of isolates from calves and 25% of isolates from pigs were multiresistant, which are increasing figures compared to previous years.

Resistance was rare in isolates of *Actinobacillus pleuropneumoniae* and *Pasteurella* spp. from the respiratory tract of pigs, in isolates of *Pasteurella* spp. from the respiratory tract of calves as well as in isolates of *Streptococcus equisimilis* from joints of piglets. Resistance to penicillin was not detected in these species, supporting the view that penicillin is the substance of choice for treatment of respiratory and joint infections. However, penicillin resistance was confirmed in *Mannheimia haemolytica* from calves in one herd, emphasizing the importance of monitoring.

In isolates of *Brachyspira* spp. from pigs, resistance to tiamulin occurred in *B. pilosicoli* but was not observed in *B. hyodysenteriae*. However, the majority of isolates of *B. pilosicoli* and *B. hyodysenteriae* was resistant to tylosin.

In *Aeromonas salmonicida* subsp. *achromogenes*, *Flavobacter columnare* and *Flavobacter psychrophilum* from farmed fish, deviating high MICs to florfenicol, tetracycline or nalidixic acid in some isolates indicate acquired resistance to these antimicrobials.

The resistance situation in **pathogenic bacteria from companion animals** is worrisome concerning *Staphylococcus pseudintermedius* from the skin of dogs. Most isolates were resistant to penicillin through beta-lactamase production and resistance to clindamycin, erythromycin, fusidic acid or tetracycline was also common. Multiresistance occurred in 36% of the isolates and 7% were resistant to five or more antimicrobials. In Sweden, isolates of methicillin resistant *S. pseudintermedius* (MRSP) are notifiable. During 2011, 53 cases were reported to the Board of Agriculture. Since first detected in 2008, ESBL resistance has been confirmed in 19 isolates of *Enterobacteriaceae*. Isolates of *Pseudomonas aeruginosa* from the external ear of dogs were susceptible to polymyxin B, but resistance to gentamicin and enrofloxacin occurred.

Resistance in **pathogenic bacteria from horses** is mostly in level with previous years. However, ESBL resistance has been confirmed in 33 isolates of *Enterobacteriaceae* since 2008, and the situation must be closely monitored. In isolates of *E. coli*, resistance to streptomycin and trimethoprim-sulphonamides was most common. Resistance to penicillin through beta-lactamase production in isolates of *Staphylococcus aureus* from skin samples occurred in 20% of the isolates. Isolates of *Streptococcus zooepidemicus* from the respiratory tract were uniformly susceptible to penicillin, but resistance to trimethoprim-sulphonamides occurred.

Sammanfattning

SVARM 2011 visar att resistensläget hos bakterier från djur är fortsatt gynnsamt ur ett internationellt perspektiv. Men trots att den samlade bilden är positiv har för första gången MRSA påvisats hos svenska kor och *Escherichia coli* med överförbar resistens mot tredje generationens cefalosporiner (ESBL) hos svenska grisar.

Båda fynden visar att resistensläget är föränderligt och de belyser därmed vikten av kontinuerlig övervakning för att förändringar ska upptäckas tidigt. Baserat på sådan kunskap kan åtgärder för att bromsa spridning av resistenta bakterier vidtas i ett tidigt skede och har då störst möjlighet att bli effektiva.

Försäljningen av antibiotika för djur var totalt 12 606 kg under 2011. Uttryckt som mg aktiv substans per skattade kilo levandevikt av livsmedelsproducerande djur var försäljningen 2011 15.4 mg/kg vilket är 26 % lägre än 2007 och mer än 50 % lägre än 1992. Minskad försäljning noterades för alla antibiotikaklasser och för alla djurslag. Försäljning av antibiotika för inblandning i foder eller vatten stod endast för cirka 10% av den totala försäljningen.

Fynd av **meticillinresistent *Staphylococcus aureus* (MRSA)** hos djur är anmälningspliktiga till Jordbruksverket. Under 2010 påvisades MRSA hos en katt, två hästar och i fyra mjölkprover från kor. Sedan det första fallet hos svenska djur 2006 har MRSA konfirmerats hos 18 hundar, 5 katter, 17 hästar, 4 mjölkkor och i ett prov från grisar till och med 2011. De fyra isolaten från kor var av *spa*-typerna t524 och t9111 och var de första fynden av MRSA från nötkreatur i Sverige. De var också de första isolaten av MRSA med den avvikande *mecA*-genen, $mecA_{LGA251}$, från svenska djur. De flesta isolat från hundar och katter och isolatet från gris var av *spa*-typ t011 och tillhörde den stordjursassocierade varianten av MRSA, CC398. Denna variant är vanlig hos framför allt livsmedelsproducerande djur i många länder men är ovanlig hos människor i Sverige. Isolaten från hundar och katter var av *spa*-typer som är vanliga hos människor i Sverige, vilket indikerar smittspridning mellan människa och djur. MRSA betraktas som ett zoonotiskt smittämne och läget i djurpopulationer bör därför övervakas. Åtgärder för att hindra smittspridning är mycket viktiga.

Salmonella är ovanligt hos svenska djur och de fall som inträffar orsakas oftast av antibiotikakänsliga stammar. Under 2011 var 72 % av isolaten känsliga för alla testade antibiotika. Bara fyra av 43 isolat från livsmedelsproducerande djur och tre av 28 isolat från sällskapsdjur och vilda djur var multiresistenta. Inget isolat var resistent mot tredje generationens cefalosporiner. Endast ett fall av multiresistent *S.* Typhimurium DT 104 påvisades. Multiresistent monofasisk *Salmonella* subspecies I, O 4,5,12;i- påvisades i ett fall hos nötkreatur och dessutom hos en hund. Sedan 2006 har totalt åtta fall med multiresistenta isolat av denna salmonellatyp påvisats hos svenska lantbruksdjur.

Alla isolat av ***Campylobacter coli*** från gris var känsliga för erytromycin men en stor andel var resistent mot kinoloner (37 %). Kinolonresistensen hos isolat från grisar har varit vanlig även tidigare år vilket troligen beror på att kinoloner (enrofloxacin) används för behandling av smågrisar och suggor.

Resistens hos indikatorbakterier (*Escherichia coli* och *Enterococcus* spp.) från tarmfloran hos friska djur anses återspegla selektion av resistens som följd av användning av antibiotika till djuren. Indikatorbakterier på livsmedel ger en uppfattning om vilka resistenta bakterier från lantbruksdjur som kan nå människor via livsmedelskedjan.

Resistens hos indikatorbakterier från såväl tarminnehåll från grisar som från griskött är ovanlig och av samma storleksordning som tidigare år. I ett internationellt perspektiv är förekomsten liten. Sedan övervakningen startade 2000 har dock resistens mot ampicillin, trimethoprim och sulfonamid hos *E. coli* successivt ökat. Dessa tre antibiotika används för att behandla sjuka grisar och ökningen är sannolikt en följd av direkt selektion. Men troligen har ko-selektion också betydelse eftersom det inte är ovanligt att multiresistenta isolat av *E. coli* är resistenta mot alla tre substanserna.

Med känslig selektiv odlingsmetod påvisades *E. coli* med överförbar resistens mot tredje generationens cefalosporiner i en liten andel (1,6 %) prov av tarminnehåll från grisar men i en stor andel sådana prov från slaktkyckling. Det är första gången denna typ av resistens påvisas hos tarmbakterier från svenska grisar medan undersökningen av slaktkyckling konfirmerar resultatet från undersökningarna i SVARM 2010. I Sverige används cefalosporiner mycket sällan till grisar och inte alls i uppfödningen av slaktkyckling. Preliminära resultat visar att orsaken till förekomst hos svensk slaktkyckling sannoliokt är spridning av resistenta bakterier från importerade avelsdjur.

Resistensläget hos **sjukdomsframkallande bakterier från livsmedelsproducerande djur** i Sverige är generellt sett gynnsamt. Resistens var vanligast hos isolat av *E. coli* från grisar och kalvar där resistens mot ampicillin, streptomycin, tetracyklin eller trimetoprim-sulfonamid var vanligast. Fyrtio procent av isolaten från kalvar och 25 % av isolaten från grisar var multiresistenta vilket är en ökning jämfört med tidigare år.

Resistens var ovanligt hos isolat av *Actinobacillus pleuropneumoniae* och *Pasteurella* spp. från luftvägarna hos grisar, hos isolat av *Pasteurella* spp. från luftvägarna hos kalvar och hos isolat av *Streptococcus equisimilis* från lederna hos smågrisar. Resistens mot penicillin påvisades inte hos dessa bakteriearter, vilket stödjer ståndpunkten att penicillin bör vara förstahandsval vid antibiotikabehandling av luftvägs- och ledinfektioner. Penicillinresistens påvisades dock hos *Mannheimia haemolytica* från kalvar i en besättning vilket belyser vikten av resistensundersökning.

Hos isolat av *Brachyspira* spp. från grisar förekom resistens mot tiamulin hos *B. pilosicoli* men kunde inte påvisas hos *B. hyodysenteriae*. Majoriteten av isolaten av *B. pilosicoli* och *B. hyodysenteriae* var resistent mot tylosin.

Hos *Aeromonas salmonicida* subsp. *achromogenes*, *Flavobacter columnare* och *Flavobacter psychrophilum* från odlad fisk förekom avvikande höga MIC-värden för florfenikol, tetracyklin eller nalidixansyra hos några isolat, vilket indikerar överförbar resistens mot dessa antimikrobiella substanser.

Resistensläget hos **sjukdomsframkallande bakterier hos sällskapsdjur** är oroande vad gäller *Staphylococcus pseudintermedius* från huden på hundar. De flesta isolat var resistenta mot penicillin genom betalaktamasproduktion och resistens mot klindamycin, erytromycin, fusidinsyra eller tetracyklin var också vanligt. Multiresistens förekom hos 36 % av isolaten och 7 % var resistenta mot fem eller fler antibiotika. I Sverige är fynd av meticillinresistent *S. pseudintermedius* (MRSP) anmälningspliktigt. Under 2011 anmäldes 53 fall av MRSP till Jordbruksverket. Resistens av ESBL-typ hos *Enterobacteriaceae* har påvisats hos 19 isolat från hundar och katter sedan 2008. Isolat av *Pseudomonas aeruginosa* från hörselgången hos hundar var känsliga för polymyxin B men resistens mot gentamicin och enrofloxacin förekom.

Resistensläget hos **sjukdomsframkallande bakterier från hästar** är i huvudsak jämförbart med tidigare år. ESBL-producerande isolat av *Enterobactericeae* har dock påvisats 33 gånger och noggrann övervakning av läget är viktigt. Hos *E. coli*-isolat var resistens mot streptomycin och trimetoprim-sulfonamid vanligast. Resistens mot penicillin genom betalaktamasproduktion hos isolat av *S. aureus* från hudprover förekom hos 20 % av isolaten. Alla isolat av *Streptococcus zooepidemicus* från luftvägarna var känsliga för penicillin men resistens mot trimetoprim-sulfonamid förekom.

Use of antimicrobials

STATISTICS ON TOTAL SALES of antimicrobials for use in animals in Sweden are available since 1980. For a review of the data from 1980-2000 as well as references to publications on which that review is based, see SVARM 2000. Data represent an approximation of the real use of antimicrobials, assuming that the amount sold is also used during the observation period. Data for 2011 were provided by Apotekens Service AB and represent sales for terrestrial animals. Data on prescription of antimicrobials for farmed fish are collected through the Fish health control program and are commented in the section 'Comments on trends by animal species'. Details on source of data and inclusion criteria are given in Appendix 2 and on antimicrobial agents with general marketing authorisation in Sweden in Appendix 5.

Trends in animal populations

Changes in the numbers of animals may affect trends in statistics on use of antimicrobials. The number of beef cows have increased by 5% in five years (i.e. since 2007), but the number of dairy cows has decreased by 6%. The number of pigs slaughtered has decreased by 5%, while the number of broilers was 5% higher in 2010 than in 2007. The number of horses was 349 000 in 2010, an estimated increase by 10-20% since 2004. Details on animal numbers are found in Appendix 1.

Completeness of data

The data coverage for products with general Swedish marketing authorisation is assumed to be 100%. However, during the analysis of data for 2011, it became clear that the data for products sold with special license (prescribed and sold on exemption from general Swedish marketing authorisation) and sold for the first time in 2010 or 2011 were not included in the retrieved data. Furthermore, a comparison of data retrieved for some products sold with special license before 2010 with sales figures for 2011 showed that the sale from drug companies to pharmacies (in number of product packages) was much larger than sales from pharmacies (in number of product packages). The difference is deemed to be larger than what can be expected to be kept in stock at the pharmacies.

In conclusion, data for products sold with special license are less complete than before 2010. In 2009, about 10% of the overall sales expressed in kg active substance were products of this type. Major antimicrobials sold with special license are products for group medication with tetracyclines, amoxicillin or colistin and products for injection with long acting penicillins. These products are mainly sold for use in pigs and poultry, and the uncertainty about completeness of data will therefore hamper assessment of trends for these animal species.

Overall use

The total yearly sales of antimicrobials over the last decade are presented in Table AC I. The potency of different antimicrobials is not equal and therefore each class should be evaluated separately. Trends in sales of individual classes from 1980 are shown in Figure AC I.

Changes in the numbers of animals over time will influence the statistics on use of antimicrobials. To correct for this, the method of estimating the weight at treatment of livestock and of slaughtered animals described in a recent publication from the European Medicines Agency was applied (EMA 2011). The term used for the total estimated weight is "population correction unit" (PCU) which is a purely technical unit of measurement. In Figure AC II, the sales of antimicrobials for animals from 1980 are presented as mg active substance per PCU. The overall sales have decreased more than 50% compared to the average figures for 1980-1984 (i.e. before the Swedish ban on growth promoting antimicrobials in 1986). This is explained both by the removal of growth promoting antimicrobials in 1986 and by a major gradual decrease from the mid 90s of the sales of veterinary products for medication via feed or water (group medication). Today, the sales of prod-

TABLE AC I. Yearly sales of antimicrobial drugs for veterinary use expressed as kg active substance. For penicillins, tetracyclines, aminopenicillins and polymyxins data on sales of products sold with special license may be incomplete for 2011 (indicated in red).

ATCvet code	Antimicrobial class	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
QJ01AA, QG01A	Tetracyclines[a]	1 415	1 307	1 329	1 562	1 516	1 853	1 649	1 174	1 115	1 073
QJ01CE, -R, QJ51	Benzylpenicillin[a,b]	8 179	7 579	7 814	7 571	7 860	7 582	7 758	7 721	7546	6 696
QJ01CA, QJ01CR	Aminopenicillins[a]	767	870	875	911	920	927	938	1 068	907	723
QJ01D	Cephalosporins	676	832	928	1 009	1 217	954	820	738	575	498
QA07AA, QJ01G, -R, QJ51R	Aminoglycosides and polymyxins[a]	753	645	606	762	750	718	643	609	557	503
QA07AB, QJ01E	Sulphonamides	2 477	2 326	2 462	2 535	2 543	2 427	2 303	2 128	1 998	1 867
QJ01E	Trimethoprim & derivatives	414	381	406	437	450	438	416	379	357	338
QJ01F	Macrolides & lincosamides	1 412	1 124	1 095	1 080	1 254	1 520	1 096	988	739	648
QJ01MA	Fluoroquinolones	185	184	187	184	195	180	169	164	148	120
QJ01XX92, - 94	Pleuromutilins	988	744	387	338	459	506	572	398	174	140
Total		*17 266*	*15 992*	*16 089*	*16 389*	*17 164*	*17 106*	*16 364*	*15 368*	*14 117*	*12 606*

[a] Includes drugs marketed with special licence prescription; [b] Also includes small amounts of penicillinase stable penicillins.

ucts for medication of groups of animals are less than 10% of what it was on average before 1986 (counting the sum of veterinary medicines and growth promoters).

Of the total sales expressed as kg active substance, about 90% are products formulated for treatment of individual animals (injectables, tablets, intramammaries) and about 10% for treatment of groups or flocks (premixes, oral powders, solutions for water medication). In table AC II, the sales of products for use in individual animals, excluding topical, intrauterine and intramammary use are presented. The sales of cephalosporins (almost entirely first generation cephalosporins) have decreased by 48% in five years, almost entirely related to decreased prescription of first generation cephalosporins for dogs. The sales of fluoroquinolones for therapy of individual animals have decreased by 33% since 2007. This is explained both by a marked decrease in sales of fluoroquinolones for oral use in dogs and cats (32% decrease of that subset) and of products for injection (34% decrease of that subset).

Data on sales of antimicrobials formulated for medication of groups of animals are given in Table AC III. Data for 1984 are given as historical reference. As noted above, data on products sold with special license is slightly incomplete for 2011 which hampers assessment of trends of some classes. For further comments see pig and poultry below.

TABLE AC II. Yearly sales of antimicrobial drugs authorised for individual treatment expressed in kg active substance. Only products for systemic use (QJ01) or for use as intestinal anti-infective (QA07) are included. For penicillins, tetracyclines aminopenicillins and intestinal anti-infectives, data on sales of products sold with special license may be incomplete for 2011 (indicated in red).

ATCvet code	Antimicrobial class	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
QA07A	Intestinal anti-infectives[a]	594	594	586	496	434	372	364	355	302	280
QJ01A	Tetracyclines	628	606	611	623	609	632	605	576	538	520
QJ01CE	Benzylpenicillin[a, b]	8 127	7 536	7 769	7 493	7 777	7 504	7 671	7641	7 492	6 627
QJ01CA -CR	Aminopenicillins	767	870	875	911	909	899	828	802	742	687
QJ01D	Cephalosporins	676	832	928	1 009	1 212	950	817	735	575	498
QJ01E	Sulfonamides & trimethoprim	2 483	2 280	2 427	2 610	2 689	2 619	2 486	2 270	2 138	2 023
QJ01F	Macrolides & lincosamides	477	430	382	400	417	413	352	332	311	287
QJ01G	Aminoglycosides[c]	460	367	344	362	345	343	318	301	274	246
QJ01M	Fluoroquinolones	178	177	180	179	190	177	164	159	144	118
QJ01X	Pleuromutilins	49	77	32	29	39	36	36	28	17	13
Total		*14 439*	*13 769*	*14 134*	*14 112*	*14 622*	*13 944*	*13 640*	*13 198*	*12 532*	*11 300*

[a] Drugs marketed with special licence prescription are included; includes aminoglycosides, formolsulfatiazole and colistin; [b] The amount includes QJ01R; [c] Does not include the aminoglycosides in QA07A, intestinal anti-infectives.

TABLE AC III. Yearly sales of antimicrobial drugs authorised for group treatment and ionophoric anticoccidials sold expressed as kg active substance. For penicillins, tetracyclines, aminopenicillins and intestinal anti-infectives, data on sales of products sold with special license may be incomplete for 2011 (indicated in red).

ATCvet code	Antimicrobial class	1984	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
QA07A	Intestinal anti-infectives[a]					163	170	158	106	107	119	77
QJ01A	Tetracyclines[a]	12 300	777	695	712	934	903	1 217	1 040	594	575	552
QJ01C	Penicillins incl. aminopenicillins[a]						11	28	111	266	164	36
QJ01F	Macrolides & lincosamides	607	935	694	713	680	837	1 107	744	657	427	361
QJ01MA	Fluoroquinolones		7	8	7	5	5	3	5	5	4	2
QJ01MQ	Quinoxalines[b]	9 900										
QJ01XX91	Streptogramins[c]	8 800										
QJ01XX92, -94	Pleuromutilins		939	667	355	309	420	471	536	370	157	127
QP51AA	Nitroimidazoles	1 440										
	Feed additives[d]	700										
Total		*33 747*	*2 658*	*2 064*	*1 787*	*2 091*	*2 346*	*2 984*	*2 543*	*1 999*	*1 447*	*1 154*
QP51AH	Ionophoric antibiotics (coccidiostats)[d, e]	7 900	8 439	10 920	10 486	11 095	12 335	12 527	13 376	12 471	15 325	NA[e]

[a] Drugs with special licence prescription are included from year 2005, includes aminoglycosides and colistin; [b] Years 1980-1984 sold as feed additives, thereafter on veterinary prescription at therapeutic dosages until 1997; [c] Feed additives other than quinoxalines and streptogramins: avoparcin, bacitracin, nitrovin, oleandomycin and spiramycin; [d] Figures are from the Feed Control of the Board of Agriculture (www.sjv.se); [e] Not available at the time of publication.

FIGURE A

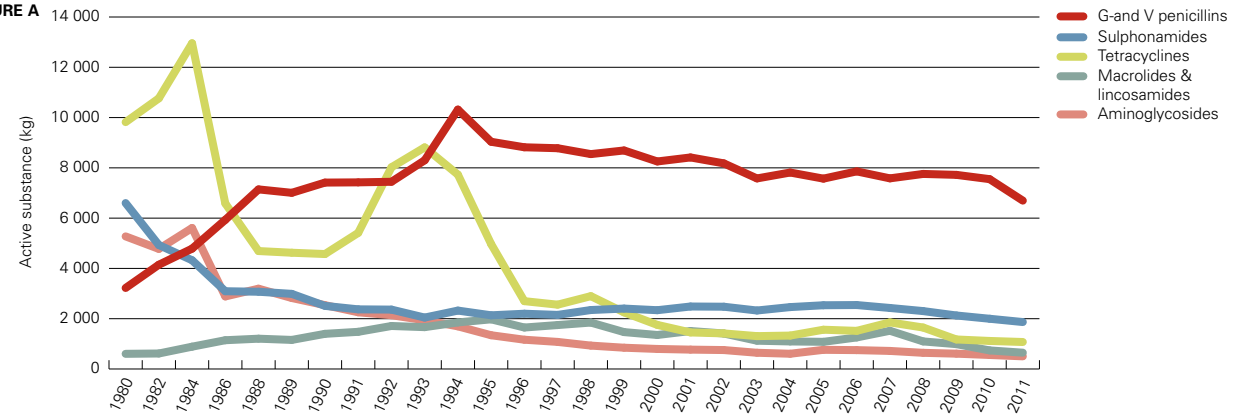


FIGURE B

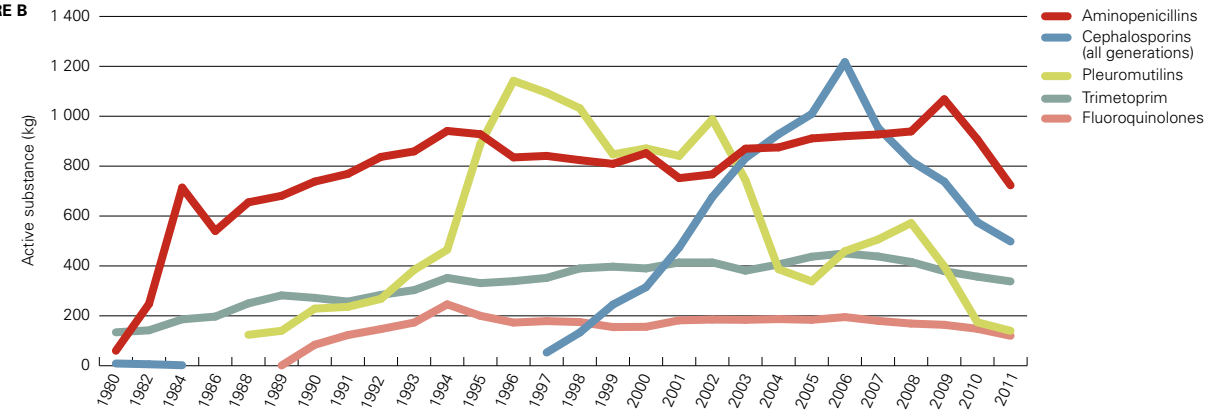


FIGURE AC I A & B. Sales of antimicrobials for animals. Amphenicols, nitroimidazoles, streptogramins, quinoxalines and other feed additives were withdrawn from the market during the time period and are not shown. Note that the scales on the Y-axis are different in figure a and b. For penicillins, tetracyclines and aminopenicillins, data on sales of products sold with special license may be incomplete for 2010 and 2011.

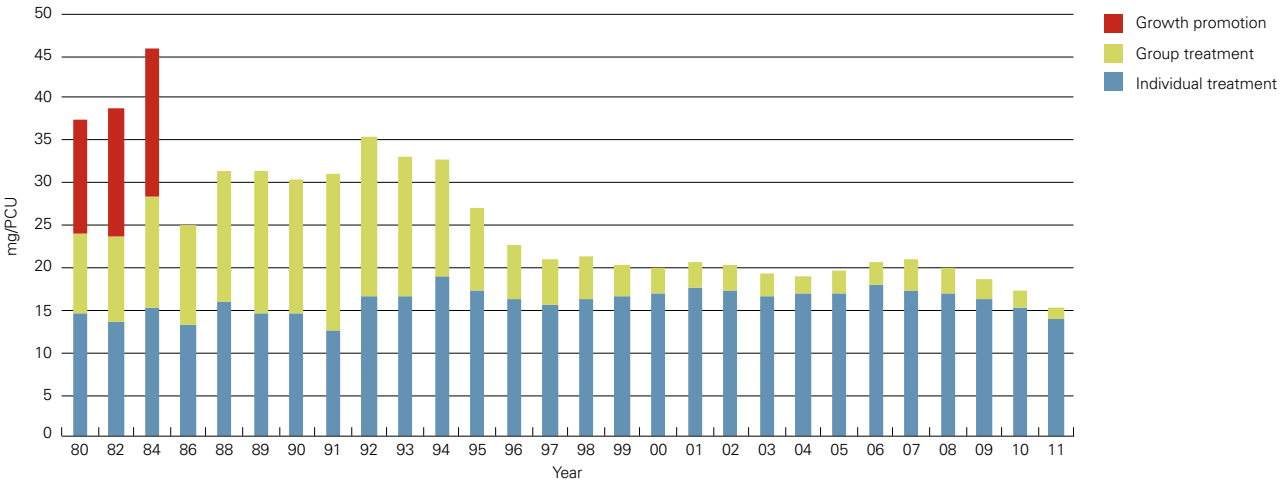


FIGURE AC II. Sales of antimicrobials for animals expressed as mg per population correction unit (PCU).

Comments on trends by animal species

Information on the volumes of antimicrobials sold for different animal species as given on the prescription is available from the Swedish Board of Agriculture. The results for years 2009-2011 have been summarised in Table AC IV as percent of the total volume sold per class. A large proportion of the aminopenicillins (76%) and cephalosporins (97%) are used for companion animals. Also, macrolides & lincosamides and fluoroquinolones are to a considerable extent sold for use in dogs and cats (39 and 30%, respectively). The current system does not permit a full stratification of the antimicrobials sold for specific food producing animal species. Therefore, non companion animal species are given as one group in Table AC IV.

In the following, trends in the use of various classes for different animal species are commented based on information from different sources, e.g. species when given on the prescriptions, knowledge on how different products are generally used in Sweden and on other available information. The comments have varying degrees of uncertainty, depending on the source of information used.

Dairy cows

The Swedish Dairy Association publishes a yearly report related to the organization's work to improve animal health and welfare in dairy cows (Swedish Dairy Association, 2011). The reporting year is from September to August which in the following will be given as, e.g., 2009/10. For statistics specifically on antimicrobial treatments, full years are reported and the latest year is 2010. The report includes statistics on disease incidence in dairy cows enrolled in the Swedish milk recording scheme. Data are mainly retrieved from a database with veterinary reported disease events and treatments (Jansson Mörk, 2010).

The by far most common indication for treatment of dairy cattle is clinical mastitis and other udder conditions. The reported incidence of clinical mastitis in dairy cows was 13.0 per 100 completed/interrupted lactations in 2010/11 which is lower than in 2009/10 (14.2 per 100). In Sweden, mastitis is generally treated systemically and any changes in treatment incidence, treatment length or choice of antimicrobial for this condition will have a noticeable influence on the statistics on sales of antimicrobials. Treatment with penicillin was by far the most common, and the decreased incidence of clinical mastitis tallies with a decrease in sales of penicillins for systemic use (Table AC II) where products with a general marketing authorisation in Sweden have decreased by 11% between 2010 and 2011. The incidence of treatment of dairy cows with third generation cephalosporins has decreased from 0.82 per 100 cow-years in 2007 to 0.32 per 100 cow-years. The reported incidence of treatment of dairy cows for mastitis with fluoroquinolones has been roughly unchanged over the last years, around 2.5 treatments per 100 cow-years. In the sales statistics from pharmacies, 13.3 kg of third generation cephalosporins and 72 kg of fluoroquinolones were recorded as sold for cows, horses or unknown animal species. This represents a decrease since 2007 by 49 and 33%, respectively.

The Swedish Dairy Association reports a 30% treatment incidence at drying off for cows enrolled in the Swedish milk recording scheme. The number of dose-applicators of intramammary products for drying off corresponds to a treatments incidence of 19.6%, assuming that four applicators are used per cow. The discrepancy in figures might be explained by fewer applicators being used per cow (e.g. only subclinically infected quarters treated) or by products formulated for use during lactation being used to some extent for this indication, or a combination of both. Products with penicillin combined with aminoglycosides are by far the most commonly used for prevention around drying off.

Pigs

The problems with retrieval of data on sales of products sold with special license mentioned above will in particular affect the statistics on sales of products with tetracycline, aminopenicillins or colistin for group medication and long acting penicillin for injection of pigs. The sales of fluoroquinolones for pigs were 12.5 kg in 2011, 38% lower than in 2007. The sales of third generation cephalosporins were insignificant (0.01 kg).

The continued drop in use of macrolides for group medication (Table AC III; 67% lower in 2011 than in 2007) is likely to reflect improved knowledge on how to manage problems with concomitant infections in herds with postweaning multisystemic wasting syndrome. This includes the introduction of vaccination strategies and an awareness that in most cases, antimicrobials have no or a limited effect. The sales of pleuromutilins also continue to decrease and the sales are 73% lower in 2011 compared to 2007. The main indication for pleuromutilins (tiamulin, valnemulin) is swine dysentery. Efforts to control the disease through e.g. a certification programme have resulted in a decreased need to treat swine dysentery, leading to overall declining sales figures since the mid 90s (Figure AC I). Further comments on trends in sales of antimicrobials for pigs 2006-2010 are presented in the Highlight 'Antimicrobials for pigs'.

Poultry

The problems with retrieval of data on sales of products sold with special license mentioned above will in particular affect the statistics on sales of pencillin V and aminopenicillins for group medication of poultry.

Antimicrobials are rarely used for treatment of bacterial diseases in commercially reared *Gallus gallus*. Localized outbreaks can therefore have a major influence on the sales in a specific year. Over the last five years, the yearly sales of fluoroquinolones for *Gallus gallus* have been below or much below 1.5 kg and in 2011 there were no sales of this class. Cephalosporins are never used.

From 2011, the Swedish poultry meat association requests all treatments of broilers, parents and grandparents to be reported as part of the Poultry health control programme. According to the reports, a total of six of 3 185 broiler flocks (0.2%) were treated with antimicrobials because of outbreaks

of botulism. In two flocks, amoxicillin was used and in four tylosin. In addition to this, one flock each of grandparent (penicillin V) and parent (amoxicillin) birds were treated. These figures are well in line with the sales statistics, keeping in mind that all the quantity sold will not be used.

Coccidiostats of the ionophore group are used as feed additives to control coccidiosis in the production of chickens for slaughter and for turkeys. Since the late 80s, narasin is by far the most widely applied substance for broilers.

Horses

Around 60% of the sales of trimethoprim-sulphonamides are products for oral use in horses (paste or powder). The sales of such products increased steadily until 2006 but since, there has been a decrease by 27%. Over the same time period, the total number of horses has increased but the number of mares covered has decreased by 31% (Anonymous 2012). Among the indications for trimethoprim-sulphonamides in horses are reproductive disorders and various conditions in foals. Thus, it is probable that the decrease in sales of trimethoprim-sulphonamides is explained by the lower number of mares covered and a lower number of foals born.

The sales of other antimicrobials for horses is difficult to estimate, as they are frequently administered by the veterinarian in connection with an examination, either in ambulatory practice or in clinics or hospitals.

Dogs

In 2006, the total sales of antimicrobials for oral use in dogs corresponded to 562 packages per 1000 dogs. Since, the sales expressed as total number of packages has decreased by 32%. The dataset includes products authorised for oral use in animals (ATC vet code QJ01 and QA07) as well as for humans (ATC code J01) and corresponds to out-patient use for dogs. The most recent estimate of the dog population in Sweden is from 2006, but there are no indications that the number of animals has decreased.

In figures AC III, the sales of the major classes of antimicrobials are shown. The most prominent changes relative to 2006 is noted for cephalosporins (-62%), aminopenicillins with clavulanic acid (-44%), and fluorquinolones (-40%). Figures on sales of antimicrobials for dogs expressed as kg active substance have only been calculated for the products authorised for use in animals. The sales of that subset represent around 95% of the total sales for dogs. The total sales of veterinary antimicrobials for oral use in dogs was 1 182 kg in 2011 which is 9% of the total sales of veterinary antimicrobials.

As described in SVARM 2008, the emergence of infections with multiresistant methicillin resistant *Staphylococcus pseudintermedius* and methicillin resistant *S. aureus* triggered a number of national and local initiatives. This has most likely led to changes in prescribers' behaviour, which in turn explains the downward trends in sales of antimicrobials for dogs.

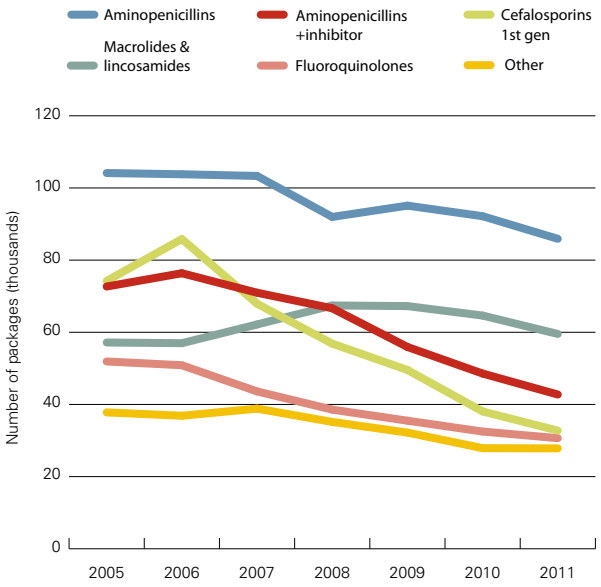
Farmed fish

The occurrence of bacterial disease in farmed fish is influenced by water temperatures in summer and the amounts prescribed may therefore vary between years. In 2011, a total of 49 kg was prescribed for in feed medication corresponding to 4 g per ton fish produced. The average annual sales 2002-2010 was 26 kg. Almost all treatments were for flavobacteriosis, and florfenicol was the most commonly used substance (42 kg). In addition, 6 kg of oxitetracycline and 1 kg of oxolinic acid were prescribed. Previously, furunculosis and cold water vibriosis were more common but today effective vaccination strategies are widely applied.

TABLE AC IV. Sales of antimicrobial drugs per category of animals in 2009-2011 given as percent of total sales in kg active substance[1].

Antimicrobial	Companion animals			Food producing animals, horses, other or unknown		
	2009	2010	2011	2009	2010	2011
Tetracyclines	8.4	9.3	7.2	91.6	90.7	92.8
Penicillin G & V	4.4	1.1	2.7	95.6	98.9	97.3
Aminopenicillins	63.3	69.7	75.6	36.7	30.3	24.4
Cephalosporins	97.2	96.6	97.2	2.8	3.4	2.8
Aminoglycosides & polymyxins	16.4	5.7	5.0	83.6	94.3	95.0
Sulphonamides	12.7	2.5	10.9	87.3	97.5	89.1
Trimethoprim	3.6	2.6	2.3	96.4	97.4	97.7
Macrolides & lincosamides	23.1	34.3	39.0	76.9	65.7	61.0
Fluoroquinolones	30.2	26.5	30.4	69.8	73.5	69.6
Pleuromutilins	0.3	0.0	0.2	99.7	100.0	99.8

[1]Data are from the Swedish Board of Agriculture's report on usage of veterinary medicines (www.jordbruksverket.se; in Swedish), includes antimicrobials authorized for animals and for humans sold for use in animals.



FIGUE AC III. Sales of antimicrobials for oral use in dogs (QJ01, QA07 and J01) expressed as number of packages (thousands).

Trends in sales of antimicrobials for pigs in Sweden

IN SWEDEN, veterinary medicinal products must be dispensed by pharmacies. All pharmacies deliver data on sales of veterinary medicinal products, including target animal species as given on the prescription, to a government owned company (Apotekens Service). In almost all commercial pig production herds, the owner has a contract with one veterinarian. In such circumstances, the veterinarian is allowed to delegate treatments of specified indications to the animal caretaker. This system is widely applied, and almost all antimicrobials for treatment of individual animals on pig farms are acquired by veterinary prescription from the pharmacies. Antimicrobials may also be mixed in feed or water, and in such cases the prescription will be handled by the pharmacy.

To study trends in sales of antimicrobials for pigs, the sales of antimicrobial products (ATCvet codes QJ01 and QA07AB) with pig specified on the prescriptions for the years 2006-2010 were extracted. In addition, all sales for unknown species of products authorized for pigs and formulated for in feed or water medication were included. Year 2011 was excluded because the figures for some antimicrobial classes are somewhat incomplete with regard to products sold with special license. To correct for changes in animal numbers, data were expressed as mg active substance per population correction unit (PCU) of pigs (an estimate of kg live weight of slaughter pigs and sows) (EMA 2011).

The sales expressed as kg active substance in 2006 and the change (%) from 2006 to 2010 are given in Table and in Figure the sales expressed as mg active substance/PCU are shown. Irrespective of unit of measurement, the sales of products for use in individual pigs, mainly injectables, increased when measured during the study period. In particular, use of benzylpenicillin increased. The sales of tetracyclines, macrolides and pleuromutilins for medication of groups of pigs decreased. A shift from medication of groups of animals via feed or water towards medication of individual clinically diseased animals, preferably with narrow spectrum antibiotics such as penicillin, is well in line with the rational and prudent use of antimicrobials.

TABLE. Sales of antimicrobials for individual and group medication of pigs in 2006 (kg active substance) and change 2006 to 2010 (%)

Antimicrobial class	Individual medication, 2006	Change (%)	Group medication, 2006	Change (%)
Tetracyclines	54.7	13%	796.3	-39%
Penicillin G	1004.6	31%		
Aminopenicillins	88.8	0%	0.0	[a]
Aminoglycosides, polymyxins	102.9	-3%	170.4	-44%
Trimethoprim & sulphonamides	415.8	17%		
Macrolides	134.5	-39%	764.0	-51%
Fluoroquinolones	20.6	-17%		
Pleuromutilins	34.5	-53%	419.5	-63%
Total	*1856.3*	*17%*	*2150.1*	*-45%*

[a]Aminopenicillins for group medication were not used in 2006, but have been sold with special license from 2008.

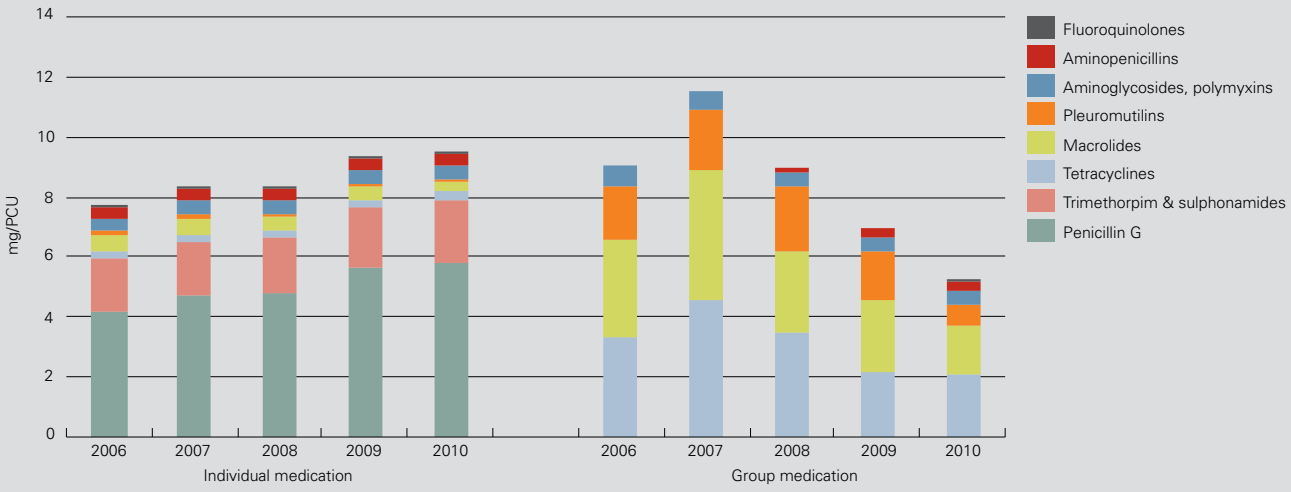


Figure. Sales of antimicrobials for individual and group medication of pigs expressed as mg/PCU.

Zoonotic bacteria

ZOONOSES ARE DISEASES and infections that can be naturally transmitted between animals and man. Antimicrobial resistance in zoonotic bacteria such as *Salmonella*, *Campylobacter* and methicillin resistant *Staphylococcus aureus* (MRSA) from animals is therefore of direct public health concern. Data regarding these bacteria from Swedish animals are presented here. More information on infections with zoonotic bacteria in Sweden is presented in the yearly report *Surveillance of zoonotic and other animal disease agents in Sweden*, available at www.sva.se.

Salmonella

Isolates included

Findings of *Salmonella* in animals are notifiable in Sweden and antimicrobial susceptibility is tested in one isolate from each warm-blooded animal species (wild and domesticated) involved in an incident. In incidents involving more than one serovar or phage type, one isolate of each serovar and phage type is tested. In SVARM 2011, isolates from incidents notified in 2011 are included but also isolates from incidents previously notified but still under restrictions. In addition, isolates obtained in the salmonella surveillance programme from samples collected at slaughter are included. For details on methodology see Appendix 3.

Results and comments

The overall situation regarding *Salmonella* among Swedish animals is favourable. Occurrence of *Salmonella* among food-producing animals is low and few incidents involve multiresistant strains.

All animals 2011

Altogether, 71 isolates were tested of which 42 were *S.* Typhimurium and six were of the monophasic serovars O 4,5:i:- or O 4:i:- (Table Salm I). The majority of isolates (72%) were susceptible to all antimicrobials tested but 20 isolates were resistant to at least one substance and seven isolates (10%) were resistant to three or more substances (Table Salm II).

The 20 resistant isolates were from 19 separate incidents of which 11 involved food-producing animals (Table Salm II). Of the eight incidents in cattle, four were notified already in 2010 but still under restrictions in 2011. Only one incident involved *S.* Typhimurium DT 104 with the common resistance phenotype: ampicillin, chloramphenicol, streptomycin, sulphonamide, and tetracycline.

Food-producing animals 2000-2011

From a public health perspective resistance in *Salmonella* from food-producing animals is of greater concern than resistance in isolates from wild animals or pets. In the period 2000-2011 isolates from the vast majority of notified incidents in food-producing animals were tested in SVARM, in total 541 isolates. Of these, 255 isolates (47%) were *S.* Typhimurium. Most isolates (40%) were from pigs, 29% were from cattle, 28% from poultry and 2% from sheep.

Distributions of MICs and occurrence of resistance among the isolates of *S.* Typhimurium are given in Table Salm VI. Fifty-nine (23%) isolates of *S.* Typhimurium were resistant to at least one antimicrobial and 19 isolates (7%) to three or more antimicrobial classes, i.e. they were multiresistant (Table Salm VII). Among serovars other than Typhimurium from food-producing animals, 11 isolates (4%) were multiresistant.

The 19 multiresistant isolates of *S.* Typhimurium were from 17 separate incidents of which 11 involved only cattle, three involved pigs and one incident involved both pigs and cattle. Of the remaining incidents one was in sheep and one in ducks in a hobby flock. Three incidents in 2004 involving cattle were epidemiologically linked through trade of calves. An epidemiological link is also suspected between four incidents 2007-2008 involving cattle, pigs and sheep. Links between the other incidents are unknown.

Monophasic *Salmonella*

Twelve incidents involving monophasic *Salmonella* subspecies I (O 4,5,12:i-/O 4,5:i:-/O 4:i:-) have been discovered since this type was first confirmed in Swedish animals in 2006. Five incidents involved cattle, three incidents pigs, one incident ducks, and one incident involved both cattle and poultry. Monophasic *Salmonella* has also been isolated from a dog and a wild bird. Epidemiological links between some of the incidents have been confirmed.

In eight incidents, isolates were resistant to ampicillin, streptomycin, sulphonamide and tetracycline but in one incident also isolates resistant only to tetracycline were found. In two incidents in pigs the isolates were resistant to streptomycin and sulphonamides. Finally, in one incident where *Salmonella* was isolated only from cattle carcasses sampled at slaughter and in one incident in a wild bird the isolates were susceptible to all antimicrobials tested.

TABLE SALM I. Number of *Salmonella enterica* tested for antimicrobial susceptibility, 2011.

Serovar	Cattle	Bison	Pigs	Sheep	Poultry	Ostriches	Horses	Dogs	Cats	Wild birds	Wild mammals	Total
S. Agona	1											1
S. Be					1							1
S. Brandenburg								1				1
S. Derby			1					1				2
S. Dublin	5											5
S. Enteritidis					1							1
S. Infantis			1									1
S. Mbandaka					1							1
S. Reading	2											2
S. Typhimurium, DT 104			1									1
S. Typhimurium, DT 110b						1						1
S. Typhimurium, DT 120	1		3									4
S. Typhimurium, DT 146	1											1
S. Typhimurium, DT 195			1									1
S. Typhimurium, DT 40									1			1
S. Typhimurium, DT 41	2											2
S. Typhimurium, NST										1		1
S. Typhimurium, NST 1:3	4	1			2		1					8
S. Typhimurium, NST 1:7									4			4
S. Typhimurium, NST 11:58	1						2					3
S. Typhimurium, NST 11:7 U277									1			1
S. Typhimurium, NST 6:1			1									1
S. Typhimurium, not phage typed	1							1	8	2	1	13
S. enterica, subsp. diarizonae (IIIb)	1			2								3
S. enterica (I), O -:r:1,5			1									1
S. enterica (I), O 4,5:-:1,5										1		1
S. enterica (I), O 4,5:i:-	3							1				4
S. enterica (I), O 4:i:-			1							1		2
S. enterica (I), O 4,5:-:5							1					1
S. enterica (I), O 6,7:d:-	2											2
Total	**24**	**1**	**10**	**2**	**5**	**1**	**4**	**4**	**14**	**5**	**1**	**71**
Percent of total	34%	1%	14%	3%	7%	1%	6%	6%	20%	7%	1%	

TABLE SALM II. MICs (mg/L) of *Salmonella enterica* resistant to at least one antimicrobial, 2011. Shaded fields indicate resistance.

Animal species	Serovar	Am	Ctx	Cm	Ff	Gm	Km	Ci	Nal	Sm	Su	Tc	Tm
Pig	S. Typhimurium DT 104	>64	0.25	256	32	1	4	0.06	4	128	>1024	32	≤0.25
Cattle	S. Typhimurium DT 120	>64	≤0.06	4	4	0.5	2	0.03	8	256	>1024	1	≤0.25
Dog	S. Typhimurium, not phage typed	>64	0.12	4	4	1	2	0.06	4	>256	>1024	2	≤0.25
Cattle	S. Typhimurium NST 11:58	1	≤0.06	4	4	1	2	0.03	4	16	>1024	2	>32
Horse	S. Typhimurium NST 11:58	1	≤0.06	4	4	1	4	0.03	4	16	1024	2	>32
Horse	S. Typhimurium NST 11:58	1	0.12	4	4	1	4	0.03	4	16	>1024	2	>32
Cattle	S. Typhimurium DT 146	1	0.12	4	4	1	2	0.03	4	16	>1024	2	>32
Cat	S. Typhimurium NST 1:7	1	0.12	4	≤2	0.5	2	0.03	4	32	64	2	0.5
Cattle	S. Typhimurium NST 1:3	1	≤0.06	≤2	≤2	0.5	2	0.03	4	32	64	1	≤0.25
Cat	S. Typhimurium, not phage typed	1	0.12	4	4	0.5	2	0.06	4	32	128	2	0.5
Cat	S. Typhimurium, not phage typed	1	≤0.06	4	4	0.5	4	0.06	4	32	128	2	0.5
Cattle	S. Typhimurium, not phage typed	1	0.12	4	4	2	2	0.06	4	>256	>1024	>64	≤0.25
Dog	S. enterica (I) O 4,5:i:-	>64	0.12	4	4	1	2	0.06	4	256	>1024	>64	≤0.25
Cattle	S. enterica (I) O 4,5:i:-	>64	0.12	4	4	1	2	0.06	8	256	>1024	>64	≤0.25
Cattle	S. enterica (I) O 4,5:i:-	1	≤0.06	4	4	0.5	4	0.06	4	8	128	>64	≤0.25
Pig	S. enterica (I) O 4:i:-	1	≤0.06	4	4	1	2	0.03	4	128	>1024	2	≤0.25
Pig	S. enterica (I) O -:r:1,5	1	0.25	8	8	1	4	0.25	256	16	128	2	0.5
Pig	S. Infantis	1	0.12	4	4	1	4	0.25	256	16	32	2	≤0.25
Cattle	S. Dublin	≤0.5	≤0.06	≤2	4	0.5	2	0.03	8	32	64	1	0.5
Dog	S. Derby	1	0.12	4	8	1	4	0.06	4	>256	1024	64	>32

TABLE SALM III. Distribution of MICs and resistance (%) in *Salmonella enterica* (n=71) from all animals, 2011.

Antimicrobial	Resistance %	Distribution (%) of MICs (mg/L)																		
		≤0.008	0.016	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	>1024
Ampicillin	7							11.3	81.7							7.0				
Cefotaxime	0				43.7	52.1	4.2													
Chloramphenicol	1									18.3	71.8	8.5					1.4			
Ciprofloxacin	3		2.8	56.3	38.0		2.8													
Florfenicol	1									22.5	64.8	11.3		1.4						
Gentamicin	0						1.4	49.3	46.5	2.8										
Kanamycin	0								4.2	63.4	32.4									
Nalidixic acid	3									2.8	84.5	9.9					2.8			
Streptomycin	18									2.8	2.8	14.1	62.0	7.0		2.8	4.2	4.2		
Sulphonamide	17													5.6	38.0	36.6	2.8		2.8	14.1
Tetracycline	8								28.2	63.4				1.4	1.4	5.6				
Trimethoprim	7						54.9	35.2	2.8						7.0					

TABLE SALM IV. Distribution of MICs and resistance (%) in *Salmonella* Typhimurium (n=42) from all animals, 2011.

Antimicrobial	Resistance %	Distribution (%) of MICs (mg/L)																		
		≤0.008	0.016	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	>1024
Ampicillin	7							7.1	85.7							7.1				
Cefotaxime	0				40.5	57.1	2.4													
Chloramphenicol	2									14.3	78.6	4.8					2.4			
Ciprofloxacin	0			61.9	38.1															
Florfenicol	2									26.2	66.7	4.8		2.4						
Gentamicin	0							47.6	47.6	4.8										
Kanamycin	0								2.4	57.1	40.5									
Nalidixic acid	0									2.4	88.1	9.5								
Streptomycin	19											9.5	71.4	9.5		2.4	2.4	4.8		
Sulphonamide	19														31.0	45.2	4.8		2.4	16.7
Tetracycline	5								26.2	69.0				2.4		2.4				
Trimethoprim	10						50.0	38.1	2.4						9.5					

TABLE SALM V. Resistance (%) and source of isolates for *Salmonella* Typhimurium from all animals, 1978-2011.

Antimicrobial	Cut-off value (mg/L)	Resistance (%)								
		1978-88[a] (n=125)	1989-99 (n=317)	2000–05 (n=291)	2006 (n=52)	2007 (n=71)	2008 (n=63)	2009 (n=67)	2010 (n=43)	2011 (n=42)
Ampicillin	>8	2	6	5	15	7	11	3	2	7
Cefotaxime	>0.5	-	-	0	0	0	0	0	0	0
Ceftiofur	>2	-	-	0	0	-	-	-	-	-
Chloramphenicol	>16	4[b]	5[b]	5	2	1	8	3	0	2
Ciprofloxacin	>0.06	-	-	0	0	0	3	1	0	0
Enrofloxacin	>0.25	-	1	<1	-	-	-	-	-	-
Florfenicol	>16	-	-	3	2	1	8	3	0	2
Gentamicin	>2	-	0[b]	2	0	0	0	0	0	0
Kanamycin	>16	-	-	0	0	0	0	0	0	0
Nalidixic acid	>16	-	-	2	0	0	2	1	0	0
Neomycin	>4	0[b]	1[b]	1	-	-	-	-	-	-
Streptomycin	>16	74	15	25	13	3	29	7	5	19
Sulphonamide	>256	-	-	5	13	6	11	7	9	19
Tetracycline	>8	13	6	5	10	3	10	3	5	5
Trimethoprim	>2	-	-	<1	0	0	0	4	5	10
Trim-sulpha	>0.5/9.5	0	3	5	-	-	-	-	-	-
Percent of isolates from:										
Cattle, sheep, pigs, poultry		100	46	30	40	53	70	49	70	47
Horses, cats, dogs			29	54	36	17	16	31	23	43
Wildlife			25	16	24	30	14	19	7	10

[a] 1988 includes isolates to September, isolates from October-December 1988 given under 1989; [b] Cut-off value for resistance >8 mg/L.

TABLE SALM VI. Distribution of MICs and resistance (%) in *Salmonella* Typhimurium (n=255) from food-producing animals, 2000-2011.

Antimicrobial	Resistance %	Distribution (%) of MICs (mg/L)																		
		≤0.008	0.016	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	>1024
Ampicillin	9							4.3	71.4	14.1	1.2				9.0					
Cefotaxime[a]	0				31.6	62.0	6.4													
Ceftiofur[b]	0							29.0	68.0	3.0										
Chloramphenicol	5									12.5	78.8	3.5				0.8	4.3			
Ciprofloxacin[c]	<1			62.6	36.8			0.6												
Enrofloxacin[d]	0				54.3	42.0	3.7													
Florfenicol	5										91.8	3.1	0.4	4.7						
Gentamicin	2							17.3	71.4	9.8	1.6									
Kanamycin[c]	0									31.1	65.5	2.9	0.6							
Nalidixic acid	<1									1.6	78.0	14.9	4.7	0.4			0.4			
Streptomycin	20										0.4	17.6	62.4	11.4	2.4	2.4	2.4	1.2		
Sulphonamide	10														51.8	31.8	6.3			10.2
Tetracycline	7								37.3	50.6	5.1		1.6	1.2	2.0	2.4				
Trimethoprim	<1						42.0	51.4	5.9						0.8					

[a] 187 isolates tested; [b] 100 isolates tested; [c] 174 isolates tested; [d] 81 isolates tested.

TABLE SALM VII. Resistance phenotypes of *Salmonella* Typhimurium (n=255) from incidents in food-producing animals, 2000-2011. All isolates were tested for susceptibility to ampicillin, ceftiofur/cefotaxime, enrofloxacin/ciprofloxacin, florfenicol, gentamicin, chloramphenicol, nalidixic acid, streptomycin, sulphametoxazole, tetracycline, and trimethoprim.

Resistance phenotype	Animal species	Phage type																					
		1	7	9	10	12	15A	39	40	41	99	104	110b	120	125	126	146	193	195	U277	NT	NST	Not typed	Total
AmFfCmNalSmSuTcCi	Pigs											1											1
AmFfCmSmSuTc	Cattle											5		1								1	7
AmFfCmSmSuTc	Pigs											2										1	3
AmFfCmSmSuTc	Sheep											1											1
AmCmSmSuTc	Cattle											1											1
AmSmSuTc	Cattle													1							2		3
AmSmSuTc	Poultry																				1		1
AmSmSu	Cattle													1									1
SmSuTc	Cattle																					1	1
AmSu	Cattle											2											2
AmSu	Pigs											1											1
GmSm	Cattle									1													1
GmSm	Pigs								1														1
GmSm	Poultry									1													1
SmSu	Poultry						2																2
SuTm	Cattle																1					1	2
Am	Poultry																				2		2
Gm	Poultry																				1		1
Nal	Pigs					1																	1
Sm	Cattle											1		1		1					4		7
Sm	Pigs								4	3		1		1							1	4	1	15
Sm	Poultry									1												3		4
Susceptible	Cattle	4			2		1	1	1	6				5	1	1					1	21	6	50
Susceptible	Pigs	1	1			2			33	5	1	1		8					1	1	2	17	8	81
Susceptible	Sheep	1																					3	4
Susceptible	Poultry	1		1		1			4	1			1	2				1	1	1	4	41	2	61
Number of isolates		**7**	**1**	**1**	**2**	**4**	**3**	**1**	**43**	**18**	**1**	**16**	**1**	**20**	**1**	**2**	**1**	**1**	**2**	**2**	**11**	**95**	**22**	**255**
percent of total		2	<1	<1	<1	2	1	<1	17	7	<1	6	<1	8	<1	<1	<1	<1	<1	<1	4	37	9	

Campylobacter

Isolates included

Campylobacter were isolated from samples of colon content from slaughter pigs collected at abattoirs for isolation of indicator bacteria. Isolates were identified as *Campylobacter jejuni* or *Campylobacter coli* by PCR (Denis et al., 1999). For details on methodology and sampling strategy, see Appendix 3.

Results and comments

Campylobacter were isolated from 85 (72%) of 118 samples cultured. The majority of isolates, 83, were *C. coli* and only two were *C. jejuni*. The isolation frequency is similar to previous studies in SVARM.

There was no resistance recorded against erythromycin, gentamicin or tetracycline (Table Camp). Resistance to ciprofloxacin, nalidixic acid, or streptomycin was common and occurred in 37, 37 and 61% of the isolates respectively. Most isolates were resistant only to a single group of antimicrobials but 21 isolates were resistant to both quinolones and streptomycin. The two isolates of *C. jejuni* were susceptible to all antimicrobials tested.

A tendency of increasing resistance to quinolones (ciprofloxacin and nalidixic acid) was recorded (Table Camp). Neither quinolones nor fluoroquinolones are authorised or used for treatment of groups of pigs via feed or water in Sweden. Over the last five years, the yearly sales of injectable fluoroquinolones for pigs were 20 kg or less, corresponding to 4-7 mg/slaughtered pig. Fluoroquinolones are probably mostly used in piglets and sows and to a lesser extent in fattening pigs older than 12 weeks. Selection for quinolone resistance in *Campylobacter* therefore probably occurs in younger pigs and/or sows before pigs are moved to the finishing stage. The high prevalence (39%) of quinolone resistance in *Campylobacter* spp. from piglets <12 weeks old reported in SVARM 2006 supports this hypothesis.

Occurrence of streptomycin resistance in *C. coli* is remarkably high (61%) but since only data from two years for Swedish isolates are available trends in resistance cannot be evaluated. A high prevalence of streptomycin resistance in *C. coli* from pigs and cattle is reported also from other countries (EFSA, 2007).

Streptomycin resistance in *Campylobacter* spp. from Swedish pigs is difficult to explain in the context of selection by use since streptomycin is rarely used in pigs in recent years. Neither is co-selection by use of other substance likely since 59% of the streptomycin resistant isolates were resistant only to this antimicrobial. However, similar *aadA2* encoding class 1 integrons, encoding streptomycin/spectinomycin resistance, have been identified in *Campylobacter*, *Escherichia coli* and *Salmonella* (O'Halloran et al., 2004). Accordingly, streptomycin resistance could be a marker for the presence of a transferable resistance element and the issue deserves further study.

TABLE CAMP. Distribution of MICs and resistance (%) in *Campylobacter coli* from slaughter pigs 2011. Data on resistance for 1999, 2003, 2005 and 2008 are given for comparison.

Substance	1999 (n= 91)	2003 (n=100)	2005 (n=97)	2008 (n=97)	2011 (n=83)	Distribution (%) of MICs (mg/L)											
						≤0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	>64
Ciprofloxacin	30[a]	17[a]	24[a]	30	37	18.1	28.9	14.5	1.2				20.5	16.9			
Erythromycin	1	0	0	1	0				26.5	37.3	32.5	3.6					
Gentamicin	0	-	0	0	0				12.0	83.1	4.8						
Nalidixic acid	30	17	24	29	37					1.2		7.2	31.3	19.3	3.6		37.3
Streptomycin	-	-	-	57	61					1.2	7.2	30.1	3.6		2.4	32.5	22.9
Tetracycline	4	3	4	2	0		14.5	43.4	37.3	4.8							

[a] Enrofloxacin tested.

Methicillin resistant *Staphylococcus aureus* (MRSA)

Isolates included

In Sweden, MRSA in animals was first verified in 2006 and was made notifiable in 2008. During 2011, MRSA was isolated from infection sites in two horses and one cat. Up to and including 2011 a total of 45 cases in animals have been confirmed at SVA (Table MRSA).

Most cases are detected in passive surveillance when animals with clinical infections are sampled and isolates of *S. aureus* with resistance to oxacillin are further analysed with confirmatory tests. Samples from animals with suspected MRSA infection or colonisation are selectively enriched in order to increase the sensitivity. Screening studies for active surveillance of MRSA have been performed with selective methods in pigs and horses and without selective methods in dogs and dairy cattle in different years.

Results and comments

Dogs and cats

During 2011, MRSA was isolated from one cat with skin infection. Altogether, MRSA has been confirmed in 18 dogs and 5 cats in Sweden since 2006, when the first detection in animals was made. Most isolates are from wound infections, mainly post operative wounds. Eighteen of the isolates were of *spa*-type t032, two of t002, one of t127, one of t020 and one of t022. All isolates were negative for the PVL-gene (coding for Panton Valentine Leukocidin toxin).

Horses

During 2011, two horses were diagnosed with MRSA-infections. Altogether, MRSA has been isolated from 17 horses in Sweden. Most isolates are from clinical cases with post operative wound infections. Screening studies have been performed twice in horses in Sweden. In a study in 2007, MRSA was found in one sample and in a study in 2010, no MRSA was found.

Most cases of clinical MRSA-infections were horses with post operative wound infections connected to two equine hospitals. One contact horse outside the hospitals was revealed as carrier without signs of infection. Of the horses identified in 2011, one had a skin infection and had no known contact with any of the equine hospitals. The isolate from that horse had a susceptibility pattern different from all the other horse isolates. Fifteen of the isolates were of *spa*-type t011, belonging to the livestock-associated MRSA clonal complex (CC)398, and two of *spa*-type t064. All isolates were PVL-negative.

Cattle

During 2011, MRSA was confirmed from four milk samples from dairy cows. This was the first detection of MRSA in cattle in Sweden. The isolates had the divergent *mecA* homologue, $mecA_{LGA251}$, reported in MRSA from bovine milk samples and humans (Garcia-Alvares et al. 2011). Isolates with this novel *mecA* gene will most likely be suspected as methicillin resistant by susceptibility testing, but, since $mecA_{LGA251}$ is only 70% identical at the DNA level to *mecA*, they will not be confirmed as MRSA with conventional confirmatory methods.

Screening studies for MRSA in milk from Swedish dairy cattle have been performed in 2001, 2002-2003, 2005, 2008-2009 and 2010-2011. During 2010-2011, 311 isolates of beta-lactamase producing *S. aureus* isolated from milk samples were investigated for methicillin resistance. In none of these studies was MRSA originally detected. However, with the knowledge of the novel *mecA* gene available, isolates with increased MIC values for oxacillin were examined with a new confirmatory method during the autumn of 2011. This led to the identification of the four MRSA isolates with $mecA_{LGA251}$ originating from three milk samples taken in 2010 and one in 2011. The isolates belonged to *spa*-type t524, ST130 and *spa*-type t9111, ST425 and were PVL-negative.

Pigs

Screening studies for MRSA in pigs have been performed four times in Sweden. During 2006-2007, fattening pigs were screened by culture of nasal swabs. None of the samples were positive. In 2008, a baseline study was performed in the European Union. Holdings with breeding pigs were screened for MRSA by culture of dust using harmonized methodology. Overall, MRSA was confirmed in 27% of the holdings in the EU, but from none of the 208 Swedish holdings sampled.

MRSA was isolated from pigs in Sweden for the first time in the summer of 2010, when fattening pigs were sampled by nasal swabs at slaughter. One out of 191 samples was positive in this screening study. The isolate belonged to *spa*-type t011 and CC398 and was PVL-negative.

In 2011, 53 nucleus and multiplying herds, which constitutes the top of the Swedish breeding pyramid, were sampled. Weaned pigs 5-12 weeks old from each herd (6 pigs per pen from 15 pens) were sampled by rubbing the skin behind one ear with a sterile compress. MRSA was not detected in any of the samples. The results from the screening studies indicate that Sweden has a favourable situation concerning MRSA in the pig population.

Public health aspects

Zoonotic transmission of MRSA occurs by direct or indirect contacts, making farmers, animal owners, veterinarians and other persons in close contact with animals the population at risk. Reported cases of MRSA in animals are still few in Sweden but the situation may easily change. Sweden is still a country with a comparatively low prevalence of human MRSA infection (SWEDRES 2011) and therefore measures should be taken to prevent a situation where animals constitute a reservoir for MRSA spreading to humans and into human healthcare.

MRSA in food-producing animals is reported globally, mostly in pigs but the prevalence is high also among veal calves and broilers and MRSA also occurs among dairy cows. The livestock-associated MRSA CC398 dominates and can be a major contributor to the overall human MRSA burden in countries with a low prevalence of human MRSA infections but is of less significance in countries where human infections are more common (EFSA, 2009).

In Sweden, PVL-negative MRSA of *spa*-types correlating to CC398 (i.e. t011, t108, t034 and t571) was documented in 31 humans in 2006-2011, of which 9 cases were from 2011 (SWEDRES 2011). In total, ten of the isolates were of *spa*-type t011 which is the dominating type among MRSA from pigs in Europe but also the most common *spa*-type among isolates from Swedish horses. MRSA with $mecA_{LGA251}$ from humans and dairy cows was reported internationally in 2011. This variant of MRSA was detected in 15 human cases in 2011 and in milk samples from four dairy cows. Three of the cows were sampled in 2010 and one cow in 2011. *Spa*-type t9111 was found in two of the human cases and in one of the samples from cows.

MRSA isolated from dogs and cats often belong to the same *spa*-types as in humans, supporting the view that humans often are a source of MRSA in small companion animals (EFSA 2009, CVMP, 2009). Most *spa*-types found in Swedish dogs and cats are common among MRSA from humans in Sweden. *Spa*-type t032 is by far the most common type among Swedish dogs and cats and it was present among the ten most common *spa*-types in humans 2007-2010 (SWEDRES 2011). *Spa*-types t032 and t002 were the most common types among human isolates of MRSA in 2007 and 2008, respectively.

The spread of MRSA among animals and between animals and man could be prevented by improved biosecurity and infection control. Basic hygiene measures such as hand washing and disinfection is of key importance. Continuous communication of relevant information and recommendations on practical measures are important strategies against MRSA.

TABLE MRSA. MICs of methicillin resistant *Staphylococcus aureus* from Swedish animals up to and including 2011. All isolates were positive for the *mecA* or *mecA*$_{LGA251}$ and *nuc* genes by molecular methods. Shaded areas indicate MIC above EUCAST cut-off values for the wild-type population.

Animal species	Year	Clinical background	Antimicrobial													Spa-type
			Ox[a]	Fox	Pc	Ct	Cl	Em	Tc	Fu	Gm	Km	Ci	Tp	Cm	
Dog	2006	post-op wound	>16	>16	>4	8	≤0.25	0.5	≤0.5	0.5	≤0.5	2	>4	1	8	t032
Dog	2006	post-op wound	>16	>16	>4	8	≤0.25	0.5	≤0.5	0.5	≤0.5	2	>4	1	8	t032
Dog	2006	post-op wound	>16	8	>4	>8	≤0.25	0.5	≤0.5	0.25	1	4	>4	2	8	t032
Dog	2007	post-op wound	>16	>16	>4	>8	≤0.25	0.5	≤0.5	0.5	≤0.5	4	>4	2	8	t032
Dog	2007	abscess	>16	>16	>4	>8	≤0.25	0.5	≤0.5	0.5	≤0.5	2	>4	1	8	t032
Dog	2007	post-op wound	>16	>16	>4	>8	0.5	0.5	2	-	1	2	>4	2	4	t032
Dog	2007	post-op wound	>16	16	>4	8	≤0.25	0.5	≤0.5	0.25	≤0.5	2	>4	1	8	t032
Dog	2007	unknown	>16	16	>4	>8	≤0.25	0.5	≤0.5	0.25	≤0.5	4	>4	2	8	t032
Dog	2008	wound	>16	>16	>4	>8	≤0.25	1	≤0.5	0.25	1	2	>4	2	8	t032
Dog	2008	unknown	>16	>16	>4	>8	≤0.25	≤0.25	≤0.5	0.5	1	2	>4	1	8	t032
Dog	2008	unknown	>16	>16	>4	>8	≤0.25	1	≤0.5	0.25	1	2	>4	2	8	t032
Dog	2008	unknown	>16	>16	>4	>8	0.5	>32	≤0.5	0.5	32	>32	>4	>32	16	t127
Dog	2009	post-op wound	8	>16	>4	>8	≤0.25	0.5	≤0.5	0.25	≤0.5	2	>4	2	8	t032
Dog	2009	wound	>16	>16	>4	>8	0.5	1	1	0.5	1	4	>4	4	16	t032
Dog	2010	wound	>16	>16	>4	>8	>32	>32	≤0.5	0.5	1	>32	>4	2	16	t002
Dog	2010	ear	8		>4	>8	≤0.25	0.5	≤0.5	0.5	≤0.5	2	>4	1	8	t032
Dog	2010	unknown	>16	16	>4	8	≤0.25	>32	≤0.5	0.5	≤0.5	2	>4	8	4	t020
Dog	2010	skin	16	16	>4	1	≤0.25	≤0.25	≤0.5	8	1	2	0.5	2	8	t002
Cat	2009	urine	>16	>16	>4	>8	≤0.25	0.5	≤0.5	0.25	≤0.5	0.5	>4	4	4	t032
Cat	2009	unknown	>16	>16	>4	>8	≤0.25	0.5	≤0.5	0.5	1	1	>4	2	8	t032
Cat	2010	ear	>16		>4	>8	≤0.25	0.5	≤0.5	1	≤0.5	2	>4	1	8	t032
Cat	2010	nose	>16	16	>4	>8	≤0.25	≤0.25	≤0.5	0.25	≤0.5	1	>4	1	8	t032
Cat	2011	skin infection	>16	>16	>4	>8	≤0.25	≤0.25	≤0.5	0.25	≤0.5	2	>4	1	8	t022
Horse	2007	screening	>16		>4	1	≤0.25	0.5	64	0.5	>64	>32	1	>32	8	t011
Horse	2008	post-op wound	>16	>16	>4	1	≤0.25	0.5	32	0.5	64	>32	1	>32	8	t011
Horse	2008	post-op wound	>16	>16	>4	2	≤0.25	1	32	1	>64	>32	1	>32	8	t011
Horse	2008	post-op wound	16	>16	>4	2	≤0.25	1	32	0.5	>64	>32	0.5	>32	8	t011
Horse	2008	post-op wound	>16	>16	>4	2	≤0.25	0.5	32	0.25	>64	>32	0.5	>32	8	t011
Horse	2008	screening	>16	16	>4	2	≤0.25	1	32	0.5	64	>32	0.5	>32	8	t011
Horse	2008	post-op wound	>16	8	>4	2	≤0.25	1	64	1	>64	>32	1	>32	16	t011
Horse	2008	post-op wound	2	>16	4	4	≤0.25	≤0.25	32	0.12	4	32	0.25	>32	4	t011
Horse	2009	wound	16	>16	>4	>8	≤0.25	0.5	64	0.25	16	>32	0.25	>32	8	t011
Horse	2009	post-op wound	16	>16	4	1	≤0.25	0.5	32	0.25	64	>32	1	>32	8	t011
Horse	2010	post-op wound	>16	>16	>4	8	0.5	2	64	1	>64	>32	1	>32	16	t011
Horse	2010	post-op wound	>16	>16	>4	4	≤0.25	1	32	0.5	>64	>32	0.5	>32	8	t064
Horse	2010	post-op wound	>16	>16	>4	8	≤0.25	0.5	64	0.25	64	>32	0.25	>32	8	t011
Horse	2010	wound	>16	>16	>4	4	≤0.25	0.5	32	0.5	>64	>32	0.25	>32	8	t011
Horse	2010	post-op wound	>16	>16	>4	2	≤0.25	1	32	0.5	16	>32	0.25	>32	8	t064
Horse	2011	post-op wound	16	>16	>4	1	≤0.25	≤0.25	32	0.12	32	>32	0.25	>32	4	t011
Horse	2011	skin infection	>16	>16	>4	2	≤0.25	≤0.25	64	0.5	≤0.5	4	0.25	1	8	t011
Pig	2010	snout	>16	>16	>4	>8	0.5	1	64	0.5	>64	>32	0.25	>32	16	t011
Cow	2010	milk	4	16	2	1	≤0.25	≤0.25	≤0.5	0.25	≤0.5	2	0.5	2	8	t524
Cow	2010	milk	4	16	1	1	≤0.25	0.5	≤0.5	0.5	≤0.5	2	0.25	1	4	t524
Cow	2010	milk	16	>16	>4	4	≤0.25	0.5	≤0.5	0.25	≤0.5	2	0.5	2	8	t524
Cow	2011	milk	2	>16	2	2	≤0.25	0.5	≤0.5	0.12	≤0.5	4	0.25	1	8	t9111

[a] tested with 2% NaCl.

Escherichia coli with ESBL or transferrable AmpC-type resistance in meat obtained from the Swedish market

ENTEROBACTERIACEAE producing extended-spectrum betalactamases (ESBL) or transferable AmpC betalactamases (pAmpC) is a rapidly emerging public health problem. These bacteria produce enzymes that hydrolyse antibiotics belonging to the betalactam group, including third generation cephalosporins, which are important antimicrobial agents in human medicine. The presence of ESBL- and pAmpC- producing *E. coli* is increasingly reported in humans and in food-producing animals, hence, a food borne transmission may be a possible link between the two populations (EFSA, 2011).

During 2009 to 2011 a project financed by the Swedish Civil Contingencies Agency (MSB) was run in collaboration between the National Veterinary Institute (SVA), the National Food Agency (SLV) and the Swedish Institute for Communicable Disease Control (SMI). This project aimed to provide data required for identifying the extent to which food serves as a source of human exposure to ESBL and/or pAmpC-producing bacteria for use in future risk management strategies. The results have been published in a report by Egervärn et al. (2011). Below is a short summary of the results.

Methodology

The prevalence of ESBL and/or pAmpC-producing *E. coli* was investigated in 518 samples of imported meat from cattle, pigs and broilers and in 100 samples of Swedish broiler meat. The latter samples were included due to the recent report of ESBL- and pAmpC-producing *E. coli* in Swedish broilers within the Swedish monitoring programme SVARM (SVARM 2010). Samples of the imported meat were collected at retail stores and outlets from June 2009 to June 2011, while the Swedish broiler meat samples were collected at slaughter-houses during ten weeks in autumn 2010. ESBL and/or pAmpC-producing *E. coli* were isolated from meat after selective culture with cefotaxime (1 mg/L) and the isolates were characterised phenotypically and by different molecular methods in accordance with the recommendations by EFSA (EFSA, 2011). To investigate the potential link between meat-associated ESBLs and pAmpCs and those found in patients in Sweden, ESBL- and pAmpC genes identified in *E. coli* from meat were compared with gene data from clinical ESBL- and pAmpC-producing *E. coli* isolates reported within the national surveillance programme SWEDRES in 2010.

Results and comments

Depending on the country of origin for the meat products ESBL- and pAmpC-producing *E. coli* were found in 0-8% of imported beef samples, 2-13% of imported pork samples and 15-95% of broiler meat samples available on the Swedish market. The highest prevalence was in South American broiler meat (95%), followed by European broiler meat (61%) and Danish broiler meat (15%). ESBL- and pAmpC-producing *E. coli* were found in 44% of the Swedish broiler meat samples tested. Thus, ESBL- and pAmpC-producing bacteria were frequently found in broiler meat, even in countries such as Sweden and Denmark with no use of cephalosporins in broiler production. In Sweden the occurrence of resistant bacteria is suspected to be due to spread from imported breeding stock into Swedish broiler production (SVARM 2010). The most prevalent ESBL gene among human clinical *E. coli* in Sweden was $bla_{\text{CTX-M-15}}$. It was found in 1% of the bacteria isolated from meat. The overall overlap between gene variants in bacteria isolated from meat and from Swedish patients was small, indicating that meat is probably only a limited source of ESBL- and pAmpC genes in human medicine. Further studies are needed, including a more detailed comparison of ESBL- and pAmpC genes/plasmids and *E. coli* isolates from meat and patients, to assess the potential public health risk of these bacteria in food.

Indicator bacteria

IN 2011 INDICATOR bacteria from slaughter pigs and from pig meat was monitored. Isolates tested were *Escherichia coli* and enterococci randomly selected from cultures of intestinal content and meat. In addition, all samples were screened for *E. coli* resistant to third generation cephalosporins by selective culture on media supplemented with cefotaxime. For details on methodology see Appendix 3.

Escherichia coli

Pigs

Isolates of *Escherichia coli* were obtained from 167 (91%) of 184 samples cultured. The majority of isolates (72%) were susceptible to all antimicrobials tested but 46 isolates (28%) were resistant to at least one substance (Table EC I). Resistance to sulphonamides (17%) or streptomycin (16%) were the most common traits.

Twenty-two isolates (13%) were resistant to three or more antimicrobials (Table EC I). Phenotypes of these isolates are presented in Table EC III and associations between resistance traits in Table EC IV.

Of the randomly selected isolates one was resistant to cefotaxime (MIC of 2 mg/L). Transferable genes coding for extended spectrum beta-lactamases were not found when the isolate was tested by molecular methods and resistance is likely caused by mutational hyperproduction of AmpC beta-lactamases.

On screening for resistance to third generation cephalosporins, *E. coli* resistant to cefotaxime (MIC of 2-8 mg/L) were isolated from nine samples. Six isolates were of the AmpC type but transferable genes for resistance to extended spectrum beta-lactamases were not found and resistance in these isolates is likely caused by mutational hyperproduction of AmpC beta-lactamases. Three isolates however had genes coding for enzymes of the CTX-M-3, CTX-M-15 or TEM-52 groups. For more details and comments see Highlight "*Escherichia coli* with ESBL- or transferrable AmpC-type resistance in production animals".

Pig meat

Escherichia coli was isolated from 20 (20%) of 100 samples cultured. The majority (70%) of isolates was susceptible to all antimicrobials tested but six isolates (30%) were resistant to at least one substance (Table EC I and II). Resistance to ampicillin was the most common trait (30%). Two isolates (10%) were resistant to three or more antimicrobials. Both these isolates were resistant to ampicillin, streptomycin, sulphonamide and trimethoprim and one of the isolates also to kanamycin.

Two isolates were resistant to ciprofloxacin with MIC 0.12 mg/L but susceptible to nalidixic acid, MIC 4-8 mg/L. This phenotype indicates resistance of *qnr*-type. No sample yielded *E. coli* resistant to third generation cephalosporins on culture on cefotaxime supplemented media.

Comments

Levels of resistance in *E. coli* from pigs and pig meat are low in an international perspective. For some antimicrobials levels of resistance have been stable over the years studied wheras resistance to other substances appears to have increased (Fig EC I). Notably resistance to ampicillin, sulphonamide or trimethoprim in *E. coli* from pigs have gradually increased from 3-7% in year 2000 to 11-17% in 2011. A similar tendency is observed in *E. coli* from diagnostic submissions (Table Pig I, Animal Pathogens). These three antimicrobials are used for treatment of pigs and resistance is likely a consequence of this. Direct selection is however probably augmented by co-selection since the three resistance traits often are linked and frequently occur in multiresistant isolates (Table EC III). Use of one of the antimicrobials thereby imposes a selection pressure also for resistance to the others.

The potential of co-selection is illustrated by chloramphenicol resistance. Although this antimicrobial has not been used for pigs in Sweden for more than twenty five years chloramphenicol resistance is more prevalent in 2011 (4%) than it was in 2000 (<1%). Chloramphenicol resistance is only observed in combination with other traits (Table EC IV), notably sulphonamide resistance, and is likely retained by use of other antimicrobials in pigs.

ESBL resistance was verified in *E. coli* from three pigs after selective culture on cefotaxime supplemented media. Apparantly such isolates are still uncommon in pigs in Sweden but the findings indicate an impaired situation since no sample was found positive for *E. coli* with ESBL resistance in 2008. For more details and analysis see Highlight "*Escherichia coli* with ESBL or transferrable AmpC-type resistance in production animals".

Altogether, 100 samples of pig meat collected at cutting plants were cultured for *E. coli* but only 20 isolates were obtained. The isolation frequency was low also in the study of pig meat in 2008. The low prevalence of *E. coli* on pig meat indicates a low level of contamination and a good hygienic quality but from the perspective of resistance monitoring the small number of isolates studied is worrisome since conclusions on trends in resistance cannot be made.

Isolates of *E. coli* from pig meat had similar resistance phenotypes as isolates from pigs indicating contamination by intestinal content from pigs. However, two isolates had a *qnr*-phenotype which is rarely found in *E. coli* from pigs in Sweden (Thyselius et al., 2007). This could signify another source of contamination than intestinal content from pigs. Notably, *E. coli* with transferable resistance to third generation cephalosporins were not obtained from pig meat even after selective culture.

TABLE EC I. Resistance (%) and multiresistance (%) for *Escherichia coli* from slaughter pigs and pig meat, 2011. Data for other animals from previous SVARM-reports given for comparison.

Antimicrobial	Cut-off value (mg/L)	Resistance (%) (95% confidence interval inside brackets)							
		Pigs	Pig meat	Broilers	Broiler meat	Horses	Calves	Sheep	Dogs
		2011 n=167	2011 n=20	2010 n=181	2010 n=77	2010-11 n=274	2009 n=223	2006-09 n=115	2006 n=257
Ampicillin	>8	13 (8.4-19.3)	30 (11.9-54.3)	6 (3.1-10.6)	10 (4.6-19.4)	2 (0.4-3.7)	<1 (0.0-2.5)	2 (0.2-6.1)	5 (3.0-9.0)
Cefotaxime	>0.25	<1 (0.0-3.3)	0 (0.0-16.8)	1 (0.1-3.9)	0 (0.0-4.7)	0 (0.0-1.3)	0 (0.0-1.6)	0 (0.0-3.2)	<1 (0.0-2.1)
Chloramph.	>16	4 (1.7-8.4)	0 (0.0-16.8)	0 (0.0-2.0)	1 (0.0-7.0)	<1 (0.0-2.0)	0 (0.0-1.6)	0 (0.0-3.2)	<1 (0.1-2.9)
Ciprofloxacin	>0.06	2 (0.7-6.0)	10 (1.2—31.7)	13 (8.2-18.4)	6 (2.1-14.5)	<1 (0.0-2.0)	0 (0.0-1.6)	<1 (0.0-4.8)	2 (0.6-4.5)
Colistin	>2	0 (0.0-2.2)	0 (0.0-16.8)	0 (0.0-2.0)	0 (0.0-4.7)	<1 (0.1-2.6)	-	-	-
Florfenicol	>16	0 (0.0-2.2)	0 (0.0-16.8)	0 (0.0-2.0)	0 (0.0-4.7)	0 (0.0-1.3)	0 (0.0-1.6)	0 (0.0-3.2)	0 (0.0-1.4)
Gentamicin	>2	1 (0.1-4.3)	0 (0.0-16.8)	0 (0.0-2.0)	0 (0.0-4.7)	<1 (0.1-2.6)	0 (0.0-1.6)	3 (0.5-7.4)	<1 (0.0-2.1)
Kanamycin	>8	1 (0.1-4.3)	5 (0.1-24.9)	4 (1.9-8.5)	1 (0.0-7.0)	4 (2.3-7.5)	<1 (0.0-2.5)	2 (0.2-6.1)	2 (0.9-5.0)
Nalidixic acid	>16	2 (0.7-6.0)	0 (0.0-16.8)	13 (8.2-18.4)	6 (2.1-14.5)	<1 (0.0-2.0)	0 (0.0-1.6)	0 (0.0-3.2)	2 (0.6-4.5)
Streptomycin	>16	16 (10.9-22.6)	10 (1.2—31.7)	7 (3.5.11.3)	4 (0.8-11.0)	13 (9.1-17.3)	4 (2.2-8.1)	3 (0.5-7.4)	7 (4.2-10.8)
Sulphonamide	>64	17 (11.4-23.3)	10 (1.2—31.7)	7 (3.5.11.3)	17 (9.3-27.1)	15 (10.9-19.7)	2 (0.5-4.5)	7 (3.1-13.2)	13.2 (9.3-18.0)
Tetracycline	>8	8 (4.7-13.7)	0 (0.0-16.8)	8 (4.3-12.6)	8 (2.9-16.2)	2 (0.6-4.2)	2 (0.5-4.5)	<1 (0.0-4.8)	2 (0.9-5.0)
Trimethoprim	>2	11 (7.0-17.2)	10 (1.2—31.7)	3 (1.2-7.1)	1 (0.0-7.0)	16 (11.9-20.9)	<1 (0.0-2.5)	2 (0.2-6.1)	4 (1.9-7.0)
Multiresistance[a]									
Susceptible to all		72	70	72	65	81	95	88	82
Resistant to 1		9	10	19	27	4	3	9	10
Resistant to 2		5	5	2	5	3	<1	2	4
Resistant to 3		3	5	3	1	9	<1	1	2
Resistant to >3		10	10	3	1	3	<1	1	2

[a] Ciprofloxacin and nalidixic acid considered as one substance.

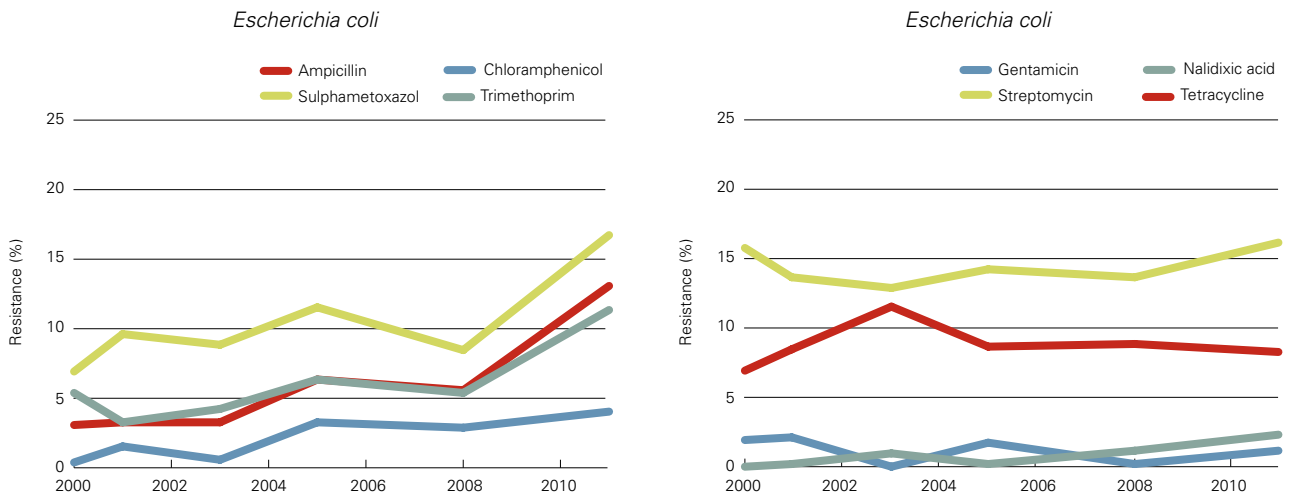


FIGURE EC I. Percent resistance in *Escherichia coli* from pigs 2000-2011.

TABLE EC II. Distribution of MICs and resistance (%) in *Escherichia coli* from intestinal content from pigs (n=167) and from pig meat (n=20), 2011.

			Distribution (%) **of MICs** (mg/L)																	
Antimicrobial	**Source**	**Resistance** %	**≤0.008**	**0.016**	**0.03**	**0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**	**512**	**1024**	**>1024**
Ampicillin	Pigs	13								12.6	56.3	18.0		0.6				12.6			
	Pig meat	30								5.0	35.0	30.0		10.0	10.0			10.0			
Cefotaxime	Pigs	<1			7.2	73.7	18.0	0.6			0.6										
	Pig meat	0			10.0	70.0	20.0														
Chloramph.	Pigs	4									9.0	73.1	13.8		1.8	2.4					
	Pig meat	0									25.0	45.0	25.0	5.0							
Ciprofloxacin	Pigs	2		1.2	80.2	16.2		1.2	0.6		0.6										
	Pig meat	10		5.0	60.0	25.0	10.0														
Colistin	Pigs	0							69.5	29.9	0.6										
	Pig meat	0							45.0	55.0											
Florfenicol	Pigs	0										50.3	47.9	1.8							
	Pig meat	0										55.0	35.0	10.0							
Gentamicin	Pigs	1						7.2	75.4	15.6	0.6	1.2									
	Pig meat	0						15.0	45.0	30.0	10.0										
Kanamycin	Pigs	1											98.8		1.2						
	Pig meat	5											95.0		5.0						
Nalidixic acid	Pigs	2								0.6	37.1	58.1	1.8				1.8	0.6			
	Pig meat	0									40.0	55.0	5.0								
Streptomycin	Pigs	16									3.6	44.3	31.7	4.2	2.4	6.6	3.6	3.0	0.6		
	Pig meat	10									10.0	45.0	20.0	15.0	5.0				5.0		
Sulphonamide	Pigs	17											15.0	40.7	24.0	3.6				0.6	16.2
	Pig meat	10											15.0	60.0	15.0						10.0
Tetracycline	Pigs	8								34.1	57.5				4.2	2.4	1.2	0.6			
	Pig meat	0								20.0	75.0	5.0									
Trimethoprim	Pigs	11					3.6	26.3	55.1	3.0	0.6			0.6	10.8						
	Pig meat	10						50.0	30.0	10.0					10.0						
			≤0.008	**0.016**	**0.03**	**0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**	**512**	**1024**	**>1024**

TABLE EC III. Phenotypes of multiresistant *Escherichia coli* from pigs (intestinal content), 2000-2011. "R" in shaded fields indicates resistance. Data from previous SVARM reports are included.

2000 (n=260)	2001 (n=308)	2003 (n=303)	2005 (n=390)	2008 (n=349)	2011 (n=167)	Sum (n=1777)	Resistance phenotypes									
							Su	Sm	Am	Tc	Tm	Cm	Km	Gm	Nal	Ctx
			1	1		2	R	R	R	R	R	R				
					1	1	R	R	R	R					R	R
					1	1	R	R	R	R	R		R		R	
1		1		1		3	R	R	R	R						
2	1	1	4	2	2	12	R	R	R	R	R					
	2		1			3	R	R	R			R				
	2			2	1	5	R	R	R		R	R				
	4		5	2		11	R	R	R							
				1		1	R	R	R				R			
3	1	2	3	5	6	20	R	R	R		R					
					1	1	R	R	R		R		R			
				1		1	R	R	R		R	R				
					1	1	R	R		R	R				R	
2	3	5	3			13	R	R		R						
		2	2	4		8	R	R		R	R					
1	1		3	1		6	R	R				R				
3	2	2	2		3	12	R	R			R					
				1	1	2	R		R	R		R				
			2			2	R		R	R	R	R				
				2	2	4	R		R			R				
		1	4	2	3	10	R		R		R	R				
			1			1	R				R	R				
				2		2	R				R				R	
		1				1		R	R						R	
		1				1		R		R	R					
				1		1		R					R	R		
		1				1			R	R					R	
12 5%	**16** 5%	**17** 6%	**31** 9%	**28** 8%	**22** 13%	**126** 7%	**Number of isolates** (percent of all isolates)									

TABLE EC IV. Association between resistance traits in *Escherichia coli* from intestinal content of pigs 2000-2011. For each antimicrobial the first row gives prevalence of resistance to other antimicrobials in susceptible isolates (S) and the second row prevalence in resistant isolates (R). All antimicrobials were not tested each year and therefore all combinations of resistance traits can not be calculated.

Single substance susceptibility		**Cross resistance** (%)									
		n	**Am**	**Cm**	**Ff**	**Gm**	**Nal**	**Sm**	**Su**	**Tc**	**Tm**
Ampicillin	S	1682	0.0	0.6	0.1	1.3	0.5	11.4	5.9	7.8	2.6
	R	95	100	29.5	0.0	0.0	4.2	64.2	83.2	28.4	59.0
Apramycin	S	788	3.1	0.9	0.0	1.5	0.3	14.1	8.9	9.4	4.3
	R	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cefotaxime	S	905	7.3	3.3	0.1	1.1	0.9	14.4	11.3	8.6	7.0
	R	1	100	0.0	0.0	0.0	100	100	100	100	0.0
Ceftiofur	S	1261	4.2	1.7	0.0	1.5	0.4	14.1	9.5	9.0	4.9
	R	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chloramp.	S	1739	3.9	0.0	0.1	1.3	0.8	13.5	8.1	8.7	4.5
	R	38	73.7	100	0.0	0.0	0.0	47.4	97.4	15.8	55.3
Ciprofloxacin	S	508	7.9	3.4	0.2	0.6	0.0	14.2	10.4	8.1	6.7
	R	8	25.0	0.0	0.0	0.0	100	37.5	62.5	50.0	50.0
Colistin	S	167	13.2	4.2	0.0	1.2	2.4	16.2	16.8	8.4	11.4
	R	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Enrofloxacin	S	1256	4.1	1.7	0.0	1.5	0.0	14.1	9.6	8.9	4.9
	R	5	40.0	0.0	0.0	0.0	100	20.0	0.0	20.0	20.0
Florfenicol	S	1776	5.4	2.1	0.0	1.2	0.7	14.3	10.0	8.9	5.6
	R	1	0.0	0.0	100	0.0	0.0	0.0	0.0	0.0	0.0
Gentamicin	S	1755	5.4	2.2	0.1	0.0	0.7	14.1	10.1	9.0	5.7
	R	22	0.0	0.0	0.0	100	0.0	27.3	0.0	0.0	0.0
Kanamycin	S	510	7.7	3.3	0.2	0.4	1.4	13.9	10.8	8.6	7.1
	R	6	50.0	0.0	0.0	16.7	16.7	66.7	50.0	16.7	33.3
Nalidixic acid	S	1764	5.2	2.2	0.1	1.3	0.0	14.1	9.8	8.7	5.4
	R	13	30.8	0.0	0.0	0.0	100	30.8	38.5	38.5	38.5
Neomycin	S	1261	4.2	1.7	0.0	1.5	0.4	14.1	9.5	9.0	4.9
	R	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Streptomycin	S	1524	2.2	1.3	0.1	1.1	0.6	0.0	3.3	5.1	2.0
	R	253	24.1	7.1	0.0	2.4	1.6	100	50.6	31.6	27.3
Sulphamethox.	S	1599	1.0	0.1	0.1	1.4	0.5	7.8	0.0	6.8	1.3
	R	178	44.4	20.8	0.0	0.0	2.8	71.9	100	27.5	44.4
Tetracycline	S	1619	4.2	2.0	0.1	1.4	0.5	10.7	8.0	0.0	4.5
	R	158	17.1	3.8	0.0	0.0	3.2	50.6	31.0	100	17.7
Trimethoprim	S	1677	2.3	1.0	0.1	1.3	0.5	11.0	5.9	7.8	0.0
	R	100	56.0	21.0	0.0	0.0	5.0	69.0	79.0	28.0	100

Escherichia coli with ESBL or transferrable AmpC-type resistance in production animals

ENTEROBACTERIACEAE producing extended-spectrum beta-lactamases (ESBL) or transferable AmpC beta lactamases (pAmpC) is a rapidly emerging public health problem (EFSA 2011). By producing hydrolyzing enzymes, these bacteria are resistant to antibiotics belonging to the betalactam group, including third-generation cephalosporins, which are important therapeutics in human medicine. The presence of ESBL- and pAmpC-producing *Escherichia coli* is increasingly reported in humans and in food-producing animals.

In most monitoring programmes in the EU, including the Swedish programme SVARM, data on prevalence of resistance in *E. coli*, are based on data from randomly selected colonies from non-selective cultures. In addition, in SVARM, healthy food animals and food are screened for ESBL- and pAmpC-producing *E. coli* by culture on media supplemented with cefotaxime. The results of all the screenings are summarized in Table I.

Data from 2011

Methodology

During 2011, 184 samples of intestinal content from slaughter pigs and 100 samples of pig meat were screened for *Escherichia coli* resistant to third generation cephalosporins. In addition, 100 samples of caecal content from broilers were screened.
The screening was performed by culturing the samples on MacConkey agar with 1 mg/L cefotaxime. Suspected ESBL- and/or pAmpC-producing *E. coli* were selected for testing of susceptibility to different antimicrobials by microdilution and tested for genotype by PCR. The specific gene variants for all the isolates from pigs and a selection of the isolates from broilers were determined by sequencing. Detailed description of the sampling strategies and laboratory methods used are given in Appendix 3, SVARM 2011.

Results

Pigs and pig meat

Escherichia coli with transferable cefotaxime resistance were isolated from 3 samples (1.6%) of intestinal content from pigs but not from any of the samples from pig meat. The genes confirmed in the three isolates were $bla_{CTX\text{-}M\text{-}3}$, $bla_{CTX\text{-}M\text{-}15}$ and $bla_{TEM\text{-}52}$, respectively (Table II). The isolates all had different antibiograms and one of them was only resistant to beta-lactams (Table II). In addition, in six of the samples of intestinal content from pigs, *E. coli* with AmpC type resistance was found but transferable genes were not detected. Resistance in these isolates is likely caused by mutational hyperproduction of AmpC beta-lactamases.

Broilers

From 54 samples (54%) of intestinal content from broilers, *E. coli* with transferable cefotaxime resistance were isolated. Of these, 3 were of the CTX-M-1 group and 51 of the CIT group. The isolates could be grouped in 14 different phenotypes based on antibiogram and genotype (Table III). Sequencing to identify the resistance gene in a selection of the isolates confirmed presence of the $bla_{CTX\text{-}M\text{-}1}$ or the $bla_{CMY\text{-}2}$ gene, respectively, depending on the group (Table III). In addition, in 3 of the samples of intestinal content from broilers, *E. coli* with AmpC type resistance was found but transferable genes were not detected. Resistance in these isolates is likely caused by mutational hyperproduction of AmpC beta-lactamases.

Comments

During 2011, ESBL-producing *E. coli* was isolated for the first time from pigs in Sweden. Among broilers, the prevalence of ESBL- and pAmpC- producing *E. coli* was even higher in 2011 than in 2010. However, in both pigs and broilers the proportion of *E. coli* in the intestinal flora that is ESBL- or pAmpC-producing seems to be low since such bacteria is only rarely detected when samples are cultured on media without cefotaxime.

The situation in Sweden regarding ESBL- and pAmpC-producing *E. coli* in farm animals is favorable compared to many other countries. This is probably a reflection of the continuous work with disease prevention and prudent antimicrobial use in Sweden. That a large proportion of broilers in Sweden are carrying ESBL- or pAmpC-producing *E. coli* is probably due to the continuous introduction of such bacteria with animals imported for breeding purpose (SVARM 2010). The imported day-old chickens are carrying ESBL- or pAmpC-producing *E. coli* already when they arrive to Sweden and these bacteria are subsequently spread down in the breeding pyramid.

Even if the situation in Swedish broiler production is worrisome, the overall situation regarding ESBL- and pAmpC-producing *E. coli* in production animals in Sweden is favourable. However, this could change if the production structures and/or the management routines are altered.

Public health aspects

The presence of ESBL- and pAmpC-producing *E. coli* in production animals in Sweden makes them a potential reservoir of both resistant bacteria and resistance genes. The importance of this reservoir is difficult to determine but likely lessened by the fact that only a small proportion of *E. coli* in colonized animals are ESBL- or pAmpC-producers. Furthermore, the only group of farm animals in Sweden where a large proportion of the animals are colonized are broilers. The most prevalent gene in isolates from broilers is $bla_{CMY\text{-}2}$ and although cases of human infections with *E. coli* carrying $bla_{CMY\text{-}2}$ have been reported it is not among the most prevalent genes (SWEDRES 2011). See also Highlight "*Escherichia coli* with ESBL or pAmpC in meat obtained from the Swedish market".

TABLE I. Number of samples with growth of *Escherichia coli* with transferable cefotaxime resistance on MacConkey agar with 1 mg/L cefotaxime and number of samples taken.

Year	Broilers	Broiler meat	Pigs	Pig meat	Fattened calves
2008			0:452	0:50	
2009					0:256
2010	68:200 (34%)	44:100 (44%)[a]			
2011	54:100 (54%)		3:184 (1.6%)	0:100	

[a] Not performed within SVARM. For further information see Highlight '*Escherichia coli* with ESBL or pAmpC in meat obtained from the Swedish market' or Egervärn et al. (2011).

TABLE II. Genotypes, resistance phenotypes and MICs of 3 isolates of *Escherichia coli* from pigs. White areas indicate MICs above EUCAST ECOFFs.

Genotype	Ctx	Am	Ci	Nal	Gm	Sm	Tc	Ff	Col	Su	Tm	Cm	Km
CTX-M-15	>2	>128	>1	>128	1	64	2	8	≤0.5	>1024	>16	32	>16
CTX-M-3	>2	>128	0.5	>128	1	256	2	<4	≤0.5	>1024	>16	4	≤8
TEM-52	>2	>128	0.03	2	1	8	2	≤4	≤0.5	32	0.5	4	≤8

TABLE III. Genotypes, resistance phenotypes and MICs of 54 isolates of *Escherichia coli* from broilers. White areas indicate MICs above EUCAST ECOFFs.

Genotype	n	Ctx	Am	Ci	Nal	Gm	Sm	Tc	Col	Ff	Cm	Km	Su	Tm
CMY-2	27	2->2	128->128	0.016-0.06	≤1-4	0.5-2	4-16	≤1-2	≤0.5-2	≤4-8	≤2-8	≤8	16-32	0.25-0.5
CMY-2	12	>2	64->128	0.06	2-4	0.5-2	4-8	≤1-2	≤0.5-1	≤4-8	4-8	≤8	>1024	0.25-0.5
CMY-2	2	>2	128	0.06	4	0.5-1	64	2	≤0.5	8	4-8	≤8	>1024	0.25
CMY-2	2	>2	64	0.12	64	0.5-1	4-8	≤1-2	≤0.5	≤4	4	≤8	16	≤0.12
CMY-2	3	2->2	128->128	0.12	2-4	1-2	8-16	2	≤0.5-1	≤4-8	4-8	≤8	32	0.25-0.5
CMY-2	1	>2	>128	0.06	4	1	8	64	1	8	8	≤8	16	0.5
CMY-2	1	>2	128	0.12	4	0.5	4	2	≤0.5	8	8	≤8	>1024	0.25
CMY-2	1	>2	128	0.06	2	1	64	64	≤0.5	≤4	4	>16	>1024	0.25
CMY-2	1	>2	128	0.03	4	2	64	2	≤0.5	8	8	16	>1024	0.5
CTX-M-1	1	>2	>128	0.03	2	1	8	64	≤0.5	8	4	16	>1024	4
CTX-M-1	1	>2	>128	0.03	4	4	8	64	≤0.5	8	8	≤8	>1024	8
CTX-M-1	1	>2	>128	0.06	2	0.5	8	64	≤0.5	8	4	≤8	>1024	4

Enterococcus

Pigs

A total of 22 isolates of *Enterococcus faecalis* and 22 isolates of *E. faecium* were obtained from 198 samples cultured. In *E. faecalis* tetracycline resistance was the most frequent trait but resistance to erythromycin was also common (Table ENT I). These traits were among the most common also in *E. faecium* but resistance to streptomycin, kanamycin or bacitracin was equally frequent in this species (Table ENT II).

Resistance to tetracycline and erythromycin are often associated in isolates of *E. faecium* and *E. faecalis* (Table IV) and often occur in multiresistant isolates (Table ENT III). Multiresistance is however rare in both species (Table ENT I & II).

Pig meat

From 100 samples of pig meat, 29 isolates of *E. faecalis* and 1 isolate of *E. faecium* were obtained. Most isolates of *E. faecalis* were susceptible to all antimicrobials tested but two isolates (7%) were resistant to tetracycline and one isolate to streptomycin (3%) (Table ENT I). The isolate of *E. faecium* was resistant to virginiamycin (Table ENT II).

Comments

In isolates from pigs, levels of resistance are low in an international perspective and mostly of the same magnitude as in previous years (Fig ENT I). The data available do not indicate any untoward trends in resistance but valid conclusions are hindered by the limited number of isolates available for testing in 2011.

In both species of enterococci, resistance to tetracycline or erythromycin (macrolide) are the most prevalent traits. This is consistent with use of tetracyclines (doxycycline) and macrolides (tylosin) for group treatment of enteritis and respiratory disease in pigs. Resistance to tetracycline and erythromycin are often linked (Table ENT II &IV) and it is therefore likely that selection for these traits is augmented by co-selection.

Resistance to ampicillin, linezolid and vancomycin in enterococci from pigs was not observed in 2011 and resistance to streptogramins (virginiamycin) was rare (Table ENT I & II). This is in agreement with previous findings in SVARM. Notably resistance to ampicillin has been documented in only four isolates of enterococci from pigs in Sweden since 2000 and resistance to virginiamycin only in a limited number of *E. faecium*. Moreover, vancomycin resistant enterococci carrying the *vanA* or *vanB* genes have never been documented from pigs, neither in randomly selected isolates nor by culture in previous years of almost 2000 samples on media supplemented with vancomycin. These findings show that enterococci in pigs in Sweden are not important reservoirs of resistance to antimicrobials used for treatment of enterococcal infections in humans.

Resistance among *E. faecalis* from pig meat was much less prevalent than among isolates from intestinal content of pigs (Table ENT I). Notably the common occurrence of resistance to erythromycin, tetracycline or streptomycin in isolates from intestinal content was not reflected in isolates from pig meat. These findings are in agreement with the results of the monitoring in SVARM 2008 and indicate that *E. faecalis* contaminating meat mostly emanate from other sources than intestinal content from the slaughtered pigs.

Only one isolate of *E. faecium* was obtained from the 100 samples of pig meat. Likewise, in 2008 only a small number of isolates of *E. faecium* was obtained. Contamination of pig meat with this species is apparently less common than contamination with *E. faecalis*.

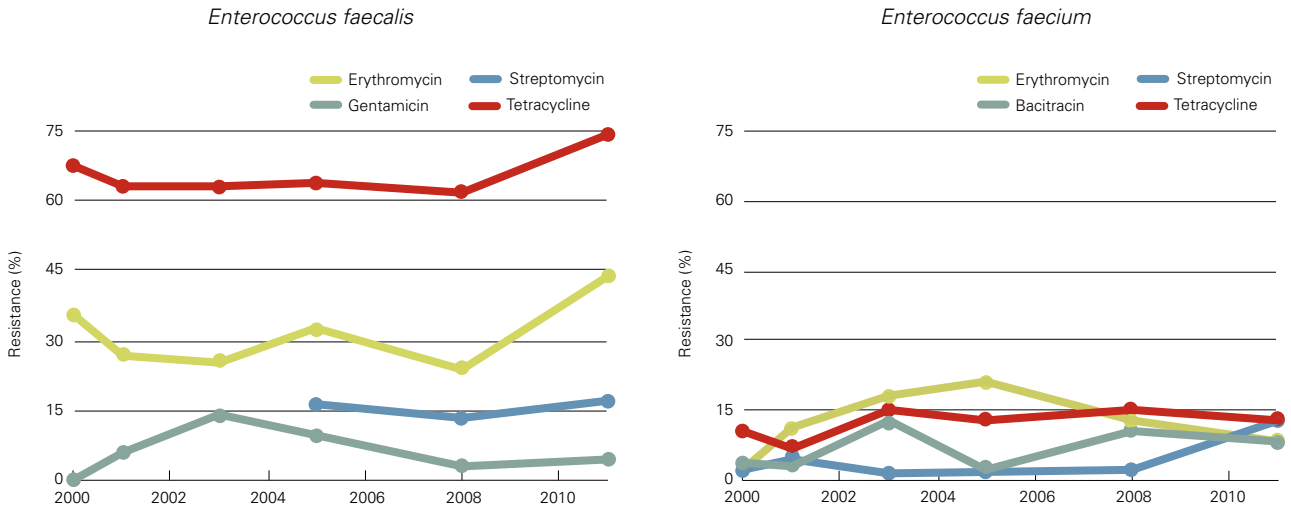


FIGURE ENT I. Percent resistance in *Enterococcus faecalis* and *Enterococcus faecium* from pigs 2000-2011.

TABLE ENT I. Resistance and multiresistance of *Enterococcus faecalis* from pigs and pig meat 2011. Data for other animals from previous SVARM-reports given for comparison.

Antimicrobial	Cut-off value (mg/L)	Resistance (%) (95% confidence interval in brackets)							
		Pigs	Pig meat	Broilers	Broiler meat	Horses	Calves	Sheep	Dogs
		2011 n=22	2011 n=29	2010 n=35	2010 n=81	2010-11 n=34	2009 n=10	2006-09 n=24	2006 n=135
Ampicillin	>4	0 (0.0-14.8)	0 (0.0-11.9)	0 (0.0-10.0)	0 (0.0-4.5)	0 (0.0-10.3)	0 (0.0-30.9)	0 (0.0-14.2)	<1 (0.0-4.1)
Bacitracin	>32	0 (0.0-14.8)	0 (0.0-11.9)	14 (4.8-30.3)	15 (7.9-24.4)	0 (0.0-10.3)	0 (0.0-30.9)	0 (0.0-14.2)	1 (0.2-5.2)
Chloramph.	>32	0 (0.0-14.8)	0 (0.0-11.9)	0 (0.0-10.0)	0 (0.0-4.5)	18 (6.8-34.5)	0 (0.0-30.9)	0 (0.0-14.2)	7 (3.1-12.3)
Erythromycin	>4	43 (23.2-65.5)	0 (8.4-58.1)	31 (16.9-49.3)	23 (14.8-34.2)	21 (8.7-37.9)	0 (0.0-30.9)	0 (0.0-14.2)	14 (8.7-21.1)
Gentamicin	>32	4 (0.1-21.9)	0 (0.0-11.9)	0 (0.0-10.0)	0 (0.0-4.5)	21 (8.7-37.9)	0 (0.0-30.9)	0 (0.0-14.2)	<1 (0.0-4.1)
Kanamycin	>1024	4 (0.1-21.9)	0 (0.0-11.9)	3 (0.1-14.9)	0 (0.0-4.5)	21 (8.7-37.9)	0 (0.0-30.9)	0 (0.0-14.2)	4 (1.6-9.4)
Linezolid	>4	0 (0.0-14.8)	0 (0.0-11.9)	0 (0.0-10.0)	0 (0.0-4.5)	0 (0.0-10.3)	0 (0.0-30.9)	0 (0.0-14.2)	0 (0.0-2.7)
Narasin	>2	0 (0.0-14.8)	0 (0.0-11.9)	37 (21.5-55.1)	19 (10.8-28.7)	0 (0.0-10.3)	0 (0.0-30.9)	0 (0.0-14.2)	1 (0.2-5.2)
Streptomycin	>512	17 (5.0-38.8)	3 (0.1-17.8)	0 (0.0-10.0)	4 (0.8-10.4)	9 (1.9-23.7)	0 (0.0-30.9)	4 (0.1-21.1)	9 (4.7-15.0)
Tetracycline	>4	74 (51.6-89.8)	7 (0.8-22.8)	31 (16.9-49.3)	37 (26.6-48.5)	44 (27.2-62.1)	30 (6.7-65.2)	8 (1.0-27.0)	32 (24.1-40.4)
Vancomycin	>4	0 (0.0-14.8)	0 (0.0-11.9)	0 (0.0-10.0)	0 (0.0-4.5)	0 (0.0-10.3)	0 (0.0-30.9)	0 (0.0-14.2)	0 (0.0-2.7)
Virginiamycin	>32	0 (0.0-14.8)	0 (0.0-11.9	0 (0.0-10.0)	0 (0.0-4.5)	0 (0.0-10.3)	0 (0.0-30.9)	0 (0.0-14.2)	0 (0.0-2.7)
Multiresistance (%)									
Susceptible to all above		17	90	31	30	56	70	92	25
Resistant to 1		35	10	34	43	24	30	4	38
Resistant to 2		43		23	27			4	27
Resistant to 3				9					2
Resistant to >3		4		3		21			7

TABLE ENT II. Resistance and multiresistance of *Enterococcus faecium* from pigs and pig meat 2011. Data for other animals from previous SVARM-reports given for comparison.

Antimicrobial	Cut-off value (mg/L)	Resistance (%) (95% confidence interval in brackets)							
		Pigs	Pig meat	Broilers	Broiler meat	Horses	Calves	Sheep	Dogs
		2011 n=22	2011 n=1	2010 n=136	2010 n=17	2010-11 n=27	2009 n=24	2006-09 n=15	2006 n=29
Ampicillin	>4	0 (0.0-14.8)	0 -	2 (0.5-6.3)	0 (0.0-19.5)	15 (4.2-33.7)	0 (0.0-14.2)	0 (0.0-21.8)	0 (0.0-11.9)
Bacitracin	>32	9 (1.1-28.0)	0 -	15 (9.8-22.6)	18 (3.8-43.4)	0 (0-12.8)	4 (0.1-21.1)	0 (0.0-21.8)	3 (0.1.17.8)
Chloramph.	>32	0 (0.0-14.8)	0 -	0 (0.0-2.7)	0 (0.0-19.5)	0 (0-12.8)	0 (0.0-14.2)	0 (0.0-21.8)	0 (0.0-11.9)
Erythromycin	>4	9 (1.1-28.0)	0 -	13 (8.0-20.1)	6 (0.1-28.7)	0 (0-12.8)	4 (0.1-21.1)	0 (0.0-21.8)	28 (12.7-47.2)
Gentamicin	>32	0 (0.0-14.8)	0 -	0 (0.0-2.7)	0 (0.0-19.5)	0 (0-12.8)	0 (0.0-14.2)	0 (0.0-21.8)	0 (0.0-11.9)
Kanamycin	>1024	9 (1.1-28.0)	0 -	0 (0.0-2.7)	0 (0.0-19.5)	0 (0-12.8)	0 (0.0-14.2)	0 (0.0-21.8)	0 (0.0-11.9)
Linezolid	>4	0 (0.0-14.8)	0 -	0 (0.0-2.7)	0 (0.0-19.5)	0 (0-12.8)	0 (0.0-14.2)	0 (0.0-21.8)	0 (0.0-11.9)
Narasin	>4	0 (0.0-14.8)	0 -	49 (39.9-57.2)	41 (18.4-67.1)	0 (0-12.8)	0 (0.0-14.2)	0 (0.0-21.8)	7 (0.8-22.8)
Streptomycin	>128	13 (2.8-33.6)	0 -	0 (0.0-2.7)	0 (0.0-19.5)	7 (0.9-24.3)	0 (0.0-14.2)	7 (0.2-32.0)	0 (0.0-11.9)
Tetracycline	>4	13 (2.8-33.6)	0 -	12 (7.5-19.3)	0 (0.0-19.5)	4 (0.1-19.0)	0 (0.0-14.2)	7 (0.2-32.0)	17 (5.8-35.8)
Vancomycin	>4	0 (0.0-14.8)	0 -	0 (0.0-2.7)	0 (0.0-19.5)	0 (0-12.8)	0 (0.0-14.2)	0 (0.0-21.8)	0 (0.0-11.9)
Virginiamycin	>4	4 (0.1-21.9)	100 -	5 (2.1-10.3)	6 (0.1-28.7)	4 (0.1-19.0)	0 (0.0-14.2)	0 (0.0-21.8)	0 (0.0-11.9)
Multiresistance (%)									
Susceptible to all above		74		35	47	74	92	87	62
Resistant to 1		13	100	45	35	22	8	13	30
Resistant to 2		4		21	18	4			6
Resistant to 3				2					
Resistant to >3		9		1					2

TABLE ENT III. Phenotypes of multiresistant *Enterococcus faecalis* and *Enterococcus faecium* from pigs (intestinal content), 2000-2011. "R" in shaded fields indicates resistance. Data from previous SVARM-reports are included.

E. faecalis

Year		Resistance pattern							
2000-08 n=318	2011 n=22	Tc	Em	Gm	Am	Sm	Cm	Km	Na
1		R	R	R	R				
1		R	R	R					R
8		R	R	R					
1		R	R	R		R	R	R	
1	1	R	R	R		R		R	
2		R	R						R
2		R	R			R			
2		R	R			R	R		
1		R			R				R
19 (5%)	**1** (5%)	**Number of isolates** (percent of all isolates)							

E. faecium

Year		Resistance pattern							
2000-08 n=311	2011 n=22	Tc	Em	Vi	Sm	Am	Cm	Ba	Gm
1		R	R	R			R		
1		R	R	R	R				
1		R	R	R					
1		R	R		R	R			
	2	R	R		R				
4		R	R					R	
1			R	R	R				
1				R	R				R
10 (3%)	**2** (9%)	**Number of isolates** (percent of all isolates)							

TABLE ENT IV. Association between resistance traits in *Enterococcus faecalis* and in *Enterococcus faecium* from pigs (intestinal content) 2000-11. For each antimicrobial the first row gives prevalence of resistance to other antimicrobials in susceptible isolates (S) and the second row prevalence in resistant isolates (R). All antimicrobials were not tested each year and all combinations of resistance traits can therefore not be calculated.

E. faecalis

Single substance susceptibility		n	Cross resistance (%)								
			Am	Ba	Em	Gm	Na	Sm	Tc	Va	Vi
Ampicillin	S	339	0.0	0.3	29.2	6.2	0.9	19.8	64.3	0.3	0.0
	R	2	100	0.0	50.0	50.0	50.0	50.0	100	0.0	0.0
Avilamycin	S	244	0.8	0.0	29.1	7.4	1.6	22.1	63.9	0.4	0.0
	R	6	0.0	16.7	50.0	16.7	0.0	16.7	83.3	0.0	0.0
Bacitracin	S	340	0.6	0.0	29.1	6.5	1.2	20.0	64.7	0.3	0.0
	R	1	0.0	100	100	0.0	0.0	0.0	0.0	0.0	0.0
Chloramph.	S	221	0.0	0.5	25.3	5.4	0.5	16.3	62.0	0.5	0.0
	R	12	0.0	0.0	83.3	58.3	0.0	58.3	100	0.0	0.0
Erythromycin	S	241	0.4	0.0	0.0	2.1	0.4	16.6	55.2	0.4	0.0
	R	100	1.0	1.0	100	17.0	3.0	28.0	87.0	0.0	0.0
Flavomycin	S	206	0.5	0.0	30.1	7.8	1.5	22.8	67.5	0.5	0.0
	R	9	11.1	0.0	11.1	0.0	11.1	0.0	33.3	0.0	0.0
Gentamicin	S	319	0.3	0.3	26.0	0.0	0.9	16.3	62.7	0.3	0.0
	R	22	4.5	0.0	77.3	100	4.5	72.7	90.9	0.0	0.0
Kanamycin	S	88	0.0	0.0	26.1	0.0	0.0	11.4	63.6	0.0	0.0
	R	3	0.0	0.0	100	100	0.0	100	100	0.0	0.0
Linezolid	S	91	0.0	0.0	28.6	3.3	0.0	14.3	64.8	0.0	0.0
	R	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Narasin	S	337	0.3	0.3	28.8	6.2	0.0	19.6	64.1	0.3	0.0
	R	4	25.0	0.0	75.0	25.0	100	50.0	100	0.0	0.0
Streptomycin	S	273	0.4	0.4	26.4	2.2	0.7	0.0	66.7	0.4	0.0
	R	68	1.5	0.0	41.2	23.5	2.9	100	55.9	0.0	0.0
Tetracycline	S	121	0.0	0.8	10.7	1.7	0.0	24.8	0.0	0.8	0.0
	R	220	0.9	0.0	39.5	9.1	1.8	17.3	100	0.0	0.0
Vancomycin	S	340	0.6	0.3	29.4	6.5	1.2	20.0	64.7	0.0	0.0
	R	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	0.0
Virginiamycin	S	341	0.6	0.3	29.3	6.5	1.2	19.9	64.5	0.3	0.0
	R	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

E. faecium

	n	Cross resistance (%)								
		Am	Ba	Em	Gm	Na	Sm	Tc	Va	Vi
S	332	0.0	6.3	12.7	0.6	0.3	3.0	11.1	0.0	9.9
R	2	100	0.0	50.0	0.0	0.0	50.0	50.0	0.0	0.0
S	271	0.7	5.5	13.3	0.7	0.4	2.6	10.7	0.0	11.8
R	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S	313	0.6	0.0	11.5	0.6	0.3	3.5	10.2	0.0	9.9
R	21	0.0	100	33.3	0.0	0.0	0.0	28.6	0.0	9.5
S	179	0.0	8.9	16.2	0.6	0.0	2.8	14.0	0.0	4.5
R	1	0.0	0.0	100	100	0.0	0.0	100	0.0	100
S	291	0.3	4.8	0.0	0.3	0.3	1.7	9.6	0.0	9.3
R	43	2.3	16.3	100	2.3	0.0	14.0	23.3	0.0	14.0
S	255	0.8	5.9	12.5	0.8	0.4	2.7	10.6	0.0	11.4
R	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S	332	0.6	6.3	12.7	0.0	0.3	3.0	11.1	0.0	9.3
R	2	0.0	0.0	50.0	100	0.0	50.0	50.0	0.0	100
S	60	0.0	10.0	8.3	0.0	0.0	3.3	11.7	0.0	1.7
R	2	0.0	0.0	100	0.0	0.0	100	100	0.0	0.0
S	62	0.0	9.7	11.3	0.0	0.0	6.5	14.5	0.0	1.6
R	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S	333	0.6	6.3	12.9	0.6	0.0	3.3	11.4	0.0	9.9
R	1	0.0	0.0	0.0	0.0	100	0.0	0.0	0.0	0.0
S	323	0.3	6.5	11.5	0.3	0.3	0.0	10.5	0.0	8.4
R	11	9.1	0.0	54.5	9.1	0.0	100	36.4	0.0	54.5
S	296	0.3	5.1	11.1	0.3	0.3	2.4	0.0	0.0	9.1
R	38	2.6	15.8	26.3	2.6	0.0	10.5	100	0.0	15.8
S	334	0.6	6.3	12.9	0.6	0.3	3.3	11.4	0.0	9.9
R	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S	301	0.7	6.3	12.3	0.0	0.3	1.7	10.6	0.0	0.0
R	33	0.0	6.1	18.2	6.1	0.0	18.2	18.2	0.0	100

TABLE ENT V. Distribution of MICs and resistance (%) in *Enterococcus faecalis* from pigs (n=22) and pig meat (n=29), 2011.

Antimicrobial	Source	Resistance %	Distribution (%) of MICs (mg/L)															
			≤0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	>2048
Ampicillin	Pigs	0			4.3	82.6	13.0											
	Pig meat	0				86.2	13.8											
Bacitracin[a]	Pigs	0								100								
	Pig meat	0								100								
Chloramphenicol	Pigs	0						17.4	78.3	4.3								
	Pig meat	0						31.0	69.0									
Erythromycin	Pigs	43			8.7	34.8	13.0						43.5					
	Pig meat	0			6.9	24.1	62.1	6.9										
Gentamicin	Pigs	4							30.4	65.2					4.3			
	Pig meat	0							69.0	31.0								
Kanamycin	Pigs	4												95.7				4.3
	Pig meat	0												100				
Linezolid	Pigs	0				8.7	78.3	13.0										
	Pig meat	0				3.4	89.7	6.9										
Narasin	Pigs	0	13.0	34.8	52.2													
	Pig meat	0	31.0	58.6	10.3													
Streptomycin	Pigs	17										21.7	60.9				17.4	
	Pig meat	3										55.2	37.9	3.4			3.4	
Tetracycline	Pigs	74			13.0	13.0					30.4	43.5						
	Pig meat	7			24.1	65.5	3.4					6.9						
Vancomycin	Pigs	0				39.1	52.2	8.7										
	Pig meat	0				13.8	79.3	6.9										
Virginiamycin	Pigs	0						4.3		73.9	21.7							
	Pig meat	0							6.9	93.1								
			≤0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	>2048

[a] MIC in U/mL, see Appendix 3 for details.

TABLE ENT VI. Distribution of MICs and resistance (%) in *Enterococcus faecium* from pigs (n=22), 2011.

Antimicrobial	Source	Resistance %	Distribution (%) of MICs (mg/L)															
			≤0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	>2048
Ampicillin	Pigs	0				56.5	26.1	17.4										
Bacitracin[a]	Pigs	9								82.6	8.7			8.7				
Chloramphenicol	Pigs	0						39.1	60.9									
Erythromycin	Pigs	9			30.4	26.1	13.0	21.7					8.7					
Gentamicin	Pigs	0						4.3	69.6	26.1								
Kanamycin	Pigs	9												82.6	8.7			8.7
Linezolid	Pigs	0				8.7	47.8	43.5										
Narasin	Pigs	0		13.0	60.9	26.1												
Streptomycin	Pigs	13									17.4	69.6					13.0	
Tetracycline	Pigs	13			73.9	13.0						8.7	4.3					
Vancomycin	Pigs	0				82.6	8.7	8.7										
Virginiamycin	Pigs	4			17.4	13.0	17.4	47.8		4.3								
			≤0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	>2048

[a] MIC in U/mL, see Appendix 3 for details.

Vancomycin resistant enterococci (VRE) in Swedish broiler production – a summary

VANCOMYCIN RESISTANT ENTEROCOCCI (VRE) are an important cause of nosocomial infections in humans. Presence of VRE in farm animals constitute a reservoir of resistance that can spread to humans via the food-chain. The existence of VRE among farm animals is due to earlier selection by extensive use of the vancomycin analog avoparcin for growth promotion. In Sweden, the use of avoparcin ceased before the middle of the 1980s, and a decade later it ceased in the whole of the European Union as a consequence of the Commission Directive 97/6/EC. Once the use of avoparcin was discontinued, the prevalence of VRE among farm animals in Europe decreased. However, VRE are still present among farm animals and by spread via food products they could potentially have a negative impact on public health.

Among randomly selected enterococci from Swedish broilers, VRE are only isolated on rare occasions. For example, within the SVARM programme, VRE have only been isolated four times since 2000, although 1850 samples from broilers have been cultured. Contrary, using selective methods by culture on media containing vancomycin an increase in the occurrence of VRE among broilers in Sweden since 2000 is visible. This increase has occurred in the absence of an obvious selective pressure as avoparcin has not been used since 1984. However, since 2005 the number of broilers colonized with VRE has decreased and seems to have stabilized (Figure VRE).

To increase the knowledge about the epidemiology of VRE in Swedish broiler production and thereby hopefully find ways to reduce the occurrence, a PhD project was initiated in 2007 and completed in 2011. Below are the major findings from the project summarised. The complete thesis is available at http://pub.epsilon.slu.se/8125/.

All VRE isolated from broilers in Sweden are *Enterococcus faecium* with a plasmid located *vanA* gene (Nilsson et al., 2009b; Nilsson et al., 2012). The majority of the isolates has the same resistance phenotype including decreased susceptibility to narasin and low level resistance to erythromycin (Nilsson et al., 2009b). Further investigations have shown that the increased occurrence is caused by the spread of one predominant clone which is of multilocus sequence type (MLST) 310 (Nilsson et al., 2009b). Clones with other sequence types and/or resistance phenotypes do however exist (Nilsson et al., 2009b; Nilsson et al., 2012).

To understand why one clone dominates, both genotypic and phenotypic characterizations of the different clones were made. This has not provided evidence to why the occurrence of VRE among Swedish broilers has increased or why one clone dominates. The vancomycin resistance is for example easily transferrable from many of the clones (Nilsson et al., 2012). Contrary, plasmid addiction systems are most likely not involved in the retention of the *vanA* gene as such systems are nearly absent among VRE from broilers in Sweden (Nilsson et al., 2012).

From some of the VRE clones, decreased susceptibility to the ionophore narasin was co-transferred with the vancomycin resistance (Nilsson et al., 2012). Thereby the use of narasin for coccidial prophylaxis could contribute to retention of the *vanA* gene. The traits are probably located close to each other, so when retaining the decreased susceptibility to narasin, the enterococci also retain the *vanA* gene. This theory is so far only a speculation and needs to be further investigated.

It has been shown that broilers are colonized with VRE persisting in the broiler houses (Nilsson et al., 2009a). However, differences in occurrence of VRE among farms indicate that a reduction could be possible if the factor(s) causing these differences could be identified. Attempts to identify differences in management routines between farms contaminated and not contaminated with VRE was unsuccessful (Jansson et al., to be published). Also the possibility that the bacteria have a reduced susceptibility to commonly used disinfectants was investigated *in vitro* but a sufficient reduction in the amount of bacteria was achieved with all tested products (Nilsson, 2011). Hence, resistance to disinfectants does not seem to be the reason for persistence of VRE at farms. Instead, the reasons could be difficulties to apply to the disinfection protocols and procedures rather than in the protocols *per se*. For example, the practical difficulties in cleaning the houses adequately can lead to quenching of the disinfectant by remaining biological substances. Also difficulties in applying the disinfectant at various locations within the houses could contribute to the unsuccessful disinfection results.

Due to the results of the *in vitro* studies, the effect on VRE of a method that combines steam and formaldehyde, originally developed to disinfect layer houses from *Salmonella*, was tested (Nilsson, 2011). A reduction in the contamination of the broiler houses was then achieved. Hopefully, this could in the future be used to reduce the occurrence of VRE on farms and subsequently in the whole Swedish broiler production.

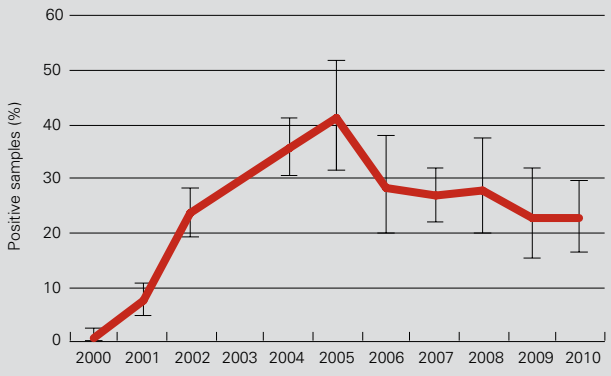


FIGURE. Proportion of Swedish broilers colonized with VRE from 2000-2010. Number of samples each year was between 100 and 350. 95% confidence intervals indicated.

Animal pathogens

ISOLATES TESTED are from clinical submission of samples to SVA if not otherwise stated. For many samples, information on the indications for sampling is not available but the vast majority of submissions are likely from diseased animals. Therefore, data are probably biased towards samples from treated animals or from herds where antimicrobial treatments are common. Any assessment of trends is based on the assumption that this bias is inherent throughout the observation period.

In SVARM, isolates are, when possible, classified as susceptible or resistant by epidemiological cut-off values issued by EUCAST (see Guidance for readers and Appendix 3 for details). This classifies isolates with acquired reduced susceptibility as resistant, which is relevant for monitoring purposes, but it should be understood that this not always implies clinical resistance.

Pigs

Escherichia coli

Isolates of *Escherichia coli* from years 1992-2011 are from clinical submissions of samples from the gastro-intestinal tract (intestinal content, faecal samples or mesenteric lymph nodes), while data from 1989-1991 include all *E. coli* isolated from pigs, irrespective of material type.

Before the first of October 2007, all *E. coli* isolates from the gastro-intestinal tract were susceptibility tested. After that date, the criteria for susceptibility testing were changed and in general only *E. coli* isolates that harbour genes coding for virulence factors are tested for susceptibility. The presence of genes coding for the following proteins are determined by PCR: enterotoxin (LT), heat-stabile enterotoxin a and b (STa and STb), verocytotoxin (VT2e) and adhesionsfactors F4, F5, F6, F18 and F41. Isolates with at least one of these genes were susceptibility tested.

As in previous years, resistance to ampicillin, streptomycin, tetracycline or trimethoprim-sulphonamides in *E. coli* was most commonly occurring in 2011 but resistance to ceftiofur was not detected (Table Pig I). In the 70s and 80s, prevalence of *E. coli* resistant to ampicillin was around 7% (Franklin, 1976; Franklin, 1984). From the late 90s, prevalence of ampicillin resistance rose gradually, but after 2004 the figures have stabilised around 20%. Multiresistance occurred in 25% of the isolates compare to 15% in 2010, 19% in 2009 and 14% in 2008. The combination with resistance to ampicillin, streptomycin and trimethoprim-sulphonamides was the most common trait, occurring in 30% of the multiresistant isolates. Ten percent of all the isolates were resistant to four or more antimicrobials and two percent were resistant to five or more. One isolate was resistant to ampicillin, enrofloxacin, streptomycin, trimethoprim-sulphonamides and tetracycline. There is no product authorised on the Swedish market for the indication intestinal infections in pigs that can be presumed to have clinical effect on *E. coli* with this resistance profile.

Brachyspira hyodysenteriae

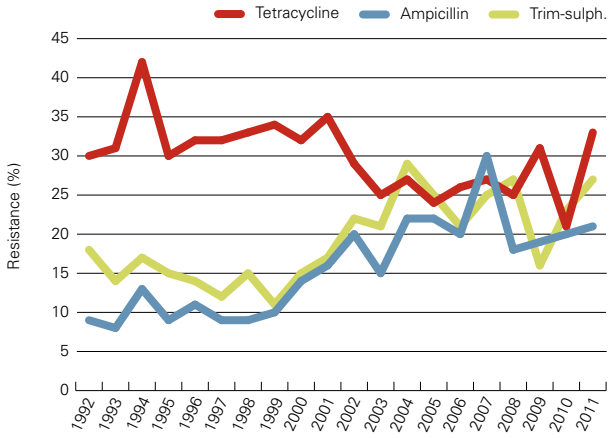
Isolates of B*rachyspira hyodysenteriae* are from clinical submissions of faecal samples from pigs.

All isolates were susceptible to tiamulin (Table Pig II). In the late 80s, susceptibility of *B. hyodysenteriae* was tested with an agar dilution technique, and 20% of the isolates were resistant

TABLE PIG I. Resistance (%) in *Escherichia coli* from pigs 1989-2011 and distribution of MICs for isolates from 2011. Isolates are from clinical submissions of faecal samples or samples taken post mortem from the gastro-intestinal tract.

Antimicrobial	Resistance (%)									Distribution (%) of MICs (mg/L)									
	1989-91 n=248	1992-94 n=431	1995-97 n=1244	1998-00 n=1074	2001-03 n=935	2004-06 n=1009	2007-09 n=278	2010 n=94	2011 n=91	≤0.12	0.25	0.5	1	2	4	8	16	32	>32
Ampicillin	6	10	9	11	17	22	21	20	21				2.2	39.6	31.9	5.5	20.9		
Ceftiofur	-	-	-	-	<1[g]	<1	0	0	0		63.7	30.8	5.5						
Enrofloxacin[a]	1[f]	7	5	6	8	9	7	6	6	94.5		4.4		1.1					
Florfenicol	-	-	-	-	<1[g]	<1	0	0	0					4.4	53.8	39.6	2.2		
Gentamicin[b]	1	1	<1	1	4	1	<1	0	1					95.6	3.3	1.1			
Neomycin	17	14	9	6	5	4	6	1	3						93.4	3.3			3.3
Streptomycin[c]	44	44	32	30	36	36	35	28	37						41.8	16.5	4.4	9.9	27.5
Tetracycline	28	35	31	33	30	26	26	21	33				20.9	36.3	9.9		33.0		
Trim-Sulph.[d,e]	17	15	13	14	19	25	20	23	27			70.3	2.2			27.5			

[a] Cut-off value >0.25 mg/L until 2001; [b] Cut-off value >8 mg/L until 2002; [c] Cut-off value >32 mg/L until 2001; [d] Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim-sulphametoxazole); [e] Cut-off value >4 mg/L until 2001; [f] 227 isolates tested; [g] 688 isolates tested.



F IGURE PIG. Resistance (%) to ampicillin, tetracycline and trimethoprim-sulphametoxazole in *Escherichia coli* from pigs 1992-2011.

to tylosin (Gunnarsson et al., 1991). In 2001, the figure had increased dramatically to around 80% and has since then been over 70% (Table Pig II).

The last four years isolates were susceptibility tested also for tylvalosin, a macrolide authorised for treatment of swine dysentery in the European Union. No cut-off value for resistance to tylvalosin is available but Karlsson et al. (2004) showed a correlation between the MICs of tylosin and tylvalosin indicating that macrolide resistance caused by structural changes of ribosomal RNA also affects the binding of tylvalosin. Since 2005 isolates have been susceptibility tested for doxycycline and valnemulin. Cut-off values are not available for these substances either.

Ongoing compilation and analysis of antimicrobial susceptibility data from isolates of *B. hyodysenteriae* from Sweden 1990-2010 (data not shown) will, hopefully, result in the proposal of epidemiological cut-off values for the substances tested at SVA. During 1990-2003, a slow increase in the number of isolates with decreased susceptibility for tiamulin was seen. This increase can only be detected if the material is divided in subpopulations from different time periods. After 2003, this increase has ceased. A slow decrease in susceptibility can easily be missed if monitoring is not continuously performed.

In Sweden, a programme for control of swine dysentery was launched in 2000. The programme has three strategies; testing of nucleus and multiplying herds for *B. hyodysenteriae* twice a year, eradication of the bacteria in infected herds and tracing the source of infection. It is imperative that all herds where treatment failure is suspected are thoroughly investigated. Since only macrolides and pleuromutilins are authorised for treatment of swine dysentery in pigs it is important to monitor resistance development in *B. hyodysenteriae*. The number of samples taken and isolates available for susceptibility testing has decreased during the years. However, this can probably be explained by a successful reduction of swine dysentery. This is supported by the marked decline in sales figures for tiamulin (see section "Use of antimicrobials").

TABLE PIG II. Resistance (%) in *Brachyspira hyodysenteriae* from pigs 2001-2003 and 2005-2011 and distribution of MICs for isolates from 2005-2011. Isolates are from clinical submissions of faecal samples.

Antimicrobial	Resistance (%)				Distribution (%) of MICs (mg/L)												
	2001 n=75	2002 n=109	2003 n=100	2005-11 n=132	≤0.03	0.06	0.125	0.25	0.5	1	2	4	8	16	32	64	128	>128
Doxycycline	-	-	-	ND[a]			16.7	63.6	6.8	6.8	6.1							
Tiamulin	0	0	0	0		31.8	46.2	11.4	8.3	2.3								
Tylosin	83	73	89	74							0.8	12.1	12.1	1.5			2.3	71.2
Tylvalosin	-	-	-	ND[a,b]				1.8	9.1	23.6	3.6	16.3	25.5	14.5	1.8	3.6		
Valnemulin	-	-	-	ND[a]	79.5	12.1	2.3	3.8	2.3									

[a] ND=not determined because no cut-off value is available; [b]55 isolates tested.

TABLE PIG III. Resistance (%) in *Brachyspira pilosicoli* from pigs 2002-2003 and 2005-2011 and distribution of MICs for isolates from 2005-2011. Isolates are from clinical submissions of faecal samples.

Antimicrobial	Resistance (%)		Distribution (%) of MICs (mg/L)													
	2002-03 n=93	2005-11 n=247	≤0.03	0.06	0.125	0.25	0.5	1	2	4	8	16	32	64	128	>128
Doxycycline	-	ND[b]			38.1	49.4	4.0	2.8	5.3	0.4						
Tiamulin	14	12		29.6	29.1	13.0	8.5	6.5	1.6		2.0	9.7				
Tylosin	50[a]	62							5.3	17.8	10.9	3.6	4.5	3.6	5.3	49.0
Tylvalosin	-	ND[b,c]					8.3	15.5	31.0	6.0	2.4	2.4	19.0	15.5		
Valnemulin	-	ND[b]	43.7	21.9	6.1	9.3	6.1	4.9	2.0	1.6	4.5					

[a] 86 isolates tested; [b] ND=not determined because no cut-off value is available; [c] 84 isolates tested.

Brachyspira pilosicoli

Isolates of *Brachyspira pilosicoli* are from clinical submissions of faecal samples from pigs.

In 2001, the first isolates of *B. pilosicoli* resistant to tiamulin were confirmed in Sweden. These isolates were associated with treatment failure in a pig herd with spirochaetal diarrhoea (see SVARM 2003). Since then, tiamulin resistant strains have been isolated every year but there is no apparent increasing trend in prevalence of resistance (Table Pig III). The proportion of isolates resistant to tylosin has been around 60% during the last years (Table Pig III).

During 2008-2011, five isolates with high MICs of tiamulin, tylosin and tylvalosin were detected. Although such isolates may be susceptible to other antimicrobials, only tiamulin and tylosin are currently licensed for treatment of spirochaetal diarrhoea in pigs in Sweden. Since resistance occurs, susceptibility testing of *B. pilosicoli* from herds where tiamulin is to be used is of importance.

Actinobacillus pleuropneumoniae

Isolates of *Actinobacillus pleuropneumoniae* from 1992-2000 were isolated from the respiratory tract (nasal swabs and lung, including regional lymph nodes) but from 2005-2011 all isolates are from lungs sampled post mortem.

Since 2005, *A. pleuropneumoniae* has been susceptible to almost all antimicrobials tested (Table Pig IV). Pneumonia caused by *A. pleuropneumoniae* is an important disease in Swedish pig production and a high frequency of sampling and susceptibility testing is desirable if emerging resistance is to be detected early. The number of samples taken and isolates tested has been few over the years, but the sampling increased modestly when the surveillance programme SVARMpat was started in 2005. In 2011, intensified sampling from slaughtered pigs at abattoirs was performed within the SVARMpat programme which increased the number of isolates available for susceptibility testing considerably.

TABLE PIG IV. Resistance (%) in *Actinobacillus pleuropneumoniae* from pigs 1992-2000 and 2005-2011. Distribution of MICs for isolates from 2011. Isolates are from clinical submissions of samples from the respiratory tract or from post mortem investigations of lungs.

	Resistance (%)				**Distribution** (%) **of MICs** (mg/L)													
Antimicrobial	**1992-00** n=18	**2005-07** n=84	**2008-10** n=79	**2011** n=57	**≤0.016**	**0.03**	**0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**>128**
Ampicillin	6	0	0	0		1.8	1.8	36.8	36.8	22.8									
Cefotaxime	-	0	0	0	96.5	3.5													
Chloramph.	11	0	0	0								100							
Ciprofloxacin	6[a]	0	0	0		35.1	64.9												
Florfenicol	-	0	0	0									100						
Gentamicin	-	0	0	0								5.3	68.4	26.3					
Nalidixic acid	-	0	0	0							3.5	84.2	12.3						
Penicillin	6	0	0	0				14.0	61.4	24.6									
Streptomycin	-	0	1	2											14.0	84.2	1.8		
Tetracycline	11[b]	1	0	0							100								
Trimethoprim	-	0	0	0				43.9	40.4	14.0	1.8								

[a] Enrofloxacin tested, cut-off value 2 mg/L.; [b] cut-off value >8 mg/L.

TABLE PIG V. Resistance (%) in *Pasteurella* spp. from pigs 2000-2001 and 2005-2011. Distribution of MICs for isolates from 2008-2011. Isolates are from the respiratory tract, isolated from nasal swabs or from post mortem investigations of lungs.

	Resistance (%)			**Distribution** (%) **of MICs** (mg/L)															
Antimicrobial	**2000-01** n=75	**2005-07** n=38	**2008-11** n=76	**≤0.008**	**0.016**	**0.03**	**0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**>128**
Ampicillin	0	0	0								100								
Cefotaxime	-	0	0[b]				100												
Chloramph.	1	0	0[b]									100							
Ciprofloxacin	1[a]	0	0[b]	11.9	61.0	25.4	1.7												
Florfenicol	-	0	0[c]										100						
Gentamicin	4	0	0									69.7	26.3	3.9					
Nalidixic acid	-	0	0[b]								42.4	44.1	11.9		1.7				
Penicillin	0	0	0					19.7	68.4	11.8									
Streptomycin	4	0	4										3.9	36.8	38.2	17.1	3.9		
Tetracycline	1	0	0								97.4	2.6							
Trimethoprim	-	0	0[b]						69.5	28.8	1.7								

[a] Enrofloxacin tested, cut-off value 2 mg/L; [b] 59 isolates tested; [c] 72 isolates tested.

TABLE PIG VI. Resistance (%) in *Streptococcus equisimilis* from pigs 2009-2011. Isolates are from joints from nursing piglets with arthritis.

Antimicrobial	Resistance (%)	Distribution (%) of MICs (mg/L)												
	2009-11 n=82	≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	>64
Cephalothin	0		24.4	42.7	32.9									
Chloramph.	0					6.1	6.1	41.5	43.9	2.4				
Ciprofloxacin	NR		3.7	18.3	7.3	35.4	32.9	2.4						
Clindamycin	7				90.2	2.4			2.4	2.4			2.4	
Erythromycin	2				90.2	1.2	1.2	4.9					2.4	
Penicillin	0	92.7	7.3											
Tetracycline	23						1.2	17.1	41.5	17.1		8.5	14.6	
Trimethoprim	ND					3.7	26.8	46.3	20.7	1.2		1.2		

NR= Not relevant as the inherent susceptibility is above concentrations that can be obtained during therapy; ND=not determined because no cut-off value is available.

In order to show the distribution of the lower MIC values, the isolates from 2011 were susceptibility tested on panels with extended ranges compared to previous years for some of the substances.

Pasteurella spp.

Isolates of *Pasteurella* spp. are from nasal swabs collected within a control programme for atrophic rhinitis in nucleus and multiplying herds or from post mortem investigation of lungs. Isolates from the control programme are likely from healthy pigs, whereas isolates from post mortem investigations of lungs are most likely from pigs with respiratory problems.

Since 2005, *Pasteurella* spp has been susceptible to almost all antimicrobials tested (Table Pig V). In 2011, enrofloxacin was tested as a representative for quinolones instead of ciprofloxacin and nalidixic acid. Since only 17 isolates were available for susceptibility testing, distribution of MICs of enrofloxacin is not included in Table Pig V. However, resistance to enrofloxacin was not detected and almost all isolates had MICs of ≤0.12.

Streptococcus equisimilis

During 2009-2011, bacteriological sampling was performed from 130 nursing piglets with arthritis. Two affected joints per pig were sampled at post mortem investigation. *Streptococcus equisimilis* (beta-hemolytic, Lancefield group C) was the most common bacterial species isolated.

In Sweden, penicillin is the substance of choice for treatment of arthritis in pigs. All isolates of *S. equisimilis* were susceptible to penicillin and there is no report of penicillin resistance in beta-hemolytic streptococci. Resistance to tetracycline was the most common trait occurring in 23% of the isolates.

Cattle

Escherichia coli

Isolates of *Escherichia coli* are from the gastro-intestinal tract of calves.

Over the last decades there has been an increase in resistance in *E. coli* from calves. During 2007-2011, resistance to tetracycline was the most common trait occurring in 64% of the isolates followed by streptomycin occurring in 49% and ampicillin in 33% (Table Cattle I). Twenty eight isolates (40%) were multiresistant, of which all were resistant to streptomycin and all but three to tetracycline.

Two isolates from 2010 had MIC (2 mg/L) above the cut-off value of ceftiofur. These two isolates were not available for further investigation. Since the MIC was just above the cut-off value, the results are probably due to methodological error, or the isolates express chromosomal AmpC.

Pasteurella spp.

Isolates from years 1997-2000 are from a field study on respiratory pathogens in calves presented in SVARM 2000 and isolates from 2005-2011 are isolated from clinical submissions of samples from calves with respiratory disease or from post-mortem investigations of lungs.

Antimicrobial resistance among isolates of *Pasteurella* spp. is rare (Table Cattle II) and penicillin is considered the substance of choice for treatment of pneumonia in calves in Sweden. One isolate in 2009 and one in 2010 had MICs above the cut-off value for ceftiofur. This is most likely not a true value, since the MICs of penicillin was 0.12 mg/L and 0.25 mg/L, respectively.

Isolates of beta-lactamase producing *Pasteurella* spp. were confirmed in Sweden from one herd in 2003. Since 2005, resistance to penicillin and tetracycline, the substances commonly used for treatment of respiratory disease in calves, has not been detected in *Pasteurella* spp. However, in 2010 an isolate of beta-lactamase producing *Mannheimia haemolytica* from a calf with pneumonia was confirmed after post mortem investigation of the lungs. The isolate was susceptible for tetracycline, quinolones and cefotaxime. The herd was known to have respiratory problems and a few months later an isolate of *M. haemolytica* with the same resistance pattern was isolated from another calf, indicating that this strain persisted in the herd.

Over the years, the number of isolates available for susceptibility testing has been low. However, the number of tested isolates increased in 2011 due to a study within the SVARMpat programme. Frequent sampling of calves with respiratory disorders and subsequent susceptibility testing is desirable if emerging resistance is to be detected early.

TABLE CATTLE I. Resistance (%) in *Escherichia coli* from cattle 1992-2002, 2004 and 2005-2011. Distribution of MICs for isolates from 2007-2011. Isolates are from diagnostic submissions of faecal samples or samples taken post mortem from the gastro-intestinal tract, except isolates from 2004 which are from a study of both healthy and diseased calves.

	Resistance (%)				**Distribution** (%) **of MICs** (mg/L)									
Antimicrobial	**1992-02** n=220	**2004** n=87[h]	**2005-06** n=63	**2007-11** n=70	**≤0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**>32**
Ampicillin	24	29	32	33				1.4	45.7	20.0		32.9		
Ceftiofur[a]	0[g]	0	0	3		27.1	65.7	4.3	2.9					
Enrofloxacin[b]	10	14	13	10	90.0	2.9	2.9		4.3					
Florfenicol	0[g]	0	0	1					4.3	28.6	64.3	1.4	1.4	
Gentamicin[c]	5	0	0	1					82.9	15.7			1.4	
Neomycin	8	7	13	24						70.0	5.7		7.1	17.1
Streptomycin[d]	42	48	54	49						5.7	25.7	20.0		48.6
Tetracycline	31	37	49	64				12.9	15.7	5.7	1.4	64.3		
Trim/Sulph.[e,f]	11	10	21	17			80.0	2.9			17.1			

[a] Cut-off value >2 mg/L until 2006; [b] Cut-off value >0.25 mg/L until 2004; [c] Cut-off value >8 mg/L until 2001; [d] Cut-off value >32 mg/L until 2006; [e] Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim/sulphametoxazole); [f] Cut-off value >4 mg/L until 2006; [g] 16 isolates tested; [h] 1/3 of the isolates were from calves with diarrhoea.

TABLE CATTLE II. Resistance (%) in *Pasteurella* spp. from calves 1997-2000 and 2005-2011. Distribution of MICs for isolates from 2011. Isolates are from the respiratory tract, isolated from nasal swabs or from post mortem investigations of lungs.

Antimicrobial	Resistance (%)				Distribution (%) of MICs (mg/L)									
	1997-00 n=254	2005-07 n=27	2008-10 n=71	2011 n=80	≤0.06	0.12	0.25	0.5	1	2	4	8	16	>16
Ampicillin	1	0	0	0					100					
Ceftiofur	-	0	3[b]	0[d]			100							
Enrofloxacin	2	0	0[c]	0		92.5	7.5							
Florfenicol	-	0	0	0							100			
Penicillin	0	0	0	0		47.5	38.8	13.8						
Tetracycline	3	0	0	0					98.8	1.3				
Trim/Sulph.[a]	2	0	0	0				96.3	2.5	1.3				

[a] Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim/sulphametoxazole); [b] 65 isolates tested; [c] 46 isolates tested; [d] 76 isolates tested.

Farmed fish

Isolates of *Aeromonas salmonicida* subsp. *achromogenes*, *Flavobacter columnare* and *Flavobacter psychrophilum* are from clinical submissions of farmed fish. Most isolates represent a unique batch of fish but occasional isolates are duplicates within the same batch. Antimicrobial susceptibility was tested by microdilution according recommendations by Alderman & Smith (2001). At SVA this methodology is used for routine testing of isolates from clinical submissions of fish.

This year data for 14 isolates of *A. salmonicida* subsp. *achromogenes*, 8 of *F. columnare* and 27 of *F. psychrophilum* were available. As in previous years the majority of the two former bacterial species are from brown trout whereas most isolates of *F. psychrophilum* are from rainbow trout. Data for 2011, 2010 and 2009 are compiled and presented as distributions of MICs in Table Fish I.

At present there are no accepted interpretative criteria for MIC data of bacteria from aquaculture. But evaluation of the distributions of MICs indicates the presence of isolates with reduced susceptibility, i.e. deviating high MICs, (Table Fish I). For example, MIC distributions for the quinolone nalidixic acid are bimodal in all three bacterial species. This indicates the presence of acquired resistance to quinolones. Likewise deviating high MICs of tetracycline in *Flavobacter*, and of florfenicol among *A. salmonicida* and *F. columnare*, indicate acquired resistance. Resistance to these antimicrobials is reasonable since there is a limited therapeutic use of florfenicol as well as of tetracycline and of the quinolone oxolinic acid in aquaculture in Sweden.

TABLE FISH I. Distribution of MICs for *Aeromonas salmonicida* subsp. *achromogenes, Flavobacter columnare* and *Flavobacter psychrophilum* from farmed fish, 2005-2011.

Bacterial species	Antimicrobial	Year	Number of isolates	Distribution (%) of MICs (mg/L)									
				≤0.25	0.5	1	2	4	8	16	32	64	>64
Aeromonas salmonicida subsp. *achromogenes*	Florfenicol	2009-11	45				97.8			2.2			
		2005-08	87				96.6	2.3	1.1				
	Nalidixic acid	2009-11	45		80.0	2.2					2.2	6.7	8.9
		2005-08	87		80.5	4.6				1.1	3.4	5.7	4.6
	Tetracycline	2009-11	45	80.0	13.3	4.4				2.2			
		2005-08	87	90.8	8.0			1.1					
Flavobacter columnare	Florfenicol	2009-11	23				100						
		2005-08	46				95.7	2.2			2.2		
	Nalidixic acid	2009-11	23		78.3	13.0	4.3	4.3					
		2005-08	46		73.9	13.0	4.3				2.2	2.2	4.3
	Tetracycline	2009-11	23	73.9	26.1								
		2005-08	46	84.8	6.5	4.3		2.2			2.2		
Flavobacter psychrophilum	Florfenicol	2009-11	72				98.6		1.4				
		2005-08	69				98.6	1.4					
	Nalidixic acid	2009-11	72				16.7	26.4	4.2	1.4	4.2	6.9	40.3
		2005-08	69		7.2		37.7	39.1		1.4	1.4		13.0
	Tetracycline	2009-11	72	37.5	9.7	22.2	6.9	19.4	4.2				
		2005-08	69	72.5	5.8	5.8	7.2	5.8	1.4	1.4			

SVARMpat

THE SVARMPAT PROGRAMME (Swedish Veterinary Antimicrobial Resistance Monitoring – farm animal pathogens) is a project in co-operation between the National Veterinary Institute (SVA) and the Swedish Animal Health Service that was launched in 2005. It is financed by the Swedish Board of Agriculture.

The purpose of SVARMpat is to reduce emergence and spread of antimicrobial resistance in pathogenic bacteria from food-producing animals. The work is performed by monitoring and documenting antimicrobial resistance, by activities that increase knowledge of antimicrobial resistance and prudent use of antimicrobials, and by communication of knowledge generated within the programme.

Studies with sampling of animals and susceptibility testing of defined pathogens are performed. The programme also encourages practitioners to submission of samples from clinical cases and post mortem investigations. Such continuous clinical submissions yield isolates of *Actinobacillus pleuropneumoniae* and *Brachyspira* spp. from pigs and *Pasteurella* spp. from cattle and pigs, and susceptibility testing is performed within SVARMpat.

Activities in SVARMpat 2011:

- **Screening for MRSA in milk samples** from cows was started in 2010 and is still ongoing. Isolates of beta-lactamase producing *Staphylococcus aureus* from routine submissions to SVA are investigated for methicillin resistance. During 2010-2011, 311 isolates were tested but MRSA was not initially detected. However, when MRSA with a divergent *mecA* homologue, $mecA_{LGA251}$, was reported, the results were re-evaluated and in subsequent studies performed outside SVARMpat, three isolates from 2010 and one from 2011 were confirmed to be MRSA with $mecA_{LGA251}$ (See "Zoonotic bacteria").
- ***Mycoplasma bovis* in calves with pneumonia.** During 2010-2011, nasal swabs were taken from calves with respiratory symptoms. Samples were also taken at post mortem investigation of lungs from calves with pneumonia. Altogether, about 300 samples were investigated and during the autumn of 2011, *M. bovis* was detected in samples from three herds. Susceptibility testing of *M. bovis* was not performed since the methodology is not available at SVA. Due to the lack of cell wall in *M. bovis*, penicillin is not effective for treatment. In herds with *M. bovis* as the known causative agent of pneumonia in calves, preventive animal health measures and treatment regimes must be carefully considered.
- ***Mycoplasma ovipneumoniae* in sheep with pneumonia.** During 2010-2011, samples were taken at post mortem investigation of lungs from sheep with pneumonia. Altogether, 71 samples were investigated and in 23 *M. ovipneumoniae* was detected.
- **Investigation of microbial aetiology of infectious arthritis in nursing piglets** and the antimicrobial susceptibility of these bacteria. One lame piglet per herd with more than 100 sows was euthanized and an autopsy was performed together with bacteriological sampling of two affected joints. The study started in 2009 and was completed in 2011. Altogether, 130 piglets were analysed. *Streptococcus equisimilis* dominated the bacteriological findings, followed by *Staphylococcus hyicus* and *E. coli*. All streptococci (See "Animal pathogens"), but less than half of the staphylococci were susceptible to penicillin.
- **Exudative epidermitis in piglets.** In an ongoing study, piglets with exudative epidermitis are sampled and isolated strains of *Staphylococcus hyicus* are susceptibility tested. During 2011, samples from one pig per herd in six herds were investigated with findings of *S. hyicus* in five of them. Both strains with and without penicillinase production were isolated, sometimes from the same pig. This indicates that penicillin may not always be effective for treatment.
- **Otitis media in pigs.** A study on pigs with "head tilt" was initiated. Affected pigs are euthanized and autopsy performed. Bacteriological samples are taken from the middle ear, nose and sometimes brain. The aim is to increase the knowledge on presumed microbial etiology to this problem.
- **The PhD project "Vancomycin resistant enterococci in Swedish broilers"** was partly financed by SVARMpat. In the project, the spread of vancomycin resistant enterococci (VRE) in Swedish broilers since 2000 was investigated. The aim was to elucidate the epidemiology of VRE in broilers and, if possible, to mitigate further spread and reduce the prevalence on farms where VRE already occur. See also SVARM 2008 for details. The project started in 2007 and was completed during 2011 (See "Vancomycin resistant enterococci (VRE) in Swedish broiler production – a summary).
- **ESBL-producing *E. coli* in broilers.** Ongoing investigations on occurrence and epidemiology of ESBL-producing *E. coli* in broilers are partly financed by SVARMpat. In collaboration with the Swedish poultry meat association and the Board of Agriculture, occurrence of ESBL-producing *E. coli* in breeding animals imported to Sweden is monitored. Furthermore, several studies aiming at finding ways to mitigate spread of such bacteria in broiler production have been initiated.

Horses

Escherichia coli

The isolates of *Escherichia coli* included are from the genital tract of mares. As in previous years, resistance to trimethoprim-sulphonamides or streptomycin are the most common resistance traits (Table Horse I).

Trimethoprim-sulphonamide resistance is probably a consequence of the frequent use of this antimicrobial combination in horses. Since the introduction of trimethoprim-sulphonamides on the Swedish market, as an oral formulation for horses in the late 80s, the prevalence of resistance in *E. coli* has increased from only 2% in years 1992-1994 to 17% in 2011.

Multiresistance occurred in 11% of the isolates, a higher figure than in 2010. A majority of the multiresistant isolates were resistant to ampicillin, streptomycin and trimethoprim-sulphonamides. None of the isolates were resistant to more than four substances.

Resistance to ceftiofur was more common than in previous years. In 2011, eight isolates had MICs higher than 1 mg/L. Seven of these isolates were tested for ESBL production of which five were positive. Four of these isolates were positive when PCR was used to detect the gene for CTX-M-1 and the fifth for SHV. Besides being ESBL-producing, these *E. coli* were also resistant to gentamicin and trimethoprim-sulphonamide. The CTX-M-1 positive isolates were also resistant to tetracycline.

A majority of the ESBL producing *E. coli* from animals in Sweden isolated from diagnostic submissions are from the genital tract of mares. Close monitoring of the situation is therefore strongly warranted. For more information on occurrence of ESBL or pAmpC in Sweden; see highlights: "*Enterobacteriaceae* producing extended spectrum beta-lactamases (ESBL) – isolates from diagnostic submissions", "*Escherichia coli* with ESBL- or transferrable AmpC-type resistance in production animals" and "*Escherichia coli* with ESBL or pAmpC in meat obtained from the Swedish market".

Streptococcus zooepidemicus

The isolates included are from the respiratory tract of horses. As in previous years, resistance in *Streptococcus zooepidemicus* is rare (Table Horse II). Occurrence of resistance to trimethoprim-sulphonamides has been high during the last 15 years, probably due to the common use of oral trimethoprim-sulphonamide in horses. However, in 2011 only 8% of the isolates were resistant to this combination. The isolates were uniformly susceptible to penicillin but had a low inherent susceptibility to fluoroquinolones and aminoglycosides (i.e. gentamicin, neomycin and streptomycin). MICs for these substances are above concentrations that can be obtained during systemic therapy with these antimicrobials.

Staphylococcus aureus

The isolates of *Staphylococcus aureus* are from skin samples, excluding wounds and abscesses. The number of resistant isolates of *S. aureus* has been stable during the last three years and resistance to penicillin dominate (Table Horse III). None of the isolates were multiresistant.

One isolate had MIC >1 mg/L for oxacillin and was tested by PCR for the presence of the *mecA*-gene and was positive, i.e. methicillin resistant. More information on methicillin resistant *S. aureus* (MRSA) isolated from horses in Sweden is presented in the chapter "Zoonotic bacteria".

TABLE HORSE I. Resistance (%) in *Escherichia coli* from horses 1992-2011 and distribution of MICs for isolates from 2011. Isolates are from clinical submissions of samples from the female genital tract.

	Resistance (%)								**Distribution** (%) **of MICs** (mg/L)									
Antimicrobial	**1992-94** n=48	**1995-97** n=216	**1998-00** n=222	**2001-03** n=457	**2004-06** n=473	**2007-09** n=657	**2010** n=236	**2011** n=174	**≤0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**>32**
Ampicillin	15	17	10	9	7	10	7	12				1.1	12.1	58.6	16.1	12.1		
Ceftiofur	-	-	-	<1	<1	2	<1	5		37.4	53.4	4.6	1.1	3.4				
Enrofloxacin[a]	8	3	3	2	4	2	5	4	96.0	3.4	0.6							
Florfenicol	-	-	-	0	0	<1	<1	0					7.5	40.8	51.1	0.6		
Gentamicin[b]	0	3	6	6	2	4	2	5					93.1	1.7		0.6	4.6	
Neomycin	4	5	5	3	4	2	1	2						94.3	3.4	0.6		1.7
Streptomycin[c]	31	24	21	23	21	21	15	20						25.3	44.8	9.8	2.3	17.8
Tetracycline	6	5	9	6	8	7	5	8				35.1	54.0	2.9		8.0		
Trim-Sulph.[d, e]	2	15	17	18	17	20	13	17			81.0	1.7			17.2			

[a] Cut-off value >0.25 mg/L until 2002; [b] Cut-off value >8 mg/L until 2002; [c] Cut-off value >16 mg/L until 2001¸ [d] Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim-sulphametoxazole); [e] Cut-off value >4 mg/L until 2001.

TABLE HORSE II. Resistance (%) in *Streptococcus zooepidemicus* from horses 1992-2011 and distribution of MICs for isolates from 2011. Isolates are from clinical submissions of samples from the respiratory tract.

	Resistance (%)								**Distribution** (%) **of MICs** (mg/L)									
Antimicrobial	**1992-94** n=218	**1995-97** n=402	**1998-00** n=409	**2001-03** n=505	**2004-06** n=534	**2007-09** n=491	**2010** n=43	**2011** n=131	**≤0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**>32**
Ampicillin	0	<1	0	0	0	0	0	0				100						
Enrofloxacin	NR[a]	NR	NR	NR	NR	NR	NR	NR			0.8	48.9	50.4					
Florfenicol	-	-	-	1	<1	0	0	2					95.4	0.8	2.3	1.5		
Gentamicin	NR	NR	NR	NR	NR	NR	NR	NR					1.5	1.5	31.3	57.3	8.4	
Penicillin	0	<1	0	0	0	0	0	0	98.5	1.5								
Spiramycin	<1	1	0	1	<1	<1	0	0						99.2	0.8			
Tetracycline	4	3	4	5	3	3	7	4				51.1	33.6	9.2	2.3	3.8		
Trim-Sulph.[b]	1	11	57	36	42	18	7	8			82.4	6.1	2.3	0.8	8.4			

[a] NR= Not relevant as the inherent susceptibility is above concentrations that can be obtained during therapy; [b] Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim-sulphametoxazole).

TABLE HORSE III. Resistance (%) in *Staphylococcus aureus* from horses 2007-2011 and distribution of MICs for isolates from 2011. Isolates are from clinical submissions of samples from skin.

	Resistance (%)					**Distribution** (%) **of MICs** (mg/L)								
Antimicrobial	**2007** n=113	**2008** n=99	**2009** n=96	**2010** n=131	**2011** n=135	**≤0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**>32**
Ceftiofur	0	2	2	<1	2		5.9	5.9	72.6	14.1	1.5				
Enrofloxacin	3	2	2	2	0	47.4	48.1	4.4							
Florfenicol	2	3	1	<1	0					4.4	84.4	11.1			
Gentamicin	9	7	6	4	5					95.6	1.5			3.0	
Oxacillin	-	-	2	<1	<1			97.8	1.5	0.7					
Penicillin[a]	26	36	36	21	20										
Spiramycin	1	0	0	0	0						80.7	16.3	3.0		
Streptomycin	12	14	9	5	4						62.2	28.1	5.2	0.7	3.7
Tetracycline	2	6	4	<1	3				97.0	2.2			0.7		
Trim-Sulph.[b]	4	5	3	2	4			96.3	1.5	0.7		1.5			

[a]Denotes beta-lactamase production; [b] Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim-sulphametoxazole).

Dogs

Escherichia coli

Isolates of *Escherichia coli* are from samples of urine, submitted either as urine or as dip-slide cultures. In 2011, there were no changes in resistance levels compared to previous years (Table Dog I), and resistance to ampicillin was the most common trait.

The isolates were tested for susceptibility to cefotaxime as an indicator of ESBL production. The ten isolates with MIC of cefotaxime >0.5 mg/L were further tested and all were confirmed AmpC-producing. For more information on occurrence of ESBL or pAmpC in Sweden see highlights:"*Enterobacteriaceae* producing extended spectrum beta-lactamases (ESBL)–isolates from diagnostic submissions", "*Escherichia coli* with ESBL- or transferrable AmpC-type resistance in production animals" and "*Escherichia coli* with ESBL or pAmpC in meat obtained from the Swedish market".

Multiresistance occurred in 5% of the isolates and this figure is on the same level as last year. Of the multiresistant isolates, 56% were resistant to at least ampicillin, trimethoprim-sulphonamide and tetracycline. Only three *E. coli*-isolates were resistant to five or more antimicrobials i.e. <1% of all isolates.

Staphylococcus pseudintermedius

Isolates of *Staphylococcus pseudintermedius* included are from skin samples. In 2005, *S. pseudintermedius*, a novel staphylococcal species was described (Devriese et al., 2005). Further on Sasaki et al. (2007) and Bannoehr et al. (2007) reported that canine strains of *S. intermedius* should be classified as *S. pseudintermedius*. Therefore, it was proposed to report strains from dogs as *S. pseudintermedius*, unless genomic investigations prove that the strain belongs to another related species (Devriese et al., 2009). Consequently, resistance data on *S. intermedius* from previous SVARM reports should be regarded as resistance data on *S. pseudintermedius*.

As in previous years, the prevalence of resistance to penicillin due to production of beta-lactamases (penicillinase) in *S.*

TABLE DOG I. Resistance (%) in *Escherichia coli* from dogs 1992-2011 and distribution of MICs for isolates from 2011. Isolates are from clinical submissions of urinary tract samples.

Antimicrobial	Resistance (%)								Distribution (%) of MICs (mg/L)									
	1992-94 n=245	1995-97 n=296	1998-00 n=418	2001-03 n=621	2004-06 n=917	2007-09 n=1527	2010 n=803	2011 n=661	≤0.12	0.25	0.5	1	2	4	8	16	32	>32
Ampicillin	18	18	18	18	19	15	14	16				1.0	42.9	38.4	1.8	16.0		
Cefotaxime	-	-	-	-	-	<1	2	2			98.2	0.3	1.5					
Enrofloxacin[a]	9	9	10	9	10	8	8	10	90.0	3.1	2.9	1.5	0.3	0.3	1.9			
Gentamicin[b]	2	1	2	2	1	1	1	<1					97.0	2.2	0.5		0.3	
Nitrofurantoin	3	3	1	2	2	1	1	<1								97.5	1.6	0.8
Polymyxin B	-	-	-	-	-	4	3	4					96.3	2.5	1.2			
Tetracycline	16	14	12	11	10	8	8	7				16.3	70.8	5.7	0.3	7.0		
Trim-Sulph[c].	9	8	11	13	15	9	5	8			91.0	1.4	0.3	0.3	7.1			

[a] Cut-off value >0.25 mg/L until 2002; [b] Cut-off value >8 mg/L until 2001; [c] Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim-sulphametoxazole) and cut-off value >4 mg/L until 2001.

pseudintermedius is high, 84% (Table Dog II). Already in the late 70s, 70% of *S. pseudintermedius* were resistant to penicillin (Franklin, 1978) and during the last two decades, the resistance frequency has been around 80-90%. Besides penicillin, resistance to clindamycin, erythromycin, fusidic acid or tetracycline was common in 2011, as in previous years.

At SVA, all isolates of *S. pseudintermedius* with oxacillin MIC >0.5 mg/L are examined for *mecA* gene with PCR (see Appendix 3 for details). In this material 8 isolates (2%) had MICs above this breakpoint and in seven of these the *mecA* gene was detected. The CLSI breakpoint for *S. pseudintermedius* (>0.25 mg/L) is not applicable on this data because of the oxacillin range in the microdilution panels used. For further information on MRSP, see highlight on "Methicillin resistant *S. pseudintermedius*".

Multiresistance occurred in 36% of the isolates. Twenty seven isolates (7%) were resistant to five or more antimicrobials and a third of these were MRSP. Resistance to penicillin, clindamycin and erythromycin was the most common phenotype, occurring in 66% of multiresistant isolates. Almost a third of these were also resistant to tetracycline. Macrolide resistance in *S. pseudintermedius* is commonly mediated by *erm*-genes, and if these genes are constitutively expressed, the bacteria will be resistant also to lincosamides (clindamycin) and streptogramin B. In this material, 77% of isolates resistant to erythromycin were also resistant to clindamycin. Resistance to enrofloxacin occurred mainly in multiresistant phenotypes.

In this material, there is a high probability of bias towards dogs with recurrent skin infections, previously treated with antimicrobials which could explain the high levels of resistance. A prospective study by Holm et al., (2002) showed higher levels of multiresistance among isolates from recurrent compared to those from first-time pyoderma. Pyoderma is a common cause for dog owners to seek veterinary consulta-

TABLE DOG II. Resistance (%) in *Staphylococcus pseudintermedius* from dogs 1992-2011 and distribution of MICs for isolates from 2011. Isolates are from clinical submissions of samples from skin.

Antimicrobial	Resistance (%)								Distribution (%) of MICs (mg/L)									
	1992-94 n=304	1995-97 n=322	1998-00 n=433	2001-03 n=382	2004-06 n=374	2007-09 n=859	2010 n=444	2011 n=388	≤0.12	0.25	0.5	1	2	4	8	16	32	>32
Cephalothin	<1	<1	0	1	1	3	4	2					97.7	0.3	2.1			
Clindamycin	12	20	21	18	19	23	26	24				74.7		1.0	24.2			
Enrofloxacin	-	-	-	2[e]	2	5	6	6	60.3	30.2	3.9	3.1	0.8		1.8			
Erythromycin[a]	21	28	27	24	26	28	30	30			69.3	0.3			30.4			
Fusidic acid	9	14	20	20	25	24	20	24					74.7	1.8	23.5			
Gentamicin	<1	<1	<1	0	1	3	3	2					96.9	0.8	1.5	0.8		
Nitrofurantoin	1	1	<1	1	<1	<1	2	1								98.2	0.5	1.3
Oxacillin	1	2	1	2	2	1	4	2			97.7	0.3	2.1					
Penicillin[b]	79	80	80	80	84	87	86	84										
Tetracycline	24	12	28	25[g]	32	30	31	26				72.7	1.3	0.3		25.8		
Trim-Sulph[c]	1	2	1	3	6	5	6	6			69.1	24.5	0.5	0.8	5.2			

[a]Cut-off value >4 mg/L until 2001; [b] Denotes betalactamase production; [c] Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim-sulphamethoxazole).

tion and this condition is often treated with clindamycin or cephalosporins. Fortunately, sales of antimicrobials for dogs continue to decline (See 'Use of antimicrobials'). To control the resistance situation in *S. pseudintermedius*, a prudent use of antimicrobials together with an effective infection control programme is of highest priority.

Pseudomonas aeruginosa

Isolates of *Pseudomonas aeruginosa* are from samples from the external ear canal. This bacterial species is considered clinically resistant to e.g. trimethoprim-sulphonamides, tetracyclines and aminopenicillins (including combinations with clavulanic acid). Fluoroquinolones, gentamicin and polymyxin B, are substances often used to treat pseudomonal ear infections in dogs and, the susceptibility data of these substances are, therefore, presented in Table Dog III. All isolates were susceptible to polymyxin B. However, resistance to gentamicin or enrofloxacin occurred and one isolate was resistant to both substances.

In addition, the maximum plasma concentration (C_{max}) of the fluoroquinolones currently licensed for use in dogs in Sweden, after oral treatment at the label dosage, ranges from 1.5-2.5 mg/L. To have beneficial effect of treatment, the C_{max} to MIC ratio should preferably be >4 (Walker & Dowling, 2006). It is clear that the ratio will not be reached in most infection sites after systemic administration even for the more susceptible isolates.

TABLE DOG III. Resistance (%) in *Pseudomonas aeruginosa* from dogs years 2002-2003, 2009-2011, and distribution of MICs for isolates from 2011. Isolates are from clinical submissions of samples from the ear canal of dogs.

Antimicrobial	**Resistance** (%)				**Distribution** (%) **of MICs** (mg/L)									
	2002-03 n=234	**2009** n=261	**2010** n=313	**2011** n=353	**≤0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**>32**
Enrofloxacin	NA[a]	25	20	12	1.4	1.7	11.3	48.7	24.6	6.5	5.7			
Gentamicin	9	5	2	2					81.3	12.5	4.2	1.1	0.8	
Polymyxin B	-	0	0	0					96.5	3.5				

[a]NA= not applicable because of the range of enrofloxacin concentrations tested.

Methicillin resistant *Staphylococcus pseudintermedius* (MRSP)

THE FIRST METHICILLIN RESISTANT *S. pseudintermedius* (MRSP) isolated in Sweden was from a healthy dog in a screening for methicillin resistant *S. aureus* in 2006 and since 2008, methicillin resistant coagulase positive staphylococci are notifiable in Sweden. On suspicion of MRSP, diagnostic laboratories are advised to send the isolates to the National Veterinary Institute (SVA) for confirmation by PCR of the presence of *mecA* gene.

The number of MRSP isolates notified to the Board of Agriculture in Sweden since 2008 is shown in Figure. Data for 2006-2007 in the figure, before MRSP was notifiable, correspond to the number of isolates sent to SVA and confirmed *mecA*-positive. MRSP have mostly been isolated from dogs but also from a few cats and two horses. The notified numbers have declined during the last two years but if there is a true reduction in the number of animals infected with MRSP is uncertain.

In 2011, 60 MRSP isolates were confirmed at SVA: 59 dogs and one cat. In 26% of the cases, MRSP were isolated from skin samples, 21% were isolated from wounds and the rest originated from miscellaneous sampling sites. Of the isolates from skin and wounds, 29 were randomly selected for further analyses. A majority of the 29 isolates (26) belonged to *spa*-type t02 and carried staphylococcal chromosomal cassette (SCC) *mec* II-III. One isolated belonged to *spa*-type t29 with SCC*mec* II-III while the other two isolates were non-typeable with *spa*-typing and had SCC*mec* II-III and a non-typeable SCC*mec*, respectively. Pulsed field gel electrophoresis (PFGE) analysis of 20 isolates of the 29 revealed that isolates in Sweden are related and that they display a high relatedness with the European clone ST71-J-t02-II-III described by Perreten and co-workers (2010).

Of the 29 isolates from 2011 tested further 12 (41%) were susceptible to chloramphenicol, tetracycline and fusidic acid, eight were susceptible to chloramphenicol, tetracycline, fusidic acid and gentamicin while three isolates were susceptible to tetracycline, fusidic acid and gentamicin. The other six isolates displayed varied antibiograms but they were all multiresistant.

In 2006 and 2007, most of the MRSP isolates had a characteristic antibiogram, being susceptible only to two of the substances in Sweden licensed for use in dogs i.e.: fusidic acid and tetracycline (SVARM 2007). In 2008, the first isolates resistant to tetracycline were detected. In 2011, of the 29 isolates tested further, two isolates were resistant to tetracycline and three were resistant to fusidic acid. One isolate was resistant to both these substances but on the other hand susceptible to fluoroquinolones.

Since the first cases of MRSP, there have been active discussions among veterinarians on how to prevent further spread and how to correctly use antimicrobials. For instance, in many animal clinics and hospitals, infection control programmes have been implemented with focus on strict hand hygiene routines. Also, veterinarians, with special interest in dermatology have agreed on an antimicrobial policy for treatment of dogs with dermatological disorders.

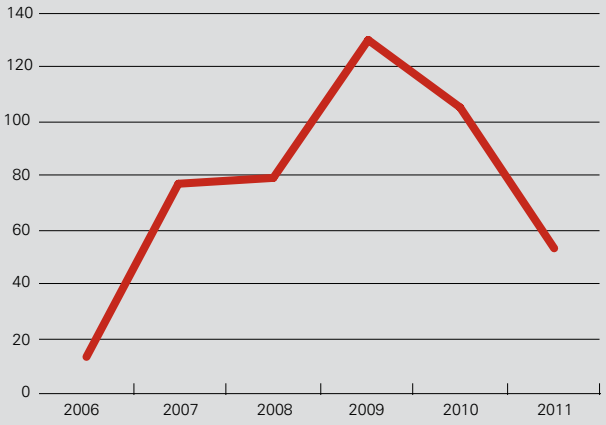


FIGURE. The number of cases of methicillin resistant *Staphylococcus pseudintermedius* notified to the Swedish Board of Agriculture 2008-2011. Data for 2006-2007 represent isolates that were sent to SVA and confirmed *mecA* positive.

Cats

Escherichia coli

Isolates of *Escherichia coli* are from samples of urine, submitted either as urine or as dip-slide cultures. Resistance to ampicillin was the most common trait (Table Cat I).

In 2011, 3% of the isolates were multiresistant and this figure is on the same level as last year. The most common resistance traits among the multiresistant isolates were; ampicillin, trimethoprim-sulphonamides and tetracycline which occurred in 44% of these isolates. None of the isolates were resistant to five or more antimicrobials.

One isolate had a MIC >1 mg/L of cefotaxime and was confirmed as ESBL-producing. For more information on occurrence of ESBL or pAmpC in Sweden see highlights:"*Enterobacteriaceae* producing extended spectrum beta-lactamases (ESBL) – isolates from diagnostic submissions", "*Escherichia coli* with ESBL- or transferrable AmpC-type resistance in production animals" and "*Escherichia coli* with ESBL or pAmpC in meat obtained from the Swedish market".

Cats with symptoms from the urinary tract are often treated with aminopenicillins or fluoroquinolones. This year, six isolates were resistant to both these antimicrobials, i.e. about 1.5% of all isolates. However, bacterial urinary tract infections are rare in cats and other causative agents or underlying causes have to be investigated prior to antimicrobial treatment.

Beta-hemolytic streptococci

The most commonly isolated species of beta-hemolytic streptococci in cats is *Streptococcus canis* (Lancefield group G). This is true both for healthy cats and cats with signs of infection. Streptococci isolated from clinical samples from cats submitted to SVA are not identified to species level and therefore antimicrobial susceptibility data for the group beta-hemolytic streptococci are presented (Table Cat II). In cats *S. canis* can cause a variety of infections such as metritis, mastitis, skin infections and septicemia in kittens. The isolates of beta-hemolytic streptococci included are from infections in various organs of cats for example the ears, the upper airways and the urogenital tract.

True penicillin resistance has never been reported for any beta-hemolytic streptococci. Recently, however, decreased susceptibility in *S. agalactiae* (Lancefield group B) has been associated to mutations causing amino acid substitutions in penicillin binding protein 2X (Kimura et al., 2008). Nonetheless these are very rare isolates and if reduced susceptibility to penicillin is recorded in any beta-hemolytic streptococci a renewed species identification and susceptibility test should be performed. One of the isolates included was penicillin resistant (MIC >1 mg/L) and the resistance phenotype indicates that this can most likely be explained by an enterococcal species mistakenly identified as a beta-hemolytic streptococci. Because the isolate was not saved this could not be verified. If this isolate is discounted all isolates were susceptible to beta-lactam antibiotics and only one isolate was resistant to trimethoprim-sulphametoxazole. Clindamycin resistance was recorded in 14% of the isolates. All of these were also resistant to erythromycin and with the exception of one isolate also to tetracycline. Such coupled resistance in *Streptococcus* spp. is typically caused by *erm* and *tet* genes carried together on transposons. The highest occurrence of resistance was to tetracycline (32%).

Beta-hemolytic streptococci have a low inherent susceptibility to fluoroquinolones and aminoglycosides and it can be observed that MICs are above concentrations that can be obtained during systemic therapy with these antimicrobials.

TABLE CAT I. Resistance (%) in *Escherichia coli* from cats 1992-2011 and distribution of MICs for isolates from 2011. Isolates are from clinical submissions of urine samples.

Antimicrobial	Resistance (%)							Distribution (%) of MICs (mg/L)									
	1992-94 n=61	1998-00 n=74	2001-03 n=135	2004-06 n=224	2007-09 n=546	2010 n=236	2011 n=273	≤0.12	0.25	0.5	1	2	4	8	16	32	>32
Ampicillin	26	34	27	22	18	17	17				3.3	51.6	26.7	1.5	16.8		
Cefotaxime	-	-	-	-	3	1	2			98.2	1.5	0.4					
Enrofloxacin[a]	5	8	13	7	7	8	5	95.2	1.5	1.5	0.7	1.1					
Gentamicin[b]	0	3	-	-	1	<1	0					99.3	0.7				
Nitrofurantoin	2	2	1	3	1	1	3								96.0	1.5	2.6
Polymyxin B	-	-	-	-	6	3	4					96.0	2.9	1.1			
Tetracycline	28	16	16	14	8	6	8				23.8	64.5	3.7	0.4	7.7		
Trim-Sulph.[c]	7	10	15	7	5	4	3			96.3	0.4	0.7	0.4	2.2			

[a] Cut-off value >0.25 (mg/L) until 2002; [b] Cut-off value >8 mg/L until 2001; [c] Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim-sulphamethoxazole), cut-off value >4 mg/L until 2001.

TABLE CAT II. Resistance (%) in beta-hemolytic streptococci from cats 2007-2011 and distribution of MICs for isolates from 2011. Isolates are from clinical submissions of samples from cats.

Antimicrobial	**Resistance** (%)	**Distribution** (%) **of MICs** (mg/L)									
	2007-11 n=184	**≤0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**>32**
Ampicillin	0				100						
Clindamycin	14				85.9			14.1			
Enrofloxacin	NR	1.6	0.5	21.2	65.8	10.9					
Erythromycin	15			81.5	1.1	1.1	1.1	15.2			
Gentamicin	NR					12.0	47.3	34.2	6.5		
Nitrofurantoin	2								96.7	1.6	1.6
Penicillin	<1	96.8	2.7			0.5					
Tetracycline	32				23.9	35.3	8.2	1.1	31.5		
Trim/Sulph.[a]	1			96.2	2.7			1.1			

[a] Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim/sulphametoxazole); b NR= Not relevant as the inherent susceptibility is above concentrations that can be obtained during therapy.

Enterobacteriaceae producing extended spectrum beta-lactamases (ESBL) – isolates from diagnostic submissions

THIS HIGHLIGHT SUMMARISES information on ESBL producing bacterial isolates from diagnostic submissions. The isolates were referred to the Section of Antibiotics at SVA from other laboratories because of phenotypic resistance to third generation cephalosporins. The number of confirmed ESBL producing bacteria per year and animal species is shown in Table ESBL below.

In 2011, 14 isolates (from 13 horses) resistant to third generation cephalosporins were sent to SVA. All were confirmed phenotypically to be ESBL-producing; nine Escherichia coli and five *Enterobacter* spp. Of these, one *E. coli* isolate and two *Enterobacter cloacae* isolates produced both ESBL and AmpC. From one horse, both ESBL-producing *E. coli* and *Enterobacter* spp. were isolated. In six horses, the ESBL-producing bacteria originated from wound samples, five isolates were from the female genital tract and the remaining three isolates were from eyes and of unknown origin. All isolates were resistant to trimethoprim, sulphonamide and gentamicin. Resistance to tetracycline was found in 13 of the isolates and three isolates were resistant to fluoroquinolones. All isolates were susceptible to colistin and to florfenicol if the epidemiological cut-off (>16 mg/L) for *E. coli* is used to define resistance also in *Enterobacter* spp.

From dogs, 22 isolates resistant to third generation cephalosporins were sent to SVA during 2011 and nine of them were confirmed being phenotypically ESBL-producing (7 *E. coli*, 1 *Enterobacter cloacae*, and 1 *Enterobacter aerogenes*) and two isolates of *E. coli* were AmpC-producing (CMY-2).

Four of the ESBL-producing isolates originated from urine samples, two were of unknown origin while the others were isolated from various sites: furuncle, eye, vagina and peritoneum. Eight isolates were resistant to fluoroquinolones, five to trimethoprim and six to sulphonamides. One isolate of *Enterobacter cloacae* was resistant to gentamicin and chloramphenicol if the clinical breakpoint of >8 mg/L is used for the latter substance. All isolates were susceptible to colistin.
During 2011, one isolate of ESBL-producing *Klebsiella pneumoniae* was isolated from an abscess in a cat. This isolate was resistant to fluoroquinolones, tetracycline, trimethoprim and sulphonamide and was susceptible to gentamicin, chloramphenicol and colistin.

Routine diagnostic laboratories are advised to submit isolates of *Enterobacteriaceae* phenotypically resistant to third generation cephalosporins to the Section of Antibiotics at SVA, where confirmatory phenotypic and genotypic tests for ESBL and AmpC are performed (See Appendix 3). In a clinical condition where the patient needs to be treated with antimicrobials, multiresistant *Enterobacteriaceae* pose a challenge for the veterinarian, especially in horses, since the number of antimicrobials licensed is limited. Increased awareness of the need for infection control and antimicrobial stewardship is essential to minimize the spread of these resistant bacteria.

TABLE ESBL. Number of extended spectrum beta-lactamases (ESBL) producing *Enterobacteriaceae* isolated from diagnostic submissions from animals during 2008-2011.

Animal species	Bacterial species	2008	2009	2010	2011
Cats	*Enterobacter* spp.				
	Escherichia coli			2	
	Klebsiella oxytoca			1	
	Klebsiella pneumoniae				1
Dogs	*Enterobacter* spp.		1	2	2
	Escherichia coli	1		1	7
	Klebsiella pneumoniae		1		
Horses	*Enterobacter* spp.		1	3	5
	Escherichia coli	2	3	7	9
	Klebsiella pneumoniae		1	1	
	Escherichia hermanii			1	

Appendix 1: Demographic data

AGRICULTURAL STATISTICS are provided by Statistics Sweden in collaboration with the Board of Agriculture and published annually as a Yearbook of Agricultural Statistics and continuously as Statistical Messages (SM). The Yearbook and Statistical Messages are available on the Internet via the websites for Statistics Sweden (www.scb.se) or the Board of Agriculture (www.sjv.se).

Annual figures on number of animals and holdings are given in Table AP1 I & II, and on numbers and volumes of animals slaughtered in Table AP1 III & IV. Details on methodology as well as comments on the data can be found in the respective data sources.

Briefly, the total number of dairy cows, pigs and laying hens has decreased notably over the last three decades concomitantly with an increase in herd size. In the same period, the number of beef cows, sheep and chickens reared for slaughtered has increased. Data on horses are not available all years but since 2004 the number of horses has increased substantially.

TABLE AP1 I. Number of livestock and horses (in thousands) 1980-2011 (Yearbook of Agricultural Statistics Sweden 2001 & 2011 and Statistical Message JO 20 SM 1102 & JO 24 SM 1101).

Animal Species	1980[a]	1985[a]	1990	1995	2000	2005	2009	2010	2011
Cattle									
Dairy cows	656	646	576	482	428	393	357	348	346
Beef cows	71	59	75	157	167	177	192	197	196
Other cattle >1 year	614	570	544	596	589	527	502	512	495
Calves <1 year	595	563	524	542	500	508	488	479	475
Total, cattle	1 935	1 837	1 718	1 777	1 684	1 605	1 538	1 537	1 512
Sheep									
Ewes & rams	161	173	162	195	198	222	254	273	297
Lambs	231	252	244	266	234	249	287	292	326
Total, sheep	392	425	406	462	432	471	540	565	623
Pigs									
Boars & sows	290	260	230	245	206	188	160	156	153
Fattening pigs >20 kg [b]	1 254	1 127	1 025	1 300	1 146	1 085	943	937	901
Piglets <20kg [c]	1 170	1 113	1 009	769	566	539	426	427	429
Total, pigs	2 714	2 500	2 264	2 313	1 918	1 811	1 529	1 520	1 483
Laying hens									
Hens	5 937	6 548	6 392	6 100	5 670	5 065	5 261	6 061	6 376
Chickens reared for laying	2 636	2 159	2 176	1 812	1 654	1 697	1 898	1 647	1 828
Total, hens	8 573	8 708	8 568	7 912	7 324	6 762	7 159	7 707	8 204
Turkeys									
Total, turkeys						122		130	
Horses									
Total, horses						283[d]		363	

[a] For 1980 and 1985 only cattle and sheep at premises with more than 2 ha counted; [b] Before 1995, the figure denotes pigs above 3 months of age; [c] Before 1995, the figure denotes pigs below 3 months of age; [d] Data from 2004.

TABLE AP1 II. Number of holdings with animals of different types, 1980-2009 (Yearbook of Agricultural Statistics, Sweden 2001 & 2011 and Statistical Message JO 20 SM 1102 & JO 24 SM 1101).

Animal Species	1980	1985	1990	1995	2000	2005	2009	2010	2011
Cattle									
Dairy cows	44 143	35 063	25 921	17 743	12 676	8 548	6 020	5 619	5 260
Beef cows	12 436	10 310	10 883	17 069	13 861	12 821	11 922	12 190	11 809
Other cattle >1 year	63 179	52 652	42 696	39 160	30 457	24 808	20 330	20 295	19 107
Calves <1 year	62 314	52 001	41 986	36 542	27 733	22 888	18 965	18 494	17 721
Total holdings with cattle	70 503	58 872	47 292	41 990	32 063	26 179	21 733	21 586	20 503
Sheep	10 238	10 595	9 749	10 037	8 089	7 653	8 245	8 657	9 449
Pigs	26 122	19 937	14 301	10 753	4 809	2 794	2027	1 695	1 515
Laying hens	23 603	17 531	12 900	9 593	5 678	4 916	3 306	3 703	3 827
Chickens reared for laying	5 093	2 714	1 875	1 405	715	634	573	487	733
Broilers						234	183	181	202
Turkeys						383		102	
Horses						56 000[a]		78 000	

[a] Data from 2004.

TABLE AP1 III. Number of animals slaughtered (in thousands) at slaughterhouses, 1980-2009. (Yearbook of Agricultural Statistics, Sweden 1981, 1986, 1991 & 2009 and Statistical Message JO 48 SM 1203).

Animal Species	1980	1985	1990	1995	2000	2005	2009	2010	2011
Cattle									
Cattle >1 year	574	584	523	502	490	433	430	425	429
Calves < 1 year	130	152	70	30	39	33	29	27	27
Total, cattle	704	736	593	532	529	466	459	453	456
Sheep	302	328	280	189	202	206	255	255	262
Pigs	4 153	4 283	3 653	3 743	3 251	3 160	2 956	2 936	2 845
Broilers	40 466[a]	36 410[a]	38 577[a]	61 313	68 617	73 458	73 504	78 507	78 182
Turkeys							477	495	574

[a] Data supplied by the National Food Administration.

TABLE AP1 IV. Quantity of livestock slaughtered (in 1000 tonnes) at slaughterhouses, 1990-2009 (Yearbook of Agricultural Statistics, Sweden 1991 & 2009 and Statistical Message JO 48 SM 1202).

Animal Species	1990	1995	2000	2004	2005	2009	2010	2011
Cattle								
Cattle >1 year	139.5	140.1	145.4	137.8	131.4	135.4	133.5	133.5
Calves < 1 year	6.8	3.2	4.4	4.6	4.5	4.6	4.3	4.4
Total, cattle	146.3	143.3	149.8	142.4	135.9	140.0	137.8	138.2
Sheep	5.0	3.5	3.9	3.8	4.1	5.1	5.0	5.1
Pigs	293.1	308.8	277.0	294.5	275.1	261.7	263.5	256.1
Broilers	44.0[a]	73.6[a]	89.9	91.2	96.2	105.2	112.0	111.5
Turkeys						3.0	3.2	3.7

[a] Data supplied by the National Food Administration.

Appendix 2: Materials and methods, use of antimicrobials

Legal framework and distribution of medicines

Marketing of drugs in Sweden is regulated by the Medicinal products act, which applies both to human and veterinary medicinal products (VMPs). According to this Act, a medicinal product may not be sold until it has been granted marketing authorisation by the Medical Products Agency (MPA). In case there are no authorised veterinary medicinal products for a certain condition, the MPA can permit special license prescription for a VMP for a specified pharmacy and prescriber. VMPs have to be dispensed through pharmacies, which are supplied by drug wholesalers or manufacturers. Veterinarians are not allowed to sell VMPs but may deliver products to the animal care-taker in relation to examination of a case, however, for self cost (no profit). Veterinarians are not permitted to own a pharmacy.

Antimicrobial drugs for veterinary use, including medicated feed, may only be sold on prescription.

All pharmacies in Sweden are required to provide prescription statistics on a daily basis to an infrastructure company owned by the state: Apotekens Service. For VMPs, the animal species as given on the prescription is also recorded, unless the product is sold for use in veterinary practice. Apotekens Service maintains a database and provides statistics to the competent national and regional authorities and to others on a commercial basis.

Feed mills may only mix antimicrobials in feed if they are controlled and authorised by the Swedish Board of Agriculture. The feed mills normally acquired the antimicrobial VMPs from a pharmacy. All quantities of VMPs used by feed mills are reported yearly to the Board of Agriculture as part of the feed control. Mixing of antimicrobials in feed may also take place on farms; provided that the Board of Agriculture has inspected and authorised the establishment for the purpose. In such cases, the premix is sold by a pharmacy following prescriptions from a veterinarian.

Data sources and inclusion criteria

Raw data on sales is obtained from Apotekens Service and represent the sales of antimicrobial VMPs sold by pharmacies. For the overall statistics (Table AC I-III), the data include all antimicrobial VMPs marketed in Sweden and sold for use in terrestrial animals in the ATCvet classes QA, QG and QJ. Previously, most antimicrobial VMPs sold with special license (products prescribed and sold on exemption from general Swedish market authorization) were also included. However, in 2011 it was noticed that the information on sales of products with special license was less complete than in previous years (see comments in chapter on use of antimicrobials). Medicinal products authorised for human use but prescribed for use in animals is not included in the overall statistics.

The ionophoric antibiotics are presently regulated as feed additives and not sold through pharmacies and are not included in the statistics from Apotekens Service. However, the Board of Agriculture collects figures on sales of ionophores from the feed mills as a part of the feed control system. As the source differs, data on ionophores are given only in Table AC III.

Data for year 2011 published by the Board of Agriculture is used to present the repartition of the sales per category of animals (Table IV) (www.jordbruksverket.se). The data include VMPs in the same ATCvet classes as given above and in addition products authorised for human use but sold for use in animals for the corresponding classes are included. The attribution to species is done using data from electronic records of prescriptions from pharmacies. Efforts are made to assign the sales of products sold for use in veterinary practice to species or to a category of animals (companion or food producing animals) as far as possible, using information on e.g. which animal species a particular product is authorised for.

The electronic records on animal species as specified on the prescription are also used to obtain data on number of prescriptions and packages sold specifically for use in dogs. That dataset closely corresponds to what is called “out-patient use”.

The data coverage is assumed to be very high. In rare cases, premixes mixed in medicated feed may be delivered from feed mills without the sales being recorded by a pharmacy. Examination of the reports by all feed mills to the Board of Agriculture shows that this happened only once during 2005-2009 (a total quantity of 40 kg active substance). In addition, as mentioned some drugs sold on special licence have not been captured in 2011.

Analysis and reporting of data

Data are retrieved as number of packages sold per product presentation and per animal species, if recorded. Calculation to kg active substance is done based on product information obtained from the national product register of the MPA.

Data on sales of antimicrobials for animals has been analysed and reported by the SVA since 1980. SVA is responsible for monitoring antimicrobial resistance but not of use, but still monitors use to support work on its mandate to stimulate rational use of antimicrobials. Statistics on usage is published in English in the yearly reports of the Swedish Veterinary Antimicrobial Resistance Monitoring programme. Since 2005, the Board of Agriculture is responsible for statistics on use of certain veterinary medicinal products, including antimicrobials. Board of Agriculture publishes the results in Swedish in an electronic report on sales of certain drugs for animals. Data are reported by companion or production animals (including horses), and to the extent possible also by specific animal species.

Appendix 3: Materials and methods, resistance monitoring

Sampling strategy

Zoonotic bacteria

Salmonella

Salmonellosis in animals is a notifiable disease in Sweden and isolates from each notified incident must be confirmed at SVA. Data presented in SVARM are from susceptibility testing of these isolates. The summary for each year include one isolate of each serovar, and when appropriate phage-type, from each warm-blooded animal species in incidents notified. In addition, isolates from incidents previously notified and still under restrictions are included in the yearly statistics. Also included are isolates obtained in the salmonella surveillance programme from samples collected at slaughter (carcass swabs, neck skins and lymph nodes).

Campylobacter

Campylobacter from pigs were cultured from samples of colon content collected at abattoirs for isolation of indicator bacteria (see below). From the total number of samples collected about one fourth was selected for culture. The selection was made sequential but ensuring that cultured samples were distributed between abattoirs according to annual slaughter volume and evenly distributed over the sampling periods. Each isolate of *Campylobacter coli* or *C. jejuni* is from a unique herd.

Methicillin resistant *Staphylococcus aureus* (MRSA)

Findings of MRSA in animals are notifiable in Sweden and hitherto all isolates from notified incidents have been confirmed at SVA. For surveillance strategies see Zoonotic bacteria MRSA.

In the screening for MRSA in pigs in 2011, 53 nucleus and multiplying herds were sampled. In each herd, samples were taken in fifteen pens with weaned pigs, 5-12 weeks old. The pigs were sampled by rubbing the skin behind one ear with a sterile compress. The same compress was used on 6 pigs in one pen and analyzed at the lab as a pooled sample. The sampling was organized by the Swedish Animal Health Service (SvDHV) and all samples were cultured at SVA.

Indicator bacteria

Pigs

Indicator bacteria, *Escherichia coli* and *Enterococcus* spp. from intestinal content were isolated from colon content of healthy pigs. Samples were collected at slaughter under the supervision of the National Food Agency (SLV) at nine abattoirs that together processed more than 90% of the total number of pigs slaughtered in Sweden 2010.

At each abattoir, an equal number of samples were collected during each of two periods (March-May, September-November). Samples were sent to SVA for culture within one week after collection and in the meantime kept refrigerated. The number of samples collected at each abattoir was proportional to the annual volume of pigs slaughtered at an abattoir and each sample represents a unique herd. By these measures, bacterial isolates included are from randomly selected healthy pigs of Swedish herds. Each isolate of *Escherichia coli*, *Enterococcus faecalis* and *Enterococcus faecium* is from a unique herd.

Pig meat

Indicator bacteria from pig meat were isolated from samples collected at cutting plants. Samples were collected under the supervision of SLV at ten cutting plants each processing more than 100 tons of pig meat in 2010.

Each cutting plant collected ten samples of processed meat packed for retail. At each plant, two samples were collected weekly for five consecutive weeks starting in November 2011. Samples were kept frozen at -18°C before and during shipment to SVA for culture.

Broilers

Selective culture for *E. coli* resistant to third generation cephalosporins was performed on caecal content from healthy broilers sampled at slaughter. Samples cultured were from the Swedish Campylobacter programme in which whole caeca are collected from each batch of broilers slaughtered. From these samples, 100 were selected by convenience in June and November for culture. Each sample is from a unique flock but not always from a unique production site.

Animal pathogens

Isolates of animal pathogens included are from routine bacteriological examinations of clinical submissions or post-mortem examinations. Isolates of *Actinobacillus pleuropneumoniae* and *Streptococcus equisimilis* from pigs and part of the isolates of *Pasteurella* spp. from calves are, however, isolated from samples collected in surveys initiated within the SVARMpat programme.

Isolates of *E. coli* from pigs are isolated from the gastrointestinal tract (gut content, faecal samples or mesenteric lymph nodes) and isolates of *Brachyspira* spp. from faecal samples. Isolates of *Pasteurella* spp. from pigs are isolated from nasal swabs collected within a control programme for atrophic rhinitis in nucleus and multiplying herds or from tissue samples from lungs taken post mortem. Isolates of *A. pleuropneumoniae* emanate from tissue samples from lungs sampled post mortem and isolates of *Pasteurella* spp. from cattle from the respiratory tract. Isolates of *S. equisimilis* are isolated from joints of piglets with arthritis sampled post mortem.

In horses, *E. coli* are isolated from the genital tract of mares, *Streptococcus zooepidemicus* from the respiratory tract and *S. aureus* from skin samples. In dogs, *E. coli* are isolated from samples of

urine, *S. pseudintermedius* from skin samples and *Pseudomonas aeruginosa* from samples in the external ear. *E. coli* from cats are isolated from samples of urine and beta-hemolytic streptococci are from infections in various organs for example the ears, the upper airways and the urogenital tract.

In farmed fish, *Aeromonas salmonicida* subsp. *achromogenes*, *Flavobacter columnare* and *Flavobacter psychrophilum* are from post mortem examination.

Isolation and identification of bacteria

Zoonotic bacteria

Salmonella

Salmonella were isolated and identified at the Dept. of Bacteriology, SVA or at regional laboratories in accordance with standard procedures. All samples within official control programmes are cultured according to the procedures detailed by the MSRV (ISO-EN 6579:2002/ Amd 1:2007). Confirmatory identification and serotyping of isolates was performed at the Dept. of Bacteriology, SVA according to the standard procedures of Kaufmann and White. The Dept. of Bacteriology, SVA is accredited for isolation, identification and serotyping of *Salmonella*.

Isolates of *Salmonella* Typhimurium and *S.* Enteritidis were phage-typed by the Swedish Institute for Infectious Disease Control (SMI), Stockholm using the Colindale scheme.

Campylobacter

Campylobacter spp. from pigs were isolated and identified at Dept. of Animal Health and Antimicrobial Strategies, SVA. Briefly, samples were cultured directly on Preston selective agar for thermophilic *Campylobacter* spp. and incubated at 42°C for 48h. Identification was based on colony morphology, microscopic appearance including motility and the production of oxidase and catalase. Additionally, all isolates of *C. coli* and *C. jejuni* were identified by PCR. A protocol from Denis et al. (1999) was followed except for the primer concentration for *mapA* and *ceuE* that was lowered to 0.24 µM. This PCR is used for species identification by the EURL campylobacter laboratory at SVA.

Methicillin resistant *Staphylococcus aureus* (MRSA)

In the screening of pigs for MRSA, samples were incubated overnight at 37°C in 30 ml Mueller-Hinton broth with 6.5% NaCl. From this pre-enrichment broth, 1 mL was inoculated into 9 mL trypton soy broth with 3.5 mg/L cefoxitin and 75 mg/L aztreonam and incubated overnight at 37°C. Of the selective broth 10 µL was spread on bovine-blood agar and on Oxoid MRSA Brilliance-agar. The plates were incubated at 37°C and inspected after overnight incubation and after 48 hours. Colonies of suspected MRSA were spread on bovine-blood agar plates with a cefoxitin disc and incubated overnight at 37°C. Isolates with suspected cefoxitin resistance (zone diameter < 10 mm) were confirmed with genotypic methods.

Indicator bacteria

Escherichia coli

Approximately 0.5 g of caecum content from pigs was diluted in 4.5 mL isotonic saline. After thorough mixing, 0.1 mL of this suspension was spread on MacConkey agar and MacConkey agar with cefotaxime 1mg/L and incubated overnight at 37°C. Twenty-five g of pig meat was stomached in 2 min with 225 mL BPW (Buffered Pepton Water). Thereafter 20 mL was transferred to 20 mL double concentrated MacConkey broth and incubated at 37°C for 18-24 h. From the pre-enrichment 100 µL was spread on MacConkey agar and incubated overnight at 37°C.

For selective culture for *E. coli* resistant to third generation cephalosporins in broilers, approximately 0.5 g of caecum content from was diluted in 4.5 mL isotonic saline. After thorough mixing, 0.1 mL of this suspension was spread on MacConkey agar with cefotaxime 1mg/L and incubated overnight at 37°C.

For species confirmation, one lactose positive colony with morphology typical for *E. coli* was sub-cultured onto horse-blood agar (5% v/v), after which the isolate was tested for production of tryptophanase (indole). Only lactose and indole positive isolates with typical morphology were selected for susceptibility tests. Colonies growing on MacConkey agar with cefotaxime were sub-cultured on horse-blood agar (5% v/v) and further tested for ESBL production.

Enterococci

Caecum content from pigs was diluted as described for *E. coli* (see above) and cultured on solid media without antibiotics. Diluted caecum content (0.1 mL) was spread onto Slanetz-Bartley (SlaBa) agar. The plates were incubated for 48 h at 37°C.

For isolation of enterococci from meat, 20 mL of the BPW from stomached pig meat (see above) was mixed with 20 mL double concentrated Enterococcosel broth, incubated at 37°C overnight. From the Enterococcosel broth 100 µL was cultured on SlaBa agar and incubated at 37°C for 48 h.

From cultures of caecal content from pigs and from pig meat two colonies, randomly chosen, were sub-cultured on bile-esculin agar and blood agar (37°C, 24 h). Colonies with morphology consistent with enterococci, and with a positive reaction on bile-esculin agar were identified to species level according to Devriese et al. (1993) by use of the following biochemical tests: mannitol, sorbitol, arabinose, saccharose, ribose, raffinose and methyl-alfa-D-glucopyranoside. Only isolates of *E. faecium* and *E. faecalis* were tested for antimicrobial susceptibility.

Animal pathogens

Most isolates of animal pathogens were isolated and identified with accredited methodology, following standard procedures at SVA. Some strains from calves and pigs were sent to SVA from other clinical laboratories. Bacteria from terrestrial animals were isolated at the Dept. of Bacteriology, and bacteria from fish at the Dept. of Animal Health and Antimicrobial Strategies.

Susceptibility testing

Microdilution

At SVA, the Dept. of Animal Health and Antimicrobial Strategies or the Dept. of Bacteriology perform antimicrobial susceptibility tests on bacteria from terrestrial animals, with accredited methodology, using dilution methods in cation adjusted Mueller-Hinton broth (CAMBH) (Difco). Tests are performed following the standards for microdilution of the Clinical and Laboratory Standards Institute (CLSI, 2008). The microdilution panels used, VetMIC, are produced at the Dept. of Vaccines and Blood products, SVA. Different panels are used depending on the bacterial species tested and the purpose of the investigation (monitoring or clinical diagnostics). Minimum inhibitory concentration (MIC) is recorded as the lowest concentration of an antimicrobial that inhibits bacterial growth.

The Dept. of Animal Health and Antimicrobial Strategies perform antimicrobial susceptibility tests on bacteria from fish, using the same methodology as described above but adapted for aquatic bacteria according to Alderman & Smith (2001), which e.g. implies incubation at 20°C for two days.

For susceptibility testing of *Brachyspira hyodysenteriae* and *Brachyspira pilosicoli*, a broth dilution method is used (Karlsson et al., 2003). The antimicrobials are dried in serial twofold dilutions in the tissue culture trays with 48 wells per plate. The wells were filled with 0.5 mL of a suspension of bacteria in brain heart infusion broth (BHI) with 10% foetal calf serum ($1x10^6$-$5x10^6$ CFU/ml). The trays were incubated in an anaerobic atmosphere at 37°C for four days on a shaker.

For susceptibility testing of *Campylobacter* spp. the CLSI standard M45-A2 for fastidious bacteria was followed (CLSI, 2010).

Screening for methicillin resistance in *S. aureus* from milk samples from cows was performed with microdilution according to CLSI (2008), testing oxacillin with 2% NaCl added to the broth, and oxacillin without added NaCl and cefoxitin.

Phenotypic confirmatory test for production of extended spectrum beta-lactamases (ESBLs) in *E. coli* was performed by the double disc diffusion test according to CLSI (2008).

Genotyping

Suspected isolates of *S. aureus* was confirmed by PCR identifying the *nuc* gene (Sasaki et al. 2010). Presence of the *mecA* gene in *S. aureus* and *S. pseudintermedius* was confirmed by PCR in isolates with a phenotype indicating methicillin resistance (Nilsson et al. 2005). To identify the *mecA* homologue $mecA_{LGA251}$ PCR was performed as described by García-Álvarez et al. (2011). If negative with the PCR by Nilsson et al. (2005) but positive by García-Álvarez et al. (2011) the isolates were determined to carry $mecA_{LGA251}$.

Spa typing, a single locus sequence typing method using the polymorphic region X of the protein A gene, was performed on all isolates confirmed as MRSA. It was performed according to the method described by Harmsen et al. (2003) and the specific *spa* type was determined using BioNumerics® (Applied Maths).

Genotypic screening of ESBL and AmpC positive *E. coli* was performed with PCR for identification of plasmid-mediated AmpC and CTX-M mediated ESBL according to Perez-Perez & Hanson (2002) and Woodford et al. (2006).
The specific gene variants were determined by sequencing using in-house primers and Big-Dye™ v1.1. or submitted to Macro Gene Inc. (South Korea) for sequencing.

Quality assurance system

The Dept. of Animal Health and Antimicrobial Strategies and Dept. of Bacteriology are accredited according to SS-EN ISO/IEC 17025 by the Swedish Board for Accreditation and Conformity Assessment (SWEDAC) to perform antimicrobial susceptibility tests with microdilution methods. The Dept. of Bacteriology is also accredited for isolation and identification of animal pathogens and *Salmonella* according to the same standard.

For susceptibility tests of zoonotic, pathogen and indicator bacteria, *Escherichia coli* ATCC 25922, *Enterococcus faecalis* ATCC 29212, *Staphylococcus aureus* CCUG15915 (analogue to ATCC 29213) and *Campylobacter jejuni* CCUG 11284 (analogue to *Campylobacter jejuni* ATCC 33560) were included as quality controls. Relevant control strains were also included and evaluated at least once weekly for animal pathogens. For testing of *Brachyspira*, the *B. hyodysenteriae* type strain $B78^T$ $ATCC\ 27164^T$ was used for quality control.

The Dept. of Animal Health and Antimicrobial Strategies participates in several proficiency tests for antimicrobial susceptibility testing. These are arranged either by the European Union Reference Laboratory - Antimicrobial resistance or as national studies. Likewise, the Dept. of Bacteriology participates in proficiency tests concerning isolation and identification of *Salmonella* spp. and general clinical veterinary bacteriology and susceptibility tests.

Data handling

Records on *Salmonella* and animal pathogens such as source of cultured sample, identification results, antimicrobial susceptibility etc. were registered in a database at SVA. Relevant data were extracted for evaluation and compilation. For indicator bacteria data was recorded in an Access database at the Dept. of Animal Health and Antimicrobial Strategies.

Calculations and analysis of data were performed in the computer programs Microsoft Access or Microsoft Excel.

Concerning confidence limits

When the prevalence of antimicrobial resistance is close to zero, e.g. when one out of 120 isolates is resistant, the question arises how to calculate the prevalence of resistance and its confidence intervals. In the example, the prevalence could be estimated to 0.83% while the 95% confidence interval is trickier. The normal approximation to the binomial distribution would give a lower confidence of -0.8% and an upper confidence limit of 2.5%. The lower limit is nonsensical and indicates the unsuitability of the normal approximation in this case.

One way out of the dilemma is to calculate the exact binomial confidence limits, which would be possible in some cases (small number of isolates). Another alternative is to run Monte-Carlo simulations based on the beta-distribution which is possible but quite laborious for a huge set of data since each prevalence estimate has to be simulated 10 000 times. Finally the relationship between the F-distribution, the beta-distribution and the binomial distribution can be used. This gives the formulae that enable calculations of the confidence interval (Rao, 1965). Using this approach, the confidence intervals in the example would be 0.021% and 4.6%.

In conclusion, the normal approximation to the binomial distribution might be unsuitable when the prevalence is close to 0% or close to 100% since the approximation might lead to confidence intervals lower than 0% or higher than 100%. Moreover, when the prevalence of resistance is less than 5% using the link between the F-distribution and the binomial distribution yield different confidence intervals compared to those obtained from the normal approximation and should accordingly be preferred.

Appendix 4: Cut-off values for resistance

FOR INTERPRETATION of results of susceptibility testing of zoonotic bacteria (*Salmonella* and *Campylobacter*) and indicator bacteria (*Escherichia coli* and enterococci) epidemiological cut-off values (ECOFF) issued by the European Committee on Antimicrobial Susceptibility Testing (EUCAST) (http://www.escmid.org) were used. When no ECOFFs are issued by EUCAST, values based on MIC distributions obtained in the SVARM programme were used.

ECOFFs were used when available also for animal pathogens. When no ECOFFs were available, or the range of concentrations tested is inappropriate for a recommended value, values based on MIC distributions obtained in the SVARM programme were used. Clinical breakpoints issued by CLSI (2008) were also taken into consideration. Epidemiological cut-off values classify isolates with acquired reduced susceptibility as resistant, which is relevant for monitoring purposes, but it should be understood that this not always implies clinical resistance.

Bacitracin values in this report are given in units/mL. In an attempt to convert unit/mL to mg/L we discovered that there appears to be some confusion in the matter. The bacitracin compound used in SVARM is obtained from Sigma and meets the standards set by the United States Pharmacopoeia (USP), stating that one unit is equivalent to 26 µg of the US standard. However, according to the International Standard Preparations, one international unit is equivalent to 13.51 µg. On the other hand, if the bacitracin is of a very high degree of purity, though unstable, it correspond to 66 (-70) units/mg, that is, one unit is equivalent to approximately 15 µg. Feedingstuff grade of bacitracin correspond to 42-50 units/mg (one unit=20-24 µg) (Otten et al., 1975).

TABLE AP4. Cut-off values (mg/L) for resistance. Values in red are current (April 2012) EUCAST epidemiological cut-off values (ECOFFs), blue underlined values deviate from ECOFFs and for values in black, ECOFFs are not defined.

Antimicrobial	*Actinobacillus pleuropneumoniae*	*Brachyspira hyodysenteriae*	*Brachyspira pilosicoli*	*Campylobacter jejuni*	*Campylobacter coli*	*Enterococcus faecalis*	*Enterococcus faecium*	*Escherichia coli (indicator)*	*Escherichia coli (pathogen)*	*Pasteurella* spp.	*Pseudomonas aeruginosa*	*Salmonella enterica*	*Staphylococcus pseudintermedius*	*Staphylococcus aureus*	*Streptococcus* spp.
Ampicillin	>1			>8	>8	>4	>4	>8	>8	>1		>8			>8
Bacitracin[a]						>32	>32								
Cefotaxime	>0.06							>0.25	>0.5	>0.06		>0.5			
Cefoxitin														>4	
Ceftiofur								>1	>1	>0.25		>2		>2	
Cephalothin													>2	>1	>4
Chloramphenicol	>2					>32	>32	>16		>2		>16		>16	>8
Ciprofloxacin	>0.06			>1	>1			>0.06		>0.06		>0.06		>1	
Clindamycin													>4	>0.25	>2
Colistin								>2							
Enrofloxacin								>0.12	>0.12	>0.25	>2	>0.25	>0.5	>0.5	
Erythromycin				>4	>16	>4	>4						>1	>1	>4
Florfenicol	>16							>16	>16	>16		>16		>8	>8
Fusidic acid													>4	>0.5	
Gentamicin	>8			>1	>2	>32	>32	>2	>4	>8	>8	>2	>4	>2	
Kanamycin						>1024	>1024	>8				>16		>8	
Linezolid						>4	>4								
Nalidixic acid	>16			>16	>32			>16		>16		>16			
Narasin						>2	>4								
Neomycin									>8			>4			
Nitrofurantoin									>32				>32		>32
Oxacillin													>0.5	>1	
Penicillin	>1									>1			[c]	[c]	>1
Polymyxin B									>2		>4				
Spiramycin														>16	>16
Streptomycin	>32			>2	>4	>512	>128	>16	>16	>32		>16		>16	
Sulphametoxazole								>64				>256			
Tetracycline	>2			>2	>2	>4	>4	>8	>8	>2		>8	>8	>1	>8
Tiamulin		>2	>2												
Trimethoprim	>4							>2	>2	>4		>2		>2	
Trim & sulpha[b]									>1	>4		>0.5	>2	>0.5	>4
Tylosin		>16	>16												
Vancomycin						>4	>4								
Virginiamycin						>32	>4								

[a] MIC in U/mL; [b] Concentration of trimethoprim given, tested with sulphametoxazole in concentration ratio 1/20; [c] beta-lactamase production.

Appendix 5: Antimicrobials licensed

ANTIMICROBIALS LICENSED for use in veterinary medicine in Sweden year 2011 are listed in Table AP5. Only substances in pharmaceutical preparations for systemic, oral, intrauterine or intramammary use are included (ATCvet codes QJ, QG, QA and QP). Data from FASS VET. 2011. For explanation of ATCvet code, see Appendix 2.

Changes since 2010

- **New substances or indications**
  - Ceftiofur (QJ01D D90), injectable for use in pigs
- **Withdrawn substances or indications**
  - Spiramycin (QJ01F A02), injectable for use in cattle

TABLE AP5. Antimicrobials licensed for use in cattle, sheep, pigs, poultry, horses, dogs and cats in Sweden, 2011. Routes of administration indicated: O = oral; I = injection; U = intrauterine; M = intramammary.

Antimicrobial agent	ATCvet code	Animal species						
		Cattle	Sheep	Pigs	Poultry	Horses	Dogs	Cats
Tetracyclines								
Doxycycline	QJ01A A02			O			O	O
Oxytetracycline	QJ01A A06, QG01A A07	I O U	I U	I O U	O			
Beta-lactams, penicillins								
Ampicillin	QJ01C A01	O		O		O	O	O
Amoxicillin	QJ01C A04	I		I			I O	O
Amoxicillin/Clavulanic acid	QJ01C R02			I			I O	I O
Penicillin G, sodium	QJ01C E01	I		I		I		
Penicillin G, procaine	QJ01C E09/QJ51C E09	I M	I	I		I	I	I
Beta-lactams, cephalosporins								
Cephalexin	QJ01D B01						O	
Ceftiofur	QJ01D D90	I		I				
Cefovecin	QJ01D D91						I	I
Sulphonamides -Trimethoprim								
Sulphadiazine - Trimethoprim	QJ01E W10	I	I	I		I O		
Sulphadoxine - Trimethoprim	QJ01E W13	I		I		I		
Macrolides								
Tulathromycin	QJ01FA94	I		I				
Gamithromycin	QJ01FA95	I						
Tylosin	QJ01F A90	I		I O	O		I	I
Lincosamides								
Clindamycin	QJ01F F01						O	O
Aminoglycosides								
Gentamicin	QJ01G B03					I U	I	
Dihydrostreptomycin (DHS)	QA07A A90	O U	O U	O U		O U	O	O
Fluoroquinolones								
Danofloxacin	QJ01M A92	I						
Enrofloxacin	QJ01M A90	I		I	O		I O	I O
Marbofloxacin	QJ01M A93						O	O
Pleuromutilins								
Tiamulin	QJ01X X92			I O	O			
Valnemulin	QJ01X X94			O				
Combinations								
Penicillin G, procaine/DHS	QJ01R A01, QJ51R C23	I M	I	I		I	I	I
Penicillin G, benzatin/DHS	QJ51R C24	M						
Penicillin G, ester/Framycetin	QJ51R C25	M						

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Appendix 7: SVARM 2000-2011 - an overview

DATA ON ANTIMICROBIAL susceptibility for over 30 000 isolates of bacteria have been presented in SVARM since 2000. The annual number of isolates of different categories is presented below.

TABLE AP7 I. *Salmonella enterica*, number of isolates 2000-2011.

Source	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Warm-blooded animals	67	52	49	101	68	105	101	112	122	117	82	71
Cold-blooded animals										17		

TABLE AP7 II. *Campylobacter* spp., number of isolates 2000-2011.

Source	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Cattle		67					68					
Pigs		98		105		100	46		97			83
Broilers		50	100		100				38		100	
Raw meat		74										
Water		19										

TABLE AP7 III. Indicator *Escherichia coli*, number of isolates 2000-2011.

Source	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Cattle	293						314			223		
Pigs	260	308		303		390		342	349			167
Pig meat									19			20
Broilers	274	296	306		300			296			181	
Broiler meat											77	
Horses											274	
Dogs							257					
Willow grouse						19						
Wild boars		87										
Sheep									115			

TABLE AP7 IV. Indicator *Enterococcus faecalis* and *E. faecium* number of isolates 2000-2011 *(E. faecalis/E. faecium).*

Source	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Cattle	22/71						13/98			10/24		
Pigs	56/48	52/106		87/71		55/47			68/39			22/22
Pig meat									17/3			29
Broilers	24/151	49/204	57/189		48/163			28/197			35/136	
Broiler meat											81/17	
Horses											34/27	
Dogs							135/29					
Wild boars		12/35										
Sheep									24/15			

TABLE AP7 V. Isolates of animal pathogens, number in SVARM 2000-2011.

Animal species & bacterial species	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Cattle												
Escherichia coli (enteric)			220		87	39	24			40	15	15
Escherichia coli (udder)				169								
Klebsiella spp. (udder)				44			24					
Pasteurella spp.	254							27	32	14	25	80
Staphylococcus aureus (udder)		100	100			96			87			
Streptococcus dysgalactiae (udder)			100									
Streptococcus uberis (udder)			100									
Fusobacterium necrophorum										41		
Pigs												
Actinobacillus pleuropneumoniae	18							84	39	24	39	57
Brachyspira hyodysenteriae	50	75	109	100		31	26	23	15	24	9	7
Brachyspira pilosicoli				93		57	72	44	31	24	13	16
Escherichia coli (enteric)	399	82	340	340	386	325	298	93	83	102	94	91
Pasteurella spp.		75						38	25	24	10	17
Staphylococcus hyicus					20							
Streptococcus equisimilis												82
Poultry (laying hens)												
Escherichia coli (infection)								70				
Sheep												
Staphylococcus aureus (udder)								25				
Fusobacterium necrophorum										24		
Fish												
Aeromonas salmonicida subsp.*achrom.*								67	20	23	8	14
Flavobacter columnare								30	16	10	5	8
Flavobacter psychrophilum								42	27	24	21	27
Horses												
Actinobacillus spp.		40										
Escherichia coli (genital)	323	103	166	188	188	161	124	273	174	210	236	174
Rhodococcus equi	73	20			187							
Streptococcus zooepidemicus	301	174	163	150	185	175	174	180	159	152	43	311
Staphylococcus aureus										308	131	135
Dogs												
Escherichia coli (urinary)	185	183	204	234	247	304	366	425	503	599	803	666
Pasteurella multocida					231							
Pseudomonas aeruginosa				234						261	313	353
Staphylococcus pseudintermedius	145	156	133	102	159	126	89	220	258	381	444	388
Cats												
Escherichia coli (urinary)			46	52	55	74	95	131	170	245	236	
Beta-hemolytic streptococci												184

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