SVARM2005

Swedish Veterinary Antimicrobial Resistance Monitoring

NATIONAL VETERINARY INSTITUTE

Printed by Edita Västra Aros, Västerås, Sweden
ISSN

Produced by SVA
Graphic production by Björn Lundquist AB, Malmö, Sweden
Photographs by Bengt Ekberg, SVA

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Suggested citation: SVARM 2005, Swedish Veterinary Antimicrobial Resistance Monitoring. The National Veterinary Institute (SVA), Uppsala, Sweden, 2006. www.sva.se, ISSN 1650-6332.

This report is available at www.sva.se
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Preface

WELCOME to the fourth Swedish report combining results from the monitoring of antimicrobial resistance and antimicrobial usage in both veterinary and human medicine: SVARM and SWEDRES. It is today generally accepted that all use of antimicrobials in different sectors contributes to the development of resistance. This joint report will facilitate comparisons of resistance levels and incidence of use in the two areas.

In 2005, surveillance of antimicrobial resistance in animal pathogens in Sweden has been significantly broadened with the initiation of SVARMpat. The objective of SVARMpat is to improve the monitoring of pathogens in farm animals by active, targeted sampling and collection of high-quality data on antimicrobial resistance. Results will be reported yearly in the SVARM report. Updated knowledge on susceptibility of animal pathogens is thereby available for practitioners, facilitating the therapeutic choice in the clinical setting. Moreover, high-quality data allows appropriate analysis of trends in resistance and of underlying causes for such trends and will be a most important complement to the data from indicator and zoonotic bacteria. SVARMpat is run in collaboration between the National Veterinary Institute (SVA) and the Swedish Animal Health Service (SvDHV) and is financed by the Swedish Board of Agriculture.

According to the Zoonosis Directive that was adopted in the EU in 2003, surveillance of antimicrobial resistance shall not only comprise zoonotic organisms such as *Salmonella* and *Campylobacter* but should also include indicator bacteria such as *Escherichia coli* and enterococci from food animals and food. The indicator bacteria constitute a reservoir of

resistance genes that may be transferred to pathogenic bacteria in animals and man. SVARM will in the near future also include zoonotic and indicator bacteria isolated from food of animal origin, according to a decision by the Swedish Parliament in 2006. The programme will be initiated and organised in collaboration between SVA and the National Food Administration.

Data in this report indicate, as also the data presented previously, that the Swedish strategies in human and veterinary medicine have been successful in containing resistance. The general concept is to use antimicrobials only when needed, on prescription by a professional only, and that the choice of treatment is based on relevant information.

Notwithstanding, some of the presented results in both veterinary and human fields are cause for concern. Examples on unfavourable development of resistance indicate that the antimicrobial arsenal available is becoming more and more limited. Further efforts must be made to prevent infectious diseases both in human and in veterinary medicine by other means.

Our hope is that this report will serve as a basis for policy recommendations and intervention strategies, and that it will increase our understanding of the dynamics of resistance. The ultimate goal is to preserve the effectiveness of available antimicrobials for man and animals.

Summary

THE SIXTH REPORT from SVARM shows that the situation regarding antimicrobial resistance in bacteria of animal origin is stable. Resistance does occur but viewed from an international perspective the prevalence is low. Likewise, data in the corresponding report covering human medicine, SWEDRES (http://www.strama.org or http://www.smittskyddsinstitutet.se) indicate a favourable situation.

The total amount of antimicrobials used for animals has declined since the mid 90s but the figures are roughly unchanged from year 2003. The sales of pleuromutilins for in-feed or in-water medication of pigs has decreased by 39% over the last five years. The decrease is probably explained by efforts to contain swine dysentery. The use of macrolides has also decreased by 31%, but the use of tetracyclines for in-feed or in-water medication, adjusted for the lower dose of doxycycline has increased by 21% since year 2000. These changes probably reflect a change in prescription pattern for treatment of respiratory infections in pigs.

The use of antimicrobials for dogs in year 2005 was estimated to 318 prescriptions/1000 dogs. Almost half (48%) of the prescriptions were for cephalosporins or amoxicillin combined with clavulanic acid, and 14% were for fluoroquinolones. The use of cephalosporins and fluoroquinolones has increased by 91% and 39%, respectively since year 1998. These increases are not fully explained by decreases in other substance classes. Multiresistant bacteria are frequently isolated from dogs, and broad-spectrum antimicrobials such as those mentioned should be reserved for those cases where antibiotics with narrower spectrum cannot be used. The high and increasing use of broad-spectrum antibiotics for dogs is also a concern from public health point of view.

Resistance in *Salmonella* from Swedish animals is rare and the situation has been stable since the late 70s, when monitoring began. Phage types that often harbour multiresistance are uncommon among food-producing animals in Sweden. This year, multiresistant *Salmonella* Typhimurium (DT104 or DT 120) was isolated in two cattle herds and from a slaughter pig carcass. Multiresistant *S.* Typhimurium (NST or NT) was isolated from four dogs. Resistance to third generation cephalosporins was not observed and only one isolate, from a dog, was resistant to quinolones. The favourable situation is most probably a result of the strategies in the Swedish *Salmonella* control programme.

***Campylobacter* spp. from slaughter pig**, were mostly identified as hippurate-negative thermophilic *Camplyobacter*, most likely *C. coli*. As in previous years, resistance among the isolates was rare except for a high proportion (24%) of resistance to nalidixic acid and enrofloxacin. These levels are difficult to explain in relation to the assumed low use of fluoroquinolones in pigs in Sweden but could be a consequence of quinolone use in treatment of diarrhea in piglets.

Indicator bacteria, i.e. *Escherichia coli* and *Enterococcus* spp. from healthy animals, are monitored since resistance in the normal gut flora reflects the antimicrobial selective pressure in an animal population. If harmonised methodology is used, data can be compared over time and on an international level. This year, indicator bacteria from healthy slaughter pigs were monitored. Levels of resistance are low in an international perspective and have been stable since monitoring began year 2000. Resistance mostly occurs to substances used in pig production. Hence, resistance to ampicillin, streptomycin, sulphonamides, tetracycline or trimethoprim in *E. coli* and resistance to tetracycline or macrolides in enterococci are the most common traits. In *E. coli*, resistance to third generation cephalosporins was not observed and quinolone resistance was rare. Vancomycin resistant enterococci were not isolated from pigs. In both *E. coli* and *Enterococcus*, there are indications of linked resistance genes. Resistance to some antimicrobials might therefore be a consequence of co-selection whereby use of one antimicrobial selects for resistance also to other substances.

Vancomycinresistant enterococci (VRE) were isolated on media supplemented with vancomycin, from 41 of 99 samples from chickens using. Since the start of monitoring year 2000, the proportion of positive samples from chickens has gradually increased. Although occurrence of VRE is low in an international perspective, the increase is cause for concern since the genes that code for resistance to vancomycin might be transferred to enterococci causing nosocomial infections in humans.

***Escherichia coli* from diagnostic submissions** were often resistant to ampicillin, streptomycin, tetracycline or trimethoprim-sulphonamides, irrespective of source (pigs, calves, horses, dogs and cats) and multiresistance involving these substances was common. In *E. coli* from pigs, resistance to ampicillin or trimetoprim/sulphonamide has gradually increased over the last fifteen years whereas tetracycline, streptomycin or neomycin resistance has decreased. For the latter two substances this likely reflects a reduced use of the respective antimicrobials.

Data on resistance in other animal pathogens are also presented. In *Brachyspira* from pigs, resistance to tiamulin occurs in *B. pilosicoli* but was not observed in *B. hyodysenteriae*. The gradual decrease in susceptibility previously observed in the latter species has seemingly not progressed.

In *Streptococcus zooepidemicus* from horses, susceptibility to penicillin was uniform, but resistance to trimethoprim-sulphonamides was common. The majority of *Staphylococcus intermedius* from dogs were resistant to penicillins. Many isolates were also resistant to clindamycin, erythromycin, fusidic acid, streptomycin or tetracycline. About one third of the isolates were multiresistant and 15% were resistant to at least five antimicrobials. Methicillin resistance in *Staphylococci* was not confirmed, neither in *S. intermedius* from dogs nor in *S. aureus* from mastitis in dairy cows

Sammanfattning

DEN SJÄTTE SVARM-rapporten visar att läget när det gäller antibiotikaresistens hos bakterier från djur är stabilt. Resistens förekommer, men i ett internationellt perspektiv är nivåerna låga. Även SWEDRES, motsvarande rapport från humansjukvården, redovisar ett i huvudsak gynnsamt läge (http://www.strama.org eller http://www.smittskyddsinstitutet.se).

Den totala förbrukningen av antibiotika till djur har minskat sedan 90-talet men är i stort oförändrad från år 2003 och framåt. Försäljningen av pleuromutiliner för inblandning i vatten eller foder till grisar har minskat med 39 % de senaste 5 åren, vilket troligen förklaras av ansträngningar att bekämpa svindystenteri. Försäljningen av makrolider har också minskat med 31 %, men användningen av tetracykliner för medicinering via foder eller vatten har ökat med 21 % när siffrorna korrigerats för den lägre dosen för doxycyklin. Dessa förändringar speglar troligen en förändring i förskrivningsmönstret för behandling av luftvägsinfektioner hos grisar.

Förskrivningen av antibiotika till hund år 2005 uppskattas till 318 recept/1000 hundar, och 48 % av dessa recept var för cefalosporiner eller amoxicillin i kombination med klavulansyra. Användningen av cefalosporiner och fluorokinoloner har sedan 1998 ökat med 91 % respektive 39 %. Dessa ökningar kan inte fullt ut förklaras av minskningar av andra typer av antibiotika. Multiresistenta bakterier isoleras ofta hos hundar, och antibiotika med brett spektrum, som t.ex. de som nämnts, bör reserveras för behandling av fall där antibiotika med smalare spektrum inte går att använda. Den höga och ökande förskrivningen av bredspektrumantibiotika till hund är oroande också ur ett folkhälsoperspektiv.

Resistens hos *Salmonella* från svenska djur är ovanligt och situationen har varit stabil sedan 70-talet då antibiotikakänslighet hos dessa bakterier började undersökas rutinmässigt. De fagtyper som ofta bär på multiresistens är ovanliga hos livsmedelproducerande djur i Sverige. I år påvisades multiresistent *S.* Typhimurium (DT104 och DT120) i två nötkreatursbesättningar och från en slaktkropp av svin. Dessutom isolerades multiresistent *S.* Typhimurium (NST och NT) från fyra hundar. Inget isolat var resistent mot tredje generationens cefalosporiner och endast ett isolat var resistent mot kinoloner. Det fördelaktiga läget är sannolikt en följd av åtgärder i det svenska salmonellakontrollprogrammet.

Majoriteten av *Campylobacter* från slaktsvin identifierades som hippurat-negativa termofila Campylobacter spp., sannolikt *C. coli.* Liksom tidigare år var resistens mot nalidixansyra och enrofloxacin vanlig (24 %) medan isolaten i huvudsak var känsliga för övriga substanser. Den stora andelen kinolonresistenta isolat är svårförklarad eftersom användningen av dessa substanser till slaktsvin antas vara liten. Möjligen är resistensen en följd av att kinoloner används vid behandling av spädgrisar.

Resistensläget hos indikatorbakterier, d.v.s. *Escherichia coli* och *Enterococcus* spp. från friska djur, anses återspegla det selektionstryck mot resistens som antibiotikaanvändning i en djurpopulation innebär. Om harmoniserade metoder används kan förändringar över tid analyseras och resistensläget mellan länder jämföras. I år undersöktes indikatorbakterier från slaktsvin. Ur ett internationellt perspektiv är resistensnivåerna låga och läget stabilt. I huvudsak förekommer resistens mot substanser som används i svinproduktionen. Resistens mot ampicillin, streptomycin, sulfonamider, tetracyklin eller trimethoprim är vanligt hos *E. coli* och resistens mot tetracyklin eller makrolider hos enterokocker. Resistens mot tredje generationens cefalosporiner påvisades inte hos *E. coli* och kinolonresistens var ovanlig. Inte heller isolerades vankomycinresistenta enterokocker.

Resultaten i SVARM tyder på att kopplad resistens förekommer hos såväl *E. coli* som enterokocker från svin. Detta innebär att användning av ett antibiotikum kan selektera för resistens även mot andra substanser, s.k. ko-selektion.

Vankomycinresistenta enterokocker (**VRE**) påvisades i 41 av 91 prov från slaktkyckling. Vid odlingen användes substrat med tillsats av vankomycin. Sedan övervakningen startade 2000 har andelen positiva prov gradvis ökat men förekomsten av VRE är låg jämfört med förhållandet utomlands. Eftersom generna som orsakar vankomycinresistens kan överföras till enterokocker som ger nosokomiala infektioner hos människor är ökningen oroande.

***Escherichia coli* från kliniska prov** var ofta resistenta mot ampicillin, streptomycin, tetracyklin och trimetoprim-sulfonamider, oavsett ursprung (grisar, kalvar, hästar, hundar och katter) och många isolat var resistenta mot flera av substanserna (multiresistens). Hos *E. coli* från svin har resistens mot ampicillin eller trimetoprim-sulfonamider ökat gradvis under de senaste femton åren medan resistens mot tetracyklin, streptomycin eller neomycin minskat. För de två sistnämnda substanserna är minskningen sannolikt en följd av minskad användning till svin.

Resistens hos andra djurpatogener presenteras också i rapporten. Hos *Brachyspira pilosicoli* förekommer resistens mot tiamulin men däremot inte hos *B. hyodysenteriae*. Årets resultat tyder inte på att den tidigare observerade trenden mot minskad tiamulinkänslighet hos *B. hyodysenteriae* fortgår.

Alla *Streptococcus zooepidemicus* från hästar var känsliga för penicillin, men resistens mot trimetoprim-sulfonamider var vanligt förekommande. Däremot var majoriteten *Staphylococcus intermedius* från hundar resistenta mot penicillin liksom de varit de senaste 30 åren. Många isolat var resistenta också mot klindamycin, erytromycin, fusidinsyra, streptomycin eller tetracyklin. Cirka en tredjedel var multiresistenta och 15 % resistenta mot minst fem antibiotika. Meticillinresistens hos stafylokocker påvisades inte, varken hos *S. intermedius* från hundar eller hos *S. aureus* från kor med juverinflammation.

Use of antimicrobials (SVARM 2005)

THROUGH AN INITIATIVE of SVA and Apoteket AB (the National Corporation of Swedish Pharmacies), statistics on total sales of antibiotics for use in animals in Sweden are available since 1980. For a review of the figures from 1980-2000 as well as references to publications on which that review is based, see SVARM 2000.

Material included

In Sweden, antimicrobials for use in animals are only available on veterinary prescription and all pharmaceuticals are dispensed by pharmacies. In 1986, the Feedstuffs Act restricted the use of antibiotics for veterinary medicinal purposes, i.e. their use as growth promoters was no longer authorised.

Drug statistics are based on sales figures provided by Apoteket AB and represent the total amount of antimicrobials authorised for veterinary use sold, calculated to kg active substance. These figures include antimicrobial formulations for systemic, intramammary and obstetric use, and intestinal anti-infectives, for all animal species (food producing animals, pets and horses etc). Up to and including year 2002, the source for the statistics has been sales of drugs from wholesalers to pharmacies. From year 2003, the statistics are based on the amount of drugs dispensed by pharmacies. In both systems, statistics represent an approximation on the actual usage of antimicrobials, assuming that the amount sold is also used during the observation period.

Drugs authorised for human use but prescribed for animals are not included in Tables AC I-ACIII. Such drugs are prescribed primarily in small animal medicine. The data on antimicrobials for use in dogs presented in the highlight this year include prescriptions dispensed for dogs at pharmacies, i.e. both drugs authorised for human and for veterinary use. This dataset corresponds to out-patient care.

Details on animal numbers are found in Appendix 1 and on methodology in Appendix 2.

Overall use of antimicrobials

The total use of antimicrobials is presented in Table AC I. The potency of the different antimicrobials is not equal and therefore each substance group should be evaluated separately. Nonetheless, the total figures may indicate trends in the material. The total amount used has decreased since the mid 90s, but was roughly unchanged during year 2000-2002. In year 2003, the amounts were 6% lower than in year 2000. From year 2003 to 2005, a slight increase (2%) is noted but the figures are still 4% lower than in year 2000. Changes in the number of animals may affect trends in statistics on use of antimicrobials. In year 2005, the numbers of dairy cows and slaughtered pigs were 7 and 3% lower than in year 2000, respectively, while the number of slaughtered broilers was roughly unchanged.

The total use of macrolides and lincosamides, tetracyclines and pleuromutilins has decreased from year 2000 to year 2005 (20, 11 and 61%, respectively). These antimicrobials are mainly used in pigs, and as the pig population has not changed to that extent, at least part of the observed decrease in total consumption is a true decrease in incidence of use. By

Table AC I. Yearly sales of antimicrobial drugs for veterinary use expressed as kg active substance (sales statistics from Apoteket AB).

ATCvet code	Antimicrobial class	1980	1984	1988	1992	1996	2000	2002	2003	2004	2005
QJ01AA, QG01A	Tetracyclines[a]	9 819	12 955	4 691	8 023	2 698	1 754	1 415	1 307	1 329	1 562
QJ01B	Amfenicols	47	49	35	-	-	-	-	-	-	-
QJ01CE, QJ01R, QJ51	Penicillin G-and V[b]	3 222	4 786	7 143	7 446	8 818	8 254	8 179	7 579	7 814	7 571
QJ01CA, QJ01CR	Aminopenicillins	60	714	655	837	835	852	767	870	875	911
QJ01D, QJ51CA	Other betalactams incl. cephalosporins	9	2	-	-	-	315	676	832	928	1 009
QA07AA, QJ01G, QJ01R, QJ51R	Aminoglycosides and polymixins[a]	5 274	5 608	3 194	2 139	1 164	797	753	645	606	762
QA07AB, QJ01E	Sulphonamides	6 600	4 325	3 072	2 362	2 198	2 338	2 477	2 326	2 462	2 535
QJ01E	Trimethoprim & derivatives	134	186	250	284	339	390	414	381	406	437
QJ01F	Macrolides & lincosamides	603	887	1 205	1 710	1 649	1 352	1 412	1 124	1 095	1 080
QJ01MA	Fluoroquinolones	-	-	-	147	173	156	185	184	187	184
QJ01XX92, QJ01XX94	Pleuromutilins	-	-	124	268	1 142	871	988	744	387	338
QJ01MB	Quinoxalines[c]	6 250	9 900	7 164	4 917	1 098	-	-	-	-	-
QJ01XX91	Streptogramins	-	8 800	1 088	1 275	525	-	-	-	-	-
QP51AA, QJ01BA	Other substances[d]	861	1 637	1 567	1 634	-	-	-	-	-	-
	Feed additives[e]	8 380	700	-	-	-	-	-	-	-	-
Total		**41 259**	**50 549**	**30 189**	**31 043**	**20 639**	**17 079**	**17 266**	**15 992**	**16 089**	**16 389**

[a] Includes drugs marketed with special marketing authorisation for years 2000-2005; [b] Calculated as benzyl-penicillin; [c] years 1980-1984 sold as feed additives, thereafter on veterinary prescription at therapeutic dosages; [d] Mainly nitroimidazoles; [e] Feed additives other than quinoxalines and streptogramins: avoparcin, bacitracin, nitrovin, oleandomycin and spiramycin.

contrast, the decrease noted for penicillin may be attributed to a decrease in the number of dairy cows, as this substance is widely used for treatment of mastitis.

About 12% of the total sales of veterinary products (1 972 kg) were prescribed for use in dogs in out-patient care. Trends in the overall use of certain classes are highly influenced by this use. Notably, the increasing trend in sales of cephalosporins and fluoroquinolones from year 2000 to 2005 (an increase by 220 and 18%, respectively) is almost entirely related to use in dogs (see Antimicrobials prescribed for dogs). This emphasises the need for animal-species specific statistics on use of antimicrobials for assessment of trends. The use of specific antimicrobial classes is further commented under 'Use for systemic treatment of individual animals', 'Use for treatment of groups or flocks' or 'Antimicrobials prescribed for dogs', as appropriate.

In chickens, ionophoric antibiotics are given to control coccidiosis. These substances are currently classified as feed additives, and are not included in the overall statistics based on sales from pharmacies. However, the sales of these products, based on data from feed mills, are discussed under the section on group treatment (see Table AC III).

Use for systemic treatment of individual animals

In table AC II, the sales of products for use in individual animals, excluding topical, intrauterine and intramammary use are presented. In year 2005, this subset was 86% of the overall use. The use of most classes of antimicrobials has decreased or been relatively unchanged over the last five years. A large part of the injectables is probably used for treatment of bovine mastitis. Therefore, some of the decrease in for example penicillins may be explained by a decreasing number of dairy cows. However, many of the drugs of concern are also used in horses. Trends in sales of drugs of this category must be made with great caution.

The use of products for individual use from the classes 'aminoglycosides' and intestinal anti-infectives (mainly aminoglycosides) has declined by 24 and 16%, respectively, since year 2000. For aminoglycosides, this trend is mainly explained by a decreased use of combinations of procaine-penicillin and dihydrostreptomycin (ATCvet code QJ01R). This is in line with current policy recommendations. For the group of macrolides and lincosamides, the decrease by 25% mainly derives from a declining use of injectable macrolides for use in cattle and pigs, while the lincosamides, exclusively used for pets, show a less prominent decrease. The use of cephalosporins and fluoroquinolones for individual use has increased by 220 and 19%, respectively, from year 2000 to 2005. In both cases, the increase is largely derived from the amounts prescribed for dogs (see below, for further discussion of use of fluoroquinolones see SVARM 2004).

The subset of antimicrobials for veterinary use prescribed for dogs (out-patient care) is presented in Table AC IIb. This data do not include drugs authorised for use in humans but prescribed off-label for dogs (see further in 'Antimicrobials prescribed for dogs'). Fourteen percent of the total sales for individual treatment in year 2005 were prescribed for use in dogs. In particular, almost all (95%) of the sales of cephalosporins are for dogs. The 'macrolides and lincosamides' and the 'fluoroquinolones' used for dogs are also a large proportion of the total individual sales of these classes, and changes in the amounts of these classes prescribed for dogs will thereby influence the observed trends in total use for individual treatment.

Table AC IIb. Sales of antimicrobial drugs for dogs in kg active substance in year 2005 in relation to total use for treatment of individual animals (as percent of amounts given in Table AC IIa).

ATCvet code	Antimicrobial class	Sales for dogs (kg)	Percent of all individual use
QA07A	Intestinal anti-infectives	40	8
QJ01A	Tetracyclines	36	6
QJ01C	Penicillins[b,c]	645	8
QJ01D	Cephalosporins	963	95
QJ01E	Sulfonamides & trimethoprim	72	3
QJ01F	Macrolides & lincosamides	166	42
QJ01G	Aminoglycosides[c, d]	<1	<1
QJ01M	Fluoroquinolones	50	28
QJ01X	Pleuromutilins	<1	<1
Total		**1 972**	**14**

[a] Drugs marketed with special marketing authorisation are included from year 2000; [b] Procaine-penicillin calculated as benzyl-penicillin; [c] The amount also includes QJ01R, combinations; [d] Does not include QA07A, intestinal anti-infectives.

Table AC IIa. Yearly sales of antimicrobial drugs authorised for individual treatment expressed in kg active substance. Intramammaries (QJ51) and formulations for dermatological use (QD06), as well as local treatment of the genito-urinary tract (QG01) are not included (sales statistics from Apoteket AB).

ATCvet code	Antimicrobial class	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
QA07A	Intestinal anti-infectives[a]	863	706	649	607	587	614	594	594	586	496
QJ01A	Tetracyclines	596	663	656	695	634	623	628	606	611	623
QJ01C	Penicillins[b, c]	9 560	9 530	9 287	9 424	9 037	9 095	8 894	8 406	8 644	8 404
QJ01	Cephalosporins	-	53	133	245	315	474	676	832	928	1 009
QJ01E	Sulfonamides & trimethoprim	2 033	2 107	2 335	2 376	2 336	2 478	2 483	2 280	2 427	2 610
QJ01	Macrolides & lincosamides	675	652	645	559	531	522	477	430	382	400
QJ01G	Aminoglycosides[c, d]	650	617	535	528	474	454	460	367	344	362
QJ01M	Fluoroquinolones	147	147	150	144	150	169	178	177	180	179
QJ01X	Pleuromutilins	73	65	64	52	56	48	49	77	32	29

[a] Drugs marketed with special marketing authorisation are included from year 2000; [b] Procaine-penicillin calculated as benzyl-penicillin; [c] The amount includes QJ01R; [d] Does not include QA07A, intestinal anti-infectives.

Use for treatment of groups or flocks

Of special interest when considering the risk for development of resistance is the consumption of antimicrobials intended for group or flock medication. The proportion of drugs authorised for treatment of groups of animals via feed or water has decreased steadily over the years and is today but 13% of the total sales, measured as kg active substance (total sum of Table AC III and I). From year 2005, products of the class 'intestinal anti-infectives' that are sold with a special marketing authorisation are included. Products for group treatment are mainly used in pigs. The number of pigs slaughtered has decreased by 19% over the last 10 years but has over the last five years remained comparatively stable (3% decrease from year 2000 to 2005); see Appendix 1 for demographics).

The sales of pleuromutilins has decreased by 71% over the last 10 years. Pleuromutilins (tiamulin, valnemulin) are only authorised for use in pigs, with swine dysentery as the main indication. Since the beginning of the 90s, swine dystentery has received much attention both in research and

Antimicrobials prescribed for dogs

An increased use of fluoroquinolones in dogs and cats was highlighted in last year's SVARM report (SVARM 2004). To further explore the use of antimicrobials for dogs, data on all prescriptions of antimicrobials for systemic use dispensed during year 2005 for use in dogs were retrieved. The dataset includes drugs authorised for systemic oral use in animals (ATC vet code QJ01) as well as for humans (ATC code J01) and corresponds to out-patient care of dogs.

The total number of prescriptions included for 2005 was 286 518, of which 8% were products authorised for human use (J01) (Table AC IV). Ninety-two percent of the antimicrobials prescribed were products authorised for veterinary use, a slight increase compared with 1998 (87%; Odensvik *et al*, 2001). Prescriptions for beta-lactam antibiotics (QJ01/J01 C-) were by far the most commonly dispensed (65% of total). Of these, 48% were the two drug classes with the broadest spectrum of activity (aminopenicillin in combination with clavulanic acid or cephalosporins), and only 3% were penicillins with a narrow spectrum (penicillin V or oxacillins). Currently, no products of the latter category are authorised for oral use in dogs. Fluoroquinolones and lincosamides were dispensed on 14 and 13%, respectively, of the total number of occasions.

Table AC IV. Number of prescriptions dispensed by Swedish pharmacies for use in dogs (sales statistics from Apoteket AB) during year 2005.

ATC vet/ ATC code		Antimicrobial class	Authorised for animals (QJ01)	Authorised for humans (J01)	Total
QJ01-/J01-	AA	Tetracyclines	8 849	4 239	13 088
QJ01-/J01-	CA	Aminopenicillins	86 988	4 140	91 128
QJ01-/J01-	CE	Penicillin V	-	5 283	5 283
QJ01-/J01-	CF	Penicilliase stable penicillins	-	154	154
QJ01-/J01-	CR	Aminopenicillins & clavulanic acid	37 637	184	37 821
QJ01-/J01-	D-	Cephalosporins	47 137	5 220	52 357
QJ01-/J01-	EW	Trimethoprim & sulphnamides	5 712	2 382	8 094
QJ01-/J01-	FA	Macrolides	2	170	172
QJ01-/J01-	FF	Lincosamides	39 262	565	39 827
QJ01-/J01-	MA	Fluoroquinolones	38 097	154	38 251
QJ01-/J01-	XC	Others	-	343	343
Total			**263 684**	**22 834**	**286 518**

The number of prescriptions/1000 dogs at risk can be used as an approximation of the incidence of antimicrobial treatment of dogs . The total number of dogs was estimated to 800 000 in year 1998 and 900 000 in year 2004 (Egenvall *et al*, 1999; Hedhammar, 2004). These estimates were used for population-based prescription statistics, with the population figure for year 2004 used for 2005 year's drug data. Interpretations of these calculations should be made with some caution, as the denominators (the population sizes) are not true census figures.

In Figure AC I, prescription data from 1998, taken from a previous study (Odensvik *et al*, 2001), and from 2005 are shown as prescriptions per 1000 dogs. For comparison, data on prescriptions of antimicrobials per 1000 inhabitants (out-patient care) were obtained from SWEDRES. The total incidence of prescriptions of antimicrobials for dogs in year 1998 was 283/1000 dogs and 318 prescriptions/1000 dogs in year 2005. This indicates an increase in the overall treatment incidence.

The use of cephalosporins has almost doubled from year 1998 to 2005 (by 28 prescriptions/1000 dogs, or 91%). This may partly be linked to an observed decrease in use of the group 'macrolides and lincosamides' (-19%). Both these drug classes are used for treatment of pyoderma in dogs, and the comparatively high percentage of resistance to lincosamides among *Staphylococcus intermedius* isolated from dogs, around 20% since the mid 90s, may have led to

in extension work in Sweden. Efforts have been made to contain the disease by, e.g. certifying breeding herds as free form the infection and eradication programmes. It is probable that these combined efforts have resulted in a decreased need to treat swine dysentery, leading to declining sales figures. Pleuromutilins are also used for treatment of porcine intestinal spirochetosis. In recent years, cases of treatment failure related to resistance to tiamulin have been reported in Sweden (see SVARM 2003). Increases in use of pleuromutilins in occasional years, such as seen in year 2002, may be related to a temporary, but extensive, use within programmes for eradication of swine dysentery.

The observed decrease in use of tetracyclines is confounded by an increased use of doxycycline. Doxycycline has a higher bioavbailability, and the dose is lower (250 ppm when mixed in feed) compared with that for, e.g. chlortetracycline (1000 ppm when mixed in feed). The use of doxycycline has increased steadily over the last six years. When the sales figures are corrected for the lower dose of doxycycline, the use of tetracyclines has decreased by 48% from years 1996

a shift in treatment preferences. However, the total decrease in macrolides and lincosamides is limited to 12 prescriptions/1000 dogs and cannot alone explain the increase in cephalosporin use.

The use of fluoroquinolones has increased by 12 prescriptions/1000 dogs (39%). A decrease of similar magnitude (-11 prescriptions/1000 dogs, or –53%) was observed for trimethoprim-sulphonamides. Both these drug classes are used for treatment of, e.g. urinary tract infections, and it is probable that the changes are to some extent related. However, aminopenicillins are also widely used for treatment of uncomplicated urinary tract infections and the use of penicillins (mostly aminopenicillins) has also increased by 18 prescriptions/1000 dogs, or 13%. To better explain all the observed changes, more information is needed on prescription patterns in relation to indications.

In Figure AC I, data on prescription of antimicrobials for humans are shown for comparison. Some of the differences in prescriptions of specific drug classes are likely to reflect differences in disease patterns and main indications. For example, the higher use of penicillins and tetracyclines for humans is likely to reflect a higher incidence of treatments for respiratory tract infections, while the higher use of cephalosporins and 'macrolides and lincosamides' for dogs is explained by pyoderma being one of the main indications for treatment of dogs. Use of fluoroquinolones for dogs is of a similar magnitude as that for humans.

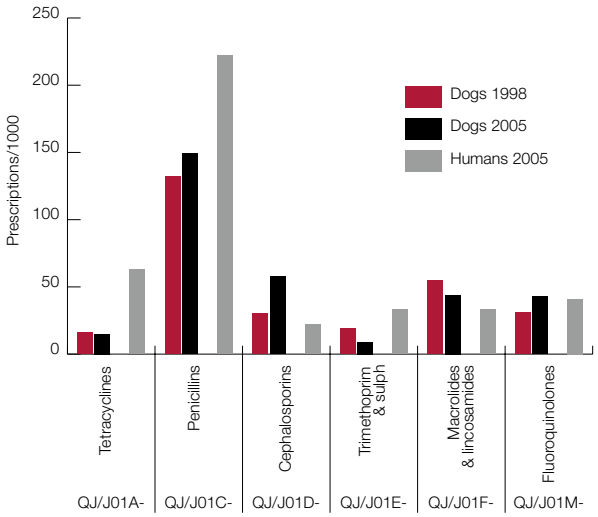

Figure AC1. Use of antimicrobials for dogs in years 1998 and 2005, expressed as prescriptions/1000 dogs and use of the corresponding classes for humans as prescriptions/1000 inhabitants.

Multiresistant bacteria are frequently isolated from common infections in dogs, and any increase in the occurrence of resistance will further limit the number of antimicrobials available for effective treatment of dogs. Zoonotic spread of resistant strains and resistance genes should also be considered. In Sweden 19% of the households were estimated to have dogs, indicating that a large proportion of the human population is in close contact with dogs and their microflora. In view of the increasing number of reports from other countries on dogs infected with, or carrying, methicillin resistant *Staphylococcus aureus* (MRSA), the use of aminopenicillins combined with clavulanic acid, of cephalosporins and of fluoroquinolones are of particular concern as these drugs have a potential to select for MRSA if, or when, the infection enters the Swedish dog population.

In the absence of studies on prescribing patterns in relation to indications and statistics on incidence of different infectious diseases, it is difficult to assess whether the use of antimicrobials for dogs is in line with the policies issued by the Swedish Veterinary Association. In year 2005, the use for humans of the classes of antimicrobials included was 425/1000 inhabitants. Considering that certain patient categories requiring more frequent treatments with antibiotics, such as the severely immunocompromised and children in day-care centres have no direct comparators in canine medicine, the overall use for dogs (318 prescriptions/1000 dogs) appears comparatively high.

to 2000 but has increased by 21% from years 2000 to 2005. From year 2004 to 2005 the dose corrected use increased by 31%. The increased use of doxycycline is probably because of increased use for treatment of respiratory diseases, but it cannot be excluded that a minor part reflects off-label use for, e.g. intestinal spirochetosis.

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

Table AC III. Yearly sales of antimicrobial drugs authorised for group treatment and ionophoric anticoccidials sold expressed as kg active substance. Based on sales statistics from Apoteket AB and from the Board of Agriculture

ATCvet code	Antimicrobial class	1980	1984	1988	1992	1996	2000	2001	2002	2003	2004	2005
QA07A	Intestinal anti-infectives[a]	-	-	-	-	-	-	-	-	-	-	163
QJ01A	Tetracyclines[b]	9 270	12 300	4 177	7 461	2 089	1 111	822	777	695	712	934
QJ01C	Penicillins	-	-	186	9	-	-	-	-	-	-	-
QJ01F	Macrolides & lincosamides	308	607	751	1 139	975	821	988	935	694	713	680
QJ01M	Fluoroquinolones	-	-	-	10	27	7	13	7	8	7	5
QJ01M	Quinoxalines[c]	6 250	9 900	7 164	4 917	1 098	-	-	-	-		-
QJ01XX91	Streptogramins[c]	-	8 800	1 088	1 275	525	-	-	-	-		-
QJ01XX92, QJ01XX94	Pleuromutilins	-	-	101	229	1 069	815	793	939	667	355	309
QP51AA	Nitroimidazoles	791	1 440	1 557	1 563	-	-	-	-	-	-	-
	Feed additives[d]	8 380	700	-	-	-	-	-	-	-	-	-
QP51AH	Ionophoric antibiotics (coccidiostats)[e]	390	7 900	6 991	8 267	11 643	9 368	10 019	8 439	10 920	10 486	11 095

[a] Drugs with special marketing authorisation are included from year 2005; [b] Drugs marketed with special marketing authorisation are included from year 2000; [c] Years 1980-1984 sold as feed additives, thereafter on veterinary prescription at therapeutic dosages; [d] Feed additives other than quinoxalines and streptogramins: avoparcin, bacitracin, nitrovin, oleandomycin and spiramycin; [e] From 1999 regulated and classified as feed additives (dir 70/524/EEC). Figures from 1999 and onwards are from the Feed Control of the Board of Agriculture (www.sjv.se).

Resistance in zoonotic bacteria

IN SVARM, antimicrobial susceptibility of zoonotic bacteria from animals in Sweden is monitored. This year, data on *Salmonella enterica* and of *Campylobacter* spp. from slaughter pigs are presented. More information regarding infections with these bacteria in Sweden is presented in the yearly report, Zoonoses in Sweden available at www.sva.se.

Some microbiological cut-off values defining resistance (breakpoints) used in SVARM 2000-2004 have been changed. To facilitate comparisons when data from these reports are presented, levels of resistance have been recalculated using current cut-off values.

Salmonella

Isolates included

Findings of *Salmonella* in animals are notifiable in Sweden and at least one isolate from each incident must be confirmed at SVA. From these isolates, one of each serovar and, when appropriate, phage-type from each warm-blooded animal species (wild and domesticated) involved in notified incidents year 2005 is included in the material, for more details see Appendix 3.

In Sweden, monitoring of antimicrobial susceptibility among *Salmonella* of animal origin has been performed regularly since 1978. Antimicrobials included in the test panels have varied but microdilution methods have been used in all these surveys. For comparison, data from previous years are therefore presented together with data for 2005.

Results and comments

This year, 105 isolates from 102 notified incidents were tested. The majority (80%) of the isolates were *S.* Typhimurium (Table Salm I). A large proportion, 42%, were from cats and only 30% from major food-producing animals (cattle, pigs and poultry). Distributions of MICs are presented in Table Salm II-III.

Nine isolates were resistant to one or more of the substances tested. One *S.* Agona isolate was resistant to streptomycin only, whereas eight *S.* Typhimurium isolates were multiresistant, i.e. resistant to at least three antimicrobials. Four of the multiresistant isolates were from dogs and there were no obvious epidemiological links between the cases. One of these isolates was of phage type NST while three could not be phage typed (NT). All these isolates were resistant to ampicillin, sulphonamides and tetracycline. In addition, one isolate was resistant to trimethoprim and one to enrofloxacin and nalidixic acid. Two isolates had the penta-resistance typical for DT 104, including ampicillin, sulphonamides, streptomycin, tetracycline and chloramphenicol.

The remaining four multiresistant isolates were from food producing animals and all had the typical penta-resist-

Table Salm I. Number of *Salmonella enterica* isolates included year 2005 presented by serovar and source.

Subspecies I	Cattle[a]	Pig	Poultry	Sheep	Dog	Cat	Horse	Wildlife	Total
Agona	1				1				2
Arizona				1					1
Chester		1							1
Dublin	5	1							6
Duesseldorf	1								1
Enteritidis phage type 1		1	1						2
Livingstone	2								2
Non serotypable	1					1			2
Senftenberg		1							1
Thompson	2								2
Typhimurium DT 10	1								1
Typhimurium DT 104	2	1							3
Typhimurium DT 120	1								1
Typhimurium DT 40		4		1				1	5
Typhimurium DT 41		1					1	4	6
Typhimurium not phage typed	1	1			1	43		15	62
Typhimurium NST	1	1			1				3
Typhimurium NT	1				3				4
Total	**19**	**12**	**1**	**2**	**6**	**44**	**1**	**20**	**105**
Percent of total	**18**	**11**	**1**	**2**	**6**	**42**	**1**	**19**	

[a] One isolate of *S.* Montevideo not available for testing.

ance phenotype. Three of these were isolated from cattle on two farms epidemiologically linked through trade of calves. *Salmonella* Typhimurium DT 104 was isolated from one of these farm and both DT 104 and DT 120 from the other farm. The two farms were put under restrictions according to the Swedish *Salmonella* control programme already in 2004 but *Salmonella* still occurred in 2005. The last isolate, a DT 104, was obtained from a pig carcass sampled at slaughter as part of routine surveys within the *Salmonella* control programme. *Salmonella* was not isolated from pigs sampled on the farm of origin.

From a public health perspective, the prevalence of resistance in *Salmonella* from food-producing animals is of greater importance than resistance in isolates from wild animals or pets. Therefore a subset 207 isolates from all incidents in food-producing animals years 2000-2005 is presented in Table Salm V. In this material, 13 isolates (6%) were resistant to any of the antimicrobials tested and eight isolates (4%) were multiresistant. All multiresistant isolates were *S.* Typhimurium, six DT104 and two DT120, resistant to ampicillin, streptomycin, tetracycline, chloramphenicol and sulphonamides. The multiresistant isolates were from three incidents of epidemiologically related cattle farms and from one incident where *Salmonella* was detected on routine sampling of pig carcasses at slaughter.

The level of resistance among *Salmonella enterica*, as well as in the subset *S.* Typhimurium, year 2005 is low and in good agreement with the results for previous years (Table Salm IV). This indicates a stable situation where a declining prevalence of streptomycin resistance is the only apparent trend.

Occurrence of multiresistance greatly influences the

Table Salm II. Distribution of MICs for all *Salmonella enterica* (n=105) from animals in 2005.

	Resistance	Distribution (%) of MICs[a] (mg/L)																	
Substance	(%)	≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	>2048
Ampicillin	8					1.9	76.4	14.2					7.5						
Cefotaxime	0		7.5	60.4	31.1	0.9													
Ceftiofur	0				3.8	17.9	77.4	0.9											
Chloramphenicol	6							4.7	84.9	4.7					5.7				
Enrofloxacin	<1		25.5	73.6		0.9													
Florfenicol	5								88.7	6.6		2.8	1.9						
Gentamicin	0					22.6	73.6	3.8											
Nalidixic acid	<1								69.8	28.3	0.9				0.9				
Neomycin	0							97.2	2.8										
Streptomycin	8								1.9	8.5	65.1	17.0	2.8	3.8	0.9				
Sulphonamide	8											0.9	26.4	56.6	8.5				7.5
Tetracycline	8						0.9	79.2	12.3				0.9	6.6					
Trimethoprim	<1				6.6	85.8	6.6						0.9						

[a] The white fields denote range of dilutions tested for each substance. MICs above the range are given as the concentration closest to the range. MICs equal to or lower than the lowest concentration tested are given as the lowest tested concentration. Bold vertical lines indicate cut-off values defining resistance.

Table Salm III. Distribution of MICs for the subset *Salmonella* Typhimurium (n=85) from animals in 2005.

	Resistance	Distribution (%) of MICs[a] (mg/L)																	
Substance	(%)	≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	>2048
Ampicillin	8					1.9	76.2	14.3					7.6						
Cefotaxime	0		7.6	60.0	31.4	1.0													
Ceftiofur	0				3.8	18.1	77.1	1.0											
Chloramphenicol	6							3.8	85.7	4.8					5.7				
Enrofloxacin	1		25.7	73.3		1.0													
Florfenicol	5								88.6	6.7		2.9	1.9						
Gentamicin	0					21.9	74.3	3.8											
Nalidixic acid	1								69.5	28.6	1.0				1.0				
Neomycin	0							97.1	2.9										
Streptomycin	8								1.9	8.6	64.8	17.1	2.9	3.8	1.0				
Sulphonamide	8											1.0	25.7	57.1	8.6				7.6
Tetracycline	8						1.0	79.0	12.4				1.0	6.7					
Trimethoprim	1				6.7	85.7	6.7						1.0						

[a] The white fields denote range of dilutions tested for each substance. MICs above the range are given as the concentration closest to the range. MICs equal to or lower than the lowest concentration tested are given as the lowest tested concentration. Bold vertical lines indicate cut-off values defining resistance.

prevalence of resistance in each year's material but such isolates are rare among Swedish animals. Since 1997, when testing of one isolate of each serovar from each notified incident commenced, only 26 of 687 isolates tested have been multiresistant. All multiresistant isolates have been *S.* Thyphimurium, 13 from a total of nine incidents in food producing animals, 12 isolates from an equal number of incidents in companion animals and one isolate from a wild boar.

Thus, multiresistant *Salmonella* was involved in only nine of about 330 notified incidents in food producing animals since 1997. Therefore, the overall situation of antimicrobial resistance in *Salmonella* among food-producing animals is favourable and spread of multiresistant clones is contained, most likely a result of the strategies in the Swedish *Salmonella* control programme. Moreover, there is no indication of spread of such clones among wild animals as only one of 102 *Salmonella enterica* isolates tested since 1997 was multiresistant.

Table Salm IV. Occurrence of resistance (%) and source of isolates in *Salmonella* Typhimurium from animals 1978 to 2005.

		Resistance (%)							
Substance	**Cut-off value** (mg/L)	**1978-88**[a] (n=125)	**1989-99** (n=317)	**2000** (n=46)	**2001** (n=31)	**2002** (n=31)	**2003** (n=49)	**2004** (n=49)	**2005** (n=85)
Ampicillin	>4	2[b]	6[b]	2	6	0	0	8	9
Cefotaxime	>0.5	-	-	-	-	-	-	-	0
Ceftiofur	>2	-	-	0	0	0	0	0	0
Chloramphenicol	>16	4[b]	5[b]	2	6	0	0	8	9
Enrofloxacin	0.25	-	1	0	0	0	0	0	3
Florfenicol	>16	-	-	2	6	0	0	6	8
Gentamicin	>4	-	0	0	0	0	0	0	0
Nalidixic acid	>16	-	-	4	3	3	0	0	1
Neomycin	>4	0[b]	1[b]	2	6	3	0	0	0
Streptomycin	>32	74	15	4	6	0	2	8	10
Sulphamethoxazole	>256	-	-	2	6	0	2	8	10
Tetracycline	>8	13	6	2	6	0	0	8	9
Trimethoprim	>2	-	-	0	0	0	0	0	0
Trim/sulph.	>0.5/9.5	0	3	-	-	-	-	-	-
Percent of isolates from:									
Cattle, sheep, pigs, poultry		100	46	57	39	36	12	33	19
Horses, cats, dogs			29	37	38	32	82	61	58
Wildlife			25	7	23	32	6	6	23

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

Table Salm V. Distribution of MICs for all *Salmonella enterica* (n=207) from food-producing animals years 2000-2005.

		Distribution (%) of MICs[a] (mg/L)															
Substance	**Resistance** (%)	**≤0.03**	**0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**	**512**	**>512**
Ampicillin	4					5.8	64.7	24.6	1.0			3.9					
Cefotaxime	0[b]		20.0	60.0	20.0												
Ceftiofur	0				5.8	24.6	66.2	3.4									
Chloramphenicol	4							11.6	66.2	18.4		3.9					
Enrofloxacin	1	0.5	54.1	40.6	3.9		1.0										
Florfenicol	3								76.8	18.8	1.0	3.4					
Gentamicin	0					14.5	52.2	27.1	6.3								
Nalidixic acid	1								54.6	34.3	9.7	0.5			1.0		
Neomycin	0							81.6	18.4								
Streptomycin	5							0.5	2.9	30.0	37.2	24.2	3.4	1.4		0.5	
Sulphonamide	5												37.7	48.8	8.7		4.8
Tetracycline	4						9.2	66.7	18.8	1.0			1.9	2.4			
Trimethoprim	<1				13.0	73.4	12.6	0.5	0.5								

[a] The white fields denote range of dilutions tested for each substance. MICs above the range are given as the concentration closest to the range. MICs equal to or lower than the lowest concentration tested are given as the lowest tested concentration. Bold vertical lines indicate cut-off values defining resistance; [b] 35 isolates tested.

Table Salm VI. Distribution of MICs for the subset *Salmonella* Typhimurium (n=86) from food-producing animals years 2000-2005.

Substance	Resistance (%)	Distribution (%) of MICs[a] (mg/L)															
		≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
Ampicillin	9						58.1	31.4	1.2			9.3					
Cefotaxime	0[b]			75.0	25.0												
Ceftiofur	0					29.1	68.6	2.3									
Chloramphenicol	9							9.3	79.1	2.3		9.3					
Enrofloxacin	3		53.5	43.0	3.5												
Florfenicol	8								88.4	2.3	1.2	8.1					
Gentamicin	0					12.8	55.8	26.7	4.7								
Nalidixic acid	1								57.0	27.9	14.0	1.2					
Neomycin	0							84.9	15.1								
Streptomycin	10								1.2	18.6	47.7	22.1	5.8	3.5		1.2	
Sulphonamide	10												38.4	41.9	9.3		10.5
Tetracycline	9						3.5	70.9	16.3				4.7	4.7			
Trimethoprim	0				19.8	67.4	12.8										

[a] The white fields denote range of dilutions tested for each substance. MICs above the range are given as the concentration closest to the range. MICs equal to or lower than the lowest concentration tested are given as the lowest tested concentration. Bold vertical lines indicate microbiological cut-off values defining resistance; [b] 16 isolates tested.

Campylobacter

Isolates included

Samples for culture of *Campylobacter* spp. were selected from the total number of samples of colon content from healthy pigs collected at abattoirs for isolation of indicator bacteria. Isolates were identified as *Campylobacter jejuni* or as hippurate-negative thermophilic *Campylobacter* spp.. Antimicrobials included in the test panels and concentration ranges are given in Table Camp I. For details on methodology, including sampling strategy, see Appendix 3.

Results and comments

Campylobacter were isolated from 76% of the cultured samples. The majority of isolates (n=97) were classified as hippurate-negative thermophilic *Campylobacter* spp. and only three were *C. jejuni*.

A large proportion, 24%, of hippurate-negative thermophilic *Campylobacter* spp. was resistant to quinolones (enrofloxacin and nalidixic acid) but resistance to other substances was uncommon (Table Camp I). Of the three *C. jejuni* tested, one isolate was resistant to nalidixic acid and enrofloxacin.

The results from this years survey agree with the results from years 1999 and 2003 (Table Camp I). Resistance to most substances is rare but the prevalence of quinolone resistance in *Campylobacter* spp. from pigs is high. This is surprising since quinolones are not authorised for group treatment of pigs in Sweden. Injectables, i.e. enrofloxacin and danofloxacin, are authorised for individual treatment and probably mainly used to treat diarrhea or respiratory disease in younger pigs and possibly the mastitis-metritis-agalactia syndrome in sows. Since consumption statistics is not available per animal species, the extent of usage in the pig population is not known but injectables are unlikely to constitute a selection pressure in the period close to slaughter. If usage in piglets and sows select for resistant *Campylobacter* remaining until slaughter deserves further study.

Only six of the 70 quinolone resistant *Campylobacter* spp. obtained in the surveys made in SVARM were resistant to any other of the substance tested. All six were resistant to tetracyclines. It is therefore unlikely that quinolone resistance is an effect of co-selection by other substances used for group treatment of pigs in Sweden, i.e. tetracyclines and macrolides.

Table Camp I. Distribution of MICs for hippurate-negative thermophilic *Campylobacter* spp. from pigs (n=97) 2005. Data for 1999 (n=91) and 2003 (n=100) are given for comparison (SVARM 2003).

Substance	Year	Resistance (%)	Distribution (%) of MICs[a] (mg/L)													
			≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	>128
Ampicillin	-05	5					1.0	16.5	20.6	46.4	10.3		4.1		1.0	
	-03	0					3.0	9.0	16.0	39.0	32.0	1.0				
	-99	0					1.1	8.8	18.7	45.1	25.3	1.1				
Enrofloxacin	-05	24		17.5	43.3	13.4	2.1		1.0	14.4	8.2					
	-03	17		30.0	44.0	8.0	1.0	1.0	1.0	8.0	7.0					
	-99	30	1.1	40.7	19.8	8.8			5.5	15.4	8.8					
Erythromycin	-05	0				1.0	5.2	24.7	41.2	24.7	2.1	1.0				
	-03	0				1.0	5.0	21.0	34.0	33.0	6.0					
	-99	1					5.5	13.2	28.6	38.5	13.2		1.1			
Gentamicin	-05	0					4.1	52.6	43.3							
	-03	-[b]														
	-99	0					1.1	39.6	59.3							
Nalidixic acid	-05	24								7.2	44.3	21.6	3.1	2.1	17.5	4.1
	-03	17							4.0	35.0	36.0	7.0	1.0	8.0	9.0	
	-99	30							2.2	27.5	34.1	6.6		7.7	18.7	3.3
Tetracycline	-05	4				60.8	20.6	9.3	5.2	2.1	1.0			1.0		
	-03	3				79.0	10.0	7.0	1.0	1.0	1.0		1.0			
	-99	4				56.0	20.9	15.4	3.3	2.2		1.1		1.1		

[a] The white fields denote range of dilutions tested for each substance. MICs above the range are given as the concentration closest to the range. MICs equal to or lower than the lowest concentration tested are given as the lowest tested concentration. Bold vertical lines indicate cut-off values defining resistance; [b] Data not presented since methodological difficulties caused a shift of the whole distribution towards higher MICs year 2003.

Resistance in indicator bacteria

THE PREVALENCE of acquired resistance to antimicrobials among bacteria of the normal enteric microflora can serve as an indicator of the selective pressure exerted by use of antimicrobial agents in exposed populations. Although these bacteria are unlikely to cause disease, they form a reservoir of transferable resistance determinants from which resistance genes can spread to bacteria that cause infections in animals or humans. Thus, monitoring of resistance among indicator bacteria in the normal enteric microbiota from healthy animals is of great value to detect trends and to follow effects of interventions. In SVARM, *Escherichia coli* and *Enterococcus* spp. from healthy animals serve as indicator bacteria. The report for year 2005 presents data on isolates from slaughter pigs. Indicator bacteria from this animal species were previously reported in SVARM years 2000, 2001 and 2003.

Of special interest in monitoring antimicrobial susceptibility among indicator bacteria is the occurrence of specific patterns of resistance. Such patterns, or phenotypes, can indicate that resistance genes are located on the same genetic element. Thereby, a single transfer event can convey resistance to several antimicrobials to the recipient bacterium (co-transfer). Thus, use of one antimicrobial can select for resistance to other unrelated antimicrobials (co-selection). In SVARM 2005, associations between resistance to different antimicrobials were analysed on the combined data for years 2000, 2001, 2003 and 2005.

Some microbiological cut-off values defining resistance (breakpoints) used in SVARM 2000-2004 have been changed. To facilitate comparisons when data from these reports are presented or used in calculations, levels of resistance have been recalculated using the current cut-off values. An overview of all cut-off values used is given in Appendix 3.

Isolates included

Escherichia coli and *Enterococcus* spp. were isolated from caecal or colon content from pigs sampled at slaughter. Each isolate originates from a unique herd. Antimicrobials tested and concentration ranges used are given in Table EC IV and ENT VII. For details on methodology, including sampling strategy, see Appendix 3.

Escherichia coli

The material includes 390 isolates of *E. coli* from slaughter pigs. Isolates were obtained from 86% of 455 samples cultured which is similar to isolation frequencies in previous SVARM surveys.

The majority of isolates (78%) were sensitive to all 13 antimicrobials tested but 85 isolates were resistant to at least one substance. Resistance to sulphonamides, streptomycin or tetracycline were the most common traits (9-11%) (Table EC I). Ampicillin, trimethoprim or chloramphenicol resistance were less common (3-6%) and resistance to neomycin, nalidixic acid or enrofloxacin occurred in occasional isolates only (<1-3%). No isolate was resistant to gentamicin or to third generation cephalosporins (ceftiofur or cefotaxime).

About thirteen percent of the isolates were resistant to more than one antimicrobial and 6% were multiresistant, i.e. resistant to three or more of the antimicrobials tested (Table EC I). All multiresistant isolates 2005 had sulphonamides in their phenotype (Table EC II). Ampicillin, trimethoprim or streptomycin resistance was also common, occurring in 60-72% of the multiresistant isolates and about one third (32%) were resistant to all four traits.

Among the 1261 isolates from years 2000, 2001, 2003 and 2005, resistance to some antimicrobials was often associated with increased occurrence of resistance to other substances (Table EC III). For several pairs of resistance traits the association was statistically significant ($P<0.001$) (Table EC III).

Overall, frequencies of resistance are low in an international perspective. Resistance mostly occurs to substances currently or previously used in Swedish pig production (sulphonamides, tetracycline, ampicillin, trimethoprim, streptomycin). Resistance to chloramphenicol occurs at a low level although this substance has not been used since the early 70s. Since this resistance trait seldom occurs alone but in combination with resistance to sulphonamides, ampicillin or trimethoprim, remaining resistance is likely due to co-selection. Quinolone resistance occurs in occasional isolates only, which is in contrast to the situation among *Campylobacter* spp. from pigs (see Resistance in zoonotic bacteria).

Occurrence of resistance appears to be stable and without statistically significant trends (Chi-Square for trend >0.05) over the years studied (Table EC I). Frequency of ampicillin resistance year 2005 is however higher than in previous years (Table EC I). An increase in resistance to ampicillin is observed also among *E. coli* from diagnostic submissions from pigs (see Resistance in animal pathogens). These tendencies could be an effect of increased use of broad-spectrum penicillins (ampicillin/amoxicillin) in later years, as observed in Denmark (DANMAP 2004). In Sweden, ampicillin has been available for oral use in pigs since the 70s. For injection, it was available until 1992 and again from 1998 when a new product (amoxicillin) was registered. Unfortunately, the extent of use in pigs is not known. Since ampicillin resistance often occurs in combination with resistance to other substances (Table II) it has the potential to co-select also for other resistance traits and, conversely, be co-selected by use of other antimicrobials. Thus, this antimicrobial should be used cautiously and only when alternatives are lacking.

Table EC I. Occurrence of resistance (%) and multiresistance (%) among isolates of *Escherichia coli* from pigs, 2005. Previous data from SVARM are given for comparison.

Substance	Cut-off value (mg/L)	Resistance (%) (95% confidence interval inside brackets)											
		Pigs								Chickens		Cattle	
		2005 n=390		2003 n=303		2001 n=308		2000 n=260		2004 n=300		2000 n=293	
Ampicillin	>8	6	(4.2-9.3)	3	(1.6-6.0)	3	(1.6-5.9)	3	(1.3-6.0)	4	(2.1-6.9)	0	(0.0-1.3)
Cefotaxime	>0.25	0	(0.0-0.9)	-		-		-		-		-	
Ceftiofur	>1	0	(0.0-0.9)	0	(0.0-1.2)	0	(0.0-1.2)	0	(0.0-1.4)	0	(0.0-1.2)	0	(0.0-1.3)
Chloramphenicol	>16	3	(1.8-5.6)	<1	(0.1-2.4)	2	(0.5-3.8)	<1	(0.0-2.1)	0	(0.0-1.2)	0	(0.0-1.3)
Enrofloxacin	>0.12	<1	(0.1-1.4)	<1	(0.2-2.9)	<1	(0.0-1.8)	0	(0.0-1.4)	5	(2.8-8.1)	<1	(0.0-1.9)
Florfenicol	>16	0	(0.0-0.9)	0	(0.0-1.2)	0	(0.0-1.2)	0	(0.0-1.4)	0	(0.0-1.2)	0	(0.0-1.3)
Gentamicin	>4	0	(0.0-0.9)	0	(0.0-1.2)	2	(0.9-4.6)	2	(0.6-2.4)	<1	(0.0-1.8)	<1	(0.1-2.4)
Nalidixic acid	>16	<1	(0.1-1.4)	1	(0.2-2.9)	<1	(0.0-1.8)	0	(0.0-1.4)	5	(2.8-8.1)	<1	(0.1-2.4)
Neomycin	>8	1	(0.3-2.6)	1	(0.2-2.9)	<1	(0.0-1.8)	1	(0.2-3.3)	3	(1.6-6.1)	0	(0.0-1.3)
Streptomycin	>32	11	(7.7-14.0)	10	(6.8-13.8)	9	(6.4-13.2)	13	(9.2-17.8)	5	(2.8-8.1)	5	(2.9-8.3)
Sulphamethoxazole	>256	11	(7.7-14.0)	9	(6.0-12.7)	10	(6.7-13.6)	7	(4.2-10.7)	9	(6.0-12.8)	1	(0.4-3.5)
Tetracycline	>8	9	(6.1-12.0)	12	(8.2-15.7)	8	(5.6-12.1)	7	(4.2-10.7)	6	(3.6-9.3)	1	(0.4-3.5)
Trimethoprim	>2	6	(4.2-9.3)	4	(2.3-7.2)	3	(1.6-5.9)	5	(3.0-8.9)	<1	(0.1-2.4)	2	(0.6-3.9)
Multiresistance													
Sensitive to all substances		78.2		77.9		77.6		78.8		83.7		91.8	
Resistant to one substance		9.0		11.2		12.3		11.5		8.3		6.5	
Resistant to two substances		6.4		5.9		5.8		5.4		2.7		<1	
Resistant to three substances		2.6		2.0		2.6		1.9		1.0		<1	
Resistant to >three substances		3.8		3.0		1.6		2.3		2.0		<1	

Table EC II. Number of *Escherichia coli* resistant to three or more antimicrobials, presented by year and resistance phenotype, pigs 2005. "R" in shaded fields indicates resistance. Previous data from SVARM are included.

Year				Resistance pattern								
2005 n=390	2003 n=303	2001 n=308	2000 n=260	Su	Am	Tm	Sm	Tc	Cm	Nm	Nal	Ef
1				R	R	R	R	R	R			
1		1	1	R	R	R	R	R		R		
3	1		1	R	R	R	R	R				
1				R	R	R	R			R		
2	1	1	3	R	R	R	R					
2				R	R	R		R	R			
4	1	2		R	R	R			R			
	1			R	R	R						
	1		1	R	R		R	R		R		
		1		R	R		R		R			
3		2		R	R		R					
1		1		R	R				R			
	2			R		R	R	R				
1	1	1	2	R		R	R					
2				R		R		R				
1				R		R			R	R		
	1			R			R	R		R		
1	3	3	1	R			R	R				
2			1	R			R		R			
	1				R		R				R	R
	1				R			R			R	R
	1					R	R	R				
			1			R	R			R		
		1				R					R	R
25	**15**	**13**	**11**	**Number of isolates**								
(6.4%)	(5.0%)	(4.2%)	(4.3%)									

[a] Sm: streptomycin; Su: sulphonamides; Tc: tetracycline; Am: ampicillin; Tm: trimethoprim; Cm: chloramphenicol; Nm: neomycin; Nal: nalidixic acid; Ef: enrofloxacin.

Table EC III. Association between resistance traits in *Escherichia coli* isolated from pigs years 2000, 2001, 2003 and 2005 (n=1261). For each substance the first line gives the resistance rates for susceptible isolates (S) and the second line rates for resistant isolates (R). Bold and underlined figures indicate statistically significant association between pairs of resistance traits (Chi-Square or Fischer's Exact test, p<0.001).

Single substance susceptibility		n	Resistance (%)[a]													
			Am	**Ap**	**Ctx**	**Ce**	**Cm**	**Ef**	**Ff**	**Gm**	**Nal**	**Nm**	**Sm**	**Su**	**Tc**	**Tm**
Ampicillin	S	1208	0.0	0.0	0.0	0.0	0.7	0.2	0.0	1.0	0.2	0.4	8.9	6.2	7.9	2.7
	R	53	100.0	0.0	0.0	0.0		3.8	0.0	0.0	3.8	11.3	**49.1**	**77.4**	**32.1**	**54.7**
Apramycin	S	788	3.0	0.0	0.0	0.0	0.9	0.3	0.0	1.5	0.3	0.9	10.7	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	0.0	0.0	0.0	0.0
Cefotaxime	S	390	6.4	0.0	0.0	0.0	3.3	0.3	0.0	0.0	0.3	1.0	10.5	10.5	8.7	6.4
	R	0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ceftiofur	S	1261	4.2	0.0	0.0	0.0	1.7	0.4	0.0	1.0	0.4	0.9	10.6	9.2	9.0	4.9
	R	0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chloramph	S	1240	3.2	0.0	0.0	0.0	0.0	0.4	0.0	1.0	0.4	0.8	10.4	7.7	8.9	4.1
	R	21	**61.9**	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	4.8	23.8	**95.2**	14.3	**52.4**
Enrofloxacin	S	1256	4.1	0.0	0.0	0.0	1.7	0.0	0.0	1.0	0.0	0.9	10.6	9.2	8.9	4.9
	R	5	40.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	20.0	20.0	20.0	20.0
Florfenicol	S	1261	4.2	0.0	0.0	0.0	1.7	0.4	0.0	1.0	0.4	0.9	10.6	9.2	9.0	4.9
	R	0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gentamicin	S	1249	4.2	0.0	0.0	0.0	1.7	0.4	0.0	0.0	0.4	0.9	10.6	9.3	9.0	5.0
	R	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	8.3	0.0	0.0	0.0
Nalidixic acid	S	1256	4.1	0.0	0.0	0.0	1.7	0.0	0.0	1.0	0.0	0.9	10.6	9.2	8.9	4.9
	R	5	40.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	20.0	0.0	20.0	20.0
Neomycin	S	1250	3.8	0.0	0.0	0.0	1.6	0.4	0.0	1.0	0.4	0.0	10.1	8.6	8.6	4.5
	R	11	54.5	0.0	0.0	0.0	9.1	0.0	0.0	0.0	0.0	100.0	72.7	72.7	54.5	54.5
Streptomycin	S	1127	2.4	0.0	0.0	0.0	1.4	0.4	0.0	1.0	0.4	0.3	0.0	4.7	5.9	2.9
	R	134	**19.4**	0.0	0.0	0.0	3.7	0.7	0.0	0.7	0.7	6.0	100.0	**47.0**	**35.1**	**21.6**
Sulphamethox	S	1145	1.0	0.0	0.0	0.0	0.1	0.4	0.0	1.0	0.4	0.3	6.2	0.0	6.9	1.7
	R	116	**35.3**	0.0	0.0	0.0	**17.2**	0.0	0.0	0.0	0.0	6.9	**54.3**	100.0	**29.3**	**36.2**
Tetracycline	S	1148	3.1	0.0	0.0	0.0	1.6	0.3	0.0	1.0	0.3	0.4	7.6	7.1	0.0	3.9
	R	113	**15.0**	0.0	0.0	0.0	2.7	0.9	0.0	0.0	0.9	5.3	**41.6**	**30.1**	100.0	**15.0**
Trimethoprim	S	1199	2.0	0.0	0.0	0.0	0.8	0.3	0.0	1.0	0.3	0.4	8.8	6.2	8.0	0.0
	R	62	**46.8**	0.0	0.0	0.0	**17.7**	1.6	0.0	0.0	1.6	9.7	**46.8**	**67.7**	**27.4**	100.0

[a] Am: ampicillin; Ap: apramycin; Ctx: Cefotaxime; Ce: ceftiofur; Cm: chloramphenicol; Ef: enrofloxacin; Ff: florfenicol; Gm: gentamicin; Nal: nalidixic acid; Nm: neomycin; Sm: streptomycin; Su: sulphamethoxazole; Tc: tetracycline; Tm: trimethoprim.

Table EC IV. Distribution of MICs for *Escherichia coli* from slaughter pigs year 2005 (n=390). Data from SVARM years 2000 (n=260), 2001 (n=308) and 2003 (n=303) are given for comparison.

Substance	Year	Resistance (%)	Distribution (%) of MICs[a] (mg/L)																	
			≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	>2048
Ampicillin	-05	6					0.8	18.2	56.2	18.5				6.4						
	-03	3						6.6	68.0	21.5	0.7		0.7	2.6						
	-01	3					0.6	6.5	39.9	49.4	0.3			3.2						
	-00	3						0.4	31.2	64.6	0.8			3.1						
Cefotaxime	-05	0		60.5	38.7	0.8														
	-03	-																		
	-01	-																		
	-00	-																		
Ceftiofur	-05	0			4.4	67.9	27.2	0.5												
	-03	0				23.8	72.3	4.0												
	-01	0				31.5	65.6	2.9												
	-00	0				30.8	65.8	3.5												
Chloramphenicol	-05	3						0.3	7.7	73.1	15.1	0.5	2.6	0.3	0.3	0.3				
	-03	<1							5.3	80.2	13.2	0.7	0.7							
	-01	2							2.9	69.5	25.3	0.6	1.6							
	-00	<1							1.9	50.0	47.7		0.4							
Enrofloxacin	-05	<1	21.3	713	7.2		0.3													
	-03	<1	11.9	78.9	8.3	0.3	0.3	0.3												
	-01	<1	36.0	62.3	1.3			0.3												
	-00	0	25.0	71.9	3.1															
Florfenicol	-05	0								54.1	44.9	1.0								
	-03	0								67.7	31.7	0.7								
	-01	0							1.6	61.7	35.7	1.0								
	-00	0							1.2	43.8	54.2	0.8								
Gentamicin	-05	0					32.8	52.6	12.8	1.8										
	-03	0					2.6	51.2	37.3	9.2										
	-01	2					0.6	17.2	51.6	28.2	2.3									
	-00	2					1.5	19.6	55.0	21.9	1.5	0.4								
Nalidixic acid	-05	<1						1.3	33.1	61.5	3.8					0.3				
	-03	1						0.3	35.3	61.1	2.0	0.3		0.3	0.3	0.3				
	-01	<1							7.5	51.3	39.3	1.6				0.3				
	-00	0							1.9	26.2	68.8	3.1								
Neomycin	-05	1							91.5	6.7	0.8	0.5	0.5							
	-03	1							59.1	34.7	5.3	0.3	0.7							
	-01	<1						3.9	53.6	36.7	5.5		0.3							
	-00	1						4.6	56.9	34.6	2.7				0.4	0.8				
Streptomycin	-05	11							0.8	25.9	51.8	7.2	3.8	3.3	4.9	1.0	1.3			
	-03	10								5.3	47.5	34.3	3.0	2.0	2.0	3.3	2.6			
	-01	9								6.2	49.0	31.2	4.2	2.3	1.9	2.6	2.6			
	-00	13								6.9	53.1	24.2	2.7	3.5	3.8	3.1	2.7			
Sulphamethoxazole	-05	11										54.4	26.2	7.9	1.0				0.5	10.0
	-03	9												71.0	19.1	1.0		8.9		
	-01	10												61.0	28.9	0.3		9.7		
	-00	7												57.7	35.4			6.9		
Tetracycline	-05	9						32.1	53.3	5.9		0.3	1.0	0.5	6.9					
	-03	12						19.8	53.1	14.9	0.7	0.3	1.0	0.7	9.6					
	-01	8						23.4	60.7	7.5		0.3	0.6	1.9	5.5					
	-00	7					0.8	8.1	70.0	13.5	0.8	0.4	0.8		5.8					
Trimethoprim	-05	6				28.2	53.3	11.0	1.0	0.8				5.6						
	-03	4				19.8	59.1	15.2	1.7				4.3							
	-01	3			2.3	18.2	62.7	13.3	0.3	0.3	0.6		2.3							
	-00	5			0.8	10.0	59.2	23.5	1.2	0.8		0.4	4.2							
			≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	>2048

[a] The white fields denote range of dilutions tested for each substance. MICs above the range are given as the concentration closest to the range. MICs equal to or lower than the lowest concentration tested are given as the lowest tested concentration. Bold vertical lines indicate microbiological cut-off values defining resistance.

Enterococcus

Of the 262 isolates from slaughter pigs, *Enterococcus hirae* (43%) was the predominant species followed by *E. faecalis* (21%), *E. faecium* (18%) and *E. durans* (7%) (Table ENT I). Other species of enterococci isolated were *E. mundtii* (2%). About ten percent of the isolates could not be typed to species level.

All enterococci

Tetracycline resistance was the most common trait (27%) followed by erythromycin resistance (13%) (Table ENT II). Resistance to the other antimicrobials was considerably less common (<1-4%). No isolate was resistant to vancomycin. Flavomycin and virginiamycin are not included in the overall comparison as the inherent susceptibility to these substances differs between species of enterococci.

All samples were also cultured selectively using media supplemented with vancomycin (16 mg/L) but no vancomycin resistant enterococci were isolated (see Appendix III for details on methodology).

Enterococcus faecalis

Most isolates of *E. faecalis* (75%) were resistant to at least one antimicrobial, 35% were resistant to more than one antimicrobial and nine percent were multiresistant (Table ENT III). Resistance phenotypes of multiresistant isolates are presented in Table ENT IV. Resistance to tetracycline (64%), erythromycin (33%), streptomycin (16%) or neomycin (7%) were the most prevalent traits. Resistance to chloramphenicol, gentamicin or bacitracin occurred in occasional isolates whereas resistance to ampicillin, avilamycin, flavomycin, narasin or vancomycin was not observed.

Among the 250 isolates from years 2000, 2001, 2003 and 2005, resistance to some substances is associated with increased occurrence of resistance to other substances (Table ENT V). For several pairs of resistance traits, the association is statistically significant (P<0.001) (Table ENT V). Notably, there is a statistically significant association between resistance to erythromycin and tetracycline, the two most common traits among *E. faecalis*.

Enterococcus faecium

The majority of *E. faecium* (62%) were sensitive to all antimicrobials tested (Table ENT III). Four isolates (9%) were resistant to more than one antimicrobial and of these, one isolate had six antimicrobials in the phenotype (Table ENT IV). Erythromycin was the most prevalent resistance trait (21%) followed by tetracycline (13%) and virginiamycin (11%). No isolate was resistant to ampicillin, narasin, streptomycin or vancomycin. Among the 272 isolates from years 2000, 2001, 2003 and 2005 resistance to some antimicrobi-

Table ENT I. Prevalence of enterococci in samples of caecal content from slaughter pigs, 2005. Species not identified as *Enterococcus faecalis*, *E. faecium* or *E. hirae* are given as "other species". Previous data from SVARM are given for comparison.

Year	No. of samples cultured	Percent positive cultures	No. of isolates tested for antimicrobial susceptibility	*Enterococcus* species isolated No. of isolates (percent of total No. of isolates inside brackets)			
				E. faecalis	*E. faecium*	*E. hirae*	Other species
2005	455	58%	262	55 (21%)	47 (18%)	112 (43%)	48 (18%)
2003	510	62%	315	87 (28%)	71 (23%)	124 (39%)	33 (10%)
2001	470	59%	279	52 (19%)	106 (38%)	77 (28%)	44 (16%)
2000	460	52%	241	56 (23%)	48 (20%)	106 (44%)	36 (13%)

Table ENT II. Occurrence of resistance (%) among isolates of *Enterococcus* spp. slaughter pigs, 2005. Previous data from SVARM are given for comparison.

Substance	Cut-off value (mg/L)	Resistance % 95% confidence interval inside brackets											
		Pigs								Chickens		Cattle	
		2005 n=262		2003 n=315		2001 n=279		2000 n= 241		2004 n=306		2000 n=277	
Ampicillin	>4	1	(0.2-3.3)	<1	(0.0-1.8)	1	(0.4-3.6)	<1	(0.0-2.3)	1	(0.4-3.3)	1	(0.4-3.7)
Avilamycin	>16	4	(1.9-6.9)	0	(0.0-1.2)	0	(0.0-1.3)	0	(0.0-1.5)	0	(0.0-1.2)	<1	(0.0-2.0)
Bacitracin[a]	>32	<1	(0.1-2.7)	3	(1.5-5.8)	1	(0.2-3.1)	2	(0.5-4.2)	25	(20.4-30.4)	<1	(0.1-2.6)
Chloramph.	>32	2	(0.4-3.9)	-		-		-		0	(0.0-1.2)	-	
Erythromycin	>4	13	(8.8-17.2)	13	(9.8-17.6)	11	(8.0-15.8)	11	(7.2-15.4)	18	(13.5-22.4)	3	(1.0-5.1)
Gentamicin	>512	2	(0.4-3.9)	2	(0.7-4.1)	1	(0.2-3.1)	0	(0.0-1.5)	0	(0.0-1.2)	0	(0.0-1.3)
Narasin	>2	3	(1.3-5.9)	3	(1.5-5.8)	3	(1.3-5.6)	2	(0.5-4.2)	81	(75.9-85.0)	1	(0.4-3.7)
Neomycin	>512	2	(0.6-4.4)	-		-		-		<1	(0.0-1.8)	-	
Streptomycin	>1024	3	(1.6-6.4)	5	(3.2-8.5)	6	(3.9-10.0)	4	(2.0-7.5)	<1	(0.1-2.3)	<1	(0.1-2.6)
Tetracycline	>2	27	(21.5-32.5)	30	(24.8-35.2)	24	(19.1-29.5)	27	(21.9-33.5)	20	(15.9-25.2)	8	(5.3-12.2)
Vancomycin	>4	0	(0.0-1.4)	<1[b]	(0.0-1.8)	0	(0.0-1.3)	<1[b]	(0.0-2.3)	1	(0.2-2.8)	1[b]	(0.2-3.1)

[a] MIC in U/mL; [b] Isolates with MIC 8 mg/L

als was associated with increased occurrence of resistance to other substances, but only the association bacitracin-narasin was statistically significant at p<0.001 (Table ENT VI).

Enterococcus hirae

The majority of isolates (82%) were sensitive to all antimicrobials and no isolate was multiresistant (Table ENT III). Resistance occurred to three antimicrobials only. Tetracycline was the most prevalent trait (11%) and seven and five percent of the isolates were resistant to avilamycin and narasin, respectively.

Comments in relation to previous years

Occurrence of resistance among enterococci from pigs 2005 is, with the exception of erythromycin resistance in *E. faecium*, of the same magnitude as in previous years and low

Table ENT III. Occurrence of resistance (%) and multiresistance (%) among *Enterococcus faecalis*, *E. faecium* and *E. hirae* from slaughter pigs, presented by bacterial species and source of isolates, 2005. Previous data from SVARM are given for comparison. Cut-off values defining resistance are given in Table ENT II.

	E. faecalis						*E. faecium*						*E. hirae*					
	Pigs				Chick-ens	Cattle	Pigs				Chick-ens	Cattle	Pigs				Chick-ens	Cattle
Substance	2005 n=55	2003 n=87	2001 n=52	2000 n=56	2004 n=48	2000 n=22	2005 n=47	2003 n=71	2001 n=106	2000 n=48	2004 n=163	2000 n=71	2005 n=112	2003 n=124	2001 n=77	2000 n=106	2004 n=34	2000 n=127
Ampicillin	0	0	4	0	0	0	0	0	2	0	2	1	0	<1	0	0	0	2
Avilamycin	0	0	0	0	0	0	2	0	0	0	0	1	7	0	0	0	0	0
Bacitracin	2	0	0	0	29	0	2	13	3	4	32	1	0	0	0	0	0	0
Chloramph.	5	-	-	-	0	-	2	0	-	-	0	-	0	0	-	-	0	-
Erythromycin	33	25	27	36	25	5	21	18	11	2	10	6	0	4	0	4	26	0
Flavomycin	0	3	2	2	4	14	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Gentamicin	5	7	4	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0
Narasin	0	1	4	2	35	0	0	3	4	2	93	1	5	2	3	2	91	2
Neomycin	7	-	-	-	2	0	2	-	-	-	0	0	0	-	-	-	0	<1
Streptomycin	16	16	25	13	4	5	0	0	4	2	0	0	0	2	0	<1	0	0
Tetracycline	64	63	67	68	48	14	13	17	8	13	18	7	11	14	12	16	3	3
Vancomycin	0	1[b]	0	0	0	0	0	0	0	0	2	1[b]	0	0	0	0	0	0
Virginiamycin	NR[a]	NR	NR	NR	NR	NR	11	1	3	2	2	1	0	0	0	0	3	0
Multiresistance																		
Sensitive to all	25.5	24.1	21.2	25.0	22.9	68.2	61.7	63.4	77.4	79.2	3.1	84.5	82.1	81.5	85.7	79.2	2.9	92.9
Resistant to 1	40.0	49.4	44.2	35.7	27.1	27.3	29.8	25.4	16.0	16.7	44.8	11.3	12.5	15.3	13.0	18.9	70.6	7.1
Resistant to 2	25.5	17.2	23.1	33.9	35.4	4.5	6.4	7.0	2.8	4.2	42.9	2.8	5.4	2.4	1.3	1.9	26.5	
Resistant to 3	1.8	4.6	5.8	5.4	10.4		0	4.2	1.9		8.0	1.4		0.8				
Resistant to >3	7.3	4.6	5.8		4.2		2.1		1.9		1.2							

[a] Not relevant as susceptibility in some species of *Enterococcus* is inherently low; [b] Isolates with MIC 8 mg/L

Table ENT IV. Number of isolates of *Enterococcus faecalis* (left panel) and *E. faecium* (right panel) resistant to three or more antimicrobials, presented by year and resistance phenotype, slaughter pigs 2005. "R" in shaded fields indicates resistance. Previous data from SVARM are given for comparison.

E. faecalis

Year				Resistance pattern[a]								
2005 n=55	2003 n=87	2001 n=52	2000 n=56	Tc	Em	Sm	Nm[b]	Gm	Cm[b]	Na	Am	Fl
1				R	R	R	R	R	R			
1				R	R	R	R	R				
1				R	R	R	R		R			
		1		R	R	R		R			R	
	1			R	R	R		R		R		
	3			R	R	R		R				
		1		R	R	R				R		
1	2	2	2	R	R	R						
1				R	R		R	R				
	2	1		R	R			R				
			1	R	R					R		
		1		R						R	R	R
5 (9%)	**8** (9%)	**6** (12%)	**3** (5%)	Total number of multiresistant isolates								

E. faecium

Year				Resistance pattern[a]								
2005 n=47	2003 n=71	2000 n=106	2001 n=48	Tc	Em	Sm	Nm[b]	Gm	Cm[c]	Vi	Na	Ba
1				R	R		R	R	R	R		
		1		R	R	R						
		1		R	R	R						
		1		R	R						R	R
	2			R	R							R
	1			R	R					R		
		1								R	R	R
1 (2%)	**3** (4%)	**4** (4%)	**0** (0%)	Total number of multiresistant isolates								

[a] Tc: tetracycline; Em: erythromycin; Sm: streptomycin; Nm: neomycin; Gm: gentamicin; Cm: chloramphenicol; Na: narasin; Am: ampicillin; Fl: flavomycin; Vi: virginiamycin; Ba: bacitracin; [b] Not included years 2000-2003, [c] Not included years 2000-2001.

Vancomycin-resistant enterococci (VRE) in Swedish broiler chickens

In last years SVARM report, the issue of vancomycin resistant enterococci (VRE) among broiler chickens in Sweden was highlighted and discussed (SVARM 2004). The motive was that the surveys on indicator bacteria in SVARM 2000-2004 showed that the proportion of broiler chickens carrying VRE had gradually increased (Fig ENT I). The increase is evident only when samples are cultured on media supplemented with vancomycin (16 mg/L), which enhance the possibility to detect the bacteria. When media without vancomycin were used, only occasional isolates of VRE were obtained (see Appendix 3 for details on methodology). This shows that VRE comprise a small fraction of the enterococci colonising the enteric tract but evidently, the proportion of colonised chickens has increased since year 2000. In the same period, VRE have not been found in samples from pigs (n=1895) or cattle (n=317) even after culture on vancomycin-supplemented media.

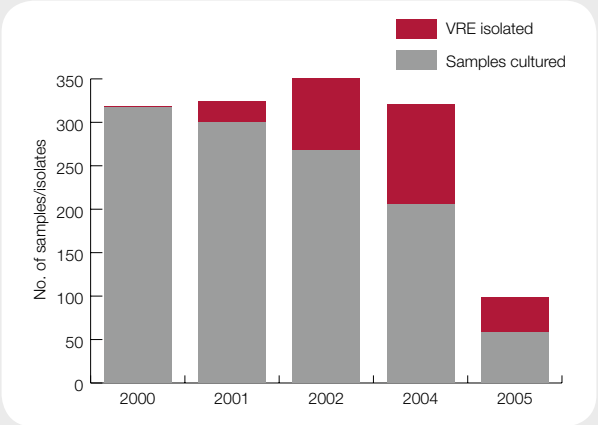

Fig ENT 1. Number of samples cultured on vancomycin supplemented media and number of samples were VRE were isolated. Caecal samples from broiler chickens cultured within SVARM.

This year, indicator bacteria from broiler chickens were not included in the routine surveys of SVARM. Therefore, the colonisation rate of VRE among broiler chickens was investigated in a separate study on samples obtained through the Swedish Campylobacter programme. From these samples, 50 caeca collected at slaughter were selected in order of arrival at SVA in the period May 10-17 and 49 caeca in the period September 14-21. Samples selected for culture were from unique flocks but not necessarily from unique production sites.

Samples were analysed according to routine procedures in SVARM (see Appendix 3 for details) but were cultured only on media supplemented with vancomycin (16 mg/L). For every fourth consecutive enterococcal isolate with MICs of vancomycin above >128 mg/L, the resistance genotype was confirmed with PCR for the *vanA*- and *vanB*-genes (Dutka-Malen *et al.*, 1995). Vancomycin resistant isolates were subtyped with the PhenePlate™ system (PhPlate Microplate Techniques AB, Stockholm, Sweden).

VRE were isolated from 41 (41%) of the 99 samples cultured, a larger proportion than year 2004 (36%) but the difference is not statistically significant (p>0.05, Chi-Square). The overall trend since year 2000 is however obvious and statistically significant (p<0.001, Chi-Square for trend) (Fig ENT 1). All 41 isolates 2005 were *Enterococcus faecium* with MICs for vancomycin >128 mg/L and all nine isolates tested by PCR carried the *vanA* gene. This is in agreement with the results of previous surveys in SVARM where all VRE isolated from chickens (n=224) have been *E. faecium* with MIC for vancomycin ≥128 mg/L. Moreover, the majority of isolates have the same antibiogram, including resistance to vancomycin, narasin and low-level resistance to erythromycin (MIC 8-16 mg/L) (Table ENT X). A minority are resistant to tetracyclines or ampicillin and resistance to aminoglycosides (gentamicin, streptomycin or neomycin) have not been observed. Eighty-eight isolates investigated by PCR all carried the *vanA* gene.

The majority of isolates from broilers have an identical phenotype when tested by the PhenePlate™ system and most isolates examined by PFGE have a pattern differing by only +/- one band. This is in contrast to the situation in an international perspective. In all species of enterococci, tetracycline resistance is the most prevalent trait, which is in agreement with the use of this antimicrobial (doxycycline) for group treatment of diarrhea or respiratory disease in pigs. Likewise, macrolides (tylosin) are used for group medication in outbreaks of diarrhea, which could explain that resistance to erythromycin is the second most common trait among *E. faecalis* and *E. faecium*.

Occurrence of resistance to erythromycin among *E. faecium* has increased gradually over the years studied in SVARM and the trend is statistically significant (Chi-Square for trend P=0.002). A similar trend is observed in Denmark and coincides with an increased consumption of macrolides in pigs (DANMAP 2004). There is however no concurrent increase in sales of macrolides for group medication of pigs in Sweden (see Use of antimicrobials) and no statistically significant trends in erythromycin resistance among *E. hirae* and *E. faecalis* (P>0.05). Moreover, the increase in resistance is due to isolates with MICs 8-16 mg/L, whereas the percentage of isolates with high-level resistance (MIC >32mg/L) is low and

abroad where several different clones occur (Heuer *et al.*, 2002, Johnsen *et al.*, 2005, Garcia-Migura *et al.*, 2005). The dominance of a single clone strongly suggests that the increased occurrence is caused by spread of a clone of VRE among Swedish chickens in recent years. The source or factors involved in this spread is currently unknown. Studies in collaboration with The Swedish Poultry Meat Association year 2002 however showed that VRE were not present in parent flocks, hatcheries or at feed-mills (unpublished).

In several European countries, occurrence of VRE in food producing animals is linked to use of the growth promoter avoparcin, a glycopeptide antimicrobial like vancomycin (Aarestrup, 1995, Klare *et al.*, 1995, Bager *et al.*, 1997). These findings led to a discontinuation of avoparcin use in the EU in 1997 but by that time VRE were common among broiler chickens and pigs in many European countries where avoparcin had been used. After the ban on avoparcin, the prevalence of VRE among animals has decreased but these bacteria are still endemic among food-producing animals in many European countries (Bonten *et al.*, 2001). In Sweden, avoparcin has not been used since the early 80s and VRE were not isolated from broiler chickens in investigations from the mid 90s (Greko 1996, Greko & Lindblad, 1996, Quednau *et al.*, 1996). The appearance and increased occurrence of these bacteria in the last years is therefore puzzling.

Table ENT X. Resistance pattern of vancomycin resistant *Entreococcus faecium* isolated from broiler chickens using vancomycin supplemented media years 2000, 2001, 2002, 2004 and 2005. Cut-off values defining resistance (mg/L) are given inside brackets.

No. of isolates	%	Resistance pattern[a]							
		Va (>128)	Na (>2)	Em (>4)	Ba (>32)	Tc (>8)	Av (>16)	Am (>4)	Vi (>8)
235	89	R	R	R					
11	4	R	R						
10	4	R	R		R				
3	1	R	R	R			R		
2	<1	R	R			R			
1	<1	R	R	R	R			R	
1	<1	R	R					R	
1	<1	R	R	R		R			
1	<1	R	R	R					R

[a] Va: vancomycin; Na: narasin; Em: erythromycin; Ba: bacitracin; Tc: tetracycline; Av: avilamycin; Am: ampicillin; Vi: virginiamycin.

VRE is of no clinical significance for animal health but are undesired since they can be transferred to humans through the food chain. In human medicine, VRE are of increasing importance as a cause of hospital acquired infections (nosocomial infections) but these are caused by VRE clones seldom found in animals (van den Braak *et al.*, 1998, Willems *et al.*, 2000, Homan *et al.*, 2002,). Occurrence of VRE in animals is however undesired since the genes coding for vancomycin resistance, *vanA* or *vanB*, can be transferred between bacteria and the same variants of these genes are found in enterococci from animals and humans (van den Braak *et al.*, 1998, Robredo *et al.*, 2000, Jensen *et al.*, 1998, Descheemaeker *et al.*, 1998). Thus, VRE in animals is not a direct threat to human health but they constitute a reservoir of resistance genes that could influence the resistance situation among bacteria in humans (Sundsfjord *et al.*, 2001, Mascini *et al.*, 2005).

VRE are seldom isolated on direct culture from Swedish broiler chickens and most likely constitute a small fraction of the intestinal microflora. In Sweden, isolates from chickens carry the *vanA* gene, whereas human isolates mainly carry the *vanB* gene (SWEDRES 2004). This is a strong indication that at present, enterococci from Swedish broiler chickens not are a likely source of genes coding for vancomycin resistance in enterococci causing human nosocomial infections. Nevertheless, further studies of the epidemiology of VRE among Swedish broiler chickens are needed.

of a similar magnitude over the years studied. Accordingly, the trend among *E. faecium* should be interpreted with caution.

Ampicillin resistance is rare in all species of enterococci from pigs and there are no tendencies for an increased occurrence of this resistance trait as observed among *E. coli*. Moreover, in the four surveys of indicator bacteria since 2000, only four ampicillin-resistant *E. faecalis* or *E. faecium* (ARE) have been isolated, two isolates of each species. In addition, no ARE were isolated on selective cultures performed on 105 samples year 2003 (SVARM 2003). Likewise no vancomycin-resistant *E. faecalis* or *E. faecium* (VRE) have been isolated from the 1895 samples from pigs examined since 2000, neither in direct cultures nor after the selective culture performed on all samples. Occasional isolates have had MIC 8 mg/L, which is above the current cut-off value for resistance (>4 mg/L). This does not indicate occurrence of the *vanA* or *vanB* genes since isolates carrying these genes have substantially higher MICs. These findings show that in Sweden, pig microflora is not a reservoir of VRE or ARE.

Table ENT V. Association between resistance traits in *Enterococcus faecalis* isolated from slaughter pigs years 2000, 2001, 2003 and 2005 (n=250). For each substance the first line gives the resistance rates for susceptible isolates (S) and the second line rates for resistant isolates (R). Bold and underlined figures indicate statistically significant association between pairs of resistance traits (Chi-Square or Fischer's Exact test, P<0.001).

Single substance susceptibility		n	Resistance[a] (%)											
			Am	Av	Ba	Cm	Em	Fl	Gm	Na	Nm	Sm	Tc	Va
Ampicillin	S	248	0.0	0.0	0.4	1.2	29.4	1.6	4.0	1.2	1.6	16.9	64.9	0.4
	R	2	100.0	0.0	0.0	0.0	50.0	50.0	50.0	50.0	0.0	50.0	100.0	0.0
Avilamycin	S	250	0.8	0.0	0.4	1.2	29.6	2.0	4.4	1.6	1.6	17.2	65.2	0.4
	R	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bacitracin	S	249	0.8	0.0	0.0	1.2	29.3	2.0	4.4	1.6	1.6	17.3	65.5	0.4
	R	1	0.0	0.0	100.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chloramphenicol	S	52	0.0	0.0	1.9	0.0	30.8	0.0	3.8	0.0	3.8	13.5	61.5	0.0
	R	3	0.0	0.0	0.0	100.0	66.7	0.0	33.3	0.0	66.7	66.7	100.0	0.0
Erythromycin	S	176	0.6	0.0	0.0	0.6	0.0	2.8	0.0	0.6	0.0	12.5	55.7	0.6
	R	74	1.4	0.0	1.4	2.7	100.0	0.0	**14.9**	4.1	5.4	28.4	**87.8**	0.0
Flavomycin	S	210	0.5	0.0	0.0	1.0	30.0	0.0	4.3	1.4	0.5	16.7	68.1	0.5
	R	5	20.0	0.0	0.0	0.0	0.0	100.0	0.0	20.0	0.0	0.0	20.0	0.0
Gentamicin	S	239	0.4	0.0	0.4	0.8	26.4	2.1	0.0	1.3	0.4	15.1	63.6	0.4
	R	11	9.1	0.0	0.0	9.1	**100.0**	0.0	100.0	9.1	**27.3**	**63.6**	100.0	0.0
Narasin	S	246	0.4	0.0	0.4	1.2	28.9	1.6	4.1	0.0	1.6	16.7	64.6	0.4
	R	4	25.0	0.0	0.0	0.0	75.0	25.0	25.0	100.0	0.0	50.0	100.0	0.0
Neomycin	S	51	0.0	0.0	2.0	2.0	27.5	0.0	0.0	0.0	0.0	11.8	60.8	0.0
	R	4	0.0	0.0	0.0	50.0	100.0	0.0	**75.0**	0.0	100.0	75.0	100.0	0.0
Streptomycin	S	207	0.5	0.0	0.5	0.5	25.6	2.4	1.9	1.0	0.5	0.0	66.7	0.5
	R	43	2.3	0.0	0.0	4.7	48.8	0.0	**16.3**	4.7	7.0	100.0	58.1	0.0
Tetracycline	S	87	0.0	0.0	1.1	0.0	10.3	4.6	0.0	0.0	0.0	20.7	0.0	1.1
	R	163	1.2	0.0	0.0	1.8	**39.9**	0.6	6.7	2.5	2.5	15.3	100.0	0.0
Vancomycin	S	249	0.8	0.0	0.4	1.2	29.7	2.0	4.4	1.6	1.6	17.3	65.5	0.0
	R	1[b]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0

[a] Am: ampicillin; Av: avilamycin; Ba: bacitracin; Cm: chloramphenicol; Em: erythromycin; Fl: flavomycin; Gm: gentamicin; Na: narasin; Nm: neomycin; Sm: streptomycin; Tc: tetracycline; Va: vancomycin; [b] One isolate with MIC 8 mg/L

Table ENT VI. Association between resistance traits in *Enterococcus faecium* isolated from slaughter pigs years 2000, 2001, 2003 and 2005 (n=272). For each substance the first line gives the resistance rates for susceptible isolates (S) and the second line rates for resistant isolates (R). Bold and underlined figures indicate statistically significant association between pairs of resistance traits (Chi-Square or Fischer's Exact test, P<0.001).

Single substance susceptibility		n	Resistance[a] (%)											
			Am	Av	Ba	Cm	Em	Gm	Na	Nm	Sm	Tc	Va	Vi
Ampicillin	S	270	0.0	0.4	5.6	0.4	13.0	0.4	2.6	0.4	1.5	11.9	0.0	3.7
	R	2	100.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	50.0	50.0	0.0	0.0
Avilamycin	S	271	0.7	0.0	5.5	0.4	13.3	0.4	2.6	0.4	1.8	12.2	0.0	3.7
	R	1	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bacitracin	S	257	0.8	0.4	0.0	0.4	11.7	0.4	1.2	0.4	1.9	10.9	0.0	3.5
	R	15	0.0	0.0	100.0	0.0	40.0	0.0	**26.7**	0.0	0.0	33.3	0.0	6.7
Chloramphenicol	S	117	0.0	0.9	8.5	0.0	18.8	0.0	1.7	0.0	0.0	14.5	0.0	4.3
	R	1	0.0	0.0	0.0	100.0	100.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0
Erythromycin	S	236	0.4	0.4	3.8	0.0	0.0	0.0	2.5	0.0	0.4	11.0	0.0	3.4
	R	36	2.8	0.0	16.7	2.8	100.0	2.8	2.8	2.8	11.1	19.4	0.0	5.6
Gentamicin	S	271	0.7	0.4	5.5	0.0	12.9	0.0	2.6	0.0	1.8	11.8	0.0	3.3
	R	1	0.0	0.0	0.0	100.0	100.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0
Narasin	S	265	0.8	0.4	4.2	0.4	13.2	0.4	0.0	0.4	1.9	12.1	0.0	3.4
	R	7	0.0	0.0	**57.1**	0.0	14.3	0.0	100.0	0.0	0.0	14.3	0.0	14.3
Neomycin	S	46	0.0	2.2	2.2	0.0	19.6	0.0	0.0	0.0	0.0	10.9	0.0	8.7
	R	1	0.0	0.0	0.0	100.0	100.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0
Streptomycin	S	267	0.4	0.4	5.6	0.4	12.0	0.4	2.6	0.4	0.0	11.6	0.0	3.4
	R	5	20.0	0.0	0.0	0.0	80.0	0.0	0.0	0.0	100.0	40.0	0.0	20.0
Tetracycline	S	239	0.4	0.4	4.2	0.0	12.1	0.0	2.5	0.0	1.3	0.0	0.0	2.1
	R	33	3.0	0.0	15.2	3.0	21.2	3.0	3.0	3.0	6.1	100.0	0.0	15.2
Vancomycin	S	272	0.7	0.4	5.5	0.4	13.2	0.4	2.6	0.4	1.8	12.1	0.0	3.7
	R	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Virginiamycin	S	262	0.8	0.4	5.3	0.0	13.0	0.0	2.3	0.0	1.5	10.7	0.0	0.0
	R	10	0.0	0.0	10.0	10.0	20.0	10.0	10.0	10.0	10.0	50.0	0.0	100.0

[a] Am: ampicillin; Av: avilamycin; Ba: bacitracin; Cm: chloramphenicol; Em: erythromycin; Gm: gentamicin; Na: narasin; Nm: neomycin; Sm: streptomycin; Tc: tetracycline; Va: vancomycin; Vi: virginiamycin.

Table ENT VII. Distribution of MICs for *Enterococcus faecalis* from slaughter pigs year 2004 (n=55). Data from SVARM years 2000 (n=56), 2001 (n=52) and 2004 (n=87) are given for comparison.

Substance	Year	Resistance (%)	Distribution (%) of MICs[a] (mg/L)															
			≤0.12	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**	**512**	**1024**	**2048**	**>2048**
Ampicillin	-05	0			5.5	83.6	9.1	1.8										
	-03	0		3.4	13.8	77.0	5.7											
	-01	4			5.8	59.6	30.8		1.9	1.9								
	-00	0				37.5	62.5											
Avilamycin	-05	0					10.9	34.5	43.6	10.9								
	-03	0				13.8	63.2	12.6	10.3									
	-01	0				3.8	53.8	42.3										
	-00	0					48.2	51.8										
Bacitracin[b]	-05	2					1.8	3.6	69.1	23.6				1.8				
	-03	0					2.3	4.6	50.6	39.1	3.4							
	-01	0					1.9	3.8	75.0	19.2								
	-00	0			1.8	1.8		1.8	17.9	64.3	12.5							
Chloramph.	-05	5					1.8	5.5	74.5	10.9	1.8	3.6	1.8					
	-03	-					1.1	18.4	62.1	9.2	9.2							
	-01	-																
	-00	-																
Erythromycin	-05	33			9.1	32.7	16.4	9.1			3.6	5.5	23.6					
	-03	25			9.2	27.6	26.4	11.5					25.3					
	-01	27		1.9	11.5	28.8	21.2	9.6				26.9						
	-00	36		1.8	7.1	3.6	33.9	17.9		1.8		33.9						
Flavomycin	-05	0					5.0	10.0	70.0	10.0	5.0							
	-03	3					72.4	20.7	3.4					3.4				
	-01	2					5.8	61.5	30.8					1.9				
	-00	2					23.2	64.3	8.9		1.8			1.8				
Gentamicin	-05	5												92.7	1.8		1.8	3.6
	-03	7						3.4	11.5	40.2	31.0				6.9	6.9		
	-01	4							7.7	48.1	38.5				1.9	3.8		
	-00	0					1.8	3.6	8.9	69.6	16.1							
Narasin	-05	0		1.8	52.7	41.8	3.6											
	-03	1	4.6	24.1	59.8	10.3					1.1							
	-01	4	1.9	11.5	73.1	9.6		1.9	1.9									
	-00	2	3.6	10.7	67.9	16.1				1.8								
Neomycin	-05	7								5.5	10.9	34.5	40.0	1.8		7.3		
	-03	-																
	-01	-																
	-00	-																
Streptomycin	-05	16												83.6			1.8	14.5
	-03	16									3.4	16.1	56.3			8.0	16.1	
	-01	25									5.8	21.2	42.3			5.8	25.0	
	-00	13									3.6	26.8	53.6			3.6	12.5	
Tetracycline	-05	64			5.5	27.3	3.6		1.8		29.1	32.7						
	-03	63			12.6	21.8	2.3			14.9	25.3	21.8	1.1					
	-01	67			3.8	5.8	23.1	3.8		5.8	23.1	34.6						
	-00	68		1.8	1.8	14.3	14.3			3.6	23.2	41.1						
Vancomycin	-05	0				29.1	50.9	20.0										
	-03	1				9.2	74.7	14.9	1.1									
	-01	0				3.8	71.2	25.0										
	-00	0				5.4	80.4	14.3										
Virginiamycin	-05	NR[c]				3.6	3.6		1.8	52.7	38.2							
	-03	NR			2.3		5.7	2.3	18.4	69.0	2.3							
	-01	NR					1.9		3.8	67.3	26.9							
	-00	NR					1.8	3.6	7.1	80.4	7.1							
			≤0.12	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**	**512**	**1024**	**2048**	**>2048**

[a] The white fields denote range of dilutions tested for each substance. MICs above the range are given as the concentration closest to the range. MICs equal to or lower than the lowest concentration tested are given as the lowest tested concentration. Bold vertical lines indicate cut-off values defining resistance; [b] MIC in U/mL, see Appendix 3 for details; [c] Not relevant as susceptibility in *E. faecalis* is inherently low.

Table ENT VIII. Distribution of MICs for *Enterococcus faecium* from slaughter pigs year 2005 (n=47). Data from SVARM years 2000 (n=48), 2001 (n=106) and 2003 (n=71) are given for comparison.

Substance	Year	Resistance (%)	Distribution (%) of MICs[a] (mg/L)															
			≤0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	>2048
Ampicillin	-05	0		6.4	4.3	57.4	31.9											
	-03	0		12.7	9.9	32.4	36.6	8.5										
	-01	2		17.0	17.0	32.1	28.3	3.8	0.9	0.9								
	-00	0		6.3	10.4	18.8	58.3	6.3										
Avilamycin	-05	2				2.1	6.4	36.2	42.6	10.6		2.1						
	-03	0			1.4	4.2	36.6	56.3	1.4									
	-01	0			0.9	7.5	18.9	59.4	12.3	0.9								
	-00	0				2.1	16.7	39.6	39.6	2.1								
Bacitracin[b]	-05	2					4.3	4.3	10.6	53.2	25.5			2.1				
	-03	13				2.8		4.2	7.0	29.6	43.7	5.6	7.0					
	-01	3			10.4	11.3	10.4	2.8	12.3	34.9	15.1	2.8						
	-00	4				6.3	2.1	4.2	12.5	12.5	58.3	4.2						
Chloramph.	-05	2						36.2	57.4	4.3		2.1						
	-03	0						32.4	64.8	2.8								
	-01	-																
	-00	-																
Erythromycin	-05	21			19.1	8.5	29.8	21.3	17.0	2.1			2.1					
	-03	18			26.8	5.6	16.9	32.4	9.9	7.0			1.4					
	-01	11		24.5	16.0	5.7	15.1	27.4	7.5	0.9		2.8						
	-00	2		2.1	14.6	6.3	25.0	50.0				2.1						
Flavomycin	-05	NR[c]								6.7			3.3	90.0				
	-03	NR						1.4					1.4	97.2				
	-01	NR						1.9				1.9	4.7	91.5				
	-00	NR						2.1				2.1		95.8				
Gentamicin	-05	2												97.9				2.1
	-03	0				1.4	4.2	38.0	38.0	14.1	2.8				1.4			
	-01	0					6.6	12.3	51.9	25.5	3.8							
	-00	0					4.2	39.6	39.6	14.6	2.1							
Narasin	-05	0		2.1	29.8	51.1	17.0											
	-03	3		1.4	40.8	47.9	7.0	2.8										
	-01	4	2.8	12.3	23.6	53.8	3.8	3.8										
	-00	2	2.1	2.1	37.5	54.2	2.1		2.1									
Neomycin	-05	2								87.2	2.1	4.3	4.3			2.1		
	-03	-																
	-01	-																
	-00	-																
Streptomycin	-05	0												100.0				
	-03	0									32.4	62.0	4.2			1.4		
	-01	4					2.8		0.9	10.4	40.6	38.7	1.9			0.9	3.8	
	-00	2								14.6	62.5	18.8	2.1				2.1	
Tetracycline	-05	13			27.7	57.4	2.1			2.1	6.4	4.3						
	-03	17			56.3	25.4	1.4	1.4			7.0	5.6	2.8					
	-01	8		6.6	2.8	63.2	18.9	1.9		0.9	2.8	2.8						
	-00	13			4.2	47.9	35.4	2.1		2.1		8.3						
Vancomycin	-05	0				66.0	27.7	6.4										
	-03	0				81.7	15.5	2.8										
	-01	0				80.2	16.0	3.8										
	-00	0				77.1	22.9											
Virginiamycin	-05	11			8.5	40.4	4.3	34.0	2.1	6.4	4.3							
	-03	1			29.6	18.3	32.4	16.9	1.4		1.4							
	-01	3			17.0	22.6	27.4	21.7	8.5	2.8								
	-00	2			20.8	16.7	25.0	12.5	22.9	2.1								
			≤0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	>2048

[a] The white fields denote range of dilutions tested for each substance. MICs above the range are given as the concentration closest to the range. MICs equal to or lower than the lowest concentration tested are given as the lowest tested concentration. Bold vertical lines indicate microbiological cut-off values defining resistance; [b] MIC in U/mL, see Appendix 3 for details; [c] Not relevant as susceptibility in *E. faecium* is inherently low.

Table ENT IX. Distribution of MICs for *Enterococcus hirae* from slaughter pigs year 2005 (n=55). Data from SVARM years 2000 (n=56) 2001 (n=52) and 2003 (n=87) are given for comparison.

Substance	Year	Resistance (%)	Distribution (%) of MICs[a] (mg/L)															
			≤0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	>2048
Ampicillin	-05	0		55.4	16.1	17.0	9.8	1.8										
	-03	<1		44.4	24.2	16.1	13.7	0.8		0.8								
	-01	0		46.8	23.4	18.2	11.7											
	-00	0		46.2	15.1	17.9	17.9	2.8										
Avilamycin	-05	7				8.0	16.1	25.0	34.8	8.9	5.4		1.8					
	-03	0			0.8	21.8	32.3	33.1	10.5	1.6								
	-01	0			3.9	18.2	24.7	49.4	3.9									
	-00	0			1.9	11.3	31.1	34.0	20.8	0.9								
Bacitracin[b]	-05	0				43.8	50.9	4.5		0.9								
	-03	0				23.4	60.5	11.3	0.8	3.2	0.8							
	-01	0			7.8	27.3	54.5	2.6	2.6	5.2								
	-00	0			1.9	33.0	45.3	16.0	0.9	1.9	0.9							
Chloramph.	-05	0				0.9	6.3	80.4	12.5									
	-03	0					1.6	71.8	26.6									
	-01	-																
	-00	-																
Erythromycin	-05	0			90.2	4.5	4.5	0.9										
	-03	4			95.2	0.8			2.4				1.6					
	-01	0		6.5	92.2	1.3												
	-00	4		32.1	61.3		2.8					3.8						
Flavomycin	-05	NR[c]										4.7	2.3	93.0				
	-03	NR										0.8	0.8	98.4				
	-01	NR						1.3		1.3		1.3		96.1				
	-00	NR								0.9			0.9	98.1				
Gentamicin	-05	0												100.0				
	-03	0			0.8		0.8	17.7	43.5	29.8	6.5				0.8			
	-01	1						3.9	54.5	33.8	6.5					1.3		
	-00	0						7.5	54.7	35.8	1.9							
Narasin	-05	5	4.5	19.6	28.6	33.0	8.9	5.4										
	-03	2	4.0	22.6	30.6	34.7	5.6	2.4										
	-01	3	14.3	18.2	31.2	33.8		2.6										
	-00	2	7.5	26.4	20.8	40.6	2.8	1.9										
Neomycin	-05	0								58.0	32.1	8.0	1.8					
	-03	-																
	-01	-																
	-00	-																
Streptomycin	-05	0												100.0				
	-03	2									6.5	71.8	20.2				1.6	
	-01	0								1.3	11.7	68.8	18.2					
	-00	<1									25.5	66.0	6.6			0.9	0.9	
Tetracycline	-05	11			49.1	40.2		0.9	0.9		1.8	7.1						
	-03	14			55.6	30.6					4.8	6.5	2.4					
	-01	12			19.5	57.1	11.7	1.3			2.6	7.8						
	-00	16			12.3	39.6	32.1	0.9			0.9	14.2						
Vancomycin	-05	0				75.0	24.1	0.9										
	-03	0				87.9	12.1											
	-01	0				76.6	22.1	1.3										
	-00	0				86.8	13.2											
Virginiamycin	-05	0			38.4	19.6	16.1	24.1	1.8									
	-03	0			46.0	8.9	36.3	8.9										
	-01	0			49.4	16.9	24.7	7.8	1.3									
	-00	0			38.7	12.3	30.2	6.6	12.3									
			≤0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	>2048

[a] The white fields denote range of dilutions tested for each substance. MICs above the range are given as the concentration closest to the range. MICs equal to or lower than the lowest concentration tested are given as the lowest tested concentration. Bold vertical lines indicate microbiological cut-off values defining resistance; [b] MIC in U/mL, see Appendix 3 for details; [c] Not relevant as susceptibility in *E. hirae* is inherently low.

Antimicrobial resistance in *Escherichia coli* from willow grouse (*Lagopus lagopus*)

Willow grouse (*Lagopus lagopus*) is a bird inhabiting the northern part of Sweden with a southern boundary in the provinces Dalarna, Värmland, Västmanland and northern Hälsingland. The habitat of the bird is mainly lower slopes of the mountains but it is also found in woodland. To investigate to what extent the pool of resistant bacteria extends to such an animal population, susceptibility of *Escherichia coli* from grouse was examined.

Hunters collected samples for culture from grouse shot in a limited area in province Jämtland during October years 2004 and 2005. The samples consisted of caeca (2004) or cloacal swabs (2005) collected within six hours after a bird was shot and were kept at ambient temperature (0-10 °C) until cultured at SVA within six days after collection. Culture and subsequent susceptibility testing was performed according to the methodology used in SVARM (see Appendix 3 for details).

In all, 19 isolates of *E. coli* were obtained from 56 samples cultured. Distributions of MICs were covered by four or less twofold dilution steps for all antimicrobials tested and acquired resistance, as defined by microbiological cut-off values suggested by EUCAST, did not occur (Table Grouse I). In contrast, distributions of MICs for *E. coli* from healthy chickens sampled at slaughter are wider, running above the cut-off values, thereby indicating occurrence of acquired resistance (Table Grouse I).

Although a small number of isolates were examined, the results suggest that the *E. coli* in willow grouse is an

Table Grouse I. Distribution of MICs for *Escherichia coli* from wild grouse (*Lagopus lagopus*) (n=19). Data for from broiler chickens investigated in SVARM year 2004 (n=300) are given for comparison. G =grouse, C = broiler chickens.

		Resistance	Distribution (%) of MICs[a] (mg/L)																	
Substance	**Year**	(%)	**≤0.03**	**0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**	**512**	**1024**	**2048**	**>2048**
Ampicillin	G	0						5.3	47.4	47.4										
	C	4					0.3	4.0	55.0	35.7	1.0		0.3	3.7						
Ceftiofur	G	0				31.6	52.6	15.8												
	C	0			1.0	15.0	69.0	15.0												
Chloramphenicol	G	0							21.1	36.8	36.8	5.3								
	C	0							8.7	72.0	19.3									
Enrofloxacin	G	0	36.8	57.9	5.3															
	C	5	19.3	62.3	13.3	2.7	1.7	0.3	0.3											
Florfenicol	G	0								53.0	46.7	0.3								
	C	0								26.3	47.4	26.3								
Gentamicin	G	0					21.1	78.9												
	C	<1					17.3	70.0	12.0	0.3	0.3									
Nalidixic acid	G	0							57.9	42.1										
	C	5						1.0	24.3	67.0	2.7			3.0	0.7	1.3				
Neomycin	G	0							100.0											
	C	3							88.0	7.0	1.7		3.3							
Streptomycin	G	0								31.6	68.4									
	C	5							0.3	29.3	57.3	7.3	0.7	1.3	2.0	1.3	0.3			
Sulphamethoxazole	G	0										36.8	36.8	26.3						
	C	9										54.0	25.3	8.7	3.0				0.7	8.3
Tetracycline	G	0						26.3	68.4	5.3										
	C	6					1.7	41.0	50.3	1.0					6.0					
Trimethoprim	G	0				15.8	31.6	36.8	15.8											
	C	<1				20.7	50.3	26.0	2.3	0.3			0.3							
			≤0.03	**0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**	**512**	**1024**	**2048**	**>2048**

[a] The white fields denote range of dilutions tested for each substance. MICs above the range are given as the concentration closest to the range. MICs equal to or lower than the lowest concentration tested are given as the lowest tested concentration. Bold vertical lines indicate microbiological cut-off values defining resistance.

example of a bacterial population not exposed to antimicrobials, and that resistant bacteria from humans or domesticated animals are rare in the environment of the birds. *Escherichia coli* from broiler chickens on the other hand show the characteristics of a population that is to some extent exposed to antimicrobials.

Knowledge on antimicrobial resistance in bacteria from wildlife is scarce but studies conducted show that bacteria with acquired resistance occur also in these animal species although occurrence is rare (Palmgren *et al.*, 1997, Waldenström *et al.*, 2005, Sellin *et al.*, 2000, Livermore *et al.*, 2001, Osterblad *et al.*, 2001, Lillehaug *et al.*, 2005). Likewise, resistance was rare in *E. coli* and *enterococci* from wild boars examined within the framework of SVARM (SVARM 2002). Resistance to ampicillin was however most common in *E. coli* from wild rodents in England (Gilliver *et al.*, 1999) and likewise resistance to streptomycin, tetracycline or sulphonamides was surprisingly frequent in *E. coli* from wild reindeer in Norway (Lillehaug *et al.*, 2005).

The prevalence of resistance in wild-life must be interpreted in relation to the habitat and feeding practices of the animal species in question. It is not surprising that animals such as rodents and birds scavenging near farms and in urban areas are to some extent colonised by resistant bacteria selected by use of antimicrobials in man or animals. Likewise, resistant bacteria among wild boars in Sweden were most likely picked up in the surroundings of animal producing farms.

In habitats remote from urban areas, wildlife are less likely to pick up resistant bacteria as demonstrated by the data for willow grouse presented. Similar finding were reported in a study on wild cervids and voles from Finland (Osterblad *et al.*, 2001) and also by data from wild cervids in Norway (Lillehaug *et al.*, 2005). The high prevalence of resistant bacteria in reindeer in the Norwegian study is however surprising and so far unresolved. Interestingly willow grouse and reindeer reside in the same environment.

Resistance in animal pathogens

Pig

Isolates included

Isolates of *Escherichia coli* for the years 1992-2005 are from diagnostic submissions of samples from the gastro-intestinal tract (intestinal content, faecal samples or mestenteric lymph nodes), while data from 1989-1991 include all *E. coli* isolated from pigs, irrespective of material type. Isolates of *Brachyspira hyodysenteriae* emanate from clinical submissions of faecal samples from pigs.

No information on the indications for sampling was available, but the vast majority of clinical submissions are likely to derive from herds with clinical problems. Therefore, data are probably biased towards herds with a high probability of being commonly treated with antimicrobials. Any assessment of trends is based on the assumption that this bias is inherent throughout the observation period.

Escherichia coli

In 2005, resistance to ampicillin, streptomycin, tetracycline or trimethoprim-sulphonamides was common as in previous years (Table Pig I). Statistical analyses indicate an increase in prevalence of resistance to ampicillin and trimethoprim-sulphonamides (P<0.00001, respectively, Chi-square for trend), and a decrease in resistance to neomycin, streptomycin (P<0.00001, respectively, Chi-square for trend) and tetracycline (P=0.0002, Chi-square for trend).

Multiresistance (i.e. resistance to three or more antimicrobials) occurred in 18% of the isolates and of those, 25% were resistant to five or more antimicrobials (4% of the whole material). In multiresistant isolates, the most frequent combination (67% of the multiresistant isolates) was resistance to ampicillin, trimethoprim-sulphonamides and streptomycin.

All ampicillin figures since the early 90s are higher compared to corresponding data from the 70s and early 80s, when resistance to ampicillin was 6 and 7% amongst *E. coli* from diarrhoeic pigs (respectively, Franklin, 1976; Franklin, 1984). An increase in prevalence of resistance to ampicillin is also observed in indicator *E. coli* (see Resistance in indicator bacteria). Also for trimethoprim-sulphonamides, there is an increasing trend. This combination has been used since 1974, amongst others, in treatment of diarrhoea in piglets, and in the beginning of the 80s the frequency of resistance was 10% (break-point for resistance >8mg/L; Franklin 1984). During 2001-2003, 86% of isolates resistant to ampicillin was also resistant to at least one other antimicrobial. For 2005, this figure has risen to 95%. The most common trait was resistance to ampicillin together with trimethoprim-sulphonamides (79% of the ampicillin resistant isolates). However, the extent of use of aminopenicillins or trimethoprim-sulphonamides for Swedish pigs is not known, as data on use of antimicrobials are not yet available per animal species.

The decline in resistance to aminoglycosides (neomycin and streptomycin) could be an effect of the withdrawal of an oral formula with neomycin for piglets from the Swedish market in the late 90s. On the other hand, the decline in tetracycline resistance cannot be explained by the extent of use since the amount of tetracycline for group-medication (via feed or water), a product type that is almost exclusively used in pigs, has increased by 21% since year 2000.

Table Pig I. Occurrence of resistance (%) among *Escherichia coli* from pigs during 1998-2005 and distribution of MICs for the isolates from 2005. Isolates are from diagnostic submissions of faecal samples or samples taken post mortem from the gastro-intestinal tract.

	Resistance (%)							Distribution (%) of MICs[a] (mg/L)									
Substance	1989-1991 n=248	1992-1994 n=431	1995-1997 n=1244	1998-2000 n=1074	2001-2003 n=935	2004 n=386	2005 n=325	≤0.12	0.25	0.5	1	2	4	8	16	32	>32
Ampicillin	6	10	9	11	17	22	22				6.8	49.2	20.9	0.9	22.2		
Ceftiofur	-	-	-	-	0[d]	<1	<1		45.8	52.0	1.8		0.3				
Enrofloxacin	1[c]	7	5	6	6	6	7	91.1	2.2	2.2	1.2	3.4					
Florfenicol	-	-	-	-	<1[d]	0	0					1.5	46.5	46.5	5.5		
Gentamicin	1	1	<1	1	1	<1	0					91.1	8.3	0.6			
Neomycin	17	14	9	6	5[e]	4	3						92.9	3.7	0.3		3.1
Streptomycin	44	44	32	30	30	28	30						15.7	32	14.5	17.7	30.2
Tetracycline	28	35	31	33	30	27	24				31.7	34.2	7.7	2.5	24.0		
Trim/Sulph.[b]	17	15	13	14	19	27	24			73.2	2.2	0.3	0.3	24.0			

[a] The white fields denote range of dilutions tested for each substance. MICs above the range are given as the concentration closest to the range. MICs equal to or lower than the lowest concentration tested are given as the lowest tested concentration. Bold vertical lines indicate cut-off values defining resistance; [b] Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim/sulphametoxazole); [c] 227 isolates tested; [d] 688 isolates tested; [e] 926 isolates tested.

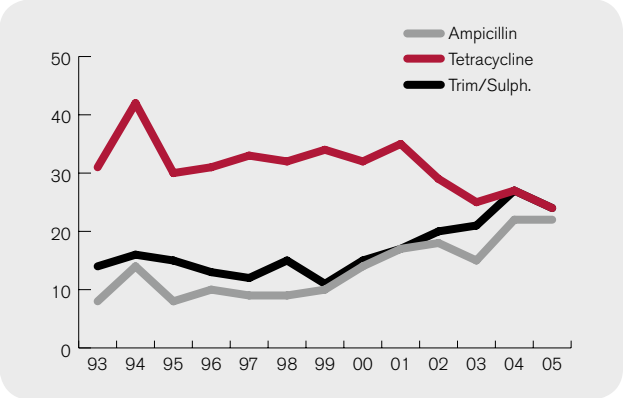

Figure Pig I. Occurrence of resistance to selected antimicrobials among *Escherichia coli* from pigs during 1992-2005. Isolates are from diagnostic submissions of faecal samples or samples taken post mortem from the gastro-intestinal tract.

Brachyspira hyodysenteriae

Resistance to tiamulin, defined by microbiological cut-off values, has not been observed among *B. hyodysenteriae* in Sweden, but in SVARM 2003, a gradual decrease in susceptibility was reported for years 2001, 2002 and 2003. However, this development has not progressed in 2005. Nevertheless, it is imperative that all herds, where treatment failure is suspected, are thoroughly investigated. If tiamulin resistant *B. hyodysenteriae* are found, efforts should be made to minimise the risk of spread of the infection to other herds.

As in previous years, the proportion of *B. hyodysenteriae* resistant to tylosin was high during 2005 (81%)(Table Pig II). Resistance appears to have increased over the last decade, as in 1988-90 only 20% of the isolates were classified as resistant when tested with an agar dilution technique (Gunnarsson *et al.*, 1991).

Brachyspira pilosicoli

The frequency of resistance to tiamulin was 16% (Table Pig III), while 61% were resistant to tylosin, which is higher compare to the figure in 2002-2003. Combined resistance to both antimicrobials was found in 16% of the isolates, and half of the *B. pilosicoli* resistant to tiamulin was also resistant to tylosin. In 2001, the first case of treatment failure associated with *B. pilosicoli* resistant to tiamulin in a Swedish pig herd with spirochaetal diarrhoea was reported (Karlsson *et al.*, 2002). Although such isolates may be susceptible to other antimicrobials, only tiamulin and tylosin are licensed for this indication in pigs in Sweden. The findings stress the need for susceptibility testing of *B. pilosicoli* isolated from pigs in herds, where tiamulin is to be used.

Cattle

Isolates included

Escherichia coli originate from the gastro-intestinal tract of cattle. There is no available information on the age of the animals sampled, nor on the indications for sampling, but the vast majority is likely to be from younger animals in herds with diarrhoeal problems. Therefore, data are probably biased towards herds with a high probability of being commonly treated with antimicrobials. Thus, any assessment of trends is based on the assumption that this bias is inherent throughout the observation period.

Staphylococcus aureus were isolated at the Department of Bacteriology at SVA from diagnostic submissions of milk samples from dairy cows. Of the ß-lactamase producing isolates, one strain from each herd, were collected and susceptibility tested at the Department of Antibiotics at SVA.

Table Pig II. Occurrence of resistance among *Brachyspira hyodysenteriae* in pigs years 2001- 2005 and distribution of MICs for the isolates from 2005. Isolates emanate from diagnostic submissions of faecal samples. Bold vertical lines indicate microbiological cut-off values.

	Resistance, %				Distribution (%) of MICs[a] 2005 (mg/L)														
Substance	2001 n=75	2002 n=109	2003 n=100	2005 n=31	≤0.01	0.031	0.063	0.125	0.25	0.5	1	2	4	8	16	32	64	128	>128
Tiamulin	0	0	0	0			22.6	51.6	16.1	9.7									
Tylosin	83	73	89	81									12.9	3.2	3.2				80.6

[a] The white fields denote range of dilutions tested for each substance. MICs above the range are given as the concentration closest to the range. MICs equal to or lower than the lowest concentration tested are given as the lowest tested concentration.

Table Pig III. Occurrence of resistance among *Brachyspira pilosicoli* in pigs years 2002–2005 and distribution of MICs among the isolates from 2005. Isolates emanate from diagnostic submissions of faecal samples. Bold vertical lines indicate microbiological cut-off values.

	Resistance, %		Distribution (%) of MICs[a] 2005 (mg/L)															
Substance	2002-2003 n=93	2005 n=57	≤0.01	0.031	0.063	0.125	0.25	0.5	1	2	4	8	16	32	64	128	>128
Tiamulin	14	16			43.8	26.3	6.3	7.0	5.3	3.5		1.8	14.0				
Tylosin	50[b]	63								1.8	17.5	7.0	10.5		1.8	8.8	52.6

[a] The white fields denote range of dilutions tested for each substance. MICs above the range are given as the concentration closest to the range. MICs equal to or lower than the lowest concentration tested are given as the lowest tested concentration; [b] 86 isolates tested.

Escherichia coli

There is a numerical increase in the proportion of *E. coli* resistant to ampicillin, streptomycin, tetracycline or trimetoprim-sulphonamides over the study period (Table Cattle I), and figures for these substances are high. The prevalence of multiresistance was 13%. However, the number of isolates studied is too few to draw any conclusions from, therefore no statistical analyses have been made on the material.

Staphylococcus aureus

Previous data on *S. aureus* isolated from mastitis, in SVARM 2002, originated from acute, clinical mastitis, and here 7% produced ß-lactamase. In this study, the aim was to screen for methicillinresistant *S. aureus* (MRSA), and therefore all ß-lactamase producing *S. aureus* isolated from bovine milk samples were susceptibility tested. The isolates in this material probably mainly emanate from sub-acute or chronic mastitis, where most cases of ß-lactamase producing *S. aureus* are found, which in turn increases the probability that the cows have been treated with antimicrobials.

Table Cattle I. Occurrence of resistance (%) among *Escherichia coli* from cattle during 1992-2002 and 2005, calves from 2004, and distribution of MICs for the isolates from 2005. Isolates are from diagnostic submissions of faecal samples or samples taken post mortem from gastro-intestinal tract.

	Resistance (%)			Distribution (%) of MICs[a] (mg/L)									
Substance	1992-02 n=220	2004 n=87 [d]	2005 n=39	≤0.12	0.25	0.5	1	2	4	8	16	32	>32
Ampicillin	24	29	31				7.7	43.6	17.9		30.8		
Ceftiofur	0[c]	0	0[e]		18.4	71.0	5.3	5.3					
Enrofloxacin	1[0]	5	3	89.7	7.7	2.6							
Florfenicol	0[c]	0	0						38.5	61.5			
Gentamicin	1	0	0					92.3	7.7				
Neomycin	8	7	10						84.6	5.1			10.2
Streptomycin	42	48	54						2.6	33.3	5.1	5.1	53.8
Tetracycline	31	37	46				15.4	30.8	5.1	2.6	46.2		
Trim/Sulph.[b]	11	10	18			74.4	5.1	2.6		17.9			

[a] The white fields denote range of dilutions tested for each substance. MICs above the range are given as the concentration closest to the range. MICs equal to or lower than the lowest concentration tested are given as the lowest tested concentration. Bold vertical lines indicate cut-off values defining resistance; [b] Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim/sulphametoxazole); [c] 16 isolates tested; [d] 1/3 of the isolates were from calves with diarrhoea; [e] 38 isolates tested.

SVARMpat – increased focus on antimicrobial resistance in animal pathogens.

In 2005, increased surveillance of antimicrobial resistance in bacteria causing disease in pigs, cattle, sheep or poultry was initiated through the new programme – SVARMpat. The programme is run in collaboration between the Swedish National Veterinary Institute (SVA) and the Swedish Animal Health Service and is financed by the Swedish Board of Agriculture.

Resistance data for animal pathogens have been reported and evaluated annually in SVARM since 2000. Data presented have mostly been compilations of results from the routine diagnostic activities at SVA but results from specific research projects in this field have also been presented. Monitoring based on diagnostic submission is to some extent unsatisfactory since a large proportion of the isolates are likely to be from herds with disease problems where antimicrobial use is common. Thereby the material is biased and most likely reflects a "worst case" scenario not relevant for the situation in most herds. In addition, anamnestic information accompanying routine diagnostic submissions is often scarce and non-systematic, thus duplicate samples from the same animal or herd can be included in the compiled data. Lack of anamnestic information also curbs the possibilities to use the data for inference in an epidemiological context. Lastly, relying on routine submissions implies that for some pathogens, very few isolates are tested for antimicrobial susceptibility. Consequently, due to a small sample size data for these pathogens are unsuited for further conclusions on occurrence of resistance and possible trends in resistance.

The objective of SVARMpat is to improve the monitoring of pathogens in farm animals by collecting high-quality unbiased data on antimicrobial resistance for an appropriate number of isolates. Results will be reported yearly in the SVARM report. Updated knowledge on susceptibility

In screening for MRSA, strains with MIC for oxacillin (tested with 2% NaCl added) higher than the CLSI break point (>2 mg/L) were retested according to CLSI standards. Fourteen isolates were retested and eight of those still had MIC >2 mg/L. These isolates were examined for presence of *mecA* with latex agglutination test (six isolates) or with PCR (two isolates), and none of the eight isolates was found positive for *mecA* (see Appendix 3 for details).

Besides resistance to penicillin, resistance to tetracycline and trimethoprim was found, and one isolate was resistant to all three antimicrobials. In SVARM 2002, one isolate with ß-lactamase production was resistant also to clindamycin, erythromycin, spiramycin, chloramphenicol and streptomycin. However, that resistance phenotype was not found in this material.

Table Cattle II. Occurrence of resistance and distribution of MICs among ß-lactamase producing *Staphylococcus aureus* isolated from mastitis in dairy cows years 2005. Bold vertical lines indicate breakpoint for resistance

	Resistance (%)	**Distribution** (%) **of MICs**[a] (mg/L)													
Substance	**2005** n=96	**≤0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**	**>256**
Cephalothin	0	1.0	2.1	13.5	70.8	12.5									
Chloramphenicol	0						2.1	17.7	78.1	2.1					
Clindamycin	0			91.7	8.3										
Erythromycin	0			8.3	81.3	8.3	1.0								
Gentamicin	0				51.0	40.6	8.3								
Neomycin	0					85.4	14.6								
Penicillin[c]	100		4.2	2.1	7.3	9.4	10.4	13.5	53.1						
Streptomycin[b]	1						2.1	44.7	39.4	9.6	3.2	1.1			
Tetracycline	5				90.6	3.1	1.0				5.2				
Trimethoprim	2				1.0	19.8	66.7	10.4	2.1						

[a] Hatched fields denote range of dilutions tested for each substance. MICs above the range are given as the concentration closest to the range. MICs equal to or lower than the lowest concentration tested are given as the lowest tested concentration; [b] 94 isolates tested; [c] denotes ß-lactamase production.

of animal pathogens is thereby available for practitioners, facilitating the therapeutic choice in the clinical setting. Moreover, high-quality data allows appropriate analysis of trends in resistance and of underlying causes for such trends.

Pathogens, like *Escherichia coli* in cattle and pigs are of highest priority in SVARMpat, together with *Brachyspira* spp. from pigs and *Pasteurella* and *Mannheimia* spp. from cattle, pigs and sheep. Udder pathogens will also be of main concern in the programme. One important activity in SVARMpat will be to encourage practitioners and pathologist to submit samples for microbiological culture and susceptibility testing. This applies specifically to *Pasteurella* and *Mannheimia* spp. from cattle where currently few isolates are tested yearly but also *Staphylococcus hyicus* and *Actinobacillus pleuropneumoniae* from pigs. Routines for collection of samples from relevant clinical cases and necropsies, and for free-of-charge culture and susceptibility will be elaborated. The same applies to *Brachyspira* spp. from pigs, where the programme must ensure that a sufficient number of samples are collected and analysed.

Also, more elaborate studies and research will be performed within the framework of SVARMpat. One aspect that will be addressed is the correlation between virulence factors (toxin production and adhesion factors) to resistance phenotype in *E. coli* in pigs. Such knowledge could help practitioners to initiate treatment only when ”true” pathogens are present, i.e. *E. coli* that produce both toxin and have adhesions factors. A similar approach will be used for *E. coli* in cattle. Other areas for research are development and validation of routine methods to distinguish pathogenic from non-pathogenic strains of *Fusobacterium necrophorum* in cattle and sheep. Likewise, methodology for routine sub-typing of *Pasteurella* and *Mannheimia* spp. will be explored within the programme.

By long term monitoring, SVARMpat will lead to increased and in-depth knowledge of antimicrobial resistance in pathogens from Swedish farm animals. This will be a keystone for prudent use of antimicrobials, which, in a wider perspective, curbs the emergence and spread of antimicrobial resistance. Thereby, effective antimicrobial therapy of farm animals, imperative for a good animal health status, is ensured in the future.

Horse

Isolates included

Escherichia coli are from the genital tract of mares, while isolates of *Streptococcus zooepidemicus* originate from the respiratory tract.

All isolates are from diagnostic submissions and exclusion of repeated isolated from the same individual or stable was not possible. Further, the data are probably biased towards treatment failures and recurrent infections. However, as these biases are assumed to be of similar magnitude throughout the period studied, assessment of resistance trends therefore appears relevant.

Escherichia coli

The occurrence of resistance in 2005 was of the same magnitude as in previous years (Table Horse I), except for ampicillin, where the proportion of *E. coli* resistant to ampicillin has decreased in the period studied (P=0.0078, Chi-square for trend). Resistance to trimethoprim-sulphonamides or streptomycin is most frequent, where trimethoprim-sulphonamides resistance could be explained by the fact that this is one of the most commonly used substance for antimicrobial therapy in horses. This usage probably co-selects for streptomycin resistance, since 14% of all isolates were resistant to both streptomycin and trimethoprim-sulphonamides.

Multiresistance occurred in only 6% of the isolates, and 75% of those were resistant to trimetoprim-sulphonamides, tetracycline and streptomycin, while 56% were resistant to these three antimicrobials and in addition to ampicillin. Although gentamicin is frequently used in equine stud practice, in extenders for semen and in solutions for uterine douching, the number of isolates resistant to gentamicin was low, only 2% (i.e. three isolates). Interestingly, gentamicin resistance only occurred in those three isolates that were resistant to five or more antimicrobials, and it is possible that gynaecological use of gentamicin selects for multiresistant *E. coli*.

Table Horse I. Occurrence of resistance among *Escherichia coli* from horses during 1992-2005 and distribution of MICs for the isolates from 2005. Isolates are from diagnostic submissions of samples from the female genital tract.

	Resistance (%)						Distribution (%) of MICs[a] (mg/L)									
Substance	1992-94 n=48	1995-97 n=216	1998-00 n=222	2001-03 n=457	2004 n=188	2005 n=161	≤0.12	0.25	0.5	1	2	4	8	16	32	>32
Ampicillin	15	17	10	9	10	4				2.5	28.6	60.9	4.3	3.7		
Ceftiofur	-	-	-	0[c]	1	0		13.7	80.1	6.2						
Enrofloxacin	8	3	3	2[d]	3	4	95.7	0.6	1.2	1.9	0.6					
Florfenicol	-	-	-	0[c]	0	0						29.2	69.6	1.2		
Gentamicin	0	3	6	2	2	2					88.8	9.3			1.9	
Neomycin	4	5	5	3[e]	5	2						89.4	8.7			1.9
Streptomycin	31	24	21	19	21	19						3.7	52.8	22.4	2.5	18.6
Tetracycline	6	5	9	6	10	6				21.1	64.6	8.1	0.6	5.6		
Trim/Sulph.[b]	2	15	17	17	20	16			80.7	3.1		0.6	15.5			

[a] The white fields denote range of dilutions tested for each substance. MICs above the range are given as the concentration closest to the range. MICs equal to or lower than the lowest concentration tested are given as the lowest tested concentration. Bold vertical lines indicate cut-off values defining resistance; [b] Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim/sulphametoxazole); [c] 353 isolates tested; [d] 456 isolates tested; [e] 455 isolates tested.

Table Horse II. Occurrence of resistance (%) among *Streptococcus zooepidemicus* from horses during 1992-2005 and distribution of MICs for the isolates from 2005. The isolates are from diagnostic submissions of samples from the respiratory tract.

	Resistance (%)						Distribution (%) of MICs[a] (mg/L)									
Substance	1992-94 n=218	1995-97 n=402	1998-00 n=409	2001-03 n=505	2004 n=185	2005 n=175	≤0.12	0.25	0.5	1	2	4	8	16	32	>32
Ampicillin	0	<1	0	0	0	0				100						
Enrofloxacin	-	-	-	NR	NR	NR[e]			1.1	67.2	31.6					
Florfenicol	-	-	-	1[d]	2	0					95.4	4.6				
Gentamicin	NR[c]	NR	NR	NR	NR	NR					1.1		7.4	74.3	17.1	
Neomycin	NR	NR	NR	NR	NR	NR						0.6	0.6	1.1	40.0	57.7
Penicillin	0	<1	0	0	0	0[e]	98.9		0.6	0.6						
Spiramycin	<1	1	0	1	1	0[f]						100				
Streptomycin	NR	NR	NR	NR	NR	NR							1.1	2.9	68.0	28.0
Tetracycline	4	3	4	5	3	3				55.4	40.0	1.7		2.9		
Trim/Sulph.[b]	1	11	57	36	49	41			41.1	9.1	6.9	1.7	41.1			

[a] The white fields denote range of dilutions tested for each substance. MICs above the range are given as the concentration closest to the range. MICs equal to or lower than the lowest concentration tested are given as the lowest tested concentration. Bold vertical lines indicate cut-off values defining resistance; [b] Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim/sulphametoxazole); [c] NR= Not relevant as the inherent susceptibility is such that the MIC range is above concentrations that can be obtained during therapy; [d] 370 isolates tested; [e] 174 isolates tested; [f] 172 isolates tested.

Streptococcus zooepidemicus

Streptococcus zooepidemicus resistant to trimethoprim-sulphonamides is common, while resistances to other antimicrobials are rare, as it has been since the late 90s (Table Horse II). As mentioned above, products containing trimethoprim-sulphonamides are commonly used in therapy of horses and an oral formula was introduced to the Swedish market in the late 80s. *Streptococcus zooepidemicus* has low inherent susceptibility to aminoglycosides, where the MIC range is above concentrations that can be obtained during therapy. Therefore, assessments of resistance to these antimicrobials are not relevant. In context of choice of antimicrobial therapy, the uniform susceptibility to penicillin among *S. zooepidemicus* must be emphasised.

Dog

Isolates included

Isolates of *E. coli* are from urine samples, submitted either as urine or as dip-slide cultures. *Staphylococcus intermedius* are from skin samples. Data may contain repeat isolates from the same patient. For all data, there is probably a bias towards isolates from dogs with recurrent disease or from therapeutic failures. The criteria for submission may have changed in the studied years, and any inferences on trends must, therefore, be made with caution.

Escherichia coli

Table Dog I shows that, the proportions of resistant *E. coli* have remained stable during the studied years, where resistance to ampicillin is the most common trait. Multiresistance occurred in 8% of the isolates, of these 70% were resistant to ampicillin, streptomycin and trimethoprim-sulphonamides,

Table Dog I. Occurrence of resistance among *Escherichia coli* from dogs during 1992 to 2005 and distribution of MICs for the isolates from 2005. The isolates are from diagnostic submissions of urinary tract samples.

	Resistance (%)						Distribution (%) of MICs[a] (mg/L)									
Substance	1992-94 n= 245	1995-97 n=296	1998-00 n=418	2001-03 n=621	2004 n=247	2005 n=304	≤0.12	0.25	0.5	1	2	4	8	16	32	>32
Ampicillin	18	18	18	18	19	17				2.3	47.0	28.0	5.6	17.1		
Enrofloxacin	9	9	10	9	12	9	89.8	1.6	2.6	2.6	3.3					
Gentamicin	2	1	2	2	1	1					88.5	10.5		0.7	0.3	
Nitrofurantoin	3	3	1	2	1	2[f]								96.7	1.7	1.7
Streptomycin	16	18	15[c]	15	13	14						6.6	58.9	18.4	2.0	14.1
Tetracycline	16	14	12	11[d]	13	7				29.9	51.3	11.2	0.3	7.2		
Trim/Sulph.[b]	9	8	11	11[e]	17	8			82.6	3.6	4.3	1.3	8.2			

[a] The white fields denote range of dilutions tested for each substance. MICs above the range are given as the concentration closest to the range. MICs equal to or lower than the lowest concentration tested are given as the lowest tested concentration. Bold vertical lines indicate cut-off values defining resistance; [b] Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim/sulphametoxazole); [c] 417 isolates tested; [d] 617 isolates tested; [e] 620 isolates tested; [f] 302 isolates tested.

Table Dog II. Occurrence of resistance among *Staphylococcus intermedius* from dogs during different years and distribution of MICs for the isolates from 2005. The isolates are from diagnostic submissions of samples from canine skin.

	Resistance (%)						Distribution (%) of MICs[a] (mg/L)									
Substance	1992-94 n=304	1995-97 n=322	1998-00 n=433	2001-03 n=382	2004 n=159	2005 n=126	≤0.12	0.25	0.5	1	2	4	8	16	32	>32
Cephalothin	<1	<1	0	1	2	1					99.2	0.8				
Clindamycin	12	20	21	18	21	18				81.7		0.8	17.5			
Enrofloxacin	-	-	-	2[f]	3	3	55.6	34.9	6.3	1.6	1.6					
Erythromycin	21	28	27	24	30	22			73.8	4.0			22.2			
Fusidic acid	9	14	20[e]	20[g]	27	25					73.8	0.8	25.4			
Gentamicin	<1	<1	<1	0	1	1					97.6	1.6	0.8			
Nitrofurantoin	1	1	<1	1	0	1								97.6	1.6	0.8
Oxacillin	1	2	1	2	2	1			96.0	3.2	0.8					
Penicillinb	79	80	80	80	80	84										
Streptomycin	-	-	-	22[f]	31	28						61.9	8.7	1.6		27.8
Tetracycline	24	12	28	25[h]	29	31				67.5	0.8	0.8		31.0		
Trim/Sulph[c]	1	2	1	3	10	6			63.5	30.2	0.8	2.4	3.2			

[a] The white fields denote range of dilutions tested for each substance. MICs above the range are given as the concentration closest to the range. MICs equal to or lower than the lowest concentration tested are given as the lowest tested concentration. Bold vertical lines indicate microbiological cut-off values defining resistance; [b] Denotes ß-lactamase production; [c] Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim/sulphametoxazole); [e] 421 isolates tested; [f] 273 isolates tested; [g] 346 isolates tested; [h] 381 isolates tested.

and 2% of all isolates were resistant to five or more antimicrobials.

Of all prescriptions of antimicrobials for dogs in 2005, 65% were ß-lactam antibiotics, but only 3% were penicillins with narrow spectrum (see Antimicrobials prescribed for dogs). Uncomplicated cystitis in dogs is commonly treated with aminopenicillins, which provide a selective pressure and may lead to a high proportion of *E. coli* resistant to ampicillin. Besides aminopenicillins, urinary tract infections are often treated with fluoroquinolones, and occasionally with trimethoprim-sulphonamides, and 3% of the isolates from 2005 were resistant to all three substances. These figures emphasise the need for culture and susceptibility testing before treatment of recurrent or non-responding urinary tract infections. Also the increasing sales of cephalosporins to small animals (see Antimicrobials prescribed for dogs), indicate a growing need to monitor the resistance rates more closely, especially to ß-lactams in *E. coli*.

The high proportion of *E. coli* resistant to enrofloxacin throughout the study period is partly explained by the use of a low cut-off value for resistance (>0.25 mg/L), compared to the clinical break-point recommended by CLSI (2004), which is >1 mg/L. Nevertheless, isolates with MIC >0.25 mg/L are less susceptible compared to inherently susceptible strains, probably due to at least one mutation in one of the genes encoding the target enzymes of this class of drugs. Therefore, resistance to one quinolone will also confer decreased susceptibility to all members of quinolone family (Webber and Piddock, 2001). If an infection caused by such a strain is treated with fluoroquinolones, there is a risk of further mutations resulting in decreased susceptibility (Drlica, 2003).

Staphylococcus intermedius

Most of the isolates (84%) were resistant to penicillin due to production of ß-lactamases (penicillinase) (Table Dog II). Already in the late 70s, about 80% of *S. intermedius* were resistant to penicillin (Franklin, 1978). Resistance rates to erythromycin, clindamycin, streptomycin and tetracycline in *S. intermedius* are stable, whereas resistance to fucidic acid has increased during the studied period (P<0.00001 Chi-square for trend).

This material is from diagnostic submissions of skin samples from dogs, and there is a high probability of bias towards dogs with recurrent skin infections, previously treated with antimicrobials. This probably explains the high resistance figures, around 20-30%, for erythromycin, clindamycin, fucidic acid, streptomycin and tetracycline. A prospective study by Holm *et al.* (2002) showed higher resistance level among isolates from recurrent pyoderma compared to those from first-time skin cases.

In 2005, 33% of the isolates were multiresistant, and this percentage is of the same magnitude as during the last years. In SVARM 2003, 26% were reported as multiresistant, and in 2004, the figure was even higher (38%). In 2005, 15% were resistant to five or more antimicrobials and all of these were resistant to penicillin, erythromycin and streptomycin, and 70% of these were resistant to tetracycline. In *S. intermedius*, resistance to macrolides is commoly mediated by *erm*-genes, and if these genes are constitutively expressed, the bacteria will also be resistant to lincosamides (clindamycin) and streptogramin B. In this material, about 80% of isolates resistant to erythromycin were also resistant to clindamycin. Interestingly, resistance to enrofloaxcin only occur in multiresistant phenotypes.

Resistance to cephalotin or oxacillin was recorded only occasionally and is probably due to methodological errors or to high production of ß-lactamases, and not to the presence of *mecA* gene. At SVA, all isolates with high MIC of oxacillin (>2 mg/L) are retested at lower temperature (33-34 ºC) and with 2% NaCl added to the broth. If oxacillin MIC still is a high, the isolates are examined for *mecA* gene with PCR. Hitherto, no *S. intermedius* have been positive for *mecA*

Cat

Isolates included

Isolates of *E. coli* are from urine samples, submitted either as urine or as dip-slide cultures. Data may contain repeat isolates from the same patient. Further, it is likely that there is a bias towards isolates from cats with recurrent disease or from therapeutic failures. The criteria for submission may have changed, and any inferences on trends must be made with caution.

Escherichia coli

The levels of resistance to ampicillin, tetracycline and enrofloxacin are above 10% (Table Cat I) and the figures are generally higher than for *E. coli* isolated from dogs.

This year only 3% of the isolates were resistant to trimetoprim-sulphonamide, and figures from previous years varies from 7 to 13%. This year's low figure is peculiar but a methodological error is unlikely, since no such drastic change is observed for the other species, and isolates from cats and dogs are tested with the same batches of broth and VetMIC™-panels.

As in dogs, the high proportion of *E. coli* resistant to enrofloxacin throughout the study period is partly explained by the low cut-off value for resistance (>0.25 mg/L), which is chosen for fluoroquinolones in SVARM, compared to breakpoint recommended by e.g. CLSI (2004), which is >1 mg/L. As mentioned above, strains with MIC >0.25 mg/L are less susceptible and there is a risk for further mutations during fluoroquinolone treatment.

During 2005, 14% of the isolates were multiresistant, but no isolate was resistant to more than four antimicrobials. Combined resistance to ampicillin, tetracycline and streptomycin was the most common pattern (60%). Urinary tract infections in cats are often treated with aminopenicillins or fluoroquinolones. In 2005, 5% of the isolates were resistant to both these antimicrobials. The observed high levels of resistance in *E. coli* from cats show that the choice of antimicrobials for treatment may be severely limited and must be based on culture and susceptibility tests.

Table Cat I. Occurrence of resistance among *Escherichia coli* from cats during 1992 to 2002, and distribution of MICs for the isolates from 2005. The isolates are from diagnostic submissions of urine samples.

	Resistance (%)					Distribution (%) of MICs[a] (mg/L)									
Substance	1992-97 n=61	1998-00 n=74	2001-03 n=135	2004 n=55	2005 n=74	≤0.12	0.25	0.5	1	2	4	8	16	32	>32
Ampicillin	26	34	27	18	20				1.4	54.1	21.6	2.7	20.3		
Enrofloxacin	5	8	13	5	11	89.2		5.4	1.4	4.1					
Gentamicin	0	3	5	0	0					94.6	5.4				
Nitrofurantoin	2	2	1	2	4								91.9	4.1	4.1
Streptomycin	25	18	21	9	18						10.8	48.6	23.0		17.6
Tetracycline	28	16	16	13	12				37.8	48.6	1.4		12.2		
Trim-Sulph.[b]	7	10	13	13	3			93.2	4.1			2.7			

[a] The white fields denote the range of dilutions tested for each substance. MICs above the range are given as the concentration closest to the range. MICs equal to or lower than the lowest concentration tested are given as the lowest tested concentration. Bold vertical lines indicate microbiological cut-off values defining resistance; [b] Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim/sulphametoxazole).

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 currently as Statistical Messages (SM). The Yearbook and Statistical Messages are is available on the Internet via the websites for Statistics Sweden (www.scb.se) or the Board of Agriculture (www.sjv.se).

The number of animals and holdings are given in Table AP1 I and II, and the number of animals slaughtered on an annual basis is given in Table AP1 III. In addition, the volume slaughtered (expressed in tonnes) is given in Table AP1 IV. Details on methodology are given in the respective sources of the statistics.

The total number of food producing animals, with the exception of sheep and beef cattle, has decreased notably over the last two decades and the herd size has increased (Table AP1 I). Changes in total number of animals are for each species reflected in the number of animals slaughtered (Table AP1 III).

Table AP1 I. Number of livestock and horses (in thousands) 1980-2005 (Yearbook of Agricultural Statistics, Sweden 2005 and Statistical Message JO 20 SM 0501).

Animal Species	1980[a]	1985[a]	1990	1995	2000	2003	2004	2005
Cattle								
Dairy cows	656	646	576	482	428	403	404	398
Beef cows	71	59	75	157	167	165	172	177
Other cattle >1 year	614	570	544	596	589	527	539	532
Calves <1 year	595	563	524	542	500	512	514	512
Total, cattle	**1 935**	**1 837**	**1 718**	**1 777**	**1 684**	**1 607**	**1 629**	**1 620**
Pigs								
Boars & sows	290	260	230	245	206	208	195	190
Fattening pigs >20 kg [b]	1 254	1 127	1 025	1 300	1 146	1 127	1 094	1 076
Piglets <20kg [c]	1 170	1 113	1 009	769	566	567	528	558
Total, swine	**2 714**	**2 500**	**2 264**	**2 313**	**1 918**	**1 903**	**1 818**	**1 823**
Sheep								
Ewes and rams	161	173	162	195	198	210	220	226
Lambs	231	252	244	266	234	238	246	253
Total, sheep	**392**	**425**	**406**	**462**	**432**	**448**	**466**	**479**
Laying hens								
Hens	5 937	6 548	6 392	6 100	5 670	4 498	4 995	-[d]
Chickens reared for laying	2 636	2 159	2 176	1 812	1 654	1 509	1 625	-[d]
Total, hens	**8 573**	**8 708**	**8 568**	**7 912**	**7 324**	**6 006**	**6 620**	-[d]
Horses								
Total, horses	-[d]	-[d]	-[d]	-[d]	-[d]	-[d]	**283**	-[d]

[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 not available.

Table AP1 II. Number of holdings with animals of different types, 1980-2004 (Yearbook of Agricultural Statistics, Sweden 2005).

Animal Species	1980	1985	1990	1995	2000	2003	2004
Cattle							
Dairy cows	44 100	35 100	25 900	17 700	12 700	9 700	9 100
Beef cows	12 400	10 300	10 900	17 100	13 900	12 700	13 000
Other cattle >1 year	63 200	52 700	42 700	39 200	30 500	26 500	26 300
Calves <1 year	62 300	52 000	42 000	36 500	27 700	24 900	24 100
Total holdings with cattle	**70 500**	**58 800**	**47 300**	**42 000**	**32 000**	**27 900**	**27 600**
Sheep, excluding lambs	10 100	10 500	9 700	10 000	8 000	7 600	8 200
Pigs	26 100	19 900	14 300	10 800	4 800	3 700	3 200
Laying hens	23 600	17 500	12 900	9 600	5 700	5 400	5 400
Chickens reared for laying	5 100	2 700	1 900	1 400	700	700	800
Horses	-[a]	-[a]	-[a]	-[a]	-[a]	-[a]	55 000

[a] Data not available.

Table AP1 III. Number of animals slaughtered (in thousands) at slaughterhouses, 1980-2005. (Yearbook of Agricultural Statistics, Sweden 1981, 1986, 1991 & 2005 and Statistical Message JO 48 SM 0602).

Animal Species	1980	1985	1990	1995	2000	2003	2004	2005
Cattle								
Cattle >1 year	574	584	523	502	490	454	458	433
Calves < 1 year	130	152	70	30	39	32	34	33
Total, cattle	**704**	**736**	**593**	**532**	**529**	**486**	**492**	**466**
Pigs	4 153	4 283	3 653	3 743	3 251	3 305	3 365	3160
Sheep	302	328	280	343	202	192	193	206
Chickens (broiler)	40 466[a]	36 410[a]	38 577[a]	61 300	68 617	74 742	69 628	73 458

[a] Data supplied by the National Food Administration.

Table AP1 IV. Quantity of livestock slaughtered (in 1000 tonnes) at slaughterhouses, 1990-2005 (Yearbook of Agricultural Statistics, Sweden 1991 & 2005 and Statistical Message JO 48 SM 0602).

Animal Species	1990	1995	2000	2001	2002	2003	2004	2005
Cattle								
Cattle >1 year	139.5	140.1	145.4	139.1	142.3	136.4	137.8	131.3
Calves < 1 year	6.8	3.2	4.4	4.1	4.2	4.1	4.6	4.6
Total, cattle	**146.3**	**143.3**	**149.8**	**143.2**	**146.5**	**140.5**	**142.4**	**135.9**
Pigs	293.1	308.8	277.0	275.9	283.8	287.5	294.5	275.1
Sheep	5.0	3.5	3.9	3.9	3.9	3.7	3.8	0.8
Chickens (broiler)	44.0[a]	73.6[a]	89.9	96.1	101.4	97.9	91.2	96.2

[a] Data supplied by the National Food Administration.

Appendix 2: Materials and methods, use of antimicrobials

Source for the statistics

Antimicrobial drugs used in veterinary medicine in Sweden are only available on veterinary prescription. Furthermore, antimicrobial drugs have to be dispensed through pharmacies, which in turn are supplied solely by two drug wholesalers. Sales statistics are available from Apoteket AB (The National Corporation of Swedish Pharmacies).

From year 2003, statistics on drug sales is based on electronic records of amount of drugs dispensed at or from pharmacies, i.e. sales statistics. Data for previous years are the amount of antimicrobial products sold from the wholesalers to the pharmacies. Wholesalers' data have a very high degree of completeness. This is explained by the fact that the wholesalers represent the entire drug distribution network, i.e., there are no other sources of antimicrobials for use or prescription by veterinarians. As the pharmacies stock a limited amount of drugs, the current prescription based statistics is judged to be comparable with previous, wholesaler based statistics.

Sweden has a long tradition in drug consumption statistics. Apoteket AB, former Apoteksbolaget AB, has since 1976 monitored the consumption of drugs for use in humans mainly by using wholesalers' statistics. In the case of drugs for animal use, SVA and Apoteket AB have collaborated over the years and data on the total use of antimicrobials for animals in Sweden are available since 1980. For a review of the figures from 1980-2000 as well as references to publications on which that review is based, see SVARM 2000. From year 2003, Apoteket AB has the formal responsibility to gather such data. Further, the Board of Agriculture has been appointed competent governmental authority and will, from 2006, report statistics per animal species (food producing animals).

Classification of drugs

Veterinary medicinal drugs are classified according to the Anatomical Therapeutic Chemical veterinary classification system (ATCvet) (WHO, Guidelines for ATCvet classification). The system is based on the same main principles as the ATC classification system for substances used in human medicine. In both the ATC and ATCvet systems, drugs are divided into groups according to their therapeutic use. First, they are divided into 15 anatomical groups, classified as QA-QV in the ATCvet system (without Q in the system for human drugs), on basis of their main therapeutic use. Thereafter subdivision is made according to therapeutic main groups, which is followed by a further division in chemical/therapeutic subgroups.

Antimicrobials are classified in the QJ group – general antiinfectives for systemic use. However, antimicrobials can also be found in other groups such as QA (alimentary tract and metabolism), QD (dermatologicals), QG (genito-urinary system) and QS (sensory organs) depending on the therapeutic use.

Inclusion criteria

All veterinary antibacterial drugs authorised for use in animals except dermatologicals, ophtalmologicals and otologicals (i.e., ATCvet codes QA, QG and QJ) were included. Veterinary drugs are preparations authorised for use in animals. Human drugs may be authorised not only for humans, but for animals as well. This latter category is not included in the statistics. However, no such drugs are authorised for use in the major food producing animal species, and the volume sold is very limited.

Drugs with antibacterial activity can also be found in other groups, notably among the antiprotozoals (QP51). Of these, the nitroimidazoles were included earlier but no such substances are presently authorised for use in animals. Sulfaclozine is licensed for treatment of coccidiosis only and has therefore not been included. The ionophoric antibiotics are presently regulated as feed additives and not sold through pharmacies and are therefore not included in the wholesalers' statistics. 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.

Prescriptions for dogs

From the spring of 2004, animal species is recorded for all prescriptions dispensed to animal care-takers. Data on all prescriptions for dogs, i.e. drugs authorised for use in animals (ATC vet code QJ01) as well as for humans (ATC code J01) were retrieved and are presented in a highlight in this year's report. The data-set corresponds to out-patient use in human medicine.

Distribution of veterinary medicines in Sweden

Marketing of drugs in Sweden is regulated by the Medicinal Products Act, which applies both to human and veterinary drugs. According to the Act, a medicinal product may not be sold until it has been granted marketing authorisation by the Medical Products Agency (MPA). The MPA has issued provisions concerning authorisation, distribution and prescription of veterinary medicinal products.

The state-owned Apoteket AB has exclusive rights regarding retail sales of medicines in Sweden. Apoteket AB operates according to guidelines set out in an agreement with the State. According to the Act only pharmacies run by Apoteket AB are permitted to sell drugs. This implies that veterinarians in Sweden are not permitted to sell drugs, although they may for practical reasons hand over medicines for emergency use. Veterinarians are, however, under no conditions permitted to make a profit from dispensing medicines.

Appendix 3: Materials and methods, resistance monitoring

Sampling strategy

Zoonotic bacteria

Salmonella

Isolates of *Salmonella* from warm-blooded animals (wild and domesticated) are included. Salmonellosis in animals is a notifiable disease in Sweden. It is mandatory that at least one isolate from each notified incident, including incidents detected in the Swedish *Salmonella* control programme, is confirmed at SVA. The first isolate of each serovar, and when appropriate phage-type, from each food animal species in each notified incident is included in the material presented in SVARM. The same inclusion criteria are also used for isolates from other warm blooded animal species, unless the epidemiological situation in a particular year is judged unusual. In year 2005, *Salmonella* was isolated from a total of 138 cats and of these isolates; the first 20 consecutive isolates were tested and thereafter every fifth isolate (total number of isolates 44).

Campylobacter

Campylobacter were isolated from colon content of healthy pigs sampled at abattoirs for isolation of indicator bacteria (see below). From the total number of samples collected (n=455), about one third (n=131) 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 four sampling periods.

Indicator bacteria

Indicator bacteria, *Escherichia coli* and *Enterococcus* spp., were isolated from colon content of healthy pigs sampled at slaughter by meat inspection staff or abattoir personnel. Eight abattoirs participated in the collection of samples. These abattoirs are geographically separated and accounted for 80% of the total volume of pigs slaughtered in Sweden during 2004.

At each abattoir, an equal number of samples were collected during each of four periods (April, May, August-September and November). The number of samples collected at each abattoir was proportional to the respective annual volume of pigs slaughtered and each sample represents a unique herd. By these measures, bacterial isolates included are from randomly selected healthy pigs of Swedish herds.

Animal pathogens

Isolates of animal pathogens included emanate from routine bacteriological examinations of clinical submissions or post-mortem examinations at SVA.

Escherichia coli from pigs and cattle are from the gastrointestinal tract (gut content, faecal samples or mesenteric lymph nodes) and *Brachyspira* spp. from faecal samples from pigs. *Escherichia coli* from horses are from the genital tract of mares and *Streptococcus zooepidemicus* from the respiratory tract. From dogs and cats *E. coli* isolated from samples of urine are included and in addition, from dogs, *Staphylococcus intermedius* isolated from skin samples.

As a screening for methicillinresistance in *Staphylococcus aureus* from dairy cows, ß-lactamase producing strains isolated on routine culture from samples of milk were selected for further testing. Each isolate is from a unique dairy herd.

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 Nordic Committee on Food Analysis (NMKL Nr 71 5th ed., 1999). 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*.

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 was isolated and identified at SVA according to standard procedures. Samples were cultured for thermophilic *Campylobacter* spp. by a modified NMKL method (NMKL Nr 119, 1990) using Preston selective agar and incubation at 42°C. Identification was based on colony morphology, microscopic appearance including motility and the following phenotypic characteristics: production of oxidase, catalase, hippurate hydrolysis reaction and indoxyl-actetate reaction (Nachamkin, 1999). With these tests, hippurate-positive *C. jejuni* can be identified whereas other isolates are described as hippurate-negative thermophilic *Campylobacter* spp.

Indicator bacteria

Escherichia coli

Approximately 0.5 g of caecal content was diluted in 4.5 mL saline. After thorough mixing, 0.1 mL of this suspension was spread on MacConkey agar. After incubation overnight at 37°C, one lactose positive colony with morphol-

ogy typical for *E. coli* was sub-cultured on horse-blood agar (5% v/v), after which the isolate was tested for production of tryptofanase (indole) and ß-glucuronidase (p-nitrophenyl-ß-D- glucopyranosiduronic acid, PGUA). Only lactose-positive isolates with typical morphology and positive reactions in both tests were selected for susceptibility tests.

Enterococci

Caecal content was diluted as described for *E. coli* and cultured both on solid media without selective antibiotics and on selective plates with vancomycin (16 mg/L).

Culture without selective antibiotics: Of the diluted intestinal content, 0.1 mL was spread onto Slanetz-Bartley (SlaBa) agar. The plates were incubated for 48 h at 37°C. One colony, randomly chosen, was 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 tested for antimicrobial susceptibility and 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-ß-D-glucopyranoside.

Selective culture for vancomycin resistant enterococci: Diluted caecal content (0.1 mL) was also cultured on SlaBa with vancomycin (16 mg/L). From plates showing growth of colonies typical for enterococci, at least one colony of each morphological type was sub-cultivated on bile-esculin agar and blood agar (37°C, for 24 h). Identification of presumptive enterococci was performed as above.

Animal pathogens

Animal pathogens were isolated and identified at the Dept. of Bacteriology, SVA with accredited methodology, following standard procedures.

Susceptibility testing

The Dept. of Antibiotics or the Dept. of Bacteriology performed antimicrobial susceptibility tests, with accredited methodology, using dilution methods in cation adjusted Mueller-Hinton broth (CAMBH). Tests were performed following the standards for microdilution of the Clinical and Laboratory Standards Institute (CLSI, formerly NCCLS). The microdilution panels used, VetMIC™, are produced at the Dept. of Antibiotics, SVA. Different panels were used depending on the bacterial species tested and the original purpose of the investigation (monitoring or clinical diagnostics). Minimum inhibitory concentration (MIC) was recorded as the lowest concentration of the antimicrobial that inhibits bacterial growth.

Presence of *mecA* gene in *S. aureus* from dairy cows was tested at the Dept. of Antibiotics, SVA by the latex agglutination test (MRSA-Screen, Denka Seiken, UK Ltd. United Kingdom) or by PCR according to Smyth *et al.* (2001).

For classification of zoonotic bacteria (*Salmonella* and *Campylobacter*) and indicator bacteria (*E. coli* and enterococci) microbiological cut-off values recommended by the European Committee on Antimicrobial Susceptibility Testing (EUCAST) were used (http://www.escmid.org). When no cut-off value was available, or the range of concentrations tested was inappropriate for the recommended value, a cut-off value was defined on basis of the actual MIC distributions obtained in the SVARM programme. The same approach was used when recommended cut-off values would have cut through distributions of MIC in a manner not in agreement with the concept of wild-type distributions, causing an erroneously high frequency of resistance in single a year(s). This applies to gentamicin and streptomycin in *E. coli*, gentamicin,streptomycin and sulphamethoxazole in *Salmonella* and virginiamycin in enterococci. Further, for enterococci a higher cut-off for streptomycin and gentamycin than that defined by EUCAST were used, with the aim to screen for high-level resistance only.

Also for animal pathogens the principle of microbiological cut-off values were used, but the clinical breakpoints recommended for animal pathogens by CLSI were also taken into consideration

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).

Quality assurance system

The Dept. of Antibiotics 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 and indicator bacteria, *Escherichia coli* ATCC 25922, *Enterococcus faecalis* ATCC 29212 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.

The Dept. of Antibiotics participates in several proficiency tests for antimicrobial susceptibility testing. These are arranged either as national or international 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. are routinely registered in an Oracle database at SVA. From this, relevant data were extracted to an Access database.

For indicator bacteria, data on animal species, date of sampling, abattoir and herd or flock of origin were recorded in an Access database on arrival of samples, and the results of culture identification and susceptibility tests were recorded on completion of testing.

Calculations and analysis of data were performed in the computer programs Access, Excel, Minitab or EpiInfo.

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.

There are several ways out of the dilemma; one 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.

Table AP3 I. Cut-off values (mg/L) defining resistance used for antimicrobial susceptibility testing of bacteria. Isolates with MIC higher than the given values are considered resistant.

Substance	*Brachyspira* spp.	*Campylobacter* spp.	*Enterococcus* spp. (indicator)	*Escherichia coli* (indicator)	*Escherichia coli* (pathogen; pig, cattle, horse)	*Escherichia coli* (pathogen; dog, cat)	*Salmonella* spp.	*Staphylococcus aureus*	*Staphylococcus intermedius*	*Streptococcus zooepidemicus*
Ampicillin		>16	>4	>8	>8	>8	>4			>8
Avilamycin			>16							
Bacitracin[a]			>32							
Cefotaxime				>0.25			>0.5			
Ceftiofur				>1	>2		>2			
Cephalothin								>1	>2	
Chloramphenicol			>32	>16			>16	>16		
Clindamycin								>4	>4	
Enrofloxacin		>0.5		>0.12	>0.25	>0.25	>0.25		>0.5	
Erythromycin		>16	>4					>2	>4	
Flavomycin			>32							
Florfenicol				>16	>16		>16			>16
Fusidic acid									>4	
Gentamicin		>2	>512	>4	>8	>8	>4	>4	>4	
Nalidixic acid		>32		>16			>16			
Narasin			>2							
Neomycin			>512	>8	>8		>4	>32		
Nitrofurantoin						>32			>32	
Oxacillin									>1	
Penicillin								[c]	[c]	>1
Spiramycin										>16
Streptomycin			>1024	>32	>32	>32	>32	>32	>32	
Sulphamethoxazole				>256			>256			
Tetracycline		>2	>2	>8	>8	>8	>8	>8	>8	>8
Tiamulin	>2									
Trimethoprim				>2			>2	>4		
Trimethoprim & sulphamethoxazole[b]					>4	>4	>0.5		>2	>4
Tylosin	>16									
Vancomycin			>4							
Virginiamycin			>8							

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

Appendix 4: Antimicrobial agents licensed

Antimicrobial agents licensed for therapy in veterinary medicine in Sweden year 2005 are listed in Table AP4 I.

Only substances licensed for systemic, oral, intrauterine or intramammary use are included (ATCvet codes QJ, QG, QA and QP). Data from FASS VET. 2005. For explanation of ATCvet code, see Appendix 2.

Table AP4 I. Antimicrobial agents authorised for therapeutic use in cattle, sheep, pigs, poultry, horses, dogs and cats in Sweden, 2005. Routes of administration are indicated [a].

		Animal species						
Antimicrobial agent	ATCvet code	Cattle	Sheep	Pigs	Poultry	Horses	Dogs	Cats
Tetracyclines								
Doxycycline	QJ01A A02			O			O	O
Oxytetracycline	QJ01A A06, QG51A A01	I O U	I O U	I O U	O		O	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, potassium	QJ01C E01	I M		I		I		
Penicillin G, procaine	QJ01C E09	I	I	I		I	I	I
Penicillin G, penetamathydroiodide	QJ01C E90	I						
beta-lactams, cephalosporins								
Cephalexin	QJ01D A01						O	
Cefadroxil	QJ01D A09						O	O
Ceftiofur	QJ01D A90	I						
Sulphonamides /Trimethoprim								
Sulphadiazine/Trimethoprim	QJ01E W10	I	I	I		I O	O	O
Sulphadoxine/Trimethoprim	QJ01E W13	I		I		I		
Sulphonamides								
Formosulphatiazole	QA07A B90	O	O	O		O	O	O
Sulphaclozin	QP51A G04				O			
Macrolides								
Spiramycin	QJ01F A02	I						
Tylosin	QJ01F A90	I		I O	O		I	I
Lincosamides								
Clindamycin	QJ01F F01						O	O
Pirlimycin	QJ51F F90	M						
Aminoglycosides								
Gentamicin	QJ01G B03					I U	I	I
Dihydrostreptomycin (DHS)	QA07A A90	O U	O U	O U		O U	O	O
Fluoroquinolones								
Enrofloxacin	QJ01M A90	I		I	O		I O	I O
Danofloxacin	QJ01M A92	I		I				
Marbofloxacin	QJ01M A93						O	O
Orbifloxacin	QJ01M A95						O	
Pleuromutilins								
Tiamulin	QJ01X X92			I 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						
Penicillin G, ester/DHS	QJ51R C25	M						

[a] O = oral; I = injection; U = intrauterine; M = intramammary.

Appendix 5: References

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