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FINRES-Vet 2010-2012

Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents

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Lääkealan turvallisuus- ja kehittämiskeskus

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Acknowledgements
The coordinators of the FINRES-Vet programme wish to thank the meat inspection personnel of Evira and slaughterhouses for collecting the samples from animals at slaughter. Also, the local municipal veterinarians are acknowledged for carrying out the sampling in the pig farms for MRSA screening.

Any use of data from FINRES-Vet 2010-2012 should include a specific reference to this report. Suggested citation: FINRES-Vet 2010-2012, Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents, Finnish Food Safety Authority Evira, Helsinki, Finland, ISSN 1797-299X, ISBN 978-952-225-143-5 (pdf).

This report is available at www.evira.fi

Description

Publisher	Finnish Food Safety Authority Evira
Title	FINRES-Vet 2010-2012. Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents
Authors	Suvi Nykäsenoja, Katariina Kivilahti-Mäntylä, Katariina Pekkanen, Merja Rantala
Abstract	Sales of veterinary antimicrobials, in kg active ingredient, showed a slight decreasing trend. Penicillin G was the most sold antimicrobial followed by the combination of sulfa-trimethoprim. The amount of critically important antimicrobials used for animals remained very low. Approximately half of antimicrobials were given as injections. Additionally, the use of products intended for group treatment remained low. The occurence of antimicrobial resistance in bacteria isolated from animals and food has remained relatively good compared to the previous reporting periods. The main reasons for this are our favourable disease situation and a controlled use of antimicrobials. However, resistance figures for certain bacteria are concerning so the need for antimicrobial treatment should always be evaluated and the choice of antimicrobial justified in every occasion. Among zoonotic bacteria (Salmonella, Campylobacter), resistance levels were relatively low. Only fluoroquinolone resistance among Campylobacter isolates from cattle and swine has clearly increased. Among indicator bacteria (*E. coli,* enterococci), resistance was most often encountered in *E. coli* isolates from pigs and enterococci isolates from broilers. Multiresistance in *E. coli* strains isolated from cases of porcine enteritis is still common. Among isolates from bovine mastitis, resistance was most commonly detected against penicillin and trimethoprim in staphylococci, and against tetracycline in streptococci. Antimicrobial resistance among animal pathogens isolated from companion animals was common. The proportion of ESBL producers of all *E. coli* isolated from dogs and cats has increased from 2011 to 2012.
Publication date	April 2015
Keywords	Antimicrobial resistance, consumption of antimicrobials
Name and number of publication	Evira publications 2/2015
Pages	60
Language	English
Confidentiality	Public
Publisher	Finnish Food Safety Authority Evira
Layout	Finnish Food Safety Authority Evira, In-house Services
	ISSN 1797-299X, ISBN 978-952-225-143-5 (pdf)

Kuvailulehti

Julkaisija	Elintarviketurvallisuusvirasto Evira
Julkaisun nimi	FINRES-Vet 2010-2012. Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents
Tekijät	Suvi Nykäsenoja, Katariina Kivilahti-Mäntylä, Katariina Pekkanen, Merja Rantala
Tiivistelmä	Eläimille käytettävien mikrobilääkkeiden myynti laski hieman. Eniten myydyin mikrobilääke oli penisilliini ja toiseksi eniten sulfatrimetopriimi-yhdistelmä. Kriittisen tärkeiden mikrobilääkkeiden kulutus eläinten lääkinnässä on pysynyt hyvin vähäisenä. Noin puolet eläinten mikrobilääkkeistä annettiin injektioina. Myös eläinten ryhmälääkintään tarkoitettujen valmisteiden käyttö oli vähäistä. Eläimistä ja elintarvikkeista eristettyjen bakteerien mikrobilääkeresistenssi Suomessa on pysynyt kohtuullisen hyvänä edellisiin raportointikausiin verrattuna. Tämä johtuu pääosin Suomen hyvästä tautitilanteesta ja mikrobilääkkeiden hallitusta käytöstä. Joidenkin bakteerien osalta resistenssitilanne on kuitenkin huolestuttava, joten lääkitystarvetta tulee aina arvioida ja mikrobilääkkeen valinnan tulee olla joka tilanteessa perusteltua. Zoonoottisilla bakteereilla (salmonella, kampylobakteeri) resistenssiä todettiin kohtalaisen vähän. Ainoastaan nautojen ja sikojen kampylobakteereilla fluorokinoloniresistenssi on selvästi lisääntynyt. Indikaattoribakteerien (*E. coli*, enterokokit) osalta resistenssiä todettiin eniten sioista eristetyillä *E. coli* - bakteereilla ja broilereista eristetyillä enterokokeilla. Sikojen suolitulehduksista eristetyillä *E. coli* -bakteereilla moniresistenssi oli edelleen yleistä. Nautojen utaretulehduksista eristetyillä stafylokokeilla resistenssi oli yleisintä penisilliinille ja trimetopriimille, vastaavasti streptokokeilla resistenssiä todettiin eniten tetrasykliinille. Resistenssin esiintyminen harraste-eläimiltä eristetyillä tautia aiheuttavilla bakteereilla oli varsin yleistä. Koirista ja kissoista eristetyt ESBL-kannat lisääntyivät vuodesta 2011 vuoteen 2012.
Julkaisuaika	Huhtikuu 2015
Asiasanat	Mikrobilääkeresistenssi, mikrobilääkkeiden käyttö
Julkaisusarjan nimi ja numero	Eviran julkaisuja 2/2015
Sivuja	60
Kieli	Englanti
Luottamuksellisuus	Julkinen
Julkaisun kustantaja	Elintarviketurvallisuusvirasto Evira
Taitto	Elintarviketurvallisuusvirasto Evira, virastopalveluyksikkö
	ISSN 1797-299X, ISBN 978-952-225-143-5 (pdf)

Beskrivning

Utgivare	Livsmedelssäkerhetsverket Evira
Publikationens titel	FINRES-Vet 2010-2012. Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents
Författare	Suvi Nykäsenoja, Katariina Kivilahti-Mäntylä, Katariina Pekkanen, Merja Rantala
Resumé	Försäljningen av antimikrobiella medel för djur sjönk något. Det mest sålda antimikrobiella medlet var penicillin och därefter kombinationen sulfa-trimetoprim. Förbrukningen av antimikrobiella medel som är av kritisk betydelse har förblivit blygsam. Cirka hälften av de mikrobläkemedlen har givits i form av injektioner. Förbrukningen av preparater avsedda för gruppbehandling av djur har också varit liten. Resistenssituationen hos bakterien som har isolerats från djur och livsmedel av animaliskt ursprung har hållits relativt god i Finland jämfört med föregående rapporteringsperioder. Det här är en följd huvudsakligen av den goda sjukdomssituationen och av den balanserade användingen av antimikrobiella medlen. Resistens hos vissa bakterier är dock bekymmersam varför behov av medicinering ska alltid uppskattas och det valet av antimikrobiella läkemedel ska vara motiverad. Hos zoonotiska bakterier (salmonella, campylobacter) konstaterades relativt litet resistens. Endast resistens mot fluorokinoloner hos kampylobakteriestammar som isolerats från svin och nötdjur hade ökat. Hos indikatorbakterier (*E. coli*, enterokocker) konstaterades resistens mest hos stammar av *E. coli* som isolerats från svin och hos enterokocker som isolerats från broilrar. Multiresistens var fortvarande allmän hos *E. coli* som isolerats från tarminfektioner hos svin. Hos stafylokocker som isolerats från juverinflammationer hos nötkreatur resistens var vanligaste mot penicillin och trimetoprim, och hos streptokocker mot tetracyklin. Särskilt mycket resistens förekom hos bakteriestammar som orsakar sjukdomar hos hobby- och sällskapsdjur. ESBL-stammarnas andel av alla *E. coli* -bakterier isolerats från hundrar ock katter ökade från år 2011 till år 2012.
Utgivningsdatum	April 2015
Referensord	Resistens mot antimikrobiella medel, användning av antimikrobiella medel
Publikationsseriens namn och nummer	Eviras publikationer 2/2015
Antal sidor	60
Språk	Engelska
Konfidentialitet	Offentlig
Förläggare	Livsmedelssäkerhetsverket Evira
Layout	Livsmedelssäkerhetsverket Evira, Enhet för ämbetsverkstjänster
	ISSN 1797-299X, ISBN 978-952-225-143-5 (pdf)

Abstract

This report presents the results obtained in the FINRES-Vet monitoring in 2010-2012. However, to better discern long-term developments most of the tables and figures about the consumption of antibiotics and feed additives contain corresponding data starting from the year 2003. The structure of the report complies with that of the previous reports of the series (the previous covering the years 2007-2009). After reviewing the consumption of antibiotics and feed additives administered to animals, the report describes the occurrence of resistance in zoonotic bacteria, in indicator bacteria and in bacteria pathogenic to animals. In addition, this report includes the results of the specific screening of extended-spectrum beta-lactamase producing bacteria from 2011-2012, and the results of the screening of methicillin-resistant *Staphylococcus aureus* (MRSA) conducted in all the top breeding farms with a special pathogen-free (SPF) status in Finland between 2011 and 2013.

Sales of veterinary antimicrobials in Finland

Sales of veterinary antimicrobials, in kg active ingredient, showed a slight decreasing trend during the observation period. Proportion of different classes of antimicrobials remained unchanged. Penicillin G was the most sold antimicrobial its proportion being almost half of the overall sales in 2012 and over 80 % of injectable products. Sales of oral tetracyclines peaked in 2008 but has since returned to pre-peak levels. Sales of antimicrobials highly important in human medicine increased during reporting period although their proportion of the total sales remained low (0.03-0.09% for 3rd generation cephalosporins, 3-3.6% for macrolides and 0.6–0.7% for fluoroquinolones in 2010-2012 respectively).

Antimicrobial resistance in zoonotic bacteria

The FINRES-Vet programme covers all salmonella isolations from cattle, swine and poultry under the National Salmonella Control Programme. The isolates of salmonella from domestic foods and those encountered in the own-control schemes of food industry plants are also examined for antibiotic resistance in the FINRES-Vet programme. The occurrence of resistance in campylobacteria isolated from cattle, swine and poultry is also monitored.

The number of salmonella isolates from production animals is annually some tens at the most, which reflects the very favourable prevalence of salmonella infections in livestock, compared internationally. The resistance encountered in production animal isolates has lately been due to *S.* Typhimurium from cattle. In addition, for the first time within the framework of resistance monitoring programme in Finland, resistance

to third generation cephalosporins among salmonella was detected in 2012: *S.* Typhimurium strain producing plasmid-mediated AmpC beta-lactamase was isolated from a pig. In 2010-2012, *S.* Enteritidis isolations from domestic production animals were rare (altogether five strains) and they were sensitive to all tested antimicrobials.

Like in previous years, resistance in *Campylobacter* isolated from broilers was very low; the proportion of resistant strains was 2-3% at the most. On the other hand, resistance among *Campylobacter* isolated from pigs and cattle was more common, especially fluoroquinolone resistance has increased compared with the last reporting period (2007-2009).

Antimicrobial resistance in indicator bacteria

Escherichia coli, *Enterococcus faecalis* and *Enterococcus faecium* were isolated from samples taken at slaughter from pigs in 2010, from broilers in 2011 and from cattle in 2012. Resistance levels were low, especially among *E. coli* from cattle. Resistance was uncommon also in indicator bacteria from broilers. The highest proportions of resistance were detected among *E. coli* from swine: 19% to tetracycline, 15% to streptomycin, 12% to sulfonamides and 11% to trimethoprim. Resistance to erythromycin was common in enterococci from all production animals. In addition, enterococci from broilers showed resistance also to narasin, and enterococci from swine to tetracycline. The resistance levels to other antimicrobials remained low in enterococci.

Specific ESBL/AmpC and VRE screening

Extended-spectrum beta-lactamase producing *E. coli* were screened in 2011 from broiler caeca and in 2012 from cattle faeces. The finding of these bacteria was rare (< 1%) in both animal species: three AmpC and two ESBL producing *E. coli* were isolated from broilers and cattle, respectively.

In addition, vancomycin resistant enterococci (VRE) were screened from broiler ceacal samples. The prevalence of VRE in slaughtered broilers was 9%: isolates were *E. faecium* harbouring *vanA* gene.

Antimicrobial resistance in animal pathogens

In *E. coli* strains isolated from porcine enteritis cases, resistance was common. The most common resistance traits were against tetracycline, streptomycin, sulfamethoxazole, trimethoprim, ampicillin, ciprofloxacin and nalidixic acid. Multiresistance was also frequent. During the past ten years, resistance has slightly varied; however, reliable trend analysis is impossible due to the low number of isolates in different years.

The antimicrobial resistance among staphylococci isolated from bovine mastitis cases was relatively low. Resistance in coagulase-negative staphylococci (CoNS) was more common that in *S. aureus.* Penicillin is widely used for the treatment of mastitis in cattle but only 23% of the *S. aureus* isolates produced beta-lactamase. At the same time, 37.5% of the CoNS isolates were beta-lactamase producers. In addition, five CoNS strains were confirmed to carry the *mecA* gene conferring resistance to methicillin. MRSA strains were not detected. High resistance against trimethoprim was also observed in staphylococci although resistance to sulfonamide-trimethoprim combination was rare.

Among *Streptococcus uberis* and *Streptococcus dysgalactiae*, resistance was most commonly detected against tetracycline (32% and 28%, respectively). Furthermore, 11% of the *S. uberis* isolates were resistant to erytromycin. All *S. dysgalactiae* isolates were susceptible to penicillin. On the other hand, four *S. uberis* isolates had low-level resistance to penicillin. This phenomenon has been described previously and it is assumed to derive from mutations in penicillin binding proteins.

The level of resistance in *E. coli* from bovine mastitis was low. The most common resistance characteristics were resistance against streptomycin (9%), ampicillin (4%), ciprofloxacin (4%), nalidixic acid (4%), sulfamethoxazole (4%) and trimethoprim (4%). Two *E. coli* strains were multiresistant.

The resistance among pathogens from bovine mastitis is not frequently followed. However, based on the data collected in this report, it can be evaluated that resistance situtation in pathogens from bovine mastitis has remained good in Finland. Also, previous studies have showed that MRSA findings from mastitis cases have been rare in Finland.

Antimicrobial resistance statistics for companion animals (mainly dogs, cats and horses) were received from the Clinical Microbiology Laboratory of the Faculty of Veterinary Medicine (University of Helsinki). The data covers the time period from June 2011 to December 2012. Bacterial species include *S. aureus*, *S. pseudintermedius* and *E. coli* isolates.

S. aureus isolates from horses, dogs, cats and one rabbit were collected. Antimicrobial resistance was low, except for penicillin for which 53% of the isolates were resistant. One MRSA isolate was discovered from a dog.

Antimicrobial resistance among *S. pseudintermedius* isolates from dogs and cats was frequent. Multi-drug resistance was also common. This is due to the emergence of methicillin resistant *S. pseudintermedius* (MRSP). The proportion of MRSP among *S. pseudintermedius* isolates was 16% in 2012.

E.coli isolates from dogs and cats were frequently resistant to betalactams (in 2012 60% were resistant to ampicillin and 27% to amoxicillin-clavulanate). Nearly one fifth of isolates were resistant to sulfonamide-trimethoprim and 11% to enrofloxacin. Increase of ESBL *E. coli* was noted: the proportion of ESBL isolates was 1.5% in 2011 and 4.3% in 2012.

Antimicrobial resistance was frequent in *E. coli* isolates from horses. In 2012, 68% of isolates were resistant to ampicillin, 58% to sulfonamide-trimethoprim, 39% to amoxicillin-clavulanate and 31% to gentamicin. The proportion of ESBL-isolates was 6.7%.

Methicillin resistant *Staphylococcus aureus* (MRSA)

In 2011-2013, a specific MRSA survey was conducted in the pig breeding farms with special pathogen-free (SPF) status. The screening included all 68 holdings of which none had MRSA.

Tiivistelmä

Tämä raportti kokoaa FINRES-Vet-seurannan tulokset vuosilta 2010-2012. Pitemmän aikavälin muutosten hahmottamiseksi raportin useimmat eläinlääkkeiden ja rehun lisäaineiden kulutustaulukot ja kaaviot sisältävät tiedot alkaen vuodesta 2003. Raportti noudattaa pääosin edellisten raporttien (viimeisin vuosilta 2007-2009) rakennetta, jossa ensin luodaan katsaus eläinlääkkeiden kulutuksessa tapahtuneisiin muutoksiin ja sen jälkeen antibioottiresistenssin ilmenemiseen zoonoottisissa bakteereissa, indikaattoribakteereissa ja eläimille tautia aiheuttavissa bakteereissa. Lisäksi raportissa on mukana vuonna 2011 alkaneen laajakirjoisia beetalaktamaaseja (ESBL/AmpC) tuottavien bakteerien seulonnan tulokset sekä vuosina 2011-2013 sikojen erityistason pitopaikoissa toteutetun metisilliinille resistentin *Staphylococcus aureus* (MRSA) -bakteerin kartoitustulokset.

Eläinten mikrobilääkkeiden kulutus Suomessa

Eläinten mikrobilääkkeiden myynti laski seurantajaksolla hieman. Eri lääkeryhmien suhteelliset osuudet pysyivät ennallaan. Eniten myydyn mikrobilääkkeen, penisilliinin, osuus kokonaismyynnistä oli edelleen lähes puolet ja injektiovalmisteista yli 80 %. Suun kautta annettavien tetrasykliinien kulutus palasi vuoden 2008 huippua edeltävälle tasolle. Ihmisten lääkinnässä kriittisen tärkeiden mikrobilääkkeiden myynti lisääntyi hieman, mutta niiden osuus kokonaismyynnistä oli edelleen pieni (3. polven kefalosporiinien osuus vuosina 2010 - 2012 oli 0,03-0,09 %, makrolidien 3-3,6 % ja fluorokinolonien 0,6–0,7 %).

Zoonooseja aiheuttavien bakteerien resistenssi

FINRES-Vet-ohjelma kattaa kansallisen salmonellavalvontaohjelman puitteissa naudoista, sioista ja siipikarjasta eristetyt salmonellat sekä kotimaisista elintarvikkeista eristetyt ja elintarvikealan toimijoiden omavalvonnassa eristetyt salmonellat. Lisäksi ohjelmassa seurataan broilereista, naudoista ja sioista eristettyjen kampylobakteerien resistenssitilannetta.

Tuotantoeläimistä eristetään vuosittain korkeintaan muutamia kymmeniä salmonelloja, mikä kuvastaa tartuntojen kansainvälisesti vertaillen erittäin alhaista tasoa. Tuotantoeläimillä resistenssiä esiintyi jonkin verran, pääasiassa naudoista eristetyillä *S*. Typhimurium -kannoilla. Lisäksi vuonna 2012 Suomessa todettiin resistenssiseurantaohjelman puitteissa ensimmäistä kertaa kolmannen polven kefalosporiinille resistentti salmonellakanta: siasta eristetty *S*. Typhimurium, jonka todettiin tuottavan plasmidivälitteistä AmpC-beetalaktamaasia. *S*. Enteritidis -kantoja

eristettiin vuosina 2010-2012 kotimaisista tuotantoeläimistä hyvin vähän (yhteensä viisi kantaa) ja ne olivat herkkiä kaikille tutkituille mikrobilääkkeille.

Broilereista eristetyillä kampylobakteereilla resistenssiä esiintyi edeltävien vuosien tapaan hyvin vähän; korkeimmillaan sitä esiintyi joillekin mikrobilääkkeille 2-3 %:lla kannoista. Sen sijaan sioista ja naudoista eristetyillä kampylobakteereilla resistenssiä esiintyi enemmän ja erityisesti fluorokinoloniresistenssi lisääntyi edelliseen raportointikauteen (2007-2009) verrattuna.

Indikaattoribakteerien resistenssi

Escherichia coli -, Enterococcus faecalis - ja *Enterococcus faecium* -kantoja kerättiin vuonna 2010 sioista, vuonna 2011 broilereista ja vuonna 2012 naudoista teurastuksen yhteydessä otetuista näytteistä. Varsinkin naudoista eristetyillä *E. coli* -kannoilla resistenssi oli harvinaista. Broilereista eristetyillä kannoilla resistenssiä esiintyi myös suhteellisen vähän. Eniten resistenssiä esiintyi sikojen *E. coli* -kannoilla, ja korkeimmat todetut resistenttien kantojen osuudet olivat 19 % tetrasykliinille, 15 % streptomysiinille, 12 % sulfonamidille ja 11 % trimetopriimille. Enterokokeilla erytromysiiniresistenssi oli yleistä kaikilla eläinlajeilla. Lisäksi broilereilta eristetyillä kannoilla resistenssiä todettiin yleisesti myös narasiinille ja sioilta eristetyillä kannoilla tetrasykliinille. Resistenssiä muille mikrobilääkkeille todettiin enterokokeilla vähän.

Erityinen ESBL/AmpC- ja VRE-seulonta

Vuonna 2011 broilereiden ja vuonna 2012 nautojen suolinäytteistä seulottiin laajakirjoisia beetalaktamaaseja (ESBL/AmpC) tuottavia *E. coli* -bakteereita. Näitä bakteereita esiintyi molemmilla eläinlajeilla erittäin vähän (alle 1 %): broilereilta eristettiin kolme AmpC-kantaa ja naudoilta kaksi ESBL-kantaa.

Vuonna 2011 broilereiden umpisuolinäytteistä seulottiin myös vankomysiinille resistenttejä enterokokkeja (VRE). VRE:n esiintyvyys teurasbroilereilla oli 9 %: kannat kuuluivat *E. faecium* -lajiin ja niillä todettiin *vanA*-geeni.

Eläimille tautia aiheuttavien bakteerien resistenssi

Sikojen suolitulehduksista eristetyillä *E. coli* -bakteereilla resistenssiä esiintyi runsaasti. Eniten resistenssiä todettiin tetrasykliinille, streptomysiinille, sulfametoksatsolille, trimetopriimille, ampisilliinille, siprofloksasiinille ja nalidiksiinihapolle. Moniresistenssi oli tavallista. Resistenssitilanne on vaihdellut kymmenen vuoden aikana jonkin verran, mutta eri vuosina havaituista resistenssitasojen eroista ei voida vetää erityisiä johtopäätöksiä vähäisen kantamäärän vuoksi.

Nautojen utaretulehduksista vuonna 2012 eristetyillä stafylokokeilla resistenssiä todettiin suhteellisen vähän. Koagulaasi-negatiivisilla stafylokeilla (KNS) resistenssi oli yleisempää kuin *S. aureus* -kannoilla. Penisilliiniä käytetään yleisesti utaretulehduksen hoitoon naudoilla, mutta vain 23 % *S. aureus* -kannoista tuotti beetalaktamaasia. Sen sijaan koagulaasinegatiivisista stafylokeista beetalaktamaasia tuotti 37,5 % kannoista. Lisäksi KNS-kannoista viidellä (6 %) todettiin metisilliiniresistenssiä aiheuttava *mecA*-geeni. MRSA-kantoja ei todettu. Trimetopriimiresistenssi oli yleistä, mutta sulfonamidi-trimetopiimi-yhdistelmälle resistenssi oli harvinaista.

Streptococcus uberis - ja *Streptococcus dysgalactiae* -kannoilla todettiin eniten resistenssiä tetrasykliinille (32 % ja 28 %). Lisäksi *S. uberis* -kannoista 11 % oli resistenttejä erytromysiinille. Kaikki *S. dysgalactiae* -kannat olivat penisilliinille herkkiä. Sen sijaan neljällä *S. uberis* -kannalla todettiin matala-asteista resistenssiä penisilliinille. Ilmiö on tunnettu ja sen katsotaan johtuvan mutaatioista penisilliiniä sitovissa proteiineissa.

Nautojen utaretulehduksista eristetyillä *E. coli* -bakteereilla todettiin vain vähän resistenssiä. Tavallisinta resistenssi oli streptomysiinille (9 %), ampisilliinille (4 %), siprofloksasiinille (4 %), nalidiksiinihapolle (4 %), sulfametoksatsolille (4 %) ja trimetopriimille (4 %). Kaksi *E. coli* -kantaa oli moniresistenttejä.

Naudoilta eristettyjen mastiittipatogeenien resistenssitilannetta seurataan suhteellisen vähän. Tähän raporttiin kerätyn aineiston perusteella voidaan kuitenkin arvioida, että resistenssitilanne on pysynyt hyvänä. Erityisen hyvää on, että Suomessa MRSA-löydökset utaretulehduksista ovat olleet harvinaisia.

Harraste- ja lemmikkieläinten osalta resistenssiaineisto koottiin eläinlääketieteellisen tiedekunnan laboratoriossa Helsingin yliopistossa. Mukaan otettiin kesäkuun 2011 ja joulukuun 2012 välisenä ajanjaksona eristetyt S*. aureus -, S. pseudintermedius* - ja *E. coli* -kannat.

S. aureus -kannat olivat peräisin hevosista, koirista, kissoista ja yhdestä kanista. Resistenssi *S. aureus* -kannoilla oli vähäistä; ainoastaan penisilliiniresistenssi oli yleistä (53 %). Yhdellä koiralla todettiin MRSA.

Koirista ja kissoista eristetyillä *S. pseudintermedius* -kannoilla resistenssiä esiintyi erittäin paljon. Moniresistenssi oli tavallista. Moniresistenttien bakteerien yleistyminen johtuu metisilliinille resistenttien *S. pseudintermedius* (MRSP) -bakteerien yleistymisestä. Vuonna 2012 MRSP-bakteerien osuus kaikista *S. pseudintermedius* -löydöksistä oli 16 %.

Koirilta ja kissoilta eristetyillä *E. coli* -bakteereilla resistenssiä todettiin eniten beetalaktaameille (vuonna 2012 resistenssi ampisilliinille 60 % ja amoksisilliini-klavulaanihapolle 27 %). Resistenssi oli yleistä myös sulfonamidi-trimetopriimiyhdistelmälle (18 % vuonna 2012) ja enrofloksasiinille (11 % vuonna 2012). Lisäksi ESBL-kantojen osuus kaikista *E. coli* -bakteereista lisääntyi vuodesta 2011 (1,5 %) vuoteen 2012 (4,3 %).

Resistenssi oli erittäin yleistä myös hevosilta eristetyillä *E. coli* -bakteereilla: eniten resistenssiä todettiin ampisilliinille (68 % vuonna 2012), sulfonamidi-trimetopriimi-yhdistelmälle (58 % vuonna 2012), amoksisilliini-klavulaanihapolle (39 % vuonna 2012) ja gentamisiniille (31 % vuonna 2012). ESBL-kantojen osuus oli 6,7 %.

Metisilliinille resistentti *Staphylococcus aureus* (MRSA)

MRSA-tilannetta kartoitettiin vuosina 2011-2013 erityistason sikaloissa. Seulonnassa tutkittiin kaikki ryhmään kuuluvaa 68 pitopaikkaa, joissa yhdessäkään ei todettu MRSA-bakteeria.

Resumé

Denna rapport sammanfattar resultaten från uppföljningen som utförts av projektet FINRES-Vet åren 2010-2012. För att ge en bild av förändringarna på längre sikt, ingår uppgifter om konsumtionen av de flesta veterinärmedicinska läkemedel och fodertillsatser i rapportens tabeller och scheman från och med år 2003. Rapporten är huvudsakligen uppbyggd på samma sätt som de tidigare rapporterna (den senaste för åren 2007-2009), och inleds med en översikt över de ändringar som har skett avseende konsumtionen av veterinärmedicinska läkemedel, och behandlar därefter uppkomsten av antibiotikaresistens hos zoonotiska bakterier, indikatorbakterier och bakterier som orsakar djursjukdomar. Rapporten innehåller också resultaten från screeningen av bakterier som producerar betalaktamaser med utvidgat spektrum (ESBL/AmpC) som inleddes år 2011 samt resultaten från kartläggningen åren 2011-2013 av den meticillinresistenta bakterien *Staphylococcus aureus* (MRSA) hos svin på djurhållningsplatser som hör till specialnivån.

Konsumtion av antimikrobiella medel för djur i Finland

Försäljningen av antimikrobiella medel för djur sjönk något under uppföljningsperioden. De proportionella andelarna av olika läkemedelsgrupper förblev oförändrade. Det mest sålda antimikrobiella medlet, penicillin, utgjorde fortfarande nästan hälften av den totala försäljningen och över 80 % av injektionspreparaten. Konsumtionen av tetracykliner som administreras oralt var tillbaka på nivån före toppen år 2008. Försäljningen av antimikrobiella medel som är av kritisk betydelse för medicinsk behandling av människa ökade något, men deras andel av den totala försäljningen var fortfarande liten (åren 2010-2012 var andelen tredje generationens cefalosporiner 0,03-0,09 %, makrolider 3-3,6 % och fluorokinoloner 0,6–0,7 %).

Resistens hos bakterier som orsakar zoonoser

Programmet FINRES-Vet täcker inom ramen för det nationella programmet för salmonellakontroll salmonella som isolerats från nötkreatur, svin och fjäderfä, samt salmonella som isolerats från inhemska livsmedel och sådana som isolerats vid livsmedelsföretagarnas egenkontroll. I programmet uppföljs därtill resistensläget hos campylobacter som har isolerats från broilrar, nötkreatur och svin.

Från produktionsdjur isoleras årligen högst några tiotal salmonella vilket reflekterar en mycket låg nivå av infektioner vid en internationell jämförelse. Hos produktionsdjur förekom resistens till en viss mån, i synnerhet hos stammar av *S*. Typhimurium som isolerats från nötkreatur. Inom ramen för programmet för uppföljning av resistens

påvisades år 2012 i Finland för första gången en salmonellastam som är resistent mot tredje generationens cefalosporiner: *S*. Typhimurium som isolerats från svin påvisades producera plasmidmedierad AmpC-betalaktamas. Mycket få stammar av *S*. Enteritidis isolerades åren 2010-2012 från inhemska produktionsdjur (totalt fem stammar) och de var känsliga för alla undersökta antimikrobiella medel.

Hos campylobacter som isolerats från broilrar förekom i likhet med tidigare år endast litet resistens; som mest förekom resistens hos 2-3 % av stammarna mot några antimikrobiella medel. Däremot förekom det mera resistens hos stammar av campylobacter som isolerats från svin och nötkreatur och i synnerhet resistens mot fluorokinoloner hade ökat jämfört med senaste rapporteringsperiod (2007-2009).

Resistens hos indikatorbakterier

Stammar av *Escherichia coli, Enterococcus faecalis* och *Enterococcus faecium* insamlades år 2010 från svin, år 2011 från broilrar och år 2012 från nötkreatur av prover som tagits i samband med slakt. Resistens hos stammar av *E. coli* som isolerats från nötkreatur var särskilt sällsynt. Även hos stammar som isolerats från broilrar förekom relativt litet resistens. Mest resistens förekom hos stammar av *E. coli* hos svin, och de högsta påvisade andelarna resistenta stammar var 19 % mot tetracyklin, 15 % mot streptomycin, 12 % mot sulfonamid och 11 % mot trimetoprim. Då det gällde enterokocker var resistens mot erytromycin allmän bland alla djurslag. Dessutom påvisades allmänt även resistens mot narasin hos stammar som isolerats från broilrar och resistens mot tetracyklin hos stammar som isolerats från svin. Hos enterokocker påvisades endast litet resistens mot andra antimikrobiella medel.

Särskild ESBL/AmpC och VRE screening

År 2011 utfördes screenodling av tarmprover från broilrar och år 2012 från nötkreatur för *E. coli* -bakterier som producerar betalaktamaser med utvidgat spektrum (ESBL/AmpC). Förekomsten av dessa bakterier var mycket låg hos båda djurslagen (under 1 %); tre AmpC-stammar isolerades från broilrar och två ESBL-stammar från nötkreatur.

År 2011 utfördes också screeningodling för enterokocker som är resistenta mot vancomycin (VRE) från prover ur ändtarmen på broilrar. Förekomsten av VRE hos slaktkycklingar var 9 %: stammarna hörde till arten *E. faecium* och genen *vanA* påvisades hos dem.

Resistens hos bakterier som orsakar sjukdomar hos djur

Hos *E. coli* -bakterier som isolerats från tarminfektioner hos svin förekom rikligt med resistens. Resistens påvisades främst mot tetracyklin, streptomycin, sulfametoxazol, trimetoprim, ampicillin, ciprofloxacin och nalidixinsyra. Multiresistens var allmän. Resistensläget har varierat något under de senaste tio åren, men på grund av det låga antalet stammar kan man ännu inte dra några specifika slutsatser om skillnaderna mellan de observerade resistensnivåerna under olika år.

Relativt litet resistens påvisades hos stafylokocker som isolerats från juverinflammationer hos nötkreatur år 2012. Resistens hos koagulasnegativa stafylokocker (KNS) var allmännare än hos stammar av *S. aureus*. Penicillin används allmänt för behandling av juverinflammation hos nötkreatur, men endast 23 % av *S. aureus* -stammarna producerade betalaktamas. Däremot producerade 37,5 %

av de koagulasnegativa stafylokockstammarna betalaktamas. Dessutom påvisades mecAgenen som orsakar meticillinresistens hos fem (6 %) av KNS-stammarna. Inga MRSA-stammar påvisades. Resistens mot trimetoprim var allmän, men resistens mot kombinationen sulfonamid-trimetoprim var ovanlig.

Hos stammarna *Streptococcus uberis* och *Streptococcus dysgalactiae* påvisades mest resistens mot tetracyklin (32 % och 28 %). Dessutom var 11 % av *S. uberis* -stammarna resistenta mot erytromycin. Alla stammar av *S. dysgalactiae* var känsliga för penicillin. Däremot påvisades hos fyra *S. uberis* -stammar en låg grad av resistens mot penicillin. Fenomenet är känt och det anses bero på en mutation hos proteiner som binder penicillin.

Hos *E. coli* -bakterier som isolerats från juverinflammationer hos nötkreatur påvisades endast litet resistens. Resistens var vanligast mot streptomycin (9 %), ampicillin (4 %), ciprofloxacin (4 %), nalidixinsyra (4 %), sulfametoxazol (4 %) och trimetoprim (4 %). Två *E. coli* -stammar var multiresistenta.

Det görs relativt litet uppföljning av resistensläget hos mastitpatogener som isolerats från nötkreatur. Utgående från materialet i den här rapporten kan ändå uppskattas att resistensläget har förblivit på god nivå. Det är särskilt glädjande att fynd av MRSA i juverinflammationer har varit sällsynta i Finland.

När det gällde hobby- och sällskapsdjur insamlades materialet om resistens av den veterinärmedicinska fakultetens laboratorium vid Helsingfors universitet. Stammarna av S*. aureus, S. pseudintermedius* och *E. coli* som isolerats under perioden mellan juni 2011 och december 2012 togs med.

Stammarna av *S. aureus* härstammade från hästar, hundar, katter och en kanin. Det fanns litet resistens hos *S. aureus*; endast penicillinresistens var allmän (53 %). MRSA påvisades hos en hund.

Särskilt mycket resistens förekom hos stammar av *S. pseudintermedius* som isolerats från hundar och katter. Multiresistens var allmän. Multiresistenta bakterier har blivit allmännare eftersom de meticillinresistenta *S. pseudintermedius* (MRSP) -bakterierna har blivit allmännare. År 2012 var andelen MRSP-bakterier 16 % av alla fynd av *S. pseudintermedius.*

Hos *E. coli* -bakterier som isolerats från hundar och katter påvisades resistens främst mot betalaktamer (år 2012 resistens mot ampicillin 60 % och amoxicillin-klavulansyra 27 %). Resistens var även allmän mot kombinationen sulfonamid-trimetoprim (18 % år 2012) och enrofloxacin (11 % år 2012). Dessutom ökade ESBL-stammarnas andel av alla *E. coli* -bakterier från år 2011 (1,5 %) till år 2012 (4,3 %).

Resistens var också mycket allmän hos *E. coli* -bakterier som isolerats från hästar: mest resistens påvisades mot ampicillin (68 % år 2012), kombinationen sulfonamid-trimetoprim (58 % år 2012), amoxicillin-klavulansyra (39 % år 2012) och gentamicin (31 % år 2012). Andelen ESBL-stammar var 6,7 %.

Meticillinresistenta *Staphylococcus aureus* (MRSA)

MRSA-läget kartlades åren 2011-2013 i svinstall som hör till specialnivån. Vid screeningen undersöktes alla 68 djurhållningsplatser som hörde till gruppen, och MRSA-bakterier påvisades inte på en enda av dem.

Contents

Introduction

The FINRES-Vet programme monitors antimicrobial resistance in bacterial zoonotic agents and indicator bacteria, as required by the Zoonosis Directive (2003/99/EC). Furthermore, antimicrobial resistance is monitored in certain animal pathogens.

Zoonotic bacteria may spread into humans by direct contact with domestic or wild animals or from foods of animal origin. The resistance of indicator bacteria in a given population reflects the selection pressure caused by the use of antimicrobials. The indicator bacteria, constituting a major component of intestinal bacterial flora, also create a pool of resistance genes, which may be transferred to pathogenic bacteria.

Monitoring the antimicrobial resistance of animal pathogens is important since it may reveal emerging resistances, which may pose a risk for human and animal health. However, it must be emphasised that the data on resistance in pathogenic bacteria isolated from clinical cases may be biased, because the isolates frequently are obtained from uncommonly severe or recurrent infections.

FINRES-Vet programme has the following objectives:

- to monitor the consumption of antimicrobial agents used to treat animals.
- to monitor resistance to antimicrobial agents in major food-producing animals and pets, and
- to analyse trends in resistance prevalence, and to monitor the emergence of resistant clones and the appearance of new resistance phenotypes

The previous FINRES-Vet reports (2002-2003, 2004, 2005-2006, 2007-2009) presented an overall favourable resistance situation among bacteria isolated from animals and food in Finland. This is probably the outcome of the strict policy; antimicrobial drugs for treating animals are prescribed by veterinarians only. However, the resistance data from some animal pathogens are of growing concern indicating that there is a need to further emphasize the prudent use of antimicrobials. Recommendations for antimicrobial usage in major infectious diseases of animals have been established to promote the prudent use. These recommendations (in Finnish) can be downloaded from the internet site of Evira [http://www.evira.fi/portal/fi/elaimet/elainten_terveys_ja_elaintaudit/laakitseminen/mikrobilaakehoidon_periaatteet/elainlajikohtaiset_kayttosuositukset/], and they are regularly updated.

This is the fifth FINRES-Vet report including data from the years 2010-2012. Indicator bacteria has been collected from broilers in 2002, 2005, 2008, 2011 (and 2014), from cattle in 2003, 2006, 2009 and 2012, and from pigs in 2004, 2007, 2009 (and 2013).

Zoonotic bacteria obtained for analysis are *Salmonella* and *Campylobacter*. Animal pathogens included in the report are *Escherichia coli* from pigs (from diarrhea cases), dogs and cats, S*taphylococcus pseudintermedius* from dogs and cats, *Staphylococcus aureus* from horses, dogs, cats and rodents, and mastitis pathogens from cattle. The monitored indicator bacteria are *E. coli, Enterococcus faecalis* and *Enterococcus faecium.*

The FINRES-Vet programme is coordinated by the Finnish Food Safety Authority Evira. The consumption of antimicrobial agents for veterinary use is monitored by Fimea, and the use of feed additives and medicated feeds by Evira. The Veterinary Teaching Hospital in Helsinki takes care of small animals and horses and is part of the Faculty of Veterinary Medicine, University of Helsinki.

1 Use of therapeutic antimicrobials and feed additives for animals in Finland

1.1 Changes in animal population

During 2010-2012 changes in animal population have been relatively small. The number of cattle has slightly decreased. However, the number of suckler cows shows a little increase. The total number of pigs has been quite constant during the last 10 years though the number of pig farms is halved during the same period. The number of poultry shows an increase especially due to rise in the number of broilers. Details on the number of holdings as well as on live and slaughtered animals are presented in Appendix 1.

1.2 Therapeutic antimicrobials

The sales of veterinary antimicrobials have been monitored in Finland since 1995. The statistics are based on sales data that is obtained at package level from the pharmaceutical wholesalers. In addition, small amounts of antimicrobials are imported as medicated feed. The data on volume is collected from feed importers. The sales statistics are expressed as weight (kg active ingredient) sold. It is assumed that the antimicrobials obtained during the observation period are also used during that period. For details on data sources and inclusion criteria see Appendix 2.

Majority of the veterinary medicinal products are used to treat several of species. As the statistics are based on number of packages sold it is not possible to obtain species specific data. However, the information available can be broken down by the route of administration. Another issue to consider is that the amount of medicine required to achieve the desired therapeutic effect varies between different classes of antimicrobials, i.e. the efficacy of medicines expressed per unit of active ingredient varies. It is thus important that levels of sales, expressed in kg, are foremost compared to sales of the same class over a longer time.

1.2.1 Overall sales of veterinary antimicrobial agents

During the reporting period the overall sales decreased by 3.5% compared to 2009 and were 16 000 kg in 2012 (Table 1, Figure 1). Penicillin G continued to be the most sold antimicrobial accounting for 46% of the overall sales in 2012. Combinations of trimethoprim and sulfonamides were the second most used antimicrobials (20%) and tetracyclines the third (11%). Altogether, these three antimicrobial classes accounted for 78% of the overall sales of veterinary antimicrobials in 2012 i.e. at the same level as during previous decade.

Table 1. Total sales of veterinary antimicrobials in Finland 2003-2012, kg active substance

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2010 EU[1]	2011 EU[1]	2012 EU[1]
Tetracyclines, doxycyclin[2]	**1 757**	**1 263**	**1 445**	**1 320**	**1 705**	**3 140**	**2 284**	**1 728**	**1 838**	**1 759**			
Amphenicols[3]							**59**	**59**	**124**	**61**			
Betalactams (penicillins)							**9 121**	**9 733**	**9 447**	**9 063**	**7 648**	**7 381**	**7 229**
Penicillin G	*6 076*	*6 754*	*6 803*	*6 905*	*7 512*	*7 740*	*7 753*	*8 301*	*8 052*	*7 624*	*6 217*	*5 985*	*5 790*
Aminopenicillins	*698*	*798*	*958*	*846*	*1 057*	*1 178*	*1 256*	*1 317*	*1 284*	*1 342*			
Cloxacillin	*145*	*140*	*132*	*109*	*96*	*97*	*113*	*114*	*112*	*97*			
Cephalosporins	**1 133**	**1 048**	**1 000**	**1 004**	**1 030**	**1 027**	**987**	**911**	**1 064**	**917**			
1st gen. cephalosporins							*985*	*906*	*1 056*	*902*			
3rd gen. cephalosporins							*2*	*5*	*9*	*15*			
Sulphonamides and trimetoprim	**2 187**	**2 368**	**2 438**	**2 946**	**2 655**	**2 933**	**3 165**	**3 274**	**3 045**	**3 149**			
Sulphonamides							*2 637*	*2 728*	*2 537*	*2 624*			
Trimetoprim							*527*	*546*	*508*	*525*			
Macrolides, lincosamides	**538**	**526**	**393**	**619**	**752**	**847**	**594**	**774**	**661**	**755**			
Macrolides							*429*	*572*	*497*	*575*			
Lincosamides							*165*	*202*	*164*	*179*			
Aminoglycosides	**291**	**280**	**238**	**225**	**180**	**170**	**179**	**166**	**128**	**108**			
Quinolones							**97**	**96**	**102**	**107**			
Fluoroquinolones	*81*	*79*	*90*	*81*	*88*	*90*	*97*	*96*	*102*	*107*			
Other Quinolones (Oxolinic acid)							*0*	*0*	*0*	*0*			
Polymyxins[3]							**0**	**0**	**0**	**0**			
Pleuromutilins[3]							**80**	**48**	**73**	**66**			
Others[3]	**186**	**107**	**112**	**74**	**80**	**120**	**-**	**-**	**-**	**-**			
Total	**13 092**	**13 362**	**13 609**	**14 129**	**15 155**	**17 342**	**16 566**	**16 790**	**16 482**	**15 984**	**14 706**	**14 415**	**14 150**

[1]EU harmonised expression of sales. Reported only for the antimicrobial classes affected. [2]2003-2004 consumption of tetracyclines in uteritorias included, 2006-2008 tetracycline consumption in local preparations included. [3]Before 2009 amphenicols, polymyxins and pleuromutilins were included in 'Others'

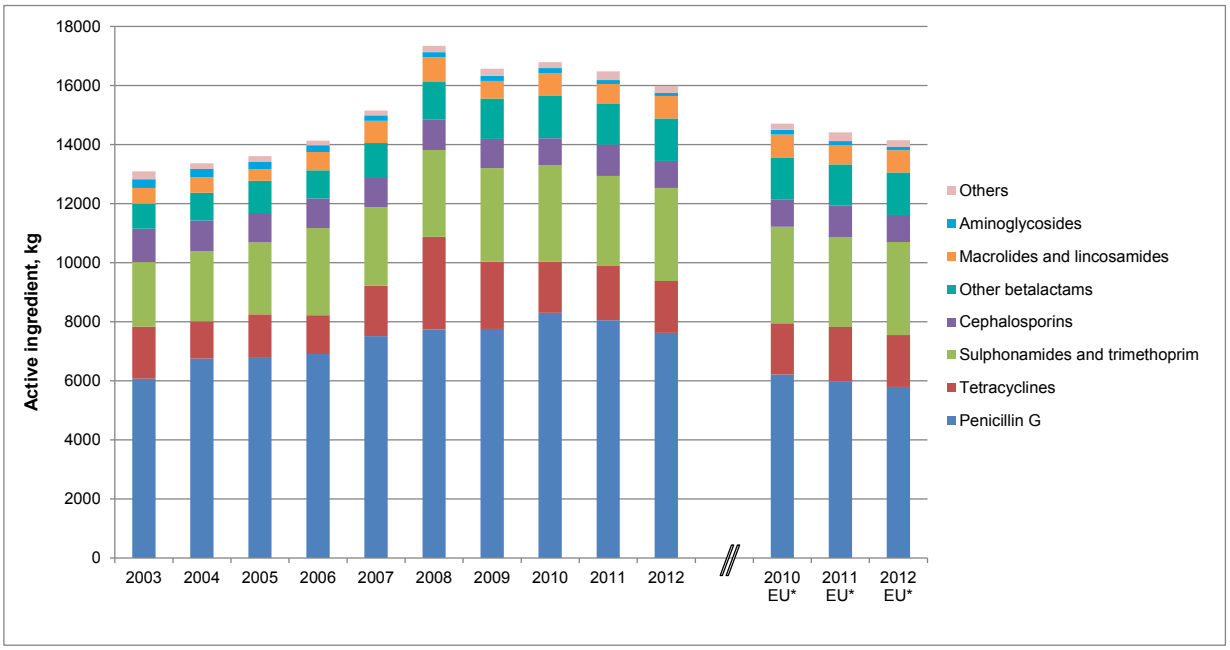

Figure 1. *Total sales of veterinary antimicrobials, kg active ingredient (Others = pleuromutilins, polymyxins, fluoroquinolones and amphenicols, EU* = EU harmonised expression of sales)*

1.2.1.1 Sales in relation to the production animal population

The sales expressed in units of weight do not reflect the possible changes in animal populations. In order to normalize the sales data for the production animal population that could be subjected to treatment with antimicrobial agents, a population correction unit (PCU) has been developed as a proxy for the size of the population within the ESVAC (European Surveillance of Veterinary Antimicrobial Consumption) project. According to the 4th ESVAC report (EMA 2014), PCU corrected sales in Finland remained relatively stable during 2010-2012 (25-24-24 mg/PCU). Because PCU includes only data on production animals the sales of antimicrobial tablets intended for small animals were excluded from the ESVAC calculations. Sales of antimicrobial tablets in 2010-2012 were approximately 2 tns/year (equivalent to 13.3-14.4% of the total kg-sales) (EMA 2014).

1.2.2 Injectable antimicrobial products

The sales of injectable antimicrobials peaked in 2010 and have thereafter decreased (Table 2). Approximately 2% less injectables were sold in 2012 compared to 2009. The changes were mainly due to altered sales of penicillin G, however its relative proportion continued to be over 80% of the sales of injectables throughout the reporting period. Tetracyclines were the second most used injectables, their proportion being approximately 6% of all injectables and aminopenicillins the third (5%).

Table 2. Sales of injectable veterinary antimicrobials in Finland 2003-2012, kg active substance

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2010 EU[1]	2011 EU[1]	2012 EU[1]
Tetracyclines, doxycyclin	**265**	**291**	**312**	**288**	**418**	**442**	**470**	**527**	**515**	**521**			
Amphenicols	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**12**	**13**			
Betalactams (penicillins)							**7 964**	**8 524**	**8 215**	**7 567**	**6 518**	**6 229**	**5 992**
Penicillin G	*5 840*	*6 529*	*6 597*	*6 739*	*7 339*	*7 552*	*7 551*	*8 084*	*7 811*	*7 324*	*6 078*	*5 825*	*5 558*
Aminopenicillins	*133*	*145*	*236*	*170*	*358*	*410*	*413*	*440*	*404*	*434*			
Cephalosporins2				**1**	**4**	**4**	**4**	**5**	**9**	**15**			
1st gen. cephalosporins							*1*	*0*	*0*	*0*			
3rd gen. cephalosporins							*2*	*5*	*9*	*15*			
Sulphonamides and trimetoprim	**425**	**442**	**463**	**457**	**420**	**415**	**370**	**329**	**297**	**360**			
Sulphonamides							*308*	*274*	*248*	*300*			
Trimetoprim							*62*	*55*	*50*	*60*			
Macrolides, lincosamides	**49**	**44**	**76**	**81**	**92**	**60**	**53**	**52**	**42**	**37**			
Macrolides							*15*	*13*	*13*	*11*			
Lincosamides							*38*	*40*	*30*	*27*			
Aminoglycosides	**1**	**1**	**11**	**12**	**10**	**12**	**18**	**19**	**18**	**20**			
Quinolones							**81**	**78**	**85**	**84**			
Fluoroquinolones	*69*	*66*	*77*	*67*	*74*	*75*	*81*	*78*	*85*	*84*			
Other Quinolones (Oxolinic acid)							*0*	*0*	*0*	*0*			
Others	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**			
Total	**6 783**	**7 518**	**7 771**	**7 815**	**8 714**	**8 970**	**8 960**	**9 534**	**9 192**	**8 808**	**7 528**	**7 205**	**7 042**

[1]EU harmonised expression of sales. Reported only for the antimicrobial classes affected. [2]Before 2006 consumption of cephalosporins was included in "Others"

1.2.3 Orally administered antimicrobial products

The sales of oral products decreased during the reporting period by 5% (Table 3.). The reduction was mainly due to diminished sales of tetracyclines. Combinations of trimethoprim and sulfonamides were the most sold oral antimicrobials (41% in 2012) followed by tetracyclines (18%), 1st generation cephalosporins (13%) and aminopenicillins (13%) (Figure 2).

Table 3. Sales of veterinary antimicrobials for oral administration in Finland 2003-2012, kg active substance

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2010 EU[1]	2011 EU[1]	2012 EU[1]
Tetracyclines, doxycyclin	**1 380**	**967**	**1 135**	**928**	**1 188**	**2 565**	**1 815**	**1 202**	**1 323**	**1 237**			
Amphenicols	**16**	**14**	**0**	**0**	**0**	**66**	**59**	**59**	**112**	**48**			
Betalactams (penicillins)							**811**	**856**	**876**	**1 002**			
Penicillin G							*0*	*0*	*17*	*110*		*17*	*110*
Aminopenicillins	*536*	*620*	*690*	*650*	*654*	*737*	*811*	*856*	*860*	*893*			
Cephalosporins							**942**	**872**	**1 025**	**871**			
1st gen. cephalosporins	*998*	*938*	*915*	*940*	*966*	*976*	*942*	*872*	*1 025*	*871*			
3rd gen. cephalosporins							*0*	*0*	*0*	*0*			
Sulphonamides and trimetoprim	**1 762**	**1 926**	**1 975**	**2 489**	**2 235**	**2 518**	**2 794**	**2 945**	**2 747**	**2 789**			
Sulphonamides							*2 329*	*2 454*	*2 289*	*2 324*			
Trimetoprim							*466*	*491*	*458*	*465*			
Macrolides, lincosamides	**497**	**481**	**316**	**538**	**659**	**786**	**541**	**721**	**618**	**717**			
Macrolides							*414*	*559*	*484*	*565*			
Lincosamides							*126*	*161*	*134*	*152*			
Aminoglycosides	**125**	**123**	**111**	**110**	**103**	**95**	**101**	**95**	**79**	**76**			
Quinolones							**16**	**19**	**17**	**23**			
Fluoroquinolones	*12*	*12*	*13*	*14*	*14*	*15*	*16*	*19*	*17*	*23*			
Other Quinolones (Oxolinic acid)	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*			
Pleuromutilines	**84**	**90**	**110**	**68**	**20**	**17**	**80**	**48**	**73**	**66**			
Others	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**			
Total	**5 410**	**5 172**	**5 264**	**5 735**	**5 838**	**7 774**	**7 158**	**6 816**	**6 871**	**6 829**	**6 816**	**6 871**	**6 829**

[1]EU harmonised expression of sales. Reported only for the antimicrobial classes affected.

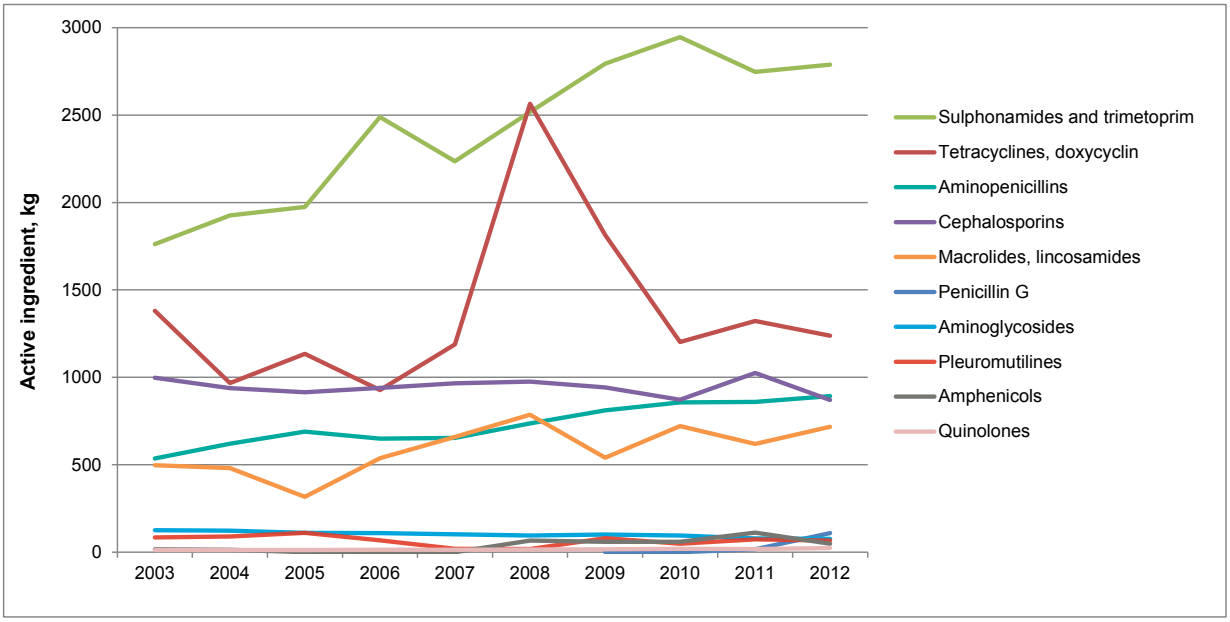

Figure 2. *Sales of products intended for oral administration, kg active ingredient*

1.2.3.1 For group treatment

The sales of tetracyclines intended for group treatment peaked in 2008 and the proportion of products suitable for group treatment thus increased to 33% of the overall sales. By 2010 the sales of tetracyclines had returned back to pre-peak level and thereafter remained roughly at the same level. In 2012 the proportion of products for group treatment was 20% of the overall sales (Figure 3).

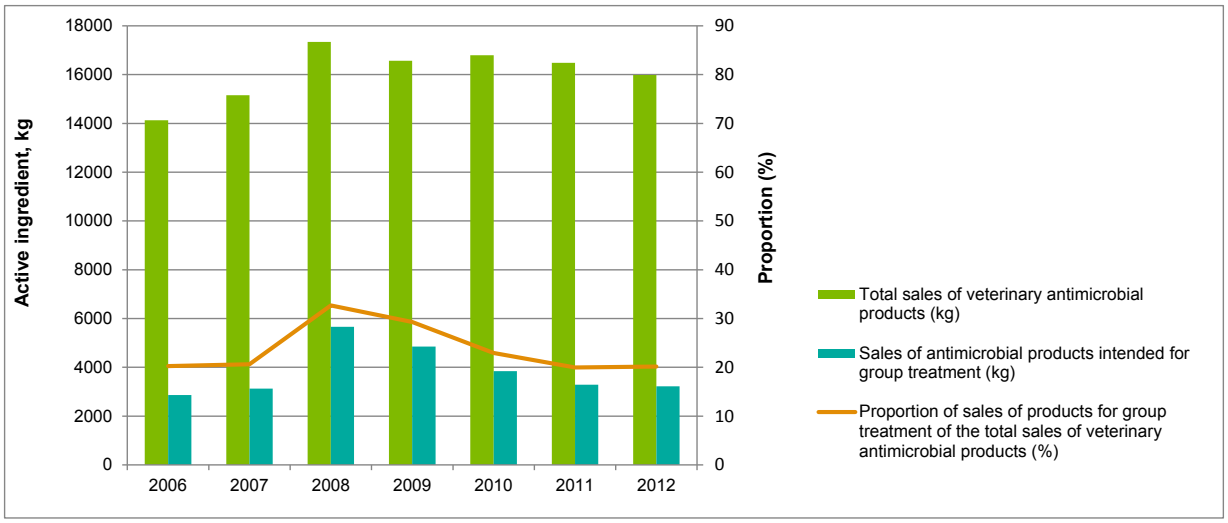

Figure 3. *Total sales and sales of products intended for group treatment*

1.2.4 Intramammary products

The sales of all intramammary products decreased by 23% compared to year 2009 (Tables 4 and 5). The antimicrobial classes most used for lactating cows were penicillin G, cloxacillin and cephalexin. For dry cow products cloxacillin was most used antimicrobial and penicillin G the second.

The sales in relation to cow population have been reviewed for over a decade. The number of intramammary tubes for lactation period sold per cow has remained relatively steady at approximately 2 tubes / cow from 2007 to 2011. However, in 2012 the sales (per cow) seemed to decrease. For intramammaries used for dry cow therapy the sales have been <1 tube / cow throughout the years (Figure 4).

Table 4. Sales of intramammary tubes for use during lactation in Finland 2003-2012, kg active substance

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2010 EU[1]	2011 EU[1]	2012 EU[1]
Penicillin	**202**	**182**	**167**	**132**	**143**	**149**	**157**	**171**	**175**	**155**	**104**	**107**	**94**
Other beta lactams	**208**	**190**	**162**	**123**	**123**	**106**	**124**	**111**	**106**	**95**			
Amino penicillins	*24*	*26*	*26*	*19*	*31*	*26*	*23*	*18*	*16*	*13*			
Cephalexin	*110*	*89*	*68*	*52*	*51*	*40*	*34*	*29*	*30*	*31*			
Cloxacillin	*74*	*75*	*67*	*52*	*41*	*40*	*67*	*65*	*60*	*51*			
Aminoglycosides	**125**	**115**	**81**	**72**	**51**	**40**	**34**	**29**	**12**	**1**			
Macrolides	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0**			
Total	**536**	**488**	**411**	**329**	**318**	**296**	**316**	**312**	**294**	**251**	**245**	**226**	**190**

[1]EU harmonised expression of sales. Reported only for the antimicrobial classes affected.

Table 5. Sales of intramammary tubes for dry cow therapy in Finland 2003-2012, kg active substance

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2010 EU[1]	2011 EU[1]	2012 EU[1]
Penicillin	**34**	**43**	**40**	**33**	**30**	**38**	**44**	**46**	**49**	**35**	**35**	**37**	**28**
Other beta lactams	**100**	**92**	**89**	**76**	**79**	**70**	**62**	**59**	**56**	**48**			
Amino penicillins	*5*	*6*	*7*	*7*	*14*	*6*	*9*	*4*	*4*	*3*			
Cephalexin	*24*	*20*	*16*	*12*	*10*	*7*	*7*	*6*	*1*	*0*			
Cloxacillin	*71*	*65*	*65*	*58*	*55*	*57*	*46*	*49*	*52*	*46*			
Aminoglycosides	**40**	**41**	**34**	**29**	**27**	**22**	**25**	**24**	**20**	**12**			
Others	**3**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**			
Total	**177**	**179**	**163**	**138**	**135**	**130**	**132**	**129**	**125**	**96**	**118**	**113**	**89**

[1]EU harmonised expression of sales. Reported only for the antimicrobial classes affected.

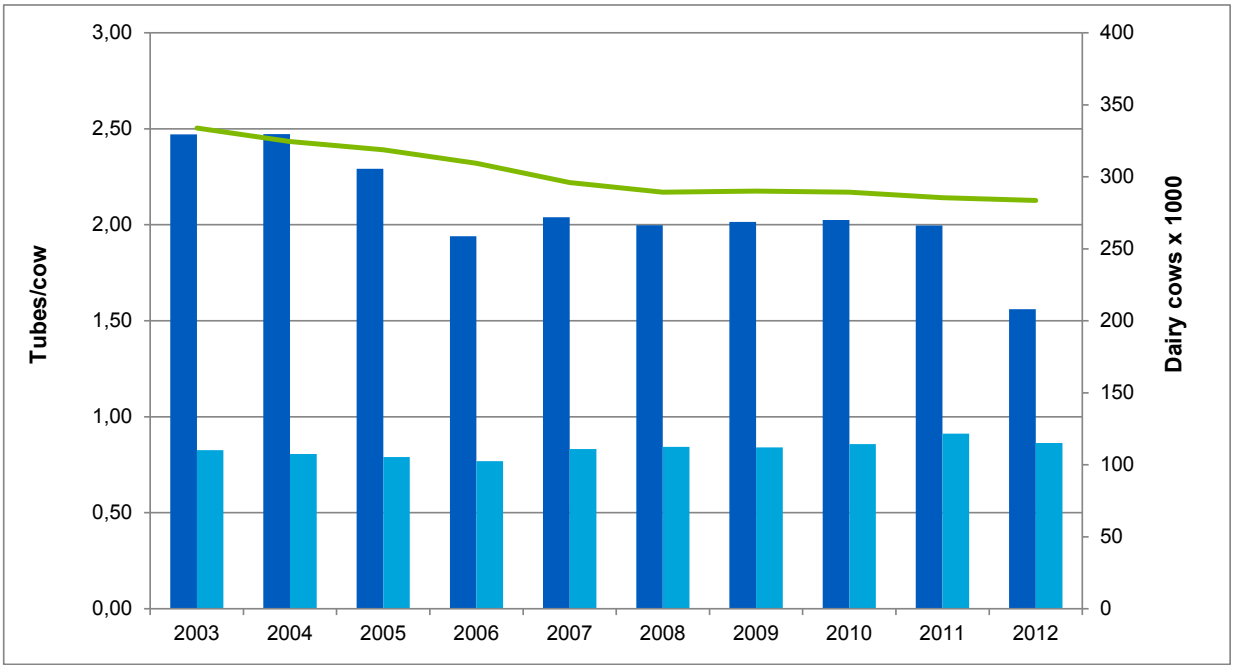

Figure 4. *Antimicrobials for intramammary use during lactation period dark (blue column) and for dry cow period (light blue column) and the number of dairy cows (green curve)*

1.2.5 Critically important antimicrobials, CIA

According to WHO classification, antimicrobials that have the highest priority in treatment of certain severe infections in humans are 3rd and 4th generation cephalosporins, fluoroquinolones, macrolides and glycopeptides (WHO 2011). Of these 3rd generation cephalosporins, fluoroquinolones and macrolides are available as veterinary antimicrobials in Finland.

The proportion of 3rd generation cephalosporins of the overall sales in 2010-2012 was 0.03-0.09%, the proportion of macrolides 3-3.6% and the proportion of fluoroquinolones 0.6–0.7%, respectively. The sales of all three classes increased during the observation period (Tables 1, 2 and 3).

Third generation cephalosporins are only available as injectable products. Though their sales increased significantly during the observation period, one must consider that these products were not introduced to the market until 2010[1].

[1]Before 2010, 3rd generation cephalosporins were available only with special license.

Majority of the macrolides are sold as oral products (98%) and their sales increased by 36% compared to 2009 (Table 3). On the contrary, the sales of injectable macrolides decreased (by 28%) (Table 2).

The sales of fluoroquinolones have gradually grown since 2004 (Table 1). During the reporting period 2010-2012 the sales of injectable fluoroquinolones increased by 10% (Table 2), for oral fluoroquinolones the increase was 42%. Oral fluoroquinolones are only available as tablets/products for small animals and their sales have almost doubled since 2004 (Table 3).

1.3 Antimicrobial feed additives

Evira monitors the annual consumption of feed additives by collecting data from feed manufacturers. The Finnish industry producing feed for food-producing animals terminated the use of antimicrobial growth promoters by their own initiative during the 1990s. The use of virginiamycin was stopped already in 1990, the use of bacitracin in 1992 and the use of flavomycin and avoparcin in 1996. No growth promoters are used at present in Finland. The European Union banned the use of avoparcin in 1997 and the use of bacitracin, spiramycin, tylosin and virginiamycin for growth promotion in 1999.

Table 6 presents the total sales of feed additives in Finland in 2001-2012. The coccidiostats monensin and narasin are used as prophylactic anti-parasitic agents mainly in broiler and turkey production; the uses of these compounds have varied between 2010 and 2012 and a slight increase was observed in the total use of monensin compared to the previous three-year period. The use of salinomycin decreased after 2009 and was not used any more in 2012. All in all, the overall use of feed additives have been stable in 2010-2012.

Table 6. The use of antimicrobial feed additives, coccidiostats and growth promoters in Finland in 2001-2012 (kg active substance/year).

Substance	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Amprolium (and ethopabate)	79	22	0	0	0	0	0	0	0	0	0	0
Avoparcin	0	0	0	0	0	0	0	0	0	0	0	0
Dimetridazole	0	0	0	0	0	0	0	0	0	0	0	0
Flavomycin	32	3	0	0	0	0	0	0	0	0	0	0
Lasalocid sodium	3 624	3 349	176	0	0	0	0	0	0	1	0	0
Carbadox	0	0	0	0	0	0	0	0	0	0	0	0
Olaquindox	0	0	0	0	0	0	0	0	0	0	0	0
Madmuramycin ammonium	0	8	43	1,5	1,5	0	0	5	0	0	0	0
Monensin natrium	1 475	1 969	4 422	5 808	8 458	[4] 9 585	[7] 5 560	5 376	5 546	6 801	5 837	7 300
Narasin	2 101	5 569	5 769	5 518	[2] 3 218	[5] 2 481	[8] 8 007	[9] 7 236	6 056	5 859	7 658	6 567
Salinomycin	3 272	28	3	[1] 10	[3] 374	[6] 1 328	[1] 35	[1] 107	[10] 1 713	[11] 1 170	[12] 495	0
Nifursol	0	0	0	0	0	0	0	0	0	0	0	0
Robenidine hydrochloride	0	0	0	0	0	0	0	0	0	0	0	0
Sum	10 583	10 948	10 413	11 338	12 249	13597	13 601	12 729	13 315	13 832	13 991	13 867

[1] 10 kg, [2] 13.2 kg, [3] 190 kg, [4] 42.6 kg, [5] 1.65 kg, [6] 317 kg, [7] 5 kg, [8] 22 kg, [9] 7 kg, [10] 117 kg, [11] 121 kg and [12] 58 kg used in exported feed mixtures

2 Antimicrobial resistance in zoonootic bacteria

2.1 *Salmonella* in production animals and domestic food

The prevalence of *Salmonella* spp. in cattle, pigs and poultry as well as in meat and eggs is monitored through the national Salmonella control programme (23/EEO/1995; 20/EEO/2001, 1172/2009, 1173/2009). The objective of the programme is to maintain the annual incidence of *Salmonella* contamination among production animals and in the respective meat and eggs at 1% or below. The results of the programme show that *Salmonella* in production animals and foods of animal origin is rare in Finland. The antibiotic resistance of all *Salmonella* isolates from cattle, pigs, poultry and domestic food are determined in the FINRES-Vet programme. All isolates from clinical cases and domestic food industry's in-house control systems are also tested for resistance. Details of sampling and isolation procedures as well as of the susceptibility testing are described in Appendix 3. Correspondences between the verbal descriptions of the resistance levels and the actual percentage categories are also given in Appendix 3.

2.1.1 Antimicrobial resistance in Salmonella in 2010-2012

A total of 23, 32 and 30 *Salmonella* isolates were detected among domestic production animals in 2010, 2011 and 2012, respectively. The different serovars from production animals are shown in Appendix 4. Like in previous years, *Salmonella* was mostly encountered in cattle. Among all animal species, *S.* Typhimurium was the most common finding comprising of 12, 19 and 25 isolates in total in 2010, 2011 and 2012, respectively.

The isolates originating from poultry were susceptible to every tested antimicrobial. Resistance was almost exclusively found in *S.* Typhimurium isolated from cattle; isolates were mostly resistant to only ampicillin and sulfamethoxazole (n=8) except three isolates that had a multiresistant phenotype (resistance to ampicillin, sulfamethoxazole, streptomycin and trimethoprim, or ampicillin, sulfamethoxazole, streptomycin, trimethoprim and tetracycline). In addition, one porcine *S.* Typhimurium isolate was resistant to ampicillin and cefotaxime in 2012. This isolate showed an AmpC phenotype and was confirmed to carry bla_{CMY-2}. This was the first finding of resistance against 3rd generation cephalosporins among *Salmonella* from Finnish production animals.

Between 2010 and 2012, seven strains from domestic food were obtained. These belonged to serovars *S.* Abony (n=1) and *S.* Typhimurium (n=6). Two of the *S.* Typhimurium strains from year 2011 were resistant to ampicillin and sulfamethoxazole. Other isolates were susceptible to all antimicrobials tested.

Table 7. Distribution of MICs for *Salmonella* in production animals in 2010-2012 (n= 23 in 2010, 32 in 2011, and 31 in 2012).

				Distribution (%) of MICs (mg l^{-1})																		
Antibiotic	**Year**	**%R**	**95% C.I.**	**≤ 0.008**	**0.016**	**0.03**	**0.06**	**0.125**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**	**512**	**1 024**	**> 1 024**
Ampicillin	2010	13.0	3.4-34.6							26.1	52.2	8.7						13.0				
	2011	12.5	4.1-29.9							15.6	71.9							12.5				
	2012	19.4	8.2-38.1							19.3	61.3							19.4				
Cefotaxime	2010	0.0	0.0-17.8				52.2	43.5	4.3													
	2011	0.0	0.0-13.3				65.6	34.4														
	2012	3.2	0.2-18.5				54.8	38.8	3.2						3.2							
Chloram-phenicol	2010	0.0	0.0-17.8									21.7	73.9	4.3								
	2011	0.0	0.0-13.3									15.6	84.4									
	2012	0.0	0.0-13.7									25.8	74.2									
Ciprofloxacin	2010	0.0	0.0-17.8			56.5	43.5															
	2011	0.0	0.0-13.3			40.6	59.4															
	2012	0.0	0.0-13.7			16.1	83.9															
Florfenicol	2010	0.0	0.0-17.8									21.7	69.6	4.3	4.3							
	2011	0.0	0.0-13.3									15.6	84.4									
	2012	0.0	0.0-13.7									6.5	90.3	3.2								
Gentamicin	2010	0.0	0.0-17.8							34.8	60.9	4.3										
	2011	0.0	0.0-13.3							25.0	75.0											
	2012	0.0	0.0-13.7							9.7	87.1	3.2										
Kanamycin	2010	0.0	0.0-17.8									56.5	39.1	4.3								
	2011	0.0	0.0-13.3								3.1	43.8	53.1									
	2012	0.0	0.0-13.7									41.9	58.1									
Nalidixic acid	2010	0.0	0.0-17.8									4.3	91.3	4.3								
	2011	0.0	0.0-13.3										100.0									
	2012	0.0	0.0-13.7										96.8	3.2								
Streptomycin	2010	0.0	0.0-17.8										4.3	21.7	60.9	13.0						
	2011	3.1	0.2-18.0										12.5	12.5	71.9					3.1		
	2012	9.7	2.5-26.9										6.5	16.1	45.2	22.6				9.7		
Sulfa-methoxazole	2010	13.0	3.4-34.6											21.7	34.8	17.4	4.3	4.3	4.3			13.0
	2011	12.5	4.1-29.9											9.4	18.8	50.0	9.4			3.1		9.4
	2012	16.1	6.1-34.4											16.1	19.4	35.5	12.9					16.1
Tetracycline	2010	0.0	0.0-17.8								65.2	30.4	4.3									
	2011	3.1	0.2-18.0								50.0	46.9						3.1				
	2012	6.5	1.1-22.9								58.1	35.5					3.2	3.2				
Trimethoprim	2010	0.0	0.0-17.8						69.6	26.1	4.3											
	2011	3.1	0.2-18.0						46.9	50.0							3.1					
	2012	9.7	2.5-26.9						38.7	51.6							9.7					

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

In addition to a very low prevalence of *Salmonella* in domestic production animals throughout the years 2002-2012, antimicrobial resistance among these isolates is not common. Furthermore, resistance have been mainly detected in *S.* Typhimurium isolates from cattle and also multiresistance among these isolates has been seen every year since 2007. These findings are thought to at least partly be explained by clonal spreading of resistant isolates among Finnish cattle.

2.2 *Campylobacter* spp. in pigs, broilers and cattle

The isolates of *Campylobacter jejuni* from broilers in 2010-2012 were obtained through the Finnish campylobacter monitoring programme. The samples were collected at slaughter and caeca from 10 birds per slaughter batch were pooled for examination. The number of isolates tested for antimicrobial resistance was 84, 40 and 83 in 2010, 2011 and 2012, respectively.

In 2010, *Campylobacter coli* were isolated in connection with the FINRES-Vet programme. Isolates were obtained from porcine faecal samples collected at slaughter. Thermophilic campylobacters were isolated from 31% of the samples, and 97% (n=87) of these were *C. coli.*

In 2012, *C. jejuni* was also isolated from cattle in accordance with the FINRES-Vet programme. The isolates were obtained from faecal samples collected at slaughterhouses. Thermophilic campylobacters were isolated from 21% of the samples, and almost 99% (n=72) of these were *C. jejuni*.

2.2.1 Developments in the situation in 2010-2012

Broilers (2010-2012)
Antimicrobial resistance to quinolones, tetracycline and gentamicin ranged from 0% to 2.5% among poultry *C. jejuni* isolates. The majority of the resistance occasions represented single findings. Resistance to erythromycin was not detected. An actual need for antimicrobials in broiler production is rare and treatments are used very seldom.

Table 8. Distribution of MICs for *Campylobacter jejuni* from broilers in 2010 (n=84), in 2011 (n=40) and in 2012 (n=83).

				Distribution (%) of MICs (mg l^{-1})											
Antibiotic	**Year**	**%R**	**95% C.I.**	**≤0.064**	**0.125**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**>64**
Ciprofloxacin	2010	2.4	0.4-9.2	13.1	67.9	16.7					2.4				
	2011	0.0	0.0-10.9	15.0	82.5	2.5									
	2012	2.4	0.4-9.2	4.8	53.1	33.7	6.0				2.4				
Erythromycin	2010	0.0	0.0-5.4				97.6	2.4							
	2011	0.0	0.0-10.9				100.0								
	2012	0.0	0.0-5.5				94.0	6.0							
Gentamicin	2010	0.0	0.0-5.4			8.3	53.6	36.9	1.2						
	2011	0.0	0.0-10.9			45.0	55.0								
	2012	0.0	0.0-5.5		2.4	30.1	48.2	19.3							
Nalidixic acid	2010	2.4	0.4-9.2						3.6	71.4	20.2	2.4			2.4
	2011	0.0	0.0-10.9						2.5	77.5	20.0				
	2012	2.4	0.4-9.2						8.4	62.7	22.9	3.6			2.4
Tetracycline	2010	0.0	0.0-5.4		89.3	9.5	1.2								
	2011	2.5	0.1-14.7		97.5				2.5						
	2012	2.4	0.4-9.2		92.8	3.6		1.2		1.2	1.2				

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

Pigs (2010)

Antimicrobial resistance to quinolones had changed from low to high after 2007 (FINRES-Vet 2007-2009). In 2010, 23 isolates (26%) were resistant to nalidixic acid and ciprofloxacin, when only 8% of the isolates were quinolone resistant in 2007. As in 2007, resistance to erythromycin or tetracycline was not found in 2010.

Table 9. Distribution of MICs for *Campylobacter coli* from pigs in 2010 (n=87).

			Distribution (%) of MICs (mg l^{-1})											
Antibiotic	**%R**	**95% C.I.**	**≤0.064**	**0.125**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**>64**
Ciprofloxacin	26.4	17.8-37.1	19.5	33.3	20.7					13.8	12.6			
Erythromycin	0.0	0.0-5.3				42.5	27.6	26.4	3.4					
Gentamicin	1.1	0.1-7.1			1.1	3.4	77.0	17.2	1.1					
Nalidixic acid	26.4	17.8-37.1						1.1	9.2	48.3	14.9		2.3	24.1
Tetracycline	0.0	0.0-5.3		21.8	40.2	37.9								

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

Cattle (2012)

All isolates were susceptible to erythromycin and gentamicin. Two isolates were resistant to tetracycline unlike in 2009 when resistance to tetracycline was not detected. Antimicrobial resistance to quinolones could be considered moderate (14%, n=10) among bovine *C. jejuni*. It had clearly increased since 2009 when only one isolate was resistant to quinolones.

Table 10. Distribution of MICs for *Campylobacter jejuni* from cattle in 2012 (n=72).

			Distribution (%) of MICs (mg l^{-1})											
Antibiotic	**%R**	**95% C.I.**	**≤0.064**	**0.125**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**>64**
Ciprofloxacin	13.9	7.2-24.5	6.9	58.3	18.1	2.8			1.4	6.9	5.6			
Erythromycin	0.0	0.0-6.3				95.8	4.2							
Gentamicin	0.0	0.0-6.3			20.8	72.2	6.9							
Nalidixic acid	13.9	7.2-24.5						4.2	33.3	37.5	11.1		1.4	12.5
Tetracycline	2.8	0.5-10.6		88.9	8.3					1.4		1.4		

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

Resistance data of *Campylobacter* have been collected systematically since 2003 from the isolates gathered yearly from the *Campylobacter* monitoring programme or from the FINRES-Vet monitoring programme. Among *C. jejuni* isolates from broilers, resistance levels have been quite stable during the whole decade (Figure 5). Resistance against the tested antimicrobials have varied from rare to low, except in 2004 when tetracycline resistance exceeded 10%. Similar levels of resistances have been observed in *C. coli* from pigs and *C. jejuni* from cattle with the exception of moderate resistance against quinolones in 2010 and 2012, respectively (Tables 9 and 10). Nevertheless, the resistance in *Campylobacter* isolates from all the main production animal species in Finland is fairly infrequent although a slight increase in quinolone resistance among *C. coli* from pigs and *C. jejuni* from cattle is of concern.

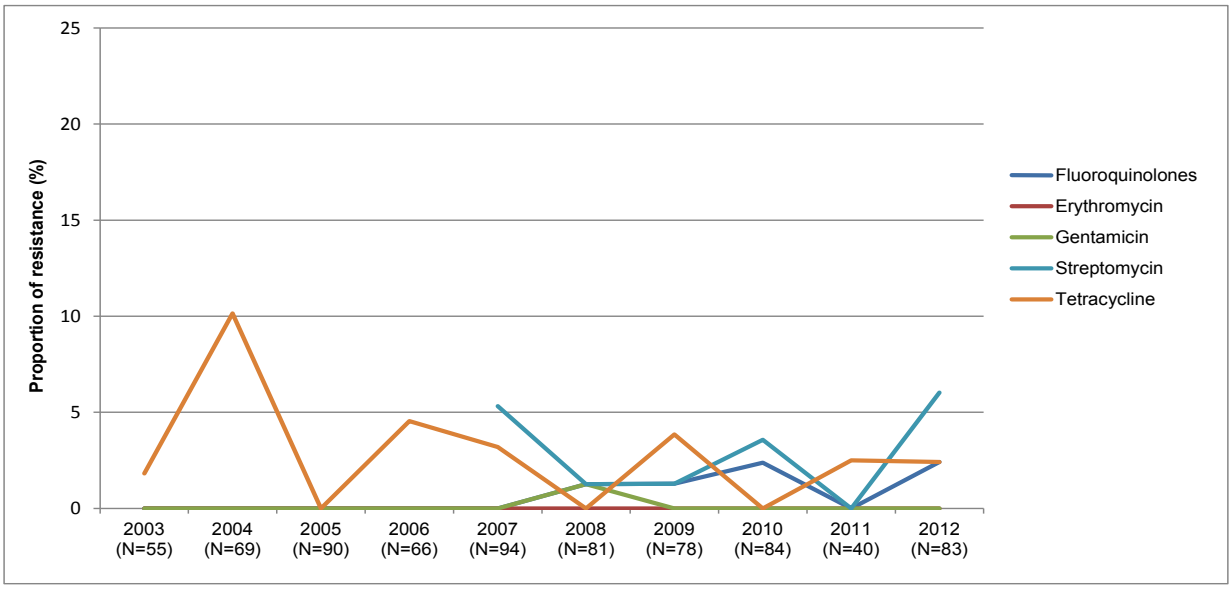

Figure 5. *Antimicrobial resistance (%) in Campylobacter jejuni isolates from broilers in Finland in 2003-2012.*

3 Antibiotic resistance in indicator bacteria

Resistance among indicator bacteria of a given population reflects the selection pressure caused by the use of antimicrobials in the population. The indicator bacteria monitored in the FINRES-Vet programme are *Escherichia coli, Enterococcus faecalis* and *Enterococcus faecium.* Isolation of bacteria from the intestines of randomly selected animals at slaughter aims to detect the development of resistance in the bacterial population level in food animals (MARAN, 2008).

Indicator bacteria were isolated from pigs, broilers and cattle in 2010, 2011 and 2012, respectively. Each sample represents a different pig or cattle herd, or a broiler production batch. Details of sampling, isolation procedures and susceptibility testing are described in Appendix 3.

3.1 *Enterococcus* spp. in pigs, broilers and cattle

The material included 46 *E. faecalis* and 36 *E. faecium* isolates from pigs (2010), 169 and 191 isolates from broilers (2011), and 93 and 155 isolates from cattle (2012), respectively.

Pigs (2010)
The resistance levels in *E. faecalis* and *E. faecium* were mostly rare or low to the majority of the antimicrobials tested (Tables 11 and 12). The most common resistance traits detected were against tetracycline and erythromycin: tetracycline resistance in 74% of the *E. faecalis* and 33% of the *E. faecium* isolates, followed by erythromycin resistance in 37% of the *E. faecalis* and 22% of the *E. faecium* isolates. Ten *E. faecalis* isolates (22%) and six *E. faecium* isolates (17%) were resistant to two antimicrobials, three *E. faecalis* isolates and one *E. faecium* isolate were resistant to three and two *E. faecalis* isolates to four or more antimicrobials.

Table 11. Distribution of MICs for indicator *Enterococcus faecalis* from pigs in 2010 (n=46).

			Distribution (%) of MICs (mg l^{-1})															
Antibiotic	**%R**	**95% C.I.**	**≤ 0.125**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**	**512**	**1 024**	**2 048**	**>2 048**
Ampicillin	0.0	0.0-9.6			2.2	91.3	6.5											
Bacitracin[1]	0.0	0.0-9.6					2.2		56.5	34.8	6.5							
Chloram-phenicol	4.3	0.7-16.0						10.9	71.7	13.0		2.2	2.2					
Erythromycin	37.0	23.6-52.5			8.7	21.7	28.3	4.3			2.2	2.2	32.6					
Gentamicin	8.7	2.8-21.7					2.2		6.5	58.7	23.9	2.2			6.5			
Kanamycin	8.7	2.8-21.7								2.2		34.8	47.8	4.3		2.2		8.7
Linezolid	0.0	0.0-9.6				4.3	73.9	21.7										
Narasin	0.0	0.0-9.6		23.9	45.7	30.4												
Streptomycin	4.3	0.7-16.0							2.2			8.7	60.9	23.9			4.3	
Tetracycline	73.9	58.6-85.2			6.5	17.4	2.2			2.2	13.0	58.7						
Vancomycin	0.0	0.0-9.6				6.5	84.8	8.7										
Virginiamycin	0.0	0.0-9.6			2.2		2.2	2.2	2.2	65.2	26.1							

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

[1] MIC in U ml^{-1}

Table 12. Distribution of MICs for indicator *Enterococcus faecium* from pigs in 2010 (n=36).

			Distribution (%) of MICs (mg l^{-1})															
Antibiotic	**%R**	**95% C.I.**	**≤ 0.125**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**	**512**	**1 024**	**2 048**	**>2 048**
Ampicillin	5.6	1.0-20.1		8.3	5.6	41.7	19.4	19.4	5.6									
Bacitracin[1]	5.6	1.0-20.1					2.8	8.3	22.2	38.9	22.2			5.6				
Chloram-phenicol	0.0	0.0-12.0						5.6	94.4									
Erythromycin	22.2	10.7-39.6			8.3	2.8	16.7	50.0	11.1	5.6	2.8		2.8					
Gentamicin	0.0	0.0-12.0							50.0	44.4	5.6							
Kanamycin	0.0	0.0-12.0										11.1	58.3	22.2	8.3			
Linezolid	0.0	0.0-12.0					11.1	88.9										
Narasin	0.0	0.0-12.0		2.8	13.9	66.7	11.1	5.6										
Streptomycin	5.6	1.0-20.1										58.3	36.1	2.8		2.8		
Tetracycline	33.3	19.1-51.0			22.2	41.7	2.8					33.3						
Vancomycin	0.0	0.0-12.0				75.0	16.7	8.3										
Virginiamycin	5.6	1.0-20.1			8.3	25.0	11.1	50		2.8	2.8							

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

[1] MIC in U ml^{-1}

Broilers (2011)

Among *E. faecalis* isolates from broilers, the resistance was high or very high only against erythromycin (58%) and moderate (i.e. exceeded 10%) or low against narasin, bacitracin and tetracycline (Table 13). Among *E. faecium*, the resistance was high against both narasin and erythromycin, moderate against bacitracin and low against tetracycline and streptomycin (Table 14). Also, two vancomycin resistant *E. faecium* isolates were detected, both of them carrying *vanA* gene.

Of all 169 *E. faecalis* isolates examined, only one was resistant to two antimicrobials and no multiresistance was observed. Among *E. faecium*, eight (4%) isolates were resistant to two antimicrobials and three (1.5%) isolates to three antimicrobials.

Table 13. Distribution of MICs for indicator *Enterococcus faecalis* from broilers in 2011 (n=169).

			Distribution (%) of MICs (mg l^{-1})															
Antibiotic	**%R**	**95% C.I.**	**≤ 0.125**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**	**512**	**1 024**	**2 048**	**>2 048**
Ampicillin	0.0	0.0-2.8			7.7	89.3	3.0											
Bacitracin[1]	13.0	8.5-19.2					1.2	3.6	63.9	15.4	3.0	1.2	5.3	6.5				
Chloram-phenicol	0.0	0.0-2.8						8.3	88.8	3.0								
Erythromycin	58.0	50.2-65.5			12.4	16.6	8.3	4.7	7.7	26.6	17.2	3.6	3.0					
Gentamicin	0.0	0.0-2.8						1.2	34.9	60.9	3.0							
Kanamycin	0.0	0.0-2.8							0.6	8.3	77.5	13.0			0.6			
Linezolid	0.0	0.0-2.8				10.7	85.2	4.1										
Narasin	14.8	10.0-21.3	3.0	19.5	11.8	21.3	29.6	7.1	7.7									
Streptomycin	0.0	0.0-2.8									1.2	27.2	67.5	4.1				
Tetracycline	7.1	3.9-12.4			38.5	53.8	0.6				1.8	5.3						
Vancomycin	0.0	0.0-2.8				13.6	45.6	40.8										
Virginiamycin	0.0	0.0-2.8						1.2	14.2	63.3	21.3							

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

[1] MIC in U ml^{-1}

Table 14. Distribution of MICs for indicator *Enterococcus faecium* from broilers in 2011 (n=191).

			Distribution (%) of MICs (mg l^{-1})															
Antibiotic	**%R**	**95% C.I.**	**≤ 0.125**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**	**512**	**1 024**	**2 048**	**>2 048**
Ampicillin	0.5	0.0-3.3		15.2	30.4	33.5	14.1	6.3	0.5									
Bacitracin[1]	17.8	12.8-24.1				33.5	3.7	7.3	13.6	18.8	5.2	2.1	5.8	9.9				
Chloram-phenicol	0.5	0.0-3.3					0.5	14.7	79.1	5.2		0.5						
Erythromycin	21.5	16.0-28.1			31.4	12.0	27.7	7.3	3.7	6.8	7.9	1.0	2.1					
Gentamicin	0.0	0.0-2.5					0.5	3.7	57.6	33.5	4.7							
Kanamycin	0.5	0.0-3.3									0.5	7.9	53.4	33.5	4.2		0.5	
Linezolid	0.0	0.0-2.5				2.6	27.7	69.6										
Narasin	44.0	36.9-51.4		1.0	0.5	1.6	3.7	49.2	43.5	0.5								
Streptomycin	2.6	1.0-6.3								0.5	9.4	55.5	31.9	2.1			0.4	
Tetracycline	6.3	3.4-11.0			81.2	12.6			2.1			4.2						
Vancomycin	1.0	0.2-4.1				89.0	6.3	3.7			0.5	0.5						
Virginiamycin	5.2	2.7-9.6			11.5	28.3	38.7	16.2	3.7	1.6								

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

[1] MIC in U ml^{-1}

Absence of most major viral infections, coupled with the favourable production conditions has kept the incidence of secondary bacterial infections well at bay. In practice, no therapeutic antimicrobials are used for broilers. Widespread use of narasin is the probable cause for the common resistance, especially in *E. faecium.* Narasin is indicated for use as a coccidiostat but it is active also against Gram-positive bacteria. Resistance to bacitracin in enterococci is still relatively common although it was withdrawn in 1992.

Cattle (2012)

Resistance to erythromycin was high (39%) in *E. faecium* and resistance to tetracycline moderate (12%) in *E. faecalis*; otherwise low or no resistance was detected (Tables 15 and 16). Only three *E. faecalis* and three *E. faecium* isolates were resistant to two antimicrobials. No multiresistant isolates were found.

The resistance situation in enterococci from cattle appears to be very favourable, with the noted exception of erythromycin and *E. faecium*. It is not clear whether this resistance represents continued selection due to use of this antibiotic or some form of indigenous resistance.

Table 15. Distribution of MICs for indicator *Enterococcus faecalis* from cattle in 2012 (n=93).

			Distribution (%) of MICs (mg l^{-1})															
Antibiotic	**%R**	**95%C.I.**	**≤ 0.125**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**	**512**	**1 024**	**2 048**	**>2 048**
Ampicillin	0.0	0.0-4.9			18.3	81.7												
Bacitracin[1]	3.2	0.8-9.8						9.7	48.4	37.6	1.1			3.2				
Chloram-phenicol	0.0	0.0-4.9						19.4	78.5	2.2								
Erythromycin	2.2	0.4-8.4			18.3	28.0	30.1	21.5	2.2									
Gentamicin	0.0	0.0-4.9							17.2	76.3	6.5							
Kanamycin	0.0	0.0-4.9									7.4	73.1	17.2	1.1	1.1			
Linezolid	0.0	0.0-4.9				5.4	87.1	7.5										
Narasin	0.0	0.0-4.9	8.6	65.6	25.8													
Streptomycin	3.2	0.8-9.8									2.2	10.8	74.2	9.7			3.2	
Tetracycline	11.8	6.3-20.5			62.4	25.8					5.4	6.5						
Vancomycin	0.0	0.0-4.9				23.7	74.2	2.2										
Virginiamycin	0.0	0.0-4.9			2.2	1.1	2.2	3.2	34.4	53.8	3.2							

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

[1] MIC in U ml^{-1}

Table 16. Distribution of MICs for indicator *Enterococcus faecium* from cattle in 2012 (n=155).

			Distribution (%) of MICs (mg l^{-1})															
Antibiotic	**%R**	**95% C.I.**	**≤ 0.125**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**	**512**	**1 024**	**2 048**	**>2048**
Ampicillin	0.0	0.0-3.0		5.2	14.8	63.9	16.1											
Bacitracin[1]	2.6	0.8-6.9				1.3		1.9	21.3	39.4	33.5	1.9		0.6				
Chloram-phenicol	0.0	0.0-3.0					0.6	40.6	54.2	4.5								
Erythromycin	39.4	31.7-47.6			14.8	3.2	8.4	34.2	24.5	14.2	0.6							
Gentamicin	0.6	0.0-4.0					0.6	9.7	63.2	24.5	1.3	0.6						
Kanamycin	0.0	0.0-3.0									1.9	27.1	41.9	20.6	8.4			
Linezolid	0.0	0.0-3.0				1.3	52.3	46.5										
Narasin	0.0	0.0-3.0		14.8	62.6	21.9	0.6											
Streptomycin	0.6	0.0-4.0							0.6		26.5	49.7	22.6	0.6				
Tetracycline	5.8	2.9-11.1			90.3	3.2		0.6			2.6	3.2						
Vancomycin	0.0	0.0-3.0				80.6	16.8	2.6										
Virginiamycin	0.6	0.0-4.0			32.3	20.6	41.3	5.2	0.6									

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

[1] MIC in U ml^{-1}

3.2 *Escherichia coli in pigs*, broilers and cattle

The number of *E. coli* isolates was 250 from pigs (2010), 316 from broilers (2011) and 295 from cattle (2012).

Pigs (2010)

Resistance among *E. coli* varied from low to rare against many of the antimicrobials (Table 17). However, moderate resistance levels were found against four antimicrobials: tetracycline (19%), streptomycin (15%), sulfamethoxazole (12%) and trimethoprim (11%). Tetracycline resistance was the highest observed resistance trait in *E. coli* just as it was in enterococci. This can probably be largely explained by the common use of tetracycline in pig production.

Resistance to two antimicrobials was found in 17 *E. coli* isolates. Multiresistance was also observed: the number of isolates resistant to three, four or more than four antimicrobials was seven, nine and ten, respectively. Resistance to 3rd generation cephalosporins was not found.

Table 17. Distribution of MICs for indicator *Escherichia coli* from pigs in 2010 (n=250).

			Distribution (%) of MICs (mg l^{-1})																		
Antibiotic	**%R**	**95% C.I.**	**≤ 0.008**	**0.016**	**0.032**	**0.064**	**0.125**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**	**512**	**1 024**	**>1 024**
Ampicillin	7.2	4.4-11.3								14.4	64.0	13.6	0.8				0.4	6.8			
Cefotaxime	0.0	0.0-1.9		0.4	10.0	72.4	16.8	0.4													
Chloram-phenicol	0.8	0.1-3.2									2.4	47.6	47.6	1.6		0.4	0.4				
Ciprofloxacin	1.6	0.5-4.3		8.0	77.6	12.8	0.8	0.4	0.4												
Colistin	0.0	0.0-1.9							88.4	11.2	0.4										
Florfenicol	0.4	0-2.6										28.8	66.4	4.4	0.4						
Gentamicin	0.8	0.1-3.2						0.4	34.8	52.0	12.0	0.8									
Kanamycin	3.6	1.8-7.0											96.4	2.4	1.2						
Nalidixic acid	1.6	0.5-4.3								4.0	22.0	68.0	4.4			0.8	0.4	0.4			
Streptomycin	14.8	10.8-20.0									0.4	18.8	55.6	10.4	2.8	2.8	2.8	4.4	2.0		
Sulfa-methoxazole	12.4	8.7-17.3											84.0	2.8	0.8						12.4
Tetracycline	18.8	14.3-24.3								40.8	38.4	2.0		0.4	5.2	7.2	4.8	1.2			
Trimethoprim	10.8	7.4-15.5					2.8	10.8	44.8	28.8	2.4	0.4			10.4						

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

Broilers (2011)

In broilers, resistance among *E. coli* was low or rare against most of the examined antimicrobials (Table 18). The resistance was moderate only against streptomycin, kanamycin and sulfamethoxazole. Sixteen *E. coli* isolates were resistant to two antimicrobials. Resistance to three and four antimicrobials was found in two and twenty isolates respectively. Only one isolate was resistant to more than four antimicrobials. Resistance to 3rd generation cephalosporins was not found among indicator *E. coli* isolated without selective plates.

Table 18. Distribution of MICs for indicator *Escherichia coli* from broilers in 2011 (n=316).

			Distribution (%) of MICs (mg l^{-1})																		
Antibiotic	**%R**	**95% C.I.**	**≤ 0.008**	**0.016**	**0.032**	**0.064**	**0.125**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**	**512**	**1 024**	**>1 024**
Ampicillin	3.8	2.1-6.7								13.6	70.6	12.0						3.8			
Cefotaxime	0.0	0.0-1.5			2.5	63.3	29.5	4.7													
Chloram-phenicol	0.0	0.0-1.5									0.6	50.0	49.1	0.3							
Ciprofloxacin	0.6	0.1-2.5			47.2	52.2		0.3	0.3												
Colistin	0.0	0.0-1.5							76.6	20.6	2.8										
Florfenicol	0.0	0.0-1.5										25.0	72.2	2.8							
Gentamicin	0.3	0.0-2.0							18.7	70.6	10.4	0.3									
Kanamycin	11.7	8.5-15.9											88.3	3.8	7.9						
Nalidixic acid	0.6	0.1-2.5								1.9	35.8	58.9	2.8		0.3			0.3			
Streptomycin	12.7	9.3-17.0										4.4	71.2	11.7	1.6	2.8	2.2	1.9	4.1		
Sulfa-methoxazole	10.8	7.7-14.9											87.6	1.3	0.3						10.8
Tetracycline	7.9	5.3-11.6								37.4	52.5	1.9	0.3		0.3	1.9	3.8	1.9			
Trimethoprim	9.5	6.6-13.4					1.3	12.3	53.5	22.8	0.6				9.5						

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

Cattle (2012)

As in previous years, resistance in *E. coli* from cattle varied from low to rare against all of the tested antimicrobials (Table 19). The figures in many cases indicate single resistant isolations. No resistance at all was found against 3rd generation cephalosporins. Resistance to two antimicrobials was found in four isolates. Resistance to three antimicrobials was observed in seven and to four antimicrobials in two isolates.

Table 19. Distribution of MICs for indicator *Escherichia coli* from cattle in 2012 (n=295).

			Distribution (%) of MICs (mg l^{-1})																		
Antibiotic	**%R**	**95% C.I.**	**≤ 0.008**	**0.016**	**0.032**	**0.064**	**0.125**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**	**512**	**1 024**	**>1 024**
Ampicillin	1.7	0.6-4.1								14.2	66.4	17.6						1.7			
Cefotaxime	0.0	0.0-1.6			5.4	64.1	29.5	1.0													
Chloram-phenicol	0.0	0.0-1.6									1.7	41.4	56.3	0.7							
Ciprofloxacin	0.3	0.0-2.1		1.0	41.4	57.3	0.3														
Colistin	0.0	0.0-1.6							73.6	24.7	1.7										
Florfenicol	0.0	0.0-1.6										30.2	65.1	4.7							
Gentamicin	0.3	0.0-2.1							12.5	76.3	10.8	0.3									
Kanamycin	2.7	1.3-5.5											97.3	2.7							
Nalidixic acid	0.0	0.0-1.6								1.4	37.6	60.0	1.0								
Streptomycin	5.4	3.2-8.8										5.8	68.8	20.0		0.3	1.7	1.7	1.7		
Sulfa-methoxazole	3.4	1.7-6.4											95.9	0.3	0.3						3.4
Tetracycline	2.4	1.1-5.1								49.2	46.1	2.4				1.7	0.7				
Trimethoprim	1.4	0.5-3.7					0.7	13.2	46.4	35.6	2.7				1.4						

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

3.3 Specific ESBL/AmpC screening in broilers and cattle

In 2011, caecal samples from broilers and in 2012, faecal samples from cattle taken in concordance with the FINRES-Vet monitoring programme, were also screened for the presence of ESBL and/or AmpC producing *E. coli*. Details of the isolation procedure and confirmatory tests are described in Appendix 3.

Samples were taken at slaughterhouses and each sample represented one slaughter batch (broilers) or herd (cattle). From broilers, 3/352 of the samples were positive for AmpC producing *E. coli*. All three isolates carried bla_{CMY-2}. From cattle, 2/324 of the samples were confirmed as ESBL producers: one of the two *E. coli* isolates carried a gene belonging to CTX-M-1 group and the other isolate carried a gene that belonged to a CTX-M-9 group.

3.4 Specific VRE screening in broilers

In 2011, caecal samples from broilers included in the FINRES-Vet monitoring programme were also screened for the presence of vancomycin resistant enterococci (VRE). Details of the isolation procedure and confirmatory tests are described in Appendix 3.

Samples were taken at slaughterhouses and each sample represented one slaughter batch. VRE were detected in 33/352 (9%) of the samples. All VRE isolates were *E. faecium* and carried *vanA*.

4 Antibiotic resistance in animal pathogens from production animals

Escherichia coli from pig enteritis cases were obtained from clinical or post-mortem samples submitted to Evira. Isolation and preliminary identification of mastitis pathogens from milk samples taken from clinical cases was performed at private and municipal mastitis laboratories and in Evira. Details of sampling, isolation procedures and susceptibility testing are described in Appendix 3.

4.1 Resistance of *Escherichia coli* strains from porcine enteritis

The material consisted of 31, 35 and 23 strains of *E. coli* isolated from pig enteritis cases in 2010, 2011 and 2012, respectively. The pathogenicity of the isolates was confirmed by demonstrating the presence of genes coding for typical fimbrial antigens and toxins. One isolate per herd was included. The representativeness of results must be interpreted guardedly because of the small numbers of isolates and because at least part of the samples originated from herds with diarrhoeal problems and frequent use of antimicrobials. The yearly MIC distributions are presented in Table 20.

Multiresistance in this group was rather common. In 2010 32%, in 2011 23% and in 2012 about 50% of the isolates were resistant to three or more antimicrobials.

As in previous years, resistance levels were high or very high to tetracycline (42%, 43% and 57%), to streptomycin (36%, 29% and 56%), to sulfamethoxazole (26%, 26%, and 44%), and to trimethoprim (29%, 17% and 39%), all percentages respective to 2010, 2011 and 2012. Resistance to nalidixic acid and ciprofloxacin was 30% in 2010 and 26% in 2012. However, in 2011 resistance to quinolones was not found. No resistance was detected either to gentamicin or to the 3rd generation cephalosporins in 2010-2012.

Table 20. Distribution of MICs for *Escherichia coli* from porcine enteritis in 2010 (n=31), 2011 (n=35) and 2012 (n=23).

				Distribution (%) of MICs (mg l^{-1})																		
Antibiotic	**Year**	**%R**	**95% C.I.**	**≤ 0.008**	**0.016**	**0.032**	**0.064**	**0.125**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**	**512**	**1 024**	**>1 024**
Ampicillin	2010	19.4	8.2-38.1								41.9	35.5	3.2		6.5				12.9			
	2011	11.4	3.7-27.6								65.7	22.9							11.4			
	2012	21.7	8.3-44.2								26.1	39.1	8.7	4.3				4.3	17.4			
Cefotaxime	2010	0.0	0.0-13.7		3.2	3.2	83.9	3.2	6.5													
	2011	0.0	0.0-12.3			8.6	71.4	20.0														
	2012	0.0	0.0-17.8				73.9	21.7	4.3													
Chloram-phenicol	2010	6.5	1.1-22.9									9.7	80.6	3.2		3.2	3.2					
	2011	2.9	0.2-16.7									37.1	51.4	2.9	5.7	2.9						
	2012	8.6	1.5-29.5									34.8	56.5			4.3	4.3					
Ciprofloxacin	2010	29.0	14.9-48.2		9.7	48.4	12.9		16.1	9.7		3.2										
	2011	0.0	0.0-12.3			77.1	22.9															
	2012	26.1	11.1-48.7			34.8	39.1		8.7	8.7		8.7										
Florfenicol	2010	3.2	0.2-18.5										80.6	12.9	3.2	3.2						
	2011	0.0	0.0-12.3										82.9	14.3	2.9							
	2012	0.0	0.0-17.8										82.6	17.4								
Gentamicin	2010	0.0	0.0-13.7						3.2	54.8	35.5	6.5										
	2011	0.0	0.0-12.3							51.4	48.6											
	2012	0.0	0.0-17.8							30.4	56.5	13.0										
Kanamycin	2010	6.5	1.1-22.9											93.5		6.5						
	2011	0.0	0.0-12.3											100.0								
	2012	4.3	0.2-23.9											95.7		4.3						
Nalidixic acid	2010	32.3	17.4-51.5								3.2	32.3	29.0	3.2			6.5	9.7	16.1			
	2011	0.0	0.0-12.3								5.7	54.3	31.4	8.6								
	2012	26.0	11.1-48.7								8.7	47.8	8.7	8.7			4.3	8.7	13.0			
Streptomycin	2010	35.5	19.8-54.6									6.5	32.3	19.4	6.5	3.2	6.5	9.7	6.5	9.7		
	2011	28.6	15.3-46.6										20.0	42.9	8.6	11.4	2.9	11.4		2.9		
	2012	56.4	34.9-76.1										17.4	26.1		4.3	8.7	21.7		21.7		
Sulfa-methoxazole	2010	25.8	12.5-44.9											67.7	6.5							25.8
	2011	25.7	13.1-43.6											65.7	8.6					2.9		22.9
	2012	43.5	23.9-65.1											52.5	4.3							43.5
Tetracycline	2010	41.9	25.0-60.7								45.2	12.9				3.2	6.5	29.0	3.2			
	2011	42.9	26.8-60.5								57.1					8.6	17.1	17.1				
	2012	56.5	34.9-76.1								30.4	13.0				8.7	26.1	21.7				
Trimethoprim	2010	29.0	14.9-48.2					35.5	22.6	6.5	6.5					29.0						
	2011	17.1	7.1-34.3					25.7	31.4	17.1	8.6					17.1						
	2012	39.1	20.4-61.2					17.4	26.1	13.0		4.3		8.7		30.4						

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

4.2 *Escherichia coli* in bovine mastitis

E. coli is one prominent pathogen of bovine mastitis ranging from subclinical infections to acute infections (Suojala *et al.*, 2013). The level of resistance was more or less at the same level as in 2006 and is internationally low (Table 21). Resistance to streptomycin was most commonly detected (9%). Low level of resistance was also detected against ampicillin (4%), ciprofloxacin (4%), nalidixic acid (4%), sulfamethoxazole (4%), trimethoprim (4%) and tetracycline (2%). No resistance to 3rd generation cephalosporins was found.

Two isolates were multiresistant: one isolate was resistant to four antimicrobials (ampicillin, tetracycline streptomycin and sulfamethoxazole) and the other to six antimicrobials (ampicillin, ciprofloxacin, nalidixic acid, tetracycline, streptomycin and sulfamethoxazole).

Table 21. Distribution of MICs of *E. coli* from bovine mastitis in 2012 (N=45).

			Distribution (%) of MICs (mg l^{-1})																		
Antibiotic	**%R**	**95% C.I.**	**≤ 0.008**	**0.016**	**0.032**	**0.064**	**0.125**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**	**512**	**1 024**	**>1 024**
Ampicillin	4.4	0.8-16.3								37.8	48.9	8.9						4.4			
Ceftazidime	0.0	0.0-9.8						95.6	4.4												
Cefotaxime	0.0	0.0-9.8		6.7	22.2	53.3	17.8														
Chloram-phenicol	0.0	0.0-9.8									8.9	44.4	46.7								
Ciprofloxacin	4.4	0.8-16.3		4.4	57.8	33.3			4.4												
Colistin	0.0	0.0-9.8							71.1	17.8	11.1										
Florfenicol	0.0	0.0-9.8										33.3	60.0	6.7							
Gentamicin	0.0	0.0-9.8						2.2	48.9	44.4	4.4										
Kanamycin	0.0	0.0-9.8											97.8	2.2							
Nalidixic acid	4.4	0.8-16.3								6.7	44.4	42.2	2.2				2.2	2.2			
Streptomycin	8.9	2.9-22.1									2.2	17.8	57.8	13.3			4.4	4.4			
Sulfa-methoxazole	4.4	0.8-16.3											88.9	6.7							4.4
Tetracycline	2.2	0.1-13.2								97.8							2.2				
Trimethoprim	4.4	0.8-16.3					11.1	24.4	37.8	20.0	2.2				4.4						

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

4.3 *Staphylococcus aureus* in bovine mastitis

The antimicrobial resistance in *S. aureus* against the majority of the tested antimicrobials varied from rare to low (Table 22). Although penicillins and cephalosporins are the most commonly used antimicrobials in mastitis in Finland, only 23% of the isolates produced beta-lactamase. Resistance to penicillin was at the same level also in 2005 (25%) (FINRES-Vet 2005-2006). The level of resistance to trimethoprim was high (25%), but resistance to trimethoprim-sulfonamide combination was not detected. Resistance to oxacillin was not found. Three isolates showed an elevated MIC (8) for cefoxitin but none of the isolates harboured a *mecA* or *mecC* gene. Traditionally, MRSA findings among Finnish cattle have been rare (Gindonis *et al.,* 2013).

4.4 Coagulase-negative staphylococci in bovine mastitis

Coagulase-negative staphylococci (CoNS) from bovine mastitis were more resistant than *S. aureus* isolates (Table 23). Of all CoNS isolates, 35.7% produced beta-lactamase and also resistance to trimethoprim and fusidic acid was very high. The *mecA* gene conferring resistance to methicillin was confirmed from five isolates (6%) although oxacillin MIC values >1 was even more commonly detected (Table 23).

4.5 *Streptococcus uberis* and *Streptococcus dysgalactiae* in bovine mastitis

The level of resistance in streptococci was more or less similar than in 2005 (FINRES-Vet 2005-2006). Tetracycline resistance was most commonly detected: 32% among *S. uberis* and 28% among *S. dysgalactiae*, followed by erythromycin resistance (11%) in *S. uberis* (Tables 24 and 25). The resistance against erythromycin (16%) and oxytetracycline (41%) among *S. uberis* has also been common in a study by Pitkälä *et al.* (2008). Interestingly, four *S. uberis* isolates showed a decreased susceptibility to penicillin as the MIC values were just above the cut-off value. This finding might be explained by mutations in penicillin-binding proteins as described previously (Haenni *et al*. 2010).

Table 22. Distribution of MICs for *Staphylococcus aureus* from bovine mastitis in 2012 (N=112).

			Distribution (%) of MICs (mg l^{-1})												
Antibiotic	**%R**	**95% C.I.**	**≤0.032**	**0.064**	**0.125**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**>64**
Cefoxitin	2.7	0.7-8.2			0.9				3.6	92.9	2.7				
Cephalothin	0.0	0.0-4.1		2.7	31.2	47.3	18.8								
Chloram-phenicol	1.8	0.3-7.0								11.6	79.5	7.1			1.8
Ciprofloxacin	0.9	0-5.6			3.6	50.9	40.2	4.5	0.9						
Clindamycin	0.9	0-5.6				99.1	0.9								
Erythromycin	0.0	0.0-4.1				4.5	80.4	15.2							
Florfenicol[2]	0.0	0.0-5.8							3.8	89.9	6.3				
Fusidic acid	8.9	4.6-16.2				13.4	77.7	8.0	0.9						
Gentamicin	0.0	0.0-4.1					79.5	17.9	2.7						
Oxacillin	0.0	0.0-4.1				3.6	14.3	58.0	24.1						
Penicillin[1]	23.2		37.5	33.0	8.0	0.9	0.9	1.8	4.5	6.2	7.1				
Streptomycin[2]	3.8	1.0-11.5								12.7	70.9	12.7	3.8		
Tetracycline	0.9	0-5.6					98.2	0.9				0.9			
Trimethoprim	24.1	16.7-33.3						3.6	72.3	22.3	1.8				
Trimethoprim[3]	0.0	0.0-5.8					100.0								

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

[1] Based on beta-lactamase production
[2] N=79
[3] Concentration of trimethoprim given, tested with sulfamethoxazole in concentration ratio 1:20

Table 23. Distribution of MICs of coagulase-negative staphylococci from bovine mastitis in 2012 (N=88).

			Distribution (%) of MICs (mg l^{-1})												
Antibiotic	**%R**	**95% C.I.**	**≤0.032**	**0.064**	**0.125**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**>64**
Cephalothin	0.0	0.0-5.2		1.1	21.6	50.0	17.0	10.2							
Chloram-phenicol	0.0	0.0-5.2							1.1	73.9	25.0				
Ciprofloxacin	0.0	0.0-5.2			31.8	52.3	15.9								
Clindamycin	10.2	5.1-19.0				89.8	9.1	1.1							
Erythromycin	5.6	2.1-13.4				13.6	75.0	5.7	1.1	1.1			1.1	2.3	
Florfenicol	0.0	0.0-5.2							26.1	71.6	2.3				
Fusidic acid	43.2	32.8-54.2				10.2	46.6	25.0	4.5	8.0	3.4	2.3			
Gentamicin	1.1	0.1-7.0					98.9	1.1							
Oxacillin	21.7[1]				1.1	4.5	46.6	26.1	8.0	8.0	2.3		3.4		
Penicillin	37.5[2]		34.1	21.6	4.5	13.6	3.4	10.2	3.4	6.8	2.3				
Streptomycin	6.0	1.9-15.4								82.1	10.4	1.5	1.5	4.5	
Tetracycline	11.4	5.9-20.4					80.7	8.0	5.7			2.3	1.1	2.3	
Trimethoprim	50.0	39.2-60.8					8.0	20.5	21.6	8.0	15.9	21.6	1.1	3.4	
Trimethoprim[3]	3.4	0.9-10.3					96.6			1.1	2.3				

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

[1] Only five isolates with oxacillin MIC >1 (5.7%) were confirmed to carry a *mec* gene
[2] Based on beta-lactamase production
[3] Concentration of trimethoprim given, tested with sulfamethoxazole in concentration ratio 1:20

Table 24. Distribution of MICs for *Streptococcus uberis* from mastitis in 2012 (N=100).

			Distribution (%) of MICs (mg l^{-1})												
Antibiotic	**%R**	**95% C.I.**	**≤0.032**	**0.064**	**0.125**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**>64**
Cephalothin	0.0	0.0-4.6		1.0	26.0	66.0	1.0	6.0							
Chloram-phenicol	0.0	0.0-4.6							31.0	69.0					
Ciprofloxacin	1.0	0.1-6.2				4.0	63.0	32.0		1.0					
Clindamycin	0.0	0.0-4.6				100.0									
Erythromycin	11.0	5.9-19.2				89.0		2.0	7.0	2.0					
Gentamicin	NR[3]								3.0	8.0	26.0	58.0	5.0	77.0	
Kanamycin	NR											5.0	18.0	79.0	
Neomycin	NR									2.0	4.0	4.0	11.0	88.0	
Penicillin[1]	4.0	1.3-10.6	60.6	32.3	3.0	4.0									
Streptomycin	NR										1.0	2.0	9.0		
Tetracycline	32.0	23.2-42.2					67.0	1.0				6.0	26.0		
Trimethoprim[2]	0	0.0-4.6					99.0	1.0							

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

[1] N=99
[2] concentration of trimethoprim given , tested with sulphamethoxazole in concentration ration 1:20
[3] not relevant

Table 25. Distribution of MICs for *Streptococcus dysgalactiae* from bovine mastitis in 2012 (N=113).

			Distribution (%) of MICs (mg l^{-1})												
Antibiotic	**%R**	**95% C.I.**	**≤0.032**	**0.064**	**0.125**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**>64**
Cephalothin	0.0	0.0-4.1		2.7	77.0	20.4									
Chloram-phenicol	0.0	0.0-4.1							51.3	47.8	0.9				
Ciprofloxacin	0.0	0.0-4.1					42.5	53.1	4.4						
Clindamycin	0.0	0.0-4.1				99.1	0.9								
Erythromycin	0.0	0.0-4.1				99.1	0.9								
Gentamicin	NR[3]							0.9	29.2	59.3	8.8	1.8			
Kanamycin	NR										0.9	19.5	48.7	31.0	
Neomycin	NR									0.9	7.1	71.7	19.5	0.9	
Penicillin	0.0	0.0-4.1	99.1	0.9											
Streptomycin	NR										5.3	40.7	53.1	0.9	
Tetracycline	28.3	20.4-37.7						2.7	23.0	46.0	12.4	1.8	3.5	9.7	0.9
Trimethoprim[2]	0.9	0-5.6					99.1			0.9					

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

[2] concentration of trimethoprim given , tested with sulphamethoxazole in concentration ration 1:20
[3] not relevant

5 Antibiotic resistance in animal pathogens from companion animals

Antimicrobial resistance figures from companion animal pathogens were collected from the Clinical Microbiology Laboratory of the Faculty of Veterinary Medicine, University of Helsinki. The data were available since June 2011; a reporting period thus covers June 2011 – December 2012. During that period of time, 4 613 clinical specimens were investigated, of which 3 279 (71%) were from dogs, 759 (16%) from horses, and 511 (11%) from cats. Approximately 70% of specimens were from the Veterinary Teaching Hospital of the University of Helsinki and 30% from private practitioners around the Finland. Details of the susceptibility testing are described in Appendix 2

In this report, antimicrobial resistance figures for *Staphylococcus aureus, Staphylococcus pseudintermedius*, and *E. coli* are presented. Since the number of investigated *S. aureus* isolates is low, isolates from dogs, cats and horses are combined. Otherwise the isolates from dogs and cats are combined, but isolates from horses are presented separately. If the total number of investigated isolates is low, the resistance figures are given for the whole period. Regarding *Staphylococcus pseudintermedius*, also some historical data are presented.

5.1 *Staphylococcus aureus* from companion animals

Altogether, the material included 49 *S. aureus* isolates from horses (n=19), dogs (n=16), cats (n=13) and a rabbit (n=1). Overall, resistance levels remained mainly low (Table 25). Thirty six isolates were tested for beta-lactamase production; of these 19 (53%) were beta-lactamase positive. One isolate out of 49 was MRSA and was derived from a dog.

Table 26. Antimicrobial resistance in *Staphylococcus aureus* isolates from companion animals in Finland in 2011-2012.

Antibiotic[1]	Tested isolates (N)	Resistant (%)	95% CI
Oxacillin[2]	48	2.1	0.1-12.5
Erythromycin	43	7.0	1.8-20.2
Clindamycin	41	0.0	0.0-10.7
Trimethoprim/Sulfamethoxazole	49	2.0	0.1-12.2
Tetracycline	42	7.1	1.8-20.5
Fusidic acid	43	2.3	0.1-13.8

[1] In addition to the antimicrobials below, nine isolates were tested for enrofloxacin and ten for gentamicin. No resistance to enrofloxacin was detected. One isolate was resistant to gentamicin.
[2] One isolate was confirmed to be MRSA.

5.2 *Staphylococcus pseudintermedius* from dogs and cats

Antimicrobial resistance among *Staphylococcus pseudintermedius* isolates from dogs and cats was alarming although a slight decrease in resistance figures was noted in 2012 compared to 2011 (Table 26). The exception was fucidic acid for which resistance increased. Almost 16% of *S. pseudintermedius* isolates were oxacillin resistant in 2012; all these were confirmed to be MRSP (*mec*A-gene positive). Trimethoprim-sulfonamides had the lowest resistance percentage. Resistance percentages to enrofloxacin and gentamicin is likely overestimated in this material due to the fact that testing for these antimicrobials was performed mainly for isolates which were resistant to oxacillin or other antimicrobials of the primary panel. Otherwise the figures between the years are comparable to all other antimicrobials.

Table 27. Antimicrobial resistance in *Staphylococcus pseudintermedius* isolates from companion animals in Finland in 2011-2012.

Antibiotic	2011			2012		
	Tested isolates (N)	Resistant (%)	95% CI (Wald)	Tested isolates (N)	Resistant (%)	95% CI (Wald)
Oxacillin[1]	204	17.6	12.4-22.9	440	15.7	12.3-19.1
Erythromycin	206	35.5	28.9-42.0	440	31.6	27.2-35.9
Clindamycin	205	34.6	28.1-41.1	439	32.2	27.8-36.5
Trimethoprim/ Sulfamethoxazole	206	15.5	10.6-20.5	439	11.6	8.6-14.6
Tetracycline	206	40.3	33.6-47.4	437	39.1	34.6-43.7
Fusidic acid	205	18.5	13.2-23.9	439	25.7	21.7-29.8
Enrofloxacin[2]	57	36.9	24.3-49.4	151	22.5	15.9-29.2
Gentamicin[2]	61	36.1	24.0-48.1	153	21.6	15.1-28.1

[1] all oxacillin resistant isolates were confirmed to be MRSP.
[2] Resistance percentages to enrofloxacin and gentamicin is likely overestimated in this material due to the fact that testing for these antimicrobials was performed mainly for isolates which were resistant to oxacillin or other antimicrobials of the primary panel. Also due to changes made in testing criteria in 2012, the figures for enrofloxacin and gentamicin are not comparable between the years. For other antimicrobials the figures are comparable.

For comparison, historical data from years 2004-2009 are given in the Figure 6. Figure shows that antimicrobial resistance among *S. pseudintermedius* started to rise rapidly since 2007. This may be explained by the appearance of a multidrug-resistance MRSP clone.

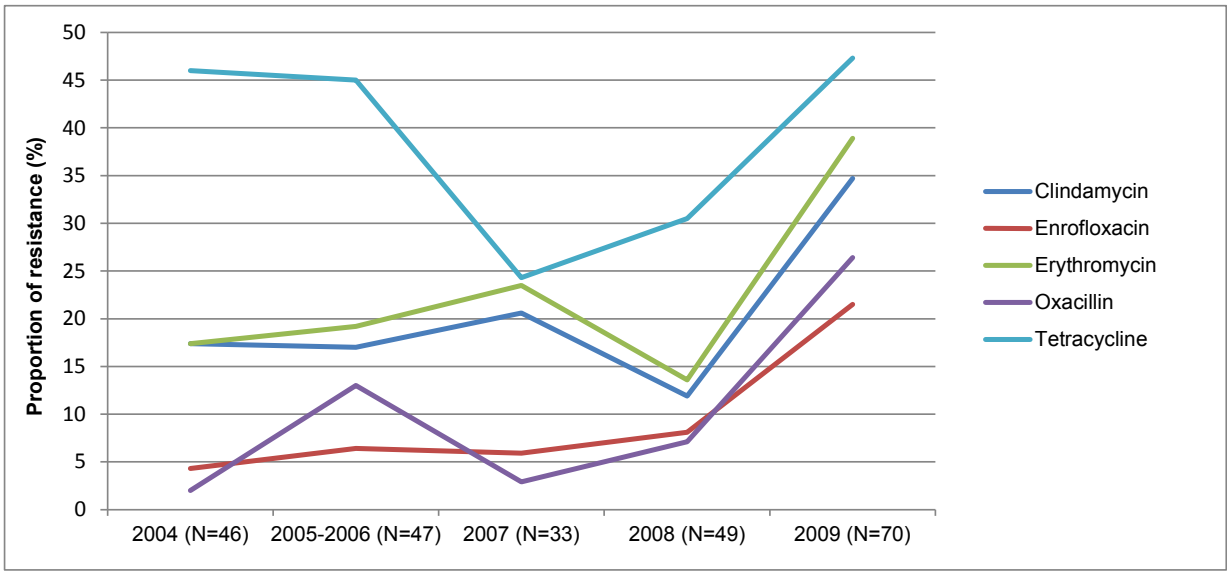

Figure 6. *Antimicrobial resistance (%) in Staphylococcus pseudintermedius isolates in Finland in 2004-2009.*

5.3 *Escherichia coli* from companion animals

Dogs and cats

Antimicrobial resistance among feline and canine *E. coli* isolates is concerning. Approximately 30% of the isolates were non-susceptible to amoxicillin-clavulanate. Increasing resistance was noted for trimethoprim-sulfonamides, enrofloxacin and gentamicin from 2011 to 2012. Cefpodoxime testing is routinely performed to detect isolates with reduced susceptibility to third generation cephalosporins. In 2011, 7% of *E. coli* had an inhibition zone ≤22 mm for cefpodoxime, but in 2012 the respective proportion was already 14.2%. The increase in ESBL isolates can also be seen from the Table 28.

Table 28. Antimicrobial resistance in *E.coli* isolates from dogs and cats in Finland in 2011-2012.

	2011			2012		
Antibiotic[1]	**Tested isolates (N)**	**Resistant (%)**	**95% CI (Wald)**	**Tested isolates (N)**	**Resistant (%)**	**95% CI (Wald)**
Ampicillin	136	49.3	40.1-57.7	323	60.4	55.0-65.7
Amoxicillin/ Clavulanic acid	135	26.0	18.5-33.3	321	27.4	22.5-32.3
Trimethoprim/ Sulfamethoxazole	136	11.0	5.8-16.3	325	17.8	13.7-22.0
Enrofloxacin	136	4.4	1.0-7.9	325	11.3	7.9-14.8
Gentamicin	136	0.7	0-4.6	325	5.5	3.4-8.7
Cefpodoxime[2]	135	7.4	3.8-13.5	323	14.2	10.7-18.6
ESBL[3]	135	1.5	0.3-4.7[4]	323	4.3	2.1-6.6

[1] In addition to these, 30 and 170 isolates were tested for nitrofurantoin in 2011 and 2012, respectively. No resistance was detected for this substance.
[2] ≤22 mm breakpoint was used for cefpodoxime and further ESBL screening.
[3] Double disk diffusion test was used for phenotypical confirmation of ESBL (these does not include AmpC isolates).
[4] Jeffreys CI calculated due to small n

Horses

Antimicrobial resistance among *E. coli* isolates from equine patients was overall at high level for all clinically relevant antimicrobials, although the number of tested isolates was small (Table 28). Resistance was most commonly detected against ampicillin (68%), trimethoprim-sulfonamides (58%), amoxicillin-clavulanate (39%) and gentamicin (31%). The proportion of ESBL isolates was 6.7%.

Table 29. Antimicrobial resistance in equine *E.coli* isolates in Finland in 2011-2012.

Antibiotic[1]	Tested isolates (N)	Resistant (%)	95% CI (Wald)
Ampicillin	43	67.5	53.4-81.4
Amoxicillin/Clavulanic acid	41	39.0	24.1-54.0
Trimethoprim/Sulfamethoxazole	45	57.8	42.3-72.0
Enrofloxacin	45	15.5	5.0-26.1
Gentamicin	45	31.1	18.6-46.8
Cefpodoxime	44	13.6	5.6-28.0
ESBL	45	6.7[1]	1.9-16.7

[1]Jeffreys CI calculated due to small n

6 MRSA in top breeding farms in Finland

Previously, two surveys of methicillin resistant Staphylococcus aureus (MRSA) have been conducted in Finland. These included the EU wide survey of pig breeding farms in 2008 (EFSA, 2009), and a national year-long survey of slaughtered pigs (2/EEO/2009) and pigs sent to Evira for pathological-anatomical diagnosis in 2009-2010 (FINRES-Vet 2007-2009). Another national survey was launched in 2011, based on a decree by the Ministry of Agriculture and Forestry (3/EEO/2011). In this survey, all the top breeding farms with a special pathogen-free (SPF) status (n=68) were examined for the presence of MRSA between October 2011 and March 2013. No MRSA was found. Therefore, it seems that MRSA situation in top breeding farms in Finland is favourable. However, as indicated by the previous studies, MRSA is present in finishing farms as well as in breeding farms in Finland and transmission between pig farms might occur.

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Appendix 1. Population statistics

The number of holdings, live animals on holdings and slaughter statistics in Finland are presented in Table 30. The displayed data originate from the statistics of Luke, the Natural Resources Institute, Finland (formerly from the statistics of Tike, the Information Centre of the Ministry of Agriculture and Forestry, Finland), Farm register, and meat inspection statistics of Evira.

Table 30. Number of farm animals and holdings in Finland in 2007-2012.

Animal species	Year	Holdings	Livestock (live animals)	Slaughtered animals
Cattle				
calves (under one year)	2007	17 722	311 100	
	2008	16 493	304 600	
	2009	15 538	304 300	
	2010	14 836	303 100	
	2011	14 116	298 600	
	2012	13 404	302 900	
dairy cows and heifers	2007	14 400	462 500	
	2008	13 340	454 000	
	2009	12 915	452 600	
	2010	12 239	453 100	
	2011	11 214	447 500	
	2012	10 552	443 300	
meat production animals	2007	11 186	181 400	
	2008	11 960	120 500	
	2009	7 567	118 700	
	2010	7 033	124 700	
	2011	6 732	120 400	
	2012	6 444	119 400	
in total	2007	18 624	926 700	291 100
	2008	17 437	915 300	265 700
	2009	16 420	918 300	268 100
	2010	15 641	925 800	264 200
	2011	14 913	914 100	264 100
	2012	14 138	912 800	263 700

Animal species	Year	Holdings	Livestock (live animals)	Slaughtered animals
Poultry				
broilers	2007	138	5 074 100	54 079 600
	2008	141	5 674 500	55 200 000
	2009	103	4 918 500	51 867 500
	2010	107	4 616 200	54 571 000
	2011	112	5 421 300	56 770 500
	2012	124	6 038 300	61 038 700
Pigs				
sows	2007	1 876	174 600	61 600
	2008	1 689	168 600	64 400
	2009	1 435	152 900	54 900
	2010	1 277	150 500	52 100
	2011	1 170	142 700	52 900
	2012	1 025	133 100	49 600
fattening pigs	2007	2 442	1 269 400	2 390 600
	2008	2 461	1 310 300	2 371 900
	2009	2 202	1 225 200	2 276 800
	2010	2 019	1 213 300	2 199 700
	2011	1 871	1 189 200	2 523 500
	2012	1 702	1 154 500	2 108 800
in total	2007	2 744	1 448 000	2 452 200
	2008	2 529	1 482 800	2 436 300
	2009	2 266	1 381 200	2 331 700
	2010	2 078	1 366 900	2 251 800
	2011	1 917	1 335 100	2 576 400
	2012	1 747	1 290 400	2 158 400

Appendix 2. Data sources of veterinary antimicrobials

Data sources

The Finnish Medicines Agency monitors the sales of VMPs and obtains the sales data at package level from wholesalers. Sales of antimicrobial agents in medicated feed are monitored by the Finnish Food Authority Evira, which collects data from feed mills and other importers.

The sales statistics include products that have marketing authorization as well as those sold under special licence. Products authorised for human use but prescribed for animals are not included. It is unlikely that their absence skews the figures markedly as the proportion of human products used in companion animal practice account for 10-15 % of all antimicrobials used for these species (Rantala, 2003; Hölsö *et. al.*, 2005).

Harmonized EU surveillance

Veterinary antimicrobial agents included in the data

The collection of sales data has been harmonized in accordance with the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) project. The classification system was adjusted and the monitoring of locally administered products (administered to skin, eyes or ears) discontinued in 2009. Sales of local products is included in the table 1. (Total sales) for years 2003-2008 their amount being less than 200 kg a year.

Table 31. Categories and ATCvet codes of antimicrobial veterinary medicinal products to be included according to the ESVAC protocol (EMA/238630/2011).

Categories of veterinary antimicrobial agents	ATCvet codes*
Antimicrobial agents for intestinal use	QA07AA; QA07AB
Antimicrobial agents for intrauterine use	QG01AA; QG01AE; QG01BA; QG01BE; QG51AA; QG51AG
Antimicrobial agents for systemic use	QJ01
Antimicrobial agents for intramammary use	QJ51
Antimicrobial agents used as antiparasitic agents	QP51AG

* No veterinary medicinal products with following ATCvet codes were authorised in Finland: QA07AB, QG01AA, QG01AE, QG01BA, QG01BE, QG51AA, QG51AG and QP51AG

Conversion factors

According to the ESVAC protocol, penicillin is expressed as an active ingredient. Therefore conversion factors according to ESVAC protocol were applied for penicillin prodrugs since 2010.

To enable comparisons, penicillin consumption for the years 2010–2012 has been calculated using both the old and new method. The new calculation method shows total penicillin sales in 2012 at approximately 22% lower than with the old calculation method. Similarly, the total sales of all antimicrobials are some 10% lower when compared with the previous calculating method. To enable meaningful comparison of the changes in the sales patterns the figures used in this report are based on the old method. Further information on the changes can be found in the detailed tables, arranged by route of administration as well as in the footnotes.

Appendix 3. Materials and methods, resistance monitoring

Sampling strategy

Zoonotic bacteria

Salmonella isolates from production animals were collected as required by the Finnish salmonella control programme. One isolate from each notified incident was included. Isolates from domestic food included also isolates originating from in-house control system.

Campylobacter jejuni were collected from broilers in association with the Finnish Campylobacter monitoring programme for broilers. *C. jejuni* from cattle and *C. coli* from pigs were isolated from the same samples as indictor bacteria in the FINRES-Vet programme.

Indicator bacteria

Indicator bacteria, *E. coli, Enterococcus faecalis* and *Enterococcus faecium*, were collected from broiler caeca, and pig and cattle faeces. The samples originated from healthy animals at slaughter between January or February and December. The number of randomly taken samples from each slaughterhouse was proportional to the annual slaughter volume. Each isolate represented one flock or herd. The pig, broiler and cattle slaughterhouses accounted for 92% (2010), 99% (2011) and 92% (2012) of the total number of slaughtered animals in Finland.

Animal pathogens

Clinical isolates originated from diagnostic submissions or postmortem examinations: *Escherichia coli* was isolated from pigs with enteritis. Only one isolate per herd was included. The samples were taken from the contents of the gastrointestinal tract.

Milk samples from cows displaying signs of clinical mastitis were received from a laboratory using a commercial real-time PCR kit. The target species for resistance testing were *Staphylococcus aureus*, coagulase negative staphylococci CNS, *Streptococcus dysgalactiae, Streptococcus uberis, Escherichia coli* and *Klebsiella* spp. One isolate per farm was included.

Antimicrobial resistance figures from companion animal pathogens were collected from the clinical microbiology laboratory of the Faculty of Veterinary Medicine,

University of Helsinki. All isolates included in this report were originated from clinical specimens. The data were available since June 2011; a reporting period thus covers June 2011 – December 2012. During that period of time, 4 613 clinical specimens were investigated, of which 3 279 (71%) were from dogs, 759 (16%) from horses, and 511 (11%) from cats. Approximately 70% of specimens were from the Veterinary Teaching Hospital of the University of Helsinki and 30% from private practitioners around the Finland.

Isolation and identification of bacteria

Zoonotic bacteria

Salmonella

Salmonella were isolated and identified according to a modification of the NMKL standard Nr 71 (1999), according to ISO standard 6579:2002 or ISO standard 6579:2002, Amendment 1/2007, at local food control or slaughterhouse laboratories. Serotyping of the isolates was performed at Evira, Veterinary Bacteriology Unit.

Campylobacter

C. jejuni from broilers were isolated at slaughterhouse laboratories and confirmed at Evira, Food and Feed Microbiology Research Unit, according to a modified method of the NMKL 119:2007. *C. coli* from pigs in 2010 and *C. jejuni* from cattle in 2012 were isolated at Evira according to the same method.

Indicator bacteria

Enterococci

Bovine faecal samples were first diluted in BHI-NaCl (brain heart infusion broth, 6.5% NaCl) pre-enrichment broth (1 g /10 ml) and incubated for 18-24 h at 37°C. After mixing, 10 µl of the diluted suspension was cultured on Slanetz-Bartley agar (Merck, Darmstadt, Germany). Broiler and pig intestinal content was directly spread on Slanetz-Bartley agar. After incubation for 48 h at 37°C, one or two typical colonies were sub-cultured on bile-esculine agar (Difco, Le Pont de Claix, France) and incubated overnight at 37°C. Colonies with a positive esculine reaction were inoculated to blood agar. In 2010 and 2011, enterococci were identified to species level with the following tests: motility, arginine dihydrolase, mannitol, arabinose, raffinose, ribose, sorbitol and melibiose. In 2012, all mannitol fermenting enterococci were further identified as *E. faecalis* or *E. faecium* by PCR (Dutka-Malen et al., 1996). If possible, both *E. faecium* and *E. faecalis* were isolated from each sample.

Escherichia coli

Intestinal content was directly spread on Brilliance™ *E. coli*/coliform Selective Agar (Oxoid) and incubated overnight at 37°C. Purple colonies were selected for susceptibility testing.

Animal pathogens

Pathogenic Escherichia coli from porcine enteritidis

Haemolytic *Escherichia coli* were isolated and identified at Evira, Veterinary Bacteriology Unit or Production Animal and Wildlife Health Unit using standard

procedures. They were isolated from blood agar plates and identified as typical colonies on eosin-methyleneblue (EMB) agar (Becton Dickinson, Sparks, USA or Merck). The isolates were further tested for indole production. Virulence of the isolates was confirmed by demonstrating the genes coding for appropriate fimbriae and toxins at the Veterinary Bacteriology Unit.

Mastitis pathogens

In order to isolate mastitis pathogens (*Staphylococcus aureus*, coagulase negative staphylococci CoNS, *Streptococcus dysgalactiae*, *Streptococcus uberis* and *Escherichia coli*), 10 µl of milk from samples that had yielded a positive PCR result (+++ or ++ for different pathogens), was cultured onto trypctic soy agar with 5% bovine blood and incubated overnight at 37°C. One isolate per farm was included in the study. Culturing of the samples and identification of the isolates were done at Evira, Veterinary Bacteriology Unit, Kuopio.

Isolates were putatively identified based on colony morphology, haemolysis, Gram stain and catalase test. Coagulase test and API Staph ID 32 strips (bioMérieux, France) were used to distinguish *S. aureus* from CNS. API Strep ID 32 strips (bioMérieux, France) were used to identify *S. uberis* and *S. dysgalactiae*. *E. coli* was distinguished from other coliforms using the API 20E strips (bioMérieux).

MRSA screening of the top pig breeding farms with SPF status

From all the breeding farms, 60 nasal swab samples from different animals (if possible) and one boot swab sample of each individual section of the farm were collected. Ten nasal swab samples were pooled in the laboratory and boot swab samples were examined separately. Screening for MRSA was performed by pre-enriching the samples in Mueller Hinton broth (DIFCO™, BD) with 6.5% NaCl (Merck) followed by a selective enrichment in tryptone soya broth (BBLTM TrypticaseTM Soy Broth (BD) with 3.5 mg/l cefoxitin and 75 mg/l aztreonam as recommended by the European Union Reference Laboratory for Antimicrobial Resistance. Ten microliters of TSB was spread on MRSASelect™ Agar (BioRad). Typical size pink colonies were inoculated on blood agar, and colonies suggestive of *Staphylococcus aureus* on the blood agar were checked with MRSA Penicillin binding protein (PBP2') Latex test. PBP2'-positive colonies were identified (coagulase test, Staph ID 32, *nuc* gene). The presence of *S. aureus* specific *nuc* gene was determined according to Brakstad *et al.* (1992), and the presence of *mecA* gene with a method described by Murakami *et al.* (1991).

Screening and/or confirmation of ESBL/AmpC producing *E. coli* and *Salmonella* spp.

The screening of ESBL and AmpC producing *E. coli* was introduced to the FINRES-Vet monitoring programme in 2011. The screening was made from the same samples as indicator bacteria. Broilers (n=352) were screened in 2011 and cattle (n=325) in 2012. Ten microliters of intestinal content were spread directly on MacConkey (Becton, Dickinson & Company, France) plates containing 1 mg/l cefotaxime (Sigma-Aldrich, Germany) and incubated overnight at 37°C. Typical lactose fermenting pink colonies

were picked and the confirmation of the presumptive *E. coli* isolates was done with API 20E test (bioMérieux® SA, France).

All indicator *E. coli* and *Salmonella* spp. that had cefotaxime and/or ceftazidime MIC above ECOFF and all *E. coli* isolates from the specific ESBL/AmpC screening were phenotypically characterized with AmpC & ESBL ID Set (D68C, Mast Diagnostics, UK) and if positive, finally tested for the presence of ESBL or plasmidic AmpC gene as described previously (Dallenne *et al*., 2010). Obtained PCR products were confirmed with sequencing. The sequencing was done in the Institute of Biotechnology (Helsinki) with the same primers as used in the PCR reactions. The sequences were analyzed with CLC Main Workbench software (version 6.6.2, CLCbio, Denmark).

Screening of VRE

In 2011, the screening of VRE was performed from the same broiler caecal samples (n=352) as indicator bacteria. Ten microliters of intestinal content were spread directly on Slanetz-Bartley (Merck, Germany) agar containing 16 mg/l vancomycin (Sigma-Aldrich, Germany) and incubated 48 h at 37°C. One or two typical colonies were sub-cultured on bile-esculine agar and incubated overnight at 37°C. Colonies with a positive esculine reaction were inoculated to blood agar. The species identification of *E. faecalis* or *E. faecium* and the detection of *vanA* or v*anB* genes were made by PCR (Dutka-Malen *et al.,* 1996).

Susceptibility testing

Susceptibility testing of zoonotic and indicator bacteria as well as diarrheagenic *E. coli* and mastitis pathogens was performed with a microdilution broth method: VetMIC™ (Department of Antibiotics, National Veterinary Institute, Uppsala, Sweden). The testing was performed following the procedures of the Clinical and Laboratory Standards Institute (CLSI, 2008). Susceptibility testing was performed at Evira, Food and Feed Microbiology Research Unit. The epidemiological cut-off values used are shown in Table 32. Bacitracin values are given in units ml^{-1}.

Susceptibility testing of bacteria isolated from companion animals was performed with a disk diffusion technique with a CLSI standard (CLSI M31-A3, 2008); respective clinical breakpoints of the standard were used to calculate resistance percentages. Resistance percentages include resistant and intermediate isolates. If veterinary breakpoints were not available, CLSI M100-S20 (2010) was used for to determine the breakpoints. Exceptions were the oxacillin non-susceptibility breakpoint for *S. pseudintermedius*, which was ≤ 17 mm (Bemis *et al.,* 2009), and the fucidic acid non-susceptibility breakpoint, which was ≤ 23 (FiRe-standard, version 6).

Table 32. Epidemiological cut-off values (mg l^{-1}) used in this report.
Isolates with MIC values higher than the given figures are considered resistant.

Antibiotic	*Salmonella enterica*	*Escherichia coli*	*Enterococcus faecalis*	*Enterococcus faecium*	*C. jejuni*	*C. coli*	*Staphylococcus pseudintermedius*	*Staphylococcus aureus*	*Coagulase-negative staphyloccoi*	*Streptococcus uberis, Streptococcus dysgalactiae*
Ampicillin	>8	>8	>4	>4						
Bacitracin[1]			>32	>32						
Cefotaxime	>0.5	>0.25								
Cefoxitin								>4		
Ceftazidime		>0.5								
Cephalothin							>1	>1	>1	>1
Chloramphenicol	>16	>16	>32	>32			>16	>16	>16	>8
Ciprofloxacin	>0.06	>0.06			>0.5	>0.5	>1	>1	>1	>2
Clindamycin							>2	>0.25	>0.25	>0.5
Colistin		>2								
Enrofloxacin							>0.5			
Erythromycin			>4	>4	>4	>8	>1	>1	>1	>0.5
Florfenicol	>16	>16						>8	>8	
Fusidic acid								>0.5	>0.5	
Gentamicin	>2	>2	>32	>32	>2	>2	>2	>2	>0.5	
Kanamycin	>8	>8	>1 024	>1 024			>8			
Linezolid			>4	>4						
Nalidixic acid	>16	>16			>16	>16				
Narasin			>2	>4						
Oxacillin							>1	>2	>1	
Penicillin										>0.125
Oxytetracycline, tetracycline	>8	>8	>4	>4	>1	>2	>2	>1	>1	>4
Streptomycin	>32	>16	>512	>128				>16	>16	
Sulfamethoxazole	>256	>64								
Trimethoprim	>2	>2						>2	>2	
Trimethoprim/ sulfamethoxazole[2]							>2	>0.5	>0.5	>2
Vancomycin			>4	>4						
Virginiamycin			>32	>4						

[1] MIC in U ml^{-1}.
[2] Concentration of trimethoprim given, concentration ratio with sulfamethoxazole 1:20

Beta-lactamase activity was tested with Cefinase™ disks (Becton Dickinson, NJ, USA). *S. aureus* and coagulase negative staphylococci from mastitis with oxacillin MIC values >2 and >1, respectively, were tested for the presence of the *mecA* and *mecC* gene using primers described in Murakami *et al.* (1991) and Stegger *et al.* (2012).

Verbal descriptions of the resistance levels (EFSA, 2010)

Rare	< 0.1%
Very low	0.1% to 1.0%
Low	>1% to 10%
Moderate	>10% to 20%
High	>20% to 50%
Very high	>50% to 70%
Extremely high	>70%

Quality assurance system

The Veterinary Bacteriology Unit participates in external quality assurance programmes for veterinary pathogens and in proficiency tests on isolation, identification and serotyping of Salmonella, and the Food and Feed Microbiology Research Unit participates in proficiency tests for antimicrobial susceptibility testing.

For susceptibility tests the following bacteria were included as quality controls on at least a weekly basis: *E. coli* ATCC 25922, E. faecalis ATCC 29212, *S. aureus* ATCC 29213 and *C. jejuni* ATCC 33560, *S. aureus* ATCC 43300.

The Veterinary Bacteriology Unit is accredited for isolation, identification and serotyping of Salmonella, and the Microbiology Research Unit for performing the VetMIC™ test according to SFS-EN ISO/IEC 17025, by the Finnish Centre for Metrology and Accreditation.

Appendix 4. *Salmonella* serovars isolated from Finnish production animals in 2010-2012

Table 33. *Salmonella* serovars isolated from the main production animal species in Finland in 2010-2012.

Serotype	Year	N	Cattle	Pigs	Poultry (Gallus gallus)	Turkeys
S. Typhimurium	2010	12	10	2	-	-
	2011	19	15	4	-	2
	2012	25	16	2	5	1
S. Enteritidis	2010	1	1	-	-	-
	2011	4	1	1	1	-
	2012	1	1	-	-	-
S. Tennessee	2010	3	-	2	1	-
	2011	1	-	2	-	-
	2012	3	-	2	-	-
S. Livingstone	2010	3	-	-	3	-
	2011	1	-	-	1	-
	2012	-	-	-	-	-
S. Infantis	2010	1	-	1	-	-
	2011	-	-	-	-	-
	2012	-	-	-	-	-
S. Altona	2010	2	2	-	-	-
	2011	1	1	-	-	-
	2012	-	-	-	-	-
S. Albany	2010	1	-	-	1	-
	2011	-	-	-	-	-
	2012	-	-	-	-	-
S. Kisarawe	2010	-	-	-	-	-
	2011	1	-	1	-	-
	2012	1	-	1	-	-
S. Muenchen	2010	-	-	-	-	-
	2011	1	1	-	-	-
	2012	1	1	-	-	-
S. Haifa	2010	-	-	-	-	-
	2011	1	1	-	-	-
	2012	-	-	-	-	-
S. Montevideo	2010	-	-	-	-	-
	2011	1	1	-	-	-
	2012	-	-	-	-	-
S. Rissen	2010	-	-	-	-	-
	2011	-	-	-	-	-
	2012	1	1	-	-	-

Cover photos: Evira/Anniina Kivilahti

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Evira publications 2/2015
ISSN 1797-299X
ISBN 978-952-225-143-5 (pdf)

Evira