Evira publications 1/2011

FINRES-Vet 2007-2009

Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents

fimea
Lääkealan turvallisuus- ja kehittämiskeskus

Evira

Evira publications 1/2011

FINRES-Vet 2007-2009

Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents

fimea
Lääkealan turvallisuus- ja kehittämiskeskus

Evira

Authors
Finnish Food Safety Authority Evira
Lasse Nuotio, Anna-Liisa Myllyniemi and Suvi Nykäsenoja

Finnish Medicines Agency FIMEA
Katariina Kivilahti-Mäntylä

Institutions participating in FINRES-Vet
Finnish Food Safety Authority Evira
Finnish Medicines Agency FIMEA (up to 2009 National Agency for Medicines)
National Institute for Health and Welfare THL (up to 2008 National Public Health Institute)

Any use of data from FINRES-Vet 2007-2009 should include a specific reference to this report. Suggested citation: FINRES-Vet 2007-2009, Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents, Finnish Food Safety Authority Evira, Helsinki, Finland, ISSN 1797-299X.

This report is available at www.evira.fi

Description

Publisher	Finnish Food Safety Authority Evira
Title	FINRES-Vet 2007-2009. Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents
Authors	Lasse Nuotio, Anna-Liisa Myllyniemi, Suvi Nykäsenoja and Katariina Kivilahti-Mäntylä
Abstract	Some increase in the consumption of antimicrobials used to treat animals was observed up to 2008, compared to the previous reporting period (2005-2006). However, the trend was discontinued in 2009. Penicillin G continued to be the most often used antimicrobial, followed by combination of sulpha and trimethoprim. The occurrence of resistance to antimicrobials in bacteria isolated from animals or foods of animal origin has in general remained favourable. This stems from a good disease situation, compared internationally, but also from the prudent use of antimicrobials. However, there was a distinct increase in the use of some antimicrobials (e.g. tetracyclines), which can pose a risk of emergence of resistant clones. Close observation of the Finnish recommendations for the use of antimicrobial agents is even more important than earlier. Resistance to antimicrobials among zoonotic bacteria (salmonella, campylobacter) is still rare. Indicator bacteria *(Escherichia coli, Enterococcus faecalis, Ent. faecium)* isolated from broilers showed resistance more often than those isolated from cattle or swine. Multiresistance in *E. coli* strains isolated from cases of porcine enteritis is still common and multiresistance is also emerging in *Staphylococcus pseudintermedius* strains isolated from canine infections. The report contains a new section reviewing the occurrence of meticillin resistant *S. aureus* (MRSA) in companion animals as well as in swine in Finland.
Publication date	March 2011
Keywords	antimicrobial resistance, consumption of antimicrobials
Name and number of publication	Evira publications 1/2011
Pages	62
Language	English
Confidentiality	Public
Publisher	Finnish Food Safety Authority Evira
Layout	Finnish Food Safety Authority Evira, In-house Services
	ISSN 1797-299X, ISBN 978-952-225-082-7 (pdf)

Kuvailulehti

Julkaisija	Elintarviketurvallisuusvirasto Evira
Julkaisun nimi	FINRES-Vet 2007-2009. Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents
Tekijät	Lasse Nuotio, Anna-Liisa Myllyniemi, Suvi Nykäsenoja ja Katariina Kivilahti-Mäntylä
Tiivistelmä	Eläimille käytettävien mikrobilääkkeiden määrässä oli jonkin verran nousua vuoteen 2008 asti, verrattuna edelliseen raportointijaksoon (2005-2006). Nousu kuitenkin taittui v 2009. Eniten käytettiin G-penisilliiniä ja toiseksi eniten sulfa-trimetopriimi yhdistelmää. Eläimistä ja eläinperäisistä elintarvikkeista eristettyjen bakteerien resistenssitilanne on pysynyt yleisesti ottaen suotuisana myös tällä raportointijaksolla. Tämä on ollut seurausta kansainvälisesti vertaillen hyvästä tautitilanteesta, mutta myös mikrobilääkkeiden hallitusta käytöstä. Joidenkin antibioottien (esimerkiksi tetrasykliini) käytössä on kuitenkin ollut selvää nousua, mikä suurentaa riskiä resistenttien kloonien kehittymiseen tai ilmaantumiseen. Eläinten hoidossa on entistä tärkeämpää noudattaa Suomessa annettuja mikrobilääkkeiden käyttösuosituksia. Zoonoottisilla taudinaiheuttajilla (salmonella ja kampylobakteeri) todettiin vain vähän resistenssiä. Broilereista eristetyillä indikaattoribakteereilla *(Escherichia coli, Enterococcus faecalis, Ent. faecium)* esiintyi resistenssiä enemmän kuin sioista tai naudoista eristetyillä kannoilla. Sikojen suolistotulehduksista eristetyillä *E. coli* -kannoilla moniresistenssi oli edelleen yleistä. Moniresistenssiä esiintyi lisääntyvässä määrin myös koirien infektioista eristetyillä *Staphylococcus pseudintermedius* -kannoilla. Uutena kohtana raportissa on katsaus metisilliinille resistentin *Staphylococcus aureus* -bakteerin (MRSA) esiintymiseen seuraeläimissä ja sioissa.
Julkaisuaika	Maaliskuu 2011
Asiasanat	mikrobilääkeresistenssi, mikrobilääkkeiden käyttö
Julkaisusarjan nimi ja numero	Eviran julkaisuja 1/2011
Sivuja	62
Kieli	Englanti
Luottamuksellisuus	Julkinen
Julkaisun kustantaja	Elintarviketurvallisuusvirasto Evira
Taitto	Elintarviketurvallisuusvirasto Evira, virastopalveluyksikkö
	ISSN 1797-299X, ISBN 978-952-225-082-7 (pdf)

Beskrivning

Utgivare	Livsmedelssäkerhetsverket Evira
Publikationens titel	FINRES-Vet 2007-2009. Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents
Författare	Lasse Nuotio, Anna-Liisa Myllyniemi, Suvi Nykäsenoja och Katariina Kivilahti-Mäntylä
Resumé	Mängden antimikrobiella medel som användes för behandling av djur ökade något fram till år 2008 jämfört med föregående rapporteringsperiod (2005- 2006). Ökningen stagnerade år 2009. Mest användes G-penicillin och därefter kombinationen sulfa-trimetoprim. Resistensen hos bakterier som har isolerats från djur och livsmedel av animaliskt ursprung har på det hela taget hållits på en fördelaktig nivå även under denna rapporteringsperiod. Det här är en följd av den i internationell jämförelse goda sjukdomssituationen, men även av en balanserad användning av antimikrobiella medel. Användningen av vissa antibiotika (exempelvis tetracyklin) har ändå stigit tydligt, vilket ökar risken för utveckling eller uppkomst av resistenta kloner. Vid behandling av djur är det viktigare än tidigare att följa rekommendationerna för användning av antimikrobiella medel i Finland. Hos zoonotiska sjukdomsalstrare (salmonella och campylobacter) konstaterades endast litet resistens. Hos indikatorbakterier som isolerats från broilrar (*Escherichia coli, Enterococcus faecalis, Ent. faecium*) förekom högre resistens än hos stammar som isolerats från svin eller nötdjur. Hos stammar av *E. coli* som isolerats från tarminflammationer hos svin var multiresistens fortfarande allmän. Multiresistens förekom i högre grad även hos stammar av *Staphylococcus pseudintermedius* som isolerats från infektioner hos hundar. Som en ny punkt i rapporten finns en översikt över förekomsten av den meticillinresistenta bakterien *Staphylococcus aureus* (MRSA) hos sällskapsdjur och svin.
Utgivningsdatum	Mars 2011
Referensord	resistens mot antimikrobiella medel, användning av antimikrobiella medel
Publikationsseriens namn och nummer	Eviras publikationer 1/2011
Antal sidor	62
Språk	Engelska
Konfidentialitet	Offentlig
Förläggare	Livsmedelssäkerhetsverket Evira
Layout	Livsmedelssäkerhetsverket Evira, Enhet för ämbetsverkstjänster
	ISSN 1797-299X, ISBN 978-952-225-082-7 (pdf)

Abstract

This report presents the results obtained in the FINRES-Vet monitoring in 2007-2009. However, to better discern long-term developments most of the tables and figures about the consumption of antimicrobials and feed additives contain corresponding data starting from the year 2001. The structure of the report complies with that of the previous reports of the series (the previous covering the years 2005-2006). After reviewing the consumption of antimicrobials 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. As a new item the report reviews the emergence of meticillin resistant *Staphylococcus aureus* (MRSA) in companion animals and swine in Finland since the year 2007.

Consumption of antimicrobials for animals in Finland
A distinct rise of 22.7% was observed in the total consumption from 2006 to 2008; however a decline of 4.8% took place between 2008 and 2009. From 2001 to 2009 the rise was 19.5% but that from the lowest figure of the decade, in the year 2003, up to 2009 was 26.1%. These changes cannot be mere statistical noise but reflect a true increase in the incidence of bacterial infections. The consumption proportioned to the total biomass of production animals (produced meat + biomass of live cattle) was 31 mg of antimicrobials/1 kg of biomass in 2009. In particular, the number of locally administered treatments for bovine mastitis during lactation was about 2/ dairy cow; this figure has remained relatively constant in 2007-2009.

Penicillin G continues to be the most often administered antimicrobial and combination of sulphonamide and trimethoprim holds the next place. Betalactams covered 61.2%, sulphonamide-trimethoprim 19.2% and tetracyclines 13.8% of the total consumption in 2009. Use of other antimicrobials was rather marginal; their combined share was only 5.8% in 2009.

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 antimicrobial 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 (e.g. 22 in 2009), which reflects the very favourable prevalence of salmonella infections in livestock, compared internationally. In addition to the isolates from production animals, 52 isolates of *S*. Tennessee originating from a feed-borne

epidemic were examined in 2009. The resistance encountered in production animal isolates has lately been due to *S*. Typhimurium from cattle located in two known infection foci in Finland. The *S*. Tennessee isolations which obviously were of a single clone, were sensitive to all tested antimicrobials. Resistance in campylobacteria isolated from broilers or cattle is so far an exception; the proportion of resistant strains is 1-2% at the most. A somewhat higher level of resistance is seen in *C. coli* from swine but the proportion of resistant strains also in these cases remained below 10%.

Antimicrobial resistance in indicator bacteria

Strains of *Escherichia coli*, *Enterococcus faecalis* and *Ent. faecium* were isolated from samples taken at slaughter from swine, broilers and cattle in 2007, 2008 and 2009, respectively. Resistance was rare in *E. coli* from cattle and unusual in broiler isolates. The *E. coli* strains from swine showed a slightly taller frequency; the highest proportions of resistant strains were 17.7% to tetracyclines, 14.8% to streptomycin and 11.9% to sulfonamides. Strains of *Ent. faecalis* from all production animals were resistant predominantly to erythromycin and tetracyclines; those originating from broilers also to bacitracin and narasin. The highest frequency of resistance, 82.7% to tetracyclines, was recorded in strains isolated from swine; however, the total number of isolates from swine was only 38. In strains of *Ent. faecium* (isolates only from cattle and broilers) the occurrence of resistance followed by and large that of *Ent. faecalis*; some resistance to erythromycin and tetracyclines; in strains from broilers also to bacitracin and narasin.

Antimicrobial resistance in animal pathogens

The results presented here pertain to *E. coli* strains isolated from cases of pig enteritis, and *Staphylococcus pseudintermedius* strains isolated from various canine infections. In *E. coli* strains from pigs resistance to ampicillin, ciprofloxacin, nalidixic acid, streptomycin, sulphonamide, tetracyclines and trimethoprim was regular and comparatively common. Multiresistance was frequent and appears to be increasing; e.g. in 2009 58% of the strains were resistant to more than two antimicrobials. However, the isolations were quite few in number, 18, 28 and 24 in 2007, 2008 and 2009, respectively, to allow broad generalisations. Resistance to especially penicillin-G was very common in *S. pseudintermedius* strains from canine infections; over 80% of the strains were resistant each year. Resistance was frequent also to other antimicrobials; in 2009 only 11% of the isolates were susceptible to all tested antimicrobials and 40% of the isolates were resistant to three or more antimicrobials. However, also here the numbers of isolations were modest: 34, 59 and 72 in 2007, 2008 and 2009, respectively.

Meticillin resistant *Staphylococcus aureus* (MRSA)

Prior to 2007 animal-associated MRSA was a chance finding in Finland. In 2007 there was an outbreak among horses visiting the University Animal Hospital (YES), which included 3 infected and 10 carrier animals. In the same year MRSA was found in two cats. One infected and one carrier horse were found in YES also in 2008, and one dog was positive in 2009. EU Member States conducted a baseline survey for MRSA among breeding and production pig farms in 2008. Out of the 207 farms examined in Finland one (0.5%) was positive. A year-long survey starting in September 2009 among 59 finishing pig and 36 farrowing farms revealed 13 positive in the former but only one positive in the latter category, yielding an overall apparent prevalence of 14.7%. This figure should be interpreted with caution as the the sampling was not actually random in either category. However, it can be concluded that the MRSA prevalence on pig farms definitely exceeds the low figure obtained in the EU baseline study.

Tiivistelmä

Tämä raportti kokoaa vuosien 2007-2009 aikana tehdyn FINRES-Vet -seurannan tulokset. Pitemmän aikavälin muutosten hahmottamiseksi raportin useimmat eläinlääkkeiden ja rehun lisäaineiden kulutustaulukot ja kaaviot sisältävät kuitenkin tiedot alkaen vuodesta 2001. Raportti noudattaa pääosin edellisten raporttien (viimeisin vuosina 2005-2006) rakennetta, jossa ensin luodaan katsaus eläinlääkkeiden kulutuksessa tapahtuneisiin muutoksiin, ja sen jälkeen antibioottiresistenssin ilmenemiseen zoonoottisissa bakteereissa, indikaattoribakteereissa ja eläintauteja aiheuttavissa bakteereissa. Uutena osiona raportissa on katsaus metisilliinille resistentin *Staphylococcus aureus* (MRSA) -bakteerin esiintymiseen Suomessa seuraeläimillä ja sioilla.

Mikrobilääkkeiden kulutus Suomessa

Kokonaiskulutuksessa oli selvästi havaittava nousu, 22,7 %, vuodesta 2006 vuoteen 2008, mutta vuodesta 2008 vuoteen 2009 kulutus laski 4,8 %. Kulutus kasvoi vuodesta 2001 vuoteen 2009 19,5 %, mutta vuosikymmenen pienimmästä kulutuksesta vuonna 2003 nousua vuoteen 2009 oli 26,1 %. Nämä muutokset eivät selity pelkällä tilastollisella vaihtelulla, vaan ne heijastavat oikeasti kasvanutta bakteeriperäisten infektioiden ilmaantuvuutta. Kulutus suhteutettuna tuotantoeläinten biomassaan (tuotetut lihakilot + elävien nautojen biomassa) oli n. 31 mg antibioottia/1 kg biomassaa v. 2009. Erityisesti nautojen utaretulehduksen hoitoon lypsykaudella paikallisesti käytettyjen antibiootti-hoitoannosten lukumäärä oli n 2/lypsylehmä; tämä määrä on pysynyt suhteellisen vakiona vuosina 2007-2009.

G-penisilliini on edelleen käytetyin mikrobilääke ja sulfonamidi-trimetopriimi yhdistelmä seuraavaksi eniten käytetty. Betalaktaamit kattoivat v. 2009 61,2 %, sulfonamidi-trimetopriimi 19,2 % ja tetrasykliini 13,8 % kokonaiskulutuksesta. Muiden antibioottien käyttö on verraten marginaalista; kokonaiskulutuksesta niiden osuus yhteensä on 5,8 %.

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 (esimerkiksi 22 eristystä v. 2009), mikä kuvastaa tartuntojen kansainvälisesti vertaillen erittäin alhaista tasoa. V. 2009 tuotantoeläimistä tehtyjen eristysten lisäksi tutkittiin 52 rehun välityksellä levinneen *S.* Tennesseen eristystä. Tuotantoeläimillä resistenssiä esiintyy jonkin verran, erityisesti naudoissa kahdesta

tunnetusta infektiofokuksesta eristetyillä *S*. Typhimurium -kannoilla. *S*. Tennessee -eristykset (samaa kloonia) olivat pääsääntöisesti herkkiä kaikille tutkituille antibiooteille. Broilereista tai naudoista eristetyillä kampylobakteereilla resistenssiä on toistaiseksi pidettävä poikkeuksellisena; korkeimmillaan sitä esiintyy joidenkin antibioottien osalta 1-2 %:lla kannoista. Sioista eristetyillä *Campylobacter coli* -kannoilla resistenssiä esiintyy hiukan enemmän, mutta resistenttien kantojen osuus jää niilläkin alle 10 %

Indikaattoribakteerien resistenssi

Escherichia coli -, *Enterococcus faecalis* - ja *Ent. faecium* -kantoja kerättiin v. 2007 sioista, v. 2008 broilereista ja v. 2009 naudoista teurastuksen yhteydessä otetuista näytteistä. Resistenssi varsinkin naudoista eristetyillä *E. coli* -kannoilla oli harvinaista; samoin sen esiintyminen broilereista eristetyillä kannoilla oli epätavallista. Eniten resistenssiä esiintyi sikojen *E. coli* -kannoilla, ja korkeimmat todetut resistenttien kantojen osuudet olivat 17,7 % tetrasykliinille, 14,8 % streptomysiinille ja 11,9 % sulfonamidille. *Ent. faecalis* -kannoilla resistenssiä esiintyi kaikilla tuotantoeläimillä lähinnä erytromysiinille ja tetrasykliinille; broilereilla myös basitrasiinille ja narasiinille. Korkein resistenttien kantojen osuus oli 82,7 % tetrasykliinille sioista eristetyillä kannoilla; eristysten kokonaismäärä oli tosin vain 38. *Ent. faecium* -kannoilla (vain broilerit ja naudat) resistenssin esiintyminen oli verraten samansuuntaista kuin *Ent. faecalis* -kannoilla: erytromysiini- ja tetrasykliiniresistenssiä jonkin verran; broilereilla myös basitrasiini- ja narasiiniresistenssiä.

Eläimille tautia aiheuttavien bakteerien resistenssi

Tähän ryhmään on koottu tietoja sikojen (porsaiden) enteriittiä aiheuttavien *E. coli* -kantojen ja koirien tulehduksia aiheuttavien *Staphylococcus pseudintermedius* -kantojen resistensseistä. Porsaiden enteriitti *E. coli* -kannoilla resistenssiä esiintyy säännöllisesti ja verraten yleisesti ampisilliinille, siprofloksasiinille, nalidiksiinihapolle, streptomysiinille, sulfonamidille, tetrasykliinille ja trimetopriimille. Moniresistenssi oli tavallista ja se näyttäisi lisääntyvän; esimerkiksi v. 2009 58 % kannoista oli resistenttejä useammalle kuin kahdelle antibiootille. Eristysten lukumäärät olivat kaikkina vuosina tilastollisen edustavuuden kannalta melko pieniä; 18 v. 2007, 28 v. 2008 ja 24 v. 2009. Koirien *S. pseudintermedius* -kannoilla resistenssi oli erityisen yleistä G-penisilliinille; kaikkina vuosina yli 80 % kannoista resistenttejä, mutta resistenssiä todettiin joka vuosi kaikille tutkituille antibioottiryhmille. V. 2009 vain 11 % kannoista oli herkkiä kaikille tutktuille antibiooteille ja 40 % kannoista oli resistenttejä kolmelle tai useammalle antibiootille. Tässäkin eristysten kokonaismäärät olivat pienehköjä ja eri antibiootteja tutkittiin 33-34 kannalta v. 2007, 49-59 kannalta v. 2008 ja 70-72 kannalta v. 2009.

Metisilliinille resistentti *Staphylococcus aureus* (MRSA)

Ennen vuotta 2007 eläimiin liittyvä MRSA oli satunnainen löydös Suomessa. V. 2007 todettiin Yliopistollisessa eläinsairaalassa (YES) hoidettavana olevilla hevosilla MRSA -taudinpurkaus, jossa oli 3 infektoitunutta ja 10 kantajaeläintä. Yksi infektoitunut ja yksi kantajaeläin löydettiin YESistä myös v. 2008. V. 2007 MRSA todettiin myös kahdella kissalla ja v. 2009 yhdellä koiralla. EUn jäsenvaltioissa tehtiin v. 2008 selvitys MRSAn esiintyvyydestä jalostus- ja tuotantosikaloissa. Suomen 207 tutkitusta tilasta yhdellä (0,5 %) todettiin MRSA. Syyskuusta 2009 elokuuhun 2010 tehtiin alustava selvitys MRSAn esiintyvyydestä lihasikaloissa ja porsastuotantosikaloissa. Tutkituista 59 lihasikalasta ja 36 porsastuotantosikalasta MRSA löytyi vastaavasti kolmestatoista ja yhdestä sikalasta. Näennäinen esiintyvyys näiden havaintojen perusteella olisi siis 14,7 %. Lukuun pitää suhtautua varauksin, koska näytteenotto ei ollut riittävän satunnaista. Voidaan kuitenkin päätellä, että MRSAn esiintyvyys on korkeampi kuin EU perustasokartoituksen perusteella näyttäisi.

Resumé

I den här rapporten sammanfattas uppföljningen av resultaten från projektet FINRES-Vet under åren 2007-2009. För att kunna uppskatta förändringarna på lång sikt, ingår tabeller och scheman över konsumtionen av de flesta veterinärmedicinska läkemedel och fodertillsatser i rapporten från och med år 2001. Rapporten är huvudsakligen uppbyggd på samma sätt som de föregående rapporterna (den senaste för åren 2005-2006), 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. Som en ny del i rapporten finns en översikt över förekomsten av den meticillinresistenta bakterien *Staphylococcus aureus* (MRSA) hos sällskapsdjur och svin i Finland.

Konsumtion av antimikrobiella medel i Finland
En klar ökning av den totala konsumtionen konstaterades, 22,7 % från år 2006 till år 2008, men från år 2008 till år 2009 sjönk konsumtionen med 4,8 %. Konsumtionen ökade från år 2001 till år 2009 med 19,5 %, men ökningen från årtiondets lägsta konsumtion år 2003 till år 2009 var 26,1 %. Dessa förändringar förklaras inte enbart av statistiska fluktuationer utan de avspeglar också att förekomsten av bakteriella infektioner verkligen har ökat. Konsumtionen i relation till produktionsdjurens biomassa (kg producerat kött + levande nötdjurs biomassa) var cirka 31 mg antibiotika/1 kg biomassa år 2009. I synnerhet antalet antibiotikabehandlingar som administreras lokalt för vård av juverinflammation hos kor under mjölkningsperioden var ca 2/mjölkko; denna mängd har förblivit relativt oförändrad under åren 2007-2009.

G-penicillin är fortfarande det mest använda antimikrobiella medlet och kombinationen sulfonamid-trimetoprim det näst mest använda. År 2009 täckte betalaktamer 61,2 %, sulfonamid-trimetoprim 19,2 % och tetracyklin 13,8 % av den totala konsumtionen. Användningen av andra antibiotika är jämförelsevis marginell; deras andel av den totala konsumtionen är totalt 5,8 %.

Resistens hos bakterier som orsakar zoonoser
Programmet FINRES-Vet täcker, inom ramarna för det nationella programmet för salmonellakontroll, salmonella som isolerats från nötdjur, svin och fjäderfä, samt salmonella som har isolerats från inhemska livsmedel och vid livsmedelsföretagarnas egenkontroll. Därtill uppföljs resistensen hos campylobacter som har isolerats från broilrar, nötdjur och svin.

Från produktionsdjur isoleras årligen högst några tiotal salmonella (t.ex. 22 isoleringar år 2009), vilket reflekterar en mycket låg nivå av infektioner vid en internationell

jämförelse. År 2009 undersöktes isoleringar från produktionsdjur och därtill gjordes 52 isoleringar av *S*. Tennessee som spridits genom foder. Hos produktionsdjur förekommer resistens till en viss mån, i synnerhet hos stammar av *S*. Typhimurium som isolerats från nötdjur från två infektionsfoci. Isoleringarna av *S*. Tennessee (samma klon) var huvudsakligen känsliga för alla undersökta antibiotika. Hos campylobacter som isolerats från broilrar eller nötdjur ska resistens tillsvidare anses vara ovanlig; som högst förekommer resistens hos 1-2 % av stammarna avseende vissa antibiotika. Hos stammar av *Campylobacter coli* som isolerats från svin förekommer något mera resistens, men andelen resistenta stammar förblir även där under 10 %.

Resistens hos indikatorbakterier

Stammar av *Escherichia coli*, *Enterococcus faecalis* och *Ent. faecium* insamlades år 2007 från svin, år 2008 från broilrar och år 2009 från nötdjur av prover som tagits i samband med slakt. Resistens i synnerhet hos stammar av *E. coli* som isolerats från nötdjur var sällsynt, vilket också gällde för dess förekomst hos stammar som isolerats från broilrar. Mest resistens påträffades hos stammar av *E. coli* hos svin, och de högsta andelarna resistenta stammar var 17,7 % för tetracyklin, 14,8 % för streptomycin och 11,9 % för sulfonamid. Hos stammar av *Ent. faecalis* påträffades resistens hos alla produktionsdjur närmast mot erytromycin och tetracyklin; hos broilrar också mot bacitracin och narasin. Den högsta andelen resistenta stammar var 82,7 % för tetracyklin hos stammar som isolerats från svin; det totala antalet isoleringar var ändå bara 38. Hos stammar av *Ent. faecium* (endast broilrar och nötdjur) förekom resistens av jämförelsevis samma slag som hos stammar av *Ent. faecalis*: resistens mot erytromycin och tetracyklin i någon mån, hos broilrar även resistens mot bacitracin och narasin.

Resistens hos bakterier som orsakar sjukdomar hos djur

I den här gruppen ingår information om resistens mot stammar av *E. coli* som orsakar enterit hos svin (grisar) och mot stammar av *Staphylococcus pseudintermedius* som orsakar inflammationer hos sällskapsdjur. Hos stammar av *E. coli* som orsakar enterit hos grisar förekommer regelbundet och förhållandevis allmänt resistens mot ampicillin, ciprofloxacin, nalidixinsyra, streptomycin, sulfonamid, tetracyklin och trimetoprim. Antalet isoleringar var under alla år ganska få med tanke på statistisk representativitet; 18 år 2007, 28 år 2008 och 24 år 2009. Resistens förekom ändå år 2009 mot flera antibiotika hos över hälften av de analyserade stammarna. Hos stammar av *S. pseudintermedius* som förekommer hos sällskapsdjur var resistens mot G-penicillin speciellt allmän; under alla år var över 80 % av stammarna resistenta, men resistens påvisades varje år inom alla analyserade antibiotikagrupper. Även här var de totala antalen isoleringar rätt få och olika antibiotika analyserades för 33-34 stammar år 2007, 49-59 stammar år 2008 och 70-72 stammar år 2009.

Meticillinresistenta *Staphylococcus aureus* (MRSA)

Före år 2007 hade man endast gjort sporadiska fynd av MRSA hos djur i Finland. År 2007 påvisades ett utbrott av MRSA hos hästar som vårdades vid Universitetets djursjukhus, med 3 infekterade djur och 10 bärardjur. Även år 2008 upptäcktes ett infekterat djur och ett bärardjur vid Universitetets djursjukhus. År 2007 påvisades MRSA också hos två katter och år 2009 hos en hund. I EU:s medlemsstater gjordes år 2008 en utredning över förekomsten av MRSA vid svingårdar med uppfödning och produktion. Av de 207 gårdar som undersöktes i Finland konstaterades MRSA på en gård (0,5 %). Från september 2009 till augusti 2010 gjordes en preliminär utredning över förekomsten av MRSA vid gödsvinsstall och svinstallar med smågrisproduktion. Av 59 gödsvinsstall och 36 svinstallar med smågrisproduktion upptäcktes MRSA vid tretton respektive en gård. Utgående från dessa observationer skulle den skenbara förekomsten alltså vara 14,7 %. Man ska ändå förhålla sig kritisk till siffran, eftersom provtagningen inte var tillräckligt slumpmässig.

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) 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 fourth FINRES-Vet report including data from the years 2007-2009. Indicator bacteria were collected from broilers in 2002, 2005 and 2008, from cattle in 2003, 2006 and 2009, and from pigs in 2004, 2007 (and 2010). Zoonotic bacteria obtained for analysis are *Salmonella* and *Campylobacter,* animal pathogens diarrheagenic

Escherichia coli from pigs and *Staphylococcus pseudintermedius* from dogs. The monitored indicator bacteria are *E. coli*, *Enterococcus faecalis* and *Ent. 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.

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.

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

1.1 Therapeutic antimicrobials

1.1.1 Antimicrobials used to treat animals

Finnish medicines agency, Fimea, (until the end of 2009 the National Agency for Medicines) monitors the quantity of veterinary medicinal products used in Finland. The statistics are based on sales figures provided by the wholesalers and the consumption is given as kg active substance. The figures include products that have marketing authorisation as well as those sold under special licence. Species-specific data are not available as many veterinary medicinal products are authorized for several species. Products authorised for human use but prescribed for animals are not included. It is unlikely that their absence markedly offsets the figures, as the proportion of human products used mainly in companion-animal practice account for 10-15% of all antimicrobials used for these species (Rantala, 2003; Hölsö *et al.*, 2005).

1.1.2 Total volume of use

The total amount of antimicrobial products, calculated as kg of the active substance, has increased during the decade 2000-2010. Compared to year 2001 the consumption was 20% (2 700 kg) higher in 2009. The total sales were at the lowest in 2003. From 2004 to 2008 the total sales increased by 30% (4 000 kg). In 2009 a decrease of 5% (equalling to 800 kg) was recorded.

Table 1 and Figure 1 show the overall consumption divided into the main antimicrobial groups. Penicillin G continues to be the most commoly used antimicrobial, while the combination of sulphonamide and trimethoprim holds the second place.

Table 1. *Total amount of antimicrobial products authorised for veterinary use expressed as kg active substance*)*

Total consumption	2001	2002	2003	2004	2005	2006	2007	2008	2009
Tetracyclines*	1 937	1 980	1 757	1 263	1 445	1 320	1 705	3 140	2 284
Amphenicols	0	1	1	0	0	0	0	0	6
Betalactams (penicillins)									9 121
Penicillin G	6 235	6 054	6 076	6 754	6 803	6 905	7 512	7 740	7 753
Aminopenicillins	532	637	698	798	958	846	1 057	1 178	1 256
Cloxacillin	149	146	145	140	132	109	96	97	113
Cephalosporins	1 153	1 055	1 133	1 048	1 000	1 004	1 030	1 027	987
1st gen. cephalosporins									985
3rd gen. cephalosporins									2
Sulphonamides and Trimetoprim total	24 90	2 342	2 187	23 68	2 438	2 946	2 655	2 933	3 165
Sulphonamides									2 637
Trimetoprim									527
Macrolides, lincosamides	492	427	538	526	393	619	752	847	594
Macrolides									429
Lincosamides									165
Aminoglycosides	632	385	291	280	238	225	180	170	179
Quinolones (total)									97
Fluoroquinolones	101	114	81	79	90	81	88	90	97
Other Quinolones (Oxolinic acid)									0
Polymyxins**									0
Pleuromutilins**									80
Others***	103	94	186	107	112	74	80	120	0
Total	**13 824**	**13 234**	**13 092**	**13 362**	**13 609**	**14 129**	**15 155**	**17 342**	**16 513**

*2001-2004 consumption of tetracyclines in uteritorias included. 2006-2008 tetracycline consumption in local preparations included
** Before 2009 consumption was included in 'Others'
*** Before 2009 included polymyxins and pleuromutilins

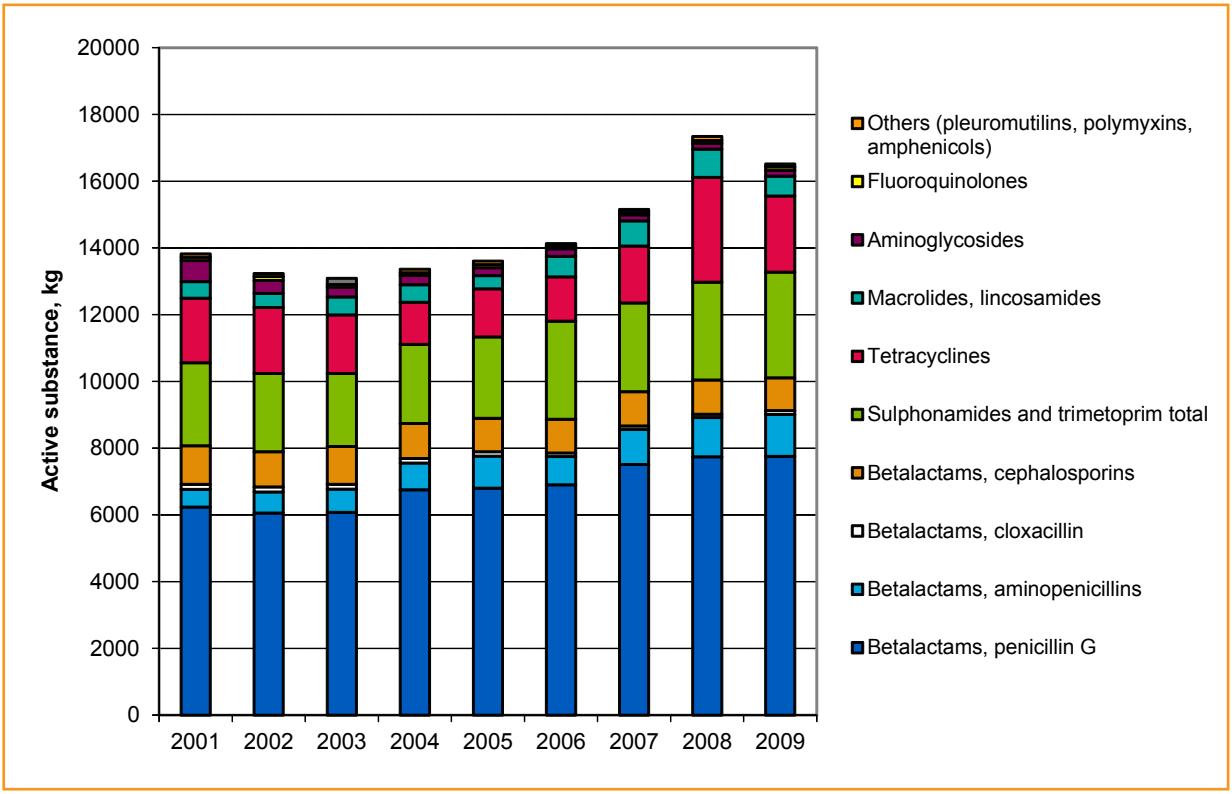

Figure 1. *Antimicrobials used for treatment of animals*

1.1.3 Sales in relation to the biomass of major production animals

The consumption statistics should be considered in respect to the actual biomass of the animal populations (Grave *et al.* 2010). Figure 2 shows the biomass of pork, beef and poultry meat, plus an estimate of the live weight of dairy cattle in Finland between 2001-2009. The live weight of dairy cattle is included because it represents a substantial proportion of the total bovine biomass. The biomass of pork and especially poultry meat represents more accurately the total respective biomasses because of the shorter production periods. The overall biomass has remained relatively constant through the decade. The number of dairy cows has decreased by 65 000 animals (18%). The production of beef has also decreased (9%) but production of pork and poultry meat has increased (19% and 25%, respectively, from 2001 to 2009).

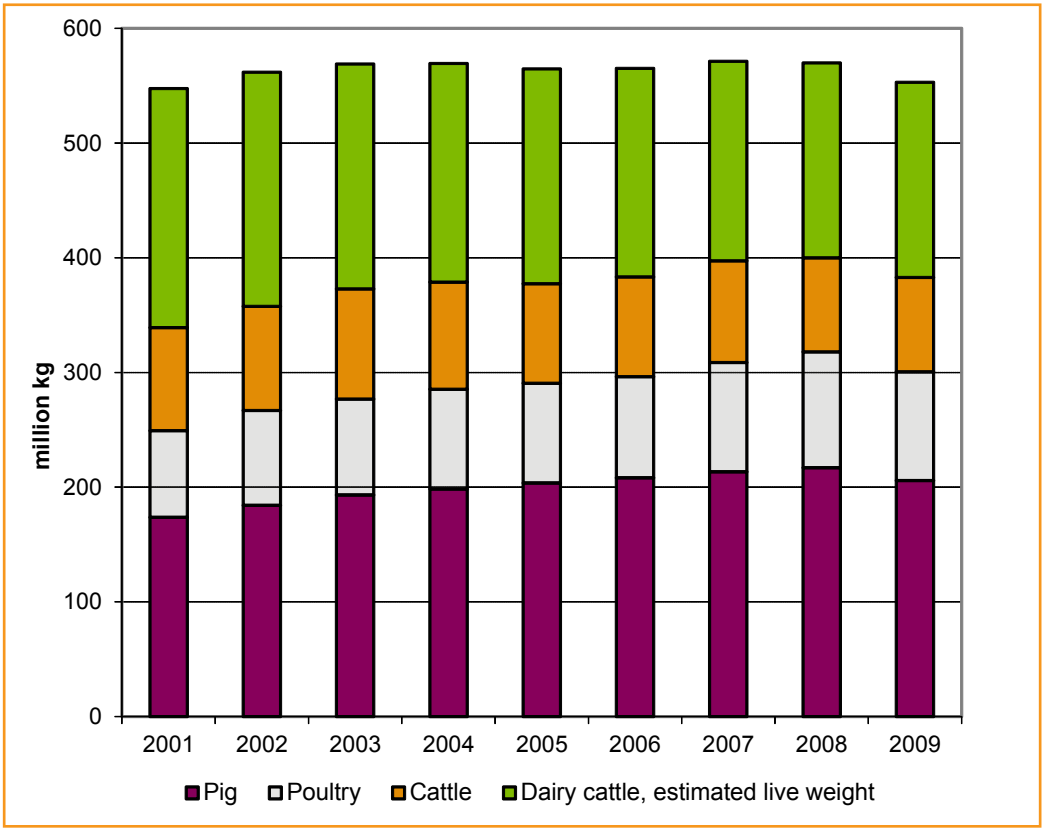

Figure 2. *Production of pig meat, poultry meat and cattle meat and estimated live weight of dairy cattle. Biomass of live dairy cattle was obtained by multiplying numbers of dairy cattle by weight of 500 kg. Data: Matilda Agricultural Statistics http://www.maataloustilastot.fi/*

1.1.4 Injectable antimicrobial products

The amount of antimicrobial vet med products given in injectable form is shown in Table 2. The sales increased from 2001 to 2009 by 28% (2 000 kg). The steepest increases took place between the years 2003–2004 and 2006–2007. Sales of especially Penicillin G increased in these years. However the highest relative rise was seen in sales of injectable aminopenicillins (four-fold increase from 2001 to 2009) and tetracyclines (sales doubled from 2001 to 2009).

Penicillin G continues to be the most commonly used injectable antimicrobial in veterinary medicine in Finland (47% of the kg-overall sales and 89 % of injectables). The use of injectable fluoroquinolones remains small (< 1% of injectables).

Table 2. *Antimicrobial substances used in injectables expressed in kg active substance*

Injectables	2001	2002	2003	2004	2005	2006	2007	2008	2009
Tetracyclines, doxycyclin	196	143	265	291	312	288	418	442	470
Amphenicols	0	1	1	0	0	0	0	0	0
Betalactams (penicillins)									7 964
Penicillin G	5 981	5 799	5 840	6 529	6 597	6 739	7 339	7 552	7 551
Aminopenicillins	76	115	133	145	236	170	358	410	413
Cephalosporins*						1	4	4	4
1st gen. cephalosporins									1
3rd gen. cephalosporins									2
Sulphonamides and Trimetoprim total	599	474	425	442	463	457	420	415	370
Sulphonamides									308
Trimetoprim									62
Macrolides, lincosamides	63	70	49	44	76	81	92	60	53
Macrolides									15
Lincosamides									38
Aminoglycosides	0	1	1	1	11	12	10	12	18
Quinolones									81
Fluoroquinolones	70	70	69	66	77	67	74	75	81
Other quinolones									0
Others	1	0	0	0	0	0	0	0	0
Total	**6 986**	**6 673**	**6 783**	**7 518**	**7 771**	**7 815**	**8 714**	**8 970**	**8 960**

* Before 2006 consumption of cephalosporins was included in "Others"

1.1.5 Orally administered antimicrobial products

The sales of orally used antimicrobial products increased by 25% (1 500 kg) from 2001 to 2009. The steepest rise in consumption was recorded between the years 2007 and 2008 (33%, 1 900 kg).

The most commonly administered oral antimicrobials in 2009 were sulphonamides (2 800 kg) and tetracyclines (1 800 kg). Compared to 2001 the sales of sulphonamides increased by 48%. Consumption of tetracyclines has fluctuated significantly through the decade. The use of tetracyclines was at its lowest in 2003 (970 kg) and since then the sales have increased significantly. However, the difference in sales figures between 2001 and 2009 is comparatively modest (Table 3).

Consumption of antimicrobial classes other than tetracyclines (e.g. macrolides and lincosamides) has also fluctuated considerably over the years; thus conclusions should be drawn only guardedly. For some classes the sales have remained comparatively steady (e.g. cephalosporins appr. 950 kg / year and fluoroquinolones < 20 kg / year). All oral cephalosporins are of 1st generation and they are used to treat companion animals.

Table 3. *Total amount of per oral antimicrobial products authorised for veterinary use expressed as kg of active substance*)*

Orally administered	2001	2002	2003	2004	2005	2006	2007	2008	2009
Tetracyclines	1 672	1 799	1 380	967	1 135	928	1 188	2 565	1 815
Amphenicols	4	0	16	14	0	0	0	66	6
Betalactams (penicillins)									811
Penicillin G									0
Aminopenicillins	424	507	536	620	690	650	654	737	811
Cephalosporins									942
1st gen. cephalosporins	939	887	998	938	915	940	966	976	942
3rd gen. cephalosporins									0
Sulphonamides and Trimetoprim total	1 892	1 868	1 762	1 926	1 975	2 489	2 235	2 518	2 794
Sulphonamides									2 329
Trimetoprim									466
Macrolides, lincosamides	428	358	497	481	316	538	659	786	541
Macrolides									414
Lincosamides									126
Aminoglycosides	150	142	125	123	111	110	103	95	101
Quinolones (total)									16
Fluoroquinolones	11	26	12	12	13	14	14	15	16
Other Quinolones (Oxolinic acid)	20	18	0	0	0	0	0	0	0
Pleuromutilines	95	89	84	90	110	68	20	17	80
Others	1	1	0	0	0	0	0	0	0
Total	**5 636**	**5 693**	**5 410**	**5 172**	**5 264**	**5 735**	**5 838**	**7 774**	**7 105**

1.1.5.1 Group treatment

Some of the oral products are administered mixed in feed or drinking water. This enables simultaneous treatment of groups of animals. Sales statistics for products intended for group treatment are available since 2006 In 2009 the sales of these products was 4 900 kg, approximately 700 kg less than in 2008. (Figure 3). The proportion of products intended for group treatment in 2006 was 20% of all oral products and 50% of all veterinary antimicrobial sales. In 2009 the figures were 29% and 68%, respectively.

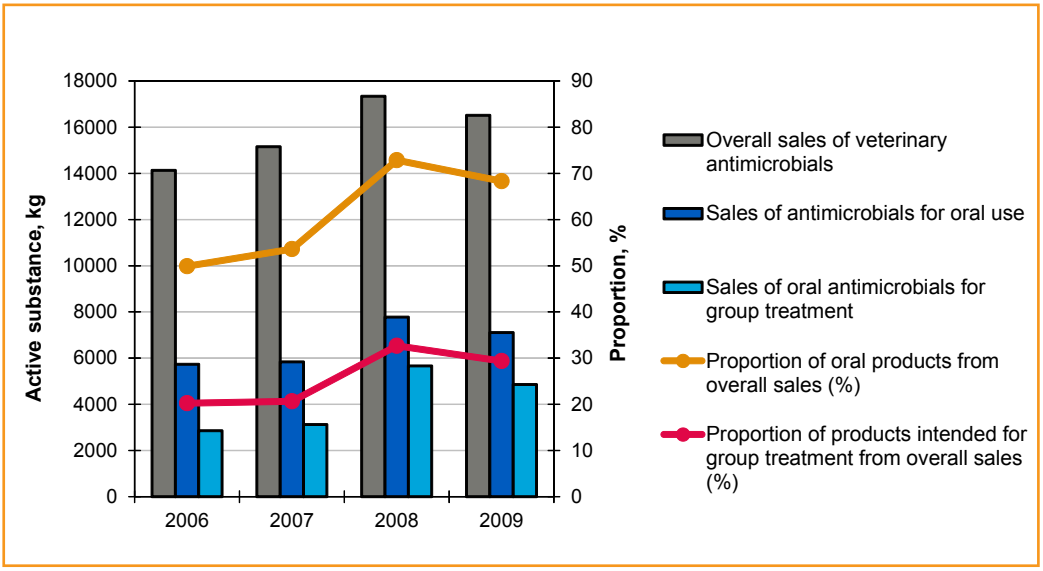

Figure 3. *Sales of veterinary antimicrobials used orally and for group treatment, and their proportion from the overall veterinary antimicrobial sales.*

1.1.6 Intramammary antimicrobials

The use antimicrobials for intramammary use for dry cow period is shown in Table 4 and that for lactation period in Table 5. The amount of antimicrobials used for treatment of mastitis during lactation and during the dry cow period, as well as the total number of dairy cows are shown in Figure 5. The major explanation for the decreasing use of intramammary products is the declining number of dairy cows, although there is also a trend to use fewer intramammary administrations per cow for treatment of mastitis during lactation. In contrast, dry-cow treatment has remained fairly steady. Antimicrobials for intramammary use calculated as the number of single-dose applications are shown in Table 6.

Table 4. *Antimicrobials for intramammary use for dry cow period expressed in kg of active substance*

Intramammary tubes, dry cow	2001	2002	2003	2004	2005	2006	2007	2008	2009
Penicillin	29	32	34	43	40	33	30	38	44
Other betalactams	125	112	100	92	89	76	79	70	62
Amino penicillins	7	5	5	6	7	7	14	6	9
Cephalexin	45	34	24	20	16	12	10	7	7
Cloxacillin	73	73	71	65	65	58	55	57	46
Aminoglycosides	67	49	40	41	34	29	27	22	25
Others	3	4	3	4	0	0	0	0	0
Total	**224**	**197**	**177**	**179**	**163**	**138**	**135**	**130**	**132**

Table 5. *Antimicrobials for intramammary use during lactation period expressed in kg of active substance.*

Intramammary tubes, lactation phase	2001	2002	2003	2004	2005	2006	2007	2008	2009
Penicillin	225	223	202	182	167	132	143	149	157
Other betalactams	270	232	208	190	162	123	123	106	124
Amino penicillins	25	25	24	26	26	19	31	26	23
Cephalexin	169	134	110	89	68	52	51	40	34
Cloxacillin	76	73	74	75	67	52	41	40	67
Aminoglycosides	414	193	125	115	81	72	51	40	34
Macrolides	0	1	1	1	1	1	1	1	1
Total	**909**	**636**	**536**	**488**	**411**	**329**	**318**	**296**	**316**

Table 6. *Antimicrobials for intramammary use calculated as the number of single-dose applicators per cow.*

	Lactating cow intrammammaries / cow	Dry cow intramammaries / cow	Cows x 1000
2001	2,72	0,86	354,8
2002	2,65	0,84	347,8
2003	2,47	0,83	333,9
2004	2,47	0,81	324,4
2005	2,29	0,79	319
2006	2,01	0,80	309,4
2007	2,04	0,83	296
2008	2,00	0,84	289
2009	2,02	0,84	290

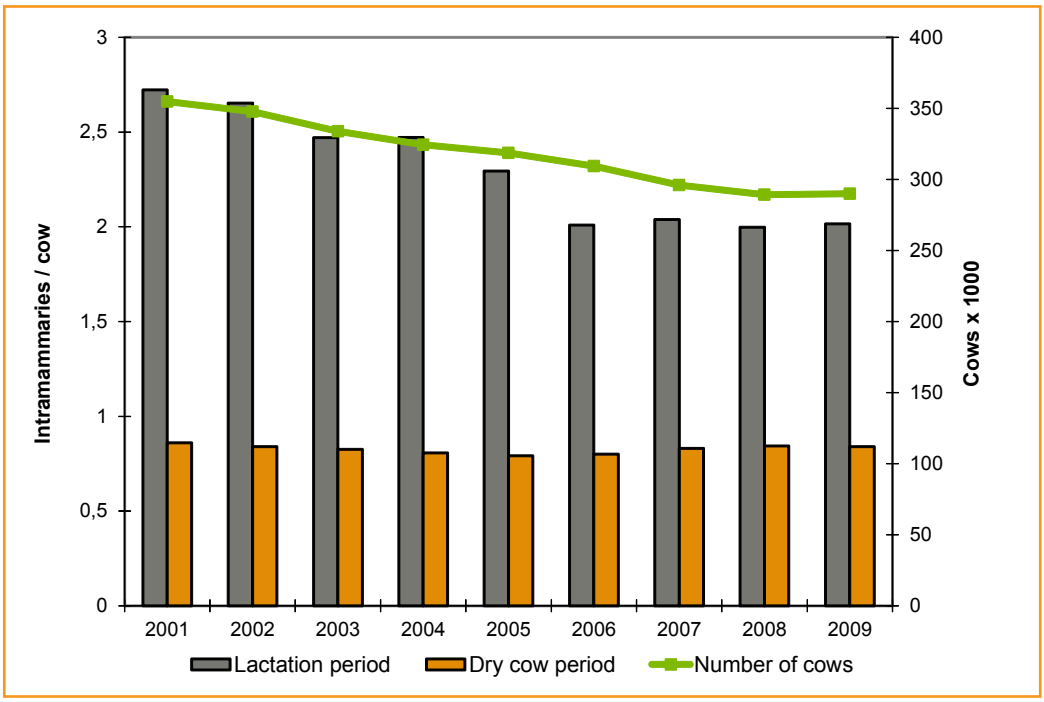

Figure 4. *Antimicrobials for intramammary use during lactation period (blue column) and for dry cow period (red column) and the number of dairy cows (green curve).*

1.2 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 7 presents the total sales of feed additives in Finland in 2000-2009. The coccidiostats monensin and narasin are used as prophylactic anti-parasitic agents mainly in broiler and turkey production; the use of narasin has increased after the year 2006 while that of monensin has been steady over the three-year period. The use of salinomycin has increased over the last three years.

Table 7. *The use of antimicrobial feed additives, coccidiostats and growth promoters in Finland in 2001-2009 (kg active substance/year).*

Substance	2001	2002	2003	2004	2005	2006	2007	2008	2009
Amprolium (and ethopabate)	79	22	0	0	0	0	0	0	0
Avoparcin	0	0	0	0	0	0	0	0	0
Dimetridazole	0	0	0	0	0	0	0	0	0
Flavomycin	32	3	0	0	0	0	0	0	0
Lasalocid sodium	3 624	3 349	176	0	0	0	0	0	0
Carbadox	0	0	0	0	0	0	0	0	0
Olaquindox	0	0	0	0	0	0	0	0	0
Madmuramycin ammonium	0	8	43	1,5	1,5	0	0	5	0
Monensin natrium	1 475	1 969	4 422	5 808	8 458	[4]9 585	[7]5 560	5 376	5 546
Narasin	2 101	5 569	5 769	5 518	[2]3 218	[5]2 481	[8]8 007	[10]7 236	6 056
Salinomycin	3 272	28	3	[1]10	[3]374	[6]1 328	[9]35	[11]107	[12]1 713
Nifursol	0	0	0	0	0	0	0	0	0
Robenidine hydrochloride	0	0	0	0	0	0	0	0	0

[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]35 kg, [10]7.2 kg, [11]107 kg, and [12]117 kg used in exported feed mixtures

1.3 Concluding remarks

The overall consumption of antimicrobial agents to treat animals increased during the decade. For example, the sales of injectable agents increased by 28% in 2001-2009, and that of orally administered products by 26% in 2001-2008. However, there was a minor decrease (9%) in the latter category in 2008-2009. The sales of injectable aminopenicillins and tetracyclines showed the steepest increase, 444% and 140% respectively, during 2001-2009 (Figure 1). Consumption of tetracyclines for oral group treatment also increased by 118% in 2007-2008, but decreased by 29% in 2009. Furthermore, the sales of orally administered trimethoprim-sulphonamides increased by 48% during 2001-2009.

Most of the products are authorised for several species and resolution of the consumption figures to animal species or treatment indication levels is not possible by sales statistics only. The information enabling this analysis does exist in the medicine consumption accounts in the farms, or in the medicine usage accounts of the veterinarians, required by the Acts 13/EEO/2000 and 8/EEO/2008, respectively, but neither data have been collected to a central register. Since 2009 there has been a system for collecting and storing data concerning health status and medical treatments of the animals on a farm. This system is built in the internet-based centralized health care register systems for swine farms (SIKAVA) and for cattle farms (NASEVA). These registers are maintained by the Association for Animal Disease Prevention ETT ry.

The increase in consumption evidently reflects a heavier burden of infectious diseases. It is for example known from the slaughterhouse lung rejection statistics that the incidence of swine pleuropneumonia increased in 2008. This is largely attributed to previous exposure of the animals to swine influenza epidemic. However, the predisposing effect of swine viral infections has been curtailed by vaccinations and improvements in the management systems. The favourable trend is seen already in the decreasing consumption statistics of 2009. Bigger size animal units, more intensive production systems and movement of animals between farms may also have an impact on the prevalence of infections. These factors are thought to be associated with the increased incidence of contagious hoof infections of cattle and pneumonia of calves, which require intensive antibiotic treatment.

2 Antimicrobial resistance in zoonootic bacteria

2.1 *Salmonella* in production animals and domestic food

The prevalence of *Salmonella* 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 antimicrobial resistance of all *Salmonella* isolates from cattle, pigs, poultry and domestic food are determined in the FINRES-Vet programme. All isolates from 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 1. Correspondences between the verbal descriptions of the resistance levels and the actual percentage categories are given in Appendix 1.

2.1.1 Developments in the situation in 2007-2009

A total of 38 salmonella isolates were detected among domestic production animals in 2007. Of these 21 were *S.* Typhimurium, 7 *S.* Livingstone, 2 *S.* Infantis, 2 *S.* Derby and 6 belonged to other serovars. Eighteen isolates originated from cattle, 6 from pigs, 11 from poultry (*Gallus gallus*) and 3 from turkeys. Of the 21 *S.* Typhimurium isolates, 14 originated from cattle, 3 from pigs, 3 from turkeys and 1 from poultry.

The isolates originating from pigs and turkeys were susceptible to every tested antimicrobial. One broiler isolate was resistant to ciprofloxacin, and seven bovine isolates were resistant to at least one antimicrobial. Six *S.* Typhimurium isolates were resistant to streptomycin, sulphonamides and tetracycline. One *S.* Rissen isolate was resistant to trimethoprim, chloramphenicol, tetracycline and ampicillin. In 2007, three isolates from domestic food were obtained. These three belonged to serovars *S.* Typhimurium, *S.* Agona and *S.* Tennessee. The isolates were susceptible to all antimicrobials tested (Table 8).

Of the 21 isolates obtained from domestic production animals in 2008, 15 were *S.* Typhimurium, three were *S.* Livingstone, and three were other serovars. Eleven isolates originated from cattle, five from pigs, four from poultry (*Gallus gallus*) and one from turkeys.

Isolates originating from pigs, poultry and turkeys were susceptible to every antimicrobial tested. Of the bovine isolates, four were resistant to at least two antimicrobials: two *S.* Typhimurium DT 104b to ampicillin, tetracycline, chloramphenicol, trimethoprim and sulphonamides, one *S.* Typhimurium DT 104 to ampicillin and sulphonamides, and one *S.* Enteritidis to ciprofloxacin and nalidixic acid. One *S.* Livingstone from broilers was resistant to ciprofloxacin. In 2008, three *S.* Typhimurium isolates from domestic food were obtained. These three were susceptible to all antimicrobials tested (Table 9).

In 2009 the Salmonella situation was exceptional due to a feed-borne *S.* Tennessee outbreak in pigs and laying hens. *S.* Tennessee was first detected in two laying hen holdings and one pig herd in routine National *Salmonella* Control Programme sampling, and the infection was traced back to contaminated product from a Finnish feed factory. More than 800 laying hen holdings and pig herds which had received the suspected feed were investigated. *S.* Tennessee was detected in 30 laying hen holdings (faecal and dust samples) and in pooled faecal samples from 12 pig herds. An additional 20 pig holdings had *S.* Tennessee in environmental samples taken from the feeding systems of farms. Official feed samples from 605 animal holdings were analysed; salmonella was detected in 40 samples taken from 39 holdings. Selected *S.* Tennessee isolates from official feed samples, hen and pig samples and environmental samples of the feed factory were genotyped by XbaI-PFGE. All isolates were identical (Kuronen *et al.* 2010).

Fifty-two isolates were included in antimicrobial resistance testing. The isolates were susceptible to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulphamethoxazole, tetracycline and trimethoprim. Apparent streptomycin resistance was detected in 3.8% of the isolates, but this figure probably reflects the ambiguities in establishing the streptomycin epidemiological cut-off value for *Salmonella*, and not true resistance (Table 10).

In addition to the 52 isolates associated with the feed-borne outbreak, 22 isolates from production animals were tested. Of these eight were *S.* Typhimurium, nine were *S.* Montevideo, and five belonged to other serovars. Seven isolates originated from cattle and the other 15 from poultry (*Gallus gallus*). Three bovine *S.* Typhimurium DT 104 isolates were resistant to ampicillin, nalidixic acid, ciprofloxacin, chloramphenicol, sulphonamides, tetracycline and trimethoprim, and two bovine *S.* Typhimurium DT 104 isolates were resistant to ampicillin and sulphonamides.

No resistance to third generation cephalosporins was detected in 2007-2009. During this period, resistance was detected mainly in bovine *Salmonella* isolates and in one broiler isolate. Antimicrobial resistance is typically encountered in *S.* Typhimurium. Occurrence of resistance in *Salmonella* in Finland in 2007-2009 can at least partly be explained by clonal spreading of resistant *S.* Typhimurium isolates among Finnish cattle (Table 11).

Table 8. *Distribution of MICs for Salmonella in production animals in 2007 (n=38).*

			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**	**1024**	**2048**	**>2048**
Ampicillin	5.3	0.9-19.1							31.6	44.7	18.4					5.3						
Cefotaxime	0.0	0.0-11.4				36.8	52.6	10.5														
Chloramphenicol	2.6	0.1-15.4									10.5	76.3	5.3	5.3			2.6					
Ciprofloxacin	2.6	0.1-15.4			10.5	86.8	2.6															
Gentamicin	0.0	0.0-11.4							18.4	76.3	5.3											
Nalidixic acid	0.0	0.0-11.4										92.1	5.3	2.6								
Streptomycin	15.8	6.6-31.9										2.6	15.8	50.0	15.8				15.8			
Sulphamethoxazole	15.8	6.6-31.9												68.4	7.9	7.9						15.8
Tetracycline	18.4	8.3-34.9								23.7	50.0	7.9					18.4					
Trimethoprim	2.6	0.1-15.4						39.5	57.9							2.6						

Tables 8-16: 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.

Table 9. *Distribution of MICs for Salmonella in production animals in 2008 (n=21).*

			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**	**1024**	**2048**	**>2048**
Ampicillin	14.3	3.8-37.4							42.9	42.9						14.3						
Cefotaxime	0.0	0.0-19.2				47.6	52.4															
Chloramphenicol	9.5	1.7-31.8									23.8	66.7				4.8		4.8				
Ciprofloxacin	4.8	0.3-25.9			42.9	52.4		4.8														
Gentamicin	0.0	0.0-19.2							28.6	71.4												
Nalidixic acid	4.8	0.3-25.9										85.7	9.5					4.8				
Streptomycin	0.0	0.0-19.2										4.8	38.1	38.1	19.0							
Sulphamethoxazole	14.3	3.8-37.4												47.6	38.1							14.3
Tetracycline	9.5	1.7-31.8								33.3	57.1			9.5								
Trimethoprim	9.5	1.7-31.8						52.4	38.1							9.5						

Table 10. *Distribution of MICs for S. Tennessee isolates from a feed-borne outbreak (n=52).*

			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**	**1024**	**2048**	**>2048**
Ampicillin	0.0	0.0-8.6							46.2	53.8												
Cefotaxime	0.0	0.0-8.6					84.6	15.4														
Chloramphenicol	0.0	0.0-8.6										57.7	42.3									
Ciprofloxacin	0.0	0.0-8.6			21.2	78.8																
Gentamicin	0.0	0.0-8.6							17.3	71.2	11.5											
Nalidixic acid	0.0	0.0-8.6										96.2	3.8									
Streptomycin	3.8	0.7-14.3												50.0	46.2	3.8						
Sulphamethoxazole	0.0	0.0-8.6												100.0								
Tetracycline	0.0	0.0-8.6								40.4	59.6											
Trimethoprim	0.0	0.0-8.6							94.2	5.8												

Table 11. *Distribution of MICs for Salmonella in production animals in 2009 (n=22).*

			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**	**1024**	**2048**	**>2048**
Ampicillin	22.7	8.7-45.8							50.0	27.3						22.7						
Cefotaxime	0.0	0.0-18.5				22.7	72.7	4.5														
Chloramphenicol	13.6	3.6-35.9									4.5	81.7						13.6				
Ciprofloxacin	13.6	3.6-35.9			22.7	63.6		4.5	9.1													
Gentamicin	0.0	0.0-18.5							4.5	86.4	9.1											
Nalidixic acid	13.6	3.6-35.9										81.8	4.5					13.6				
Streptomycin	18.2	6.0-41.0											9.1	63.6	9.1	4.5	9.1	4.5				
Sulphamethoxazole	22.7	8.7-45.8												72.7	4.5							22.7
Tetracycline	13.6	3.6-35.9								54.5	31.8			4.5	9.1							
Trimethoprim	0.0	0.0-18.5						68.2	31.8													

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

The isolates of *Campylobacter jejuni* from broilers in 2007-2009 were obtained through the Finnish campylobacter monitoring programme. The samples were collected at slaughter and caeca from 10 birds per batch were pooled for examination. The number of isolates tested for antimicrobial resistance was 94, 81 and 78 in 2007, 2008 and 2009, respectively.

In 2009, also cattle was examined for the presence of *C. jejuni*, in accordance with the FINRES-Vet programme. The isolates were obtained from faecal samples collected at slaughterhouses. Thermophilic campylobacters were isolated from 34% of the samples, and 48% (n=48) of these were *C. jejuni*.

In 2007, *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 39% of the samples, and 85% (n=62) of these were *C. coli*.

2.2.1 Developments in the situation in 2007-2009

Broilers (2007-2009)
Antimicrobial resistance to quinolones, tetracycline and gentamicin ranged from 0% to 5% among poultry *C. jejuni* isolates. The majority of the resistance occasions represents 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 12. *Distribution of MICs for Campylobacter jejuni in broilers in 2007 (n=94).*

			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	0.0	0.0-4.9	1.1	12.8	59.6	26.6								
Erythromycin	0.0	0.0-4.9				8.5	42.6	44.7	4.3					
Gentamicin	5.3	2.0-12.5			2.1	26.6	66.0	5.3						
Nalidixic acid	0.0	0.0-4.9							43.6	54.3	2.1			
Tetracycline	3.3	0.8-9.7		54.3	40.4	2.1				2.1	1.1			

Table 13. *Distribution of MICs for Campylobacter jejuni in broilers in 2008 (n=81).*

			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	1.2	0.1-7.6	12.3	79.0	7.4			1.2						
Erythromycin	0.0	0.0-5.6				92.6	7.4							
Gentamicin	1.2	0.1-7.6		1.2	2.5	71.6	23.5				1.2			
Nalidixic acid	1.2	0.1-7.6					1.2	8.6	75.3	12.3	1.2			1.2
Tetracycline	0.0	0.0-5.6		90.1	6.2	3.7								

Table 14. *Distribution of MICs for Campylobacter jejuni in broilers in 2009 (n=78).*

			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	1.3	0.1-7.9	3.8	73.1	19.2	2.6					1.3			
Erythromycin	0.0	0.0-5.8				87.2	9.0	3.8						
Gentamicin	1.3	0.1-7.9			1.3	52.6	44.9	1.3						
Nalidixic acid	1.3	0.1-7.9							56.4	39.7	2.6			1.3
Tetracycline	2.6	0.5-9.9		85.9	10.3			1.3			1.3	1.3		

Pigs (2007)

Antimicrobial resistance to quinolones was low. Five isolates (8%) were resistant to nalidixic acid and ciprofloxacin. Resistance to quinolones was at the same level as in 2004 (9% to enrofloxacin and 12% to nalidixic acid, FINRES-Vet 2004). In contrast to 2004, resistance to erythromycin or tetracycline was not found in 2007. It can be concluded that antimicrobial resistance is infrequent in Finnish *Campylobacter* isolates in all main production animal species.

Table 15. *Distribution of MICs for Campylobacter coli in pigs in 2007 (n=62).*

			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	8.1	3.0-18.6		33.9	43.5	14.5					8.1			
Erythromycin	0.0	0.0-7.3				8.1	25.8	33.9	19.4	12.9				
Gentamicin	0.0	0.0-7.3				1.6	79.0	19.4						
Nalidixic acid	8.1	3.0-18.6							40.3	45.2	6.5			8.1
Tetracycline	0.0	0.0-7.3		32.3	54.8	9.7	3.2							

Cattle (2009)

All isolates were susceptible to erythromycin, gentamicin and tetracycline. Antimicrobial resistance to quinolones was low among bovine *C. jejuni* isolates. Only one isolate (2%) was resistant to nalidixic acid and ciprofloxacin. Resistance profiles were different from those in 2006 (FINRES-Vet 2005-2006) when resistance to gentamicin (4%) and oxytetracycline (4%) was detected. Also in a Finnish study by Hakkinen *et al.* (2007) antimicrobial resistance levels in bovine *C. jejuni* isolates were low.

Table 16. *Distribution of MICs for Campylobacter jejuni in cattle in 2009 (n=48).*

			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	2.1	0.1-12.5	31.2	54.2	10.4	2.1					2.1			
Erythromycin	0.0	0.0-9.2				91.7	8.3							
Gentamicin	0.0	0.0-9.2			4.2	85.4	10.4							
Nalidixic acid	2.1	0.1-12.5						4.2	39.6	41.7	12.5			2.1
Tetracycline	0.0	0.0-9.2		91.7	8.3									

3 Antimicrobial 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 *Ent. 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 2007, 2008 and 2009, 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 1. Trends possibly emerging in the resistance levels from the previous years to the years covered in this study, are analyzed using the Cochran-Armitage Test for Trend (CATT), the p-values referring to the probability of the findings under a zero hypothesis of no observable trend.

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

The material included 38 *Ent. faecalis* and 15 *Ent. faecium* isolates from pigs (2007), 202 and 214 isolates from broilers (2008), and 50 and 89 isolates from cattle (2009), respectively. The number of *Ent. faecium* isolates from pigs in 2007 (15) is considered too low to yield conclusive averages, and the data are omitted from the report.

Pigs (2007)
The incidence of resistance in E*nt. faecalis* varied from rare to somewhat frequent but low against the majority of the examined antimicrobials. There are two antimicrobials displaying a higher incidence: tetracycline (83%) and erythromycin (24%). The prominence of tetracycline resistance suggests a sustained selection. Seventeen isolates (45%) were resistant to two antimicrobials; the number of isolates resistant to three, four or five antimicrobials was 8, 0 and 2, respectively (Table 17).

Broilers (2008)
Among *Ent. faecalis* the resistance was high against narasin, bacitracin, tetracycline and erythromycin. Very low or low resistance was also detected against linezolid (<1%) and streptomycin (3%). In *Ent. faecium* the resistance was extremely high

against narasin and moderate against bacitracin, erythromycin and tetracycline. Low or very low resistance was also detected against vancomycin (5%), ampicillin (1%), chloramphenicol, linezolid (<1%) and streptomycin (<1%).

Resistance to two antimicrobials was seen in 58 (29%) of *Ent. faecalis* and 54 (25%) of *Ent. faecium* isolates. Multiresistance was observed in *Ent. faecalis*: the number of isolates resistant to three, four or five antimicrobials was 13, 4 and 5, respectively. The corresponding figures for *Ent. faecium* were 13, 4 and 4 (Tables 18 and 19).

In addition to 2008, the resistance in enterococci of broilers was monitored in 2002 and 2005. Some trends from 2005 to 2008 could be resolved using the CATT test. The resistance to ampicillin was in both years nonexistent for *Ent. faecalis*; however, for *Ent. faecium* the resistance showed a highly significant decrease ($p << 0.001$). The resistance to tetracycline appeared to decrease for both species; the p values were 0.014 for *Ent. faecalis* and 0.008 for *Ent. faecium*. Contrarily, the resistance to narasin showed a highly significant increase ($p << 0.001$) for *Ent. faecalis*, while for *Ent. faecium* the resistance remained on a high level. These trends can not be explained by changes in the use of the respective antimicrobials, for except the increase of narasin resistance, which may be caused by the increased use of narasin. The contribution to the offspring of resistant microbial flora originating from parents and grandparents is one possible further explanation.

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 *Ent. 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 (2009)

Resistance to erythromycin was high in both *Ent. faecalis* and *Ent. faecium*. Resistance against tetracycline was moderate in *Ent. faecalis*; otherwise low or no resistance was detected. Only three *Ent. faecalis* and three *Ent. faecium* isolates were resistant to two antimicrobials. Multiresistance was found only in one *Ent. faecium* isolate showing resistance to five antimicrobials.

The resistance situation in enterococci from cattle appears to be very favourable, with the noted exception of erythromycin. It is not clear whether this resistance represents continued selection due to use of this antimicrobial or some form of indigenous resistance in enterococci (Tables 20 and 21).

Table 17. *Distribution of MICs for Enterococcus faecalis from swine in 2007 (n=38).*

			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**	**1024**	**2048**	**>2048**
Ampicillin	0.0	0.0-11.4			5.3	92.1	2.6											
Bacitracin[1]	0.0	0.0-11.4						44.7	44.7	10.5								
Chloramphenicol	0.0	0.0-11.4						31.6	65.8		2.6							
Erythromycin	23.7	12.0-40.6			2.6	7.9	52.6	13.2					23.7					
Gentamicin	2.6	0.1-15.4							26.3	65.8	5.3				2.6			
Kanamycin	5.2	0.9-19.1								2.6	36.8	55.3					2.6	2.6
Linezolid	0.0	0.0-11.4				18.4	73.7	7.9										
Narasin	0.0	0.0-11.4	7.9	57.9	31.6	2.6												
Streptomycin	7.9	2.1-22.5										36.8	52.6	2.6			7.9	
Tetracycline	82.7	65.1-91.7			5.3	10.5	2.6				13.2	63.2	5.3					
Vancomycin	0.0	0.0-11.4				23.7	68.4	7.9										

Tables 17-24: 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 18. *Distribution of MICs for indicator Enterococcus faecalis from broilers in 2008 (n=202).*

			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**	**1024**	**2048**	**>2048**
Ampicillin	0.0	0.0-2.3		0.5	11.9	85.6	2.0											
Bacitracin[1]	33.7	27.3-40.7				1.5	2.5	10.9	37.6	10.9	3.0	4.0	10.4	19.3				
Chloramphenicol	0.0	0.0-2.3					0.5	55.9	43.1	0.5								
Erythromycin	25.9	20.1-32.6			20.4	16.4	22.4	14.9	9.5	9.5	3.0	0.5	3.5					
Gentamycin	0.0	0.0-2.3					2.0	2.5	42.1	52.0	1.5							
Kanamycin	0.0	0.0-2.3								4.0	27.7	59.9	6.4	2.0				
Linezolid	0.5	0.0-3.2			0.5	34.2	58.4	6.4	0.5									
Narasin	38.6	31.9-45.7	2.0	24.8	23.3	3.5	7.9	15.8	20.3	2.0	0.5							
Streptomycin	2.5	0.9-6.0								0.5	3.5	42.6	51.0			0.5	2.0	
Tetracycline	29.7	23.6-36.6			54.0	14.9	1.5		1.0	0.5	5.4	19.8	3.0					
Vancomycin	0.0	0.0-2.3				13.9	59.9	26.2										

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

Table 19. *Distribution of MICs for indicator Enterococcus faecium from broilers in 2008 (n=214).*

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**	**1024**	**2048**	**>2048**
Ampicillin	1.4	0.4-4.4		8.4	25.7	34.6	22.4	7.5	1.4									
Bacitracin[1]	17.8	13.1-23.7				25.7	4.7	5.1	26.2	16.8	3.7	6.5	4.7	6.5				
Chloramphenicol	0.5	0.0 -3.0					1.4	28.0	69.6	0.5		0.5						
Erythromycin	14.0	9.8-19.5			35.0	23.4	26.2	1.4	0.5	4.2	5.6	0.5	3.3					
Gentamicin	0.0	0.0-2.2					0.9	16.8	70.6	11.7								
Kanamycin	0.0	0.0-2.2								0.5	5.6	11.7	46.3	28.5	7.0	0.5		
Linezolid	0.9	0.1-3.6				4.2	22.0	72.9	0.9									
Narasin	71.5	64.9-77.3		1.9	1.9	1.9	1.4	21.5	65.0	6.5								
Streptomycin	0.9	0.1-3.6								0.9	20.1	70.6	7.5			0.5	0.5	
Tetracycline	14.5	10.2-20.4			70.1	14.5		0.9	1.4		3.3	9.3	0.5					
Vancomycin	5.1	2.7-9.2				86.4	5.6	2.8	0.5			1.4	1.9	1.4				

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

Table 20. *Distribution of MICs for indicator Enterococcus faecalis from cattle in 2009 (n=50).*

			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**	**1024**	**2048**	**>2048**
Ampicillin	0.0	0.0-8.9		2.0	28.0	70.0												
Bacitracin[1]	0.0	0.0-8.9				2.0	2.0	6.0	30.0	58.0	2.0							
Chloramphenicol	0.0	0.0-8.9					16.0	56.0	26.0	2.0								
Erythromycin	20.0	10.5-34.1			22.0	8.0	28.0	22.0	18.0	2.0								
Gentamicin	0.0	0.0-8.9						2.0	12.0	56.0	30.0							
Kanamycin	0.0	0.0-8.9								4.0	10.0	54.0	26.0	4.0	2.0			
Linezolid	0.0	0.0-8.9			6.0	50.0	40.0	4.0										
Narasin	0.0	0.0-8.9	6.0	48.0	38.0	8.0												
Streptomycin	4.0	0.7-14.9									4.0	22.0	62.0	8.0			4.0	
Tetracycline	12.0	5.0-25.0			80.0	8.0					2.0	10.0						
Vancomycin	0.0	0.0-8.9				26.0	50.0	24.0										

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

Table 21. *Distribution of MICs for indicator Enterococcus faecium from cattle in 2009 (n=89).*

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**	**1024**	**2048**	**>2048**
Ampicillin	0.0	0.0-5.2		3.4	18.0	64.0	14.6											
Bacitracin[1]	3.4	0.9-10.3					3.4	5.6	30.3	48.3	9.0			3.4				
Chloramphenicol	0.0	0.0-5.2					12.4	61.8	25.8									
Erythromycin	38.2	28.3-49.1			11.2	5.6	13.5	31.5	21.3	15.7			1.1					
Gentamicin	0.0	0.0-5.2					4.5	10.1	48.3	32.6	4.5							
Kanamycin	1.1	0.1-6.9								3.4	11.2	13.5	40.4	20.2	9.0	1.1	1.1	
Linezolid	0.0	0.0-5.2				22.5	66.3	11.2										
Narasin	1.1	0.1-6.9		3.4	62.9	32.6			1.1									
Streptomycin	1.1	0.1-6.9								4.5	19.1	68.5	6.7				1.1	
Tetracycline	3.4	0.9-10.3			93.9	3.4						3.4						
Vancomycin	2.2	0.4-8.6				75.3	12.4	10.1	2.2									

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

3.2 *Escherichia coli* in pigs, broilers and cattle

The number of *E. coli* isolates was 135 from pigs (2007), 371 from broilers (2008) and 272 from cattle (2009).

Pigs (2007)
The incidence of resistance in *E. coli* varied from low to rare against many of the examined antimicrobials. However, the proportion of resistant isolates exceeds 10% for four antimicrobials: tetracycline, streptomycin, sulphamethoxazole and trimethoprim (in order of descending proportions). Furthermore, the actual levels of resistance against these antimicrobials in most cases are well above the set cut-off limits. Resistance to two antimicrobials was found in 4 isolates. Multiresistance was also observed: the number of isolates resistant to three, four or five antimicrobials was 7, 8 and 2, respectively.

Tetracycline resistance was the highest observed resistance trait in both *Ent. faecalis* and *E. coli* and can probably be largely explained by the common use of tetracycline in pig production (Table 22).

Broilers (2008)
The incidence of resistance in *E. coli* is low or rare against most of the examined antimicrobials. The incidence exceeds 10% only against streptomycin. Thirteen *E. coli* isolates were resistant to two antimicrobials. Multiresistance to three, four, five or six antimicrobials was found in 5, 12, 0 and 3 isolates, respectively.

In broiler *E. coli* isolates, there was a decreasing trend of ampicillin and gentamicin resistances and an increasing trend of streptomycin resistance from 2002 to 2008 (p-values 0.009, < 0.001 and << 0.001, respectively). The observed trends cannot be attributed to changes in the use of aminoglycosides or tetracyclines. In the case of *E. coli* the contribution of parent and grandparent resistant microbial flora to the offspring is one further possibility (Table 23).

Cattle (2009)
The incidence of resistance in *E. coli* varied from low to rare against all of the tested antimicrobials. 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 4 isolates. Multiresistance to three antimicrobials was observed on 3 isolates. However, a decreasing trend of trimethoprim resistance was noted from 2003 to 2009 (p value < 0.001). Some indication of a decreasing trend of resistance was noted also to ampicillin (p-value 0.052) and tetracycline (p-value 0.086) (Table 24).

Table 22. *Distribution of MICs for indicator Escherichia coli from swine in 2007 (n=135).*

			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**	**1024**	**2048**	**>2048**
Ampicillin	7.4	3.8-13.5							1.5	18.5	48.1	19.3	5.2			7.4						
Cefotaxime	0.0	0.0-3.4				66.7	27.4	5.9														
Ceftiofur	0.0	0.0-3.4					3.0	38.5	56.3	2.2												
Chloramphenicol	0.7	0.0-4.6									3.7	63.7	31.1	0.7		0.7						
Ciprofloxacin	0.7	0.0-4.6		6.7	55.6	37.0		0.7														
Florfenicol	0.0	0.0-3.4										34.8	59.3	5.9								
Gentamicin	0.0	0.0-3.4							17.8	67.4	14.8											
Kanamycin	0.0	0.0-3.4									14.8	80.7	4.4									
Nalidixic acid	0.7	0.0-4.6								1.5	43.0	50.4	3.7	0.7		0.7						
Streptomycin	14.8	9.5-22.2									0.7	25.2	56.3	3.0	3.0	3.7	3.0	4.4	0.7			
Sulphamethoxazole	11.9	7.2-18.9												88.1								11.9
Tetracycline	17.7	12.0-25.5								23.0	54.1	3.7	1.5		0.7	7.4	9.6					
Trimethoprim	11.8	7.2-18.9						20.7	41.5	25.2	0.7	0.8				11.1						

Table 23. *Distribution of MICs for indicator Escherichia coli from broilers in 2008 (n=370-371).*

			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**	**1024**	**2048**	**>2048**
Ampicillin[1]	5.7	3.7-8.7							1.9	20.5	61.7	11.3	0.3			4.3						
Cefotaxime	1.4	0.5-3.4				72.2	21.9	4.6	1.4													
Ceftiofur[1]	1.3	0.5-3.2					3.6	41.8	49.9	4.9												
Chloramphenicol	0.0	0.0-1.2									1.3	51.5	46.1	1.1								
Ciprofloxacin	1.8	0.8-3.9		7.0	72.0	19.1	0.5	0.3	0.5	0.3	0.3											
Florfenicol	0.0	0.0-1.2										24.8	67.9	7.3								
Gentamicin	0.0	0.0-1.2							17.0	75.2	7.8											
Kanamycin	3.4	1.9-5.9									14.3	70.9	11.3	0.8	2.7							
Nalidixic acid	1.6	0.7-3.6								0.5	27.2	65.0	4.3	1.3	0.3		0.5	0.8				
Streptomycin	14.1	10.9-18.1									0.5	28.8	51.2	5.4	5.9	6.5	0.8	0.8				
Sulphamethoxazole	7.6	5.2-10.8												91.9	0.3	0.3				0.8	1.3	5.5
Tetracycline	6.5	4.3-9.6								18.6	73.0	1.9			0.3	2.4	3.8					
Trimethoprim	2.3	1.1-4.5						9.7	58.0	28.6	1.3		0.5			1.9						

[1]five isolates with cefotaxime MIC = 0.5 mg/ml were also interpreted resistant to ampicillin and ceftiofur

***Table 24**. Distribution of MICs for indicator Escherichia coli from cattle in 2009 (n=272).*

			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**	**1024**	**2048**	**>2048**
Ampicillin	0.4	0.0-2.4							1.5	13.6	63.2	20.6	0.7			0.4						
Cefotaxime	0.0	0.0-1.7				69.1	28.7	2.2														
Ceftiofur	0.0	0.0-1.7					1.5	31.6	64.0	2.9												
Chloramphenicol	0.7	0.1-2.9									1.1	36.0	59.2	2.9	0.7							
Ciprofloxacin	1.1	0.3-3.5		2.9	72.4	23.5	0.7	0.4														
Florfenicol	0.7	0.1-2.9										12.9	72.8	13.6	0.4	0.4						
Gentamycin	1.1	0.3-3.5							4.4	83.8	10.7	1.1										
Kanamycin	1.8	0.7-4.4									11.0	62.1	25.0	1.8								
Nalidixic acid	0.4	0.0-2.4								1.8	26.5	68.0	3.3					0.4				
Streptomycin	1.8	0.7-4.4										11.8	70.6	15.8	0.4	0.4	1.1					
Sulphamethoxazole	0.7	0.1-2.9												99.3								0.7
Tetracycline	1.1	0.3-3.5								30.5	62.5	5.5	0.4		0.4	0.4	0.4					
Trimethoprim	0.4	0.0-2.4						22.8	36.4	33.1	7.4	0.4										

4 Antimicrobial resistance in animal pathogens

4.1 Resistance of *Escherichia coli* strains from porcine enteritis

The material consisted of 18, 28 and 24 strains of *E. coli* isolated from pig enteritis cases in 2007, 2008 and 2009, respectively. The pathogenicity of the isolates was confirmed by demonstrating the presence of genes coding for typical fimbrial antigens and toxins. One isolate/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 25.

Multiresistance in this group was rather common. In 2007 6% of the isolates were resistant to 3, 17% to 4 and 6% to 6 antimicrobials; altogether 29% of isolates resistant to more than 2 antibimicrobials. In 2008 14% of the isolates were resistant to 3, 25% to 4 and 7% to 5 antimicrobials, altogether 46%, and in 2009, 8% of the isolates were resistant to 3, 38% to 4, 4% to 5, and 8% to 6 antimicrobials, altogether 58% resistant to more than 2 antimicrobials.

As in previous years, resistance levels were high or very high to tetracycline (33%, 36% and 58%), to streptomycin (28%, 36% and 63%), to sulphamethoxazole (22%, 29%, and 54%), and to trimethoprim (28%, 36% and: 46%), all percentages respective to 2007, 2008 and 2009.

Resistance to nalidixic acid and ciprofloxacin was in 28% (2007), 29% (2008), and 21% (2009). One isolate in 2009 was resistant to cefotaxime with MIC value (0,5 mg/l) just above the cut-off value. No resistance was detected to gentamicin or florfenicol. The latter is registered for use in pigs in Finland, but no products containing gentamicin are approved for veterinary use, except on special license for horses.

4.2 Resistance of canine *Staphylococcus pseudintermedius*

In 2005 a novel staphylococcal species, *Staphylococcus pseudintermedius*, was described (Devriese *et al.*, 2005). Later studies (e.g. Sasaki *et al.*, 2007, Devriese *et al.*, 2009) reported that canine *S. intermedius* strains should be classified as *S. pseudintermedius*. This approach has been adopted in the present report. The results in the previous FINRES-Vet reports pertaining the *S. intermedius* isolates should be regarded as resistance data on *S. pseudintermedius*.

The material consisted of 34, 59 and 72 isolates of *S. pseudintermedius* isolated from canine clinical infections in 2007, 2008 and 2009, respectively. Only the first isolate from each dog was included. The yearly MIC distributions are presented in Table 26.

Only 15% of the isolates in 2007, 14% in 2008, and 11% in 2009 were susceptible to all antimicrobials tested. Resistance to one antimicrobial (mainly penicillin) was found in 44%, 41% and 35% of the isolates in 2007, 2008 and 2009, respectively. Eighteen %, 27% and 14% of the isolates were resistant to two antimicrobials (mainly penicillin and tetracycline) in 2007, 2008 and 2009, respectively. Twenty four %, 19% and 40% of the isolates were resistant to 3 or more antimicrobials in 2007, 2008 and 2009, respectively. Of the resistant isolates, 14%, 16% and 44% were resistant to five or more antimicrobials in 2007, 2008 and 2009, respectively. The resistance levels were overall higher in 2009 than in 2007-2008 (Figure 6). Resistance to penicillin, erythromycin, kanamycin, and clindamycin was found in 75% of the multiresistant isolates in 2007, 64% in 2008, and 79% in 2009

Resistance to penicillin was extremely high and steady during the three-year period (82-85%). Resistance to tetracycline was found in 24%, 31% and 47% of the isolates in 2007, 2008 and 2009, respectively. In 2007, 2008 and 2009, resistance to erythromycin was found in 24, 14 and 39% of the isolates, of which 83, 88 and 89% were also resistant to clindamycin, respectively. In 2009, inducible macrolides-lincosamides-streptogramin B resistance was found in two isolates.

Resistance to aminoglycosides was higher in 2009 than in 2007-2008. In 2009, 18% of the isolates were resistant to gentamicin and 39% to kanamycin. In comparison, no gentamicin resistance was detected in 2007 and only 2% of the isolates were resistant in 2008. Resistance to kanamycin was 24% in 2007 and 17% in 2008.

In 2009, resistance to oxacillin was found in 26% of the isolates, which is significantly higher than in 2007 (3%) and 2008 (7%); p –values 0.003 and 0.005, respectively. It appears that the proportion of meticillin resistant *S. pseudintermedius* (MRSP) is steadily increasing. In 2007-2009, all of the *S. pseudintermedius* isolates with oxacillin MIC > 1 mg/l and two isolates in 2008-2009 with oxacillin MIC = 1 mg/l harboured the *mec*A gene. Isolates confirmed *mec*A-positive were classified as resistant to all betalactams.

Resistance to fluoroquinolones was rare or low in 2007 and in 2008 but in 2009, 18% of the isolates were resistant to ciprofloxacin and 21% to enrofloxacin. Of all the isolates resistant to enrofloxacin and/or ciprofloxacin, 81% were multiresistant. Altogether, resistance levels were higher in 2009 than in previous years and the number of multiresistant isolates in canine infections has increased.

Table 25. *Distribution of MICs for Escherichia coli from porcine enteritis in 2007 (n=18), in 2008 (n=28) and in 2009 (n=24).*

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	1024	2048	>2048
Ampicillin	2007	16.7	4.4-42.3							5.6	16.7	38.9	11.1	11.1			16.7						
	2008	17.9	6.8-37.6								35.7	28.6	17.9				17.9						
	2009	33.3	16.4-55.3								25.0	37.5	4.2			8.3	25.0						
Cefotaxime	2007	0.0	0.0-21.9				55.6	33.3	11.1														
	2008	0.0	0.0-15.0				85.7	10.7	3.6														
	2009	4.2	0.2-23.2				70.8	20.8	4.2	4.2													
Chloramphenicol	2007	5.6	0.3-29.4									16.7	66.7	11.1					5.6				
	2008	0.0	0.0-15.0								3.6	32.1	53.6	7.1	3.6								
	2009	8.3	1.4-28.4									16.7	70.8		4.2	8,3							
Ciprofloxacin	2007	27.9	10.7-53.6			27.8	44.4	5.6	11.1	5.6		5.6											
	2008	28.5	14.0-48.9		10.7	46.4	14.3	7.1	10.7	7.1		3.6											
	2009	20.9	7.9-42.7			66.7	12.5	4.2	8.3		4.2	4.2											
Florfenicol	2007	0.0	0.0-21.9										77.8	16.7	5.6								
	2008	0.0	0.0-15.0										75.0	25.0									
	2009	0.0	0.0-17.2										75.0	20.8	4.2								
Gentamicin	2007	0.0	0.0-21.9							44,4	50	5.6											
	2008	0.0	0.0-15.0							39.3	57.1	3.6											
	2009	0.0	0.0-17.2							16.7	70.8	12.5											
Kanamycin	2007	5.6	0.3-29.4									27.8	61.1	5.6		5.6							
	2008	3.6	0.2-20.3									57.1	39.3			3.6							
	2009	12.5	3.3-33.5									20.8	58.3	8.3		12.5							

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	1024	2048	>2048
Nalidixic acid	2007	27.8	10.7-53.6									55.6	16.7				16,7		11.1				
	2008	28.6	14.0-48.9									35.7	21.4	10.7	3.6	3.6	7.1	3.6	14.3				
	2009	20.9	7.9-42.7								4.2	50.0	20.8	4.2		4.2	8.3	4.2	4.2				
Streptomycin	2007	27.9	10.7-53.6										38.9	27.8	5.6		5.6	5.6		16.7			
	2008	35.8	19.3-55.9									7.1	28.6	21.4	7.1	3.6	3.6	10.7	3.6	14.3			
	2009	62.6	40.8-80.5										4.2	25.0	8.3	4.2	29.2	4.2	8.3	16.7			
Sulphamethoxazole	2007	22.2	7.4-48.1												77.8								22.2
	2008	28.6	14.0-48.9												67.9	3.6							28.6
	2009	54.2	33.3-73.9												45.8					4.2	4.2		45.8
Tetracycline	2007	33.3	14.3-58.8								22.2	38.9		5.6				33.3					
	2008	35.7	19.3-55.9								53.6	10.7					10.7	25.0					
	2009	58.4	36.9-77.2								33.3	8.3				4.2	12,5	41.7					
Trimethoprim	2007	27.8	10.7-53.6						61.1	5.6		5.6			5.6		22.2						
	2008	35.7	19.3-55.9						50.0	10.7	3.6				3,6		32.1						
	2009	45.8	26.1-66.7						29.2	12.5	8.3	4.2					45.8						

Tables 25-26: 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.

Table 26. *Distribution of MICs for S. pseudintermedius from canine clinical samples (n=33-34 in 2007, n=49-59 in 2008, n=70-72 in 2009)*

Antibiotic	Year	% R	95 % C.I.	≤0.032	0.064	0.125	0.25	0.5	1	2	4	8	16	32	64	>64
Cephalothin[1]	2007	2.9	0.1-17.0			94.1	2.9	2.9								
	2008	6.9	2.2-17.6		17.2	72.4	6.9	1.7			1.7					
	2009	26.4	17.0-38.3			75.0	6.9	1.4	1.4	1.4	4.2	9.7				
Chloramphenicol	2007	5.9	1.0-21.1								70.6	23.5			5.9	
	2008	8.5	3.2-19.4							1.7	86.4	3.4		1.7	6.8	
	2009	25.0	15.9-36.8							1.4	63.9	9.7		2.8	22.2	
Ciprofloxacin	2007	0.0	0.0-13.0		9.1	72.7	12.1	6.1								
	2008	1.8	0.1-10.7		7.0	68.4	10.5	10.5	1.8			1.8				
	2009	18.1	10.4-29.3		8.3	56.9	11.1	5.6				18.1				
Clindamycin[2]	2007	20.6	9.3-38.4				73.5	2.9	2.9						20.6	
	2008	11.9	5.3-23.6				83.1	5.1			1.7	1.7			8.5	
	2009	34.7	24.1-46.9				59.7	4.2	1.4	2.8		1.4		2.8	27.8	
Enrofloxacin	2007	5.9	1.0-21.1			64.7	29.4		5.9							
	2008	8.1	2.7-20.5			65.3	20.4	6.1	6.1	2.0						
	2009	21.5	12.8-33.1			64.3	11.4	2.9	2.9	18.6						
Erythromycin	2007	23.5	11.4-41.5				20.6	55.9							23.5	
	2008	13.6	6.5-25.6				49.2	37.3							13.6	
	2009	38.9	27.9-51.1				13.9	44.4	2.8						38.9	
Gentamicin	2007	0.0	0.0-12.6					97.1	2.9							
	2008	1.7	0.1-10.3					96.6	1.7				1.7			
	2009	18.1	0.4-29.3					80.6	1.4		1.4	2.8	6.9	1.4	5.6	

[1]due to a positive result in *mec*A PCR one isolate in 2007, three isolates in 2008, and nine isolates in 2009 with cephalotin MIC ≤ 1 mg/l were also interpreted as resistant to cephalotin

[2]in 2009, inducible macrolides-lincosamides-streptogramide B resistance was detected in two isolates with clindamycin MIC ≤ 2 mg/l; these isolates were also interpreted as resistant

Antibiotic	Year	% R	95 % C.I.	≤0.032	0.064	0.125	0.25	0.5	1	2	4	8	16	32	64	>64
Kanamycin	2007	23.5	11.4-41.5					5.9	38.2	26.5	2.9	2.9			23.5	
	2008	16.9	8.8-29.4				1.7	8.5	64.4	8.5					16.9	
	2009	38.9	27.9-51.1					4.2	34.7	19.4	2.8				38.9	
Oxacillin[3]	2007	2.9	0.1-17.0			2.9	20.6	64.7	8.8	2.9						
	2008	7.1	2.3-18.1			1.8	28.6	57.1	7.1	3.6				1.8		
	2009	26.4	7.0-38.3				9.7	41.7	23.6	5.6		2.8	1.4	15.3		
Penicillin G[4]	2007	82.4	64.9-92.6	5.9	5.9	8.8	2.9		5.9	5.9	8.8	55.9				
	2008	84.7	72.5-92.3	15.3	1.7	8.5	1.7	10.2	6.8	11.9	16.9	27.1				
	2009	84.7	73.9-91.7	15.3		1.4	9.7	8.3	4.2	6.9	18.1	36.1				
Tetracycline	2007	24.3	11.7-42.6					72.7	3.0					15.2	9.1	
	2008	30.5	19.5-44.0					64.4	3.4	1.7			1.7	22.0	6.8	
	2009	47.3	35.5-59.2					52.8						43.1	4.2	
Trimethoprim / Sulphamethoxazole[5]	2007	2.9	0.1-17.0					73.5	23.5		2.9					
	2008	3.5	0.6-12.8					86.4	6.8	3.4	1.8	1.7				
	2009	13.9	7.2-24.5					69.4	16.7			13.9				

[3]all the resistant isolates harboured *mec*A gene and in 2008-2009, two isolates with oxacillin MIC = 1 mg/l were also interpreted as resistant due to a positive result in mecA PCR

[4]based on beta-lactamase production

[5]concentration of trimethoprim given, tested with sulphamethoxazole in concentration ratio 1:20

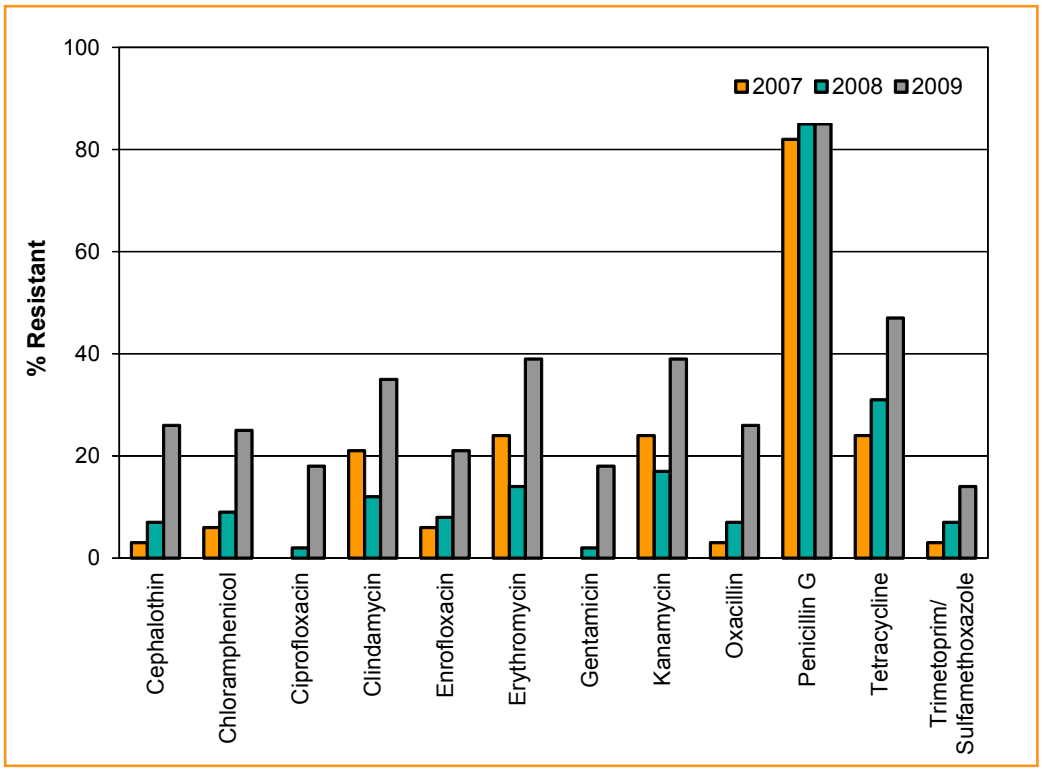

Figure 6. *Resistance situation in Staphylococcus pseudintermedius in 2007-2009*

5 MRSA in animals in Finland

Meticillin resistant *Staphylococcus aureus* (MRSA) was found for the first time in animals already in 1972, in a bovine mastitis case in Belgium. The frequency of MRSA findings particularly in production animals started to rapidly increase after the year 2000. The prevalence of especially the MRSA clonal complex (CC) 398 in pigs has exceeded 50% of farms in many central European countries. The animals are for the most part only colonized by the MRSA and show no signs of infection. In addition to pigs, the MRSA CC398 has been associated with veal calves, broiler chickens, and also with people in close contact with livestock. Especially the MRSA CC398 but also other clonal types found in production animals are increasingly referred to as Livestock Associated MRSA, or LA-MRSA.

The earliest record of MRSA in animals in Finland is from the 1990's, a sporadic finding in a horse. In 2005/2006 MRSA was found in two dairy herds, and in the same year there was a small epidemic in horses visiting the University Animal Hospital (YES). In the latter outbreak there were two infected animals and three more were found to be colonized. There was also an epidemic among horses visiting YES in 2007 (three infected, 10 colonized) (Rantala *et al.*, 2008), and in 2008 (one infected, one colonized). The *spa* type of the MRSA was different in each case. MRSA CC398 was encountered in animals in Finland for the first time in the 2007 epidemic. MRSA was also found in two cats in 2007, and one dog in 2009.

EU Member States conducted a survey in 2008 to estimate the prevalence of MRSA in pig breeding and production facilities, employing environmental (dust) samples. 207 pig farms were sampled in Finland and one (0.5%) was found to be contaminated with MRSA CC398. A year-long survey in the pig industry, based on a decree by the Ministry of Agriculture and Forestry (2/EEO/2009) to obtain a more accurate estimate on the prevalence of the MRSA infection, was launched in September 2009. The survey employed respiratory mucosal samples taken in the slaughterhouse and from animals sent routinely in to Evira for pathological-anatomical diagnosis. Slaughterhouse samples from 59 farms and pathology samples from 36 farms were examined for MRSA. Thirteen (22%) of the former but only 1 (3%) of the latter turned out to be MRSA -positive. Taken together, the apparent prevalence is 14.7% The representativenes of the figure, 14.7% of farms positive, must be interpreted guardedly, as the sampling was not satisfactorily random in either category. However, it can be concluded that the prevalence of MRSA positive pig farms is definitely higher than indicated by the 2008 survey.

6 References

Brakstad, OG., Aasbakk, K. and Maeland, JA. 1992. Detection of *Staphylococcus aureus* by polymerase chain reaction amplification of the nuc gene. J. Clin. Microbiol. 30: 1654–1660.

CLSI. 2004. Performance standards for antimicrobial disk and dilution susceptibility tests for bacteria isolated from animals; informational supplement. CLSI document M31-S1 [ISBN1-56238-534-8]. CLSI, 940, West Valley Road, Suite 1400, Wayne, Pennsylvania, 190987-1898 USA.

CLSI. 2008. Performance standards for antimicrobial disk and dilution susceptibility tests for bacteria isolated from animals; approved standard – third edition. CLSI Document M31-A3 [ISBN 1- 56238-659-X]. CLSI, 940, West Valley Road, Suite 1400, Wayne, Pennsylvania, 19087-1898, USA.

Decrees of Ministry of Agriculture and Forestry: Decree on salmonella control in pigs and cattle MMMa 23/EEO/1995 wwwb.mmm.fi/el/laki/d/d105.html and in laying hens MMMa 1172/2009 www.finlex.fi/fi/laki/alkup/2009/20091172 (in Finnish and Swedish).

Devriese LA, Vancanneyt M, Baele M, Vaneechoutte M, De Graef E, Snauwaert C, Cleenwerck I, Dawyndt P, Swings J, Decostere A, Haesebrouck F. 2005. *Staphylococcus pseudintermedius* sp. nov., a coagulase-positive species from animals. Int J Syst Evol Microbiol. 55(Pt 4):1569-73.

Devriese LA, Hermans K, Baele M. and Haesebrouk F., 2009. S*taphylococcus pseudintermedius* versus *Staphylococcus intermedius*. Vet Microbiol 133:206-207.

EFSA 2010. Community Summary Report: Antimicrobial resistance in zoonotic agents from animals and food in the European Union in 2004-2007. EFSA Journal 2010; 8(4):1309 [304 pp].

The Finnish Salmonella Control Programme for Live Poultry, Poultry Meat and Eggs. Report to the European Commission, 21st December 2005, Ministry of Agriculture and Forestry, Food and Health Department

FINRES-Vet 2004, Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents. National Veterinary and Food Research Institute (EELA), Helsinki, Finland. ISSN 1458-6878.

FINRES-Vet 2005-2006, Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents, Finnish Food Safety Authority Evira, Helsinki, Finland. ISSN 1796-4369.

Grave, K., Torren-Edo, J. and Mackay, D. 2010. Comparison of the sales of veterinary antibacterial agents between 10 European countries. J. Antimicrob. Chemother. 65(9): 2037-40.

Hakkinen, M., Heiska, H. and Hänninen, ML. 2007. Prevalence of *Campylobacter* spp. in cattle in Finland and antimicrobial susceptibilities of bovine *Campylobacter jejuni* strains. Appl. Environ. Microbiol. 73(10): 3232-8.

Hölsö, K., Rantala, M., Lillas, A., Eerikäinen, S., Huovinen, P. and Kaartinen, L. 2005. Prescribing Antimicrobial Agents for Dogs and Cats via University Pharmacies in Finland - Patterns and Quality of Information. Acta Vet. Scand. 46: 87-93.

ISO. 2002. Microbiology of food and animal feeding stuffs – Horizontal method for the detection of Salmonella spp. International Organization for Standardization. Standard no ISO 6579: 2002.

Jones, R. D., Kania, S. A., Rohrbach, B. W., Frank, L. A. and Bemis, D. A. 2007. Prevalence of oxacillin- and multidrug-resistant staphylococci in clinical samples from dogs: 1,772 samples (2001-2005). JAVMA 230: 221-227.

Kuronen, H., Pohjanvirta, T., Hakola, S., Kauko, T., Siitonen, A., Ruoho, O. and Pelkonen, S. 2010. Feed-borne outbreak of *Salmonella Tennessee* in laying hen holdings and pig herds in Finland. I3S International Symposium *Salmonella* and Salmonellosis 28.-30.6.2010, Saint-Malo, France.

Leonard, F.C. and Markey, B.K. 2008. Meticillin-resistant *Staphylococcus aureus* in Animals: A review. Vet. J. 175: 27-36.

Evira. Recommendations for the use of antimicrobial agents in the treatment of the most significant infectious diseases in animals. Memorandum 2003:9a. ISBN 952-453-164-X. ISSN 0781-6723.

MAF. 2005. The Finnish Salmonella Control Programme for Live Poultry, Poultry Meat and Eggs. Report to the European Commission, 21st December 2005, Ministry of Agriculture and Forestry, Food and Health Department.

MARAN-2008 – Monitoring of Antimicrobial Resistance and Antibiotic Usage in Animals in The Netherlands in 2008.

Murakami, K., Minamide, W., Wada, K., Nakamura, E., Teraoka, H. and Watanabe, S. 1991. Identification of methicillin-resistant strains of *staphylococci* by polymerase chain reaction. J. Clin. Microbiol. 29: 2240-2244.

NMKL. 1990. Nordic committee in food analysis. NMKL No 119. *Campylobacter jejuni/coli*. Detection in foods.

NMKL. 1999. Nordic committee in food analysis. 5th edition, NMKL No 71. Salmonella. Detection in foods.

NMKL. 2007. Nordic committee in food analysis. NMKL No 119. *Campylobacter jejuni/coli.* Detection in foods.

Rantala, M., Thomson, K., Myllyniemi, A-L., Pitkälä, A., Seppänen, J., Kanerva, M., Vuopio-Varkila, J., Vainio, A. and Lyytikäinen, O. 2008. Methicillin-resistant *Staphylococcus aureus* in horses and horse personnel at the Finnish veterinary teaching hospital, 2006-2007. 18th European Congress of Clinical Microbiology and Infectious Diseases. Barcelona, Spain.

T. Sasaki, K. Kikuchi, Y. Tanaka, N. Takahashi, S. Kamata, and K. Hiramatsu, 2007. Reclassification of Phenotypically Identified *Staphylococcus intermedius* Strains J. Clin. Microbiol. 45(9): 2770-2778.

SVARM, 2009. Swedish Veterinary Antimicrobial Resistenace Monitoring. The National Veterinary Institute (SVA), Uppsala, Sweden, 2010. www.sva.se, ISSN 1650-6332.

Appendix 1. 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 *Ent. 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 97% (2007), 92 % (2008) and 93 % (2009) 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.

Staphylococcus pseudintermedius was isolated from canine clinical infections. Only the first isolate was included.

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, Microbiology Research Unit, according to a modified method of the NMKL 119:1990 or NMKL 119:2007. *C. coli* from pigs in 2007 and *C. jejuni* from cattle in 2009 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. Non-motile, ribose positive enterococci were identified to species level with the following tests: arginine dihydrolase, mannitol, arabinose, raffinose, ribose, sorbitol and melibiose. In 2007, one *Ent. faecium* or *Ent. faecalis* isolate was randomly chosen for susceptibility testing. In 2008 ad 2009, if possible, both *Ent. faecium* or *Ent. faecalis* were isolated from each sample.

Escherichia coli

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

Animal pathogens

Haemolytic *Escherichia coli* were isolated and identified at Evira, Veterinary Bacteriology Unit or Production Animal and Wildlife 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. *Staphylococcus* colonies growing on blood agar plates as greyish white colonies with a beta-toxic zone were further identified as *S. pseudintermedius* using rabbit coagulase plasma (BD), hyaluronidase test, and Staph ID 32 (Biomerieux, Marcy L'Etoile, France).

Screening for MRSA was performed by pre-enriching the samples and spreading 10 µl of the incubated enrichment broth, or by spreading the clinical samples directly on Brilliance™ MRSA Agar (Oxoid). In case of suspected heavy contamination an additional selective enrichment step was made before plating. Typical size blue-green 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*A gene) and the resistance profile determined with VetMIC™ (see below). The presence of *S. aureus* specific *nuc*A gene was determined according to Brakstad *et al.* (1992) with modifications, and the presence of *mec*A gene with a method described by Murakami *et al.* (1991).

Susceptibility testing

Susceptibility testing 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, 2004; CLSI, 2008). Susceptibility testing was performed at Evira, Microbiology Research Unit. The epidemiological cut-off values used are shown in Table 23. Bacitracin values are given in units ml^{-1} (SVARM, 2009).

***Table 27**. Epidemiological cut-off values (mg l^{-1}) used in this report.*
Isolates with MIC values higher than the given figures are considered resistant.

Antimicrobial	*Salmonella enterica*	*Escherichia coli*	*Enterococcus faecalis*	*Enterococcus faecium*	*Staphylococcus pseudintermedius*	*C. jejuni*	*C. coli*
Ampicillin	>4	>8	>4	>4			
Bacitracin[1]			>32	>32			
Cefotaxime	>0.5	>0.25					
Ceftiofur		>1					
Cephalothin					>1		
Chloramphenicol	>16	>16	>32	>32	>16		
Ciprofloxacin	>0.06	>0.06			>1	>1	>1
Clindamycin					>2		
Enrofloxacin					>0.5		
Erythromycin			>4	>4	>1	>4	>16
Florfenicol		>16					
Gentamicin	>2	>2	>32	>32	>2	>1	>2
Kanamycin		>8	>1024	>1024	>8		
Linezolid			>4	>4			
Nalidixic acid	>16	>16				>16	>32
Narasin			>2	>4			
Oxacillin					>1		
Oxytetracycline, tetracycline	>8	>8	>4	>4	>2	>2	>2
Streptomycin	>32	>16	>512	>128			
Sulphamethoxazole	>256	>256					
Trimethoprim	>2	>2					
Trimethoprim / Sulphamethoxazole[2]					>2		
Vancomycin			>4	>4			

[1] MIC in U ml^{-1}.
[2] concentration ratio 1:20.

Production of beta-lactamase was tested with Nitrocefin disc test (AB Biodisk, Solna, Sweden). As suspected MRSA isolates, also all *S. pseudintermedius* isolates were tested for the presence of the *mec*A gene. Polymerase chain reaction (PCR) for *mec*A gene detection was performed according to Murakami *et al.* (1991), with minor modifications.

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 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 and *S. aureus* ATCC 33592 each time MRSA screening was performed.

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 2. Population satistics

The number of holdings, live animals on holdings and slaughter statistics in Finland are presented in Table 28. The displayed data originate from the Yearbook of Farm Statistics 2009, published by TIKE, the Information Centre of the Ministry of Agriculture and Forestry, Finland (ISSN 1795-5165), Farm register, and meat inspection statistics of Evira.

Table 28. *Number of farm animals and holdings in Finland in 2007-2009.*

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	
dairy cows and heifers	2007	14 400	434 200	
	2008	13 340	423 500	
	2009	12 915	421 500	
meat production animals	2007	11 186	181 400	
	2008	11 960	120 500	
	2009	7 567	118 700	
in total	2007	18 624	926 700	291 100
	2008	17 437	915 300	265 700
	2009	16 420	918 300	268 100
Chickens				
broilers	2007	138	5 074 100	54 079 600
	2008	141	5 674 500	55 200 000
	2009	103	4 918 452	51 867 498
Pigs				
breeding animals	2007	1 876	178 700	61 600
	2008	1 689	168 600	64 400
	2009	1 435	156 000	54 900
fattening pigs	2007	2 442	1 269 400	2 390 600
	2008	2 461	1 310 200	2 371 900
	2009	2 202	1 225 200	2 276 800
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

Appendix 3. Overview of FINRES-Vet reports

Bacterial species presented in previous FINRES-Vet reports are listed in Table 29.

Table 29. *Bacterial species presented in FINRES-Vet reports in 2002-2009.*

Bacterial species	Source	FINRES-Vet 2002-2003	FINRES-Vet 2004	FINRES-Vet 2005-2006	FINRES-Vet 2007-2009
Animal pathogens					
Escherichia coli	Porcine enteritis	X	X	X	X
Escherichia coli	Bovine mastitis			X	
Klebsiella spp.	Bovine mastitis			X	
Staphylococcus pseudintermedius	Canine infections	X	X	X	X
Staphylococcus aureus	Bovine mastitis			X	
Streptococcus uberis	Bovine mastitis			X	
Streptococcus dysgalactiae	Bovine mastitis			X	
Zoonootic bacteria					
Salmonella enterica	Production animals	X	X	X	X
	Exotic pets		X		
	Domestic Food	X			X
Campylobacter jejuni	Broilers	X	X	X	X
	Cattle	X		X	X
Campylobacter coli	Pigs		X		X
Indicator bacteria					
Escherichia coli	Broilers	X		X	X
	Cattle	X			X
	Pigs		X		X
Enterococcus spp.	Broilers	X		X	X
(faecium and/or faecalis)	Cattle	X			X
	Pigs		X		X

Cover photos: Juha Tuomi/Rodeo

Finnish Food Safety Authority Evira
Mustialankatu 3, FI-00790 Helsinki, Finland
Tel. +358 20 69 0999 • Fax +358 20 77 24350
www.evira.fi

Evira publications 1/2011
ISSN 1797-299X
ISBN 978-952-225-082-7 (pdf)

Evira