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FINRES-Vet 2005-2006

Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents

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Any use of data from FINRES-Vet 2005-2006 should include a specific reference to this report. Suggested citation: FINRES-Vet 2005-2006, Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents, Finnish Food Safety Authority Evira, Helsinki, Finland, ISSN 1796-4369.

This report is available at www.evira.fi

Kuvailulehti

Julkaisija	Elintarviketurvallisuusvirasto Evira
Julkaisun nimi	FINRES-Vet 2005-2006. Eläimistä eristettyjen bakteerien mikrobilääkeresistenssi ja mikrobilääkkeiden käyttö eläimillä Suomessa.
Tekijät	Anna-Liisa Myllyniemi, Anna Pitkälä ja Helmi Heiska, Evira Katariina Kivilahti-Mäntylä, Liisa Kaartinen ja Jouko Koppinen, Lääkelaitos
Tiivistelmä	Vuosien 2005 ja 2006 FINRES-Vet-ohjelman mukaan eläimistä ja elintarvikkeista eristettyjen bakteerien resistenssitilanne Suomessa on edelleen hyvä, mikä johtuu hyvästä tautitilanteesta ja varsin hallitusta mikrobilääkkeiden käytöstä. Joidenkin bakteereiden osalta tilanne on kuitenkin huolestuttava, joten eläinten hoidossa on yhä tärkeämpää noudattaa Suomessa annettuja mikrobilääkkeiden käyttösuosituksia. Eläimille käytettävien mikrobilääkkeiden määrä on ollut 2000-luvulla melko vakaa. G-penisilliiniä käytetään edelleen eniten ja sulfa-trimetopriimi -yhdistelmää toiseksi eniten. Zoonoosibakteereilla (salmonella ja kampylobakteeri), todettiin vain vähän resistenssiä. Broilerien indikaattoribakteereilla todettiin resistenssiä enemmän kuin nautojen indikaattoribakteereilla. Sikojen suolitulehduksista eristetyillä *E. coli* -bakteereilla moniresistenssi oli edelleen yleistä. Nautojen utaretulehduksesta eristetyistä *S. aureus* -bakteereista 25 % tuotti beetalaktamaasia. Muiden utaretulehdusbakteereiden resistenssi oli vähäistä eikä MRSA-kantoja todettu. Koirien *Staphylococcus intermedius* -bakteereista 32 % oli moniresistenttejä.
Julkaisuaika	Marraskuu 2007
Asiasanat	Mikrobilääkeresistenssi, mikrobilääkkeiden käyttö
Julkaisusarjan nimi ja numero	Eviran julkaisuja 22/2007
Sivuja	56
Kieli	Englanti
Luottamuksellisuus	Julkinen
Julkaisija | hinta	Elintarviketurvallisuusvirasto Evira (www.evira.fi) | 15 €
Julkaisun kustantaja	Elintarviketurvallisuusvirasto Evira
Painopaikka ja -aika	Multiprint Oy, Helsinki 2007
	ISSN 1796-4369 ISBN 952-5662-99-3 ISBN 952-5662-90-X (pdf)

Beskrivning

Utgivare	Livsmedelssäkerhetsverket Evira
Publikationens titel	FINRES-Vet 2005-2006. Kartläggning över resistens mot antibiotika inom veterinärmedicin i Finland samt förbrukning av antibiotika
Författare	Anna-Liisa Myllyniemi, Anna Pitkälä och Helmi Heiska, Evira Katariina Kivilahti-Mäntylä, Liisa Kaartinen och Jouko Koppinen, Läkemedelsverket
Resumé	Resultaten av programmet FINRES-Vet år 2005 och 2006 bevisar, att resistensläget hos bakterier som isolerats från djur och livsmedel i Finland är fortfarande gott. Det goda läget torde bland annat bero på vår goda sjukdomssituation och behärskad användning av mikrobläkemedel. Resistensläget för vissa bakteriers del är ändå oroväckande och därför är det allt viktigare att följa de bruksrekommendationer som getts i Finland om användning av mikrobläkemedel. Förbrukningen av mikrobläkemedel har hållit sig rätt stabil under 2000-talet. G-penicillin är fortsättningsvis det mest använda mikrobläkemedlet och kombinationen sulfonamid-trimetoprim den näst mest använda. Hos zoonotiska bakterier (*Salmonella* och *Campylobacter*) konstaterades resistens mycket sällan. Hos indikatorbakterier från kycklingar konstaterades resistens oftare än hos indikatorbakterier från nötdjur. Multiresistens var, liksom under tidigare år, vanligt hos *E. coli* som isolerats från svin med enterit. Endast 25 % av *Staphylococcus aureus* -bakterier från kor med mastit producerade betalaktamas. Hos andra mastitpatogener konstaterades endast små mängder resistens; ingen MRSA konstaterades. Multiresistens konstaterades hos 32 % av *Staphylococcus intermedius* från hundar.
Utgivningsdatum	November 2007
Referensord	Antibiotikaresistens, förbrukning av antibiotika
Publikationsseriens namn och nummer	Eviras publikationer 22/2007
Antal sidor	56
Språk	Engelska
Konfidentialitet	Offentlig handling
Utgivare | pris	Livsmedelssäkerhetsverket Evira (www.evira.fi) | 15 €
Förläggare	Livsmedelssäkerhetsverket Evira
Tryckningsort	Multiprint Oy, Helsingfors 2007
	ISSN 1796-4369 ISBN 952-5662-99-3 ISBN 952-5662-90-X (pdf)

Description

Publisher	Finnish Food Safety Authority Evira
Title	FINRES-Vet 2005-2006. Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents
Authors	Anna-Liisa Myllyniemi, Anna Pitkälä and Helmi Heiska, Evira Katariina Kivilahti-Mäntylä, Liisa Kaartinen and Jouko Koppinen, National Agency for Medicines
Abstract	The results of the FINRES-Vet programme from the years 2005 and 2006 revealed furthermore an overall favourable resistance situation among bacteria isolated from animals and food in Finland. Reasons for this are our favourable disease situation and a very controlled use of antimicrobials. However, the resistance data from some bacteria are of concern, indicating an increased need to follow the Finnish recommendations for using antimicrobial agents. The total amount of antimicrobial products has remained steady during the 2000's. Penicillin G continues to be the antimicrobial mostly used followed by sulfonamide-trimethoprim. In zoonotic bacteria (*Salmonella* and *Campylobacter*), resistance was detected only rarely. Resistance was detected in indicator bacteria from broilers more often than in indicator bacteria from cattle. Multiresistance was, as in previous years, common in *E. coli* isolated from pigs with enteritis. Of the *Staphylococcus aureus* isolates from bovine mastitis 25% produced betalactamase. Resistance was rare among other mastitis pathogens, and no MRSA isolates were detected. Of the canine *S. intermedius* isolates 32% were multiresistant.
Publication date	November 2007
Key words	Antimicrobial resistance, use of antimicrobials
Name and number of publication	Evira publications 22/2007
Pages	56
Language	English
Confidentiality	Public
Distributor | price	Finnish Food Safety Authority Evira (www.evira.fi) | 15 €
Publisher	Finnish Food Safety Authority Evira
Printed in	Multiprint Oy, Helsinki 2007
	ISSN 1796-4369 ISBN 952-5662-99-3 ISBN 952-5662-90-X (pdf)

Tiivistelmä

Tämä on vuosien 2005 ja 2006 FINRES-Vet-ohjelman tuloksista kertova raportti. Aiempien FINRES-Vet-raporttien (2002-2003 ja 2004) mukaan eläimistä ja elintarvikkeista eristettyjen bakteerien resistenssitilanne Suomessa on hyvä. Tilanne on pysynyt melko samanlaisena myös vuosina 2005-2006. Hyvä tilanne johtunee muun muassa tiukasta mikrobilääkepolitiikastamme. Joidenkin eläimille tautia aiheuttavien bakteerien resistenssitilanne on kuitenkin huolestuttava, mikä korostaa hallitun mikrobilääkkeiden käytön merkitystä myös tulevaisuudessa. On siis entistä tärkeämpää noudattaa Suomessa annettuja mikrobilääkkeiden käyttösuosituksia eläinten tärkeimpiin tulehdus- ja tartuntatauteihin.

Mikrobilääkkeiden kulutus Suomessa

Eläimille käytettävien mikrobilääkkeiden määrä (kg aktiivista ainetta) on pysynyt 2000-luvun alkupuoliskolla melko vakaana. Vuoteen 2004 verrattuna kokonaiskulutus vuosina 2005 ja 2006 on noussut noin 6 %. Se, onko kyseessä todellinen lisäys mikrobilääkkeiden kulutuksessa, vai tilastollinen vaihtelu, selviää tulevina vuosina. Tuotantoeläinten kasvatuksen tehostuminen ja tilakoon kasvu saattavat vaikuttaa mikrobilääkkeiden käyttötapoihin Suomessa.

Injektiona annettava G-penisilliini on edelleen eniten käytetty mikrobilääke ja suun kautta annettava sulfonamidi-trimetopriimi -yhdistelmä toiseksi käytetyin. Fluorokinolonien kulutus on pysynyt vähäisenä. Umpeenpanoon käyttävien mikrobilääkkeiden, samoin kuin lypsykauden utaretuubien käyttö on vähentynyt edelleen.

Zoonoosia aiheuttavien bakteerien resistenssi

FINRES-Vet -ohjelmassa ovat mukana kansallisessa salmonellavalvontaohjelmassa naudoista, sioista ja siipikarjasta eristetyt salmonellat. Lisäksi ohjelmassa ovat mukana kotimaisista elintarvikkeista eristetyt ja myös omavalvonnan yhteydessä todetut salmonellat. Koska salmonellaa todetaan tuotantoeläimissä ja niistä saatavissa elintarvikkeissa vain vähän, tutkimukseen tulevien bakteerikantojen määrä on pieni.

Resistenssiä todettiin hyvin vähän. Vuonna 2005 kaikki tutkitut kannat olivat herkkiä testatuille mikrobilääkkeille. Vuonna 2006 siprofloksasiiniresistenssiä todettiin kolmessa tuotantoeläimeltä eristetyssä kannassa.

Broilereilta eristettiin *Campylobacter jejuni* -bakteereita vuosina 2005 ja 2006 kampylobakteerien valvontaohjelman yhteydessä. Naudoilta eristettiin vuonna 2006 *C. jejuni* -bakteereita samoista näytteistä kuin indikaattoribakteereita. Kuten aiempinakin vuosina, resistenssiä todettiin vain vähän.

Indikaattoribakteerien resistenssi

Escherichia coli, Enterococcus faecalis ja *Enterococcus faecium* -bakteereita kerättiin broilereilta vuonna 2005, ja *E. coli* -bakteereita naudoilta vuonna 2006.

Siipikarjan hyvä tautitilanne ja monien virustautien puuttuminen sekä hyvät tuotanto-olosuhteet ovat pitäneet sekundaaristen bakteeritautien määrät vähäisinä. Mikrobilääkkeitä tarvitaan vain harvoin. Tästä huolimatta broilerien *E. faecium*- ja *E. faecalis* -bakteereilla todettin resistenssiä mm. basitrasiinille (30 ja 33 %), erytromysiinille (12 ja 22 %) ja oksitetrasykliinille (27 ja 41 %). Syynä voi olla lääkkeiden käyttö aiempina vuosina tai resistenssitekijöiden samanaikainen valikoituminen. Kokkidiostaatti narasiinin laajamittainen käyttö selittänee *E. faeciumin* korkean narasiiniresistenssin (86 %).

Broilerien *E. coli* -bakteereista 66 % ja naudan *E. coli* -bakteereista 95 % oli herkkiä kaikille testatuille mikrobilääkkeille. Broilerien *E. coli* -bakteereilla tavallisimpia olivat oksitetrasykliini- (17 %), ampisilliini- (16 %) ja sulfaresistenssit (13 %). Nautojen *E. coli* -bakteereilla tavallisimpia olivat kanamysiini- ja streptomysiiniresistenssit, joita tosin todettiin vain 3 %.

Eläimille tautia aiheuttavien bakteerien resistenssi

Moniresistenssi oli tavallista sikojen suolitulehduksista eristetyillä *E. coli* -bakteereilla: vuonna 2005 43 % ja vuonna 2006 32 % oli resistenttejä ainakin kolmelle mikrobilääkeaineelle. Resistenssi on pysynyt suurin piirtein samalla tasolla vuodesta 2002 lähtien. Kuten aiempinakin vuosina, resistenssi oli tavallista tetrasykliineille (2005 40 %, 2006 35 %), streptomysiinille (2005 40 %, 2006 32 %), sulfametoksatsolille (2005 45 %, 2006 35 %) ja trimetopriimille (2005 35 %, 2006 29 %). Enrofloksasiiniresistenssiä todettiin vuonna 2005 8 %:lla tutkituista kannoista, ja siprofloksasiiniresistenssiä vuonna 2006 24 %:lla tutkituista kannoista.

Nautojen utaretulehduksesta vuonna 2005 eristetyillä *Staphylococcus aureus* -bakteereilla todettiin vähän resistenssiä. Vaikka penisilliiniä käytetään yleisesti naudan utaretulehduksen hoidossa, vain 25 % kannoista tuotti beetalaktamaasia. Tetrasykliinien käyttö on vähentynyt mastiitin hoidossa 1990 -luvun alkupuolelta asti. Aiemmissa, subkliiniseen mastiittiin liittyvissä selvityksissä todettu tetrasykliiniresistenssin väheneminen on jatkunut: tässä aineistossa vain 2 % kannoista oli tetrasykliinille resistenttejä.

Viime vuosina MRSA:ta on todettu maailmanlaajuisesti enenevässä määrin myös eläimillä, erityisesti koirilla ja hevosilla. Suomalaisessa mastiittikartoituksessa vuonna 2001 ei todettu *mec*A-positiivisia *S. aureus* - bakteereita. Vuonna 2005 Suomessa todettiin ensimmäinen mastiitista eristetty MRSA. Niitä ei kuitenkaan todettu vuoden 2006 MRSA-kartoituksessa.

Kaikki vuonna 2005 tutkitut *Streptococcus uberis* ja *Streptococcus dysgalactiae* -kannat olivat herkkiä penisilliinille. *S. uberis* –bakteereista 37 % ja *S. dysgalactiae* -bakteereista 36 % oli resistenttejä tetrasykliinille. *S. uberis* -bakteereista 15 % oli resistenttejä erytromysiinille. Streptokokeilla ei todettu moniresistenssiä.

Naudan mastiitista vuonna 2006 eristetyillä *E. coli* -bakteereilla todettiin vain vähän resistenssiä. Koliformimastiitin hoitoon ei rutiininomaisesti suositella mikrobilääkkeitä, mikä saattaa näkyä resistenssin vähäisyytenä. Tavallisinta oli streptomysiiniresistenssi (9 %), seuraavaksi yleisintä resistenssi ampisilliinille (7 %), sulfalle (7 %) ja tetrasykliinille (5 %). Naudan mastiitista eristetyillä klebsielloilla tavallisinta oli streptomysiiniresistenssi (11 %), seuraavaksi yleisimpiä olivat tetrasykliini-(10 %) ja sulfaresistenssi (4 %).

Koirien iho-, haava- ja korvatulehduksista vuosina 2005 ja 2006 eristetyistä *Staphylococcus intermedius* -bakteereista vain 17 % oli herkkiä kaikille testatuille mikrobilääkkeille. Kaksikymmentäkolme prosenttia oli resistenttejä ainakin yhdelle mikrobilääkkeelle (tavallisimmin penisillinille) ja 28 % kahdelle (tavallisimmin penisilliinille ja oksitetrasykliinille). Moniresistenssiä todettiin 32 %:lla kannoista. Kolmesta enrofloksasiinille resistentistä kannasta yksi oli moniresistentti. Kolmella kannalla, joista yksi oli eristetty ihotulehduksesta, yksi haavatulehduksesta ja yksi korvatulehduksesta, todettiin *mec*A-geeni.

Resumé

Det här är den tredje rapporten över resultaten av programmet FINRES-Vet år 2005 och 2006. Enligt de tidigare FINRES-Vet rapporterna (2002-2003 och 2004) är resistensläget hos bakterier som isolerats från djur och livsmedel i Finland gott. Läget har förblivit rätt oförändrat även åren 2005-2006. Det goda läget torde bland annat bero på vår strikta mikrobläkemedelspolicy. Resistensläget för vissa sjukdomsalstrande bakteriers del är ändå oroväckande och därför är det även framöver viktigt att mikrobläkemedel används på ett behärskat sätt. Det är alltså essentiellt att de bruksrekommendationer som getts i Finland om användning av mikrobläkemedel mot de viktigaste infektionssjukdomarna och smittsamma sjukdomarna bland djur följs.

Förbrukningen av mikrobläkemedel i Finland

Förbrukningen av mikrobläkemedel (kg aktivt läkemedel) inom veterinärmedicinen har hållit sig rätt stabil under början av 2000-talet. Jämfört med året 2004 har totalförbrukningen ökat med cirka 6 %. Om det rör sig om en faktisk ökning i förbrukningen av mikrobläkemedel eller om statistisk variation klarnar under de kommande åren. En effektivare uppfödning av husdjur och allt större gårdar kan påverka sätten på vilka antibiotika används i Finland.

G-penicillin i form av injektioner är fortsättningsvis det mest använda mikrobläkemedlet och kombinationen sulfonamid-trimetoprim intagen via munnen den näst mest använda. Förbrukningen av fluorokinoloner har förblivit blygsam. Användningen av mikrobläkemedel vid sinläggning liksom juvertuber under laktationsperioden har ytterligare minskat.

Resistensen hos zoonotiska bakterier

I programmet FINRES-Vet finns de salmonellor med som isolerats från nötdjur, svin och fjäderfä inom ramen för det nationella salmonellakontrollprogrammet. Med i programmet finns dessutom salmonellor som förekommit i inhemska livsmedel och sådana som konstaterats i samband med egenkontroll. Eftersom endast små mängder salmonella konstateras hos husdjur och livsmedel av animaliskt ursprung, är också mängden isolat som kommer in för undersökning liten.

Resistens konstaterades mycket sällan. År 2005 var samtliga testade isolat känsliga mot de testade mikrobläkemedlen. År 2006 konstaterades resistens mot ciprofloxacin i tre isolat som isolerats från husdjur.

Hos kyckling isolerades *Campylobacter jejuni* bakterier åren 2005 och 2006 i samband med programmet för kontroll av campylobakterier. Hos nötdjur isolerades år 2006 *C. jejuni* och indikatorbakterier i samma prover. Liksom under tidigare år konstaterades endast små mängder resistens.

Resistensen hos indikatorbakterier

År 2005 undersöktes förekomsten av bakterierna *Escherichia coli, Enterococcus faecalis* och *Enterococcus faecium* hos kyckling och år 2006 förekomsten av *E. coli* bakterier hos nötdjur.

Det goda sjukdomsläget bland fjäderfä, det faktum att många viktiga virussjukdomar inte alls förekommer och de goda produktionsförhållandena har hållit mängden sekundära bakteriesjukdomar blygsam. Mikrobläkemedel behövs sällan. Trots det konstaterades resistens till exempel mot bacitracin (30 och 33 %), erytromycin (12 och 22 %) och oxitetracyklin (27 och 41 %) hos bakterierna *E. faecium* och *E. faecalis* bland kyckling. Orsaken kan vara att dessa läkemedel använts under tidigare år eller co-selektion av resistensfaktorerna. Den omfattande användningen av koccidiostaten naracin torde förklara den höga naracinresistensen (86 %) hos *E. faecium*.

66 % av bakterierna *E. coli* bland kyckling och 95 % av bakterierna *E. coli* bland nötdjur var känsliga för alla de testade mikrobläkemedlen. Hos bakterierna *E. coli* bland kyckling var resistens mot oxitetracyklin (17 %), ampicillin (16 %) och sulfa (13 %) vanligast. Hos bakterierna *E. coli* bland nötdjur var resistensen mot kanamycin och streptomycin vanligast. Sådana konstaterades visserligen endast 3 %.

Resistensen hos sjukdomsalstrande bakterier

Multiresistens var vanligt hos *E. coli* som isolerats från enteriter från svin: år 2005 var 43 % och år 2006 32 % resistenta mot minst tre mikrobläkemedel. Resistensen har hållit sig på en i stort sett oförändrad nivå sedan år 2002. Liksom under tidigare år var resistens vanligt mot tetracykliner (2005 40 %, 2006 35 %), streptomycin (2005 40 %, 2006 32 %), sulfametoxasol (2005 45 %, 2006 35 %) och trimetoprim (2005 35 %, 2006 29 %). Enrofloxacinresistens konstaterades år 2005 hos 8 % av de undersökta stammarna och ciprofloxacinresistens år 2006 hos 24 % av de undersökta stammarna.

Hos bakterierna *Staphylococcus aureus* isolerade år 2005 från mastit hos nötdjur konstaterades sällan resistens. Även om penicillin allmänt används mot mastit hos nötdjur, producerade endast 25 % av stammarna betalaktamas. Användningen av tetracykliner har minskat vid behandling av mastit allt sedan början av 1990-talet. Minskningen i resistensen mot tetracyklin, som konstaterats i tidigare undersökningar som hänfört sig till subklinisk mastit, har fortsatt: i detta material var endast 2 % av stammarna resistenta mot tetracyklin.

På senare år har allt mer MRSA konstaterats globalt även hos djur, särskilt hos hundar och hästar. I den finska mastitkartläggningen år 2001 konstaterades inga *mec*A-positiva *S. aureus* stammar. År 2005 konstaterades för första gången MRSA isolerad från mastit i Finland. I kartläggningen år 2006 konstaterades ändå ingen MRSA.

Samtliga stammar av *Streptococcus uberis* och *Streptococcus dysgalactiae* undersökta år 2005 var känsliga mot penicillin. 37 % av *S. uberis* bakterierna och 36 % av *S. dysgalactiae* bakterierna var resistenta mot tetracyklin. 15 % av *S. uberis* bakterierna var resistenta mot erytromycin. Hos streptokocker konstaterades ingen multiresistens.

Hos *E. coli* bakterier isolerade från mastit hos nötdjur konstaterades endast små mängder resistens. Mikrobläkemedel rekommenderas inte rutinmässigt för behandling av koliform mastit och detta kan visa sig som ringa resistens. Resistens mot streptomycin (9 %) var vanligast och därefter resistens mot ampicillin (7 %), sulfa (7 %) och tetracyklin (5 %). Klebsiellor isolerade från mastit hos nötdjur var oftast resistenta mot streptomycin (11 %) och därefter mot tetracyklin (10 %) och sulfa (4 %).

Endast 17 % av *Staphylococcus intermedius* isolerade från hud-, sår- och öroninflammationer hos hundar åren 2005-2006 var känsliga för alla de testade mikrobläkemedlen. Tjugotre procent var resistenta mot åtminstone ett mikrobläkemedel (vanligen penicillin) och 28 % mot två (vanligen penicillin och oxitetracyklin). Multiresistens konstaterades hos 32 % av isolaten. Av tre isolat som var resistenta mot enrofloxacin var en multiresistent. Hos tre isolat, av vilka en var isolerad från hudinflammation, en från sårinflammation och en från öroninflammation, konstaterades *mec*A gen.

Abstract

This is the third FINRES-Vet report including data from the years 2005 and 2006. Previous FINRES-Vet reports (2002-2003 and 2004) revealed an overall favourable resistance situation among bacteria isolates from animals and food in Finland. The resistance situation has remained fairly similar in 2005-2006 when compared to previous years. One possible explanation for this is our strict antimicrobial policy. However, the resistance data from some animal pathogens are of concern, indicating the need to further emphasize the importance of prudent use of antimicrobials. Therefore, the importance of following the existing Finnish recommendations for using antimicrobial agents to treat the most significant infectious diseases in animals is highlighted in order to further promote the prudent use of antimicrobials in animal therapeutics.

Use of therapeutic antimicrobials for animals in Finland

The total amount of antimicrobial products, calculated as kg of the active substance, has remained steady for several years. However some increase (6%) in the overall consumption since the year 2004 is seen. Future will show if this is true increase in antimicrobial consumption or just statistical variation. Livestock production in Finland is changing towards more intensive production and increasing herd size will probably affect the use patterns of the antimicrobials.

Injectable penicillin G continues to be the antimicrobial mostly used followed by oral combination of sulfonamide-trimethoprim. The use of fluoroquinolones remains small. The amount of antimicrobials used for dry cow treatment as well as for treatment during lactation continues to diminish.

Resistance in zoonotic bacteria

Salmonella isolates from domestic food, cattle, pigs and poultry, collected in the national *Salmonella* control programme, were included in the FINRES-Vet programme. From domestic food, also isolates from in-house control system were included. As *Salmonella* is only rarely isolated from production animals and products thereof, only a small number of isolates was available for susceptibility testing. Resistance was rare. In 2005, all isolates submitted were sensitive to every antimicrobial drug tested. In 2006, resistance was detected for ciprofloxacin in three isolates from production animals.

Isolates of *Campylobacter jejuni* were collected from broilers in association with the Finnish Campylobacter control programme in 2005 and 2006, and bovine *C. jejuni* in 2006 from the same samples as indicator bacteria. As in the previous years, resistance was detected only rarely.

Resistance in indicator bacteria

In 2005, *Escherichia coli, Enterococcus faecalis* and *Enterococcus faecium* isolates were collected from broilers, and *E. coli* were collected from cattle in 2006.

In poultry, low infection prevalence and absence of many significant viral infections, coupled with favourable production conditions, have kept the incidence of secondary bacterial infections negligible.

The need for antimicrobial therapy is small. However, resistance was detected e.g. to bacitracin (30% and 33%), erythromycin (12 and 22%), and oxytetracycline (27 and 41%) in broiler *E. faecium* and *E. faecalis* isolates, respectively. The reason may be their use over recent years or co-selection. Widespread use of the coccidiostat narasin is the likely cause for the widespread narasin resistance in *E. faecium* (86%).

Of the broiler *E. coli* isolates 66%, and of the cattle isolates 95% were susceptible to all antimicrobials tested. In broiler *E. coli*, the most common resistance characteristics were resistance to oxytetracycline (17%), ampicillin (16%), and sulfamethoxazole (13%). In bovine *E. coli* resistances to kanamycin and streptomycin were the most prevalent, though only 3% for both.

Resistance in animal pathogens

Multiresistance was common in *E. coli* isolated from pigs with enteritis: 43% and 32% of the isolates were resistant to at least three antimicrobials in 2005 and 2006, respectively. As in previous years, resistance to tetracyclines (2005: 40%, 2006: 41%), streptomycin (2005: 40%, 2006: 32%), sulfamethoxazole (2005: 45%, 2006: 35%), and trimethoprim (2005: 35%, 2006: 29%) was common. Resistance to enrofloxacin was 8% in 2005, and resistance to ciprofloxacin 24% in 2006.

The level of resistance in *Staphylococcus aureus* isolated in bovine mastitis in 2005 was low. Penicillin is widely used for the treatment of mastitis in cattle, but only 25% of the isolates produced betalactamase. The use of tetracyclines in mastitis therapy has decreased since the beginning of 1990's, and the decrease in resistance to tetracycline observed in earlier surveys on subclinical mastitis has continued: in the present material only 2% of the isolates were resistant.

In recent years MRSA has been worldwide increasingly reported in veterinary medicine, especially from dogs and horses. In the Finnish mastitis survey in 2001 no *mec*A -positive *S. aureus* isolates were found. In 2005 the first MRSA was isolated from clinical mastitis in Finland. However, in the pilot MRSA screening in bovine mastitis in 2006, no MRSA isolates were detected.

In 2005, all *Streptococcus uberis* and *Streptococcus dysgalactiae* isolates were susceptible to penicillin. Thirty-seven % of *S. uberis* and 36% of *S. dysgalactiae* isolates were resistant to oxytetracycline. Of the *S. uberis* isolates, 15% were resistant to erythromycin. No multiresistance was found in streptococci.

In 2006, the level of resistance in *E. coli* from bovine mastitis was in general low. Use of antimicrobial treatment is not routinely recommended for coliform mastitis in Finland, which may affect the results. Resistance to streptomycin (9%) was most common, followed by resistance to ampicillin (7%), sulfamethoxazole (7%) and tetracycline (5%). In Klebsiella species from bovine mastitis, resistance to streptomycin (11%) was most common, followed by resistance to tetracycline (10%) and sulfamethoxazole (4%).

Of the *Staphylococcus intermedius* isolates from canine skin, post-operative wound or ear infections in 2005 and 2006 only 17% were sensitive to all antimicrobials tested. Twenty-three % were resistant to at least one (mainly penicillin) and 28% to two (mainly penicillin and oxytetracycline) antimicrobials. Multiresistance was found in 32% of the isolates. Of the three isolates resistant to enrofloxacin, one was multiresistant. Three isolates, one isolate from a skin infection, one from a post-operative wound infection and one from an ear infection, were found to have the *mec*A gene.

Contents

Johdanto

FINRES-Vet-ohjelmassa seurataan zoonoosia aiheuttavien bakteerien ja indikaattoribakteerien mikrobilääkeresistenssiä zoonoosidirektiivin 2003/99/EC edellyttämällä tavalla. Lisäksi seurataan joidenkin eläimille tautia aiheuttavien bakteerien resistenssiä.

Ihmiset voivat saada zoonoosia aiheuttavan bakteerin tartunnan joko suoraan eläimistä tai niistä saatavista elintarvikkeista. Tietyn populaation indikaattoribakteerien resistenssi kuvaa ko. populaatioon kohdistunutta, mikrobilääkkeiden käytön aiheuttamaa valintapainetta. Lisäksi indikaattoribakteerit muodostavat varaston, josta resistenssigeenit voivat siirtyä tautia aiheuttaviin bakteereihin.

Eläimille tautia aiheuttavien bakteerien resistenssin seuraaminen on tärkeää, koska resistenssiä seuraamalla voidaan havaita ihmisten ja eläinten terveyden kannalta merkityksellisen resistenssin lisääntyminen. On kuitenkin otettava huomioon se, että tautitapauksista eristettyjen, eläimille tautia aiheuttavien bakteerien resistenssitiedot voivat painottua väärin, koska bakteerit on usein eristetty vakavista tai uusiutuvista infektioista.

FINRES-Vet-ohjelman tavoitteena on

- seurata tärkeimmistä tuotantoeläinlajeista ja lemmikkieläimistä eristettyjen bakteerien mikrobilääkeresistenssiä
- analysoida resistenssin levinneisyyden muutoksia sekä
- havaita uusien resistenttien kloonien ja fenotyyppien kehittyminen sekä seurata mikrobilääkkeiden kulutusta

Aiemmissa FINRES-Vet-raporteissa (2002-2003 ja 2004) todettiin Suomen resistenssitilanteen olevan sekä eläimistä että elintarvikkeista eristetyillä bakteereilla pääosin hyvä. Tämä johtunee pääasiassa tiukasta mikrobilääkepolitiikastamme; vain eläinlääkärit voivat määrätä mikrobilääkkeitä eläimille. Joidenkin eläimille tautia aiheuttavien bakteerien resistenssitilanne on kuitenkin huolestuttava, minkä takia mikrobilääkkeiden hallittu käyttö on entistä tärkeämpää myös tulevaisuudessa. Eläinten tärkeimpiin tulehdus- ja tartuntatauteihin annettujen mikrobilääkkeiden käyttösuositusten tarkoituksena onkin edistää mikrobilääkkeiden hallittua käyttöä eläinlääkinnässä.

Tämä on kolmas FINRES-Vet-ohjelman tuloksista kertova raportti, joka kattaa vuosien 2005-2006 tulokset. Vuonna 2002 indikaattoribakteereita kerättiin broilereilta, vuonna 2003 naudoilta, vuonna 2004 sioilta, vuonna 2005 broilereilta ja 2006 naudoilta. Zoonoosia aiheuttavista bakteereista mukana ovat *Salmonella* ja *Campylobacter*, eläimille tautia aiheuttavista bakteereista sikojen *Escherichia coli*, koirien *Staphylococcus intermedius* ja naudan mastiitista eristetyt *Staphylococcus aureus-, Streptococcus uberis-, Streptococcus dysgalactiae-*, *Escherichia coli-* ja *Klebsiella* -bakteerit. Indikaattoribakteereista mukana ovat *Escherichia coli, Enterococcus faecalis* ja *E. faecium*.

Elintarviketurvallisuuvirasto Evira koordinoi FINRES-Vet-ohjelmaa. Lääkelaitos seuraa eläimille käytettyjen mikrobilääkkeiden kulutusta ja Evira lääkerehujen ja rehun lisäaineiden kulutusta.

Kiitokset

FINRES-Vet-ohjelman koordinoijat kiittävät Eviran ja teurastamoiden lihantarkastushenkilökuntaa teurastamonäytteiden keräämisestä sekä mastiittilaboratorioiden henkilökuntaa bakteerikantojen ja maitonäytteiden keräämisestä.

Introduktion

I programmet FINRES-Vet följs resistensen mot mikrobläkemedel hos zoonotiska bakterier och indikatorbakterier upp på det sätt som zoonosdirektiv 2003/99/EC förutsätter. Utöver det följs också resistensen hos vissa sjukdomsalstrande bakterier upp.

Människor kan smittas av en zoonotisk bakterie antingen direkt från djur eller från livsmedel av animaliskt ursprung. Resistensen hos indikatorbakterier i en viss population beskriver det selektionstryck som användning av mikrobläkemedel medfört och som riktat sig mot populationen i fråga. Indikatorbakterierna bildar dessutom ett förråd, från vilket resistensgener kan överföras till sjukdomsalstrande bakterier.

Uppföljningen av resistens hos sjukdomsalstrande bakterier är viktigt, eftersom man så kan uppdaga om en resistens som är viktig med tanke på människors och djurs hälsa ökar. Det är ändå skäl att beakta att informationen om resistensen hos sjukdomsalstrande bakterier som isolerats från sjukdomsfall kan få fel tyngd, eftersom bakterierna ofta isolerats från allvarliga eller upprepade infektioner.

Målet med programmet FINRES-Vet är att

- följa upp resistensen mot mikrobläkemedel hos bakterier som isolerats från de viktigaste husdjursslagen och sällskapsdjuren
- analysera förändringar i resistensens förekomst och
- uppdaga tillkomsten av nya resistenta kloner och fenotyper och följa upp förbrukningen av antibiotika

I de tidigare FINRES-Vet rapporterna (2002-2003 och 2004) konstaterades att resistensläget i Finland huvudsakligen är gott för såväl bakterier som isolerats från djur som bakterier som isolerats från livsmedel. Det torde huvudsakligen bero på vår strikta mikrobläkemedelspolicy; endast veterinärer kan ordinera mikrobläkemedel till djur. Resistensläget hos vissa sjukdomsalstrande bakterier är ändå oroväckande och därför är det även framöver allt viktigare att antibiotika används på ett behärskat sätt. Syftet med bruksrekommendationer för mikrobläkemedel som ges mot de viktigaste infektionssjukdomarna och smittsamma sjukdomarna bland djur är också att främja en behärskad användning av mikrobläkemedel inom veterinärmedicinen.

Det här är den tredje rapporten över resultaten av programmet FINRES-Vet. Den presenterar resultaten åren 2005-2006. År 2002 insamlades indikatorbakterier bland kyckling, år 2003 bland nötdjur, år 2004 bland svin, år 2005 bland kyckling och 2006 bland nötdjur. Av de zoonotiska bakterierna ingår *Salmonella* och *Campylobacter*, av de sjukdomsalstrande bakterierna *Escherichia coli* bland svin, *Staphylococcus* intermedius bland hundar och de från mastit hos nötdjur isolerade bakterierna *Staphylococcus aureus*, *Streptococcus uberis*, *Streptococcus dysgalactiae*, *Escherichia coli* och *Klebsiella*. Av indikatorbakterierna ingår *Escherichia coli*, *Enterococcus faecalis* och *E. faecium*.

Livsmedelssäkerhetsverket Evira koordinerar programmet FINRES-Vet. Läkemedelsverket följer upp förbrukningen av mikrobläkemedel för djur och Evira förbrukningen av läkemedelsfoder och tillsatser i foder.

Varmt tack

Koordinatorerna av programmet FINRES-Vet vill tacka köttbesiktningspersonalen i Evira och slakterierna för insamlandet av slakteriprov och mastitlaboratoriernas personal för insamlandet av bakteriestammar och mjölkprov.

Introduction

The FINRES-Vet programme monitors antimicrobial resistance in zoonotic agents and indicator bacteria, as required in 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 animals or of food of animal origin. The resistance of indicator bacteria in a certain population reflects the selection pressure caused by the use of antimicrobials. They also create a pool of resistance genes, which may be transferred to pathogenic bacteria.

Monitoring of antimicrobial resistance of animal pathogens is important since it may reveal emerging resistance, which is a risk for human and animal health. It must, however, be emphasised that the data on resistance in pathogenic bacteria isolated from diagnostic submissions may be biased, because the samples are often obtained from complicated or recurrent cases.

FINRES-Vet programme has the following objectives:

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

The first FINRES-Vet reports (2002-2003 and 2004) revealed an overall favourable resistance situation among bacteria isolated from animals and food in Finland. This is probably the outcome of the strict antimicrobial policy; antimicrobials used for treating animals are prescribed only by veterinarians. However, the resistance data from some animal pathogens were of concern indicating that there is a need to further enforce the prudent use of antimicrobials. Recommendations for using antimicrobial agents to treat the most significant infectious diseases in animals have been given to promote the prudent use of antimicrobials in animal therapeutics.

This is the third FINRES-Vet report including data from the years 2005 and 2006. In 2002, indicator bacteria were collected from broilers, in 2003 from cattle, in 2004 from pigs, 2005 from broilers and 2006 from cattle. Zoonotic bacteria obtained for analysis are *Salmonella* and *Campylobacter*, animal pathogens *Escherichia coli* from pigs, *Staphylococcus intermedius* from dogs and *Staphylococcus aureus*, Streptococcus uberis, Streptococcus dysgalactiae, *Escherichia coli* and *Klebsiella* species from bovine mastitis. Indicator bacteria are *E. coli*, *Enterococcus faecalis* and *E. faecium*.

FINRES-Vet is coordinated by the Finnish Food Safety Authority Evira. The consumption of antimicrobial agents for veterinary use is monitored by the National Agency for Medicines and the consumption of feed additives and medicated feeding stuffs by Evira.

Acknowledgements

The coordinators of the FINRES-Vet programme would like to thank the meat inspection personnel of Evira and slaughterhouses for collecting the samples from animals at slaughter, and personnel in mastitis laboratories for collecting bacterial isolates and milk samples.

Use of therapeutic antimicrobials and feed additives for animals in Finland

Antimicrobials for treatment of animals

The National Agency for Medicines monitors the quantity of veterinary medicinal products used in Finland. The sales figures of antimicrobial products are collected from pharmaceutical wholesale companies.

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 skews the figures markedly, as the proportion of human products used in companion-animal practice account for 10-15% of all antimicrobials used for these species (Rantala, 2003; Hölsö et al., 2005).

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

ATCvet code	Substance class	2001	2002	2003	2004	2005	2006
QG01AA, QJ01AA, QD06AA,	Tetracyclines	1 937	1 980	1 757	1 263	1 445	1 320
QJ01CE, QJ01R, QJ51R	Penicillin G	6 235	6 054	6 076	6 754	6 803	6 905
QJ01CA, QJ01CR	Aminopenicillins	532	637	698	798	958	846
QJ01D, QJ51RD01, QJ51CF, QJ51CR	Other beta-lactam antimicrobials	0	0	0	0	0	0
QJ51RD, QJ01DA	Cephalosporins	1 153	1 055	1 133	1 048	1 000	1 004
QJ51CR, QJ51CF	Cloxacillin	149	105	145	140	132	109
QA07AA, QJ01G, QJ01R, QJ51R	Aminoglycosides	632	385	291	280	238	225
QJ01E	Sulfonamides and trimethoprim	2 490	2 342	2 187	2 368	2 438	2 946
QJ01F, QJ51FF90, QJ01FA94	Macrolides and lincosamides	492	422	538	526	393	619
QJ01MA, QJ01MB	Fluoroquinolones, quinoxalines	101	95	81	79	90	81
QJ01XX, QJ01B	Other substances	103	97	186	107	112	74
		13 824	**13 172**	**13 091**	**13 362**	**13 609**	**14 130**

*) Total consumption of sulfonamides and trimethoprim in 2003-2005 corrected

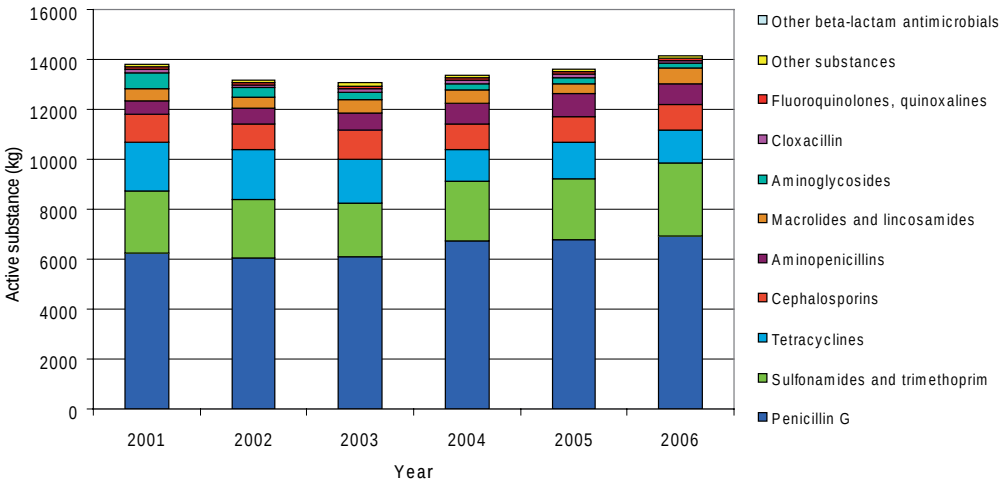

Figure 1. *Antimicrobials used for treatment of animals*

Volume of use

The total amount of antimicrobial products, calculated as kg of the active substance, remained steady for several years. Since 2004, approximately 6 % increase in overall consumption is seen. Future will show if this is true increase in antimicrobial consumption or just statistical variation. Livestock production in Finland is changing towards more intensive production and changes in the herd size will probably affect the use patterns of the antimicrobials. If the overall consumption of antimicrobials continues to rise after a decade of a favourable development, the reasons behind this phenomenon should be examined.

Table 1 and Figure 1 show the breakdown of the overall consumption into main antimicrobial groups. Penicillin G continues to be the antimicrobial mostly used and the combination of sulphonamide-trimethoprim the second.

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

ATCvet code	Substance class	2001	2002	2003	2004	2005	2006
QG01AA	Tetracyclines, doxicyclin	196	143	265	291	312	288
QJ01CE, QJ01R, QJ51R	Penicillin G	5 981	5 799	5 840	6 529	6 597	6 739
QJ01CA, QJ01CR	Aminopenicillins	76	115	133	145	236	170
QJ01E	Sulfonamides and trimethoprim	599	474	425	442	463	457
QJ01F	Macrolides and lincosamides	63	70	49	44	76	81
QJ01MA	Fluoroquinolones	70	70	69	66	77	67
QJ01GB, QJ01DA	Other substances	2	0	2	1	11	12
		6 987	**6 671**	**6 783**	**7 518**	**7 771**	**7 815**

Injectable administered antimicrobial products

The amount of antimicrobial medicines given as injectable form is depicted in Table 2. The volume of injectables increased in 2004 and in 2005, mainly due to changes in the penicillin G and the tetracycline group. This increase could be speculated to be partly due to increased treatment of bovine respiratory infections. Specialized rearing units where calves from different farms are mixed have become more common in Finland, and resulted in new health problems in the calf-rearing farms. Another explanation could be that especially in 2004 all the more piggeries joined the National Health Care system (https://www.sikava.fi). When a piggery takes part to the Health Care system and the veterinarian visits the farm regularly it is possible to leave injectable penicillin to the farmer in reserve for the treatment of certain infections (porcine arthritis and infections caused by tail biting). It is also possible that despite the preventive work done within the Health Class system the incidence of porcine arthritis and/or infection caused by tail biting has increased.

The use of injectable fluoroquinolones remains small.

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

ATCvet code	Substance class	2001	2002	2003	2004	2005	2006
QJ01A, QD06AA, QS03CA	Tetracyclines	1 672	1 799	1 380	967	1 135	928
QJ01CA, QJ01CR	Aminopenicillins	424	508	536	620	690	650
QJ01DA	Other beta-lactam antimicrobials (Cephalosporins)	939	887	998	938	915	940
QA07AA, QJ01R	Aminoglycosides	150	142	125	123	111	110
QJ01E	Sulfonamides and trimethoprim	1 892	1 868	1 762	1 926	1 975	2 489
QJ01F	Macrolides and lincosamides	428	357	497	481	316	538
QJ01MA, QJ01MB	Fluoroquinolones, quinoxalines	31	44	12	12	13	14
QJ01XX, QJ01B	Other substances	101	87	100	104	110	68
		5 637	**5 692**	**5 410**	**5 172**	**5 264**	**5 735**

*) Total consumption of per oral sulfonamides and trimetoprim in 2003-2005 corrected

Orally administered antimicrobial products

The consumption of orally used antimicrobial products has decreased or has remained steady through the 2000s, however a rise is seen in 2006 (Table 3).

The rise can be explained almost alone by the higher consumption of oral sulfonamide-trimethoprim combination. Conclusions should however be made with caution, as the consumption of various antimicrobial classes may fluctuate considerably between the years (e.g. macrolides and lincosamides). Orally administered sulfonamide-trimethoprim combination is used especially in the treatment of gastrointestinal and respiratory infections in different species. It would be useful to find out whether the amount and class of antimicrobials used in herds of different size and production environment differ from another.

There seems to be a tendency towards diminishing consumption of per oral tetracycline products. The use of fluoroquinoles remains small.

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

ATCvet code	Substance class	2001	2002	2003	2004	2005	2006
QJ51CR, QJ51CF, QJ51RD	Aminopenicillins, cephalosporins, cloxacillins	125	112	100	92	89	76
QJ51RC	Penicillin G	29	32	34	43	40	33
QJ51RC	Aminoglycosides and other substances	70	53	43	45	34	29
Total		**224**	**197**	**177**	**179**	**163**	**138**

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

ATCvet code	Substance class	2001	2002	2003	2004	2005	2006
QJ51CR, QJ51CF, QJ51RD	Cephlosporin and cloxacillin	245	207	184	164	136	104
QJ51CR	Aminopenicillins	25	25	24	26	26	19
QJ51RC	Penicillin G	225	223	202	182	167	132
QJ51RC	Aminoglycosides and other substances	414	194	126	115	82	73
Total		**909**	**649**	**536**	**488**	**411**	**329**

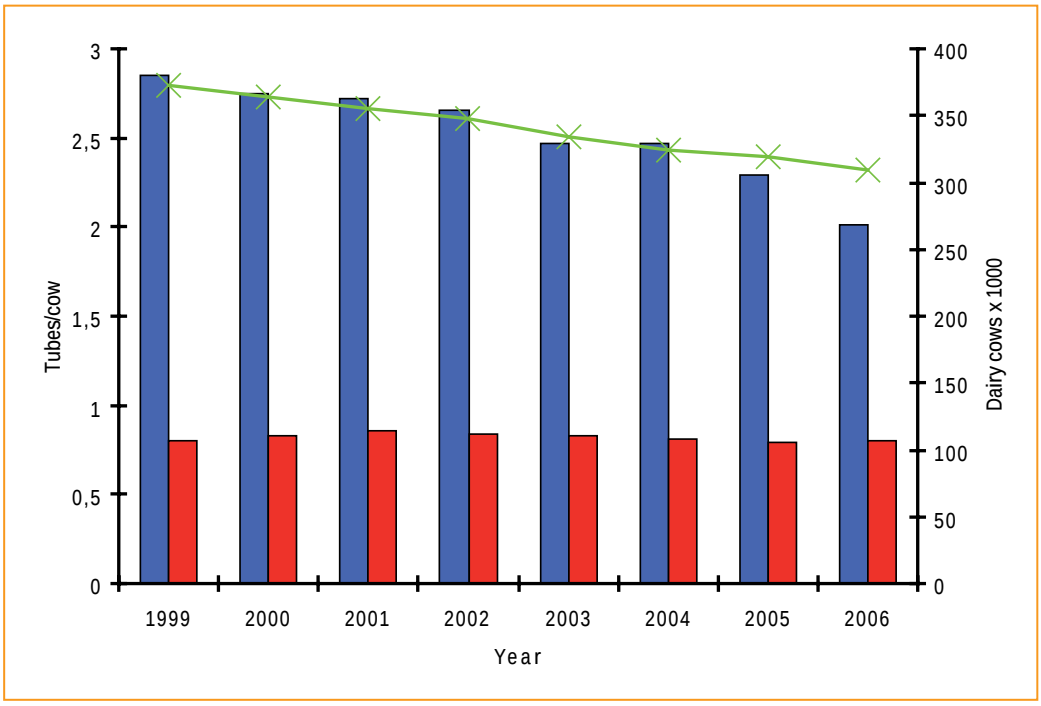

Figure 2. *Antimicrobials for intramammary use during lactation period (blue column) and for dry cow period (red column) and the number of dairy cows (green curve)*

Intramammary antimicrobials

The amount of antimicrobials used for dry cow treatment (Table 4) as well as for treatment during lactation (Table 5) continues to diminish. Decrease is seen in all antimicrobial classes. Figure 2 shows the use of both classes of intramammary antimicrobials in proportion to the dairy cow number. The major explanation for the decreasing consumption of intramammary products (Table 6) is the declining number of dairy cows, but there is also a trend to use fewer intramammaries per cow for treatment of mastitis during lactation. In contrast, dry-cow treatment remains fairly steady.

Table 6. *Antimicrobials for intramammary use calculated as the number of single-dose applicators per 1000 cows and day (DDDcow / 1000 cows at risk and day)*

Indication	2001	2002	2003	2004	2005	2006
For therapy during lactation*	3.73	3.64	3.38	3.39	3.14	2.66
For dry cow treatment**	0.59	0.58	0.57	0.55	0.54	0.53
Total	**4.32**	**4.22**	**3.95**	**3.94**	**3.68**	**3.19**

*calculated as total no. of tubes/2 (daily dose per cow)/days in a year/(no. of cows / 1000)

**calculated as total no. of tubes/4 (daily dose per cow)/days in a year/(no. of cows / 1000)

Antimicrobial feed additives

Evira monitors the consumption of feed additives annually by collecting data from feed manufacturers. The Finnish feed industry (producing feed for food-producing animals) voluntarily terminated the use of antimicrobial growth promoters in the 1990s.

The European Union banned the use of avoparcin in 1997 and the use of bacitracin, spiramycin, tylosin and virginiamycin for growth promotion in 1999. In Finland, the use of virginiamycin was stopped already in 1990, the use of bacitracin in 1992 and the use of flavomycin and avoparcin in 1996.

Table 7 presents the total sales of feed additives in Finland in 1996-2006. At present, no growth promoters are used in Finland. The coccidiostats monensin, narasin and salinomycin are used as prophylactic anti-parasitic agents mainly in broiler and turkey production; the use of monensin and salinomycin used has increased from the year 2004, and the use of narasin diminished.

Table 7. *The use of antimicrobial feed additives, coccidiostats and growth promoters in Finland in 1996-2006*

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Amprolium (and ethopabate)			427 (27)	148 (9)	74 (5)	79	22	0	0	0	0
Avoparcin	47	0	0	0	0	0	0	0	0	0	0
Dimetridazole	204	63	42	0	0	0	0	0	0	0	0
Flavomycin	7	0	0	0	0	32	3	0	0	0	0
Lasalocid sodium			3 024	3 019	2 796	3 624	3 349	176	0	0	0
Carbadox	1 841	1 123	3 286	1 082	0	0	0	0	0	0	0
Olaquindox	2 882	2 883	730	0	0	0	0	0	0	0	0
Madmuramycin ammonium	0	0	0	0	0	0	8	43	1,5	1,5	0
Monensin natrium	3 653	4 375	632	353	0	1 475	1 969	4 422	5 808	8 458	[4]9 585
Narasin	2 232	1 959	2 866	2 568	2 549	2 101	5 569	5 769	5 518	[2]3 218	[5]2 481
Salinomycin	1 705	3 657	2 320	3 246	2 829	3 272	28	3	[1]10	[3]374	[6]1 328
Nifursol				188	0	0	0	0	0	0	0
Robenidine hydrochloride	0	0	0	0	67	0	0	0	0	0	0

[1] Used in exported feed mixtures
[2] 13.2 kg used in exported feed mixtures
[3] 190 kg used in exported feed mixtures
[4] 42.6 kg used in exported feed mixtures
[5] 1.65 kg used in exported feed mixtures
[6] 317 kg used in exported feed mixtures

Resistance in zoonotic bacteria

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. The objective of the programme is to maintain the annual incidence of *Salmonella* contamination among production animals and in associated meat and eggs at 1% or less. The results from the programme show that *Salmonellae* in production animals and foods of animal origin are uncommon in Finland. *Salmonella* isolates from domestic food, cattle, pigs and poultry were included in the FINRES-Vet programme. From domestic food, also isolates from in-house control system were included.

Details of sampling and isolation procedures as well as susceptibility testing are described in Appendix 1.

Of the 32 isolates obtained from domestic production in animals in 2005, 22 were identified as *S*. Typhimurium, 4 *S*. Infantis, 2 *S*. Livingstone, and 4 were other serovars. Eleven isolates originated from cattle, 12 from pigs, 5 from poultry (*Gallus gallus*) and four from turkeys.

No resistance was detected (Table 8).

In 2005, five isolates from domestic food were included. Of these, one was *S.* Typhimurium, one *S.* Infantis, and three were *S.* Enteritidis. The isolates were sensitive to every antimicrobial drug tested.

Of the 28 isolates obtained in 2006 from domestic production animals, 13 were *S.* Typhimurium, 5 *S.* Infantis, 5 *S.* Livingstone, 2 *S*. Enteritidis, and 3 were other serovars. Eleven isolates originated from cattle, 6 from pigs, 9 from poultry (*Gallus gallus*) and 2 from turkeys.

Resistance was detected only for ciprofloxacin (n=3) (Table 9). It should however be noted, that ciprofloxacin was included for the first time instead of enrofloxacin, and the epidemiological cut off for ciprofloxacin was set to > 0.06 mg l^{-1} The cut-off value for enrofloxacin was > 0.25 mg l^{-1}

In 2006, nine isolates from domestic food were included. Of these, six were *S.* Typhimurium, two *S.* Infantis, and one *S.* Enteritidis. The isolates were sensitive to every antimicrobial drug tested.

Table 8. *Distribution of MICs for Salmonella in production animals in 2005 (n=32).*

Substance	% resistant (95 % CI)	Distribution (%) of MICs (mg l^{-1})																	
		≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	>2048
Ampicillin	0 (0.0-10.9)					3.1	84.4	12.5											
Ceftiofur	0 (0.0-10.9)					46.9	50.0	3.1											
Chloramphenicol	0 (0.0-10.9)							9.4	75.0	12.5	3.1								
Enrofloxacin	0 (0.0-10.9)		37.5	43.8	18.8														
Florfenicol	0 (0.0-10.9)								87.5	9.4	3.1								
Gentamicin	0 (0.0-10.9)					37.5	59.4	3.1											
Nalidixic acid	0 (0.0-10.9)								50.0	43.8	6.2								
Neomycin	0 (0.0-10.9)							100.0											
Oxytetracycline	0 (0.0-10.9)						3.1	78.1	18.8										
Streptomycin	0 (0.0-10.9)								3.1	46.9	50.0								
Sulfamethoxazole	0 (0.0-10.9)										75.0	18.8	3.1	3.1					
Trimethoprim	0 (0.0-10.9)				46.9	46.9	3.1	3.1											

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

Table 9. *Distribution of MICs for Salmonella in production animals in 2006 (n=28).*

Substance	% resistant (95 % CI)	Distribution (%) of MICs (mg l^{-1})																			
		≤0.008	**0.016**	**0.03**	**0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**	**512**	**1024**	**2048**	**>2048**
Ampicillin	0 (0.0-15.0)							57.1	42.9												
Cefotaxime	0 (0.0-15.0)				10.7	78.6	10.7														
Ceftiofur	0 (0.0-15.0)							14.3	78.6	7.1											
Chloramphenicol	0 (0.0-15.0)									3.6	78.6	10.7	7.1								
Ciprofloxacin	11 (2.8-29.4)				89.3	10.7															
Florfenicol	0 (0.0-15.0)										64.3	28.6	7.1								
Gentamicin	0 (0.0-15.0)							17.9	67.9	14.3											
Kanamycin	0 (0.0-15.0)									42.9	53.6	3.6									
Nalidixic acid	0 (0.0-15.0)										67.9	32.1									
Streptomycin	0 (0.0-15.0)										3.6	10.7	82.1	3.6							
Sulfamethoxazole	0 (0.0-15.0)												57.1	35.7	7.1						
Tetracycline	0 (0.0-15.0)								3.6	82.1	14.3										
Trimethoprim	0 (0.0-15.0)						28.6	71.4													

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

Campylobacter jejuni in broilers

Isolates of *C. jejuni* were collected from broilers in association with the Finnish *Campylobacter* control programme in 2005 and 2006. All samples originated from different slaughter batches. The samples were collected at slaughter. In 2005, of the 94 *C. jejuni* isolates obtained, antimicrobial susceptibility results were obtained from 90 isolates. In 2006, 66 *C. jejuni* isolates were included.

As in previous years, resistance to antimicrobial agents was rare. In 2005, 5% of the isolates were resistant to one antimicrobial agent included in the test panel. Rare and low-level resistance to ampicillin (3%) and nalidixic acid (2%) was observed (Table 10); the minimum inhibitory concentrations (MICs) of these resistant isolates were not distinctly higher than the cut-off values used for defining resistance.

Table 10. *Distribution of MICs for Campylobacter jejuni in broilers in 2005 (n=90).*

Substance	% resistant (95 % CI)	Distribution (%) of MICs (mg l^{-1})													
		≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	>128
Ampicillin	3 (0.8-10.1)						2.2	8.9	72.2	12.2	1.1	3.3			
Enrofloxacin	0 (0.0-5.1)	1.1	1.1	63.3	32.2	2.2									
Erythromycin	0 (0.0-5.1)			1.1	2.2	7.8	58.9	26.7	3.3						
Gentamicin	0 (0.0-5.1)				1.1	61.1	37.8								
Nalidixic acid	2 (0.4-8.5)								22.2	73.3	2.2	2.2			
Oxytetracycline	0 (0.0-5.1)				93.3	6.7									

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

In 2006, only two isolates (3%) were resistant to one antimicrobial agent included in the test panel; the isolates were resistant to oxytetracycline (Table 11).

The need for antimicrobials in broiler production is rare (MAF, 2003), and generally no therapeutic antimicrobials are used. There is some use of penicillin V, ampicillin, sulfa-trimethoprim and oxytetracycline for broiler parents.

Table 11. *Distribution of MICs for Campylobacter jejuni in broilers in 2006 (n=66).*

Substance	% resistant (95 % CI)	Distribution (%) of MICs (mg l^{-1})													
		≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	>128
Ampicillin	0 (0.0-6.9)					3.0	6.1	34.8	48.5	4.5	3.0				
Enrofloxacin	0 (0.0-6.9)		4.5	74.2	19.7	1.5									
Erythromycin	0 (0.0-6.9)				4.5	10.6	59.1	25.8							
Gentamicin	0 (0.0-6.9)				1.5	65.2	33.3								
Nalidixic acid	0 (0.0-6.9)							1.5	59.1	39.4					
Oxytetracycline	3 (0.5-11.4)				87.9	4.5	3.0	1.5				1.5	1.5		

Bold vertical lines indicate breakpoints 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.

Campylobacter jejuni in cattle

In 2006, *Campylobacter jejuni* were isolated in connection with the FINRES-Vet programme from cattle faecal samples collected at slaughter. Thermophilic campylobacters were isolated from 19% of the samples, and 55% (n=28) of these were *C. jejuni.*

Antimicrobial resistance was rare (Table 12). Two isolates (7%) were resistant to one antimicrobial agent tested: one was resistant to oxytetracycline, and one to gentamicin. The lowered breakpoint for resistance may explain the observed resistance for gentamicin, as the MIC of the resistant isolate was only one dilution higher than the breakpoint. After the previous FINRES-Vet report the breakpoint for resistance for gentamicin was lowered from > 4 mg l^{-1} to > 1 mg l^{-1}. Gentamicin has not been used for cattle in Finland.

Table 12. *Distribution of MICs for Campylobacter jejuni in cattle in 2006 (n=28).*

Substance	% resistant (95 % CI)	Distribution (%) of MICs (mg l^{-1})													
		≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	>128
Ampicillin	0 (0.0-15.0)					10.7	7.1	42.9	35.7	3.6					
Enrofloxacin	0 (0.0-15.0)			53.6	46.4										
Erythromycin	0 (0.0-15.0)					28.6	60.7	10.7							
Gentamicin	4 (0.2-20.3)				3.6	82.1	10.7	3.6							
Nalidixic acid	0 (0.0-15.0)								46.4	53.6					
Oxytetracycline	4 (0.2-20.3)				78.6	17.9					3.6				

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

Resistance in indicator bacteria

Resistance among indicator bacteria among a certain population reflects the selection pressure caused by antimicrobial use. Indicator bacteria can also be considered as a pool of resistance genes, from which the resistance determinants can spread to pathogenic bacteria.

Indicator bacteria analysed in the FINRES-Vet programme are *Escherichia coli, Enterococcus faecalis* and *Enterococcus faecium*.

In 2005 indicator bacteria were isolated from broilers, and in 2006 from cattle. Because of the small number of enterococci isolated from bovine samples, they were excluded from the report. The samples were collected from caeca of broilers originating from different slaughter batches. Cattle faecal samples originated from different herds. Details of sampling, isolation procedures and susceptibility testing are described in Appendix 1.

Enterococcus spp. in broilers

The number of enterococci isolates tested for antimicrobial susceptibility was 347, of which 239 were *E. faecalis* and 108 *E. faecium*.

In poultry, low infection prevalence and absence of many significant viral infections, coupled with favourable production conditions, have kept the incidence of secondary bacterial infections negligible. The need for antimicrobials is rare (MAF, 2003), and in practice no therapeutic antimicrobials are used for broilers. There is some use of penicillin V, ampicillin, sulfa-trimethoprim and oxytetracycline for broiler parents.

Table 13. *Distribution of MICs for Enterococcus faecalis from broilers (n=239)*

Substance	% resistant (95 % CI)	Distribution (%) of MICs (mg l^{-1})															
		≤0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	>2048
Ampicillin	0 (0.0-2.0)			5.0	84.9	10.0											
Avilamycin	<1 (0.0-2.6)					16.3	61.1	22.2				0.4					
Bacitracin[1]	33 (26.8-39.0)					0.4	8.8	35.6	21.3	1.3	4.2	9.2	19.2				
Chloramphenicol	<1 (0.0-2.6)					0.4	28.5	70.7				0.4					
Erythromycin	22 (16.8-27.7)			19.7	28.0	20.9	9.6	15.5	5.4	0.4		0.4					
Flavomycin	7 (4.0-10.9)					2.1	16.8	51.3	23.1	6.7							
Gentamicin	0 (0.0-2.0)												100.0				
Narasin	14 (10.2-19.4)	0.8	16.7	42.7	23.8	1.7	5.9	5.9	1.3	1.3							
Neomycin	0 (0.0-2.0)								5.4	48.5	41.8	4.2					
Oxytetracycline	41 (34.4-47.1)			6.3	37.2	15.5	0.4	0.8	1.7	8.4	21.8	7.9					
Streptomycin	3 (1.0-5.6)												97.5	0.4		0.8	1.3
Vancomycin	0 (0.0-2.0)				11.3	70.3	18.4										
Virginiamycin	NR[2]				0.4		0.8	11.7	73.2	13.4	0.4						

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

[1]MIC in U/ml

[2] not relevant

Table 14. *Distribution of MICs for Enterococcus faecium from broilers (n=108)*

Substance	% resistant (95 % CI)	Distribution (%) of MICs (mg l^{-1})															
		≤0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	>2048
Ampicillin	0 (0.0-4.3)		9.3	19.4	15.7	13.9	22.2	19.4									
Avilamycin	<1 (0.5-8.0)				1.9	9.3	42.6	40.7	4.6	0.9							
Bacitracin[1]	30 (21.4-39.3)				14.8	12	3.7	12	24.1	3.7	8.3	10.2	11.1				
Chloramphenicol	0 (0.0-4.3)					2.8	49.1	46.3	1.9								
Erythromycin	12 (6.8-20.0)			59.3	23.1	3.7	1.9	4.6	2.8			4.6					
Flavomycin	NR[2]							0.9	1.9	6.5	6.5	6.5	77.8				
Gentamicin	<1 (0.0-5.8)												99.1	0.9			
Narasin	86 (77.8-91.8)	0.9	0.9	2.8	6.5	2.8	7.4	59.3	15.7	3.7							
Neomycin	0 (0.0-4.3)								87	11.1	0.9	0.9					
Oxytetracycline	27 (19.0-36.4)			26.9	40.7	4.6	0.9	1.9	2.8	1.9	7.4	13					
Streptomycin	<1 (0.0-5.8)												99.1	0.9			
Vancomycin	3 (0.7-8.5)				77.8	17.6	1.9	0.9				0.9	0.9				
Virginiamycin	7 (3.5-14.5)			6.5	20.4	14.8	40.7	10.2	6.5	0.9							

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

[1]MIC in U/ml

[2] not relevant

The MIC distribution and the occurrence of resistance among enterococci from broilers are presented in Tables 13 and 14. Because of the inherent resistance, virginiamycin resistance in *E. faecalis* and flavomycin resistance in *E. faecium* were excluded from overall comparisons.

Widespread use of the coccidiostat narasin is the likely cause for widespread narasin resistance in *E. faecium* (Table 14). In comparison, no resistance to narasin was detected in *E. faecium* isolated from pigs (FINRES-Vet 2004).

Although the use of Zn bacitracin ended already in 1992, resistance to bacitracin was 30% in *E. faecium* and 33% in *E. faecalis* isolates. Neither the comparatively common resistances to erythromycin (12 and 22%) nor oxytetracycline (27 and 41%) in *E. faecium* and *E. faecalis* isolates, respectively, can be explained by their current use; the reason may be co-selection or their use over recent years.

E. faecalis

Most isolates of *E. faecalis* (73%) were resistant to at least one antimicrobial substance in the test panel: 39% were resistant to one, 24% to two, 9% to three and 1% to four antimicrobials. Resistance to oxytetracycline was most common (41%), followed by resistance to bacitracin (33%), erythromycin (22%) and narasin (14%).

The use of flavomycin ended in 1996. Low level resistance to flavomycin (7%) was detected in *E. faecalis* isolates (Table 13). Resistance to narasin was 14%. Resistance to streptomycin (3%), avilamycin (<1%) and chloramphenicol (<1%) was rare. All *E. faecalis* isolates were susceptible to ampicillin, gentamicin, neomycin and vancomycin. The samples were not enriched in vancomycin broth.

Among the isolates resistant to three or more antimicrobials, the following combination was the most prevalent: bacitracin, erythromycin and oxytetracycline (5%).

The MIC for erythromycin was higher than 32 mg l^{-1} in <1% of *E. faecalis* and in 5% of *E. faecium* isolates.

E. faecium

Of the *E. faecium* isolates, 94% were resistant to at least one antimicrobial in the test panel: 37% were resistant to one, 45% to two, 6% to three and 6% to four or more antimicrobials.

Resistance to narasin was most common (86%), followed by resistance to bacitracin (30%), oxytetracycline (27%), and erythromycin (12%) (Table 14). Resistance to virginiamycin was 7%. A small proportion of the *E. faecium* isolates was resistant to avilamycin (<1%), streptomycin (<1%), gentamicin (<1%) and vancomycin (3%). No resistance was detected to ampicillin, chloramphenicol or neomycin. The samples were not enriched in vancomycin broth.

Of the isolates resistant to three or more antimicrobials, the following combination was the most prevalent: oxytetracycline, bacitracin and narasin (4%).

Escherichia coli in broilers and cattle

The material included 380 *E. coli* isolates from broilers (2005) and 185 isolates from cattle (2006). The MIC distribution and the occurrence of resistance among *E. coli* from broilers are presented in Table 15 and from cattle in Table 16. Of the broiler isolates 66%, and of the cattle isolates 95% were susceptible to all antimicrobials tested.

Broilers

Of the broiler isolates, 18% were resistant to one antimicrobial, 8% to two, 2% to three, and 6% to four or more antimicrobials in the test panel.

Table 15. *Distribution of MICs for Escherichia coli from broilers (n=380).*

Substance	% resistant (95 % CI)	Distribution (%) of MICs (mg l^{-1})																	
		≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	>2048
Ampicillin	16 (12.3-19.9)						2.4	44.2	34.5	3.2	0.5	1.1	14.2						
Ceftiofur	0 (0.0-1.0)			3.4	41.1	51.6	3.7	0.3											
Chloramphenicol	<1 (0.0-1.5)							4.5	72.9	22.4					0.3				
Enrofloxacin	1 (0.3-2.7)	11.3	79.7	7.9		0.3	0.8												
Florfenicol	0 (0.0-1.0)								49.2	48.9	1.8								
Gentamicin	0 (0.0-1.0)					18.2	71.8	8.4	1.6										
Nalidixic acid	1 (0.3-2.7)						0.5	13.4	72.1	12.9		0.5			0.5				
Neomycin	6 (3.5-8.3)							89.2	5.3	1.6	0.8	3.2							
Oxytetracycline	17 (13.2-21.0)						18.4	60.3	3.4	1.1	0.5	0.5	0.5	15.3					
Streptomycin	7 (4.7-10.2)							0.5	18.7	67.1	6.6	2.4	2.9	1.1	0.5	0.3			
Sulfamethoxazole	13 (9.7-16.7)										82.4	4.7						0.5	12.4
Trimethoprim	5 (3.2-8.0)				36.8	44.7	12.1	0.5	0.5	0.3			5.0						

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

Table 16. *Distribution of MICs for Escherichia coli from cattle (n=185).*

Substance	% resistant (95 % CI)	Distribution (%) of MICs (mg l^{-1})																	
		≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	>2048
Ampicillin	<1 (0.0-3.4)				1.1	1.6	20.5	64.9	10.8	0.5			0.5						
Cefotaxime	0 (0.0-2.5)		62.1	35.7	2.2														
Ceftiofur	0 (0.0-2.5)			1.6	25.4	67.6	5.4												
Chloramphenicol	0 (0.0-2.5)							3.8	37.3	57.8	1.1								
Ciprofloxacin	1 (0.1-3.9)	38.3	60.5	1.1															
Florfenicol	0 (0.0-2.5)								18.9	62.9	11.9								
Gentamicin	0 (0.0-2.5)					4.3	69.7	22.7	3.2										
Kanamycin[a]	3 (1.2-7.7)							3.2	69.7	23.9	1.9	1.3							
Nalidixic acid	0 (0.0-2.5)						2.2	27.0	65.4	5.4									
Streptomycin	3 (1.0-6.5)								4.3	76.8	16.2		1.1	1.6					
Tetracycline	<1 (0.0-3.4)						11.4	81.6	6.5					0.5					
Sulfamethoxazole	0 (0.0-2.5)										100.0								
Trimethoprim	0 (0.0-2.5)				25.4	37.8	33.5	3.2											

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

[a]n=155

The most common resistance characteristics found were resistance to oxytetracycline (17%), ampicillin (16%), and sulfamethoxazole (13%) (Table 15). Seven percent were resistant to streptomycin and 6% to neomycin. These resistance figures were higher than in 2002. Resistance to trimethoprim was 5%.

Enrofloxacin resistance was rare: one isolate had a slightly increased MIC of 0.5 mg l^{-1}, and three isolates had a MIC of 1 mg l^{-1}. These isolates were also resistant to nalidixic acid.

No resistance to ceftiofur, florfenicol or gentamicin was detected. Occasional isolates were resistant to chloramphenicol (<1%).

Cattle

Resistance was at the same level as in 2003, which is internationally set low. No resistance was detected to 3rd generation cefalosporins, chloramphenicol, florfenicol, gentamicin, nalidixic acid, sulfamethoxazole or trimethoprim. Resistances to kanamycin and streptomycin were most prevalent, though only 3% for both. Occasional isolates were resistant to ampicillin (<1%), ciprofloxacin (1%) and tetracycline (<1%) (Table 16). Of the bovine isolates, 4% were resistant to one antimicrobial and 1% to two antimicrobials. No multiresistance was detected.

Table 17 presents the occurrence of resistance in *E. coli* from broilers, cattle and pigs from the years 2002, 2003, 2004, 2005 and 2006, respectively.

***Table 17**. Occurrence of resistance in indicator Escherichia coli from broilers, 2005 and cattle, 2006. Data for broilers (2002), cattle and pigs are given for comparison (FINRES-Vet 2002-2003 and 2004).*

Resistance (%) (95% confidence intervals inside brackets)						
Substance	**Cut-off value (mg l^{-1})**	**Broilers 2002 (n=300)**	**Broilers 2005 (n=380)**	**Cattle 2003 (n=356)**	**Cattle 2006 (n=185)**	**Pigs 2004 (n=391)**
Ampicillin	>8	11 (8.0-15.5)	16 (12.3-19.9)	1 (0.8-4.0)	<1 (0.0-3.4)	6 (4.0-9.0)
Ceftiofur	>2	0 (0.0-1.2)	0 (0.0-1.0)	0 (0.0-1.0)	0 (0.0-2.5)	0 (0.0-0.9)
Chloramphenicol	>16	<1 (0.1-2.4)	<1 (0.0-1.5)	<1 (0.0-1.6)	0 (0.0-2.5)	1 (0.4-3.0)
Enrofloxacin	>0.25	2 (0.5-3.9)	1 (0.3-2.7)	0 (0.0-1.0)		<1 (0.2-2.2)
Ciprofloxacin	>0.06				1 (0.1-3.9)	
Florfenicol	>16	0 (0.0-1.2)	0 (0.0-1.0)	0 (0.0-1.0)	0 (0.0-2.5)	0 (0.0-0.9)
Gentamicin	>4	<1 (0.0-1.8)	0 (0.0-1.0)	0 (0.0-1.0)	0 (0.0-2.5)	0 (0.0-0.9)
Nalidixic acid	>16	2 (0.9-4.8)	1 (0.3-2.7)	1 (0.3-2.9)	0 (0.0-2.5)	<1 (0.2-2.2)
Neomycin	>4	2 (0.5-3.9)	6 (3.5-8.3)	0 (0.0-1.0)		1 (0.3-2.6)
Kanamycin	>8				3 (1.2-7.7)	
Oxytetracycline/ tetracycline	>8	10 (7.1-14.4)	17 (13.2-21.0)	<1 (0.2-2.4)	<1 (0.0-3.4)	16 (12.8-20.4)
Streptomycin	>16	3 (1.6-6.0)	7 (4.7-10.2)	5 (3.2-8.2)	3 (1.0-6.5)	15 (11.2-18.5)
Sulfamethoxazole	>256	8 (5.5-12.1)	13 (9.7-16.7)	2 (0.6-3.6)	0 (0.0-2.5)	12 (8.5-15.1)
Trimethoprim	>4	4 (1.8-6.5)	5 (3.2-8.0)	<1 (0.0-1.6)	0 (0.0-2.5)	8 (5.2-10.8)

Resistance in animal pathogens

Escherichia coli were obtained from clinical or post-mortem samples submitted to Evira. Isolation and preliminary identification of mastitis pathogens was performed at eleven private and municipal mastitis laboratories and at Evira, and species confirmation at Evira. Details of isolation procedures are described in Appendix 1.

Escherichia coli in pig enteritis

The material comprised 40 *E. coli* isolates from pigs with enteritis in 2005, and 34 isolates in 2006. One isolate/herd was included. The samples were taken post mortem from the gastrointestinal tract. At least part of the samples originated from herds with diarrhoeal problems and frequent use of antimicrobials.

The MIC distribution and occurrence of resistance are presented in Tables 18 and 19. Multiresistance was common; in 2005 43%, and in 2006 41% of the isolates were resistant to at least three antimicrobials. In 2005, fifteen percent of the isolates were resistant to three, 23% to four, and 5% to six antimicrobials in the test panel. In 2006, twenty-nine percent of the isolates were resistant to three, 6 % to four, and 3% to five and seven antimicrobials in the test panel.

As in previous years, resistance to oxytetracycline/tetracycline (2005: 40%, 2006: 41%), streptomycin (2005: 40%, 2006: 32%), sulfamethoxazole (2005: 45%, 2006: 35%), and trimethoprim (2005: 35%, 2006: 29%) was common.

In 2005, resistance to nalidixic acid was 15%, and to enrofloxacin 8%. In 2006 enrofloxacin was replaced by ciprofloxacin. In 2006, resistance to nalidixic acid was 24%, and to ciprofloxacin 24%.
Of the isolates studied, 10% and 6% were in 2005 in 2006, respectively, resistant to ampicillin and 5% and 3% to chloramphenicol.

No resistance was detected to ceftiofur, gentamicin or florfenicol. Florfenicol is registered for use in pigs in Finland, but no products containing gentamicin are approved for veterinary use, except on special license for horses.

Table 18. *Distribution of MICs for Escherichia coli from porcine enteritis in 2005 (n=40).*

Substance	% resistant (95 % CI)	Distribution (%) of MICs (mg l^{-1})																	
		≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	>2048
Ampicillin	10 (3.3-24.6)						5.0	72.5	12.5		2.5		7.5						
Ceftiofur	0 (0.0-10.9)				42.5	47.5	7.5	2.5											
Chloramphenicol	5 (0.9-18.2)						2.5	7.5	75.0	10.0		2.5	2.5						
Enrofloxacin	8 (2.0-21.5)	17.5	62.5	5.0	7.5			5.0		2.5									
Florfenicol	0 (0.0-10.9)								65.0	32.5	2.5								
Gentamicin	0 (0.0-10.9)					42.5	55.0	2.5											
Nalidixic acid	15 (6.2-30.5)						2.5	35.0	45.0	2.5			5.0		10.0				
Neomycin	5 (0.9-18.2)							87.5	7.5		2.5	2.5							
Oxytetracycline	40 (25.3-56.6)					2.5	27.5	30.0						40.0					
Streptomycin	40 (25.3-56.6)							5.0	27.5	22.5	5.0		15.0	7.5	10.0	7.5			
Sulfamethoxazole	45 (29.6-61.3)										55.0							2.5	42.5
Trimethoprim	35 (21.1-51.7)				40.0	15.0	5.0	2.5	2.5		2.5		32.5						

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

Table 19. *Distribution of MICs for Escherichia coli from porcine enteritis in 2006 (n=34).*

Substance	% resistant (95 % CI)	Distribution (%) of MICs (mg l^{-1})																			
		≤0.008	0.016	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	>2048
Ampicillin	6 (1.0-21.1)						2.9	2.9	17.6	52.9	14.7	2.9			5.9						
Cefotaxime	0 (0.0-12.6)				52.9	44.1	2.9														
Ceftiofur	0 (0.0-12.6)					2.9	61.8	29.4	5.9												
Chloramphenicol	3 (0.0-17.0)									23.5	58.8	11.8	2.9	2.9							
Ciprofloxacin	24 (11.4-41.5)		14.7	32.4	29.4	8.8	5.9	2.9		5.9											
Florfenicol	0 (0.0-12.6)										70.6	26.5	2.9								
Gentamicin	0 (0.0-12.6)							61.8	26.5	11.8											
Kanamycin	3 (0.0-17.0)									35.3	47.1	14.7		2.9							
Nalidixic acid	24 (11.4-41.5)									26.5	47.1	2.9		2.9	2.9	2.9	14.7				
Streptomycin	32 (18.0-50.7)									5.9	29.4	20.6	11.8	2.9	5.9	8.8	2.9	11.8			
Sulfamethoxazole	35 (20.3-53.5)												61.8	2.9							35.3
Tetracycline	41 (25.1-59.2)								2.9	50	5.9			2.9		38.2					
Trimethoprim	29 (15.7-47.7)						55.9	5.9		8.8					29.4						

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

Staphylococcus aureus in bovine mastitis

The level of resistance in *S. aureus* was low (Table 20). Penicillin is widely used for the treatment of mastitis in cattle, but only 25% of the isolates produced betalactamase. This proportion is at the same level (23%) as in staphylococci isolated from clinical mastitis samples in the practice area of Saari Ambulatory Clinic in 2002-2003 (Nevala et al., 2004). In the Finnish mastitis survey on subclinical mastitis in 2001, 53% of *S. aureus* isolates were betalactamase producers (Pitkälä et al., 2004). Higher penicillin resistance in isolates from subclinical or chronic mastitis than acute mastitis has been reported also in other Nordic Countries (Bengtsson, 2004; NORM-VET 2000).

Methicillin resistance in bovine *S. aureus* has been detected in several countries, but the frequency has been low (Aarestrup and Schwarz, 2006). Resistance to oxacillin in this material was 12%, but none of the isolates was highly resistant, and none of them harbored the *mec*A -gene.

The use of tetracyclines in mastitis therapy has decreased since the beginning of 1990's, and decrease in resistance to tetracycline observed in earlier surveys on subclinical mastitis (12% in 1995 and 5% 2001) has continued: in the present material only 2% of the isolates were resistant. Resistance towards fusidic acid was seen in 7% of the isolates.

One *S. aureus* isolate was multiresistant with a resistance pattern including penicillin, oxacillin, virginiamycin and fusidic acid.

Staphylococcus aureus (pilot MRSA screening) in bovine mastitis

The prevalence of methicillin resistant Staphylococcus aureus (MRSA) in animals has been generally low, but in recent years MRSA has been increasingly reported in veterinary medicine, especially from dogs and horses (Leonard and Markey, 2007). In the Finnish mastitis survey in 2001 no *mec*A -positive *Staphylococcus aureus* isolates were found. Anyhow, in 2005 the first MRSA was isolated from mastitis in Finland.

Rapid methods for the detection of MRSA from human clinical screening samples using selective agars have been developed. The aim of this study was to screen for MRSA from milk samples, where β-lactamase producing *Staphylococcus aureus* had previously been isolated. Altogether 172 milk samples were cultured on Chromogenic MRSA Agar or Oxacillin Resistance Screening Agar. No growth was detected indicating the absence of MRSA.

***Table 20**. Distribution of MICs for Staphylococcus aureus from bovine mastitis in 2005 (n=102).*

Substance	% resistant (95 % CI)	Distribution (%) of MICs (mg l^{-1})														
		≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	>256
Avilamycin	1 (0.0-6.2)								23.5	55.9	19.6	1.0				
Cephalothin	0 (0.0-6.4)		2.0	21.6	39.2	32.4	4.9									
Chloramphenicol	0 (0.0-4.5)								20.6	78.4	1.0					
Clindamycin	0 (0.0-4.5)				94.1	5.9										
Enrofloxacin	0 (0.0-4.5)			19.6	64.7	15.7										
Erythromycin	0 (0.0-4.5)				43.1	54.9	2.0									
Fusidic acid	7 (3.1-14.2)			2.9	37.3	52.9	4.9			2.0						
Gentamicin	0 (0.0-4.5)					87.3	11.8	1.0								
Neomycin	0 (0.0-4.5)						99	1.0								
Oxacillin[1]	12 (6.5-20.1)				5.9	11.8	36.3	34.3	11.8							
Oxytetracycline	2 (0.4-7.6)					60.8	36.1	1.0						2.0		
Penicillin	25[2]	31.4	38.2	7.8	1.0	2.0	6.9	2.9	2.9	6.9						
Spiramycin	0 (0.0-4.5)								20.6	63.7	15.7					
Streptomycin	1 (0.0-6.2)							6.9	73.5	16.7	2.0				1.0	
Trimethoprim[3]	0 (0.0-4.5)					100.0										
Vancomycin	0 (0.0-4.5)						87.3	12.7								
Virginiamycin	1 (0.0-6.2)				1.0	39.2	54.9	3.9		1.0						

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

[1]n=none of the isolates with MIC higher than 1 had a *mec*A gene

[2]based on beta-lactamase production

[3]concentration of trimethoprim given, tested with sulfamethoxazole in concentration ratio 1:20.

Streptococcus uberis and *Streptococcus dysgalactiae* in bovine mastitis

All streptococcal isolates were susceptible to penicillin (Tables 21 and 22). Penicillin resistance of *S. uberis* has occasionally been reported. This may be partly reflect inclusion of enterococci and lactococci in the streptococcal population. However, continuous monitoring of penicillin resistance of mastitis streptococci is important.

Thirty-seven % of *S. uberis* and 36% of *S. dysgalactiae* isolates were resistant to oxytetracycline (Tables 21 and 22, respectively). In the survey 2001 on subclinical mastitis (Pitkälä et al., 2004), only 1% of *S. uberis* isolates were resistant to oxytetracycline, but the proportion of resistant *S. dysgalactiae* isolates was at the same level as now.

Of the *S. uberis* isolates, 15% were resistant to erythromycin. *S. uberis* is reported to be more resistant to erythromycin than other streptococci (Erskine et al., 2002; Rossitto et al., 2002) which was seen also here.

No multiresistance was found in streptococci. Of the 11 *S. uberis* isolates resistant to oxytetracycline, 10 were resistant also to erythromycin and one to trimethoprim-sulfonamide.

Table 21. *Distribution of MICs for Streptococcus uberis from bovine mastitis in 2005 (n=75).*

Substance	% resistant (95 % CI)	Distribution (%) of MICs (mg l^{-1})														
		≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	>256
Avilamycin	0 (0.0-6.1)						4	28	61.3	61.3	6.7					
Cephalothin	0 (0.0-6.1)			9.3	89.3	1.3										
Chloramphenicol	0 (0.0-6.1)						1.3	9.3	88	1.3						
Clindamycin	0 (0.0-6.1)				98.7	1.3										
Erythromycin	15 (7.9-25.2)				80	5.3	4	8	2.7							
Gentamicin	NR[1]									5.3	32	61.3	1.3			
Neomycin	NR[1]									1.3	4	13.3	61.3	18.7	1.3	
Oxytetracycline	37 (26.6-49.3)					58.7	2.7	1.3	2.7	6.7	16	12				
Penicillin	0 (0.0-6.1)	21.3	69.3	9.3												
Spiramycin	NR[1]								97.3	1.3	1.3					
Streptomycin	NR[1]											8	65.3	24	1.3	1.3
Trimethoprim[2]	1 (0.0-8.2)					98.7			1.3							
Vancomycin	0 (0.0-6.1)						96.0	4.0								
Virginiamycin	0 (0.0-6.1)				8.0	89.3	2.7									

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

[1] not relevant

[2] concentration of trimethoprim given, tested with sulfamethoxazole in concentration ratio 1:20.

Table 22. *Distribution of MICs for Streptococcus dysgalactiae from bovine mastitis in 2005 (n=62).*

Substance	% resistant (95 % CI)	Distribution (%) of MICs (mg l^{-1})														
		≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	>256
Avilamycin	0 (0.0-7.3)						85.5	12.9	1.6							
Cephalothin	0 (0.0-7.3)			35.5	59.7	3.2	1.6									
Chloramphenicol	0 (0.0-7.3)							59.7	40.3							
Clindamycin	0 (0.0-7.3)				98.4	1.6										
Erythromycin	0 (0.0-7.3)				96.8	3.2										
Gentamicin	NR[1]						1.6	6.5	41.9	48.4	1.6					
Neomycin	NR[1]							1.6	1.6	4.8	38.7	51.6	1.6			
Oxytetracycline	36 (24.1-48.7)					4.8	1.6	22.6	35.5	3.2	1.6		11.3	19.4		
Penicillin	0 (0.0-7.3)	88.7	9.7	1.6												
Spiramycin	NR[1]								100							
Streptomycin	NR[1]							1.6		19.4	69.4	8.1	1.6			
Trimethoprim[2]	0 (0.0-7.3)					100										
Vancomycin	0 (0.0-7.3)						95.2	4.8								
Virginiamycin	0 (0.0-7.3)				1.6	95.2	3.2									

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

[1] not relevant

[2] concentration of trimethoprim given, tested with sulfamethoxazole in concentration ratio 1:20.

Escherichia coli in bovine mastitis

The level of resistance in *E. coli* was in general low (Table 23) and mostly at the same level as in *E. coli* isolated in samples from clinical mastitis in 90 herds during 1990-1996 (Lehtolainen et al., 2003). Use of antimicrobial treatment is not routinely recommended for coliform mastitis in Finland, which may affect the results. The proportion of resistant isolates was the same or lower as reported elsewhere (AFSSA 2006, MARAN 2005, SVARM 2004). All isolates (n=93) were susceptible to 3rd generation cefalosporins and to ciprofloxacin. Resistance to streptomycin was most common, followed by resistance to ampicillin, sulfamethoxazole and tetracycline. Resistance to kanamycin and trimethoprim was occasionally seen. Two isolates (2%) were resistant to chloramphenicol. Intramammary products containing chloramphenicol were on the market in Finland before 1993. The result probably reflects the previous use, because the resistance can persist over ten years after withdrawal of chloramphenicol (Aalbaek et al., 1991; White et al., 2000).

Seven *E. coli* isolates were multiresistant: one isolate was resistant to 6, one isolate to 5, two isolates to 4 and three isolates to 3 antimicrobials.

***Table 23**. Distribution of MICs for Escherichia coli from bovine mastitis in 2006 (n=93).*

Substance	% resistant (95 % CI)	Distribution (%) of MICs (mg l^{-1})																	
		≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	>2048
Ampicillin	7 (2.7-14.1)					1.1	37.6	50.5	3.2	1.1			6.5						
Cefotaxime	0 (0.0-4.9)		77.4	21.5		1.1													
Ceftiofur	0 (0.0-4.9)				36.6	59.1	4.3												
Chloramphenicol	2 (0.4-8.4)							3.2	63.4	31.2					2.2				
Ciprofloxacin	0 (0.0-4.9)	51.7	48.4																
Florfenicol	0 (0.0-4.9)								33.3	64.5	2.2								
Gentamicin	0 (0.0-4.9)					1.1	74.2	23.7	1.1										
Kanamycin	3 (0.8-9.8)							2.2	76.3	18.3	1.1	2.2							
Nalidixic acid	0 (0.0-4.9)							36.6	60.2	3.2									
Streptomycin	9 (4.1-16.7)								3.2	73.1	15.1			3.2	3.2	2.2			
Tetracycline	5 (2.0-12.7)						9.7	83.9	1.1				3.2	2.2					
Sulfamethoxazole	7 (2.7-14.1)										92.5	1.1						1.1	5.4
Trimethoprim	1 (0-6.7)				49.5	45.2	4.3						1.1						

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

Klebsiella species in bovine mastitis

Klebsiella species are inherently resistant to ampicillin. All isolates (n=81) were sensitive to 3rd generation cephalosporins. Resistance to streptomycin was most common, followed by resistance to tetracycline and sulfamethoxazole. Two isolates were resistant to chloramphenicol and kanamycin. One isolate was resistant to ciprofloxacin and one to trimethoprim. These were the only multiresistant isolates; the former was resistant also to streptomycin, sulfamethoxazole, chloramphenicol and tetracycline and the latter also to streptomycin, sulfamethoxazole and tetracycline (Table 24).

Table 24. *Distribution of MICs for Klebsiella species from bovine mastitis in 2006 (n=81);* Klebsiella pneumoniae 53, *Klebsiella oxytoca* 9, *Klebsiella* sp. 19.

Substance	% resistant (95 % CI)	Distribution (%) of MICs (mg l^{-1})																	
		≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	>2048
Ampicillin	NR[1]								1.2	1.2	39.5	48.1	9.9						
Cefotaxime	0 (0.0-5.6)		97.5	2.5															
Ceftiofur	0 (0.0-5.6)			3.7	45.7	45.7	4.9												
Chloramphenicol	3 (0.4-9.5)						1.2	29.6	64.2	2.6					2.5				
Ciprofloxacin	1 (0.0-7.6)	3.7	88.9	6.2			1.2												
Florfenicol	0 (0.0-5.6)								86.4	13.6									
Gentamicin	0 (0.0-5.6)					63.0	37.0												
Kanamycin	3 (0.4-9.5)							82.7	14.8		1.2	1.2							
Nalidixic acid	0 (0.0-5.6)							29.6	66.7	2.5	1.2								
Streptomycin	11 (5.5-20.5)							2.5	76.5	8.6	1.2	4.9	3.7	1.2		1.2			
Tetracycline	10 (4.7-19.1)						21.0	67.9	1.2			2.5	4.9	2.5					
Sulfamethoxazole	4 (1.0-11.2)										92.6	2.5	1.2						3.7
Trimethoprim	1 (0.0-7.6)				2.5	67.9	24.7	2.5	1.2				1.2						

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

[1]NR= not relevant

Table 25. *Distribution of MICs for Staphylococcus intermedius from canine skin, post-operative wound or ear infections in 2005-2006 (n=47).*

Substance	% resistant (95 % CI)	Distribution (%) of MICs (mg l^{-1})														
		≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	>256
Avilamycin	0 (0.0-9.4)						17.0	44.7	34.0	4.3						
Cephalothin[1]	9 (2.8-21.3)		2.1	72.3	14.9	4.3	2.1				4.3					
Chloramphenicol	11 (4.0-23.8)							2.1	76.6	8.5	2.1	4.3	6.4			
Clindamycin	17 (8.1-31.3)				70.2	6.4	4.3	2.1		2.1			14.9			
Enrofloxacin	6 (1.7-18.6)			48.9	34.0	10.6	2.1		4.3							
Erythromycin	19 (9.6-33.7)				63.8	14.9	2.1		2.1				17.0			
Fusidic acid	17 (8.1-31.3)		8.5	25.5	36.2	12.8		4.3	2.1	4.3	6.4					
Gentamicin	6 (1.7-18.6)					87.2	2.1	4.3		4.3	2.1					
Neomycin	26 (14.4-40.6)						74.5		10.6	10.6	2.1	2.1				
Oxacillin[2]	13 (5.3-26.5)			2.1	17.0	25.5	27.7	19.1	6.4			2.1				
Oxytetracycline	45 (30.5-59.8)					51.1	2.1	2.1		2.1	2.1	19.1	19.1	2.1		
Penicillin[3]	72 (54.1-85.6)	14.9		10.6	2.1	8.5	6.4	8.5	6.4	42.6						
Streptomycin	23 (12.8-38.4)							44.7	27.7	4.3				6.4	12.8	4.3
Trim.-sulfamethoxazole[4]	4 (0.8-15.8)					72.3	21.3	2.1	2.1	2.1						
Vancomycin	0.0 (0.0-9.4)						66.0	34.0								
Virginiamycin	0.0 (0.0-9.4)				6.4	70.2	14.9	6.4	2.1							

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

[1] two isolates were interpreted as resistant to cephalotin due to a positive result in *mec*A PCR

[2] one of the resistant isolates harboured *mec*A gene, and two isolates were interpreted as resistant due to a positive result on *mec*A PCR

[3] based on betalactamase production

[4] concentration of trimethoprim given, tested with sulfamethoxazole in concentration ratio 1:20.

Table 26. *Resistance phenotypes of multiresistant S. intermedius from canine skin, post-operative wound or ear infections.*

No. of isolates	PEN	OTC	STR	NEO	ERY	CLI	SXT	CEP	OXA	FUS	GEN	CHL	EF
1	■		■	■	■	■	■	■	■		■	■	
1	■		■	■	■	■		■	■	■		■	
1	■	■	■	■		■		■	■		■		■
1	■		■	■	■	■			■			■	
2	■	■	■	■	■	■						■	
2	■	■	■	■	■	■							
1		■	■	■	■		■			■			
1	■	■	■	■						■			
1	■	■	■	■									
1	■				■				■		■		
1	■							■	■				
1	■	■		■									
1	■	■								■			

PEN=penicillin, OTC=Oxytetracycline, STR=streptomycin, NEO=neomycin, ERY=erythromycin, CLI=clindamycin, SXT=trimethoprim-sulfamethoxazole, CEP=cephalothin, OXA=oxacillin, FUS=fusidic acid, GEN=gentamycin, CHL=chloramphenicol, EF=enrofloxacin

Staphylococcus intermedius in canine infections

Forty-seven isolates of *Staphylococcus intermedius* from canine skin, post-operative wound or ear infections were included. Although only the first isolate from each dog was included, we do not know the antimicrobial history of the dogs, which may have biased the results. MIC distribution and the occurrence of resistance are presented in Table 25. The results are comparable with previously reported results (Hartmann et al., 2005; Jones et al., 2007; Werkenthin et al., 2001). Only 17% of the isolates were sensitive to all antimicrobials tested. 23% of the isolates were resistant to one (mainly penicillin) and 28% to two (mainly penicillin and oxytetracycline) antimicrobials. Multiresistance was found in 32% of the isolates (Table 26). Resistance to penicillin, tetracycline, streptomycin and neomycin was seen in 53% of the multiresistant strains. Of the 9 isolates resistant to erythromycin, 7 were also resistant to clindamycin. Of the three isolates resistant to enrofloxacin, one was multiresistant.

There are reports describing increasing resistance of *S. intermedius* to fucidic acid. In Norway, one half and in Sweden one quarter of the *S. intermedius* -isolates have been resistant to it (Norm-Vet 2004, Svarm 2005). In Finland the proportion of resistant isolates has been stable since 2004 (14% and 17%, $p > 0.05$, previous data not available).

Three isolates, one isolate from a skin infection, one from a post-operative wound infection and one from an ear infection, were found to have the *mec*A gene. The MIC for oxacillin of the isolates was 4, 2 and 2 mg l^{-1} and for cephalotin 0.5, 0.5 and 16 mg l^{-1}, respectively. The isolates were classified resistant to all betalactams based on the PCR result. One isolate with oxacillin MIC >16 mg l^{-1} and cephalotin MIC > 8 mg l^{-1} did not harbour *mec*A gene, thus having other mechanism of resistance.

References

Aalbaek B., Rasmussen J., Nielsen B. and Olsen, J.E. 1991. Prevalence of antibiotic-resistant *Escherichia coli* in Danish pigs and cattle. APMIS 99:1103-1110.

Aarestrup, F. M. and Schwarz, S. 2006. Antimicrobial Resistance in Staphylococci and Streptococci of Animal Origin. In: Antimicrobial Resistance in Bacteria of Animal Origin, ed. Aarestrup F. M.,. ASM Press, Washington DC, pp. 187-212.

Bengtsson, B. 2004. Antibiotic susceptibility of bacteria isolated from clinical and subclinical mastitis, Sweden. In: Report from Nordic Meeting on Mastitis Diagnostics. Uppsala 1-3 October 2003. SVA, Uppsala, Sweden.

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.

Erskine, R. J., Walker, R. D., Bolin, C. A., Bartlett, P.C. and White, D. G. 2002. Trends in antibacterial susceptibility of mastitis pathogens during a seven-year period. J. Dairy Sci. 85, 1111-1118.

Farm 2003-2004, French antimicrobial resistance monitoring in bacteria of animal origin. Agence Française de Sécurité Sanitaire des Aliments (AFSSA) 2006. ISBN 2-11-095838-3.

FINRES-Vet 2002-2003, Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents. National Veterinary and Food Research Institute (EELA), Helsinki, Finland. ISSN 1458-6878.

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.

Hartmann, F. A., White, D. G., West, S. E. H., Walker, R. D., DeBoer, D. J. 2005. Molecular characterization of *Staphylococcus intermedius* carriage by healthy dogs and comparison of antimicrobial susceptibility patterns to isolates from dogs with pyoderma. Vet. Microbiol. 108: 119-131.

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., 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.

Lehtolainen, T., Schwimmer, A., Shipgel, N.Y., Honkanen-Buzalski, T. and Pyörälä, S. 2003. In Vitro Antimicrobial Susceptibility of *Escherichia coli* Isolates from Clinical Bovine Mastitis in Finland and Israel. J Dairy Sci 86:3927-3932.

Leonard, F.C. and Markey, B.K. Meticillin-resistant Staphylococcus aureus in Animals: A review. The Veterinary Journal (2007), doi:10.1016/j.tvj1.2006.11.008

MAF. 2003. Recommendations for the use of antimicrobial agents in the treatment of the most significant infectious diseases in animals. Memorandum 2003:9a. ISSN 0781-6723.

MARAN-2005 – Monitoring of Antimicrobial Resistance and Antibiotic Usage in Animals in the Netherlands In 2005. www.cidc-lelystad.nl.

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.

Nevala M, Taponen S. Pyörälä S. Naudan kliinisen utaretulehduksen bakteerietiologia – Saaren ambulatorisen klinikan aineisto vuosilta 2002-2003. Bacterial ecology of bovine clinical mastitis – data from Saari Ambulatory Clinic in 2002-2003. Suomen Eläinlääkärilehti 2004, 110, 363-369.

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.

NORM/NORM-VET. 2000. Consumption of antimicrobial agents and occurrence of antimicrobial resistance in Norway. TromsØ/Oslo 2000. ISSN: 1502-2307.

NORM/NORM-VET 2004. Usage of Antimicrobial Agents and Occurrence of Antimicrobial Resistance in Norway. Tromsø/Oslo 2005. ISSN: 1502-2307.

CLSI. 2002. Performance standards for antimicrobial disk and dilution susceptibility tests for bacteria isolated from animals; approved standard – second edition. CLSI Document M31-A2 [ISBN 1- 56238-461-9]. CLSI, 940, West Valley Road, Suite 1400, Wayne, Pennsylvania, 19087-1898, USA.

Pitkälä, A., Haveri, M., Pyörälä, S., Myllys, V. and Honkanen-Buzalski, T. 2004. Bovine mastitis in Finland 2001-prevalence, distribution of bacteria, and antimicrobial resistance. J. Dairy Sci. 87, 2433-2441.

Rantala, M. 2003. Mikrobilääkkeiden käyttö eläimillä – kyselytutkimuksen tuloksia. [Questionnaire on veterinary practitioners' antimicrobial use pattern]. Lääkepäivä 2003, MMMELO.

Rossitto, P. V., Ruiz, L., Kikuchi, Y., Glenn, K. K. Luiz, K., Watts, J. L. and Cullor, J. S. 2002. Antibiotic susceptibility patterns for environmental streptococci isolated from bovine mastitis in Central California dairies. J. Dairy Sci. 85, 132-138.

SVARM 2004, Swedish Veterinary Antimicrobial Resistance Monitoring. The National Veterinary Institute (SVA), Uppsala, Sweden, 2005. www.sva.se, ISSN 1650-6332.

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

Werckenthin, C., Cardoso, M., Martel, J.-L., Schwarz, S. 2001. Antimicrobial resistance in staphylococci from animals with particular reference to bovine Staphylococcus aureus, porcine S*taphylococcus hyicus,* and canine *Staphylococcus intermedius*. Vet. Res. 32: 341-362.

White, D.G., Hudson, C., Maurer, J.J., Ayers, S., Zhao, S., Lee, M.D., Bolton, L., Foley, T. and Sherwood, J. 2000. Characterization of Chloramphenicol and Florfenicol Resistance in *Escherichia coli* Associated with Bovine Diarrhea. J. Clin. Microbiol. 38: 4593-4598.

Appendix 1. Materials and methods, resistance monitoring

Sampling strategy

Zoonotic bacteria

Salmonella isolates from production animals were collected in accordance with the Finnish salmonella control programme. Isolates from domestic food included also isolates originating from in-house control system. Of the isolates collected in accordance with the control programme, one isolate from each notified incident was included.

C. jejuni were collected from broilers in connection with the Finnish *Campylobacter* control programme between June and October. *C. jejuni* from cattle were collected in connection with the FINRES-Vet programme.

Indicator bacteria

Indicator bacteria, *E. coli, Enterococcus faecalis* and *E. faecium*, were collected from broiler caeca and cattle faeces. The samples were isolated from healthy animals. The sampling period was February to December.

The number of randomly taken samples from each slaughterhouse was proportional to the annual number of slaughtered animals. Each isolate represented one flock or herd. The broiler and cattle slaughterhouses accounted for 100% and 95 %, respectively, 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/herd was included. The samples were taken from the gastrointestinal tract.

Mastitis pathogens (*Staphylococcus aureus, Streptococcus dysgalactiae, Streptococcus uberis, Escherichia coli* and *Klebsiella species*) were isolated from milk samples, which were taken from clinical cases of bovine mastitis and collected from mastitis laboratories. One isolate per species per farm was included. Mastitis milk samples positive for betalactamase producing *Staphylococcus aureus* were collected from two mastitis laboratories.

Staphylococcus intermedius was isolated from canine skin, post-operative wound or ear infections. Only the first isolate was included.

Isolation and identification of bacteria

Zoonotic bacteria

Salmonella

Salmonella serotypes were isolated and identified according to a modification of the NMKL standard Nr 71 (1999), or according to ISO standard 6579:2002, at local community or slaughterhouse laboratories. Serotyping of the isolates was performed at Evira, Kuopio Research Unit.

Campylobacter

C. jejuni were isolated at slaughterhouse laboratories and confirmed at Evira, Microbiology Research Unit according to a modification of the NMKL 119:1990.

Indicator bacteria

Enterococci (broilers)

One gram of intestinal content was diluted in 9 ml of peptone saline broth. After mixing, 10 µl of the suspension was spread on Slanetz-Bartley agar (Merck, Darmstadt, Germany) and incubated for 48 h at 37°C. One or two typical colonies were plated on bile-esculine agar (Difco, Le Pont de Claix, France) and incubated at 37°C overnight. Colonies with a positive esculine reaction were cultivated on 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. If two enterococci were isolated from a sample, one of them was randomly chosen for sensitivity testing.

Escherichia coli

In 2005 the isolation procedure was as follows. One gram of intestinal content was diluted in 9 ml of peptone saline broth. After mixing, 10 µl of the suspension was spread on MacConkey agar (Difco) and incubated overnight at 44°C. A typical lactose-positive colony was subcultivated on blood agar and incubated overnight at 37°C. Oxidase-negative and indole positive colonies were further cultivated in lactose tryptone lauryl sulfate broth (Oxoid, Basingstoke, UK), in motility and urea agars, and incubated at 37°C overnight.

In 2006, one gram of intestinal content was diluted in 9 ml of peptone saline broth. After mixing, 10 µl of the suspension was spread on Selective E. coli/Coliform Chromogenic medium (Oxoid) and incubated overnight at 37°C. Purple colonies were selected for susceptibility tests. The isolation procedure was validated against the method described previously and, during the validation process, the isolates were confirmed biochemically to be *E. coli*.

Animal pathogens

Haemolytic *Escherichia coli* were isolated and identified at Evira, Microbiology Research Unit, and Kuopio, Oulu and Seinäjoki Research Units using standard procedures. They were isolated on blood agar plates and identified as typical colonies on EMB agar (Becton Dickinson, Sparks, USA or Merck). The isolates were further tested for indole production.

Isolation and preliminary identification of mastitis pathogens was performed at eleven private and municipal mastitis laboratories and Evira, Microbiology Research Unit. Species identification was performed at Evira using accredited methodology. Klebsiella species included *Klebsiella pneumoniae* (n=53), *Klebsiella oxytoca* (n=9) and 19 *Klebsiella* sp. isolates which were indistinguishable by the conventional methods, which leaves the possibility that some of the isolates may belong to the genus Raoultella (formerly *Klebsiella*).

Milk samples were delivered frozen to Evira, Microbiology Research Unit. An aliquot of 50 µl was spread on one half of a plate of Chromogenic MRSA Agar (Oxoid) (n=127) or Oxacillin Resistance Screening Agar (Oxoid) (n=45). The inoculated part of the plate was streaked to the remaining half of the plate using a disposable loop to ensure single colonies. The plates were incubated according to manufacturer's instructions.

Staphylococcus colonies growing on blood agar plates as greyish white colonies with a beta-toxic zone were further identified as *S. intermedius* using rabbit coagulase plasma (BD), Staphytect Plus (Oxoid), hyaluronidase test, Voges Proskauer test (Rosco, Taastrup, Danmark) and Staph ID 32 (Biomerieux, Marcy L'Etoile, France).

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 standards of the Clinical and Laboratory Standards Institute (former National Committee of Clinical Laboratory Standards), except for *Campylobacter,* for which the VetMIC™ and CLSI standards were modified. Susceptibility testing was performed at Evira, Microbiology Research Unit.

Between 2005 and 2006 some changes were made in the microdilution panels used in susceptibility testing of *E. coli* and *Salmonella* spp.: enrofloxacin, neomycin and oxytetracycline were deleted, and cefotaxime, ciprofloxacin, kanamycin and tetracycline were added.

Table 27. *Epidemiological cut-off values (mg l^{-1}) used in this report*

Antimicrobial agent	*Salmonella enterica*	*Escherichia coli*	*Enterococcus spp.*	*Staphylococcus intermedius*	*Campylobacter jejuni*	*Klebsiella sp.*	*Staphylococcus aureus*	*Streptococcus spp.*
Ampicillin	>4	>8	>8		>16			
Avilamycin			>16	>16			>16	>16
Bacitracin[1]			>32					
Cefotaxime	>0.5	>0.5				>0.5		
Ceftiofur	>2	>2				>2		
Cephalotin				>1			>1	>1
Chloramphenicol	>16	>16	>16	>16		>16	>16	>8
Ciprofloxacin	>0.06	>0.06				>0.12		
Clindamycin				>2			>2	>0.5
Enrofloxacin	>0.25	>0.25		>0.5	>0.5		>0.5	
Erythromycin			>4	>2	>4		>2	>0.5
Flavomycin			>16					
Florfenicol	>16	>16				>16		
Fucidic acid				>0.5			>0.5	
Gentamicin	>2	>4	>256	>2	>1	>4	>2	
Kanamycin	>8	>8				>8		
Nalidixic acid	>16	>16			>16	>16		
Narasin			>2					
Neomycin	>4	>4	>256	>2			>2	
Oxacillin				>2			>2	
Oxytetracycline, tetracycline	>8	>8	>4	>2	>2	>8	>2	>4
Penicillin G								>0.12
Spiramycin							>16	
Streptomycin	>32	>16	>256	>32		>16	>32	
Sulfamethoxazole	>256	>256				>256		
Trimethoprim	>2	>4				>4		>2
Trim.-sulfamethoxazole[2]				>2			>2	
Vancomycin			>4	>4			>4	>2
Virginiamycin			>8	>4			>4	>4

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

[2] concentration of trimethoprim given, tested with sulfamethoxazole in concentration ratio 1:20.

The cut-off values used are shown in Table 27. Bacitracin values are given in units ml^{-1} (SVARM, 2005). Production of betalactamase was tested with Nitrocefin disc test (AB Biodisk, Solna, Sweden).

All *S. intermedius* isolates and other staphylococci with a MIC > 1 mg l^{-1} were tested for the carriage of the *mec*A gene. Polymerase chain reaction (PCR) for *mec*A gene detection was performed according to Murakami et al. (1991).

Quality assurance system

All departments of Evira participate in external quality assurance programmes for veterinary pathogens. The Kuopio Research Unit also participates in proficiency tests on isolation, identification and serotyping of *Salmonella*, and the Microbiology Research Unit 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. jejun*i ATCC 33560, and *S. aureus* ATCC 43300 and *S. aureus* ATCC 33592 each time MRSA screening was performed.

Kuopio Research Unit is accredited for isolation, identification and serotyping of *Salmonella*, and the Microbiology Research Unit for the isolation and identification of mastitis pathogens, and performing the VetMIC™ test for *E. coli, Salmonella*, enterococci and staphylococci according to SFS-EN ISO/IEC 17025, by the Finnish Centre for Metrology and Accreditation.

Appendix 2: Population statistics

Table 28. *Number of farm animals and holdings in Finland in 2005 and 2006.*

Animal category		Holdings	Livestock (live animals)	Slaughtered animals
Cattle				
calves (under one year)	2005	20 353	328 968	
	2006	19 038	317 656	
dairy cows and heifers	2005	17 442	462 244	
	2006	16 233	453 090	
meat production animals	2005	10 659	167 713	
	2006	10 078	178 545	
in total	2005	21 493	958 925	294 804
	2006	20 098	949 231	293 014
Chickens				
broilers	2005	144	5 472 291	53 179 866
	2006	124	5 366 137	53 727 251
Pigs				
breeding animals	2005	2 568	459 665	48 822
	2006	2 390	457 415	61 873
fattening pigs	2005	2 525	941 406	2 306 475
	2006	2 362	979 055	2 306 717
in total	2005	3 086	1 401 071	2 356 709
	2006	2 876	1 436 470	2 422 590

Table 28 presents the number of farm animals and holdings in Finland. Data on holdings and live animals originate from the Information Centre of the Ministry of Agriculture and Forestry, Farm Register, and data on slaughtered animals from meat inspection statistics of Evira.

Cover photos: Evira's Image Bank/Anniina Kivilahti

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Evira publications 22/2007
ISSN 1796-4369
ISBN 952-5662-99-3
ISBN 952-5662-90-X (pdf)

Evira