VLA ANTIMICROBIAL SENSITIVITY REPORT 2003

AUTHORS:
C J TEALE
P K MARTIN
Dr G H WATKINS

CONTRIBUTORS:
Dr. C CASSAR, S COBB, B NAIDU, K SPEED, J ROGERS, A MARS.

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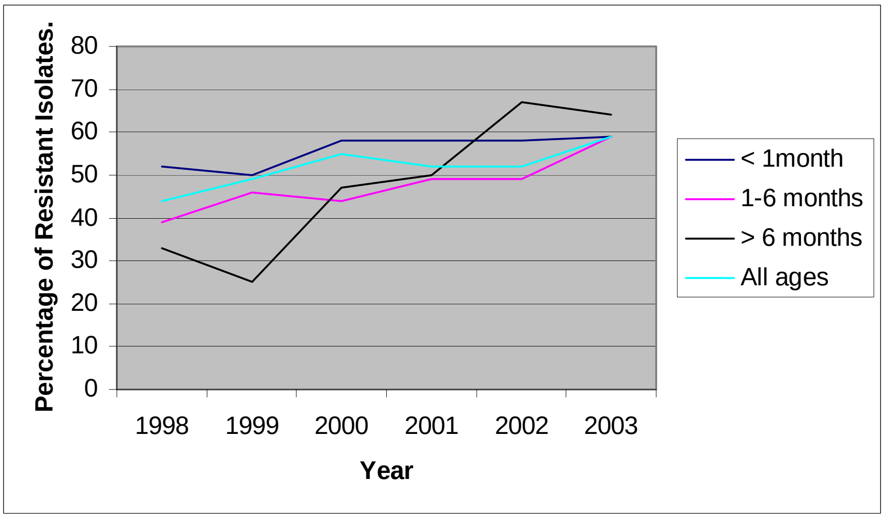
ANTIMICROBIAL SENSITIVITY REPORT

SUMMARY

This report summarises the antimicrobial resistance data on clinical veterinary bacteria and *Salmonella* collected by the Veterinary Laboratories Agency over the period 1998 to 2003. It does not include the results of surveillance at abattoirs for antimicrobial resistance in bacteria from cattle, sheep and pigs performed over this period. The total number of susceptibility tests performed for clinical veterinary purposes in 2001 was more than 25% lower than the figure for 2000 and this was a direct result of the outbreak of foot and mouth disease that occurred at this time. The number of susceptibility tests performed in 2002 and 2003 was greater than the figure for 2001, though has still not yet reached the number of tests performed in 1999 or 2000. Taken overall, the resistance levels for the majority of veterinary bacteria have not changed greatly over the five to six year monitoring period. It is in some respects surprising that resistance levels have changed so little for many organisms and this is particularly exemplified by the levels of resistance observed in *Escherichia coli* and coliforms from bovine mastitis cases, which have remained remarkably stable.

- In *E. coli* /coliforms from cattle resistance levels have been relatively stable over the monitoring period. However, in calves less than one month old amoxicillin /clavulanate resistance increased to 27% in 2003, whereas in 1999-2002 it had fluctuated at lower levels of between 19-22%. This occurred against a background of relatively stable resistance to ampicillin in calves, which has fluctuated between 70 and 73% since 1998. In growing cattle at 1-6 months of age in 2003 resistance to ampicillin, amoxicillin/ clavulanate and the numbers of isolates showing multiple resistance were all at slightly higher levels than those recorded in 1999-2002. In cattle older than six months, resistance to ampicillin and amoxicillin/ clavulanate has remained within 2 percentage points of the mean 1999-2002 value. Levels of resistance in all ages of cattle to fluoroquinolones remain low and have declined to very low levels from the low values observed in 1998 and 1999.
- The levels of resistance to enrofloxacin in young pigs are higher than those recorded in other domestic farmed species and were 8% in 2003. In general, levels of resistance to most antimicrobials in pigs less than 1 month old have remained relatively stable over the last four years, though the percentage of isolates with multiple resistance has shown an overall upward trend since monitoring began, as has multiple resistance in K88-positive *E. coli* from pigs.
- More than 50% of *E. coli* isolates from pigs under 1 month old are resistant to tetracyclines and trimethoprim/ sulphonamides and in pigs of all ages levels of resistance to tetracyclines are consistently more than 70%, with 84% of isolates from pigs at 1-6 months resistant to tetracyclines in 2003.
- Trimethoprim/ sulphonamide resistance has increased in *E. coli* isolates from pigs of all ages; increased resistance to this antimicrobial has also been observed in a number of other bacteria isolated from pigs and there has also been an overall trend to increasing resistance to trimethoprim /sulphonamides in K88+ *E.coli* isolates from pigs over the monitoring period.

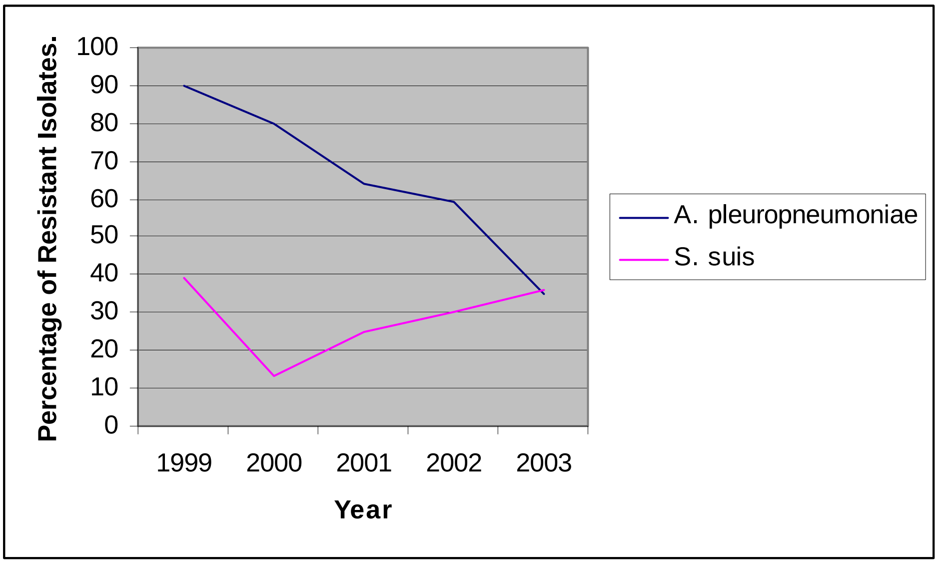
Figure 1: Resistance to trimethoprim/ sulphonamides in *E. coli* /coliforms from Pigs of Different Ages.



- In general, lower levels of resistance have been consistently observed in *E. coli* isolates from sheep than in isolates from pigs and cattle of the same age. In sheep less than one month old the levels of resistance for several antimicrobials which had remained relatively unchanged in 1999-2001 declined in 2002 and this decline was maintained in 2003 for ampicillin and tetracyclines. In animals aged 1-6 months, a decline in tetracycline resistance was observed in 2002 and 2003, compared to 1999-2001 levels, whilst in 2003 ampicillin resistance levels increased to 27% from levels of 15-17% seen in 2000-2002.
- Resistance to enrofloxacin in *E. coli* isolates from chickens and turkeys has been consistently less than 5% over the monitoring period. Levels of resistance in *E. coli* from chickens for most other antimicrobials have remained relatively stable over the monitoring period, though resistance to tetracyclines has shown wider fluctuations. The population of chickens from which samples were examined will include a variable proportion of broilers and layers and flock types in each year and this may account for some of the observed variation. In general, a slightly higher proportion of *E. coli* isolates from turkeys were resistant to several antimicrobials than isolates from chickens.
- No resistance to penicillin or amoxicillin/ clavulanate was reported in *Streptococcus agalactiae, S.dysgalactiae* or *S.uberis* from bovine mastitis incidents in 2003. All *S. agalactiae* isolates from 2003 were also susceptible to erythromycin.
- Resistance to penicillin in *Staphylococcus aureus* from bovine mastitis samples which increased to 46% in 2002 from the low of 29% in 1999, was 36% in 2003. Only 0.8% of *S. aureus* isolates were resistant to amoxicillin/ clavulanate in 2003, a marked decline on values from previous years.
- Levels of resistance in *E. coli* from incidents of bovine mastitis have remained remarkably constant over the monitoring period.

- A generally low prevalence of resistance to a number of antimicrobials (ampicillin, amoxicillin/ clavulanate, cephalexin, tetracyclines, florfenicol and trimethoprim/ sulphonamide) was recorded in bovine *Pasteurella multocida* isolates over the monitoring period. Resistance to tetracyclines was detected for the first time in *Pasteurella multocida* from sheep in 2002 and again in 2003; in 2003 resistance to ampicillin, amoxicillin/ clavulanate and cephalexin was also reported in ovine strains.
- 9 - 15% of porcine P*asteurella multocida* isolates were resistant to tetracyclines over the reporting period, higher than the figure seen in bovine isolates; resistance to ampicillin, trimethoprim/ sulphonamide, apramycin and neomycin was also reported in porcine strains
- Resistance to ampicillin was detected for the first time in *Pasteurella trehalosi* from sheep in 2002; a single resistant isolate was also reported in 2003.
- An overall trend of increasing multiple resistance was reported from 1999 to 2003 in *Actinobacillus pleuropneumoniae* isolates recovered from pigs. [The trend was not maintained in 2002, when levels of multiple resistance declined].
- *Actinobacillus pleuropneumoniae* isolates recovered from pigs showed a decline in resistance to tylosin from 90% in 1999 to 59% in 2002 and then to 35% in 2003 and this period coincides with the period of withdrawal of tylosin as a growth promoter.

Figure 2: Resistance to Tylosin in *S. suis* and *Actinobacillus pleuropneumoniae* in Pigs.



- Resistance to trimethoprim/ sulphonamides in *Actinobacillus pleuropneumoniae* increased markedly in 2003 to 46%, from levels of 11-19% seen in 1999-2002.
- Resistance to trimethoprim/ sulphonamides in *Erysipelothrix rhusiopathiae* increased in 2002 and declined to previously-observed levels in 2003. However, the small sample size suggests that this trend should be interpreted cautiously.
- Resistance to tetracyclines in *Streptococcus suis* which had increased in 2002, declined in 2003, to levels seen in 1999-2001. Trimethoprim/ sulphonamide

resistance showed no increase in *S. suis* in 2003 and has declined since 1999-2000. Trimethoprim/ sulphonamide was detected for the first time in 2003 in *Streptococcus equisimilis* isolates from pigs however.

- Resistance to tetracyclines was detected for the first time in *Corynebacterium pseudotuberculosis* in 2002; all isolates proved susceptible to the antimicrobials tested in 2003.
- The percentage of *S.* Dublin isolates sensitive to all 16 antimicrobials has shown a modest decline over the period 1996-2003, though the majority of isolates remain susceptible and this has been the situation since surveillance began in 1971. The majority of *S.*Dublin isolates originate from cattle.
- Considering all definitive types of *S.* Typhimurium, there has been a marked increase in resistance to sulphamethoxazole/ trimethoprim from levels of around 16-24% in 1996-2001 to 44.1% in 2002 and 37.5% in 2003. There is a contribution from DT 104 to this overall figure; it is mainly other phage types of *S.*Typhimurium isolated from pigs that account for the remainder of this rise. A high percentage of many definitive types of *S.*Typhimurium isolated from pigs are resistant to sulphamethoxazole/trimethoprim, a situation that was also observed in 2002.
- The proportion of *S.* Typhimurium isolates resistant to nalidixic acid rose in 2003, compared to levels seen since 1999, though were similar to values recorded in 1997 and 1998. Amongst *S.* Typhimurium DT 104 isolates, those originating from cattle and turkeys were most likely to show nalidixic acid resistance.
- In 2003, 93 *Salmonella* isolates resistant to nalidixic acid in the disc diffusion test were examined to determine their MIC for ciprofloxacin. Four isolates had an MIC for ciprofloxacin of ≥1mg/l. The serotypes involved were *Salmonella* Senftenberg, *S.* Newport (2) and *S.* Typhimurium DT 104; the Newport and Typhimurium DT 104 isolates originated from turkeys, whilst the *Salmonella* Senftenberg isolate was from cull chicks (fowls).
- The limited number of *Clostridium perfringens* isolates examined in 2003 were generally susceptible to the antimicrobial agents they were tested against.

Ongoing surveillance of this type will allow trends in the emergence and spread of resistance to be identified; the report also serves to highlight areas where data is limited. The data presented complements the data already published by Defra on the results of major surveys of antimicrobial resistance in bacteria from cattle, sheep and pigs at slaughter.

PREFACE

This report summarises the antimicrobial resistance data collected by the Veterinary Laboratories Agency (VLA) in the years 1998 to 2003 as part of ongoing surveillance studies funded by Defra. Summary data is presented for a range of bacterial organisms isolated at a network of 14 veterinary diagnostic laboratories situated throughout England and Wales including *Salmonella* isolates recovered from animals and their environment. The *Salmonella* data has been previously published in the "Salmonella in Livestock" booklet produced by the VLA. Antimicrobial susceptibility testing was performed using a disc diffusion test (unless otherwise stated) and the report provides base-line data against which future trends in resistance or the effects of interventions may be monitored. An interim system, designed to capture and report the existing data collected at VLA regional laboratories, is currently in place; further refinement and development of this system, including a move to collection of zone size data, is anticipated. Direct comparison with the susceptibility results reported in other countries is difficult because of differences in methodology. There has been a general improvement in quality of the data recorded from the time at which the new recording system was set up in 1998. The data set complements the data on the susceptibility of bacterial organisms recovered from structured surveillance surveys of cattle, sheep and pigs at abattoirs performed in 1999/2000 (available at http://defraweb/animalh/diseases/zoonoses/index.htm) and again in 2003 (summary also available on the Defra web-site). It is planned where possible to link the surveillance data from animals and man in combined HPA/VLA reports. The first of these, covering *Salmonella* in man and animals, was published in the journal Microbial Drug Resistance (Threlfall et al. 2003)

INTRODUCTION

This report summarises the data on antimicrobial resistance collected by the Veterinary Laboratories Agency (VLA) between the years 1998 and 2003 under the VLA's Food and Environmental Safety Programme, funded by Defra. It includes data from the *Salmonella* surveillance programme collected over this period and also from the national antimicrobial sensitivity database which was introduced to VLA regional laboratories in 1998 and which collects data from all of the sensitivity tests that are performed on clinical samples. The population of organisms examined reflects, for the most part, isolates from samples of field cases of clinical disease submitted by practising veterinary surgeons for diagnostic purposes. When a potential bacterial pathogen is identified, antimicrobial sensitivity testing is generally performed to provide the practitioner with information on which to base treatment. The figures therefore reflect the antimicrobial resistance of organisms of clinical significance recovered from farms in England and Wales. Many of the samples will come from animals that have been treated with antimicrobials and will therefore have been under selective pressure. In addition to this data collected from clinical samples, statistically designed surveys of the susceptibility of organisms recovered from animals at slaughter have also been performed over this period. These two data sets complement each other; the results of the abattoir surveillance performed in 1999/ 2000 have been published and are available at http://defraweb/animalh/diseases/zoonoses/index.htm. For a number of organisms, very few isolates have been made during the five years that the report covers, therefore trends need to be treated with considerable caution. Similarly, the figures for percentage resistance and trends in these figures should always be interpreted taking into account the numbers of isolates that have been recovered. Any laboratory isolating a *Salmonella* from farmed domestic livestock in England or Wales is required under the Zoonoses Order of 1989 to notify the nominated officer within Defra and to submit the isolate to Defra for examination. Therefore, this data will include the majority of recognised *Salmonella* incidents in farmed livestock in England and Wales.

METHODOLOGY

The majority of tests were performed using a disc diffusion technique on Oxoid "sensitest" agar (*Salmonella* to 1998) or "isosensitest" agar (other organisms; *Salmonella* from 1999), with media supplementation for fastidious organisms where appropriate. The disc concentrations are as stated in the tables and a semi-confluent inoculum is used in the test procedure. The method used has evolved over many years and is similar to that described by the British Society for Antimicrobial Chemotherapy (BSAC) (Phillips 1991). However, a uniform cut-off point of 13mm is used to discriminate between sensitive and resistant strains; an intermediate category of susceptibility is not recorded. Multiple antimicrobial resistance is defined as resistance to four or more antimicrobials. All 14 of the VLA Regional Veterinary Laboratories have received United Kingdom Accreditation Service (UKAS) accreditation.

The minimum inhibitory concentration (MIC) of ciprofloxacin for *Salmonella* isolates resistant to nalidixic acid in the disc diffusion test was determined using the agar dilution method of the HPA Laboratory of Enteric Pathogens, Colindale. Overnight cultures of *Salmonella* were inoculated into nutrient broth and incubated for two hours at 37^{o}C. The optical density of the diluted cultures was adjusted by the addition of sterile distilled water to be equivalent to that of a 0.5 McFarland standard. These adjusted suspensions were spot inoculated onto duplicate isosensitest agar plates, containing a doubling dilution series of concentrations of ciprofloxacin. Four National Collection of Type Cultures (NCTC) bacterial strains were included on each plate as control organisms according to the recommendations of BSAC (Andrews 2001). All plates were incubated at 37^{o}C for 18 hours before recording the presence or absence of growth and determining the MIC.

The antimicrobial susceptibility of anaerobic organisms was determined using the "ATB ANA" susceptibility testing system, produced by bioMerieux (France). The method is essentially a breakpoint method, using a semisolid medium in cupules in which selected antimicrobials have been incorporated (some of these antimicrobials are incorporated into separate cupules at two dilutions, others at a single dilution). The antimicrobials and concentrations used are listed in part C of this report.

PART A: VETERINARY PATHOGENS OTHER THAN SALMONELLA

A network of 14 VLA regional laboratories collects the data on veterinary pathogens other than *Salmonella* and this ensures coverage of all regions of England and Wales.

The reporting period includes a variable period of 1998 at different Centres, dependent on the point at which the system was introduced. All regional laboratories except VLA Winchester (because of local difficulties) contributed a full data set for 1999, 2000, 2001, 2002 and 2003.

NUMBERS OF SENSITIVITY TESTS CARRIED OUT BY VLA REGIONAL LABORATORIES:

Year	1998*	1999	2000	2001	2002	2003
Aberystwyth	46	500	562	312	357	374
Newcastle	59	285	189	202	142	141
Penrith	153	1446	1360	532	1313	1488
Preston	275	1614	1270	1076	1628	1313
Sutton Bonington	725	986	642	603	788	716
Shrewsbury	1207	1657	1657	1260	1432	1414
Luddington	385	1219	1140	662	827	993
Bury St Edmunds	62	1133	1116	754	708	736
Winchester	443	245	783	536	535	444
Langford	266	928	810	701	770	684
Starcross	219	1274	1094	807	881	964
Thirsk	543	1392	780	544	784	799
Carmarthen	181	1186	1282	1027	1250	1233
Truro	Nil return	591	457	295	352	378
Total number of tests performed	4564	14456	13142	9311	11767	11677

* Date of introduction at each regional laboratory in 1998 was variable

RESULTS

Results are presented in full in tabular form. Readers should be aware that the raw data has been supplied in full as far as possible and that any inconsistencies or incongruities have also been reported. There are some anomalies in the data and these are discussed further in the Discussion section. Percentage resistance figures are rounded to the nearest whole number, unless less than one. For a number of organisms, very few isolates have been made during the period covered by the report, therefore trends need to be treated with considerable caution. Similarly, the figures for percentage resistance and trends in these figures should always be interpreted taking into account the numbers of isolates that have been recovered.

ESCHERICHIA COLI/COLIFORMS FROM DOMESTIC ANIMALS

This section includes all isolates of *Escherichia coli* and coliform bacteria presumptively identified as *E.coli,* with the exception of those isolates cultured from milk, which are included in the section on mastitis organisms. The majority of isolates in this section were cultured from faeces or intestinal contents.

Table 1

Cattle: *E.coli/*coliforms

<1 month old

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Total isolates	764	3278	2831	1835	1957	1309
Number showing multiple resistance	300	1089	958	806	735	507
Percentage showing multiple resistance	39	33	34	44	38	39
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10ug	73	71	72	71	70	72
Amoxicillin/Clavulanate 20/10ug	24	19	20	21	22	27
Tetracycline 10ug	79	78	79	77	76	76
Neomycin 10ug	44	42	42	43	43	43
Apramycin 15ug	9	7	7	7	6	5
Trimethoprim/Sulphonamide 25ug	42	40	41	41	36	39
Enrofloxacin 5ug	1	1	0	0.1	0.1	0

Table 2

Cattle: *E.coli*/coliforms

1-6 months old

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Total isolates	105	336	339	190	288	251
Number showing multiple resistance	29	70	62	37	60	68
Percentage showing multiple resistance	28	21	18	19	21	27
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10ug	47	44	40	41	41	50
Amoxicillin/Clavulanate 20/10ug	17	15	11	13	11	18
Tetracycline 10ug	55	59	58	55	55	55
Neomycin 10ug	32	21	19	21	24	26
Apramycin 15ug	7	6	4	2	2	4
Trimethoprim/Sulphonamide 25ug	33	29	29	27	25	31
Enrofloxacin 5ug	0	2	0	0	0.3	0.4

Table 3

Cattle: *E.coli*/coliforms

>6 months old

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Total isolates	44	843	1073	163	1540	731
Number showing multiple resistance	5	42	97	8	104	50
Percentage showing multiple resistance	11	5	9	5	7	7
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10ug	23	16	18	16	13	15
Amoxicillin/Clavulanate 20/10ug	0	5	5	3	4	6
Tetracycline 10ug	25	20	20	21	13	15
Neomycin 10ug	11	8	10	7	7	6
Apramycin 15ug	5	1	1	1	0.1	0.4
Trimethoprim/Sulphonamide 25ug	21	8	10	6	6	7
Enrofloxacin 5ug	0	0.2	0	0	0	0

Table 4

Cattle: *E.coli*/coliforms

All ages

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Total isolates	1197	6066	5127	2468	4193	2659
Number showing multiple resistance	423	1472	1255	894	993	693
Percentage showing multiple resistance	35	24	25	36	24	26
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10ug	66	52	53	63	44	49
Amoxicillin/Clavulanate 20/10ug	21	14	14	19	14	19
Tetracycline 10ug	71	59	59	69	48	52
Neomycin 10ug	40	30	30	37	26	27
Apramycin 15ug	8	5	5	6	3	3
Trimethoprim/Sulphonamide 25ug	39	29	30	37	23	27
Enrofloxacin 5ug	1	1	0.1	0.1	0.1	0.04

Table 5

Cattle: *E.coli K99+ve*

All ages

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Total isolates	3	38	32	25	18	6
Number showing multiple resistance	1	10	11	9	9	2
Percentage showing multiple resistance	33	26	34	36	50	33
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10ug	66	29	94	80	83	50
Amoxicillin/Clavulanate 20/10ug	33	10	50	24	22	15
Tetracycline 10ug	66	26	75	60	61	50
Neomycin 10ug	0	8	25	28	44	15
Apramycin 15ug	0	2	0	0	6	0
Trimethoprim/Sulphonamide 25ug	66	19	56	48	50	50
Enrofloxacin 5ug	0	0	0	0	0	0

Table 6

Pigs: *E.coli/*coliforms

<1 month old

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Total isolates	68	215	144	93	114	90
Number showing multiple resistance	20	61	51	39	41	42
Percentage showing multiple resistance	29	28	35	42	36	47
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10ug	38	37	54	53	44	48
Tetracycline 10ug	70	81	83	78	85	82
Neomycin 10ug	19	18	15	15	11	12
Apramycin 15ug	9	12	11	18	16	11
Trimethoprim/Sulphonamide 25ug	52	50	58	58	58	59
Enrofloxacin 5ug	6	2	9	8	11	8

Table 7

Pigs: *E.coli*/coliforms

1-6 months old

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Total isolates	52	185	161	78	195	155
Number showing multiple resistance	17	49	49	40	57	67
Percentage showing multiple resistance	33	27	30	51	29	43
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10ug	46	46	44	59	44	54
Tetracycline 10ug	79	88	83	91	90	84
Neomycin 10ug	19	22	19	19	10	23
Apramycin 15ug	6	16	19	15	11	19
Trimethoprim/Sulphonamide 25ug	39	46	44	49	49	59
Enrofloxacin 5ug	0	1	3	1	4	0.6

Table 8

Pigs: *E.coli*/coliforms

>6 months old

Year	1998	1999	2000	2001	2002	2003
Total isolates	9	20	36	6	15	69
Number showing multiple resistance	1	2	8	2	4	25
Percentage showing multiple resistance	11	10	22	33	27	36
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10ug	22	50	33	33	40	58
Tetracycline 10ug	56	85	69	83	60	88
Neomycin 10ug	0	0	8	17	7	23
Apramycin 15ug	0	5	11	17	0	19
Trimethoprim/Sulphonamide 25ug	33	25	47	50	67	64
Enrofloxacin 5ug	0	0	3	0	20	0

Table 9

Pigs: *E.coli/*coliforms

All ages

Year	1998	1999	2000	2001	2002	2003
Total isolates	163	818	567	215	365	352
Number showing multiple resistance	48	192	198	93	115	145
Percentage showing multiple resistance	29	24	35	43	32	41
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10ug	41	45	49	53	43	51
Tetracycline 10ug	74	83	84	85	85	83
Neomycin 10ug	20	18	19	16	11	19
Apramycin 15ug	7	15	16	14	12	16
Trimethoprim/Sulphonamide 25ug	44	49	55	52	52	59
Enrofloxacin 5ug	3	3	4	5	8	2

Table 10

Pigs: *E.coli* K88+ve

All ages

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Total isolates	No data	61	43	16	52	52
Number showing multiple resistance	No data	18	13	0	25	28
Percentage showing multiple resistance	No data	30	30	0	48	54
	Percentage Resistant					
	1998	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10ug	-	54	63	56	54	58
Tetracycline 10ug	-	87	84	88	94	92
Neomycin 10ug	-	23	23	25	8	29
Apramycin 15ug	-	25	28	44	23	35
Trimethoprim/Sulphonamide 25ug	-	51	56	88	65	71
Enrofloxacin 5ug	-	0	5	13	13	0

Table 11

Sheep: *E.coli*/coliforms

<1 month old

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Total isolates	24	363	275	143	187	102
Number showing multiple resistance	5	59	48	30	30	15
Percentage showing multiple resistance	21	16	18	21	16	15
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10ug	50	39	33	37	26	25
Amoxicillin/Clavulanate 20/10ug	8	9	4	8	4	7
Tetracycline 10ug	66	56	51	57	43	43
Neomycin 10ug	38	23	23	24	18	21
Apramycin 15ug	4	3	6	8	4	4
Trimethoprim/Sulphonamide 25ug	25	24	21	24	17	19
Enrofloxacin 5ug	0	0	0	0	0	0

Table 12

Sheep: *E.coli*/coliforms

1-6 months old

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Total isolates	14	104	73	37	36	44
Nu mber showing multiple resistance	0	7	6	2	3	4
Percentage showing multiple resistance	0	7	8	5	8	9
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10ug	14	25	15	16	17	27
Amoxicillin/Clavulanate 20/10ug	0	5	3	5	0	5
Tetracycline 10ug	21	40	36	41	28	30
Neomycin 10ug	7	16	8	3	11	11
Apramycin 15ug	0	0	7	3	0	7
Trimethoprim/Sulphonamide 25ug	7	11	10	11	8	9
Enrofloxacin 5ug	0	1	0	0	0	0

Table 13

Sheep: *E.coli*/coliforms

>6 months old

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Total isolates	13	40	63	10	50	36
Number showing multiple resistance	1	3	3	0	2	0
Percentage showing multiple resistance	8	8	5	0	4	0
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10ug	23	10	21	10	16	3
Amoxicillin/Clavulanate 20/10ug	15	0	0	0	2	0
Tetracycline 10ug	15	20	27	10	20	14
Neomycin 10ug	8	8	11	0	6	6
Apramycin 15ug	0	0	3	0	0	0
Trimethoprim/Sulphonamide 25ug	8	8	2	0	6	0
Enrofloxacin 5ug	0	0	0	0	0	0

Table 14

Sheep: *E.coli*/coliforms

All ages

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Total isolates	65	645	484	227	299	202
Number showing multiple resistance	6	83	64	37	36	21
Percentage showing multiple resistance	9	13	13	16	12	10
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10ug	32	33	28	32	22	21
Amoxicillin/Clavulanate 20/10ug	9	6	3	7	3	5
Tetracycline 10ug	39	49	44	49	36	35
Neomycin 10ug	20	19	17	18	14	14
Apramycin 15ug	2	3	5	6	2	5
Trimethoprim/Sulphonamide 25ug	14	18	17	19	13	12
Enrofloxacin 5ug	0	0.2	0	0	0	0

Table 15

Sheep: *E.coli* K99+ve

All ages

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Total isolates	2	6	0	0	1	0
Number showing multiple resistance	0	2	-	-	0	-
Percentage showing multiple resistance	0	33	-	-	0	-
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10ug	100	83	-	-	0	-
Amoxicillin/Clavulanate 20/10ug	100	0	-	-	0	-
Tetracycline 10ug	0	67	-	-	0	-
Neomycin 10ug	100	33	-	-	0	-
Apramycin 15ug	0	33	-	-	0	-
Trimethoprim/Sulphonamide 25ug	0	50	-	-	0	-
Enrofloxacin 5ug	0	0	-	-	0	-

Table 16

Chickens: *E.coli*/coliforms

All ages

Year	**1999**	**2000**	**2001**	**2002**	**2003**
Total isolates	152	93	69	82	167
Number showing multiple resistance	18	14	1	15	19
Percentage showing multiple resistance	12	15	1	18	11
	Percentage Resistant				
Year	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10ug	38	33	42	33	43
Tetracycline 10ug	57	52	42	50	60
Apramycin 15ug	3*	5*	3	5*	3
Neomycin 10ug	14*	7*	1	11*	6
Trimethoprim/Sulphonamide 25ug	24	26	26	29	22
Enrofloxacin 5ug	2	4	0	0	3

*One isolate not tested.

Table 17

Turkeys: *E.coli*/coliforms

All ages

Year	**1999**	**2000**	**2001**	**2002**	**2003**
Total isolates	36	44	19	17	6
Number showing multiple resistance	3	6	3	2	1
Percentage showing multiple resistance	8	14	16	12	17
	Percentage Resistant				
Year	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10ug	39	48	58	47	50
Tetracycline 10ug	58	64	84	65	83
Apramycin 15ug	0	0	0	0	0
Neomycin 10ug	0	9	5	0	0
Trimethoprim/Sulphonamide 25ug	25	34	37	35	17
Enrofloxacin 5ug	0	5	5	0	0

MASTITIS ORGANISMS.

Table 18

Cattle: *Streptococcus agalactiae*

All ages

Year	1998	1999	2000	2001	2002	2003
Total isolates	8	36	22	29	36	28
Number showing multiple resistance	0	0	0	1	1	0
Percentage showing multiple resistance	0	0	0	3	3	0
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Penicillin 10iu	0	0	0	0	3*	0
Ampicillin 10ug	0	0	0	0	3*	0
Amoxicillin/Clavulanate 2/1ug	0	0	0	0	3*	0
Tetracycline 10ug	0	14	14	10	17	14
Erythromycin 5ug	0	0	0	3*	3*	0
Neomycin 30ug	63	50	45	39	56	46

*Unconfirmed

Table 19

Cattle: *Streptococcus dysgalactiae*

All ages

Year	1998	1999	2000	2001	2002	2003
Total isolates	56	211	175	211	278	193
Number showing multiple resistance	0	1	2	2	2	3
Percentage showing multiple resistance	0	0.5	1	1	1	2
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Penicillin 10iu	0	0	0	0.5*	0.7*	0
Ampicillin 10ug	0	0.5*	0	0	0.3*	0
Amoxicillin/Clavulanate 2/1ug	0	0.5*	0	0.5*	0.7*	0
Tetracycline 10ug	36	45	36	38	46	47
Erythromycin 5ug	4	3	4	4	3	5
Neomycin 30ug	55	56	50	53	52	45

*Unconfirmed

Table 20

Cattle: *Streptococcus uberis*

All ages

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Total isolates	198	811	733	878	1195	775
Number showing multiple resistance	2	4	10	23	31	22
Percentage showing multiple resistance	1	0.5	1	3	3	3
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Penicillin 10iu	0	0.5*	0.6*	0.6*	0.3*	0
Ampicillin 10ug	0	0.25*	0.4*	0	0.2*	0.1*
Amoxicillin/Clavulanate 2/1ug	1*	0.75*	1*	0.3*	0.1*	0
Tetracycline 10ug	9	16	15	16	15	11
Erythromycin 5ug	6	6	7	7	8	8
Neomycin 30ug	70	71	70	73	72	74

*Unconfirmed

Table 21

Cattle: Mastitis *Staphylococcus aureus*

All ages

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Total isolates	211	596	483	555	688	378
Number showing multiple resistance	5	31	15	36	54	9
Percentage showing multiple resistance	2	5	3	7	8	2
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Penicillin 10iu	47	29	34	38	46	36
Ampicillin 10ug	46	29	32	37	45	36
Amoxicillin/Clavulanate 2/1ug	3	5	8	9	11	0.8
Tetracycline 10ug	5	5	6	7	8	3
Erythromycin 5ug	4	4	4	5	3	4
Neomycin 30ug	0	1	3	1	0.4	0

Table 22

Cattle: Mastitis *E.coli*/coliforms

All ages

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Total isolates	598	1303	1176	1235	1612	825
Number showing multiple resistance	39	57	70	77	101	53
Percentage showing multiple resistance	7	4	6	6	6	6
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10 ug	12	12	14	13	12	13
Amoxicillin/Clavulanate 20/10ug	4	4	5	4	4	6
Cephalexin 30ug	5	5	6	8	6	5
Neomycin 10ug	6	6	7	7	7	5
Tetracycline 10ug	13	15	13	14	12	14
Trimethoprim/Sulphonamide 25ug	5	5	5	6	5	7

Table 23

Cattle: *Arcanobacterium pyogenes*

All ages.

ANTIMICROBIAL	**NUMBER RESISTANT/ TOTAL NUMBER OF ISOLATES TESTED**					**PERCENTAGE RESISTANT**				
	1999	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Penicillin 10 iu	1/83	3/72	2/61	1/103	0/71	1	4	3	1	0
Ampicillin 10 ug	1/113	2/72	2/62	0/106	0/71	1	3	3	0	0
Amoxicillin/Clavulanate 2/1 ug	1/107	3/72	2/62	1/102	0/69	1	4	3	1	0
Neomycin 30 ug	16/83	11/54	14/53	13/82	5/57	19	20	26	16	9
Tetracycline 10 ug	31/111	22/72	24/62	31/106	14/71	28	31	39	29	20
Erythromycin 5 ug	5/85	3/54	3/53	8/82	9/57	6	6	6	10	16

60 of 113 isolates were recovered from bovine mastitic milk samples in 1999.
40 of 75 isolates were recovered from bovine mastitic milk samples in 2000.
43 of 62 isolates were recovered from bovine mastitic milk samples in 2001.
62 of 106 isolates were recovered from bovine mastitic milk samples in 2002.
25 of 71 isolates were recovered from bovine mastitic milk samples in 2003.

Table 24

Cattle: ***Klebsiella pneumoniae***

All ages

ANTIMICROBIAL	NUMBER RESISTANT/TOTAL NUMBER OF ISOLATES TESTED.					PERCENTAGE RESISTANT				
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10 ug	4/12	6/15	9/17	6/11	8/16	33	40	53	55	50
Amoxicillin/Clavulanate 20/10 ug	0/12	0/15	0/16	0/11	1/16	0	0	0	0	6
Neomycin 10 ug	1/10	0/15	0/16	0/11	0/16	10	0	0	0	0
Tetracycline 10 ug	3/12	1/15	1/17	3/11	1/16	25	7	6	27	6
Trimethoprim/Sulphonamide 25 ug	0/12	1/15	0/16	1/11	1/16	0	7	0	9	6

11 isolates were recovered from mastitic milk in 1999.
10 isolates were recovered from mastitic milk and 2 from lung in 2000.
15 isolates were recovered from mastitic milk in 2001.
11 isolates were recovered from mastitic milk in 2002.
11 isolates were recovered from mastitic milk in 2003.

Table 25

Cattle: ***Pseudomonas aeruginosa***

All ages

(All isolates from bovine mastitis samples)

ANTIMICROBIAL	NUMBER RESISTANT/ TOTAL NUMBER OF ISOLATES TESTED					PERCENTAGE RESISTANT				
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10 ug	31/33	28/30	25/25	27/27	22/23	94	93	100	100	96
Amoxicillin/Clavulanate 20/10 ug	31/33	29/30	25/25	26/26	22/23	94	97	100	100	96
Tetracycline 10 ug	27/32	27/30	21/25	25/27	21/23	84	90	84	93	91
Trimethoprim/Sulphonamide 25 ug	27/32	26/29	22/25	22/26	20/23	84	90	88	85	87
Enrofloxacin 5 ug	1/4	0/1[a]	0/1[b]	-[c]	0/3[d]	25	0	0	-	0
Cefoperazone 30ug	2/24	4/19	1/14	2/12	0/12	8	21	7	17	0
Streptomycin 25ug	3/18	1/14	1/9	0/8	1/7	17	7	11	0	14

[a] 0/6 isolates resistant to marbofloxacin.
[b] 0/3 isolates resistant to marbofloxacin.
[c] 0/5 isolates resistant to marbofloxacin.
[d] 0/5 isolates resistant to marbofloxacin.

RESPIRATORY PATHOGENS.

Table 26

Cattle: *Pasteurella multocida*

All ages

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Total isolates	44	77	113	45	113	154
Number showing multiple resistance	2	1	1	0	3	2
Percentage showing multiple resistance	5	1	1	0	3	1
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10ug	2	1	2	9	1	0.6
Amoxicillin/Clavulanate 20/10ug	2	1	0	4	2	0
Cephalexin 30ug	2	3	1	2	2	1
Tetracycline 10ug	2	5	2	2	6	4
Trimethoprim/Sulphonamide 25ug	2	3	3	2	3	1
Enrofloxacin 5ug	0	0	0	0	0	0
Florfenicol 30ug	0	0	0	0	2*	0.6*

*Unconfirmed

Table 27

Cattle: *Mannheimia haemolytica*

All ages

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Total isolates	54	91	127	33	78	90
Number showing multiple resistance	2	1	0	0	0	2
Percentage showing multiple resistance.	4	1	0	0	0	2
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10ug	4	2	8	0	0	10
Amoxicillin/Clavulanate 20/10ug	0	0	2	0	0	3
Cephalexin 30ug	0	0	0	0	4*	2
Tetracycline 10ug	13	5	9	3	3	13
Trimethoprim/Sulphonamide 25ug	2	3	3	6	1	4
Enrofloxacin 5ug	0	0	0.7*	0	0	0
Florfenicol 30ug	0	0	0	0	0	1*

*Unconfirmed

Table 28

Cattle: *Histophilus* *somni* (formerly known as *Haemophilus somnus*)

All ages

Year	1998	1999	2000	2001	2002	2003
Total isolates	8	36	45	33	42	47
Number showing multiple resistance	0	0	1	0	0	1
Percentage showing multiple resistance	0	0	2	0	0	2
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10ug	0	0	4	0	0	4
Amoxicillin/Clavulanate 20/10ug	0	0	2	0	0	6*
Cephalexin 30ug	0	0	4	3	0	9
Tetracycline 10ug	0	0	2	0	2	6
Trimethoprim/Sulphonamide 25ug	13	6	4	3	7	0
Enrofloxacin 5ug	0	0	0	0	0	0
Florfenicol 30ug	0	0	0	0	0	0

*Unconfirmed.

Table 29

Sheep: *Pasteurella multocida*

All ages

Year	1998	1999	2000	2001	2002	2003
Total isolates	5	22	17	7	10	13
Number showing multiple resistance	0	0	0	0	0	0
Percentage showing multiple resistance	0	0	0	0	0	0
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10ug	0	5	0	0	0	8
Amoxicillin/Clavulanate 20/10ug	0	0	0	0	0	8
Cephalexin 30ug	0	0	0	0	0	15
Tetracycline 10ug	0	0	0	0	10	23
Trimethoprim/Sulphonamide 25ug	0	0	0	0	0	0
Enrofloxacin 5ug	0	0	0	0	0	0
Florfenicol 30ug	0	0	0	0	0	0

Table 30

Sheep: *Mannheimia haemolytica*

All ages

Year	1998	1999	2000	2001	2002	2003
Total isolates	59	169	178	38	75	106
Number showing multiple resistance	3	0	0	0	0	0
Percentage showing multiple resistance	5	0	0	0	0	0
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10ug	0	0	0.5	0	0	1
Amoxicillin/Clavulanate 20/10ug	0	1	0	0	0	0
Cephalexin 30ug	0	0	1	3	0	0
Tetracycline 10ug	2	1	1	8	3	1
Trimethoprim/Sulphonamide 25ug	0	0	1	0	0	2
Enrofloxacin 5ug	0	0	0	0	0	0
Florfenicol 30ug	0	0	0	0	0	0

Table 31

Sheep: *Pasteurella trehalosi*

All ages

ANTIMICROBIAL	NUMBER RESISTANT/ TOTAL NUMBER OF ISOLATES TESTED					PERCENTAGE RESISTANT				
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10 ug	0/47	0/39	0/10	1/37	1/48	0	0	0	3**	2**
Amoxicillin/Clavulanate 20/10 ug	0/47	0/39	0/10	1/37	0/46	0	0	0	3**	0
Tetracycline 10 ug	0/47*	1/39	0/10	0/37	2/48	0	3	0	0	4
Cephalexin 30 ug	0/47	0/39	0/10	2/34	0/48	0	0	0	6**	0
Trimethoprim/Sulphonamide 25 ug	0/47	1/39	0/10	0/37	1/48	0	3	0	0	2
Enrofloxacin 5 ug	0/47	0/38	0/10	0/34	0/48	0	0	0	0	0

* One isolate of *P. trehalosi* recovered from bovine lung in 1999 was resistant to tetracycline. Two isolates of *P. trehalosi* were recovered from cattle in 2000 and three in 2001; all were susceptible to tetracyclines. Two isolates of *P.trehalosi* were recovered from cattle in 2002; one of these isolates was resistant to ampicillin and amoxycillin/ clavulanate, the other was resistant to tetracyclines. Five isolates of *P. trehalosi* were recovered from cattle in 2003; all were susceptible to ampicillin and tetracyclines.
** Unconfirmed.

Table 32

Pigs: *Pasteurella multocida*

All ages

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Total isolates	No data	101	204	107	161	171
Number showing multiple resistance	No data	2	1	2	0	1
Percentage showing multiple resistance	No data	2	0.5	2	0	0.6
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10ug	-	2	3	3	3	1
Trimethoprim/Sulphonamide 25ug	-	7	7	9	8	12
Tetracycline 10ug	-	14	11	15	9	9
Enrofloxacin 5ug	-	0	0	0	0	0
Apramycin 15ug	-	40	19*	20**	20 [a]	12[b]
Neomycin 10ug	-	0	4*	8***	5 [a]	10[b]

*195 isolates tested; **97 isolates tested; ***98 isolates tested.
[a]148 isolates tested; [b]163 isolates tested.

Table 33

Pigs: *Actinobacillus pleuropneumoniae*

All ages

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Total isolates	No data	45	67	35	54	46
Number showing multiple resistance	-	11	24	17	19	22
Percentage showing multiple resistance	-	24	36	49	35	48
	Percentage Resistant					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10ug	-	4	10	6	4	7
Tetracycline 10ug	-	27	33	40	22	37
Trimethoprim/Sulphonamide 25ug	-	11	19	14	13	46
Neomycin 10ug	-	55*	62[a]	68[c]	63	85
Apramycin 15ug	-	55*	67[a]	70[d]	61	67
Enrofloxacin 5ug	-	0	0	0	4[p]	0
Ceftiofur 30ug	-	3**	2[b]	0[e]	0[g]	0[q]
Spectinomycin 25ug	-	44***	35	65[f]	69[h]	100[r]
Tylosin 30ug	-	90[m]	80[k]	64[j]	59[I]	35[s]

*42 isolates tested; **31 isolates tested; ***41 isolates tested; [a]66 isolates tested; [b]41 isolates tested; [c]34 isolates tested; [d]33 isolates tested; [e]21 isolates tested; [f]34 isolates tested; [g] 29 isolates tested; [h]49 isolates tested; [i]22 isolates tested; [j]14 isolates tested; [k] 25 isolates tested; [m] 10 isolates tested; [p] Unconfirmed; [q]18 isolates tested; [r]19 isolates tested; [s]20 isolates tested.

ARCANOBACTERIUM PYOGENES FROM SHEEP AND PIGS (CATTLE RESULTS REPORTED IN MASTITIS SECTION)

Table 34

Sheep: ***Arcanobacterium pyogenes***

All ages

ANTIMICROBIAL	NUMBER RESISTANT/ TOTAL NUMBER OF ORGANISMS TESTED					PERCENTAGE RESISTANT				
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Penicillin 10 iu	0/23	0/33	0/14	1/13	0/18	0	0	0	8*	0
Ampicillin 10 ug	0/23	0/33	0/16	0/14	0/18	0	0	0	0	0
Amoxicillin/Clavulanate 2/1 ug	0/22	0/33	0/14	0/13	0/18	0	0	0	0	0
Neomycin 30 ug	0/9	3/9	0/4	0/5	0/10	0	33	0	0	0
Tetracycline 10 ug	2/23	2/33	1/16	1/14	0/18	9	6	6	7	0
Erythromycin 5 ug	0/10	0/9	0/4	1/5	1/10	0	0	0	20*	10*
Tylosin 30ug	-	0/18	0/11	0/6	0/7	-	0	0	0	0
Trimethoprim/ sulphonamide 25 ug	0/22	5/28	1/15	2/13	0/17	0	18	7	15	0

* Unconfirmed

Table 35

Pigs: ***Arcanobacterium pyogenes***

All ages

ANTIMICROBIAL	NUMBER RESISTANT/ TOTAL NUMBER OF ISOLATES TESTED					PERCENTAGE RESISTANT				
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Penicillin 10 iu	0/19	0/28	0/12	0/20	0/15	0	0	0	0	0
Ampicillin 10 ug	0/19	0/28	0/12	0/20	0/15	0	0	0	0	0
Tetracycline 10 ug	0/19	1/28	0/12	0/20	0/15	0	4	0	0	0
Trimethoprim/Sulphonamide 25 ug	0/19	1/28	1/12	2/20	1/15	0	4	8	10	7
Ceftiofur 30 ug	0/19	0/28	0/11	0/19	0/15	0	0	0	0	0
Enrofloxacin 5 ug	0/19	0/28	0/11	0/19	0/15	0	0	0	0	0
Tylosin 30 ug	0/15	0/27	0/8	0/8	0/13	0	0	0	0	0
Lincomycin 10 ug	0/15	0/27	0/9	0/13	0/13	0	0	0	0	0

ZOONOTIC ORGANISMS

Table 36

Erysipelothrix rhusiopathiae

ANTIMICROBIAL	NUMBER RESISTANT/ TOTAL NUMBER TESTED.					PERCENTAGE RESISTANT				
	1999	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Penicillin 10 iu	0/6	0/21	0/9	0/7	0/12	0	0	0	0	0
Ampicillin 10 ug	0/6	0/21	0/9	0/7	0/12	0	0	0	0	0
Tetracycline 10 ug	4/7	6/21	0/9	1/7	1/12	57	29	0	14	8
Trimethoprim/Sulphonamide 25 ug	3/6	11/21	6/9	6/7	8/12	50	52	67	86	67
Erythromycin 5 ug	0/4	1/12	0/2	-	0/2	0	8	0	-	0
Tylosin 30 ug	0/2	0/3	0/1	0/3	0/10	0	0	0	0	0
Ceftiofur 30 ug	0/5	0/18	0/7	0/6	0/9	0	0	0	0	0

The total number of isolates in 1999 was 7 (Isolates from chickens (3), turkeys (2), pheasant (1), sheep (1)).
The total number of isolates in 2000 was 21 (Isolates from chickens (4), turkeys (6), pheasants (7), sheep (1), pigs (2) and 1 grey seal).
The total number of isolates in 2001 was 9 (Isolates from turkeys (3), pheasants (4), pigs (1) and one other avian not specified)
The total number of isolates in 2002 was 7 (Isolates from turkeys (3), pigs (2), sheep (1) and 1 goose)
The total number of isolates in 2003 was 11 (Isolates from pigs (7), cattle (1), sheep (1), chickens (1), turkey (1) and 1 grey seal).

Table 37

Cattle: *Listeria monocytogenes*

All ages
Including isolates from eye, brain, liver, fetal stomach and mastitic milk.

ANTIMICROBIAL	NUMBER RESISTANT/ TOTAL NUMBER OF ISOLATES TESTED					PERCENTAGE RESISTANT				
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Penicillin 10 iu	0/10	0/5	0/5	0/6	0/6	0	0	0	0	0
Ampicillin 10 ug	0/11	0/5	0/5	0/6	0/6	0	0	0	0	0
Amoxicillin/Clavulanate 2/1 ug	0/10	0/5	0/5	0/6	0/5	0	0	0	0	0
Tetracycline 10 ug	0/11	0/5	0/5	0/6	0/6	0	0	0	0	0
Trimethoprim/Sulphonamide 25 ug	1/10	0/5	0/4	0/4	0/6	10	0	0	0	0
Cephalexin 30ug	5/11	3/5	1/5	2/5	1/6	45	60	20	40	17

Table 38

Sheep: *Listeria monocytogenes*

All ages

ANTIMICROBIAL	NUMBER RESISTANT/ TOTAL NUMBER TESTED.					PERCENTAGE RESISTANT				
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Penicillin 10 iu	0/13	0/15	0/7	0/11	0/8	0	0	0	0	0
Ampicillin 10 ug	0/13	0/16	0/7	0/11	0/8	0	0	0	0	0
Amoxicillin/Clavulanate 2/1 ug	0/13	0/14	0/7	2/10	1/7	0	0	0	20*	14*
Tetracycline 10 ug	0/13	0/16	0/7	0/11	0/8	0	0	0	0	0
Trimethoprim/Sulphonamide 25 ug	0/12	2/15	1/7	0/11	0/7	0	13	14	0	0
Cephalexin 30 ug	2/13	10/15	2/7	4/11	3/8	15	67	29	36	38
Tylosin 30 ug	0/10	1/6	0/4	0/4	0/2	0	17**	0	0	0
Florfenicol 30 ug	0/11	1/6	0/4	0/3	0/2	0	17**	0	0	0

*Result considered erroneous, since isolates susceptible to ampicillin. ** Unconfirmed.
The total number of isolates in 1999 was 13 (10 isolates from brain; 2 from viscera; 1 unspecified).
The total number of isolates in 2000 was 16 (8 isolates from brain, 6 from viscera).
The total number of isolates in 2001 was 7 (4 from brain and 3 from viscera).
The total number of isolates in 2002 was 11 (7 from brain and 4 from viscera).
The total number of isolates in 2003 was 8 (4 from brain and 4 from viscera).

Table 39

Sheep: *Listeria ivanovii*

All ages

ANTIMICROBIAL	NUMBER RESISTANT/ TOTAL NUMBER TESTED.					PERCENTAGE RESISTANT				
	1999	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Penicillin 10 iu	0/5	0/2	0	0	0	0	0	-	-	-
Ampicillin 10 ug	0/5	0/2	0	0	0	0	0	-	-	-
Amoxicillin/Clavulanate 2/1 ug	0/5	0/2	0	0	0	0	0	-	-	-
Tetracycline 10 ug	0/5	0/2	0	0	0	0	0	-	-	-
Trimethoprim/Sulphonamide 25 ug	1/5	0/2	0	0	0	20	0	-	-	-
Cephalexin 30 ug	3/5	0/2	0	0	0	60	0	-	-	-

1999 Isolates from spleen and liver; 2000 isolates from liver and fetal stomach contents.

Table 40

Rhodococcus equi.

ANTIMICROBIAL	NUMBER RESISTANT/ TOTAL NUMBER OF ISOLATES TESTED					PERCENTAGE RESISTANT				
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Penicillin 10iu	NT	-	0/1	NT	0/1	-	-	0	-	0
Ampicillin 10 ug	0/1	-	0/1	1/1	0/1	0	-	0	100	0
Amoxicillin/Clavulanate 2/1 ug	NT	-	0/1	NT	1/1	-	-	0	-	100*
Neomycin 30 ug	NT	-	0/1	NT	0/1	-	-	0	-	0
Tetracycline 10 ug	0/1	-	1/1	1/1	1/1	0	-	100	100	100
Erythromycin 5ug	NT	-	0/1	NT	0/1	-	-	0	-	0

*Result considered erroneous – isolate susceptible to penicillin and ampicillin.
NT – not tested.
1999 isolate from equine lymph node
2001 isolate was from bovine mastitis
2002 isolate was from bovine mastitis and reported as *Rhodococcus spp*.

Table 41

Pigs: *Streptococcus suis*

All ages.

ANTIMICROBIAL	NUMBER RESISTANT/ TOTAL NUMBER TESTED					PERCENTAGE RESISTANT				
	1999	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Penicillin 10 iu	0/32	0/22	0/22	0/16	0/34	0	0	0	0	0
Ampicillin 10 ug	0/32	0/23	0/23	0/16	0/34	0	0	0	0	0
Tetracycline 10 ug	23/32	16/23	15/23	15/16	23/34	72	70	65	94	68
Trimethoprim/Sulphonamide 25 ug	4/32	3/23	1/23	1/16	1/34	13	13	4	6	3
Enrofloxacin 5 ug	0/32	0/23	0/23	0/15	0/33	0	0	0	0	0
Ceftiofur 30 ug	0/32	0/21	0/22	0/15	0/31	0	0	0	0	0
Tylosin 30 ug	11/28	2/16	5/20	3/10	10/28	39	13	25	30	36
Lincomycin 10 ug	11/28	3/18	6/21	6/11	8/28	39	17	29	55	29

The total number of isolates in 1999 was 32, including 21 from pigs less than six months. (Age of pig unknown for 11 isolates). 14 isolates were recovered from brain.
The total number of isolates in 2000 was 23, including 18 from pigs less than 6 months. 10 isolates were recovered from brain.
The total number of isolates in 2001 was 23, including 16 from pigs less than 6 months (1 animal older and 6 age not stated). 2 isolates were recovered from brain, the site of origin was not specified in 17 cases.
The total number of isolates in 2002 was 16, including 14 from pigs less than 6 months. Six isolates were from brain.
The total number of isolates in 2003 was 34, including 10 from pigs less than 6 months. Six isolates were from brain.

Table 42

Pigs: ***Streptococcus equisimilis***

All ages

ANTIMICROBIAL	NUMBER RESISTANT/ TOTAL NUMBERS OF ORGANISMS TESTED					PERCENTAGE RESISTANT				
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Penicillin 10 iu	0/6	0/10	0/4	0/5	0/6	0	0	0	0	0
Ampicillin 10 ug	0/6	0/10	0/4	0/5	0/6	0	0	0	0	0
Tetracycline 10 ug	5/6	8/10	3/4	4/5	5/6	83	80	75	80	83
Trimethoprim/Sulphonamide 25 ug	0/5	0/9	0/4	0/5	1/6	0	0	0	0	17
Enrofloxacin 5 ug	0/5	0/9	0/4	0/5	0/5	0	0	0	0	0
Ceftiofur 30 ug	0/5	0/9	0/4	0/5	0/4	0	0	0	0	0
Tylosin 30 ug	0/5	2/7	0/2	1/2	0/1	0	29	0	50	0
Lincomycin 10 ug	1/5	2/7	0/2	1/5	1/1	20	29	0	20	100

In 2003 2/4 isolates`resistant to erythromycin 5mcg.

.

Table 43

Horses and Donkeys: ***Streptococcus equi zooepidemicus***

All ages

ANTIMICROBIAL	NUMBER RESISTANT/ TOTAL NUMBER OF ISOLATES TESTED					PERCENTAGE RESISTANT				
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Penicillin 10 iu	0/15	0/17	0/2	0/3	0/3	0	0	0	0	0
Ampicillin 10 ug	0/15	0/17	0/1	0/3	0/3	0	0	0	0	0
Amoxicillin/Clavulanate 2/1 ug	0/15	0/15	0/1	0/3	0/3	0	0	0	0	0
Tetracycline 10 ug	8/15	5/17	1/2	3/3	0/3	46	29	50	100	0
Trimethoprim/Sulphonamide 25 ug	2/14	1/9	0/2	0/2	NT	14	11	0	0	-

In 2000, one isolate of *S. equi zooepidemicus* was recovered from a bovine mastitis sample. The isolate was resistant to enrofloxacin, tetracyclines and to trimethoprim/sulphonamides. In 2002, three isolates of *S. equi zooepidemicus* were recovered from zoo animals, including two big cats. These isolates, unlike the equine isolates, were susceptible to tetracyclines.

Table 44

Avian Species: *Klebsiella pneumoniae*

All ages

ANTIMICROBIAL	NUMBER RESISTANT/ TOTAL NUMBER OF ORGANISMS TESTED					PERCENTAGE RESISTANT				
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10 ug	3/3	2/2	1/1	0/1	0	100	100	100	0	-
Neomycin 10 ug	0/3	0/2	0/1	0/1	0	0	0	0	0	-
Amoxicillin/Clavulanate 20/10 ug	0/2	-	-	-	0	0	-	-	-	-
Tetracycline 10 ug	1/3	0/2	1/1	0/1	0	33	0	100	0	-
Apramycin 15 ug	0/3	0/2	0/1	0/1	0	0	0	0	0	-
Trimethoprim/Sulphonamide 25 ug	0/3	0/2	1/1	0/1	0	0	0	100	0	-
Enrofloxacin 5 ug	0/2	0/2	0/1	0/1	0	0	0	0	0	-

1999 one isolate from a fowl and two from 2 turkeys.
2000 one isolate from a pheasant and one from a macaw.
2001 one isolate from a pheasant.
2002 one isolate from an avian, species not stated.
2003 no isolates from avian species.

Table 45

Sheep: *Yersinia pseudotuberculosis*

All ages

ANTIMICROBIAL	NUMBER RESISTANT					PERCENTAGE RESISTANT				
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10 ug	0/14	0/1	0/2	0/2	0	0	0	0	0	-
Neomycin 10 ug	0/14	0/1	0/2	0/2	0	0	0	0	0	-
Tetracycline 10 ug	0/14	0/1	0/2	0/2	0	0	0	0	0	-
Apramycin 15 ug	0/14	0/1	0/2	0/2	0	0	0	0	0	-
Trimethoprim/Sulphonamide 25 ug	0/14	0/1	0/2	0/2	0	0	0	0	0	-
Cephalexin 30 ug	0/14	0/1	0/2	0/2	0	0	0	0	0	-
Enrofloxacin 5 ug	0/14	0/1	0/2	0/2	0	0	0	0	0	-

Table 46

All avian species: *Yersinia pseudotuberculosis*

All ages

ANTIMICROBIAL	NUMBER RESISTANT/ TOTAL NUMBER OF ORGANISMS TESTED					PERCENTAGE RESISTANT				
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10 ug	0/7	0/7	0/2	0/2	0/1	0	0	0	0	0
Neomycin 10 ug	0/7	0/7	0/2	0/1	0/1	0	0	0	0	0
Tetracycline 10 ug	0/7	1/7	0/2	0/2	0/1	0	14	0	0	0
Apramycin 15 ug	0/7	0/7	0/2	0/1	0/1	0	0	0	0	0
Trimethoprim/Sulphonamide 25 ug	1/7	0/7	0/2	0/2	0/1	14	0	0	0	0
Enrofloxacin 5 ug	0/7	0/7	0/2	0/2	0/1	0	0	0	0	0

1999 Isolates from exotic birds (5), chicken (1), partridge (1)) – the isolate from a partridge was resistant to trimethoprim/sulphonamide.
2000 Isolates from fowl (2), partridge (1) pigeon (1) lory (1) avian unspecified (2)
2001 Isolates from a cockatiel and a partridge.
2002 Isolates from a partridge and a canary.
2003 Isolate from a parakeet.

Table 47

Cattle and Sheep: *Yersinia enterocolitica*

All ages

ANTIMICROBIAL	NUMBER RESISTANT/ TOTAL NUMBER OF ISOLATES TESTED					PERCENTAGE RESISTANT				
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Ampicillin 10 ug	0/3	0/1	0/2	0/1	0/1	0	0	0	0	0
Amoxicillin/Clavulanate 20/10 ug	0/3	0/1	0/2	0/1	0/1	0	0	0	0	0
Neomycin 10 ug	0/3	0/1	0/2	0/1	0/1	0	0	0	0	0
Tetracycline 10 ug	1/3	0/1	0/2	0/1	0/1	33	0	0	0	0
Apramycin 15 ug	0/3	0/1	0/2	0/1	0/1	0	0	0	0	0
Trimethoprim/Sulphonamide 25 ug	0/3	0/1	0/2	0/1	0/1	0	0	0	0	0
Enrofloxacin 5 ug	0/3	0/1	0/2	0/1	0/1	0	0	0	0	0
Cephalexin 30 ug	0/3	0/1	0/1	0/1	0/1	0	0	0	0	0

OTHER ANIMAL PATHOGENS

Table 48

Sheep: *Corynebacterium pseudotuberculosis*

(This organism has occasionally been reported as a zoonosis).

All ages

ANTIMICROBIAL	NUMBER RESISTANT/ TOTAL NUMBER OF ISOLATES TESTED					PERCENTAGE RESISTANT				
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Penicillin 10 iu	0/4	1/7	0/6	0/7	0/5	0	14	0	0	0
Ampicillin 10 ug	0/4	0/7	0/6	0/7	0/5	0	0	0	0	0
Amoxicillin/Clavulanate 2/1 ug	0/4	0/7	0/6	0/7	0/5	0	0	0	0	0
Tetracycline 10 ug	0/4	0/7	0/6	1/7	0/5	0	0	0	14	0
Trimethoprim/Sulphonamide 25 ug	1/4	0/7	0/6	0/7	0/5	25	0	0	0	0
Cephalexin 30 ug	0/4	1/7	0/6	0/7	0/5	0	14	0	0	0

[The isolate recovered in 2000 that was resistant to penicillin was also resistant to cephalexin though susceptible to amoxycillin /clavulanate. This resistance and the resistance to tetracyclines observed in 2002 has not been confirmed by mic determination].

Table 49

Sheep: *Streptococcus dysgalactiae*

All ages.

ANTIMICROBIAL	NUMBER RESISTANT/ TOTAL NUMBER OF ISOLATES TESTED					PERCENTAGE RESISTANT				
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Penicillin 10iu	0/29	0/27	0/23	0/35	0/31	0	0	0	0	0
Ampicillin 10ug	0/29	0/27	0/25	0/36	0/32	0	0	0	0	0
Amoxicillin/Clavulanate 2/1ug	0/27	0/25	0/22	0/34	0/30	0	0	0	0	0
Tetracycline 10ug	17/29	16/27	13/25	15/36	21/32	59	59	52	42	66
Trimethoprim/Sulphonamide 25ug	1/21	1/17	0/19	1/21	1/21	5	6	0	5	5

Table 50

Poultry/ Game birds: ***Staphylococcus aureus.***

All ages.

ANTIMICROBIAL	NUMBER RESISTANT/ TOTAL NUMBER OF ISOLATES TESTED					PERCENTAGE RESISTANT				
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Penicillin 10iu	7/32	2/22	6/25	3/19	5/16	22	9	24	16	31
Ampicillin 10ug	6/31	2/22	6/25	4/19	5/16	19	9	24	21	31
Amoxicillin/Clavulanate 2/1 ug	0/6	0/3	0/6	0/2	0/2	0	0	0	0	0
Tetracycline 10ug	5/32	8/22	12/25	10/19	10/16	16	36	48	53	63
Trimethoprim/Sulphonamide 25ug	1/29	1/21	2/21	0/17	0/16	3	5	10	0	0
Erythromycin 5ug	4/29	2/19	4/23	2/16	5/15	14	11	17	13	33
Enrofloxacin 5ug	2/26	0/21	0/21	0/17	0/14	8	0	0	0	0
Lincomycin 10ug	4/18	2/18	4/19	4/14	4/12	22	11	21	29	33

In 1999 a total of 32 S.aureus were isolated including 14 from pheasants, 5 from chickens, 3 from turkeys and 2 from ducks or geese.
In 2000 a total of 22 S.aureus were isolated including 11 from pheasants, 5 from chickens and 3 from turkeys.
In 2001 a total of 25 S.aureus were isolated including 15 from pheasants, 5 from chickens and 3 from partridges.
In 2002 a total of 19 S.aureus were isolated, including 9 from pheasants, 4 from chickens and 2 from turkeys.
In 2003 a total of 16 S.aureus were isolated, including 11 from chickens, 2 from partridges, 2 from pigeons and 1 from a canary.

Table 51

Horses: ***Streptococcus equi equi***

All ages

ANTIMICROBIAL	NUMBER RESISTANT/ TOTAL NUMBER OF ISOLATES TESTED					PERCENTAGE RESISTANT				
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Penicillin 10 iu	0/8	0/4	1/2	0/1	0/1	0	0	50*	0	0
Ampicillin 10 ug	0/8	0/4	1/2	0/1	0/2	0	0	50*	0	0
Amoxicillin/Clavulanate 2/1 ug	0/8	0/2	0/2	0/1	0/1	0	0	0	0	0
Tetracycline 10 ug	0/8	0/4	1/2	0/1	0/2	0	0	50*	0	0
Trimethoprim/Sulphonamide 25 ug	0/7	0/3	1/2	0/1	0/2	0	0	50*	0	0
Cephalexin 30 ug	0/7	0/2	0/2	0/1	0/1	0	0	0	0	0

*Unconfirmed

Table 52

Staphylococcus xylosus

All ages

ANTIMICROBIAL	NUMBER RESISTANT/ TOTAL NUMBER OF ISOLATES TESTED					PERCENTAGE RESISTANT				
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Penicillin 10 iu	0/6	0/8	0/2	0/1	0/2	0	0	0	0	0
Ampicillin 10 ug	0/6	0/8	0/2	0/1	0/2	0	0	0	0	0
Amoxicillin/Clavulanate 2/1 ug	0/6	0/4	0/2	0/1	0/2	0	0	0	0	0
Neomycin 30 ug	0/6	0/4	0/2	0/1	0/2	0	0	0	0	0
Tetracycline 10 ug	0/6	1/8	0/2	0/1	0/2	0	13	0	0	0
Erythromycin 5 ug	0/6	0/4	0/2	0/1	0/2	0	0	0	0	0
Cephalexin 30 ug	0/6	0/2	0/2	0/1	0/2	0	0	0	0	0
Novobiocin 30 ug	0/5	0/2	NT	NT	NT	0	0	-	-	-

1999 four isolates from bovine mastitis samples, 1 from caprine milk, 1 from an ovine abscess.
2000 three isolates from bovine mastitis samples, one from an ovine abscess, 3 from pigs (2 skin, 1 brain), 1 from a pheasant.
2001 one isolate from a bovine mastitis sample and one from bovine semen
2002 one isolate from a bovine mastitis sample.
2003 two isolates from bovine mastitis samples.

COMMENSALS OF PUBLIC HEALTH INTEREST

Table 53

Cattle: *Enterococcus faecalis* from bovine mastitis samples.

ANTIMICROBIAL	NUMBER RESISTANT/ TOTAL NUMBER OF ISOLATES TESTED					PERCENTAGE RESISTANT				
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Penicillin 10iu	1/30	1/16	0/17	0/15	0/8	3	6	0	0	0
Ampicillin 10ug	1/30	1/16	0/17	0/15	0/9	3	6	0	0	0
Amoxicillin/Clavulanate 2/1 ug	0/30	0/16	0/17	0/15	0/8	0	0	0	0	0
Tetracycline 10ug	5/30	4/16	6/17	10/15	5/9	17	25	35	67	56
Erythromycin 5ug	2/30	2/16	2/17	1/15	1/8	7	13	12	7	13
Neomycin30ug	5/30	4/16	6/17	5/15	2/8	17	25	35	33	25

Table 54

All species: *Enterococcus faecium*

ANTIMICROBIAL	NUMBER RESISTANT/ TOTAL NUMBER OF ISOLATES TESTED					PERCENTAGE RESISTANT				
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**1999**	**2000**	**2001**	**2002**	**2003**
Penicillin 10iu	0/9	-	0/7	1/6	0/4	0	-	0	17	0
Ampicillin 10ug	0/9	0/3	1/8	0/6	0/4	0	0	13	0	0
Amoxicillin/Clavulanate 2/1 ug	0/9	0/1	0/6	0/5	0/4	0	0	0	0	0
Tetracycline 10ug	2/9	0/3	1/8	4/6	1/4	22	0	13	67	25
Trimethoprim/Sulphonamide 25ug	0/7	1/3	1/8	0/2	0/1	0	33	13	0	0
Erythromycin 5ug	2/9	0/2	0/5	1/6	0/4	22	0	0	17	0
Enrofloxacin 5ug	-	0/2	0/2	1/1	NT	-	0	0	100	-
Neomycin 10ug	1/9	-	-	1/4	NT	11	-	-	25	-

In 1999 a total of 9 *E.faecium* were tested, including 7 from bovine mastitis cases and 2 from chicken lung –the avian isolates were resistant to erythromycin and tetracyclines.
In 2000 a total of 3 *E.faecium* from birds (falcon, finch, avian unspecified) were tested. There were no *E.faecium* isolates from bovine mastitis cases.
In 2001 a total of 8 *E.faecium* were isolated, including 4 from bovine mastitis cases, 2 from pheasants, 1 from a pig and 1 from the umbilicus of a grey seal pup.
In 2002 a total of 6 *E.faecium* were isolated, including 5 from bovine mastitis cases and a single isolate from the kidney of an Amazon Parrot.
In 2003 four *E. faecium* were isolated from bovine mastitis cases.

DISCUSSION.

Taken overall, the resistance levels for the majority of veterinary bacteria have not changed greatly over the four to five year monitoring period. The numbers of isolates that are multiply resistant has also remained relatively unchanged over this period. There are some exceptions to this generalisation however, and some organisms have shown significant increases in resistance or multi-resistance, whilst levels in others have declined. In general, it is surprising that the resistance levels have changed so little and this is particularly exemplified by the levels of resistance in *E.coli* and coliforms from bovine mastitis cases, which have remained remarkably stable. Levels of resistance will be influenced by a number of factors, including the degree of epidemic spread of certain bacterial clones that may be resistant, the emergence, dissemination and transfer of resistance determinants between and amongst bacteria and by the selective pressure exerted by the use of antimicrobials.

In general, there was a decline in submissions in 2001 that can be directly related to the outbreak of Foot and Mouth disease, since sampling of animals on farms over large parts of the country was not permitted except under licence for much of this period. Over the sampling period, the VLA began to accept samples from companion animals only in cases where there were public health or zoonotic considerations that were being addressed. This explains the decline in specimens received from these species.

The disc diffusion sensitivity testing method currently in use classes isolates as either sensitive or resistant and relies on a uniform zone size diameter cut-off point of 13mm to discriminate between these categories. There is no intermediate category of resistance and the size of the zone of inhibition observed in the test is not currently recorded. The OIE (Office International des Epizooties) and the European ARBAO (Antibiotic Resistance in Bacteria of Animal origin) network both recommended that a quantitative system rather than a qualitative system of sensitivity testing should preferably be adopted. This enables more subtle shifts in resistance of organisms to be detected at the earliest opportunity. The VLA is aiming to adopt a quantitative method of disc diffusion susceptibility testing in which zone size will be measured as soon as practical considerations allow and methods will be harmonised with those of BSAC as far as possible.

The disc concentrations used are generally in accordance with those listed in the BSAC recommendations. It is assumed that the concentration of a given antimicrobial reached in the tissues of domestic animals will in general be of a similar order of magnitude to those reached in man. However, this may not be the case in all situations and for all species. It should also be noted that for some antimicrobials, data on appropriate disc charge and cut-off zone size are not available for "isosensitest" agar (Oxoid), the agar commonly used in the UK for both medical and veterinary diagnostic sensitivity testing. There are no internationally agreed standard methods for the determination of susceptibility of some organisms of veterinary importance. The disc diffusion method described has been used in VLA laboratories for more than 30 years with only minor modifications over this period.

Notwithstanding the above considerations, the disc diffusion sensitivity test can be effectively used to assess trends in development of resistance and the effects of interventions over time. In this report, unusual resistance patterns will not in general have been confirmed by determination of minimum inhibitory concentration (MIC) and these unusual resistance patterns are further discussed below in the sections on individual organisms. There are only a few instances of incorrect data entry that have been identified during data processing and analysis and the overall quality of the data is considered good, although the limitations of the test methodology and data input system are acknowledged.

The monitoring system was introduced in 1998 and relatively low numbers of samples were recovered for many organisms during the period of 1998 in which the system was in place. These low sample numbers mean that the numbers of resistant organisms are unlikely to be as representative of the total population of organisms as the data from later years, when a full year's data set is available. Trends from 1998 to 2003 should therefore be interpreted bearing in mind the numbers of samples that have been tested in each time period. Certain animal diseases are uncommon and for these conditions, low numbers of bacterial isolates are generally recovered. The influence of small sample size on levels and trends of resistance also needs to be considered for such organisms.

Highlights and possible trends observed within the data are listed below:

ENTERIC BACTERIA.

E.coli/ **Coliforms**

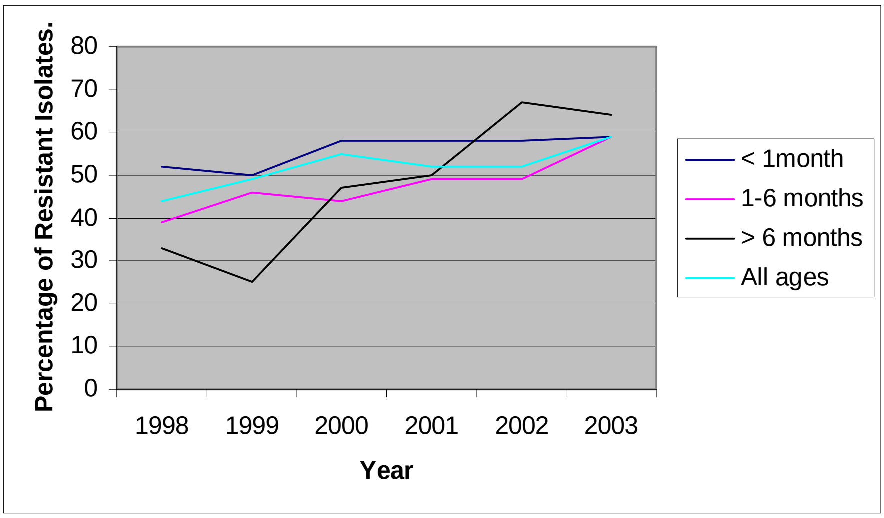
There is a general trend towards decreasing resistance in isolates from older animals in all species, as compared to younger animals of the same species and this is consistent with previous work performed at VLA and with studies recorded in the literature (Hinton 1986).

The *E.coli* and coliforms presumptively identified as *E.coli* referred to in the tables in this report will include some pathogenic strains as well as commensals. Where possible, separate tables are included giving the results for *E.coli* in which virulence determinants (K99 or K88 adhesins) have been detected. In some instances however, there were very low numbers of isolates recovered in which virulence determinants were detected. For example, in sheep in 1999 only 6 isolates of *E.coli* that were K99 positive are recorded and this will mean that a small difference in resistance patterns of one or two isolates will have a great effect on the percentage resistant figures.

There has been relatively little change in the levels of resistance detected in *E.coli* /coliforms recovered from calves over the last six years. However, amoxicillin/ clavulanate resistance increased to 27% in 2003, whereas in 1999-2002 it had fluctuated at lower levels of between 19-22%. This occurred against a background of relatively stable resistance to ampicillin, which has fluctuated between 70 and 73% since 1998. Fluctuations in the percentage of isolates showing multiple resistance may reflect the spread of certain bacterial clones or resistance plasmids in the calf population. The figures for growing cattle at 1-6 months of age in 2003 are mostly similar to previous years, though resistance to ampicillin, amoxicillin/ clavulanate and the numbers of isolates showing multiple resistance were all at higher levels than those recorded in 1999-2002. In cattle older than six months, resistance to ampicillin and amoxicillin/ clavulanate has remained within 2 percentage points of the mean 1999-2002 value. Levels of resistance in all ages of cattle to fluoroquinolones remain low and have declined to very low levels from the low values observed in 1998 and 1999. The relatively high frequency at which *E.coli* /coliform isolates resistant to ampicillin are recovered from young calves may reflect the use of dry cow intra-mammary infusions in the dam and transfer of antibiotics to calves in colostrum. When neonatal calves ingest colostrum containing significant levels of antimicrobials such as ampicillin, there is likely to be a strong selective pressure on the intestinal microflora of the neonate. In K99 positive *E.coli* isolates from cattle there have been quite wide fluctuations in the levels of resistance in different years, with an increased level of resistance observed in 2000 to ampicillin, amoxicillin/ clavulanate and tetracycline and then a decline in 2001/ 2002. These fluctuations may represent either dissemination of certain clones of the organism or the influence that small sample size may have on the final figures. Only six K99 positive *E.coli* isolates were isolated in 2003 and the small sample size means that fluctuations in resistance levels are very difficult to interpret.

Ampicillin resistance in *E.coli*/coliform isolates from pigs less than 1 month old is lower than that recorded in calves, although resistance has increased compared to levels recorded in 1998/ 1999. The levels of resistance to enrofloxacin in young pigs are higher than those recorded in calves and other domestic farmed species and were 8% in 2003. In general, resistance levels in pigs less than 1 month old have remained relatively stable over the last four years, though the percentage of isolates with multiple resistance has shown an overall upward trend since monitoring began. Trimethoprim/ sulphonamide resistance has increased in *E. coli* from pigs of all ages; increased resistance to this antimicrobial has also been observed in a number of other bacteria isolated from pigs. The numbers of isolates that are multi-resistant increased in 2001 in pigs at 1-6 months of age, but then declined in 2002 and has risen once more in 2003. The increase in 2001 may be attributable to an increase in anti-microbial use as a result of post-weaning multi-systemic wasting syndrome (PMWS). More than 50% of isolates from pigs under 1 month old are resistant to tetracyclines and trimethoprim/ sulphonamides and in pigs of all ages levels of resistance to tetracyclines are consistently more than 70%, with 84% of isolates from pigs at 1-6 months resistant in 2003. Resistance levels in pigs older than six months have shown marked fluctuations over the monitoring period, probably reflecting the low number of samples examined in certain years. In 2002, the level of resistance recorded to enrofloxacin was 20%, though two of the isolates tested, originated from pigs on the same farm. In 2003, a reasonable number of isolates were tested (69) and resistance to tetracycines (88%) and trimethoprim/ sulphonamides (64%) was similar to that observed in other ages of pig.

Figure 3: Resistance to trimethoprim/ sulphonamides in *E. coli* from Pigs.



In K88+ *E.coli* isolates from pigs there has been an overall trend to increasing resistance to trimethoprim /sulphonamides over the monitoring period. The level of enrofloxacin resistance in K88 positive *E.coli* isolates from pigs increased from 0% in 1999 to 13% in 2001 and 2002, although the sample size in 2001 was rather smaller than in previous years. However, in 2003, levels of resistance to enrofloxacin declined, with no resistant isolates detected. Levels of resistance to ampicillin and tetracyclines in K88 positive *E.coli* have remained relatively stable over the reporting period whilst resistance to neomycin which had been relatively stable at 23-25%, declined to 8% in 2002, but returned to levels similar to those seen in 1999-2001 in

2003; the reason for this fluctuation is not known. Numbers of K88+ *E. coli* from pigs showing multiple resistance, which were 30% in 1999 and 2000, were 48 and 54% in 2002 and 2003 respectively.

In general, lower levels of resistance have been consistently observed in sheep than in pigs and cattle. In sheep less than one month old the levels of resistance for several antimicrobials which had remained relatively unchanged in 1999-2001 declined in 2002 and this decline was maintained in 2003 for ampicillin and tetracyclines. In animals aged 1-6 months, a decline in tetracycline resistance was observed in 2002 and 2003, compared to 1999-2001 levels. However, in 2003 ampicillin resistance levels increased to 27% from levels of 15-17% seen in 2000-2002. When all age groups are considered levels of resistance have been much more stable. There are only limited numbers of isolates from older animals and in these resistance to tetracycline and ampicillin has been most frequently detected. There were no isolates of K99-positive *E.coli* from sheep in 2003.

Levels of resistance detected to enrofloxacin in *E.coli*/coliforms from chickens have fluctuated between 0 and 4% over the five-year sampling period. Resistance levels to trimethoprim/sulphonamide in *E.coli*/coliforms from chickens have remained at 22 to 29% for the last five years, whilst tetracycline resistance in *E.coli*/coliforms from chickens varied between 42% and 60% over the same period. Ampicillin resistance fluctuated between 33 and 43% over the monitoring period; resistance to neomycin and apramycin has been consistently less than 14% and 5% respectively. These figures are interesting in that they span the period in which certain of the growth promoting antimicrobials were banned. There has been some speculation that prohibition of the use of certain growth promoters in 1997-1999 could lead to increased consumption of antimicrobials, because certain of the growth promoters in addition to their growth promoting effect also have a significant action in preventing development of necrotic enteritis. Thus with some growth promoters no longer included in feed, it was speculated that increased use of therapeutic antimicrobials might be necessary to combat an increased incidence of necrotic enteritis and this in turn would place the commensal and pathogenic flora under an increased selective pressure. Levels of resistance in chickens have shown some fluctuations over the monitoring period and the population of chickens examined will include both broilers and layers. The cause of the observed drop in levels of multiple resistance in 2001 is unknown.

Ampicillin, tetracycline and trimethoprim/ sulphonamide resistance in turkeys has in general been seen in a slightly higher proportion of isolates when compared to the values observed in chickens. However, enrofloxacin resistance remained low at 5% or less and there was limited resistance to neomycin and no resistance to apramycin.

Resistance to the fluoroquinolone enrofloxacin was detected in *E.coli*/coliform isolates from cattle, sheep, pigs, chickens and turkeys. The mechanism for this resistance is assumed to be via chromosomal mutations, since plasmid-mediated resistance to this antimicrobial is rare (Martinez 1998).

MASTITIS ORGANISMS

Streptococcus agalactiae:

Streptococcus agalactiae is a Lancefield Group B Streptococcus considered to be an obligate parasite of the mammary gland of cows. It is not regarded as zoonotic and human Group B Streptococci probably constitute a separate population.

Resistance to penicillin, ampicillin, amoxicillin/ clavulanate and erythromcin was reported in a single isolate of *Streptococcus agalactiae* in 2002. Unfortunately, the isolate was not retained for confirmatory susceptibility testing and this result remains unconfirmed. Penicillin resistance has been reported in the literature in some types of streptococci such as *Streptococcus pneumoniae*, an important human pathogen and has also been reported in veterinary isolates of *S.agalactiae* from some other parts of the world. Development of resistance in commensal streptococci, such as *Streptococcus mitis*, via mutation of the genes encoding penicillin binding proteins and subsequent recombination with the homologous genes in *Streptococcus pneumoniae* has been reported, reinforcing the role that the commensal flora may play as a reservoir of resistance genes. No resistance to penicillin, ampicillin, amoxicillin/ clavulanate or erythromcin was detected in 2003 and this followed the introduction of a computerised alert in mid 2003, flagging up these unusual resistances at the point of data entry.

Resistance to neomycin was commonly recorded in *S.agalactiae* and also in other streptococci, throughout the reporting period. This is to be expected, since streptococci are in general naturally resistant to aminoglycosides because they lack the active transport mechanism that is required for these drugs to be taken up into the bacterial cell. There are several mechanisms of tetracycline resistance but one of the commonest is through production of a cytoplasmic membrane protein that actively pumps the antimicrobial out of the bacterial cell. The gene encoding this protein may be located on a plasmid and therefore can be readily transferred between bacteria. The exact mechanism of resistance has not however been confirmed in these isolates.

Erythromycin resistance was recorded for the first time in one of 29 isolates of *S.agalactiae* isolated in 2001 and then again in the multiply-resistant isolate recovered in 2002 (described above). These results have not been confirmed by determination of the erythromycin MIC and should be treated with caution. However, erythromycin resistance in *S.agalactiae* isolates from bovine mastitis has been reported from other parts of Europe and from North America. Resistance to macrolide antibiotics, which is quite common in human streptococci in some countries, can be mediated via an inducible, plasmid-mediated enzyme that alters (methylates) the target site on ribosomal RNA or by possession of an efflux pump.

The development of erythromycin or penicillin resistance is important because these drugs may be used in so-called “blitz” therapy to eradicate *S.agalactiae* from a herd.

Streptococcus dysgalactiae:

Streptococcus dysgalactiae is a Lancefield Group C Streptococcus and a commensal of the mucous membranes of cattle; it is a cause of mastitis and occasionally other diseases in cattle. It is not considered a zoonosis and Group C Streptococci that can cause disease in humans constitute a separate population.

Penicillin resistance was recorded in a single isolate in 2001 and in two isolates in 2002. The isolate recovered in 2001 was apparently resistant to penicillin and amoxicillin/ clavulanate but susceptible to ampicillin; this is an anomalous result and likely to be erroneous but might be explained by a narrow zone of inhibition close to the discriminatory cut-off point of 13mm. Likewise, resistance to amoxicillin/ clavulanate and ampicillin recorded in a single isolate in 1999 is also likely to be an anomalous result as it is very unlikely that bacteria could develop resistance to these antibacterials without also developing resistance to penicillin. Of the two penicillin resistant isolates recorded in 2002, both were resistant to amoxicillin/ clavulanate, though only one was resistant to ampicillin – again an anomalous result. MIC determinations have not been performed on these isolates and penicillin, ampicillin and amoxicillin/ clavulanate resistance remains unconfirmed in *Streptococcus dysgalactiae*.

Between 3% and 5% of isolates of *Streptococcus dysgalactiae* recorded in each time period were resistant to erythromycin, a macrolide. These results have not been confirmed by determination of the minimum inhibitory concentration (MIC), but the consistency of the results suggests that there may be a low prevalence of erythromycin resistance in this species. Erythromycin resistance in *S.dysgalactiae* isolates from bovine mastitis has been reported from other parts of the world. Resistance to neomycin, recorded in 45 to 56% of isolates between 1998 and 2003 is to be expected (see *S.agalactiae*) and tetracycline resistance, recorded in between 36 and 47% of isolates in this period is also recognised as being common in this species.

Streptococcus uberis

Streptococcus uberis is widely distributed in the environment and a normal commensal resident of the bovine vagina, tonsil and skin. It is a common cause of mastitis and not regarded as zoonotic.

Low numbers of isolates were recorded as resistant to penicillin in 1999 (4), 2000 (5), 2001 (5) and 2002 (4). Ampicillin resistance was also recorded in 2 isolates in each of years 1999, 2000 and 2002; there was also one isolate in 2001 and 2003 apparently resistant to penicillin but susceptible to ampicillin and this is an anomalous result. (However, as with the *S. dysgalactiae* isolate described above it may reflect a zone of inhibition obtained in the disc diffusion test that was close to the 13 mm cut-off point). Figures for 1998 to 2000 describe isolates that are apparently resistant to amoxicillin/clavulanate but sensitive to penicillin and ampicillin. These results are considered to be erroneous since this finding is unlikely and is probably due to inactivation of the amoxicillin/clavulanate test discs by moisture. Penicillin/ ampicillin/ amoxicillin/clavulanate resistance in *S.uberis* remains unconfirmed.

In each year between 6 and 8% of *Streptococcus uberis* strains were resistant to erythromycin in the disc diffusion test; determination of MIC values would be useful to confirm this resistance. Resistance to erythromycin has been recorded in human and some veterinary Streptococci. Resistance can be mediated by the induction of a plasmid-encoded enzyme that methylates the 20S ribosomal RNA sub-unit and prevents binding of erythromycin to the ribosome and so disrupts protein synthesis. However, the exact mechanism of resistance has not been elucidated in the VLA *S. uberis* isolates.

Resistance to tetracyclines was detected in a small proportion of *S. uberis* strains; the levels rose from 9 to 16% in 1998-1999, remained relatively stable in 1999-2002 and then declined to 11% in 2003.

Staphylococcus aureus

Staphylococcus aureus is normally resident on the skin and mucous membranes of cattle and is a common cause of mastitis. It is not generally regarded as zoonotic and strains are for the most part considered to be host species-specific.

A large proportion of strains was resistant to penicillin and ampicillin and the numbers of penicillin-resistant strains declined from almost 50% in 1998 to 29% in 1999. A similar decline was observed in the late 1980s in many European countries and it was postulated that this may have been due to the introduction of compounds unrelated to penicillin for treatment of staphylococcal mastitis which removed the selective pressure on the organism to carry beta-lactamase genes (Aarestrup and Jensen 1998). However, since 1999, there has been an increase in penicillin resistance in these isolates, which in 2002 approached the level observed in 1998, though a decline was then observed in 2003. Although the prevalence of penicillin resistance in bovine *Staphylococcus aureus* make this drug of limited use for treatment of this type of mastitis, the prevalence is well below the 75-95% recorded in clinical human isolates of this bacterium (Kloos 1999). Penicillin resistance in bovine *Staphylococcus aureus* is thought to be mainly via the production of beta-lactamase enzymes that break down both penicillin and ampicillin. The genes encoding beta-lactamases can be located on plasmids and often on transposons and may be readily transferable by conjugation.

The overall proportion of strains resistant to amoxicillin/clavulanate has been relatively low, lying between 0.8% and 11%. No methicillin resistant strains of *Staphylococcus aureus* have been identified, but neither methicillin nor cloxacillin is included in the routine panels of antibacterial agents against which Staphylococci are tested. (Both of these agents require special test conditions to detect resistance and these antimicrobials are not therefore included on routine sensitivity plates). Methicillin-resistant strains of *Staphylococcus aureus* generally possess an altered penicillin-binding protein and would be expected to be resistant to amoxicillin/clavulanate, although it is not currently known if the amoxicillin/clavulanate resistant isolates reported in the recent VLA data are resistant or sensitive to methicillin. Hyperproduction of beta-lactamases can also result in resistance to amoxicillin/ clavulanate.

Erythromycin (macrolide) resistance was recorded in a small proportion (3-5%) of isolates each year. There are several possible mechanisms, the most important of which are production of enzymes that alter the ribosomal binding site by methylation and possession of an efflux pump. Genes for these enzymes may be on plasmids or transposons and may be readily transferable.

Resistance to tetracycline has remained below 8% over the monitoring period, whilst neomycin resistance has been consistently under 3%.

E.coli/coliforms

E.coli and other coliforms are one of the three main causes of bovine mastitis. Most strains originate from the immediate environment of the cow and it is thought that no special virulence factors are required to infect the mammary gland. These isolates therefore represent the normal types that are present in the environment of dairy cattle, particularly cattle sheds and cubicle houses, and are probably mainly of faecal origin. The levels of resistance in *E.coli* and other coliforms from milk are broadly similar to those coliforms found in the intestine of older cattle. However, for most drugs against which both groups were tested, the prevalence of resistance was slightly lower in those of mammary origin. This may relate to factors such as the lower exposure to antimicrobials within the bovine udder and the general absence of a commensal flora within the udder that could act as a potential reservoir of resistance genes.

E.coli/coliform isolates from bovine mastitis samples have shown very little change in the percentage levels of resistance over the last 5 years.

Arcanobacterium pyogenes

Arcanobacterium pyogenes isolates from cattle (the majority from cases of mastitis) have shown resistance to a range of antimicrobials, with up to 39% of isolates resistant to tetracyclines. The pattern of resistance was different from that observed in both pigs and sheep and in general higher levels of resistance were seen in the bovine isolates than in those from pigs – a reversal of the pattern seen in many other bacteria. The reasons for this are unknown, but may possibly reflect clonal spread of isolates. A low number of bovine isolates were resistant to penicillin, ampicillin or erythromycin; resistance to penicillin, ampicillin or tylosin was not detected in porcine strains and resistance to both penicillin and erythromycin was detected in only a single ovine isolate in 2002, with a further single ovine isolate resistant to erythromycin recovered in 2003. The ovine strain that was resistant to penicillin was susceptible to ampicillin and this is an anomalous result. In 2002, a single bovine isolate was reported to be resistant to penicillin and amoxicillin/ clavulanate, but susceptible to ampicillin. This is again an anomalous result and has not been confirmed.

Klebsiella pneumoniae

Klebsiella pneumoniae isolates, the majority of which originate from bovine mastitis cases, showed levels of resistance to ampicillin varying between 33 and 55%, though rather low numbers of isolates were recovered. Resistance to tetracyclines, neomycin and trimethoprim/ sulphonamides was also detected, though was less common. Neomycin resistance has not been observed since 1999; 2003 saw the first appearance of an isolate resistant to amoxicillin/ clavulanate since monitoring began.

Pseudomonas aeruginosa

Pseudomonas aeruginosa isolates are commonly resistant to a range of antimicrobials and bovine mastitis organisms are no exception in this regard. Although resistance levels have fluctuated for some antimicrobials, the overall pattern of resistance appears relatively stable.

RESPIRATORY PATHOGENS.

Pasteurella multocida

Pasteurella multocida is a relatively uncommon cause of respiratory or systemic disease in cattle in the UK (the incidence of disease caused by this bacterium is much greater in North America and certain other parts of the world). Certain toxigenic strains are responsible for the development of atrophic rhinitis in pigs; strains of the organism can also affect poultry (fowl cholera). It is a rare pathogen of sheep in the UK. There is probably carriage in the upper respiratory tract of some animals and bovine strains are likely to be distinct from those infecting other species.

A generally low prevalence of resistance to a number of antimicrobials (ampicillin, amoxicillin/ clavulanate, cephalexin, tetracyclines and trimethoprim/ sulphonamide) was recorded in bovine isolates over the monitoring period. MIC determinations have not been performed on these isolates to confirm these resistances and in 2002, a single isolate was reported as resistant to amoxicillin/ clavulanate though susceptible to ampicillin and this is an anomalous result.

Two *Pasteurella multocida* isolates from cattle were reported as resistant to florfenicol in 2002. Both of these isolates originated from calves aged less than 6 months from a single premises. A further single isolate resistant to florfenicol and isolated from a different region of England and Wales was reported from a bovine of unknown age in 2003. The isolates were unfortunately not retained for further examination or determination of MIC and these result remains unconfirmed.

As in *M.haemolytica* in cattle, a low number of bovine strains have been recorded that show multiple resistance in the years 1998-2000 and 2002-2003, though none were isolated in 2001. The level of resistance to ampicillin in 2001 was 9% in bovine *P.multocida* isolates, an increase on the levels of 1 or 2% seen in previous years, though levels declined markedly in 2002 and 2003. Amongst isolates from sheep, a single isolate was recorded as resistant to ampicillin in 1999 and 2003 and a single isolate was resistant to tetracyclines in 2002 with three isolates resistant to this antimicrobial in 2003; the isolate resistant to ampicillin was also resistant to amoxicillin/ clavulanate.

9 - 15% of porcine P*asteurella multocida* isolates were resistant to tetracyclines over the reporting period, higher than the figure seen in bovine isolates; resistance to ampicillin, trimethoprim/ sulphonamide, apramycin and neomycin was also reported in porcine strains.

There was no resistance detected to enrofloxacin in any of the domestic species.

Mannheimia (Pasteurella) haemolytica

Mannheimia (Pasteurella) haemolytica is a common cause of respiratory disease in both cattle and sheep in the UK although different serotypes predominantly affect each species. There is carriage in the upper respiratory tract in healthy animals and ovine Mannheimia strains can also cause mastitis. *Mannheimia haemolytica* has also been more rarely recorded as causing mastitis in cattle.

A low number of isolates of this organism were recorded as being multiply resistant in cattle in 1998, 1999 and 2003, with no multi-resistant isolates recorded in 2000-2002. The 1998 results report that 3 of the ovine strains were multi-resistant, although the only resistance recorded amongst isolates is to tetracyclines. An error at the input stage is suspected to account for this discrepancy. A further result which is likely to be erroneous is contained in the ovine *Mannheimia haemolytica* data where a single isolate was reported to be resistant to amoxicillin/clavulanate yet sensitive to ampicillin in 1999. The discrepancy is likely to be the result of inactivation of the amoxicillin/clavulanate disc by moisture.

In cattle, levels of tetracycline resistance in *M. haemolytica* have fluctuated between 3% and 13% over the monitoring period whilst resistance to trimethoprim/ sulphonamides has ranged between lower levels of 1 to 6% over the same period. Very low numbers of bovine isolates have been reported as resistant to amoxicillin/ clavulanate, cephalexin, enrofloxacin and florfenicol and these results have not been confirmed by determination of MIC; caution is therefore advised when interpreting these results.

The levels of resistance in ovine isolates were generally much lower than those seen in bovine isolates; the reason for this is not known but may be related to the more intensive husbandry systems for rearing cattle and the greater use of antibacterial drugs to treat respiratory disease.

Levels of tetracycline resistance which were 1 or 2 % in 2000 and earlier, rose to 8% in *M. haemolytica* isolates from sheep in 2001, though declined in 2002 to 3% and then to 1% in 2003. Only 1% of ovine *M. haemolytica* isolates were resistant to ampicillin and only 2% to trimethoprim/ sulphonamides. No resistance to enrofloxacin or florfenicol has been detected in ovine *M. haemolytica* isolates since monitoring began.

<u>Pasteurella trehalosi</u>

No resistance was detected in *Pasteurella trehalosi* recovered from sheep in 1999, although a single isolate recovered from bovine lung was resistant to tetracyclines. In 2000, resistance was observed to both tetracyclines and trimethoprim/ sulphonamide though all ovine isolates were susceptible in 2001. In 2002, resistance in ovine isolates was reported to ampicillin, amoxicillin/ clavulanate and cephalexin, though this was not confirmed by MIC determination. In 2003, resistance to ampicillin, tetracyclines and trimethoprim/ sulphonamides was detected in a very low number of ovine isolates; isolates resistant to one of these antimicrobials were susceptible to the remaining two – no isolates were resistant to all three antimicrobials.

<u>Histophilus somni</u>

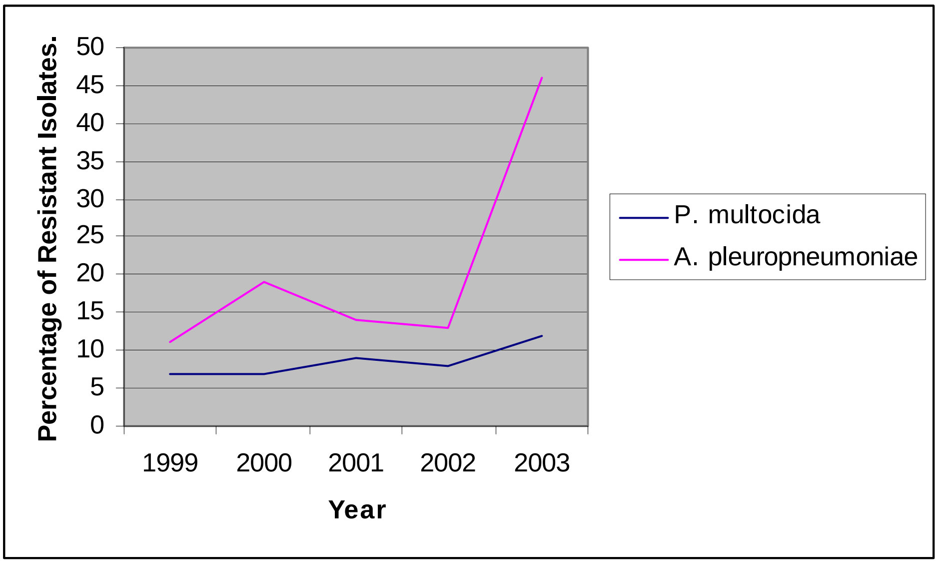
Histophilus somni (formerly known as *Haemophilus somnus*) is a cause of pneumonia in calves. There were two reports of trimethoprim/sulphonamide resistance in the 36 isolates recovered during 1999 and resistance to this antimicrobial was also observed in subsequent years, with the exception of 2003, with levels varying between 3 and 13%. Although resistance to a number of compounds (including penicillin) was detected in 2000, isolates in 2001 showed resistance to only cephalexin and trimethoprim/sulphonamide. In 2002, isolates were reported as resistant to only tetracylines and trimethoprim/ sulphonamides and resistance remains uncommon in this organism. MIC determinations have not been performed to confirm these resistances. In 2003, resistance to ampicillin, amoxicillin/ clavulanate, cephalexin and tetracyclines was detected in low numbers of isolates. The amoxicillin/\clavulanate result is likely to be erroneous since a lower percentage of isolates is resistant to ampicillin than to amoxicillin/ clavulanate. The discrepancy is likely to be the result of inactivation of the amoxicillin/ clavulanate disc by moisture. No resistance to enrofloxacin or florfenicol has been detected in *H. somni* isolates since monitoring began.

Actinobacillus pleuropneumoniae

Actinobacillus pleuropneumoniae is a cause of pneumonia in the pig. Levels of resistance to spectinomycin and other aminoglycosides detected in the disc diffusion test may reflect the rather high minimal inhibitory concentrations that have been described for *Actinobacillus pleuropneumoniae* in the scientific literature for some aminoglycoside compounds (Leman et al. 1986). Both neomycin and spectinomycin resistance increased in 2003, whilst apramycin resistance was relatively unchanged. Resistance to tetracyclines increased in 2001, declined in 2002 and rose again in 2003. Resistance to ampicillin was 7% in 2003, declined to 4% in 2002 relative to the figures for 2000 (10%) and 2001 (6%). Two isolates were reportedly resistant to fluoroquinolones in 2002, though these results have not been confirmed by MIC determination. No resistance to fluoroquinolones or ceftiofur was detected in 2003. A trend of increasing multiple resistance was noted from 1999 (24%) to 2001 (49%) and although the proportion of multi-resistant isolates declined in 2002, it rose once more in 2003.

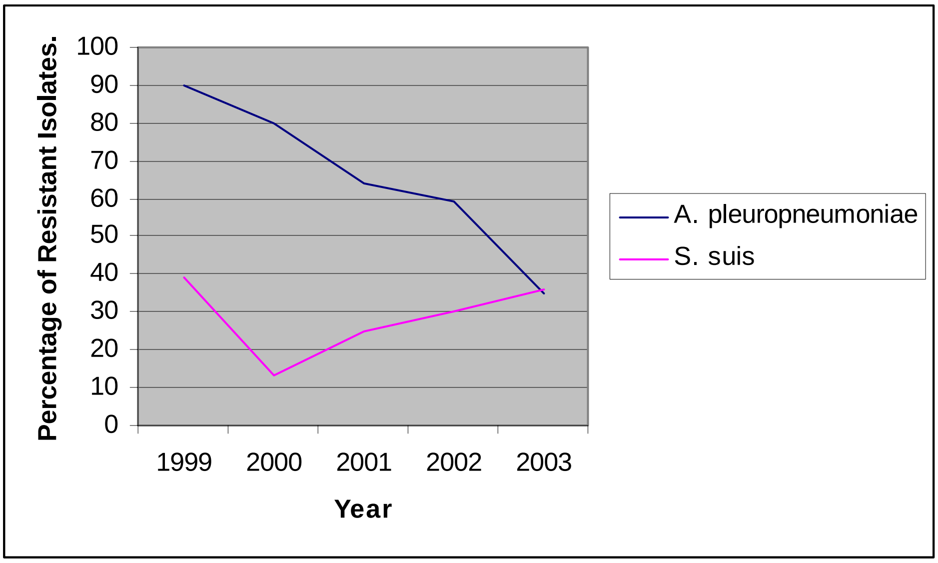
Resistance to trimethoprim/ sulphonamides increased in *A. pleuropneumoniae* from pigs in 2003 and this parallels a general trend seen in several other bacterial species recovered from pigs, particularly *E. coli* and *Salmonella enterica.* Not all organisms demonstrate this trend to the same degree and figure 4 shows graphically the changes observed in ***P.** multocida* and *A. pleuropneumoniae* recovered from pigs.

Figure 4: Resistance to trimethoprim/ sulphonamides in *P. multocida* and *Actinobacillus pleuropneumoniae* in Pigs.



Actinobacillus pleuropneumoniae isolates recovered from pigs showed a decline in resistance to tylosin from 90% in 1999 to 59% in 2002 and then to 35% in 2003 and this period coincides with the period of withdrawal of tylosin as a growth promoter. Unfortunately, detailed usage figures for tylosin over this period are not available.

Figure 5: Resistance to Tylosin in *S. suis* and *Actinobacillus pleuropneumoniae* in Pigs.



<u>Arcanobacterium pyogenes</u>

This organism is slow-growing and can take up to 48 hours to appear on culture plates. Since the disc diffusion test is intended to be read at 24 hours one might expect wider zones of inhibition as antimicrobial diffuses out from the discs over a 48 hour rather than a 24 hour period. For this reason, the disc diffusion test may over-estimate susceptibility in this organism.

Isolates of *Arcanobacterium pyogenes* from sheep and pigs were in general less resistant than isolates recovered from cattle. This is counter to the usual trend, where isolates from pigs tend to be more resistant than those from sheep or cattle. For example, the numbers of isolates resistant to tetracyclines were highest in bovine strains and levels of resistance to tetracyclines were lower in pigs than in sheep. No penicillin, ampicillin or macrolide resistance was detected in porcine strains, though a single ovine isolate was resistant to penicillin and erythromycin in 2002 (though the ovine results are anomalous since this strain did not show resistance to ampicillin). A single ovine isolate was also resistant to erythromycin in 2003; no other resistances were detected in ovine isolates in 2003. Porcine isolates have shown resistance to only tetracyclines and trimethoprim/ sulphonamides since monitoring began and this is in contrast to the situation in bovine isolates, where resistance to penicillin, ampicillin and erythromycin has been detected. Test methodology is identical for ovine, porcine and bovine strains and so despite the limitations of the test methodology for this organism there do appear to be genuine differences in susceptibility between bovine and ovine/porcine strains of *Arcanobacterium pyogenes.*

ZOONOTIC ORGANISMS

Erysipelothrix rhusiopathiae

Erysipelothrix rhusiopathiae is widely distributed in nature and can be a commensal or pathogen of a very wide range of vertebrate and invertebrate species. The main reservoir amongst the domestic species is probably pigs, though infection of both birds and rodents is said to be common. A low number of isolates of this organism have been tested and the main resistance detected has been to tetracyclines and trimethoprim/sulphonamides. A single isolate was reported as resistant to erythromycin in 2000. All isolates were susceptible to penicillin and ampicillin.

Listeria monocytogenes

Listeria organisms are widely distributed in the environment and can be isolated from soil, decaying vegetation and poorly fermented silage. Asymptomatic faecal carriage occurs in man and in many species of animal. Two main disease syndromes exist: neural infection and infection of the fetus *in utero* resulting in abortion/ neonatal septicaemia. Humans may be infected, usually through consumption of contaminated foods such as soft cheese, poultry meat or milk.

Only low numbers of bovine and ovine isolates were tested. Cephalexin resistance was observed in both bovine and ovine isolates and this may reflect a degree of intrinsic resistance; the fluctuation in the numbers of isolates resistant to cephalexin was mirrored in both species in 2000 and 2002, with increased resistance reported in these years from both cattle and sheep. However, in 2003, isolates from sheep showed a further slight increase in resistance to cephalexin, whilst resistance in cattle isolates declined. A single bovine isolate was found to be resistant to trimethoprim/ sulphonamides in 1999; low numbers of ovine isolates were resistant to trimethoprim/

sulphonamides in 2000 and 2001. A single ovine isolate in 2000 was resistant to tylosin and florfenicol, though this result was not confirmed by MIC determination. Resistance to penicillin was not observed in isolates from either species. The resistance to amoxicillin/ clavulanate reported in 2002 and 2003 in the absence of resistance to ampicillin is likely to be an erroneous result. The discrepancy is likely to be the result of inactivation of the amoxicillin/ clavulanate disc by moisture.

<u>Listeria ivanovii</u>

A low number of *Listeria ivanovii* isolates were recovered from the viscera of sheep. All isolates were sensitive to penicillins and tetracyclines, although one isolate was resistant to trimethoprim/sulphonamide and three isolates were resistant to cephalexin. No isolates have been tested in the last three years.

<u>Rhodococcus equi</u>

There were very few isolates of this organism recovered during the period covered by this report. Resistance was detected to tetracyclines and ampicillin, though not to any other antimicrobials. The resistance to amoxicillin/ clavulanate reported in 2003 in the absence of resistance to penicillin or ampicillin is likely to be an erroneous result. The discrepancy is likely to be the result of inactivation of the amoxicillin/ clavulanate disc by moisture.

<u>Streptococcus suis</u>

Streptococcus suis is a pathogen of pigs that can cause pneumonia, meningitis and arthritis. It can also rarely infect man.

No resistance to penicillin, ceftiofur or enrofloxacin was detected in isolates of *S.suis*, though isolates resistant to tetracylines, trimethoprim/sulphonamide, tylosin and lincomycin were all recorded. Levels of resistance to tetracyclines ranged from 65 to 94%, with macrolide resistance at 13-39% and resistance to trimethoprim/ sulphonamides at 4-13% over the period 1999-2002. The prevalence of tetracycline resistance in these porcine streptococci was higher than that seen in many bovine and ovine streptococcal species and this may reflect differences in husbandry practices or the greater exposure of pigs to tetracyclines; tetracyclines may be administered orally to pigs but not to ruminants. A particularly high proportion of isolates was resistant to tetracylines in 2002 and the reason for this is unknown.

<u>Streptococcus equisimilis</u>

A low number of isolates were recovered, all originating from pigs. 75 - 83% of isolates were resistant to tetracyclines over the reporting period and macrolide resistance was also detected. All isolates were susceptible to penicillin and a single isolate was resistant to trimethoprim/ sulphonamides in 2003 – the first occasion that trimethoprim/ sulphonamide resistance has been detected in this organism since monitoring began.

Streptococcus equi zooepidemicus

Streptococcus equi zooepidemicus is a pathogen and occasionally a commensal of equines and less commonly other species. Humans may be infected by consuming infected milk, although the organism is rare in cattle.

Tetracycline resistance was common and reported in 1999-2000, though in 2003 the three isolates recovered were susceptible to tetracyclines and the other antimicrobials tested. Trimethoprim/ sulphonamide resistance was reported in 1999 and 2000. The Swedish Veterinary Antimicrobial Resistance Monitoring Report for 2000 (SVARM 2000) reports that resistance in *S. equi zooepidemicus* to trimethoprim/ sulphonamides appears to have risen markedly since 1992.

In 2002, three isolates of *Streptococcus equi zooepidemicus* were recovered from zoo animals, including two big cats. These isolates were susceptible to tetracyclines.

A single isolate recovered from a bovine mastitis case in 2000 was resistant to tetracyclines, trimethoprim/ sulphonamide and enrofloxacin.

There were no isolates of *Streptococcus equi zooepidemicus* reported in 2003 from species other than horses.

***Klebsiella pneumonia* from Avian Species**

A limited number of isolates of *Klebsiella pneumoniae* have been recovered from avian species, with no isolates recorded in 2003. The majority of isolates recovered in previous years have been resistant to ampicillin. This can be compared to the situation in cattle where between 33 and 55% of isolates have been resistant to ampicillin. Resistance to tetracyclines and trimethoprim/ sulphonamides was observed in both bovine and poultry strains. All avian strains were susceptible to neomycin, whereas a single bovine isolate was resistant to this antimicrobial.

***Yersinia pseudotuberculosis* in sheep and birds**

A low number of isolates of *Yersinia pseudotuberculosis* (19) was examined over the reporting period 1999-2003 from avian species - mainly from exotic birds. Only single isolates were found to be resistant to either trimethoprim/sulphonamides or tetracyclines. No resistance has been detected amongst *Yersinia pseudotuberculosis* isolates recovered from sheep over the period 1999-2002; no isolates of this organism were reported in 2003.

Yersinia enterocolitica

A very low number of isolates (8) was recovered over the period 1999-2003 from sheep and cattle and resistance to tetracyclines was detected in one of these isolates in 1999; the isolates have been susceptible to all other antimicrobials tested.

ANIMAL PATHOGENS.

Corynebacterium pseudotuberculosis

This organism, the cause of caseous lymphadenitis in sheep, has been reported as a zoonosis though rarely infects man. However, *Corynebacteria* may be an emerging zoonoses particularly in humans with intercurrent immunosuppresive disease, such as HIV infection. Resistance was detected to trimethoprim/sulphonamide, penicillin, tetracyclines and cephalexin although only low numbers of isolates were subjected to sensitivity testing. In 2003, all isolates were susceptible to the panel of antimicrobials tested. Treatment of clinical cases of this infection in sheep is often difficult because of the difficulties in delivering sufficient antimicrobial to the typical "onion-ring" abscesses that occur.

***Streptococcus dysgalactiae* in Sheep**

This organism is the major cause of infectious arthritis in young lambs and is probably carried on the mucous membranes of a small proportion of sheep. The degree of relatedness between ovine and bovine strains of *Streptococcus dysgalactiae* is not known. Levels of resistance to tetracyclines in ovine isolates of *Streptococcus dysgalactiae* were in general higher than those recorded for bovine isolates. Resistance to trimethoprim/ sulphonamides was also detected in ovine isolates in 1999, 2000, 2002 and 2003, though not in 2001. There was no resistance to penicillin or ampicillin detected in ovine *Streptococcus dysgalactiae* isolates.

Staphylococcus aureus **in Poultry and Game Birds.**

Staphylococcus aureus causes a number of infections in poultry and game birds, including septicaemia, yolk sac infection, arthritis and osteomyelitis. The strains affecting poultry and avian species are generally considered to be a separate population from those affecting man and other animals.

Resistance to ampicillin ranged from 9 to 31% between 1999 and 2003, whilst no resistance to amoxicillin/ clavulanate was detected over this period. Tetracycline resistance has increased over the same period 1999 – 2003 from 16 to 63%. All of the resistant isolates in 2003 originated from chickens and in this species 10/11 (91%) isolates were resistant to tetracyclines in that year. Resistance to trimethoprim/ sulphonamides was consistently less than 10%, and resistance to erythromycin which had been at levels of 11-17% in 1999-2002, rose to 33% in 2003. All isolates resistant to erythromycin in 2003 also originated from chickens and all of the isolates that were resistant to erythromycin from chickens were also resistant to tetracyclines and lincomycin. A trend of increasing resistance to lincomycin has been observed since 2000. It is perhaps surprising, given the diverse origins of these avian strains of *S.aureus,* that fluctuations in the levels of resistance have not been greater.

Streptocococus equi equi

Streptococcus equi equi is the cause of strangles in horses.

A low number of isolates were examined and all proved fully susceptible apart from a single isolate in 2001 that was reported to be resistant to penicillin, ampicillin, tetracyclines and trimethoprim/ sulphonamides. These resistances were not confirmed by determination of MIC.

Staphylococcus xylosus

Staphylococcus xylosus is one of the coagulase-negative group of Staphylococci and is emerging as a cause of bovine mastitis and skin disease. Very little resistance was detected in *Staphylococcus xylosus* recovered from cattle, sheep and goats, with only one isolate of bovine origin resistant to tetracyclines, although only low numbers of isolates were tested.

COMMENSALS OF PUBLIC HEALTH INTEREST.

Enterococcus faecalis

A low number of isolates of *Enterococcus faecalis* were recovered from bovine mastitis samples in 1999-2003. These isolates were identified using phenotypic tests only and the genotype has not been confirmed. Between 17 and 67% of isolates were resistant to tetracyclines, with 7-13% of isolates resistant to erythromycin. A single isolate in 1999 and 2000 was resistant to penicillin. Resistance to neomycin was also detected in between 17 and 35% of isolates in each year of monitoring. Resistance to tetracyclines and erythromycin has also been detected elsewhere in Europe in bovine *Enterococcus faecalis* isolates (DANMAP 2001).

Enterococcus faecium

A low number of isolates of *E.faecium* were recovered from a variety of species. As with *E.faecalis*, the identity of the organisms was confirmed using phenotypic tests only and was not confirmed by genotyping. Resistance was detected to tetracyclines, trimethoprim/ sulphonamide, neomycin and erythromycin. A single isolate was resistant to ampicillin but susceptible to penicillin in 2001, with the reverse pattern being obtained in 2002 in a single isolate. These are unusual result (since resistance or susceptibility to both compounds is expected) and may be erroneous or reflect a zone size close to the 13mm discriminatory cut-off point. Resistance to tetracyclines, neomycin, erythromycin and ampicillin has also been detected in other parts of Europe in *E.faecium* isolates recovered from animals (DANMAP 2001, SVARM 2001). A single isolate in 2002 proved resistant to enrofloxacin, although this result has not been confirmed by MIC determination. Tetracycline resistance in both *E. faecium* and *E. faecalis* was higher in 2002 compared to previous years. Resistance to tetracycline was the only resistance detected in *E.faecium* isolates from 2003.

PART B

ANTIMICROBIAL SENSITIVITY IN SALMONELLAS 2003

Salmonellas received for serological identification at VLA Weybridge and Lasswade are tested for their *in vitro* sensitivity to 16 antimicrobials. All these isolates come from animals and their environment in England and Wales. The choice of antimicrobials, which is reviewed periodically, is designed to comprise a core set which has been used in veterinary practice for many years, some of the more recently licensed antimicrobials and some of limited usage in Great Britain which are used in other European countries. In 2001, the 30 µg cefuroxime disc that had been used in previous years, was replaced with a 30 µg ceftazidime disc.

All tests are performed using a disc diffusion technique on Oxoid "Isosensitest" agar using antibiotic discs as follows:

	Antimicrobial	Concentration	Code
1	Nalidixic acid	(30 µg)	NA
2	Tetracycline	(10 µg)	T
3	Neomycin	(10 µg)	N
4	Ampicillin	(10 µg)	AM
5	Furazolidone	(15 µg)	FR
6	Ceftazidime	(30 µg)	CAZ
7	Sulphamethoxazole/trimethoprim	(25 µg)	TM
8	Chloramphenicol	(10 µg)	C
9	Amikacin	(30 µg)	AK
10	Amoxicillin/clavulanic acid	(30 µg)	AMC
11	Gentamicin	(10 µg)	CN
12	Streptomycin	(25 µg)	S
13	Sulphonamide compounds	(300 µg)	SU
14	Cefoperazone	(30 µg)	CF
15	Apramycin	(15 µg)	APR
16	Colistin	(25 µg)	CT

Prior to 1996, all salmonella isolates received were tested for antimicrobial susceptibility, but since then only the first isolate from each incident has been tested. The number of cultures received from a farm varies enormously, especially in the case of those from poultry. Some poultry companies have a continuous monitoring programme and large numbers of salmonellas may be received from a particular company. Thus the numbers of a particular serotype and its antimicrobial susceptibility may not reflect its prevalence in the animal population as a whole but reflect the monitoring programme on a farm or group of farms. Therefore, to better indicate the prevalence of resistance, only the first isolate from each incident has been tested since the start of 1996.

SALMONELLA DUBLIN

Of the 949 *Salmonella* Dublin cultures tested during 2003, 96.4% were susceptible to all 16 antimicrobial drugs (Table 55). The percentage of *S.* Dublin isolates sensitive to all 16 antimicrobials has shown a modest decline over the period 1996-2003, though the majority of isolates remain susceptible and this has been the situation since surveillance began in 1971. Most *S.* Dublin isolates originate from cattle. Resistance to ampicillin, which had been observed for the first time for several years in a very low number of bovine isolates in 2000, was not recorded in 2001 or 2002 and re-appeared in 2003. Resistance to furazolidone and neomycin, which had also not been detected for several years in *S*. Dublin, was observed for the first time in recent years in 2002 and again in 2003. 0.9% of *S*. Dublin isolates were resistant to trimethoprim/sulphonamides in 2002, higher than the figure for 2001, when only 0.2% of isolates were resistant. This figure is of interest, since trimethoprim/ sulphonamide resistance also increased in *Salmonella* Typhimurium in 2002, though by a much greater degree. In 2003, resistance to trimethoprim/sulphonamides in *S.* Dublin declined to 0.4%. Resistance to streptomycin increased in 2003, with 1.4% of cultures resistant. These fluctuations are probably related to clonal spread of particular isolates as a result of husbandry and animal movement factors, in addition to variation in the selective pressure exerted by antimicrobial usage.

Table 55: *Salmonella* Dublin: antimicrobial sensitivity monitoring 1996-2003

Year	No of cultures	Percentage sensitive to all 16 antimicrobials	Percentage of cultures resistant to:							
			S	C	SU	T	N	AM	FR	TM
1996	325	99.7	0.3	0.3	0.3	-	-	-	-	-
1997	284	98.2	0.7	1.4	0.7	0.7	-	-	-	-
1998	281	99.3	0.4	0.4	0.4	-	-	-	-	-
1999	357	98.3	1.1	-	-	-	-	-	-	-
2000	863	98.7	0.7	0.6	0.7	0.5	-	0.1	-	0.2
2001	467	98.3	0.2	0.6	1.3	0	-	-	-	0.2
2002	687	97.5	0.3	0.4	0.7	0.6	0.4	-	0.6	0.9
2003	949	96.4	1.4	1.3	1.2	0.8	0.2	0.6	0.4	0.4

SALMONELLA TYPHIMURIUM

The number of cultures of *Salmonella* Typhimurium examined in 2003 was 613, of which 44.5% were definitive type (DT) 104, DT104B or U302 (Table 56).

19.6% of the cultures were sensitive to all of the antimicrobials tested, similar to the figure for 2001, when 20.6% of *S*. Typhimurium cultures were fully sensitive and reversing the fluctuation observed in 2002, when 14.5% of cultures were fully sensitive (Table56). The generally high level of resistance of *Salmonella* Typhimurium isolates is partly a reflection of the numbers of DT104 and its variants DT 104B and U302, only 1.5% of which were sensitive to all the antimicrobials tested in 2003. However, the proportion of *Salmonella* Typhimurium isolates comprising DT104 and its variants has declined significantly in recent years and this has been reflected in a decrease in resistance to several antimicrobials, particularly those conferring the pentavalent resistance pattern that is typical of *Salmonella* Typhimurium DT 104. In 2003, despite a continuing decline in the proportion of *S*. Typhimurium that were DT104 or its variants, the levels of resistance to some antimicrobials in fact increased. This occurred because the definitive types that are replacing DT 104 are themselves commonly resistant to one or more antimicrobials. Figure 7 illustrates this fact graphically, showing the percentage of each of the eight commonest definitive types of *S*. Typhimurium that are fully susceptible to all of the antimicrobials tested.

Most *S*. Typhimurium DT104 isolates recovered from cattle had the typical pentavalent resistance pattern AM,C,S,SU,T and were also resistant to CF; this was also the commonest pattern observed in isolates of DT104 from pigs, chickens and sheep. The commonest pattern for isolates from turkeys was AM,C,S,SU,T,CF,NA and this was the third most common pattern in isolates from cattle. All of the isolates that were resistant to cefoperazone were susceptible to ceftazidime and cefoperazone resistance in these isolates is therefore considered to indicate hyperproduction of betalactamase enzymes, rather than possession of extended spectrum betalactamase enxymes. There were no *Salmonella* Typhimurium isolates resistant to ceftazidime recovered in 2003, 2002 or 2001 and no *Salmonella* Typhimurium isolates resistant to cefuroxime were recorded in 1998, 1999 or 2000. This is an important finding, since third generation cephalosporins are one of the important groups of antimicrobials for the treatment of invasive salmonellosis in man.

In 2003, 24.2% of DT104 and 104B isolates were resistant to nalidixic acid and 25.4% resistant to sulphamethoxazole/trimethoprim. This is an increase on the figures for 2002, when 6.3% of DT104 and 104B isolates were resistant to nalidixic acid and 20.5% resistant to sulphamethoxazole/trimethoprim. In 2001, 19.8% of DT104 and 104B isolates were resistant to nalidixic acid and 12.5% resistant to sulphamethoxazole/trimethoprim. Therefore over this three-year period there have been fluctuatons in nalidixic acid resistance, though trimethoprim/sulphonamide resistance has steadily increased. Taking a longer-term view, the figure of 25.4% resistance to sulphamethoxazole/trimethoprim in DT104 and 104B isolates in 2002 can be compared to 17.6% resistance in 1999 and 15.9% in 1998. Nalidixic acid resistance in *S*. Typhimurium DT 104 by species of origin is listed in Table 57, which shows that isolates from cattle and turkeys are the main contributors accounting for the observed rise in nalidixic acid resistance. Table 58 gives the equivalent figures for trimethoprim/ sulphonamide resistance by species of origin in *S*. Typhimurium DT 104 for 2003.

Considering all definitive types of *S*. Typhimurium, there has also been a marked increase in resistance to sulphamethoxazole/trimethoprim from levels of around 16-24% in 1996-2001 to 44.1% in 2002 and 37.5% in 2003. There is a contribution from DT 104 to this overall figure and this has been discussed in the paragraph above. In relation to other phage types of *S*.Typhimurium it is mainly isolates of from pigs that account for this rise; a high percentage of many definitive types of *S*.Typhimurium isolated from pigs are resistant to sulphamethoxazole/trimethoprim, a situation that was also observed in 2002. These definitive types of *S*.Typhimurium recovered from pigs include DT 193 (47 isolates, 85% resistant to TM in 2002; 38 isolates, 92% resistant to TM in 2003), DT 208 (14 isolates, all resistant to TM in 2002; 7 isolates, 43% resistant to TM in 2003), U288 (51 isolates, 94% resistant to TM in 2002; 72 isolates, 90% resistant to TM in 2003) and U308A (59 isolates, 95% resistant to TM in 2002; no isolates in 2003). Three factors have influenced the sulphamethoxazole/trimethoprim resistance figures for *S*. Typhimurium isolates from pigs: (1) The numbers of incidents involving strains which have been highly resistant to TM in previous years, have increased. (2) The proportion of TM-resistant isolates from some definitive types that have previously shown TM resistance has increased (for example in 2000, 53% and 38% of isolates of DT 193 and 208 respectively, were resistant to sulphamethoxazole/trimethoprim). (3) There has also been a minor contribution from some definitive types of *S*. Typhimurium from pigs that have not previously shown sulphamethoxazole/trimethoprim resistance in recent years (eg DT 12), but which have now shown resistance in either 2002 or 2003.

Table 56: *Salmonella* Typhimurium: antimicrobial sensitivity monitoring 1995-2003

Year	No of cultures	Percentage sensitive to all 16 Antimicrobials	Percentage of cultures resistant to:									
			S	SU	T	N	AM	FR	TM	C	APR	NA
1996	2323*	10.8	82.0	87.1	86.5	1.9	81.9	0.4	18.3	78.5	0.6	9.3
1997	1480†	11.4	81.2	85.9	86.1	1.1	79.8	0.3	16.2	75.1	0.7	13.4
1998	1112**	14.7	77.8	82.3	81.7	1.4	77.8	0.2	18.0	73.1	0.8	14.7
1999	1177 ‡	18.4	61.2	72.0	78.8	2.0	63.0	0.3	23.1	53.2	1.6	11.3
2000	864***	15.3	63.2	70.8	80.4	2.5	63.8	0.1	23.4	56.5	3.2	7.5
2001	519††	20.6	57.8	71.7	75.5	2.9	66.7	0.4	24.3	55.9	2.3	11.9
2002	533[11]	14.5	61.0	77.9	80.1	3.4	70.5	2.6	44.1	62.1	2.4	7.1
2003	613[#]	19.6	61.7	73.1	74.2	6.2	68.5	0.7	37.5	58.9	3.8	13.5

* 1717 (73.9%) of these strains were DT104 and its variants.

† 1091 (73.7%) of these strains were DT104 and its variants.

** 814 (73.2%) of these strains were DT104 and its variants.

‡ 620 (52.7%) of these strains were DT104 and its variants

*** 460(53.2%) of these strains were DT104 and its variants

†† 274 (52.8%) of these strains were DT104 and its variants.

[11] 239 (44.8%) of these strains were DT 104 and its variants.

[#] 273 (44.5%) of these strains were DT 104 and its variants.

Table 57: Nalidixic acid resistance in *Salmonella* Typhimurium DT104 from domestic livestock. Number of cultures tested (percentage resistant to nalidixic acid)

	Livestock species					
Year	**Turkeys**	**Chickens**	**Ducks**	**Cattle**	**Pigs**	**Sheep**
1995	120 (63.3)	119 (0.8)	4 (0)	2109 (1.6)	130 (0.8)	150 (0)
1996	81 (75.3)	100 (6.0)	0	1006 (5.3)	102 (6.9)	89 (9.0)
1997	69 (78.3)	31 (16.1)	3 (0)	597 (11.1)	88 (4.5)	66 (12.1)
1998	80 (71.3)	63 (4.8)	7 (14.3)	369 (10.3)	56 (10.7)	53 (5.7)
1999	24(66.7)	5(20.0)	1(0)	231(5.2)	114(9.6)	35(2.9)
2000	7(0)	7(14.3)	1(0)	223(10.8)	51(2.0)	21(0)
2001	25(60)	22(0)	0(0)	115(15.7)	19(21.1)	8(12.5)
2002	17(11.8)	32(0)	0(0)	67(7.5)	36(5.6)	5(40)
2003	41(63.4)	12(8.3)	0(0)	100(20)	27(11.1)	6(0)

Table 58: Trimethoprim/ sulphonamide resistance in *Salmonella* Typhimurium DT104 from domestic livestock in 2003. Number of cultures tested (percentage resistant to trimethoprim/ sulphonamide)

	Livestock species					
Year	**Turkeys**	**Chickens**	**Ducks**	**Cattle**	**Pigs**	**Sheep**
2003	41(7.3)	12(33.3)	0(0)	100(33)	27(14.8)	6(0)

1.5% of DT 104 and its variants were resistant to neomycin; the main contribution to the overall levels of neomycin resistance seen in *Salmonella* Typhimurium in 2003 came from DT 193 of porcine origin (23.7% of 38 isolates tested) and U288 of porcine origin (19.1% of 73 isolates tested). Apramycin resistance levels have increased since 2000 and in 2003, the main phage types involved were *Salmonella* Typhimurium DT 193 (11 resistant isolates) and U288 (5 resistant isolates). All of these isolates were of porcine origin and all were also resistant to gentamicin, suggesting that the mechanism involved may be possession of the enzyme aminoglycoside acetyltransferase AAC(3)IV.

Multiple antibiotic resistance (i.e. resistance to four or more antimicrobial agents in the panel of 16) was detected in DTs 12, 104, 104B, 120, 193, 193A, U288 and U302 from cattle; in DTs 41 variant, 104, 193, 193A, U288, U302 from poultry; in DT 104 and U288 from sheep and in DTs 12, 12A, 104, 104B, 120, 193, 193A, 195, U288 and U302 from pigs. Of the 34 different definitive types detected, 11 (namely 1, 2A, 30, 40, 49, 56 variant, 85, 96 variant, 99 169 and U317) were fully susceptible to all of the antimicrobials in the test panel.

SEROTYPES OTHER THAN SALMONELLA *DUBLIN* AND SALMONELLA *TYPHIMURIUM*

Of the 3652 cultures tested 67.7% were sensitive to all the antimicrobials tested (Table 59), reversing the decline seen in 2002 when 60.3% were sensitive. 124 (3.4%) of the cultures were *S.* Enteritidis, of which 47 were *S.* Enteritidis Definitive Type 4 and of these *S.* Enteritidis Definitive Type 4 isolates, 91.5% were sensitive to all of the antimicrobials used in the test panel. Levels of resistance to furazolidone and neomycin were higher than those observed in recent years, maintaining the trend observed in 2002. Neomycin resistant isolates originated mainly from poultry (8.5% of isolates from poultry were resistant, with 2541 isolates tested), and most of these neomycin resistant poultry isolates were from ducks, with lower numbers from chickens and turkeys. Furazolidone resistant isolates also originated mainly from poultry (12.4% of isolates from poultry were resistant, of 2541 isolates tested), and many of these isolates were *Salmonella* Indiana and again originated from ducks. This is discussed further below.

Table 59: Salmonellas, other than *Salmonella* Dublin and *Salmonella* Typhimurium antimicrobial sensitivity monitoring 1995-2003.

Year	No of cultures	Percentage sensitive to all 16 antimicrobials	Percentage of cultures resistant to:									
			S	SU	T	N	AM	FR	TM	C	APR	NA
1995	5085	64.5	6.5	17.0	8.4	1.4	4.1	1.2	10.6	1.6	0.2	1.7
1996	3141	70.6	5.5	21.6	8.9	1.2	5.2	1.0	16.3	1.5	0.2	3.0
1997	2442	74.8	6.3	17.7	10.9	1.1	3.1	0.9	13.7	1.1	0.2	3.0
1998	2227	74.4	6.2	16.3	11.0	0.4	3.3	0.8	11.6	1.8	0.2	4.0
1999	2417	73.7	6.8	12.6	16.1	1.0	2.8	0.4	6.6	2.2	0.3	3.1
2000	2877	70.7	5.0	18.0	9.5	0.9	4.8	0.5	13.7	3.5	0.1	5.5
2001	1814	69.8	8.1	20.0	10.0	1.0	5.7	0.6	12.1	6.4	0.2	1.4
2002	2167	60.3	11.2	24.0	13.7	5.2	6.5	3.7	19.5	8.0	0.3	1.9
2003	3652	67.7	10.0	19.0	15.7	6.2	4.4	8.7	12.4	4.5	0.1	2.2

INDIVIDUAL ANTIMICROBIALS

Of the 5214 salmonellas tested in 2003, 67.3% were sensitive to all of the antimicrobials tested – similar to the figure of 61.1% recorded in 2002. This can be compared with figures of 65.5% in 2001 and 59.5% in 1999. Levels of resistance to tetracyclines in isolates from all sources decreased from 33.3% in 1999 to 21.1% in 2000 and further declined to 20.5% in 2001; levels of resistance to tetracyclines were 21.2% in 2002 and 19.9% in 2003. This probably reflects both the proportionate decrease in salmonella isolates of all serotypes from pigs and the relative decline in frequency of isolation of *S.*Typhimurium DT 104. The level of resistance to neomycin in all salmonella serotypes was 5.1% in 2003 and 3.9% in 2002, an increase on the figure of 1.2% recorded in 2001. Levels of resistance to furazolidone remained at

0.3% in 1999 and 2000, though increased slightly to 0.5% in 2001 and increased further in 2002 when levels of 2.9% were recorded. In 2003, 6.3% of all isolates were resistant to furazolidone. The observed increase is considered to reflect increased surveillance of salmonella isolates from ducks rather than a genuine increase in resistance to this antimicrobial, since *Salmonella* Indiana is a frequent salmonella isolate from ducks and is commonly resistant to furazolidone. Numbers of salmonella isolates received from ducks have increased over this period as surveillance of this species has increased. Examination of previous records shows that furazolidone-resistant *Salmonella* Indiana has been present in poultry in England and Wales for many years. In 2002, it is interesting to note that there were no cases of *Salmonella* Indiana infection in humans in England and Wales that were resistant to furazolidone (personal communication, Professor E J Threlfall, Laboratory of Enteric Pathogens, HPA Colindale). Resistance of *S.* Virchow isolates to furazolidone declined from 53% in 1998 to 28.5% in 1999, although the numbers of *S.* Virchow isolates tested each year were relatively low at 15 in 1998 and 7 in 1999. 39 isolates of *S.* Virchow were examined in 2001 and 12.8% were resistant to furazolidone; 59 isolates of *S.* Virchow were examined in 2002 and only 1.7% were resistant to furazolidone. In 2003, 132 isolates of *S.* Virchow were examined and 0.8% were resistant to furazolidone. Resistance to apramycin in all salmonella serotypes was 0.5% in 2003, similar to the figure of 0.6% observed in 2003. The overall trend of decreasing resistance to nalidixic acid was not maintained with 3.2% of all salmonella isolates resistant in 2003, compared with 2.4% of all salmonella isolates resistant in 2002, 3.2% in 2001, 4.9% in 2000, 5.3% in 1999, 7.0% in 1998 and 6.5% in 1997.

No resistance was detected to amikacin or ceftazidime.

Table 60: All salmonellas: antimicrobial sensitivity 2003

Origin	No of cultures	Percentage sensitive to all 16 Antimicrobials	Percentage of cultures resistant to:									
			S	SU	T	N	AM	FR	TM	C	APR	NA
Cattle	1248	81.2	12.7	14.5	15.3	0.3	13.8	0.3	6.2	13.1	0	2.3
Sheep	274	93.1	2.9	2.9	4.7	0	2.9	0.4	0.4	3.3	0	0
Pigs	297	6.4	56.6	82.2	80.8	11.4	59.9	1.0	59.3	49.5	6.4	8.4
Chickens	1395	64.4	6.7	24.4	8.3	1.9	5.4	6.0	20.1	8.4	0	1.8
Turkeys	433	53.6	16.9	33.7	30.7	2.5	17.3	1.2	11.5	9.7	0	15.5
Ducks	799	57.2	22.9	15.9	32.3	22.5	1.1	28.2	5.4	1.3	0	0.4
Horses	29	72.4	13.8	20.7	20.7	0	13.8	0	20.7	13.8	3.4	6.9
Other non-avian species	210	65.7	23.8	29.0	27.6	2.9	24.3	1.9	11.4	17.1	2.4	5.7
Other avian species	36	69.4	19.4	8.3	11.1	0	13.9	0	5.6	0	0	5.6
Feed	468	91.0	2.1	7.5	4.1	0.6	1.3	0.2	5.8	1.5	0	0
Environment	25	92.0	0	0	0	0	4	0	0	4	0	4
Total	5214	67.3	14.5	22.1	19.9	5.1	11.2	6.3	13.2	10.3	0.5	3.2

Fig 6: Number of isolates of *Salmonella* Typhimurium of ten most frequent definitive types presented to VLA in 2003.

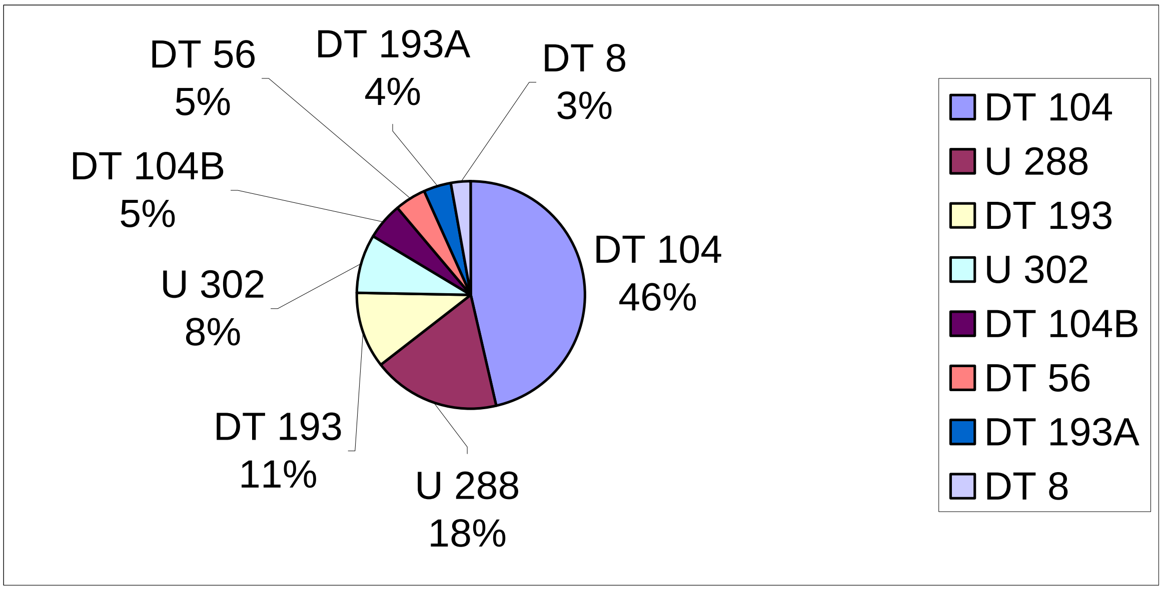
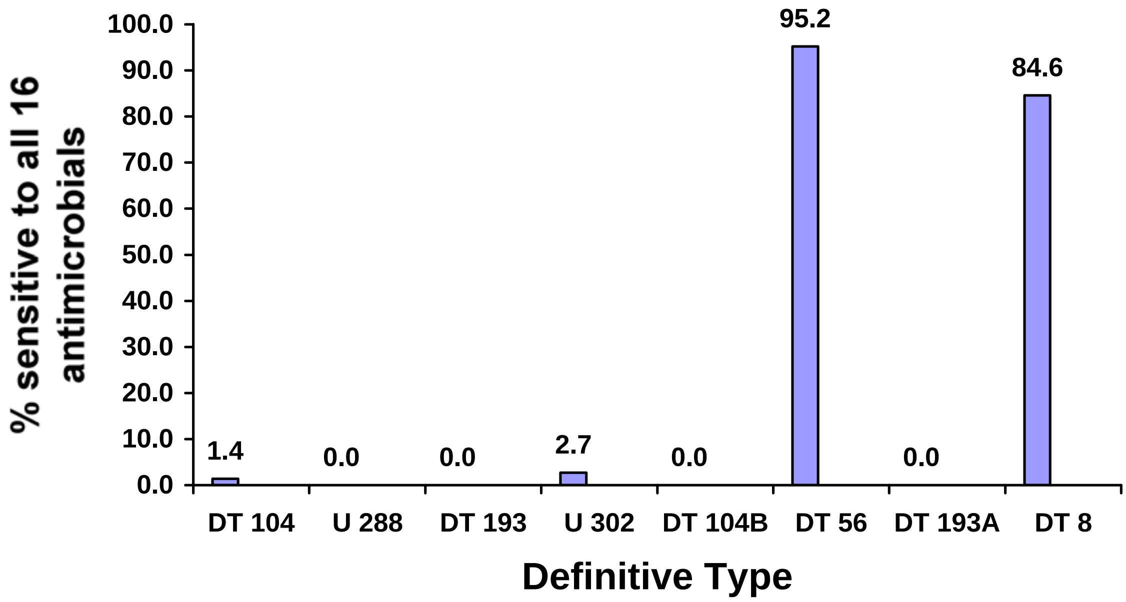


Fig 7: Percentage of the eight most common definitive types of *Salmonella* Typhimurium sensitive to 16 antimicrobial agents in 2003.



CIPROFLOXACIN RESISTANCE IN SALMONELLAS IN 2001-2003.

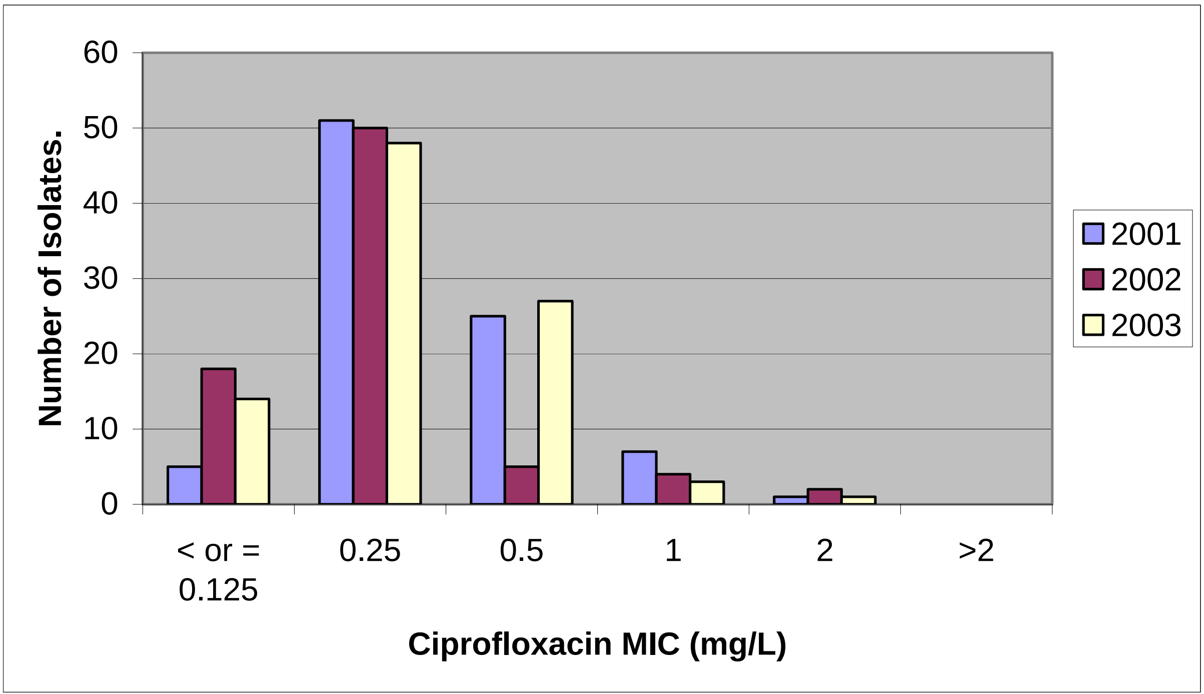
The MIC for ciprofloxacin was determined for a number of salmonellas resistant to nalidixic acid in the disc diffusion test. Results are shown in tabular form in Table 61and are represented graphically in Figure 8. Of the isolates tested, the number of salmonellas with an MIC ≥1mg/l remained low. In 2002, the proportion of these isolates with an MIC of 0.5 to ciprofloxacin declined, whilst that with an MIC of ≤0.125 increased.

The serotypes in 2001 with an MIC for ciprofloxacin of ≥1mg/l were *Salmonella* Typhimurium DT 104B, *S.* Senftenberg, *S.* Fischerkietz and *S.* Cholerae-suis var. kunzendorf whilst in 2002 the serotypes involved were *S.* Typhimurium DT 104, *S.* Typhimurium DT 193, *S.* Typhimurium (untypable with phages) and *S*. Fischerkietz. In 2003, the serotypes with an MIC for ciprofloxacin of ≥1mg/l were *Salmonella* Senftenberg, *S*. Newport (2) and *S*. Typhimurium DT 104. The Newport and Typhimurium DT 104 isolates originated from turkeys, whilst the *Salmonella* Senftenberg isolate was from cull chicks (fowls).

Table 61: Minimum Inhibitory Concentration of Ciprofloxacin for Salmonellas resistant to Nalidixic Acid in 2001-2003 – number of isolates with a given MIC (per centage of total number of nalidixic acid resistant isolates tested).

MIC for Ciprofloxacin mg/l	2001	2002	2003
≤0.125	5 (5.6%)	18 (22.8%)	14 (15%)
0.25	51 (57.3%)	50 (63.3%)	48 (51.6%)
0.5	25 (28.1%)	5 (6.3%)	27 (29%)
1	7 (7.9%)	4 (5.1%)	3 (3.2%)
2	1 (1.1%)	2 (2.5%)	1 (1.1%)
>2	0 (0%)	0 (0%)	0
Total number of Salmonella isolates tested, resistant to nalidixic acid.	89	79	93

Fig 8: Minimum Inhibitory Concentration of Ciprofloxacin for Salmonellas resistant to Nalidixic Acid in 2001-2003.



PART C: ANAEROBIC BACTERIA.

A small number of anaerobic bacteria, comprising 13 isolates of *Fusobacterium necrophorum necrophorum* and seven isolates of *Fusobacterium necrophorum funduliforme* isolates were examined for antimicrobial susceptibility in 2001, using the commercial ATB-ANA System (bioMerieux). Results are shown in Table 62. In 2003 a limited number of *Clostridium perfringens* isolates were examined and results are shown in Table 63.

Table 62: Anaerobic Susceptibility Test Results *Fusobacterium necrophorum* 2001.

	Fusobacterium necrophorum necrophorum			*Fusobacterium necrophorum funduliforme*	
Species of origin.	**Cattle**	**Sheep**	**Pigs**	**Cattle**	**Sheep**
Number of Isolates.	1	11	1	4	3
Antimicrobial (Concentration in mg/l)	**Number Resistant**				
Penicillin (0.5 and 2)	0	0	0	0	0
Amoxycillin/ Clavulanate (4/2 and 8/4)	0	0	0	0	0
Piperacillin (32 and 64)	0	0	0	0	0
Piperacillin and Tazobactam (32/4 and 64/4)	0	0	0	0	0
Ticarcillin/ Clavulanate (32/2 and 64/2)	0	0	0	0	0
Cefoxitin (16 and 32)	0	0	0	0	0
Cefotetan (16 and 32)	0	0*	0	0	0
Imipenem (4 and 8)	0	0	0	0	0
Clindamycin (2 and 4)	0	0	0	0	0
Chloramphenicol (8 and 16)	0	0	0	0	0
Metronidazole (8 and 16)	0	0	0	0	0
Amoxycillin (2 and 4)	0	0	0	0	0
Amoxycillin (16)	0	0	0	0	0
Amoxycillin/ Clavulanate (16/2)	0	0	0	0	0
Ticarcillin (64)	0	0	0	0	0
Metronidazole (4)	0	0	0	0	0

* A single isolate was of intermediate susceptibility to cefotetan though susceptible to all other antimicrobials.

Table 63: Anaerobic Susceptibility Test Results *Clostridium perfringens*.

Year of Isolation.	**2003**				
Species of origin.	**Cattle**	**Sheep**	**Pigs**	**Avian**	**Other species**
Number of Isolates.	6	7	2	3	7
Antimicrobial (Concentration in mg/l)	**Number Resistant**				
Penicillin (0.5 and 2)	0*	1	0	0	0
Amoxycillin/ Clavulanate (4/2 and 8/4)	0	0	0	0	0
Piperacillin (32 and 64)	0	0	0	0	0
Piperacillin and Tazobactam (32/4 and 64/4)	0	0	0	0	0
Ticarcillin/ Clavulanate (32/2 and 64/2)	0	0	0	0	0
Cefoxitin (16 and 32)	0	0	0	0	0
Cefotetan (16 and 32)	0	0	0	0	0
Imipenem (4 and 8)	0	0	0	0	0
Clindamycin (2 and 4)	0	1	0	0	0
Chloramphenicol (8 and 16)	0	0	0	0	0
Metronidazole (8 and 16)	0	1	0	0	1
Amoxycillin (2 and 4)	0	0	0	0	0
Amoxycillin (16)	0	0	0	0	0
Amoxycillin/ Clavulanate (16/2)	0	0	0	0	0
Ticarcillin (64)	0	0	0	0	0
Metronidazole (4)	0	1	0	0	1

* A single isolate was of intermediate susceptibility to penicillin though susceptible to all other antimicrobials. The ovine isolate that was resistant to penicillin was susceptible to amoxicillin – an unexpected result.

DISCUSSION

The *Fusobacterium necrophorum* isolates from 2001 were all fully-susceptible, with the possible exception of one isolate showing intermediate susceptibility to cefotetan. However, this isolate was susceptible to all other cephalosporin and beta-lactam compounds, casting some doubt as to whether this intermediate result was genuine.

Clostridium perfringens isolates examined in 2003 from cattle, sheep, pigs, avian and other species were susceptible to most of the antimicrobials tested. A single ovine isolate was resistant to metronidazole; this isolate was also resistant to clindamycin and penicillin, though was apparently susceptible to amoxicillin. This is an unexpected result, since one would expect isolates resistant to penicillin to also be resistant to amoxicillin.

PART D

BACTERIAL ISOLATES FROM WILD ANIMALS.

There were very low numbers of bacteria recovered from wild animals at VLA Regional Laboratories and recorded in the susceptibility database over the reporting period. These bacteria may have originated from animals at wildlife treatment centres or in veterinary practises and may not therefore reflect the levels of resistance that might be observed in free-living populations of wild animals.

Table 64:

Resistance in Bacteria recovered From Common and Grey Seals.

BACTERIAL SPECIES AND YEAR OF ISOLATION	**NUMBER RESISTANT/ TOTAL TESTED AGAINST:**					
	Ampicillin 10ug	Amoxicillin /clavulanate 20/10 ug	Tetracycline 10ug	Trimethoprim/ sulphonamide 25ug	Enrofloxacin 5ug	Cephalexin 30ug
Escherichia coli 1999	1/5	0/5	1/5	0/5	0/5	0/5
Erysipelothrix rhusiopathiae 2000	0/1	NT	0/1	0/1	NT	0/1
Escherichia coli 2000	0/1	0/1	1/2	1/2	1/2	NT
Streptococcus phocae 2000	0/2	NT	0/2	0/2	NT	0/2
Arcanobacterium phocae 2000	0/2	NT	0/2	0/2	NT	0/2
Klebsiella pneumoniae 2001	1/1	1/1	1/1	0/1	1/1	NT
Escherichia coli/ nonhaemolytic coliforms 2002	6/9	3/9	3/9	4/9	3/9	0/3
Streptococcus phocae 2002	0/4	NT	0/4	0/4	NT	0/4
Arcanobacterium phocae 2002	0/3	NT	0/3	0/3	NT	0/3
Streptococcus phocae 2003	0/2	0/2	0/2	0/2	NT	0/2
Arcanobacterium phocae 2003	0/2	0/2	0/2	1/2	NT	0/2
Erysipelothrix rhusiopathiae 2003	0/1	0/1	0/1	1/1	NT	0/1
Escherichia coli/ nonhaemolytic coliforms 2002	2/2	2/2	2/2	1/2	2/2	NT

NT – not tested.

Table 65:

Bacteria Isolated from Other Wild Animals.

BACTERIAL SPECIES, YEAR OF ISOLATION AND SPECIES FROM WHICH ISOLATED	**NUMBER RESISTANT/ TOTAL TESTED AGAINST:**					
	Ampicillin 10ug	Amoxicillin /clavulanate 20/10 ug (2/1 ug for Gram-positive organisms).	Tetracycline 10ug	Trimethoprim/ sulphonamide 25ug	Enrofloxacin 5ug	Cephalexin 30ug
Staphylococcus aureus 2001 Mammary gland of an Otter.	0/1	NT	1/1	0/1	NT	0/1
Salmonella Enteritidis 2001 from liver and kidney of two Hedgehogs, less than 1 month old.	0/2	0/2	0/2	0/2	0/2	NT
Haemolytic coliform 2001 Nasal Discharge in a Red fox	0/1	NT	0/1	0/1	0/1	NT
Escherichia coli/ non haemolytic coliforms 2002. One isolate from meninges, hedghog less than 1 month old; one faecal isolate, hedghog, age unknown.	0/2	0/2	0/2	0/2	0/2	NT
Escherichia coli/ non haemolytic coliform 2002. Intestine of a leveret less than one month old.	1/1	0/1	1/1	1/1	1/1	NT
Escherichia coli haemolytic 2003. Lungs of two squirrels, less than 1 month old.	0/2	0/2	0/2	0/2	0/2	NT

Bordetella bronchiseptica 2003. Lung, red squirrel older than 6 months.	1/1	0/1	0/1	0/1	0/1	1/1
Escherichia coli/ non haemolytic coliform 2003. Kidney, red fox older than 6 months.	0/1	0/1	0/1	0/1	0/1	NT
Pasteurella multocida 2003. Lung, muntjac deer, older than 6 months.	0/1	0/1	0/1	0/1	0/1	0/1
Streptococcus equisimilis 2003. Abscess, hedgehog older than 6 months.	0/1	0/1	0/1	NT	NT	0/1

NT - not tested.

DISCUSSION

There were only low numbers of bacterial isolates tested from wild animal species. The detection of enrofloxacin resistance in *E.coli* and *Klebsiella pneumoniae* isolates from seals is interesting and may relate to treatment with fluoroquinolones in veterinary practices or wildlife centres. However, it is interesting to note that seals might be exposed to bacteria in sewage outflows and this might represent another potential source of such organisms. Only limited resistance was detected in the low number of bacterial isolates recovered from the other wildlife species.

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