

SALMONELLA IN LIVESTOCK PRODUCTION IN GB 2003

INTRODUCTION

This publication presents data on *Salmonella* reports from livestock species in Great Britain (England, Wales and Scotland) collected and collated by the Department for Environment, Food and Rural Affairs (Defra) during 2003 and also provides data from previous years for comparative purposes. The data in the first four chapters cover the reason for sampling and place of sampling, reports of *Salmonella* in livestock with separate sections for the main species covered, reports of *Salmonella* in livestock products and reports of *Salmonella* in animal feedingstuffs. The fifth chapter covers the antimicrobial sensitivity of *Salmonella* (England and Wales only).

Since 1993 the date of a *Salmonella* incident has been recorded as the date it was reported to an Officer of the Minister. Under the present system any *Salmonella* reports that are confirmed or identified after the publication of the annual report will be incorporated into the revised tables that appear in the following year's publication. This may cause the number of incidents and/or isolations to differ from that previously given for a particular year. The most recent version of the report should therefore always be used when comparing incidents from year to year.

Revisions in the way that data have been compiled and presented since 1993 mean that, with the exception of the tables on *Salmonella* in animal feedingstuffs, data in this report cannot be compared directly with information published prior to 1993. A more detailed comparison can be generated, if required, for any *Salmonella* serovar, phage type (in the case of *S. Enteritidis*, *S. Hadar*, *S. Pullorum*, *S. Thompson* and *S. Virchow*) or definitive phage type (in the case of *S. Typhimurium*). Requests for such data should be made to the Centre for Epidemiology and Risk Analysis (CERA), Veterinary Laboratories Agency, Weybridge who will be happy to assist with requests (s.a.kidd@vla.defra.gsi.gov.uk).

Care should be taken when comparing data from one year to another as an increase or decrease in the number of incidents and isolations does not necessarily indicate a similar change in prevalence. This is because the total number of samples examined and their distribution are not known.

STATUTORY ASPECTS OF *SALMONELLA* CONTROL IN GREAT BRITAIN

On 1 March 1989 the Zoonoses Order 1975 was revoked and replaced by the Zoonoses Order 1989. The 1989 Order added horses, deer and pigeons to the range of species from which *Salmonella* isolations are subject to reporting¹. Under the 1989 Order the responsibility for reporting the isolation of a *Salmonella* was placed on the laboratory carrying out the examination or in the case of examinations elsewhere, the person carrying out the examination. In practice, reports of *Salmonella* isolations must be made to the Senior Veterinary Investigation Officer at one of the Regional Laboratories of the Veterinary Laboratories Agency or to a Divisional Veterinary Manager in Scotland. If so required, the Department must be provided with a culture of the organism.

The requirement to test poultry for *Salmonella* on a regular basis under the Poultry Laying Flocks (Testing and Registration etc.) Order 1989 and the Poultry Breeding Flocks & Hatcheries (Registration and Testing) Order 1989, increased the number of examinations carried out from 1989 onwards. These two Orders were revoked in 1993 with the implementation of the Poultry Breeding Flocks and Hatcheries Order 1993, which brought *Salmonella* control measures in poultry into line with the European Union Directive 92/117/EEC, with the result that the level of monitoring in some poultry sectors altered. This needs to be borne in mind when examining long term data for poultry. This Order only applies to chickens in its requirement for regular monitoring of breeding flocks and hatcheries using methods laid down in the Order.

DEFINITION OF AN INCIDENT AND ISOLATION

In contrast to *Salmonella* in humans, many isolations of *Salmonella* from livestock are not associated with clinical disease, or occur on farm premises in which *Salmonella* has been isolated from a group of animals rather than an individual. Since 1993 reports of *Salmonella* from livestock have been separated into isolations and incidents. "Isolations" comprise individual reports of *Salmonella* made from samples and reported to Officers of the Minister. "Incidents" afford a truer picture of the amount of *Salmonella* in the animal population as they do not include repeat isolations of a serovar that may result from a number of samplings during the course of an investigation, or monitoring activities on a particular premises. Isolates, isolations and incidents are defined in the following way:

¹ *Salmonella* isolations from the following species must be reported to an Officer of the Minister: cattle, sheep, goats, pigs, rabbits, horses, deer, domestic fowl (chickens), turkeys, ducks, geese, guinea fowl, pheasants, partridges, pigeons and quail.

An isolate is a single culture of a particular *Salmonella*, and results from a single sample.

An isolation is defined as the report of the first isolate of a given *Salmonella* (defined by serovar, and/or phage type, if available) from the same group of animals on a given occasion. If two submissions from the same group of animals on different dates give the same serovar, this is reported as two isolations.

An incident comprises the first isolation and all subsequent isolations of the same serovar or serovar and phage/definitive type combination of a particular *Salmonella* from an animal, group of animals or their environment on a single premises, within a defined time period (usually 30 days).

The first such report of any particular serovar or serovar and phage/definitive type combination of *Salmonella* from a particular animal, group of animals or their environment will therefore be recorded as one incident and one isolation. Further reports of the same *Salmonella* from the same group during the incident investigation will be recorded as further isolations, but not as further incidents unless the isolation is from an epidemiologically distinct group of animals. Examples of this would include a distinct group of the same species on a separate part of the same premises. Reports of a different serovar or phage/definitive type of *Salmonella* from the same animals will be recorded as a new incident. Thus two reports of *S. Typhimurium*, one of DT104 and another of DT193, from the same group of animals would count as one incident and one isolation of *S. Typhimurium* DT104 and one incident and one isolation of *S. Typhimurium* DT193, whilst two reports of *S. Typhimurium* DT12 from the same group of animals would count as one incident but two isolations.

The concept of an "incident" is clearly inappropriate when referring to isolations from animal feedingstuffs or human foodstuffs of animal origin, so data for these are only reported in terms of isolations of *Salmonella*. With this in mind the tables reporting the reason for sampling and the place from which the sample originated have been divided to indicate the number of incidents for samples taken at premises other than slaughterhouses, and the number of isolations for samples taken at slaughterhouses or human food premises.

SEROTYPING AND PHAGE TYPING METHODS

Salmonella isolated from animals and feed is biochemically confirmed and serotyped by micro, tube and slide agglutination tests. Each culture is tested for the presence of somatic and flagella antigens by mixing with specific *Salmonella* antisera. Where homologous antiserum and antigen

react, clumps of bacteria form as visible agglutination. Serovars are derived by reference to the Kauffmann White Scheme. *Salmonella* Typhimurium, *S. Enteritidis*, *S. Hadar*, *S. Thompson*, *S. Virchow* and *S. Pullorum* are phage typed according to the Health Protection Agency phage typing schemes. Cultures are seeded onto special agar plates and a specific set of phages applied to the culture. After incubation the degree and pattern of lysis is read and a phage type or definitive type (for *S. Typhimurium*) attributed to the culture (Anderson and others 1977, Ward and others 1987).

Some phage types are 'related variants' although they are still reported as distinct types, eg. PTs 4 and 7 of *S. Enteritidis* and DT12, DT104, DT104b and U302 of *S. Typhimurium*.

NOMENCLATURE

The nomenclature used throughout this publication follows that devised by Le Minor and Popoff which divides the bacterial species *Salmonella enterica* into six subspecies: *enterica*, *salamae*, *arizonae*, *diarizonae*, *houtenae* and *indica*.

The method of naming serovars of subspecies *enterica* differs from that used for the other five subspecies in that the familiar serovar names are assigned to subspecies *enterica* whilst the other subspecies are designated by antigenic structure.

For example, following this method the serovar originally referred to as *S. typhimurium* is now known as *S. enterica* subspecies *enterica* serovar Typhimurium which may be shortened to *S. Typhimurium* and the naming of serovars of subspecies *diarizonae* is, for example, *S. enterica* subspecies *diarizonae* serovar 61:k:1,5,7 (or *S. 61:k:1,5,7*). For further details of this nomenclature see: Le Minor, L., Popoff, M.Y. (1987).

The serovar formally known as *Salmonella* Java has now been reclassified, on the basis of genetic similarity studies, as *S. Paratyphi* B variant (var.) Java. It is a group B *Salmonella* and has the same antigenic structure as *S. Paratyphi* B (O = 4, 12: H = b : 1.2). *S. Paratyphi* B var. Java and *S. Paratyphi* B are differentiated by the dextro-tartrate test, in which *S. Paratyphi* B var. Java produces a positive acid reaction, whereas *S. Paratyphi* B is negative.

FOOT AND MOUTH DISEASE EPIDEMIC 2001

On 20th February 2001, Foot and Mouth Disease (FMD) caused by the O1 Pan Asia strain of virus was confirmed in Great Britain. A Controlled Area Order was imposed across the whole of the country on 23rd February 2001, which prohibited the movement of livestock except under official control and banned livestock markets. During the subsequent epidemic 2,026 outbreaks were confirmed by laboratory testing and/or clinical diagnosis. The final confirmed outbreak was on 30th September 2001.

FMD was controlled by the slaughter of infected animals and animals that were judged to be dangerous contacts. More than three million adult sheep, 500,000 cattle and 140,000 pigs were killed, from more than nine thousand holdings. Approximately two million additional animals were slaughtered under the Livestock Welfare Disposal Scheme, bringing the total to more than 6 million adult animals, plus 3-4 million youngstock, mainly lambs (MLC estimate, 2001). On the basis that no cases of FMD had occurred for three months and extensive statistically based serological surveys, every administrative area in Great Britain had achieved FMD free status by 14th January 2002 – three and a half months after the last outbreak was confirmed. The European Commission recognised Great Britain's FMD-free status through Commission Decision 2002/153/EC of 20th February 2002 which repealed requirements to provide FMD related certification for intra-community trade. Further information about the 2001 FMD epidemic can be found on the DEFRA website <http://defraweb/footandmouth>.

The FMD epidemic impacted upon surveillance for *Salmonella* in two distinct ways. Firstly, the epidemic caused significant disruption to normal farming practice with unpredictable consequences for the incidence of *Salmonella* infection. Secondly, surveillance activities were constrained. VLA laboratories were unable to accept samples from infected areas and cattle, sheep or pig carcasses from any areas between late February and October 2001. Field visits were halted from late February 2001 but essential visits were later permitted providing strict Agency procedures were followed.

The peculiar circumstances of the FMD epidemic preclude any meaningful comparison of the *Salmonella* data for 2001 with other years. Therefore, these data have been visually highlighted in all tables and graphs that present information on an annual basis to emphasise the unusual nature of the 2001 data compared to other years.

Farms where all livestock were slaughtered due to FMD were able to re-stock during 2002. Livestock may have been purchased from multiple sources and these re-stocked herds would tend to contain a

preponderance of younger animals. These factors may have altered the risk of *Salmonella* infection entering a herd and of the subsequent transmission of infection within the herd.

NEW SALMONELLA DATABASE

A new integrated *Salmonella* recording and reporting system went live in January 2003. *Salmonella* data and test results are now entered into the VLA networked FarmFile database, which contains baseline data for all VLA submissions. Data entry has been de-centralised in England and Wales and is now entered at the Regional Laboratory receiving the submission. The VLA Sample Manager and Laboratory Information Management IT systems have been extended to incorporate the results of tests carried out on *Salmonella* isolates (group, serovar, phage type and antimicrobial resistance testing). The new system has replaced both the *Salmonella* incident recording system (ZO2 database) and the antimicrobial sensitivity database (Sentest). Automatic e-mail alerts are sent to relevant personnel when a *Salmonella* of potential public health importance is isolated, and the VLA Regional Laboratories and Government Veterinary Advisers have the ability to view data directly.

The new database was developed with the aim of facilitating the linkage of related data, to reduce the paper flow involved in reporting isolations and to avoid duplication of data recording and consequently reduce the potential for errors. The overall objectives were to improve the quality and timeliness of the information obtained from *Salmonella* cases, to make the data more accessible to those involved with deciding and implementing control policies, and to allow enhanced epidemiological analysis of the data.

Under the previous data recording systems an isolation was flagged as a new incident by the Nominated Officer dealing with the report, however the new *Salmonella* database automatically designates new incidents using a series of pre-defined criteria which are matched against those reported for previous isolations in the database. The criteria interrogated are: date (within 30 days of the previous isolation), serovar (and phage type if available), animal species, flock type (poultry) and the location from which the sample was taken. If the Nominated Officer indicates that the automatically-designated incident reference is not correct, for example, if he/she is aware that an isolation made more than 30 days after a previous isolation of the same serotype is, in fact, part of an ongoing incident, or that two isolations were made from different epidemiological groups, a 'manual over-ride' function can be used to ensure that the incident is identified correctly on the database. This report therefore includes incidents as

defined by the Nominated Officer, for submissions received until 31st December 2002 and incidents generated automatically, for submissions received from 1st January 2003 onwards.

Chapter 1

REASON FOR SAMPLING AND PLACE OF SAMPLING

Only some of the isolations of *Salmonella* reported to Defra have been responsible for outbreaks of clinical disease in livestock (60% in 2003). This is in contrast to data reported for *Salmonella* in humans, reports of which usually correlate with incidents of clinical disease. This chapter gives the reason why samples were taken and the place from which they originated (Tables 1, 2, 3 and 4). The majority of the incidents reported in chicken flocks are the result of statutory monitoring or surveillance activities; 67% in 2003. From 1993 to 1999 there was a marked increase in the proportion of incidents resulting from non-statutory surveillance of chickens, mainly broiler flocks. However since 2000 the proportion of incidents resulting from non-statutory surveillance has decreased, and there has been a corresponding increase in incidents reported as a result of statutory monitoring. *Salmonella* surveillance of healthy flocks is also a common practice in the turkey and duck industries. By contrast, the majority of *Salmonella* incidents reported from other species are the result of examinations carried out to diagnose clinical disease.

Tables 3 and 4 report incidents and isolations of *Salmonella* in relation to the place where the samples were taken. The majority of incidents reported result from samples taken on the farm (78%). However, 34% of incidents in chickens result from samples taken at hatcheries which are one of the locations at which samples are taken under the Poultry Breeding Flocks and Hatcheries Order (PBFHO) 1993. There were ten reports of *Salmonella* from samples taken at slaughterhouses in 2003, but no reports of *Salmonella* from human food-stuffs of animal origin sampled at premises other than a slaughterhouse.

Chapter 2

REPORTS OF *SALMONELLA* IN LIVESTOCK AND HUMANS

This chapter provides information on *Salmonella* isolated from livestock from samples taken on all premises, including farms, hatcheries, veterinary surgeries, zoos, slaughterhouses and human food premises. An overview of the number of incidents and isolations of *Salmonella* reported in farm animal species is given at Tables 8 & 9 and Figures 1 to 5. Poultry refer to reports from chickens, turkeys, ducks, geese and game birds.

For comparison purposes, data have been reproduced here on the number of laboratory reports of human isolations of *Salmonella* reported in England and Wales to the Health Protection Agency (HPA) Communicable Disease Surveillance Centre (CDSC) and in Scotland to the Scottish Centre for Infection and Environmental Health (SCIEH) (Tables 5 - 7). Clinical microbiology laboratories voluntarily report data and there are a number of factors which influence these reports. These are discussed in the Zoonoses Report UK 2003 (Defra 2004, in press).

Since 1998 tables have been produced comparing the relative frequency of *Salmonella* serovars in each animal species over the last five years. These data should be considered alongside absolute numbers of reports as the relative proportions may remain similar despite a change in number of reports, in which case we conclude that the change in number of reports is likely to be constant across serovars. Similarly, if there is a change in serovar relativity, it is only by examining changes in absolute numbers that we can ascertain the size of any increase or decrease. For example, in 2003 the total number of *Salmonella* incident reports increased by 17.6% compared with 2002 and increased by 1.8% compared with 2000. However, this was not consistent across serovars. Reports of *S. Typhimurium* increased by 1.4%, reports of *S. Senftenberg* fell by 39.3% and there was a small increase in the number of reports of *S. Enteritidis*. Therefore there was a change in the distribution of reports between these three serovars; the proportion of *S. Typhimurium* fell to 11.3%, the proportion of *S. Enteritidis* was little changed at 1.8% of all incidents and the proportion of *S. Senftenberg* reports decreased to 2.2% of all incidents. *S. Dublin* was, for the fourth year running, the most commonly isolated serovar from livestock in 2003, responsible for almost one third of reports. *S. Typhimurium* was the second most common type (11.3%). In 2003, *S. Livingstone* was the third, *S. enterica diarizonae* subspecies the fourth and *S. Indiana* the fifth most common.

Some serovars of *Salmonella* can infect a wide variety of host species, for example, *S. Typhimurium*. Others tend to be associated with particular animal species, for example, *S. Enteritidis* and poultry, *S. Dublin* and cattle

and *S. enterica diarizonae* subspecies and sheep. Thus the serovar distribution reflects the species distribution of reports. In 2003, 47.2% of reports were from poultry, 34.1% from cattle, 6.1% from pigs and 8.2% from sheep (see Figure 1). There were 28 reports of *Salmonella* from horses in 2003 and a single report from rabbits. There were no reports from either deer or goats in 2003.

Changes in the number of incidents have to be treated with caution in view of the inherent biases associated with the data collection. In particular, in 2001 the livestock industry was affected by an epidemic of Foot and Mouth Disease resulting in fewer clinical specimens being submitted for examination.

Tables 8 & 9 and Fig 1 show that in 2003 the total number of incidents of *Salmonella* reported rose by 471 (17.6%) compared with 2002 and increased by 985 (45.5%) compared with 2001.

The changes in the number of reports relating to cattle, pigs and turkeys mirrored those seen in livestock as a whole, but the number of reports from game birds and chickens fell compared with both 2002 and 2001 and the number of reports from sheep increased.

The relative frequency of reports of *S. Enteritidis* in 2003 (1.8%) was similar to 2002 (1.1%). There were 11 reports of *S. Enteritidis* in cattle, three reports in sheep, two reports each in pigs and horses, 6 in ducks and 36 in chickens in 2002. The decline in reports of *S. Enteritidis* which has been seen over the previous five years was reversed in 2003, specifically in chickens.

The frequency of reports of *S. Typhimurium* fell to 11.3% of all reports in 2003. The relative frequency of *S. Typhimurium* was reduced in cattle, sheep, chickens and turkeys, and little changed in pigs. There was a small increase in frequency of *S. Typhimurium* DT104 (53.2% of all STM reports) in cattle in 2003. *S. Typhimurium* DTs 166 and 169 and *S. Typhimurium* U311 were isolated in cattle for the first time since recording began in 1985. *S. Typhimurium* U315 was isolated from pigs for the first time since recording began in 1985.

The number of incidents of *S. Dublin* reported in cattle increased by 20.3% in 2003, much of which was due to an increase in reports from cattle of unknown age. The proportion of incidents of *S. Dublin* in cattle also increased in 2003 and this serovar was again the most common reported in cattle (78.9%).

Salmonella Virchow is a serovar often isolated from human cases of salmonellosis in Great Britain in, but is less frequently isolated from

livestock and only 88 incident reports were recorded in 2003 (2.8% of all *Salmonella* incidents in livestock) (Table 8). However, reports of *S. Virchow* increased in chickens and turkeys in 2003 to 9.3% and 4.2% of all incidents respectively.

Reports of *S. enterica* subspecies *diarizonae* (mainly from sheep) rose by 24% and for the fifth year running *S. enterica* subspecies *diarizonae* 61:k:1,5(7) was the most common serovar isolated from sheep (53.7%).

These trends and others are highlighted further in the relevant species sections.

Table 5 ranks the most common *Salmonella* serovars isolated from livestock in Great Britain in 2003 against the most common serovars isolated from human cases of salmonellosis in Great Britain. Tables 6 and 7 provide a similar comparison for phage types of *S. Typhimurium* and *S. Enteritidis* in livestock and humans. Apart from *S. Typhimurium* and *S. Enteritidis* the other serovars associated with human cases are reported relatively rarely from British livestock. The total number of isolation reports to the HPA from human cases of salmonellosis increased by 3.8% in 2003.

Perhaps the most important factor which may bias the number of *Salmonella* reports is the submission rate. This report presents numerator data but the denominator, in most cases, is unknown and may change over time. Most *Salmonella* incident reports from cattle, sheep and pigs result from the investigation of clinically diseased animals. Economic factors may exert a strong influence on diagnostic practices, such as whether a veterinary surgeon is consulted and whether samples are submitted for laboratory examination, and 2003 again saw a depressed livestock industry.

Diagnostic submissions to the Veterinary Laboratories Agency (VLA) and the Scottish Agricultural Colleges (SAC) have declined in recent years and were particularly affected in 2001 by the epidemic of Foot and Mouth Disease during which the testing of carcass samples from all areas and all samples from infected areas was suspended for a number of months (see Introduction). Despite increases in the number of submissions received in 2003 compared with 2002, over the five year period since 1999 cattle submissions have fallen by 7.1% and sheep submissions by 4.9%. Submissions from pigs have continued to decline steadily since 1998 (by 17.8% over the five year period) (VLA 2004). Additionally as most of the data from species other than poultry relate to clinical investigations, the prevalence of subclinical infection in these species of livestock is not usually known. A targeted national abattoir survey provides data for the period 1999 – 2000 on the prevalence of *Salmonella* in prime cattle, sheep

and pigs at slaughter in GB. Results of this survey are given in Chapter 3. Results of a similar survey conducted in 2003 will be available in late 2004.

Changes in the denominator population for *Salmonella* reports from poultry, particularly chickens, turkeys and ducks, are difficult to assess and most sample submissions are associated with statutory or voluntary surveillance activities. Statutory monitoring of chicken breeding flocks for *Salmonella* detailed in the PBFHO 1993 has been supplemented by additional voluntary testing of many flocks in recent years. Turkeys and duck breeding flocks undertake voluntary monitoring for *Salmonella* following protocols in the PBFHO 1993 and there is also some voluntary monitoring in production flocks. Therefore, it is likely that there has been an increase in surveillance of poultry flocks for *Salmonella* over the five year period. Of particular note is the continued increase in surveillance of duck flocks for *Salmonella* over the past two years. The assessment of submission rates in poultry is further complicated by the large proportion of *Salmonella* testing undertaken by private laboratories. In 2003, the total number of poultry diagnostic submissions (to VLA/SAC laboratories) remained static having fallen in 2002 to the lowest level ever recorded.

Although trends in *Salmonella* reports can be compared with diagnostic submission rates to VLA/SAC it should be remembered that not all submissions will have been examined for *Salmonella*. Private laboratories also report the isolation of *Salmonella* and the total number of submissions to these laboratories is unknown.

Livestock population data are reported by the June Agricultural Census and trends in *Salmonella* reports can be compared with changes in the animal populations by consulting these data. The numbers of cattle, sheep and pigs in Great Britain fell in 2003 but there was an increase in the numbers of poultry.

The VLA *Salmonella* database has clearly identified past epidemics of *Salmonella* strains in livestock including *S. Enteritidis* PT4 (Fig 33) in chickens and *S. Typhimurium* DT104 (Fig 7) in cattle both of which are still in decline.

Chapter 2.1

REPORTS OF *SALMONELLA* IN CATTLE

Results are given for adult cattle (10 months of age and older), calves (less than 10 months of age) and cattle of all ages (adult cattle, calves and cattle of unknown age). All isolations are recorded by the age of the individual animal. If an incident involves both adult cattle and calves then the age of the index case is used to classify the incident. For example, an incident affecting calves and adults in which the first case was reported in a calf would be reported as a calf-associated incident, but all isolations would be recorded separately for calves and adult cattle. It is therefore possible that the number of incidents of a particular serovar in one age class may be zero, although several isolations are listed.

There were 8.83 million cattle in Great Britain in 2003, 2% more than in 2002 and 1% less than in 2001. Over half a million adult cattle were slaughtered during the FMD epidemic in 2001. 605,816 cattle were slaughtered in the Over Thirty Months Scheme (OTMS) of the Government's control programme for Bovine Spongiform Encephalopathy (BSE) in the period up to the end of 2003. There have been some changes in the cattle industry with fewer larger farms staying in business in recent years and in some areas more male calves are being kept alive and reared either on their farm of origin or other farms than in recent years. Larger farms with increased numbers of young calves could potentially increase the risk of *Salmonella* isolations. Additional changes post-FMD include increased requirements to clean and disinfect vehicles and livestock movement restrictions, both of which would be expected to have reduced *Salmonella* transmission between premises in recent years, if sustained.

Although there has been a general decrease in the number of diagnostic submissions from cattle reported to the VIDA database in recent years, this number increased in 2003 to a number (45,496) similar to those seen prior to the FMD epidemic (46,868 in 1999; 43,714 in 2000). In 2001 there were fewer diagnostic submissions (31,280) due to the epidemic of FMD (see Introduction). Many farms that were de-populated during the FMD epidemic have been re-stocked and in some cases clinical disease including salmonellosis was reported subsequently. Additional changes post-FMD include increased awareness of the requirements to clean and disinfect vehicles, and additional livestock movement restrictions etc. *Salmonella* data for 2001 are included in italics in the tables because it is not possible to evaluate temporal trends using the 2001 data because of the uncertain impact of FMD control measures.

There is no routine *Salmonella* monitoring of cattle in Great Britain, therefore the majority of isolates come from cattle with clinical disease. The

number of reports is dependent on the total cattle population and number of diagnostic submissions to government veterinary laboratories, both of which have decreased in recent years. As in previous years, the majority (93%) of *Salmonella* incidents (n = 1087) reported in cattle were from samples taken for clinical diagnostic purposes (see Table 1, Chapter 1) and came from cattle on farms.

There were 17% more *Salmonella* incidents in cattle reported in 2003 (1172) than in 2002 (1004). However, there was a 26% increase in the number of cattle submissions from which a diagnosis of *Salmonella* could have been made (from 8180 in 2002 to 10291 in 2003). This may be partly related to increased submission numbers, but is possibly also due to the differences in the way that incidents are allocated by the new computer system (see Chapter 1). Some serovars were reported in cattle in 2003 for the first time in the last five years including *S. Goerlitz*, *S. Kimuenza*, *S. Oslo*, *S. Stanley*, *S. Stourbridge* and *S. Paratyphi B dT⁺* (var Java). There were a further three incidents of *S. Vejle* infection affecting adult cattle (all in the first quarter), reported for the first time in cattle in 2002. Of the 1172 *Salmonella* incidents in cattle, 41% were in adult cattle, 36.5% in calves and 22.5% in cattle of unknown age. For the fifth year, *S. Dublin* was the most common (79% of incidents) serovar reported in cattle and was the second most common *Salmonella* reported in sheep (see Chapter 2.2).

***Salmonella* Dublin**

For the fifth consecutive year, *S. Dublin* was the most common serovar in adult cattle (74% of incidents; Figure 8) and calves (85% of incidents; Figure 10). The relative proportion of *S. Dublin* in adult cattle decreased slightly (from 76 to 74%), as did the relative proportion of *S. Typhimurium* (from 14 to 13%) in 2003 compared to 2002 (Table 12). In contrast, although *S. Typhimurium* reports decreased in calves (from 12% to 8%), the relative proportion of incidents due to *S. Dublin* increased from 81 to 85% (Table 14). There appears to be regional differences in reports, with the majority of *S. Dublin* incidents being reported in Wales and North West England with a few reports from South West England. There continues to be a seasonal increase in the number of incidents during September to October (see Figure 6). *Salmonella* Dublin infection is associated with sporadic cases as well as outbreaks of disease, including enteric or reproductive disease in adult cattle and pneumonia or septicaemia in calves. Nervous signs have been recorded in calves. *S. Dublin* was the second most common infectious cause of bovine fetopathy in GB (11% of diagnosed submissions; VIDA 2003).

***Salmonella* Typhimurium**

There is a continuing decline in the number of reports of *S. Typhimurium* in cattle (Table 10). The proportion of *Salmonella* incidents due to this serovar, which is steadily declining, is similar to that in 2002 in adult cattle (13%) but has declined further in calves to 9% (Tables 12 and 14). Several definitive types (DT166, DT169, U288 and U311) were reported in 2003 for the first time in the last five years (Table 15). The DT U288 strain, showing multiple antibiotic resistance, was isolated from the faeces of two-week old dairy calves with diarrhoea. A multiple resistant DT104 was isolated from an incident in which 7 cows and 10 calves died. DT104 remains the most common definitive type (59% of incidents, including DT104b), and is usually found in dairy cattle. Forty-one per cent of incidents were due to non-DT 104 phage types. One incident of *S. Typhimurium* in dairy calves was linked with contamination of feedstores with cat faeces.

Other serovars

Salmonella Enteritidis, *S. Hadar*, *S. Thompson* and *S. Virchow* are phage typed routinely. There were 11 reported incidents of *S. Enteritidis* (Table 18). These comprised one incident each of PT 1, 7,8 and 13a in adult cattle, two incidents of PT13a and one of 6a in calves, and two incidents of PT13a and one each of PT4 and PT11 in cattle of unknown ages. All these phage types of *S. Enteritidis* have been reported in cattle in the last five years except PTs 7 and 8 which were last reported in cattle in 1998. There was one incident of *S. Hadar* PT9, the first since 1997 (Table 21), one incident of *S. Thompson* PT3, the first in the last 10 years (Table 23) and no incidents of *S. Virchow* (Table 23). There was a continued increase in the number of *S. Anatum* incidents, particularly in adult cattle (4.4% incidents; Table 12). This serovar was isolated from cases of sporadic peri-parturient dysentery in four dairy herds with no direct links, but in an area noted for its large population of waterfowl.

Salmonella Goerlitz (since 1998), *S. Kimuenza* (since 1997), *S. Oslo* (since 1996), *S. Stanley* (since 1998), *S. Stourbridge* (since 1998) and *S. Paratyphi B dT⁺* (var Java) (since 1996) were reported in cattle (adult and other ages) for the first time in recent years. *Salmonella* Kottbus had never been isolated from cattle during routine surveillance until 2002, and one further incident was reported in 2003. *Salmonella* Vejle had never been reported from cattle until 2002, and was also responsible for three incidents in 2003. This serovar was last reported in 1990 from chickens and has been seen infrequently in a variety of livestock species and human beings in different countries including Germany, Senegal and Israel. The three incidents of *S. Vejle* originated in the same dairy/dealer enterprise and were associated with clinical disease and mortality in adult cattle, particularly peri-parturient cattle.

Salmonella Agama was reported in 13 incidents in cattle, in one case linked to *S. Agama* infection in a badger.

There were 6 incidents of *Salmonella* Newport in cattle, representing 1% of incidents in adult cattle, a slight decrease from 2002. There were no incidents of *S. Newport* in calves in 2003. None of the isolates were resistant to eight or more antimicrobials which is typical of multiple drug resistant *Salmonella* Newport (MDRSN). This latter strain has not yet been reported in GB, but is causing concern in the USA because of its effect in livestock, particularly cattle, and its public health importance (Rankin and others 2002). MDRSN has reduced sensitivity to ceftriaxone, in addition to resistance to at least 8 antimicrobials. In affected dairy herds in the USA, adult cows are reported to have a watery diarrhoea and rapid drop in milk production and clinical signs are often present around calving time. Morbidity and mortality has also been seen in calves on some farms. Like other *Salmonellae*, asymptomatic carriage of the organism occurs (http://www.aphis.usda.gov/vs/ceah/cahm/Food_Safety/foodsfs.htm). The VLA, in collaboration with other organisations, has established case definitions and protocols for fast-tracking the identification and reporting of the organism. In addition, new sampling protocols and epidemiological questionnaires have been developed to be used by the Nominated Officers investigating incidents associated with MDRSN.

An outbreak of salmonellosis in calves associated with a multiple antibiotic resistant strain of *Salmonella* Paratyphi B variant Java (*S. Java*) occurred in October 2003 (Evans and others, submitted 2004). In this incident, multi-resistant *S. Java* was isolated from a group of scouring calves on a calf unit in South West England. Of a group of 300 calves, 8 to 10 one-week old calves were clinically affected with a dark scour, and 5 or 6 of them were reported to have died. An isolate of *S. Java* PT3b var. 2 was obtained, which was resistant to ampicillin, chloramphenicol, streptomycin, sulphonamides, tetracycline, trimethoprim and cefoperazone (ACSSuTTmCfp). This is the first report of *S. Java* with this resistance pattern in Great Britain, and *S. Java* was last isolated from cattle in this country in 1996. There has been a dramatic increase in multi-resistant *S. Java* isolations from poultry in some Member States, and it has become widespread and difficult to control. The HPA reports 100-200 isolates of *S. Java* per year in human beings in Great Britain. Further investigations (carried out in early 2004) included a longitudinal study on the index premises and visits to farms linked to it by animal movements.

Chapter 2.2

REPORTS OF *SALMONELLA* IN SHEEP AND GOATS

Sheep

33.6 million sheep were kept in GB in 2003, which is roughly equal to the number recorded in June 2002. In general the number of diagnostic submissions from sheep reported to the VIDA database has decreased in recent years, but slightly more samples were submitted in 2003 (10,728) than in 2002 (9,165). This reflects a significant increase in submissions over 2001 (6,545) when many sheep were slaughtered for control and welfare reasons during FMD, and is approaching the number recorded in 2000 (11,000).

There was a 56% increase in the number of *Salmonella* incidents reported in sheep in 2002 compared with 2001, back to similar levels observed in the years preceding the FMD epidemic. This trend was continued in 2003, with a 35% increase in *Salmonella* incidents in sheep over the number reported in 2002. The number of incidents in sheep in 2003 (274) is the highest recorded, although this may be partly due to the way in which incidents are allocated by the new system. The majority (91%) of the reports originated from diagnostic submissions and most of them (99%) were from sheep on farms (Table 1, Chapter 1).

Salmonella enterica* subspecies *diarizonae

Salmonella enterica subspecies *diarizonae* serovar 61:k:1,5,7 (and associated incomplete antigenic structures) continues to be the most common serovar reported in sheep, constituting 57% of all incidents in 2003, compared to 62% in 2002 (Table 25). Half of the 70 abortion incidents involving *Salmonella* in 2003 were associated with *S. diarizonae*. *Salmonella diarizonae* is associated with diarrhoea and abortions, but can be isolated from sheep with other infections (eg coccidiosis, *Nematodirus*, and fluke) and from healthy sheep.

***Salmonella* Dublin**

As observed in cattle, reports of *S. Dublin* remain high (15% of ovine incidents), but the proportion has reduced from the 19% of incidents observed in 2002 (Table 25, Figure 19). This serovar has been the second most common *Salmonella* isolated from sheep in recent years. These incidents have occurred in different counties in Great Britain. Sixteen incidents of *S. Dublin* with a presenting sign of ovine abortion were

reported in 2003. The other 26 incidents of *S. Dublin* were associated with other clinical signs, most commonly diarrhoea. Incidents have occurred throughout GB, but particularly in the North and West with the highest number in Wales. There was a small decrease in the proportion of abortions that were attributed to *S. Dublin* in 2003 (1.8%) compared with 2002 (2.5%) (VIDA 2003). Several outbreaks due to *S. Dublin* were associated with significant morbidity and mortality in ewes and lambs. In some of these incidents *S. Dublin* had been isolated from cattle on the same premises in previous years, but other outbreaks have occurred in sheep kept without any known contact with cattle.

***Salmonella* Typhimurium**

The proportion of incidents due to *S. Typhimurium* continued to fall (4% in 2003; Figure 19) due to low numbers of DT104 compared with the number of incidents reported in the 1990s. However, DT104 remains the most common (6 of 11 incidents) definitive type (Figure 20). In one incident, multiresistant DT104 was isolated from the intestines of week-old lambs, 50 of which had died. Definitive types 40, 41 and U288 were reported in sheep in 2003 for the first time in five years. *S. Typhimurium* is generally more commonly associated with sudden death and diarrhoea than abortion.

Other serovars

There continue to be changes in the relative frequency of other serovars. *Salmonella* Montevideo was isolated from 26 incidents, double the number in 2002, of which 16 were associated with abortion. No clinical disease was reported to be associated with this serovar in 2002. *Salmonella* Agama was reported thirteen times and *S. Derby* eleven times in 2003, the latter compared with only once in 2002; these serovars are also associated with ovine abortion. One incident of *S. Derby* was associated with enteritis in lambs, which were kept in a building which had previously housed pigs. *Salmonella* Give, *S. Nagoya* and *S. Oslo* were isolated for the first time in sheep. There were three isolations of *S. Enteritidis* (PTs 1, 11 and 14b), and one each of *S. Newport* and *S. Thompson*. *Salmonella* Livingstone, which is more commonly isolated from poultry, was recovered from a group of two-to-three month-old lambs with intermittent diarrhoea and ill-thrift. *Salmonella* Durham, a serovar more commonly associated with wildlife, was isolated from a group of aborting ewes. There have been no reports of *S. Hadar*, *S. Virchow*, *S. Amsterdam*, *S. Mbandaka*, *S. Reading*, *S. Rubislaw* or *S. Stourbridge* in sheep in the last five years.

Goats

86,000 goats were kept in Great Britain in 2003. There were no incidents of salmonellosis recorded in goats in 2003. There was a decrease in the number of diagnostic submissions from goats in 2003 (588) compared to 2002 (668), with numbers remaining lower than in previous years (eg 873 in 1998; 752 in 2000; [VIDA 2003]).

Chapter 2.3

REPORTS OF *SALMONELLA* IN PIGS

The British pig industry's decline continued in 2003 and the June census showed that there were 510,000 breeding sows. This was a 2% decrease since the end of 2002 compared to an approximately 5% reduction when data from 2002 were compared to 2001, suggesting that the rate of the decline may have reduced. There were 9.11 million clean pig slaughterings, a fall of 11% on the previous year and the lowest level recorded since 1956. Consumer demand increased by 2% overall and this combined with the reduced British production resulted in a 22% increase in pork imports.

During 2003 there were 3,269 submissions to VLA's Regional Laboratories for the investigation of clinical disease on pig farms. A total of 213 incidents of *Salmonella* infection were detected although these were not all associated with clinical disease. Clinical signs were most commonly reported as diarrhoea with respiratory disease being the second most frequently reported clinical sign. In one case, on an organic farm, multiresistant *Salmonella* Typhimurium DT193 was isolated from weaners that were experiencing ill-thrift, respiratory disease and death. This unit was also affected by post-weaning multisystemic wasting syndrome (PMWS).

The Zoonoses Action Plan (ZAP) Salmonella Programme is run by an industry body, the British Pig Executive (BPEX). It monitors the exposure of pigs to *Salmonella* through an enzyme-linked immunosorbent assay (ELISA test) for antibodies to group B and C1 *Salmonella* in meat juice. In the year to the end of June 2003, approximately 25% of 83,094 meat juice samples were positive. Since July 2003, all farm assured holdings where 15 samples were reported in the previous three months were assigned a ZAP level as follows:

- ZAP level 3: 85% or more of meat-juice samples were positive
- ZAP level 2: Between 65% and 85% of meat-juice samples were positive
- ZAP level 1: Less than 65% of meat-juice samples were positive.

Farms with ZAP level 2 or 3 designations must act to reduce these or ultimately face the loss of their quality assured status. Further information is available from the BPEX website www.bpex.org.

A cross-sectional study of 107 randomly selected British pig farms was conducted in 2003 by VLA as part of a Defra-funded research project. Pooled faecal samples were collected from up to 30 pens on each farm

and up to 40 meat juice samples were collected from slaughtered pigs from each farm. The results showed that on 56 of these farms (52%), fewer than 10% of pooled pen faecal samples were positive for culture of *Salmonella*. The predominant serovars were *S. Typhimurium* and *S. Derby*. The two most frequent phage types of *Salmonella Typhimurium* to be identified were U288 (21 farms) and DT193 (20 farms). As noted later, U288 was the most frequent phage type found in surveillance data in 2003 whilst DT193 was the most frequent phage type to be identified in 2002. The prevalence of meat juice positive samples was 20% or less on 52 of 101 of these farms (51%). It should be noted that samples obtained for research purposes are not included in the surveillance data presented in the remainder of this chapter.

The number of incidents and isolations of *Salmonella* reported from pigs is shown in Table 31. Table 32 gives the proportion of the five most frequently isolated serovars in 2003 and of these serovars in the preceding four years. *Salmonella Typhimurium* remains the most frequent isolate and was detected in 153 incidents (71.8%), which is virtually identical to 2002 when it was isolated from 71% of incidents. *Salmonella Derby* was once again the second most frequent serovar to be isolated (28 incidents; 13.1%), which was an increase on 2002 when it was isolated from 7.7% of incidents.

Six serovars have not been isolated from pigs since 1998 and these have been dropped from Table 31. These were *S. Carno*, *S. Give*, *S. Kentucky*, *S. Newington*, *S. Schwarzengrund* and *S. enterica diarizonae* (a single unspecified "arizona" was isolated in 1998). *S. Idikan* and *S. Saint Paul* were each isolated on one occasion and these were the first isolates from pigs since 1997 and 1998 respectively.

Table 33 reports the definitive phage types of *S. Typhimurium* that were isolated between 1999 and 2003. Three definitive types have not been isolated since 1998 and are not listed. These were DT29, DT30 and DT204. The most frequently isolated serovar was *Salmonella Typhimurium* U288 which was identified in 51 incidents (33.3%) compared to 8 out of 148 incidents (5.4%) in 2002.

Chapter 2.4

REPORTS OF *SALMONELLA* IN DEER, HORSES AND RABBITS

There were no reports of *Salmonella* in deer in 2003 (Table 37). A total of 28,160 deer were registered in GB in the Livestock Census, which was 5480 less than in 2002. Deer, together with rabbits, are included in statutory reports of *Salmonella*, because they may be commercially raised for human consumption.

One incident of *S. Kedougou* was reported in rabbits in 2003 (Table 40), representing the first case of *Salmonella* in rabbits since 2000.

S. Kedougou has not previously been reported in rabbits in Great Britain, but has frequently been reported in many livestock species.

A total of 28 *Salmonella* incidents were reported from the 288,830 horses on agricultural holdings in Great Britain in 2003 (Table 38). This is less than in 2002 (35) and 2000 (55). *S. Typhimurium* (54%) dominated again, but represented fewer cases than the previous years (63% in 2002 and 62% in 2000). The most common definitive type *S. Typhimurium* was DT56, as previously. DT49 was reported for the first time since 1998, whereas all others have been reported within the last two years (Table 39).

This year *S. Agama* (5) was reported as the second most common serovar in horses instead of *S. Enteritidis* (2) (Table 38). *S. Brandenburg* was reported for the first time in horses in 2003, but has previously been reported in cattle, sheep, pigs, poultry and humans. *S. Oslo* was reported for the first time in GB since 1996. All other *Salmonella* serovars were only reported once this year and had all been reported previously in horses.

Chapter 2.5

REPORTS OF *SALMONELLA* IN POULTRY

Poultry are subject to a number of statutory and voluntary testing programmes for *Salmonella*. The Poultry Breeding Flocks and Hatcheries Order (PBFHO) 1993 requires regular monitoring of breeding flocks throughout their lifespan by bacteriological sampling of composite faeces at farms and testing of progeny at hatcheries, following standardised sampling protocols and laboratory methods. In addition to the statutory scheme, an increasing number of commercial companies operate voluntary testing schemes, particularly involving broiler production and table egg laying flocks. This is reflected in the data presented in Table 1 which show that, in contrast to other species, the largest number of reports of *Salmonella* from poultry are the result of surveillance activity rather than the investigation of clinical disease (69% of *Salmonella* submissions from chickens, turkeys and ducks resulted from voluntary surveillance activities). Most incidents in poultry are therefore not associated with clinical disease but with identification of subclinical carriage of *Salmonella*.

The numbers of incidents and isolations of *Salmonella* reported from poultry species are shown at Tables 41, 42, 51, 52, 56, 57, 62 and 63. The uncertain effect of the GB epidemic of Foot and Mouth Disease on diagnostic sampling and laboratory submissions for *Salmonella* examination may limit the comparability of 2001 data with other years. Statutory monitoring of chicken breeding flocks and hatcheries for *Salmonella* continued during the FMD epidemic but with some disruption. The number of poultry diagnostic submissions to VLA/SAC laboratories rose by 2.8% in 2003 (1,825 submissions) compared to 2002 (1,775 submissions), but was still below the 2001 level of 1,974.

Vaccines against *Salmonella* Enteritidis and *S. Typhimurium* are now very widely used in the commercial layer sector and are also used in broiler breeders. Their use will have undoubtedly contributed to the control of *Salmonella* in poultry flocks.

Chickens

There were 142.7 million chickens in GB reported in the June 2003 census, compared with 130.5 million in 2002. Table 41 shows that the number of reported incidents of *Salmonella* in chickens in 2003 (796) was slightly lower than the number in 2002 (869). The majority of incidents arose from private surveillance of broiler flocks by the poultry industry. Because the amount of private testing has increased by an unknown quantity in recent years it is difficult to interpret long term trends.

Approximately 60,491 *Salmonella* tests were performed under the monitoring requirements of the PBFHO 1993 and 141 (0.23%) were positive for *Salmonella*. This compares to 0.22% positive in 2002. The organism was isolated most frequently from day old chick carcasses and was isolated from three out of 2923 composite faeces samples (0.1%) collected when the chicks were four weeks of age.

The number of reports of *Salmonella* from statutory monitoring of chicken breeding flocks continued to decline and only 15 incidents were reported in 2003 (Table 1). In contrast to 2002, there was a decrease in reports associated with voluntary surveillance activities, which in 2002 represented 94% of all reports from chickens but in 2003 represented 65% of reports, and there was a marked increase in reports associated with clinical disease (from 5.6 to 28.6% of all reports) (Table 1). The reasons for this increase are being investigated, but may in part be due to changes in data recording which have occurred with the new *Salmonella* database.

***Salmonella* Enteritidis**

Numbers of reports of this serovar had been declining steadily since 1996, except for a small increase in reports in 1997 (Fig 33). In 2002, only 11 incidents were reported; but this rose to 36 in 2003. These represented 4.5% of all *Salmonella* incident reports in chickens. The reported phage types were: PT4 (20 incidents), PT6 (seven incidents), PT6a (five incidents), and one incident each of PTs 1, 7 and 12. One isolate was not phage-typed. These incidents included two incidents in breeding flocks (PTs 6 and 6a), four incidents in broiler flocks (two each of PTs 4 and 6) and 23 incidents in laying flocks (14 of PT 4, 3 of PT 6 and 6 others).

***Salmonella* Typhimurium**

There were 17 reported incidents of *Salmonella* Typhimurium in 2003 (from a total of 17 flocks), a decrease of 53% compared with 2002. Reports of *S. Typhimurium* represented 2% of all reports, a decrease compared with recent years (Fig 33). The most common phage type was DT104 (7 incidents: 41%), but other definitive types reported were: DT193 (two incidents), DT193a (two incidents), U302 (two incidents) and single incidents of DTs 2, 49, U317 and RDNC. There was one report of DT104 from a layer flock in 2003, one from a breeding flock, and the remainder were isolated from broiler flocks.

Most reports of *S. Typhimurium* arise from voluntary surveillance of broiler flocks. There was one report of Typhimurium (DT104) in a breeding flock in 2003.

Other Serovars

The most common serovar isolated from chickens in 2003 was *S. Livingstone* (15.6% of all chicken incidents). In addition there were 112 reports of *S. 6,7:-*, which are likely to be *S. Livingstone* (these are not shown separately in Table 41, but are included under “structure only”). Reports of this serovar have risen in recent years. Most reports were from broiler flocks, but there were 7 incidents reported in broiler breeder flocks.

The number of reports of *S. Virchow* rose by 57% compared with 2002, making it the second most commonly reported serovar (9.3% of incidents). Of 74 reports, the most common phage types were PT2 (68%) and PT4 (22%). There were 43 reports of *S. Virchow* from broiler breeder flocks and the remaining 31 incidents were from broilers; most reports were associated with a single poultry company. The number and proportion of reports of *S. Senftenberg* fell in 2003; it was the third most commonly reported serovar. Other common serovars (~5-6% of total each) were *S. Kedougou*, *S. Montevideo*, *S. Ohio* and *S. Mbandaka*. There were 28 reports of *S. 4,12:d-* compared with none in 2002. These are possibly a variant of monomorphic *S. Schwarzengrund* and were largely associated with investigations in one company. There was a decrease in reports of *S. Binza*, *S. Heidelberg*, *S. Give*, *S. Hadar* and *S. Thompson* compared with 2002.

There were 6 reports of *S. Hadar* (PT's 2, 10, 14 and 22) in 2002, five from broilers and one from a broiler breeder flock. There were two reports of *S. Pullorum*, both from backyard flocks of traditional British laying hens. There were 7 reports of *S. Newport* in 2003, five from broiler flocks and two from broiler breeders; none were associated with multiple antibiotic resistant strains (resistance to ≥ 4 antibiotics) and there was no evidence of resistance to third generation cephalosporins.

Salmonella *Carno*, *S. Reading*, *S. Stourbridge* and *S. Meleagridis* were isolated from chickens for the first time in the last 10 years. *Salmonella* *Braenderup* was isolated for the first time since 1999. There was an increase in reports of *S. Agama*, *S. Anatum*, *S. Havana*, *S. Infantis* and isolates for which structure only was obtained. These serovars were isolated from broiler breeder flocks as well as broiler flocks in 2003 and none were as a result of monitoring in any one particular poultry company.

National trends in *Salmonella* in chickens are difficult to interpret since a large proportion of reports of a specific serovar may originate from a small number of large integrated companies. Most incidents were identified by private environmental sampling of broiler farms when the birds were two to five weeks of age.

Turkeys

Table 51 shows a large increase (150%) in the number of incidents of *Salmonella* reported in turkey flocks in 2003. 15% of reports were associated with clinical disease; the remainder arose through voluntary surveillance activities. This increase may possibly reflect increased monitoring within companies. The most common serovar reported in 2003 was *S. Montevideo* (18.5% of incidents). The number of reports of *S. Indiana* increased from 9 in 2002 to 37 in 2003, and it became the second most commonly reported serovar (12% of incidents). *Salmonella* Typhimurium, the most common serovar reported in turkeys in 2002, was the third most commonly reported serovar in 2003. All but one of the 32 incidents (74%) involved DT104. There were no reports of DT104b for the second consecutive year; this previously common definitive type was also not reported from chickens in 2002 or 2003. U288 was reported for the first time in 2003. This strain has been reported with increasing frequency from pig herds in recent years.

There were no reports of *S. Enteritidis* from turkey flocks in 2003.

There was an increase in the number of reports of *S. Newport*, but a decrease in the proportion from 2002 (from 18% to 10% of reports). There is little evidence for any trend over the last five years and no reported resistance to 3rd generation cephalosporins. Other common serovars reported were *S. Agona*, *S. Derby*, and *S. Kottbus*. *Salmonella* *Corvallis*, *S. Manhattan*, *S. Menston* and *S. Virchow* were reported for the first time in turkeys since 1995. The latter serovar also increased markedly in chicken flocks in 2003.. There were no further reports of *S. Anatum*, *S. Taksony* or *S. Stanley*, which were isolated for the first time in recent years in 2002; however, there was one report of *S. Meleagridis*.

Ducks and Geese

There were no reports of *Salmonella* from geese in 2003.

The increase in reports of *Salmonella* from ducks seen in 2002 was sustained in 2003 – the number of reports increased by 54% compared with 2002. These represented 1.5% of all reports in 2001 compared with 8.3% in 2002 and 10.4% in 2003. This is the result of enhanced voluntary surveillance activities by the duck industry (Table 1). Only a third of incidents were reported to be associated with clinical disease. However, this proportion has increased in 2003 from 7% in 2002. As with the chicken data, the reasons for this increase are being investigated, but may in part be due to changes in data recording which have occurred with the new *Salmonella* database.

The most common serovars reported were *S. Indiana* (29%), *S. Binza* (15%), *S. Livingstone* (12%), *S. Orion* (11%), and *S. Hadar* (8%) . The relative proportion of these serovars changed slightly from 2002, with incidents of *S. Livingstone* increasing from 15 (6% of incidents) to 41 (12%). The number, but not proportion, of isolates of *S. Hadar* remained relatively constant; the most common phage types were PT11 and PT22. A variety of other serovars were reported, the number of incidents of *S. Give* and *S. Kedougou* had increased compared with 2002. There were no new serovars reported in ducks in 2003.

There were 13 reports of *S. Typhimurium*, a slight increase over previous years. The most common phage type was DT8 (10 reports) and there were three reports of DT30. There were no reports of DT104 or DT104b. There were 6 reports of *S. Enteritidis* in ducks, decrease of 45% compared to 2002; all were PT9b.

Game Birds

Reports of *Salmonella* in game birds decreased by 33% in 2003, continuing a long term trend. Most reports were associated with clinically diseased pheasants and, as in previous years, most reports were associated with *S. Binza* or *S. Orion* (63%). There were two incidents of *S. Enteritidis* PT13a in pheasants. There was only one report of *S. Typhimurium* (DT104b) which was from pheasants. There were three reported incidents of *S. Pullorum* associated with clinical disease in pheasants.

Chapter 3

REPORTS OF *SALMONELLA* IN LIVESTOCK PRODUCTS

This chapter contains, as in previous years, information on reports of *Salmonella* from animal products. Isolations of *Salmonella* have been collated and presented in Tables 67, 68 and 69 when isolated from the following products:

- Live animals sampled at a slaughterhouse.
- Animal carcasses and parts of carcasses sampled at a slaughterhouse.
- Human foodstuffs of animal origin sampled at a premises other than a slaughterhouse.

National abattoir surveys

In a one year survey (1999 – 2000) of a statistically derived sample of prime cattle and sheep at slaughter in Great Britain, *Salmonella* was found in 1g samples of rectal contents from two cattle (0.2%) and one sheep (0.1%) (Davies and others, 2000). All three isolates were *S. Typhimurium*. In a similar survey of slaughter pigs, caecal carriage of *Salmonella* was identified in 23% of pigs but in only 5.3% of carcass swabs. The predominant *Salmonella* serovars were *S. Typhimurium* and *S. Derby* (Davies and others 2001). See Table 70. A similar survey was carried out in 2003, and results will be available late in 2004.

Chapter 4

REPORTS OF *SALMONELLA* IN ANIMAL FEEDINGSTUFFS

1) COMPOUND ANIMAL FEEDINGSTUFFS

In 1989, as part of its package of measures to control *Salmonella* in animals, particularly poultry, the Department, with the co-operation of the feedingstuffs industry, introduced a number of voluntary Codes of Practice for the hygienic production, storage, handling and transport of animal feedingstuffs (Defra 1989). The Codes contain measures for the testing of animal feedingstuffs for *Salmonella*, and the adoption of the Codes by all the major animal feedingstuff companies in Great Britain has resulted in a large volume of testing being undertaken each year.

This chapter contains details on the results of that testing including the number of samples of various categories of feedingstuffs tested for *Salmonella*, the number of samples that proved positive and the contamination rate (Table 71). This table indicates no change in the overall contamination rate in animal feedingstuffs between 2002 and 2003. The number of tests carried out (37% increase in numbers from 2002), particularly on feed ingredients, was considerably higher compared with the previous year, but was still 27% lower than the number carried out in 2001.

Tables 72 and 73 give results of *S. Typhimurium* and *S. Enteritidis* isolations from feedingstuffs. They show that the number of isolations of these serovars from feedingstuffs is low (2 and 15 isolates respectively of 40,213 tests carried out – in 2002 the respective figures were 0 and 6).

Tables 74 to 76 suggest that a previous problem relating to contamination of compound feeds with *S. Agona* originating from the vegetable oil extraction process has reduced further during 2003, although the organism was still regularly recovered from soya, rape and other feed ingredients (Table 77). *S. Anatum*, *S. Mbandaka* and *S. Senftenberg* were the most frequently isolated serovars from ruminant, pig and poultry compound feeds respectively in 2003. As usual a wide range of other serovars were found in feed ingredients, reflecting their diversity of origin. Examples of the risk of introducing *Salmonella* serovars of potential public health significance in feed ingredients are provided by the isolation of *S. Typhimurium* in maize and soya.

A small number of feed isolates were not fully typed as reports rather than isolates were supplied by the testing laboratories.

2) PROCESSED ANIMAL PROTEIN

Processed animal protein is subject to statutory testing schemes at the point of production or importation and voluntary testing is also undertaken, mainly by feed mills receiving the material, where typically higher rates of contamination are found.

The feeding of mammalian meat and bone meal (MBM) to all farmed livestock was made illegal from 4 April 1996 and this resulted in much of it being disposed of by burial or incineration. As such, it no longer fell within the definition of "processed animal protein" as defined in the Processed Animal Protein Order 1989 (replaced by the Animal By-Products Order, 1999) and producers were no longer under a legal obligation to test products for *Salmonella* on each day they were consigned from their premises. However, official quarterly testing of products has continued under the Animal By-Products Order 1992, and since under the Animal By-Products Order 1999. The Animal By Products Regulations 2003 are due to be implemented on July 1st 2003.

From 1 August 2001, under the Processed Animal Protein Regulations 2001, the feeding of processed animal protein to animals kept, fattened or bred for the production of food is prohibited, with some exceptions including non-ruminant gelatin used for coating feed additives, animal-derived dicalcium phosphate and hydrolysed protein produced under certain conditions when fed to non-ruminants; fishmeal produced under certain conditions may be fed farmed animals other than ruminants. Table 78 details the results obtained from the statutory official testing of domestic processed animal protein.

There has been an increase in the numbers of batches of domestically produced processed animal protein tested in 2003 (152) compared with 2002 (93). In 2003 the overall contamination rate rose to 5.9% from 1.1% in 2002.

The contamination rate of 10.8% of imported animal proteins (Table 80) was lower than that in 2002 (16.3%). It is also worthy of note that slightly fewer tests were carried out: 130 in 2003 as opposed to 147 in 2002.

Trends in contamination rates for domestically processed and imported animal proteins are shown in Figure 43 and Figure 44 respectively.

A wide range of serovars was again recorded. Of note in 2003 is the presence of *S. Enteritidis* in imported feed ingredients. In view of the risk of multiple antibiotic resistance strains of *Salmonella* such as *S. Newport* and *S. Paratyphi B* var *Java* or new phage types of *S. Enteritidis* it is

important to maintain thorough surveillance testing of imported feed ingredients.

Chapter 5

ANTIMICROBIAL SENSITIVITY IN *SALMONELLA*

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 (µg per ml)	Code
1	Nalidixic acid	30	NA
2	Tetracycline	10	T
3	Neomycin	10	N
4	Ampicillin	10	AM
5	Furazolidone	15	FR
6	Ceftazidime (from 1/1/01)	30	CAZ
6	Cefuroxime (used until 31/12/00)	30	CX
7	Sulphamethoxazole/trimethoprim	25	TM
8	Chloramphenicol	10	C
9	Amikacin	30	AK
10	Amoxycillin/clavulanic acid	30	AMC
11	Gentamicin	10	CN
12	Streptomycin	25	S
13	Sulphonamide compounds	300	SU
14	Cefoperazone	30	CF
15	Apramycin	15	APR
16	Colistin	25	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 serovar 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 82). 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 82: *Salmonella* Dublin: antimicrobial sensitivity monitoring 1999 - 2003

Year	No of cultures	Percentage sensitive to all 16 anti-microbials	Percentage of cultures resistant to:							
			S	SU	T	N	AM	FR	TM	C
1999	357	98.3	1.1	-	-	-	-	-	-	-
2000	863	98.7	0.7	0.7	0.5	-	0.1	-	0.2	0.6
2001	467	98.3	0.2	1.3	-	-	-	-	0.2	0.6
2002	687	97.5	0.3	0.7	0.6	0.4	-	0.6	0.9	0.4
2003	949	96.4	1.4	1.2	0.8	0.2	0.6	0.4	0.4	1.3

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 83).

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 (Table 83). The generally high level of resistance of *Salmonella* Typhimurium isolates is partly a reflection of the numbers of DT104 and its variants DT104b 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 DT104. In 2003, despite a continuing decline in the proportion of *S. Typhimurium* tested 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 DT104 are themselves commonly resistant to one or more antimicrobials. Figure 46 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 enzymes. 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 fluctuations 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 2003 can be compared to 17.6% resistance in 1999 and 15.9% in 1998. Nalidixic acid resistance in *S. Typhimurium* DT104 by species of origin is listed in Table 84, which shows that isolates from cattle and turkeys are the main contributors accounting for the observed rise in nalidixic acid resistance. Table 85 gives the equivalent figures for trimethoprim/ sulphonamide resistance by species of origin in *S. Typhimurium* DT104 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 DT104 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 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 DT193 (47 isolates, 85% resistant to TM in 2002; 38 isolates, 92% resistant to TM in 2003), DT208 (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 DT193 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 DT12), but which have now shown resistance in either 2002 or 2003.

Table 83: *Salmonella* Typhimurium: antimicrobial sensitivity monitoring 1999 – 2003

Year	No of cultures	Percentage sensitive to all 16 anti-microbials	Percentage of cultures resistant to:									
			S	SU	T	N	AM	FR	TM	C	APR	NA
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 ^{**}	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

[†] 620 (52.7%) of these strains were DT104 and its variants.
^{*} 460 (53.2%) of these strains were DT104 and its variants.
^{††} 247 (52.8%) of these strains were DT104 and its variants.
^{**} 239 (44.8%) of these strains were DT104 and its variants.
^{†††} 273 (44.5%) of these strains were DT104 and its variants.

Table 84: Nalidixic acid resistance in *Salmonella* Typhimurium DT104 from domestic livestock. Number of cultures tested (percentage resistant to nalidixic acid) 1999 - 2003

Year	Livestock species					
	Cattle	Sheep	Pigs	Chickens	Turkeys	Ducks
1999	231 (5.2)	35 (2.9)	114 (9.6)	5 (20.0)	24 (66.7)	1 (0)
2000	223 (10.8)	21 (0)	51 (2.0)	7 (14.3)	7 (0)	1 (0)
2001	115 (15.7)	8 (12.5)	19 (21.1)	22 (0)	25 (60.0)	0 (0)
2002	17 (11.8)	32 (0)	0 (0)	67 (7.5)	36 (5.6)	5 (40)
2003	100 (20)	6 (0)	27 (11.1)	12 (8.3)	41 (63.4)	0 (0)

Table 85: Trimethoprim/sulphonamide resistance in *Salmonella* Typhimurium DT104 from domestic livestock in 2003. Number of cultures tested (percentage resistant to trimethoprim/sulphonamide)

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

1.5% of DT104 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 DT193 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 DT193 (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 DT104 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.

SEROVARS OTHER THAN *SALMONELLA* DUBLIN AND *SALMONELLA* TYPHIMURIUM

Of the 3652 cultures tested 67.7% were sensitive to all the antimicrobials tested (Table 86), 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* Phage Type 4 and of these *S. Enteritidis* Phage 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 86: Salmonellas, other than *Salmonella* Dublin and *Salmonella* Typhimurium: antimicrobial sensitivity monitoring 1999 - 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
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 serovars from pigs and the relative decline in frequency of isolation of *S. Typhimurium* DT104. The level of resistance to neomycin in all salmonella serovars 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. Thirty-nine 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 serovars was 0.5% in 2003, similar to the figure of 0.6% observed in 2002. 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 87: All salmonellas: antimicrobial sensitivity 2003

Origin	No of cultures	Percentage sensitive to all 16 anti-microbials	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	-	2.3
Sheep	274	93.1	2.9	2.7	4.7	-	2.9	0.4	0.4	3.3	-	-
Pigs	297	6.4	56.6	82.2	80.8	11.4	59.9	1.0	59.3	49.5	6.4	8.4
Chicken	1395	64.4	6.7	24.4	8.3	1.9	5.4	6.0	20.1	8.4	-	1.8
Turkey	433	53.6	16.9	33.7	30.7	2.5	17.3	1.2	11.5	9.7	-	15.5
Duck	799	57.2	22.9	15.9	32.3	22.5	1.1	28.2	5.4	1.3	-	0.4
Horse	29	72.4	13.8	20.7	20.7	-	13.8	-	20.7	13.8	3.4	6.7
Other non-avian spp	210	65.7	23.8	29.1	26.7	2.9	24.3	1.9	11.4	17.1	2.4	5.7
Other avian spp	36	69.4	19.4	8.3	11.1	-	13.9	-	5.6	-	-	5.6
Feed	268	91.0	2.1	7.5	4.1	0.6	1.3	0.2	5.8	1.5	-	-
Environment	25	92.0	-	-	-	-	4.0	-	-	4.0	-	4.0
Total	5214	67.3	14.5	22.1	19.9	5.1	11.2	6.3	13.2	10.3	0.5	3.2

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Acknowledgements

Incidents were reported by Nominated Officers of the Veterinary Laboratories Agency for England and Wales and Divisional Veterinary Managers for Scotland and, through them, by private laboratories.

Divisional Veterinary Managers of the State Veterinary Service are responsible for the collection of samples of processed animal protein.

Staff of the Veterinary Laboratories Agency processed the data.

The following reference laboratories made or confirmed the majority of isolations:

- Veterinary Laboratories Agency, Weybridge and Lasswade.
- HPA Laboratory of Enteric Pathogens, Colindale.
- Scottish *Salmonella* Reference Laboratory, Glasgow.

This report was compiled by:

Sarah Binns and Sue Kidd,
Centre for Epidemiology and Risk Analysis,
Veterinary Laboratories Agency,
New Haw,
Addlestone,
Surrey,
KT15 3NB

Telephone: + 44 (0)1932 - 357622

Fax: + 44 (0)1932 - 349983

E-mail s.a.kidd@vla.defra.gsi.gov.uk

Further copies of the report are available from the above address

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