ANNEX

To EFSA Scientific Opinion on a Quantitative estimation of the impact of setting a new target for the reduction of *Salmonella* in breeding hens of *Gallus gallus*

(EFSA-Q-2008-291)

Analysis of *Salmonella* monitoring and prevalence figures in poultry (*Gallus gallus*) in the European Union between 2004-2007

SUMMARY

This annex has been prepared out in order to support the Scientific Opinion on a quantitative estimation of the impact of setting a new target for the reduction of *Salmonella* in breeding hens of *Gallus gallus* (EFSA-Q-2008-291), and should be read as part of this opinion.

The annex presents an analysis of *Salmonella* serovar prevalence in the breeding and commercial lines for both layers and broilers (*Gallus gallus*), employing data reported by EU member states in the framework of Directive 2003/99/EC, Regulation (EC) 2160/2003 and Regulation (EC) 1003/2005.

In most cases, the descriptive data analysis did not find indications of differing proportion positive flocks between the breeding and production stages, by line of production – based on the regular monitoring results. This can be explained firstly by the fact that some Member States (MSs) have few flocks and/or positive flocks (rare phenomena below or around 1%). An exception was the comparison between the proportion of positive flocks based on the regular monitoring results and the prevalence estimates of the baseline survey figures. Clearly, most MSs had productive flocks being substantially more positive covered by the latter figures. This may be explained by the more sensitive sampling design applied in the baseline surveys.

Several issues presented further in this annex are related to data comparability/reliability. These include:

(a) Regulatory requirement constraints, on serovar reporting beyond legal requirements both for breeding and production flocks;

(b) Statistical applicability constraints due to the design of the data collection strategies;

(c) Intra- and extra- Community movement of poultry, which interferes in the within member correlation of prevalence levels and serovars in the different flocks;

(d) The novel, but not fully harmonised, monitoring regime in breeding flocks. There are some differences between MSs in the detailed implementation of monitoring programmes which may result in different sensitivities in detecting and reporting positive flocks. This is most evident for the practice of applying confirmatory tests after positive results found during official controls by some MSs, sometimes with less sensitive sampling schemes. Since results are only reported after confirmation, this may result in biased reporting for the regulated *Salmonella* serovars.

Any attempt to statistically analyse these data and infer conclusions on the impact of prevalence values in parent breeding flocks to production lines would have limited scientific validity and might produce biased results. Furthermore, correlation analyses are based on sets of data from which neither mechanistic nor biological correlations can be inferred. It is expected that the current harmonised protocols for monitoring of *Salmonella* in breeding hens, and the forthcoming ones for laying hens and broilers, should provide a better database for analysis in future years. It is therefore recommended that a further consideration of the relationship between breeding and production flocks be carried out when harmonised data from control programmes in each sector is available. Such analysis should also be supported by modelling.

Beyond these limitations, different serovar correlation analyses of the EU data for the period 2004 to 2007 and of the GB data for the period 2000 to 2008 are presented in this annex, the later as a study in an individual Member State where more data were available. The different analysis performed showed some degree of temporal correlation between serovar occurrence in breeding and production lines. Moreover, this correlation was stronger for *S*. Enteritidis and *S.* Typhimurium than for the other targeted serovars. Nevertheless, the results are not consistent between the different types of analysis performed.

ACKNOWLEDGEMENTS

The European Food Safety Authority wishes to thank the members of the Working Group on *Salmonella* in breeding hens for the preparation of this annex: Mariann Chriél, Pierre Colin, Robert Davies, Arie Havelaar (Chair), Bela Nagy, Antonia Ricci and Ekelijn Thomas. Assistance to the working group from Juan Carrique-Mas and Andy Wales is acknowledged. At the same time, the support and contribution from EFSA's Unit on Zoonoses Data Collection is gratefully acknowledged.

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1. Introduction

The objectives of this document are to support the development of the opinion EFSA-Q-2008-291, and should be read as part of it. The report presents an analysis of *Salmonella* serovars in the breeding and commercial lines for both layers and broilers (*Gallus gallus*) employing data reported by EU member states.

In the EU, zoonoses data collection is based on an own legal basis, the Directive 2003/99/EC[1]. This zoonoses Directive came into force into 2004, and since then EFSA examines the zoonoses monitoring data collected from the Member States and publishing the annual zoonoses Community report.

Throughout this document, flock-level data were considered – not sample-level or holding-level. An exception was the data related to the EU-wide baseline survey in laying hens, where holding-level data prevailed. At the same time, the following proportions of *Salmonella* positive poultry flocks (*Gallus gallus*), according to the following subsets of data, were investigated:

The considered breeding flocks of *Gallus gallus* are:

- parent breeding flocks for egg production line, in the productive period;
- parent breeding flocks for meat production line, in the productive period;

Consequently, in these breeding flocks are not included:

- elite breeding flocks; day-old-chicks, rearing period and productive period;
- grand parent flocks; day-old-chicks, rearing period and productive period;
- parent breeding flocks; day-old-chicks and rearing period.

The considered production flocks of *Gallus gallus* are:

- laying hen flocks of all age-groups; day-old-chicks, rearing period and productive period, and
- broiler flocks (there are only 'rearing period' birds).

The MS is the epidemiological unit, and only aggregated data were available.

The annex also presents information on the implementation of monitoring programmes in MS to comply with Reg. (EC) 1003/2005, with a view of understanding the data quality for statistical analysis and the evaluation of the achievement of the targets for *Salmonella* control in breeding flocks.

Finally, both the analysis of the EU data and data from Great Britain, as a case study of an individual MS where data were available for a longer period of time (2000-2008) presented in this document (Appendices A and B respectively).

Please note that through the document poultry exclusively refers to the species *Gallus gallus*.

[1] http://eurlex.europa.eu/smartapi/cgi/sga_doc?smartapi!celexapi!prod!CELEXnumdoc&lg=EN&numdoc=32003L0099&model=guichett

2. The different *Salmonella* monitoring systems in *Gallus gallus* in the EU.

Member States of the European Union are obliged to follow common minimum measures for the monitoring and control of *Salmonella* in breeder flocks of *Gallus gallus* since 1994, as foreseen by Annex III of Council Directive (EC) 92/117. According to this Directive, samples had to be taken in day-old chicks, in pullets at four weeks of age and two weeks prior to entering the laying phase, and during the laying phase, and were aimed to detect a positive flock if its *Salmonella* prevalence was ≥ 5% (60 faecal samples per flock). Control measure had to be applied in case of positivity for S. Enteritidis or S. Typhimurium; such measures were the slaughtering or destruction of the positive flock, but also antibiotic treatment was allowed. According to Directive (EC) 92/117, MS has to submit their national control programs to the European Commission for approval, but just a few countries had their programmes approved in the framework of this Directive.

A much wider harmonisation of monitoring and control measures was obtained through the application of Directive 2003/99/EC, which provides for the monitoring of zoonoses in animal populations in Europe. The purpose of this Directive is to ensure that zoonoses, zoonotic agents and related antimicrobial resistance are properly monitored, and that foodborne outbreaks receive proper epidemiological investigation, to enable the collection in the Community of the information necessary to evaluate relevant trends and sources (article 1).

According to article 4 of this directive, monitoring shall be based on the systems in place in Member States. However, where necessary to make data easier to compile and compare, detailed rules for the monitoring of zoonoses and zoonotic agents listed in Annex I to the regulation may be laid down.

Such detailed rules shall lay down minimum requirements for the monitoring of certain zoonoses or zoonotic agents. They may, in particular, specify:

(a) the animal population or subpopulations or stages in the food chain to be covered by monitoring;

(b) the nature and type of data to be collected;

(c) case definitions;

(d) sampling schemes to be used;

(e) laboratory methods to be used in testing; and

(f) the frequency of reporting, including guidelines for reporting between local, regional and central authorities.

The first indications on criteria for *Salmonella* monitoring have been laid down in Regulation (EC) 2160/2003, which in annex II lists minimum requirements that food business operators have to respect having samples taken and analysed for the control of *Salmonella* in different animal species and categories. As far as breeding flocks of *Gallus gallus* are concerned, Reg. (EC) 2160/2003 requires all *Salmonella* strains with public health significance to be monitored, both during the rearing and the laying phase. Samples, to be taken and analysed in the framework of own checks, must include day-old chicks, four-week-old birds, and flocks two weeks before moving to laying phase or laying unit. In adult breeding flocks samples must be taken every second week during the laying period.

No other details are given in Regulation (EC) 2160/2003 concerning the kind or number of samples to be taken, or the laboratory methods to be used for the analysis. No criteria are defined for official control.

With the adoption of Regulation (EC) 1003/2005, the European Commission has set the target for the reduction of the prevalence of certain *Salmonella* serovars (*i.e. S.* Enteritidis, *S.* Typhimurium *S.* Hadar, *S.* Infantis, and *S.* Virchow) in breeding flocks of *Gallus gallus*, and has described the testing scheme necessary to verify its achievement. The sampling frame covers all adult breeding flocks comprising at least 250 birds; the rearing phase is not comprised in this scheme, and therefore for this phase the only reference is Regulation 2160/2003 (and consequently no official controls are foreseen before the production period).

As far as own checks are concerned, according to Regulation (EC) 1003/2005 sampling takes place every two weeks either at the hatchery or at the holding.

Official control shall consist in sampling every 16 weeks at the hatchery and on two occasions during the production cycle at the farm, if sampling at the initiative of the operator takes place at the hatchery. If the own checks are performed at the farm, official control will consist in sampling at farms three times during the production cycle.

In hatcheries, the sample consists of a minimum of one composite sample of visibly soiled hatcher basket liners taken at random from five separate hatcher baskets or locations in the hatcher, to reach a total of at least 1 m^2. If the hatching eggs from a breeding flock occupy more than one incubator, then one such composite sample shall be taken from each incubator.

Where hatcher basket liners are not used, 10 g broken eggshells shall be taken from 25 separate hatcher baskets, crushed, mixed and a 25 g sub sample taken.

At farms, sampling primarily consists of faecal samples and shall aim to detect a 1 % within flock prevalence, with 95 % confidence limit. To that effect, the samples shall comprise one of the following:

(a) pooled faeces made up of separate samples of fresh faeces each weighing not less than 1 g., pooled for analysis up to a minimum of two pools. The number of sites from which separate faeces samples are to be taken in order to make a pooled sample ranges from 200 to 300 depending on the number of animals in the flock;

(b) five pairs of boot swabs, which may be pooled for analysis into a minimum of two pools;

(c) in cage breeding flocks, sampling may consist of naturally mixed faeces from dropping belts, scrapers or deep pits, depending on the type of house. Two samples of at least 150 g shall be collected to be tested individually.

3. Descriptive analysis of the data available for the EU.

Data employed in this analysis originate from that reported in the framework of Directive 2003/99/EC, and included all tests and serovars isolated from chickens (breeder and commercial sectors) by year and type of production in all EU member states (excluding Malta and Rumania), plus Norway. The data include the 2004-2007 period only. Data were extracted from EFSA's Zoonoses database and exported to MS-Excel spreadsheets. This is presented in here in Appendix C.

3.1.1. Distribution of *Salmonella* serovars occurrence in poultry flocks

A minimum of 92 and 70 serovars were reported in broiler and egg production, respectively (many reports do not specify the serovar, so it is likely that additional relevant serovars were actually detected). The majority of serovars are however, as expected in view of the relative sizes of the sectors, present in commercial production, but not in breeders (Table 1 and 2), although all five currently regulated serovars are present in both breeders and commercial production.

Table 1. Distribution of serovars in broiler production (N=number of serovars).

Present in breeding and in production flocks (any country) (N=28)	*S.* Enteritidis, *S.* Typhimurium, *S.* Infantis, *S.* Virchow *S.* Agona, *S.* Hadar, *S.* Mbandaka, *S.* Montevideo, *S.* Senftenberg, *S.* Tennessee, *S.* Anatum, *S.* Indiana, *S.* Kentucky, *S.* Livingstone, *S.* Bredeney, *S.* Saintpaul, *S.* Blockley, *S.* Braenderup, *S.* Kottbus, *S.* London, *S.* Newport, *S.* Essen, *S.* Havana, *S.* Isaszeg, *S.* Lexington, *S.* Rissen, *S.* Schwarzengrund, *S.* Yoruba
Present in breeders but not in production flocks (N=9)	*S.* 4,12:d:-, *S.* 6,7:-:-, *S.* Agama, *S.* Bovismorbificans *S.* Give, *S.* IIIb61:k:1,5,7, *S.* Kedougou, *S.* Liverpool *S.* Panama
Present in production flocks but not in breeders (N=55)	*S.* Derby, *S.* Thompson, *S.* Heidelberg, *S.* Muenchen *S.* Corvallis, *S.* Gallinarum, *S.* Meleagridis, *S.* Orion *S.* 3,10:-:-, *S.* 4,12:b:-, *S.* 4,5:i:-, *S.* 6,7:-:1,5, *S.* 6,7:b:-, *S.* 6,7:d:-, *S.* 6,7:r:-, *S.* Abony, *S.* Albany *S.* Amersfoort, *S.* Bareilly, *S.* Bere, *S.* Boecker, *S.* Brandenburg, *S.* Carno, *S.* Chartres, *S.* Coeln *S.* Emek, *S.* Escanaba, *S.* Galiema, *S.* Glostrup, *S.* Goldcoast, *S.* India, *S.* Irumu, *S.* Kiambu, *S.* Kimuenza, *S.* Kisii, *S.* Lagos, *S.* Lille, *S.* Litchfield, *S.* Manhattan, *S.* Mishmarhaemek, *S.* Muenster, *S.* Nigeria, *S.* Pakistan, *S.* Paratyphi B var. Java, *S.* Pomona, *S.* Potsdam, *S.* Regent, *S.* Singapore, *S.* Stanley, *S.* Stockholm, *S.* Umbilo, *S.* Veneziana, *S.* Wangata, *S.* Washington, *S.* Worthington

Table 2. Distribution of serovars in egg production (N=number of serovars).

Present in breeding and in production flocks (any country) (N=21)	*S.* Enteritidis, *S.* Typhimurium, *S.* Infantis, *S.* Agona *S.* Havana, *S.* Tennessee, *S.* Virchow, *S.* Hadar, *S.* Livingstone, *S.* Rissen, *S.* Senftenberg, *S.* Blockley, *S.* Gallinarum, *S.* Montevideo, *S.* Isangi, *S.* Thompson, *S.* Corvallis, *S.* enterica subsp. Salamae, *S.* Indiana, *S.* Lexington, *S.* Ohio
Present in breeders but not in production flocks (N=2)	*S.* Brandenburg *S.* Dublin
Present in production flocks but not in breeders (N=47)	*S.* Mbandaka, *S.* Braenderup, *S.* Derby, *S.* Newport, *S.* Anatum, *S.* Bredeney, *S.* Give, *S.* Heidelberg, *S.* Saintpaul, *S.* Albany, *S.* Cubana, *S.* Jerusalem, *S.* Kentucky, *S.* Menden, *S.* Schwarzengrund, *S.* 42:-:- *S.* 6,7:-:-, *S.* 6,8:-:-, *S.* Akanji, *S.* Altona, *S.* Bareilly, *S.* Bere, *S.* Cerro, *S.* Coeln, *S.* Cremieu, *S.* Djugu, *S.* Essen, *S.* Galiema, *S.* Idikan, *S.* IIIb61:k:1,5,7, *S.* Ikeja, *S.* Istanbul, *S.* Kedougou, *S.* Kottbus, *S.* Lille, *S.* London, *S.* Mishmarhaemek, *S.* Nanga, *S.* Oranienburg, *S.* Panama, *S.* Poona, *S.* Saintemarie, *S.* Stanleyville, *S.* Umbilo, *S.* Veneziana, *S.* Westhampton, *S.* Worthington

3.1.2. Prevalence of *Salmonella* in individual MS

The *Salmonella* serovars of interest are basically the five targeted ones mentioned in Regulation (EC) No 1003/2005[2] : *Salmonella* Enteritidis, *S.* Typhimurium, *S.* Infantis, *S.* Hadar or *S.* Virchow.

For this exercise the following three *Salmonella* serovar groups were of interest;

- *Salmonella* Enteritidis or Typhimurium.
- *Salmonella* Infantis or Hadar or Virchow.
- Serovars other than *Salmonella* Enteritidis, Typhimurium, Infantis, Hadar or Virchow.

The first two outcome variables are thus currently targeted *Salmonella* serovars; the group of five serovars in breeding flocks and the group of two serovars in the production flocks.

To descriptively compare occurrences of *Salmonella* in breeding and production flocks, a horizontal bar graph displaying the point estimates with exact confidence intervals (CI), for the breeding and production flocks data, by MS was produced.

[2] Reg. (EC) No 1003/2005 implementing Regulation (EC) No 2160/2003 as regards a Community target for the reduction of the prevalence of certain *Salmonella* serovars in breeding flocks of *Gallus gallus* and amending Regulation (EC) No 2160/2003.

Data were analysed according to the following subsets of data:

- 2004:
    - Regular monitoring data: parent breeding flocks for egg production *versus* laying hen flocks of all age-groups
    - Monitoring data: parent breeding flocks for meat production *versus* broiler flocks
- 2005:
    - Regular monitoring data: parent breeding flocks for egg production *versus* laying hen flocks of all age-groups
    - Regular monitoring data parent breeding flocks for egg production *versus* EU-wide baseline survey prevalence data in laying hen holdings
    - Regular monitoring data: productive parent breeding flocks for meat production line *versus* broiler flocks
- 2006:
    - Regular monitoring data: parent breeding flocks for egg production *versus* laying hen flocks of all age-groups
    - Regular monitoring data: parent breeding flocks for meat production *versus* broiler flocks
    - Regular monitoring data parent breeding flocks for meat production *versus* EU-wide baseline survey prevalence data in broiler flocks
- 2007:
    - Regular monitoring data: parent breeding flocks for egg production *versus* laying hen flocks of all age-groups
    - Regular monitoring data: parent breeding flocks for meat production *versus* broiler flocks

Depending on data availability, the prevalence depicted in the figures represent the proportion of positive flocks for one of the serovars of a given category or, when more than one serovar was detected, the summing of both proportions.

Figures were only produced where subsets of data were available for a minimum of 10 MS.

An overview of the data available is presented in table 3, while full dataset employed in the analysis is presented in Appendix C.

Table 3. Regular reporting from 2007 to 2004, number of MSs with paired datasets

Year	Production line	*Salmonella* serovars	Total number of MSs reporting	Countries
2007	egg	SE + STM	14	**MSs :** AT, BG, CZ, DE, DK, EL, ES, FI, FR, LV, NL, SE, SI, SK
		SI + SH + SV	3	**MSs :** AT, SI, SK
		Other serovars	4	**MSs :** AT, DE, FI, SK
		Unspecified	1	**MS :** CZ
	meat	SE + STM	11	**MSs :** AT, BU, DE, DK, EL, ES, FI, LV, NL, SI, SK
		SI + SH + SV	4	**MSs :** AT, FI, LV, SI
		Other serovars	5	**MSs :** AT, DE, FI, SK **Non-MS :** NO
		Unspecified	2	**MSs :** NL, ES
2006	egg	SE + STM	14	**MSs :** AT, BE, CZ, DE, DK, EL, ES, FI, FR, NL, PL, SE, SI, SK
		SI + SH + SV	0	-
		Other serovars	1	**MS :** DE
		Unspecified	1	**MS :** PL
	meat	SE + STM	14	**MSs :** AT, BE, DE, DK, EE, EL, ES, FI, LT, NL, PL, SE, ,SI, SK
		SI + SH + SV	1	**MS :** PL
		Other serovars	3	**MSs :** DE, EL, SK
		Unspecified	3	**MSs :** DK, PL, ES
2005	egg	SE + STM	10	**MSs :** AT, BE, DK, FI, FR, DE, IE, PL, SI, SE
		SI + SH + SV	0	-
		Other serovars	0	-
		Unspecified	1	**MS :** PL
	meat	SE + STM	8	**MSs :** AT, BE, DE, DK, FI, PL, SE, SI
		SI + SH + SV	0	-
		Other serovars	0	-
		Unspecified	2	**MSs :** DE, PL
2004	egg	SE + STM	4	**MSs :** AT, FR, PL, PT
		SI + SH + SV	0	-
		Other serovars	0	-
		Unspecified	0	-
	meat	SE + STM	3	**MSs** : IT, PL, SI
		SI + SH + SV	0	-
		Other serovars	0	-
		Unspecified	0	-

3.1.2.1. *Salmonella* Enteritidis or Typhimurium in breeding flocks for egg production line *versus* laying hen flocks

The horizontal bar graphic below (Figure 1) presents the proportion of positive flocks and the confidence intervals (CIs) ("x" axis, values as a percentage), for the different MS where data were available from the regular monitoring in 2005("y" axis, abbreviation of MS name can be found in the table in page 25), and for the *Gallus gallus* lines ("y" axis, P=parents, L=Layers).

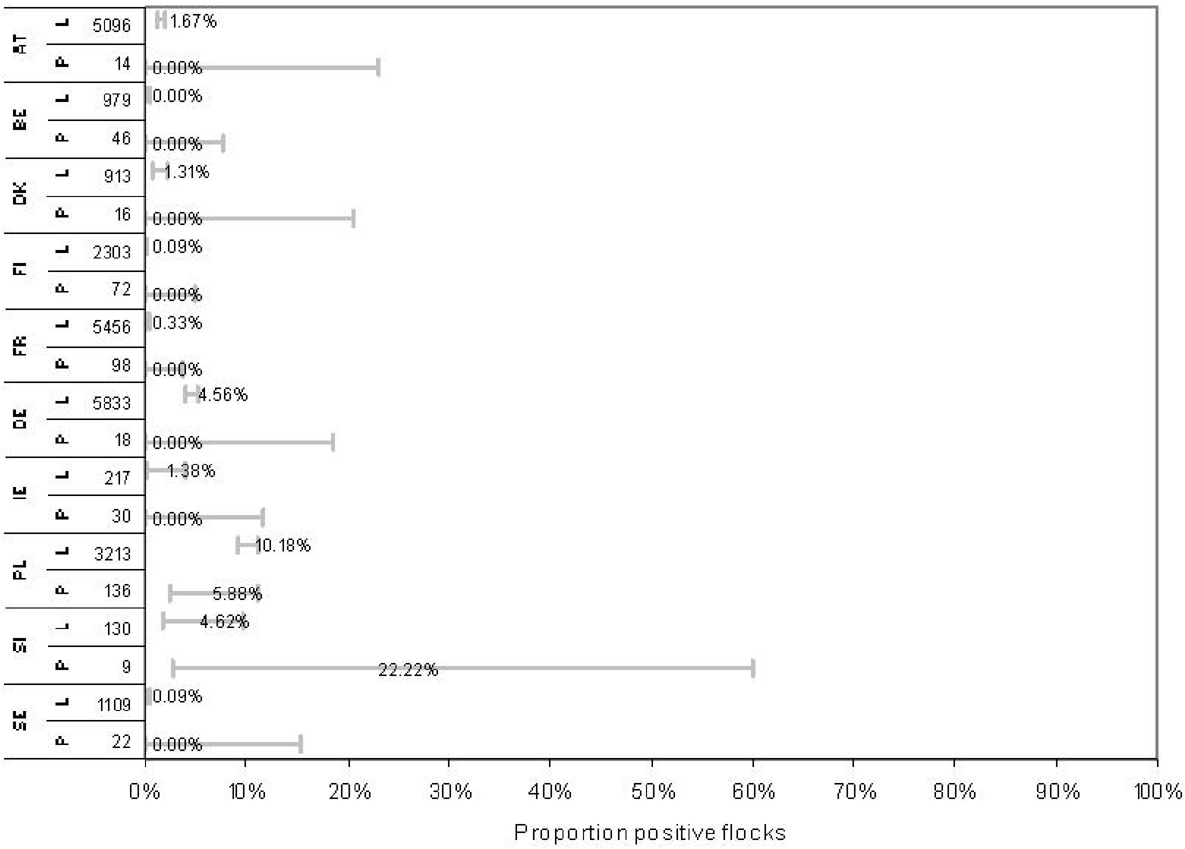

Figure 1. Confidence Intervals (CIs) for S. Enteritidis and/or Typhimurium proportion of positive *Gallus gallus* parents and layer flocks (Source: CSR monitoring data, 2005). P = Parents, L=Layers. Point estimate indicated on CI bars.

As it can be seen, figure 1 indicates that the proportions Salmonella Enteritidis and/or Typhimurium positive parent breeding flocks and those in the laying hen flocks do not seem different, based on monitoring data, for any MS with sufficient reported data for 2005. This is because the CIs overlap.

For 2005 comparisons were also made between regular monitoring programmes in breeding flocks for egg production and the EU-wide baseline survey in laying hen holdings. The underneath horizontal bar graphic (Figure 2) presents the proportion of positive flocks and the confidence intervals (CIs) ("x" axis, values as a percentage), for the different MS where data were available ("y" axis, abbreviation of MS name can be found in the table in page 25), and for the *Gallus gallus* lines of interest ("y" axis, P=parents, L=layers).

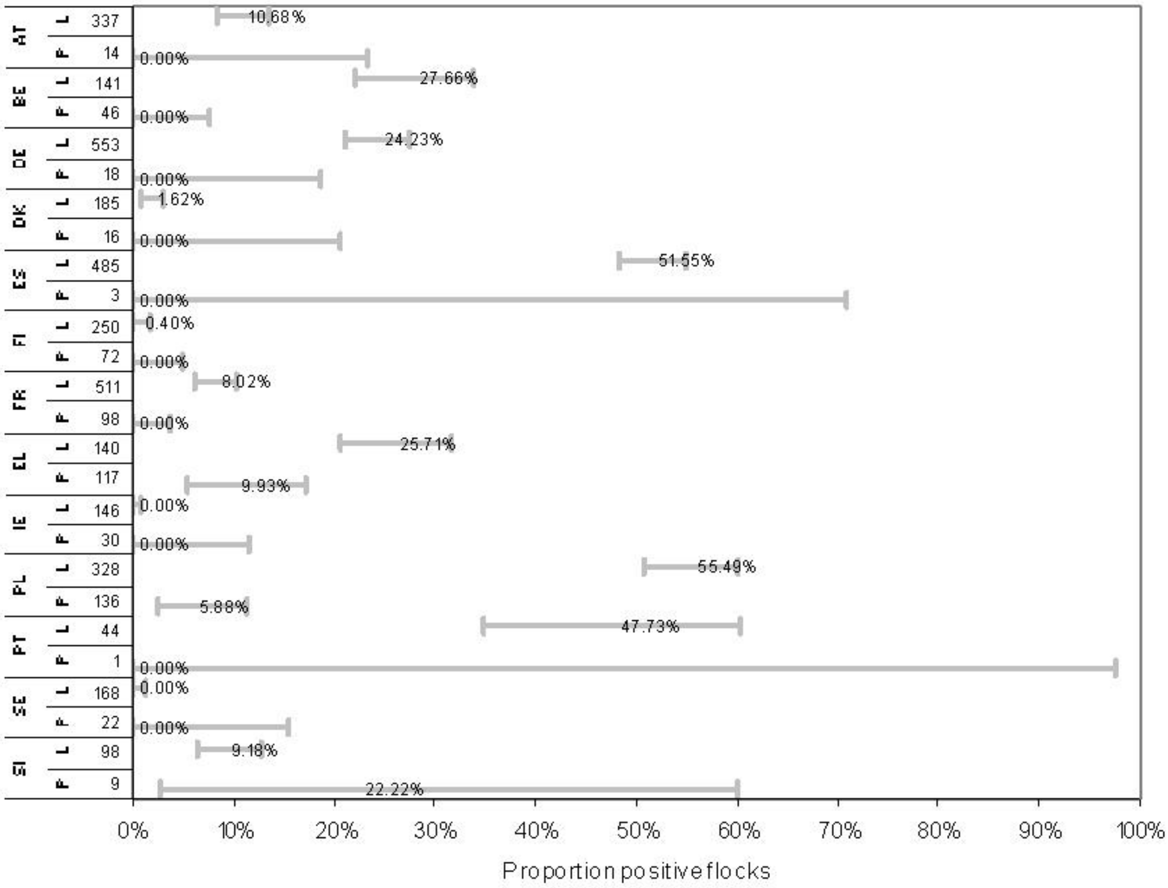

Figure 2. Confidence Intervals (CI) for S. Enteritidis and/or Typhimurium proportion of positive *Gallus gallus* parents flocks and layer holdings (Source: CSR monitoring and Baseline survey data, 2005). P = Parents, L=Layers. Point estimate indicated on CI bars.

As it can be seen, figure 2 indicates that the monitored proportions *Salmonella* Enteritidis and/or Typhimurium positive parent breeding flocks and the estimated prevalence in the laying hen flocks covered by the EU-baseline survey analysis, appear similar for Austria, Denmark, Spain, Finland, Ireland, Sweden and Slovenia, because the CIs overlap. For Belgium, Germany, Greece, Poland the proportion of positive production flocks seems higher.

Data from 2006 regular monitoring are presented below (Figure 3). It presents the proportion of positive flocks and the confidence intervals (CIs) ("x" axis, values as a percentage), for the different MS where data were available ("y" axis, abbreviation of MS name can be found in the table in page 25), and for the *Gallus gallus* lines of interest ("y" axis, P=parents, L=layers).

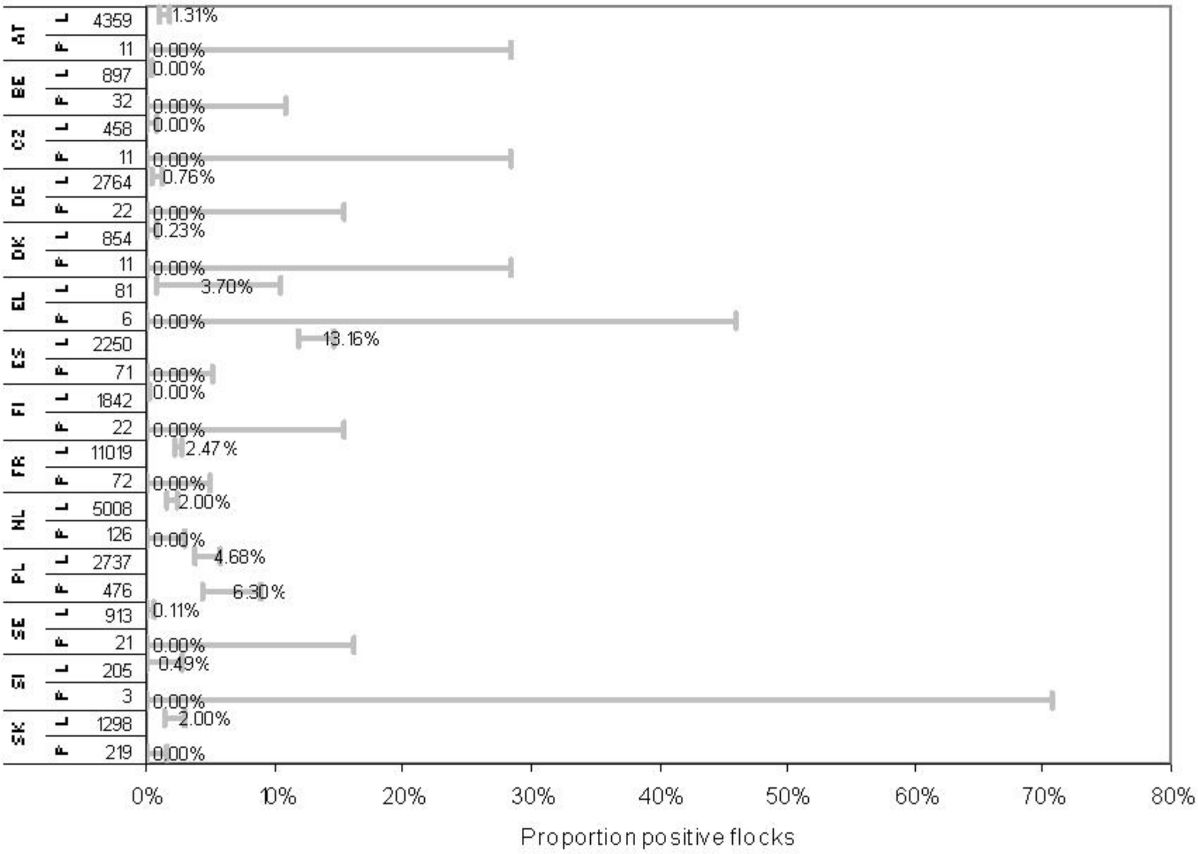

Figure 3. Confidence Intervals (CI) for S. Enteritidis and/or Typhimurium proportion of positive *Gallus gallus* parents and layer flocks (Source: CSR monitoring data, 2006). P = Parents, L=Layers. Point estimate indicated on CI bars.

As it can be seen, figure 3 indicates that the proportion *Salmonella* Enteritidis and/or Typhimurium positive flocks in parent breeding flocks and those in the laying hen flocks do not seem different, because the CIs overlap. One exception is Spain, with a higher proportion *Salmonella* Enteritidis or Typhimurium positive productive laying hen flocks.

Data from 2007 regular monitoring are presented below (Figure 4). It presents the proportion of positive flocks and the confidence intervals (CIs) ("x" axis, values as a percentage), for the different MS where data were available ("y" axis, abbreviation of MS name can be found in the table in page 25), and for the *Gallus gallus* lines of interest ("y" axis, P=parents, L=layers).

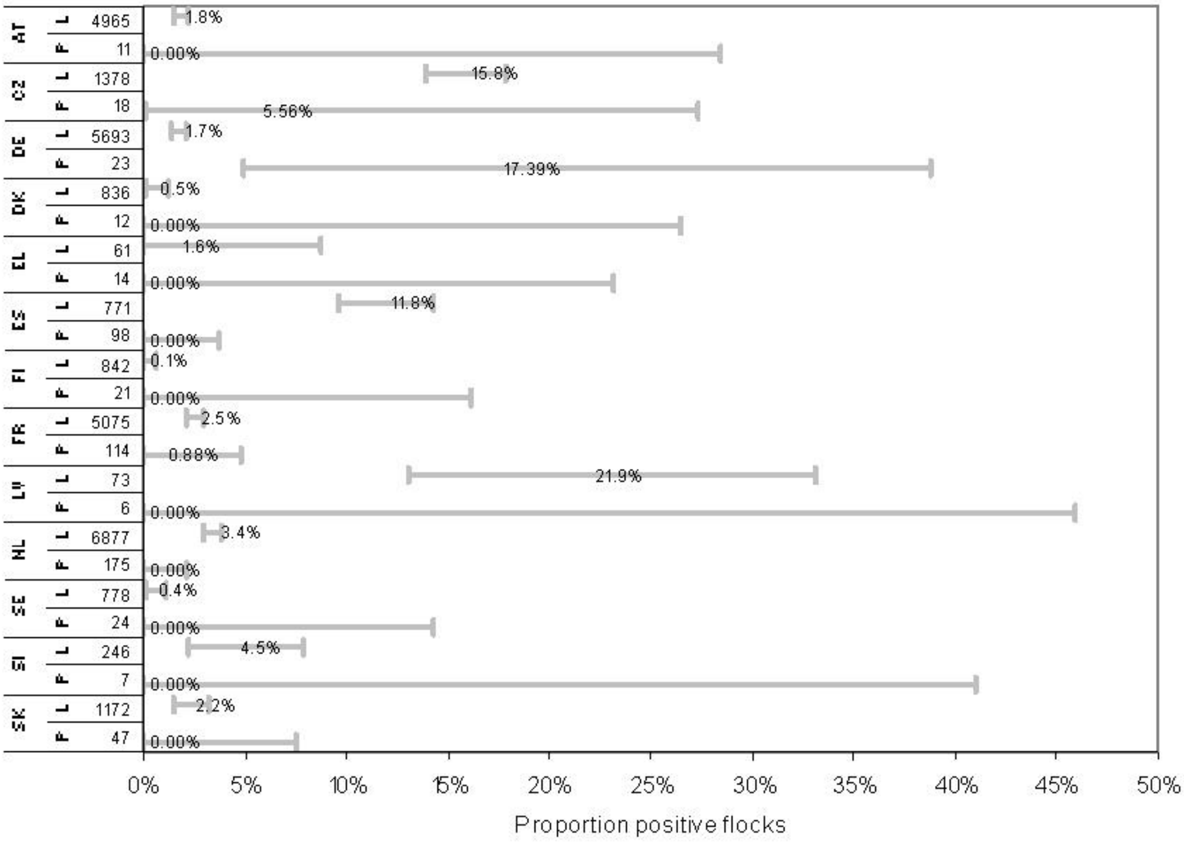

Figure 4. Confidence Intervals (CI) for S. Enteritidis and/or Typhimurium proportion of positive *Gallus gallus* parents and layer flocks (Source: CSR monitoring data, 2007). P = Parents, L=Layers. Point estimate indicated on CI bars. ,

As it can be seen, figure 4 shows that the proportion *Salmonella* Enteritidis and/or Typhimurium positive flocks monitored in parent breeding flocks and those in the laying hen flocks do not seem different, for a number of MSs because the CIs overlap. For the Netherlands and Spain the positivity in the production flocks seems higher compared to the parent flocks, whereas for Germany the reverse seems true.

3.1.2.2. *Salmonella* Enteritidis or Typhimurium in breeding flocks for meat production versus broiler flocks.

Data from 2006 regular monitoring are presented below (Figure 4). It presents the proportion of positive flocks and the confidence intervals (CIs) ("x" axis, values as a percentage), for the different MS where data were available ("y" axis, abbreviation of MS name can be found in the table in page 25), and for the *Gallus gallus* lines of interest ("y" axis, P=parents, B=broilers).

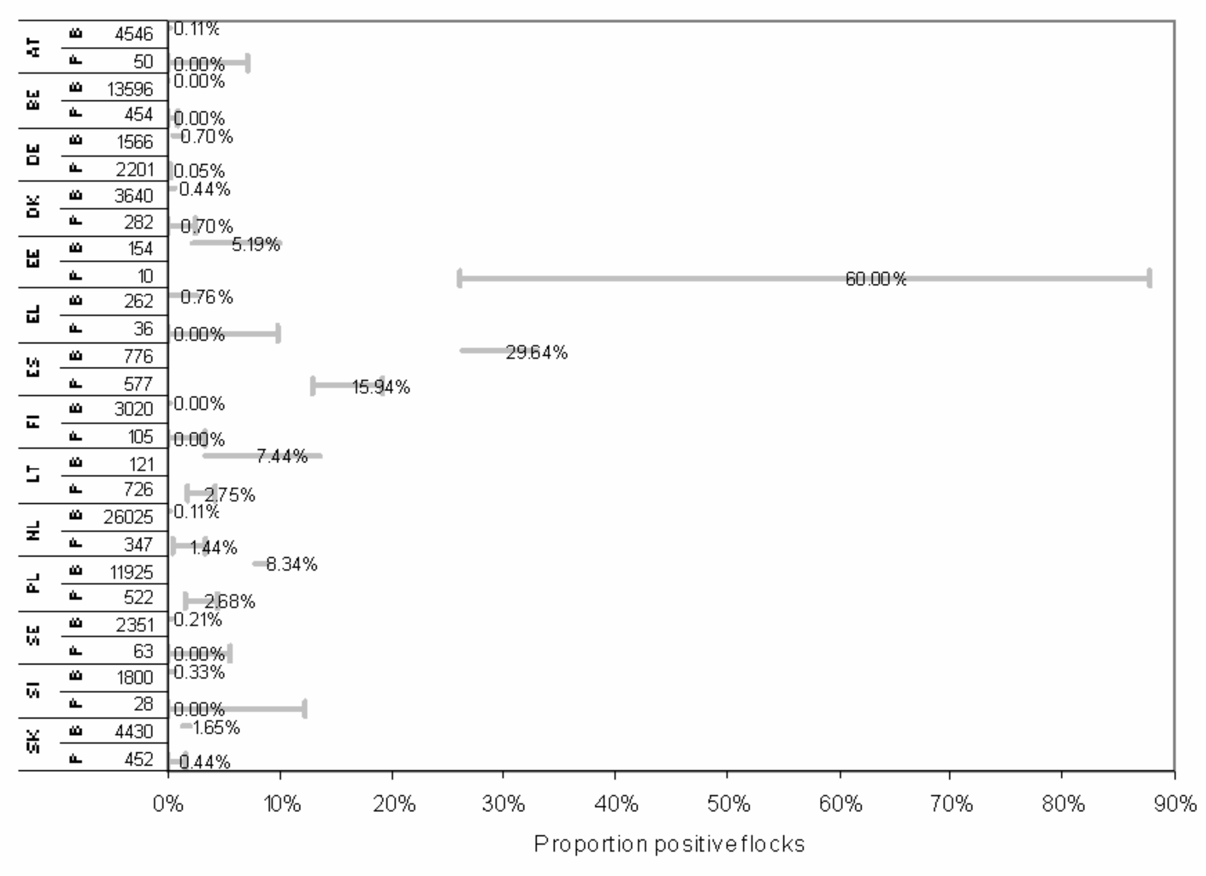

Figure 5. Confidence Intervals (CI) for S. Enteritidis and/or Typhimurium proportion of positive *Gallus gallus* parents and broiler flocks (Source: CSR monitoring data, 2006). P = Parents, L=Layers. Point estimate indicated on CI bars.

As it can be seen, figure 5 indicates that the proportion *Salmonella* Enteritidis and/or Typhimurium positive flocks in the parent breeding flocks and broiler flocks do not seem different, because the CIs overlap. Only exceptions are Estonia, with a higher proportion *Salmonella* Enteritidis or Typhimurium positive breeding flocks, and Spain and Poland with a higher proportion *Salmonella* Enteritidis or Typhimurium positive broiler flocks.

For 2006 comparisons were also made between monitoring programmes in breeding flocks for meat production and the EU-wide baseline survey in broiler flocks (Figure 6). It presents the proportion of positive flocks and the confidence intervals (CIs) ("x" axis, values as a percentage), for the different MS where data were available ("y" axis, abbreviation of MS name can be found in the table in page 25), and for the *Gallus gallus* lines of interest ("y" axis, P=parents, B=broilers).

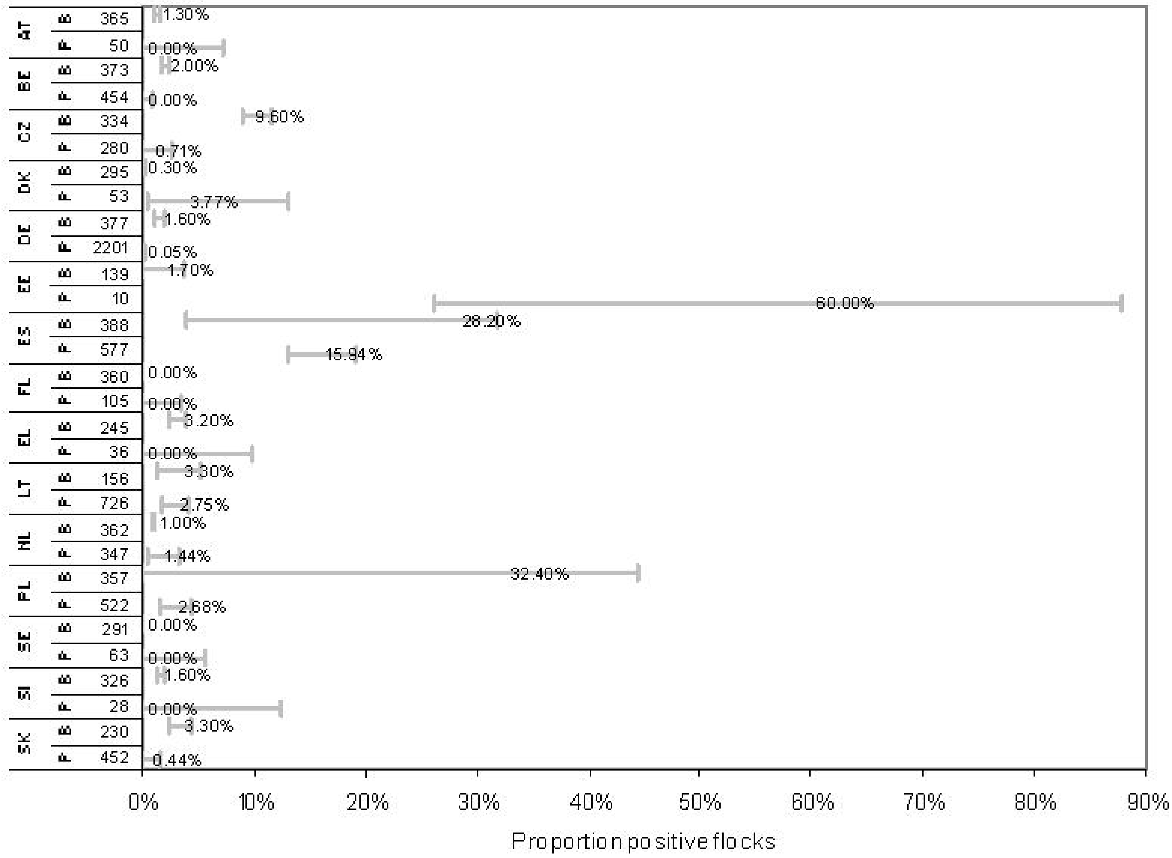

Figure 6. Confidence Intervals (CI) for S. Enteritidis and/or Typhimurium proportion of positive *Gallus gallus* parents and broiler flocks (Source: CSR monitoring and Baseline survey data, 2006). P = Parents, L=Layers. Point estimate indicated on CI bars.

As it can be seen, figure 6 indicates that the monitored proportions *Salmonella* Enteritidis and/or Typhimurium positive parent breeding flocks is lower than the estimated prevalence in the broiler flocks covered by the EU-baseline survey analysis, for Belgium, Czech Republic, Germany, and Slovakia. For Estonia, the positivity in the broiler flocks seems lower.

Figure 7 below presents data from regular monitoring for 2007. It presents the proportion of positive flocks and the confidence intervals (CIs) ("x" axis, values as a percentage), for the different MS where data were available ("y" axis, abbreviation of MS name can be found in the table in page 25), and for the *Gallus gallus* lines of interest ("y" axis, P=parents, B=broilers).

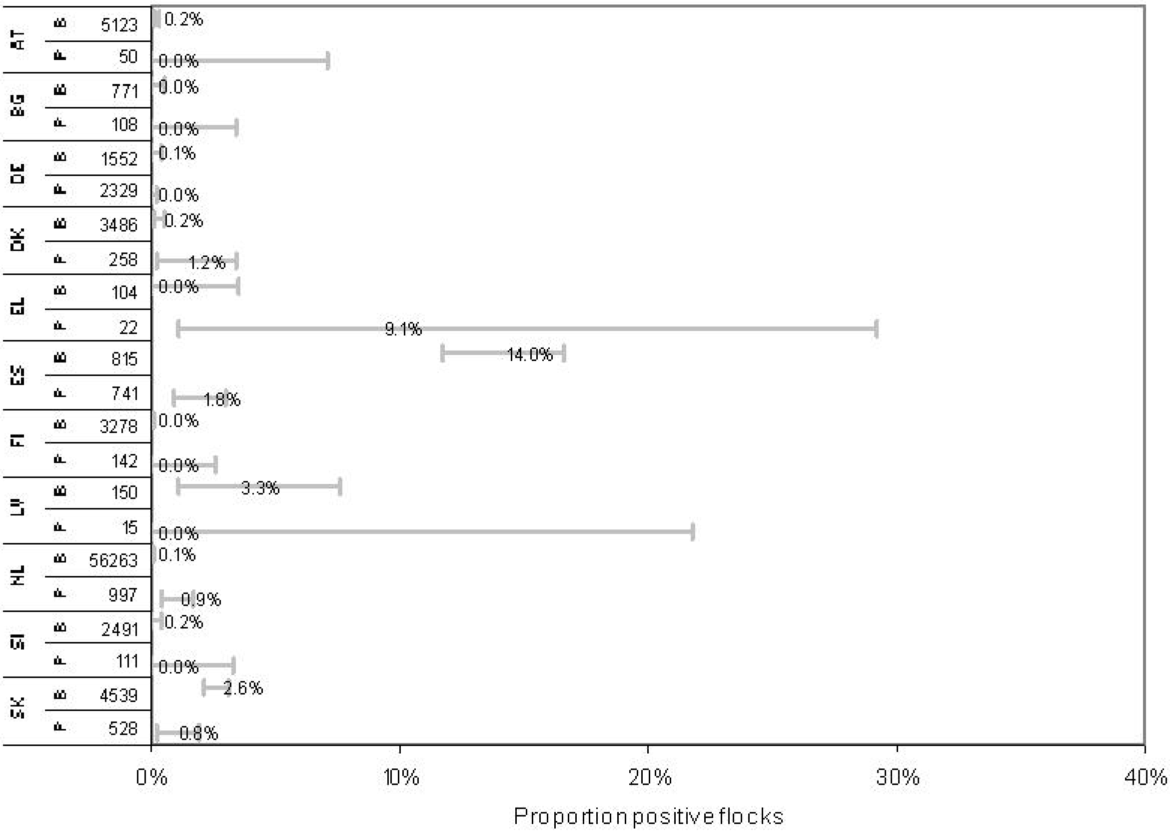

Figure 7. Confidence Intervals (CI) for S. Enteritidis and/or Typhimurium proportion of positive *Gallus gallus* parents and broiler flocks (Source: CSR monitoring data, 2007). P = Parents, L=Layers. Point estimate indicated on CI bars.

As it can be seen, the monitored proportion *Salmonella* Enteritidis and/or Typhimurium positive flocks in the parent breeding flocks and broiler flocks do not seem different, for most MSs with both types of data reported for 2007, because the CIs overlap. For the Netherlands, the positivity in the broiler flocks seems lower compared to the parent flocks, whereas for Spain the reverse seems true.

In general, in most cases the descriptive data analysis did not find indications of differing proportions positive flocks – based on the regular monitoring results - between the breeding and production stages, by line of production. This can be explained firstly by the fact that some MSs have few flocks and or positive flocks (rare phenomena below or around 1%).

An exception was the comparison between the proportions positive flocks based on the regular monitoring results and the prevalence estimates of the baseline survey figures. Clearly, most MSs had productive flocks being substantially more positive covered by the latter figures. This may be explained by the more sensitive sampling design applied in the baseline surveys. Indeed the number of samples taken from a flock was generally higher, and the variety of sample material collected greater (for laying hen survey), than those normally used by most MS. Furthermore, the baseline survey specifically investigated flocks at the end of their production period (for laying hen survey), where the within flock *Salmonella* prevalence is presumably the highest, whereas the laying hen flocks monitoring results reported in the Community zoonoses report covered all age groups (day-old chicks, rearing and production). Also for the broiler survey, the sampling period was not the same compared to the regular monitoring. Moreover, only the figures extracted from the baseline surveys took account of design aspects such as clustering and weighting.

4. Notes of caution on the interpretation of the available data

4.1. Data interpretation beyond the legal reporting requirements

The reported data are spanning the years 2004-2007 and during this period there were varying legal minimum reporting requirements regarding *Salmonella*. This implies that the data quality varied in between subsets of data.

MSs were obliged to report any positive findings in the parent breeding flocks regarding any of the five regulated *Salmonella* serovars, whether *Salmonella* Enteritidis, or *S.* Typhimurium, or *S.* Infantis, or *S.* Virchow, or *S.* Hadar, in the year 2007. For the years 2004-2006 this obligatory reporting was restricted to *Salmonella* Enteritidis and *S.* Typhimurium. It follows that the quality of the data on the regulated serovars in the parent breeding flocks is likely to be fairly good and more directly comparable between the MSs. Consequently, these data are appropriate for hypothesis testing.

No such legal minimum *Salmonella* reporting requirements existed for the production flocks of laying hens or broilers during 2004-2007. The reported data have been submitted by MSs, on a voluntary basis, beyond the legal minimum requirements. It follows that these data are less comparable between the MSs and must be analysed cautiously and only in an exploratory way[3]. This is because in case MSs voluntarily reported ‘negative findings for *Salmonella* spp.’, it could be reliably assumed that no single *Salmonella* serovar was detected, also none of the targeted ones; but when ‘*Salmonella* spp. positivity’ was voluntarily reported without any further specification, no assumptions could be made about the presence of any specific serovar.

In conclusion, these data may be biased due to underreporting. This can be further supported by the EU-wide baseline surveys results that were covered by a harmonized design – including obligatory serotyping of all *Salmonella* isolates - and are thus fully comparable in between

[3] Source: ‘Use and abuse of mathematical models: an illustration from the 2001 foot and mouth disease epidemic in the United Kingdom. Kitching et al., Rev. sci. techn. Off. Int. Epiz., 2006, 25 (1) 293-311.’

MSs. The baseline surveys prevalence in the production flocks (laying hens and broilers) in MSs were substantially higher compared to the prevalence reported by the MSs for production flocks in the national zoonoses reports. This may be explained by the more sensitive sampling design applied in the baseline surveys. Such under-reporting is also likely to apply to breeders as several MSs reported substantially increased detection of *Salmonella* in official samples compared with operator samples.

4.2. Data analysis: use of confidence interval based on aggregated data

The yearly reported monitoring data are aggregated (collapsed) and generally no individual unit-level (flock-level, holding-level) characteristics (risk indicators/factors) are available for further analysis. This means that no information exists on the design underpinning these data. Consequently, it is as such not possible to answer to specific questions in a scientific reliable and quantitative way. An example can be provided regarding *Salmonella* monitoring data in adult breeding flocks of *Gallus gallus*. In 2007, data provided by MSs, are census data and include:

- Number of existing flocks.
- Number of tested flocks.
- Number of *Salmonella* spp. positive flocks (or positive to certain – targeted – serovars).

Still, the sampling and testing procedures underlying these flock-based data varies, because of:

- differences in sampling frequency amongst the flocks (flocks are set up at different times during a reporting year and since they are tested every two weeks, the sampling frequency differs);
- differences in the harmonised monitoring programmes:
    - Sampling done by the competent authorities or own checks by the operator.
    - Sampling of flocks at farm or at hatchery.
    - Bootswab samples, or individual faeces samples, pooled faeces samples, other.
    - Differences in amount of sample (weight).
    - Confirmatory testing done or not.
- differences in pluri-annual data monitoring data before and after 2007 not comparable, due to legislative requirements.

Essentially, flocks are tested until they are found positive or slaughtered.

Based on this description, it is clear that the probabilities of finding specific flocks positive differ and consequently no easy statistical inference can be made, like the production of exact or binomial CIs. Hence, the aim of displaying CIs in this report is solely to give the reader an idea of the sample size and is not aimed at statistical inference.

To conclude, only aggregated data availability without having an idea of the design covering the data collection scheme means higher needs for hypotheses/assumptions, as opposed to more individual data availability where statistical inference can more readily be attempted.

4.3. Implementation of monitoring systems in the different EU MS

In order to evaluate the degree of harmonisation of data arising from monitoring schemes applied for *Salmonella* in breeding flocks in MS, a questionnaire has been prepared and sent to the Commission contacts for the monitoring of zoonoses in MSs (see Appendix D). The aim of this survey was to collect information to support interpretation of prevalence data used to compile EFSA reports, through a better understanding of the practical aspects that characterise the generation of data at local level. The questionnaire has been circulated twice: in the second circulation a question concerning confirmation of positive results was more detailed, and it was clearly mentioned that information gained through this questionnaire could be published within an EFSA opinion. Only countries that have replied to this second circulation have been considered for reporting.

The questionnaire composes of 3 main parts: (A) monitoring schemes applied during rearing and laying period; (B) Reporting; (C) use of vaccines.

24 countries have replied the questionnaire (23 MSs and Switzerland). Two of the countries that replied reported not having breeding flocks in their territory.

Part A: monitoring schemes

All the countries perform a control in day-old chicks, mostly as own check. Samples collected are generally dead chicks (from 5 to 60 animals) and box liners (from 10 to 40). In 3 countries, 250 faecal samples are collected.

In 4-week old animals and 2 weeks before laying, controls are performed as own checks in most countries. Samples collected are boot swabs (1, 2, 3 or 5 pairs) or faecal samples (2x150 gr., 2x30 gr., 6x25 gr.).

During laying, official controls are generally performed 3 times/cycle, collecting 5 pairs of boot swabs. 8 countries indicate that official controls are performed also in hatcheries. Differently from provisions by Regulation 1003/2005, one country indicate the collection of boot swabs only (hatchery control is not mentioned), 2 times/cycle, one country mention the collection of 2 pairs of boot swabs instead of 5, and another country report the collection of 345 and 988 broken eggs and faecal samples, respectively.

Own checks are performed every 2 weeks, by boot swabs in farm or basket liners or broken eggs in hatcheries.

Part B: Reporting

Of the 22 answering countries that have breeding farms in their territory, 11 require confirmation (by re-sampling) of a positive result in a control performed as own check at the hatchery,. Confirmation is performed using 5 or 20 animals, 5-10 pairs of boot swabs, faecal samples and animals. 14 countries require confirmation after a positive result in a control performed as own check at the farms, by 5-10 pairs of boot swabs, 20 animals, 2 pools of 150 cloacal swabs, 5 pairs of boot swabs + 2 samples of dust.

8 countries require confirmation also after a positive result for the 5 targeted serovars during official controls, while 3 require this on exceptional basis (e.g. suspicion of false positive result). Confirmation methods vary: 5 animals per house, 20 animals per house, 5 pairs of boot swabs + 2 dust samples, 2 pools of 150 cloacal swabs; if vaccinated 9 pools of 50 swabs, 5 pairs of boot swabs + 2 dust samples + 5 animals for residues, 7-10 pairs of boot swabs.

Part C: vaccination

Data were obtained from the summary of national zoonoses reports provided by the Zoonoses Unit of EFSA in order to evaluate the use of *Salmonella* vaccines in MSs.

As far as the legislation is concerned, in breeder flocks of *Gallus gallus* the use of both killed and live vaccines is permitted, apart from live vaccines which are not distinguishable from the wild strains, according to Regulation (EC) 1177/2006.

According to the Community Summary Report of 2007, vaccination for *Salmonella* was prohibited in Finland, Norway, Sweden and Switzerland, in Belgium is prohibited for grand parent flocks of layers and elite and grand parent flocks of broilers, and in France is prohibited in breeding flocks of layers, whereas killed vaccines for broilers parent breeding flocks and laying hens are allowed. In Denmark, vaccination can not be carried out as no vaccines have been approved by the Danish Veterinary and Food Administration.

In Bulgaria, Spain, Hungary, Latvia, Slovenia and UK the use of vaccines is permitted.

In Germany, vaccination can be ordered by competent authorities for breeding flocks of layers, in Belgium it is recommended against *S.* Typhimurium for parent flocks of layers and broilers, but discouraged for grandparent flocks.

In Austria, Belgium, Czech Republic and Portugal vaccination against *S.* Enteritidis in parent flocks is mandatory.

For other countries, no specific information on vaccination in parent flocks is available.

Comments

The response rate for the questionnaire was good, and gave an overview but might not be representative of the whole situation in EU, since seven MSs have not replied.

Therefore, conclusions are only applicable to the respondents, and should not be generalised to the whole EU.

As far as the monitoring schemes applied are concerned, some differences appear in the rearing phase, where the legislation (Regulation (EC) 2160/2003) is not so detailed in the details of monitoring schemes. As far as the laying phase is concerned, instead, harmonised protocols are more widely but not yet fully applied, and generally follow the provision of Regulation (EC) 1003/2005. However, some differences in the number and of samples taken and sampling frequency exist, which can influence the sensitivity of the testing scheme, making sometimes difficult the comparison of results.

This is more evident if we consider the practice of confirmation of positive cases. Some MS perform a confirmation test after positivity during official controls, sometimes with methods that are much less sensitive than the one prescribed by Regulation (EC) 1003/2005. This may result in biased reporting for the regulated *Salmonella* serovars, since results are reported only after confirmation. All these possible biases must be taken into consideration when evaluating prevalence data in different countries, and consequently the achievement of the expected target.

4.4. Intra and extra community movement of poultry fertilised eggs and chicks

Due to the economical high value of breeding poultry, breeding steps (selection and breeding) are managed by few global companies. Consequently there is a very large exchange of materials (fertilised eggs, one day old chicks) not only at the EU level. Grand-parent and parent flocks are distributed worldwide to be hatched and reared in a different definite place. Moreover, there is an active intra and extra community movement of laying hens and broilers.

Data on the export and import of poultry (intra and extra community trade) are compiled and available in the EUROSTAT database[4]. Information on these activities is reported by the different MSs at their discretion on voluntary bases, and thus caution has to be taken as underreporting would probably be quite common.

Overall and according to EUROSTAT data, the intra-community trade of both parent lines and production lines is considerably higher than extra-community imports of birds. At the same time, there is a considerable variability between MSs. For example, countries like France, Spain, The Netherlands, Greece and the United Kingdom report considerable number of movements of both breeding and production chicks (up to the magnitude of 10^6 for same types), while the other EU MSs barely report any movement. There are control measures in place specified in regulatory instruments for the trade of poultry and hatching eggs (Council Directive 90/539/EEC of 15 October 1990 on animal health conditions governing intra-Community trade in, and imports from third countries of, poultry and hatching eggs; Commission Regulation (EC) No 798/2008 of 8 August 2008 laying down a list of third countries, territories, zones or compartments from which poultry and poultry products may be imported into and transit through the Community and the veterinary certification requirements).

5. Discussion

It should be noted that the zoonoses data collection is based on a legal requirement, the Directive 2003/99/EC[5]. This zoonoses Directive came into force into 2004 and EFSA is responsible for examining the zoonoses monitoring data collected from the Member States and publishing the annual zoonoses Community report.

This Directive obliges the Member States to report and monitor on their own cost. Wide variability in the regular monitoring schemes exists between reporting countries, thereby often limiting meaningful data interpretation. For instance, some monitoring schemes lack sensitivity to detect certain zoonotic agents. Also, the laboratory reporting may not be set to report all strains of a zoonotic agent or not all *Salmonella* serovars.

However, in some fields, where the Member States are obliged to have Community approved control or eradication programmes (e.g. *Salmonella*, *Brucella* and *Mycobacterium* control and eradication programmes in some animal populations) Member States may receive Community co-financing for implementing these programmes[6]. In case no mandatory control or

[4] EUROSTAT dedicated database available at: http://epp.eurostat.ec.europa.eu/portal/page?_pageid=1073,46870091&_dad=portal&_schema=PORTAL&p_product_code=APRO_EC_POULA

[5] Available at: http://eurlex.europa.eu/smartapi/cgi/sga_doc?smartapi!celexapi!prod!CELEXnumdoc&lg=EN&numdoc=32003L0099&model=guichett

[6] For further information, see http://ec.europa.eu/food/food/biosafety/*Salmonella*/impl_reg_en.htm

eradication programmes exist for the zoonotic agent in the specified animal population, Member States can omit to report.

When taking account of data comparability and quality issues as described in section 4, attempting to statistically analyse these data and inferring conclusions on the impact of prevalence values in parent breeding flocks to production lines would have limited scientific validity and might produce biased results. It is expected that the current harmonised protocols for monitoring of *Salmonella* in breeding hens, and the forthcoming ones for laying hens and broilers, should provide a better database for analysis in future years. It is therefore recommended that a further consideration of the relationship between breeding and production flocks be carried out when harmonised and specific data from control programmes in each sector is available. At the same time, it has to be understood that these correlation analyses are based on sets of data from which neither mechanistic nor biological correlations have been inferred. Further correlation analysis should also be supported with modelling.

Beyond these limitations, the analysis of the EU data for the period 2004 to 2007 and of the GB data for the period 2000 to 2008 (Appendices A and B respectively) showed some degree of correlation between serovar occurrence in breeding and production lines. Moreover, this correlation was stronger for *S.* Enteritidis and *S.* Typhimurium than for the other targeted serovars. Nevertheless, the results are not consistent between the different types of analysis performed as presented in Table 4 in the next page.

Table 4. Comparison of the outcome of the different analysis carried out (only results were p-value was less than 0.05 are presented).

Data source and period	Type of analysis	Lines	Serovars with possible association
EU, 2004-2007	Qualitative (Descriptive)	Breeder-broiler	*S.* Enteritidis, *S.* Typhimurium, *S.* Virchow, *S.* Hadar.
		Breeder-layer	*S.* Typhimurium
	Qualitative (Temporal)	Breeder-layer	*S.* Typhimurium
	Quantitative (Prevalence data)	Breeder-broiler	*S.* Enteritidis, S. Typhimurium
		Breeder-layer	*S.* Enteritidis
GB, 2000-2008	Qualitative* (Temporal)	Breeder-broiler	*S.* Enteritidis, S. Typhimurium and non-targeted serovars
		Breeder-layer	Non-targeted serovars

* It has to be noted that before 2007 the GB breeder data for serovars other than *S.* Enteritidis or *S.* Typhimurium was based on unconfirmed hatchery positives, which is likely to overstate the link between breeders and commercial flocks for non-regulated serovars.

Member State abbreviations

AT	Austria
BE	Belgium
BU	Bulgaria
CY	Cyprus
CZ	Czech Republic
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France
DE	Germany
EL	Greece
HU	Hungary
IE	Ireland
IT	Italy
LV	Latvia
LT	Lithuania
LU	Luxembourg
MT	Malta
NL	The Netherlands
PL	Poland
PT	Portugal
RO	Romania
SK	Slovakia
SI	Slovenia
SE	Sweden
UK	The United Kingdom

APPENDICES

APPENDIX A. QUALITATIVE AND QUANTIATIVE CORRELATION ANALYSES OF THE EU DATA PLUS NORWAY

1. Qualitative correlation of the occurrence of the different *Salmonella* serovars between poultry breeding and production lines in the EU MS (plus Norway).

First, a descriptive analysis was carried out in order to map out the presence/absence of each serovar at country level. Contingency tables were built investigating the relationship between presence of each serovar in the breeding and commercial sectors for both broilers and layers. From these tables a chi-square statistic and associated p-value was calculated. Relative risks (or risk ratios) (RR) were calculated as the ratio of probability of the occurrence of each serovar in the commercial sector depending on whether they were, or were not, isolated from the breeding sector in that country[7].

The analysis investigating the association between the presence of a serovar in breeders and in production is presented in Table 1 (broilers) and Table 2 (layers).

Table 1 Occurrence of *Salmonella* serovars in meat production (broilers) in relation to presence/absence in breeders. Only serovars present in broiler production in at least 5 countries are shown. Units indicate number of countries (N=26).

	Presence in breeders			Absence in breeders			RR	p-value
	Presence in broilers	Absence in broilers	Risk	Presence in broilers	Absence in broilers	Risk		
S. Enteritidis	17	1	0.94	4	4	0.50	1.89	0.020
S. Typhimurium	12	2	0.86	6	6	0.50	1.71	0.090
S. Infantis	5	1	0.83	9	11	0.45	1.85	0.169
S. Virchow	4	0	1.00	4	18	0.18	5.50	0.005
S. Agona	1	3	0.25	6	16	0.27	0.92	1.0
S. Hadar	5	3	0.63	2	16	0.11	5.63	0.013
S. Mbandaka	2	3	0.40	5	16	0.24	1.68	0.587
S. Montevideo	1	1	0.50	5	19	0.21	2.40	0.313
S. Senftenberg	1	2	0.33	5	18	0.22	1.53	1.0
S. Tennessee	2	2	0.50	4	18	0.18	2.75	0.218
S. Anatum	1	2	0.33	4	19	0.17	1.92	0.488
S. Derby	0	0	NC	5	21	0.19	NC	NC
S. Indiana	1	1	0.50	4	20	0.17	3.00	0.353
S. Kentucky	0	2	NC	5	10	0.21	NC	NC
S. Livingstone	1	1	0.50	4	20	0.17	3.00	0.353
S. Bredeney	0	1	NC	4	21	0.16	NC	NC

NC = Not calculated; Risk = Probability of observing a *Salmonella* serovar in broilers given presence/absence in breeders; RR= Risk ratio or relative risk

[7] Methodology as described in Thrusfield, M, 2005. Veterinary Epidemiology, 3rd edition, Blackwell, Oxford, UK. ISBN: 9781405156271

Table 2. Occurrence of *Salmonella* serovars in egg production in relation to presence/absence in breeders (commercial layers). Only serovars present in egg production isolated from at least 5 countries are shown. Units indicate number of countries (N=26).

	Presence in breeders			Absence in breeders			RR	p-value
	Presence in layers	Absence in layers	Risk	Presence in layers	Absence in layers	Risk		
S. Enteritidis	12	0	1.0	12	2	0.86	1.17	0.280
S. Typhimurium	6	0	1.0	13	7	0.65	1.54	0.020
S. Infantis	2	2	0.50	7	15	0.32	1.57	0.590
S. Agona	0	1	0.0	7	18	0.28	NC	NC
S. Mbandaka	0	0	NC	6	20	0.23	NC	NC
S. Braenderup	0	0	NC	5	21	0.19	NC	NC
S. Havana	0	1	0.0	5	20	0.20	0.0	NC
S. Tennessee	0	1	0.0	5	20	0.20	0.0	NC
S. Virchow	2	2	0.50	3	19	0.14	3.67	0.155
S. Derby	0	0	NC	4	22	0.15	NC	NC
S. Hadar	1	2	0.33	3	20	0.13	2.56	0.40
S. Livingstone	1	1	0.50	3	21	0.13	4.00	0.289
S. Newport	0	0	NC	4	22	0.15	NC	NC
S. Rissen	0	1	0.0	4	21	0.16	0.00	NC

NC = Not calculated; Risk = Probability of observing a *Salmonella* serovar in layers given presence/absence in breeders; RR= Risk ratio or relative risk.

Out of this first analysis, it can be seen that there is a statistically significant ($p<0.05$) association between the presence in breeders and in broilers for *S*. Enteritidis, S. Virchow, S. Hadar and *S*. Typhimurium (the latter was only borderline significant). For layers, there was a statistically significant association between breeders and commercial flocks at the country level only in the case of *S*. Typhimurium ($p=0.020$).

A second analysis involved the investigation of temporal associations between the detection of *Salmonella* serovars in breeders and in commercial production. For each type of production, a total number of Member State (MS)-years was calculated by multiplying the total number of years by the number of countries with relevant data (i.e. presence of a particular serovar in either breeders and/or commercial production). MS-years of observation were classified into: 1) MS-years in which a particular serovar was isolated from the breeders; 2) MS-years in which that serovar was not isolated from breeders; 3) MS-years immediately following a year when a particular serovar was isolated from breeders. A comparison using standard chi-square test was carried out between the detection of a particular serovars in the different types of MS-year. For each serovar the countries included in the analysis were those countries from which that particular serovar had been isolated from either type of poultry (broiler production (table 3) and egg production (table 4).

Table 3. Temporal associations between the presence of particular serovars in breeder and in commercial production (broilers) (all 26 countries included)

Serovar	MS-years where no *Salmonella* serovar isolated from breeders (%)	MS-years where *Salmonella* serovar isolated from breeders (%)	MS-years during the year after serovar was isolated from breeders (%)
S. Enteritidis	26 / 46 (56.5)	29 / 39 (74.4)	23 / 32 (71.9)
S. Typhimurium	28 / 51 (54.9)	17 / 25 (68.0)	13 / 20 (65.0)
S. Virchow	8 / 24 (33.3)	3 / 8 (37.5)	1 / 7 (14.3)
S. Hadar	9 / 27 (33.3)	3 / 12 (25.0)	2 / 9 (22.2)
S. Infantis	24 / 49 (49.0)	1 / 7 (14.2)	0 / 5 (0)

Thus, table 3 above shows the sum of the number of years in which a MS that reported the serovar listed reported the same serovar in commercial flocks (numerator) in years when the same serovar was either not reported, reported, or reported in the previous year in breeders (denominator = sum of breeder years). There was about a 50% increase (from 56.5% to 74.4%) (but not significant, p=0.137) of the probability of isolation of *S.* Enteritidis from broilers when *S.* Enteritidis was also isolated from breeders in any particular year. This increase was marginally significant in the case of S. Typhimurium (p=0.09), and not significant in the case of any other serovar.

Table 4. Temporal associations between the presence of particular serovars in breeder and in commercial production (layers).

Serovar	MS-years where no *Salmonella* serovar isolated from breeders (%)	MS-years where *Salmonella* serovar isolated from breeders (%)	MS years during the year after serovar was isolated from breeders (%)
S. Enteritidis	57 / 88 (64.8)	11 / 16 (68.7)	3 / 14 (21.4)
S. Typhimurium	39 / 88 (44.3)	7 / 8 (87.5)	2 / 7 (28.6)
S. Virchow	6 / 72 (8.3)	1 / 4 (25.0)	2 / 3 (66.7)
S. Hadar	7 / 72 (9.7)	1 / 4 (25.0)	1 / 4 (25.0)
S. Infantis	13 / 75 (17.3)	2 / 5 (40.0)	1 / 4 (25.0)

Thus, table 4 above shows that in the case of layers *S.* Typhimurium was about twice as likely to be found in the same year when it was isolated from breeders (in 87.5% years, compared with 44.3% when it could not be isolated from breeders) (p=0.048).

2. Quantitative correlation of the occurrence of the different *Salmonella* serovars between chicken breeding and production lines in the EU MS plus Norway employing amalgamated data.

The percentages of positive tests were calculated for each serovar, country and year. These data were plotted after adding 1 to all the results and being log-transformed. For each production system (broilers, layers) the Kendall's coefficient of concordance was calculated between the proportion tests positives in breeders and production.

2.1. Correlations between breeder data and broiler data.

The correlation between test results in breeders and broilers is presented in Figure 1 and Table 5.

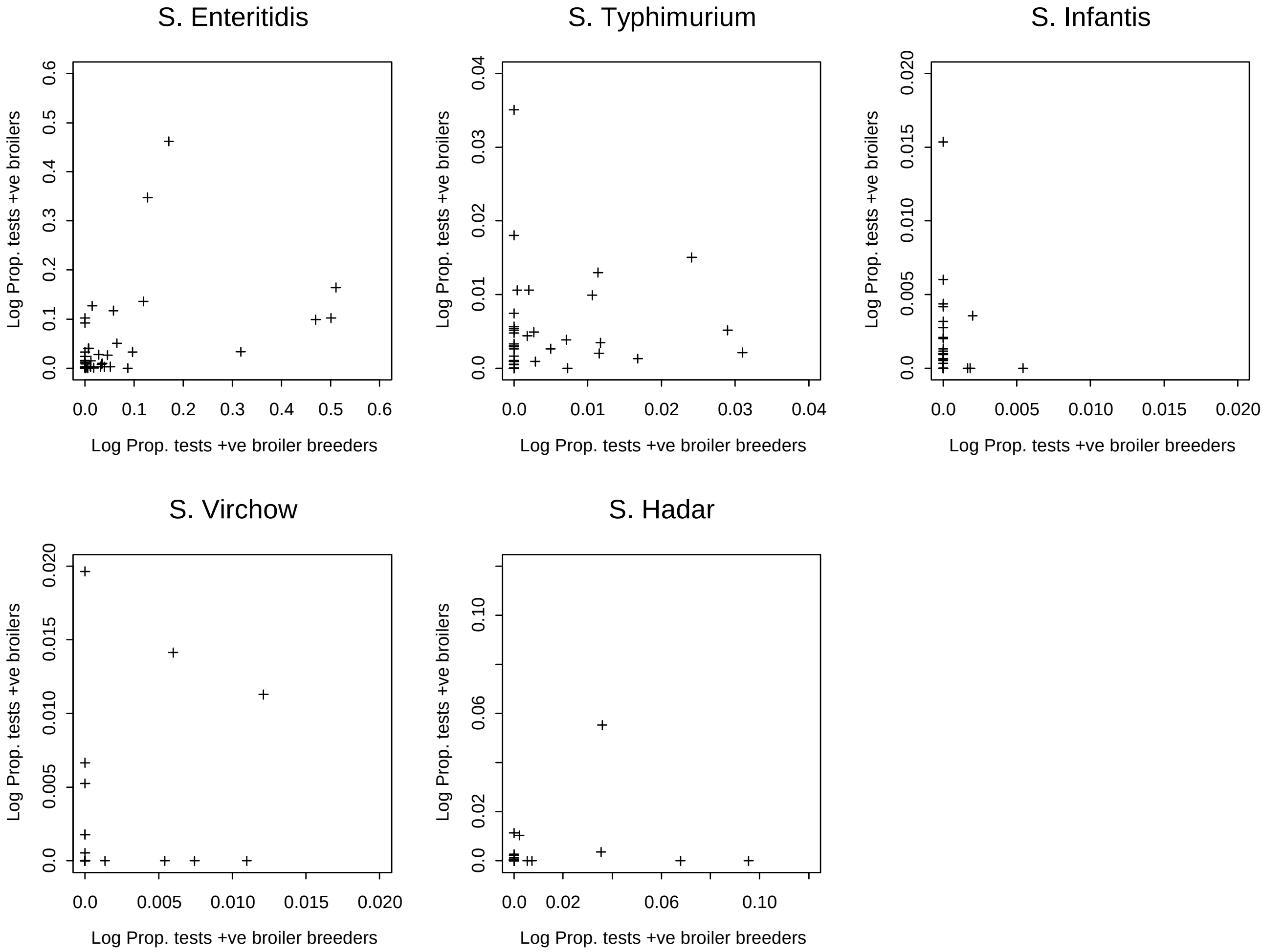

Figure 1. Correlation between isolation rates in breeders and in broiler production. The data have been log-transformed to reduce extremes.

In Figure 1, in each of the graphs (one graph per regulated *Salmonella* serovar) values for broiler breeders are presented in the x axis, and values for broilers are presented in the y axis. Each cross represents a country (only presented when paired data were available). Data from Bulgaria, Czech Republic, Hungary and UK are excluded, due to missing data on number of tests in either breeding and/or production.

Table 5. Correlation between isolation rates of selected serovars in broilers and breeders.

Serovar	Kendall's tau	p-value
S. Enteritidis	0.464	<0.001
S. Typhimurium	0.241	0.003
S. Infantis	-0.052	0.381
S. Virchow	0.024	0.827
S. Hadar	0.078	0.724

As it can bee seen in table 5, a moderate correlation between results in breeders and broilers was found for *S.* Enteritidis and *S.* Typhimurium only ($p<0.05$).

2.2. Correlations between breeder data and layer data

The correlation between test results in breeders and layers is presented in Figure 2 and Table 6 and Figure 16.

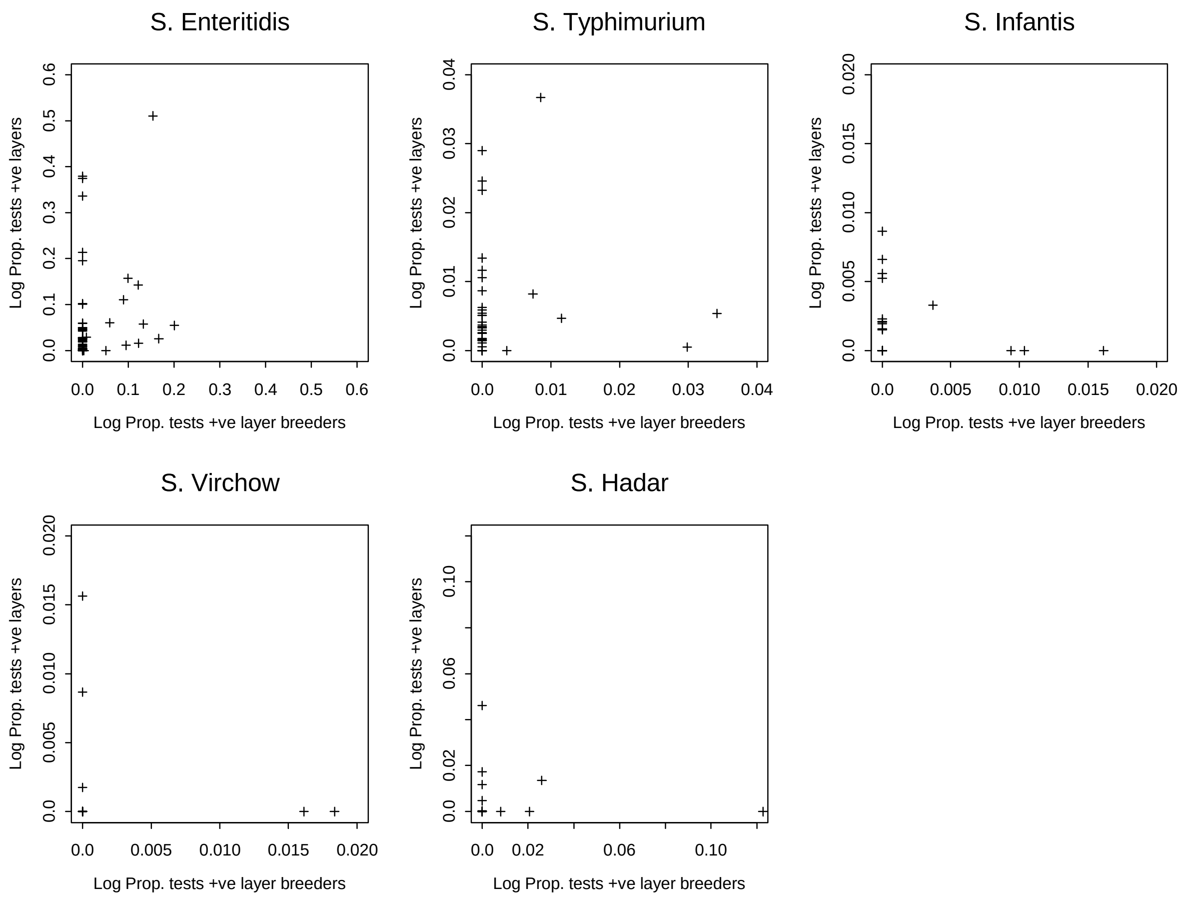

Figure 2. Correlation between isolation rates in breeders and in layer production. The data have been log-transformed to reduce extremes. Data from the UK are excluded, due to missing data on number of tests in production.

In Figure 2, in each of the graphs (one graph per regulated *Salmonella* serovar) values for layer breeders are presented in the x axis, and values for layers are presented in the y axis.

Each cross represents a country (only presented when paired data were available). Data from the UK are excluded, due to missing data on number of tests in production.

Table 6. Correlation between isolation rates of selected serovars in layers and breeders.

Serovar	Kendall's tau	p-value
S. Enteritidis	0.148	0.017
S. Typhimurium	0.068	0.165
S. Infantis	0.035	NC
S. Virchow	0.024	NC
S. Hadar	0.022	NC

NC = Not calculated

As it can be seen in table 6, a correlation between results in breeders and layers was only found for *S*. Enteritidis, although it was weaker than that found for broilers ($p<0.05$).

APPENDIX B. CASE STUDY: EVALUATION OF THE ASSOCIATION BETWEEN *SALMONELLA* SEROVARS IN BREEDERS AND IN COMMERCIAL POULTRY PRODUCTION IN GREAT BRITAIN (GB) (2000-2008)

1. Introduction

The aim of this evaluation was to investigate the association between the presence of *Salmonella* serovars in the breeding and commercial sectors for both layers and broilers (*Gallus gallus)* in GB (England, Wales and Scotland).

Data originate form a combination of statutory and voluntary monitoring carried out by poultry business operators and the competent authority. In the case of breeders, most samples were meconium taken at the hatchery up to 2007 when sampling switched to bootswabs at the holding. Samples from laying flocks largely originate from voluntary monitoring carried out under the Lion Code quality assurance scheme and are largely cloacal swabs. Samples from broiler flocks mainly originate from litter samples carried out before slaughter as part of retailer quality assurance schemes. It has to be noted that before 2007 the GB breeder data for serovars other than *S.* Enteritidis or *S.* Typhimurium were based on unconfirmed hatchery positives, which is likely to overstate the possible link between breeders and commercial flocks for non-regulated serovars.

For definition purposes, 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.

2. Method

The temporal associations between the detection of *Salmonella* serovars in breeders and in commercial production of broilers and layers was investigated for GB. A comparison was made between the risk (probability) of isolating a specific *Salmonella* serovar/phage type in the same or a subsequent year after isolation from breeders, versus the risk (probability) of isolating that particular *Salmonella* serovar/phage type in years when that serovar/phage type was not isolated from breeders. Separate comparisons were calculated for broilers and layers. These comparisons were expressed in the form of relative risks[8] (risk ratios). In addition, a chi-square statistic and associated p-values were calculated.

Separate analyses were carried out for *Salmonella* serovars currently regulated in breeding flocks and all other serovars.

3. Results

Data on the *Salmonella* serovars and phagetypes with incidents involving both broiler breeder and production flocks from 2000 to 2008 and occurring in the same or adjacent years are presented in Table 1.

A total of 42 sero/phage types and a total number of 4609 incidents have been reported.

[8] Methodology as described in Thrusfield, M, 2005. Veterinary Epidemiology, 3rd edition, Blackwell, Oxford, UK. ISBN: 9781405156271

Table 1. *Salmonella* sero/phage types with incidents involving both broiler breeder (‘Bre’) and production (‘Bro’) flocks and occurring in the same or adjacent years.

	2000		2001		2002		2003		2004		2005		2006		2007		2008	
	Bre	Bro	Bre	Bro	Bre	Bro	Bre	Bro	Bre	Bro	Bre	Bro	Bre	Bro	Bre	Bro	Bre	Bro
3,19:rough:-	-	-	-	-	-	-	-	-	1	1	4	2	-	-	-	-	-	-
3,19:-:-	-	2	1	3	1	-	2	1	1	2	-	2	-	-	-	-	-	-
4,12:d:-	-	-	-	-	-	-	2	6	-	2	-	-	-	-	3	-	-	-
6,7,14:-:-	-	15	-	27	1	4	-	-	-	-	-	1	-	-	-	-	-	-
6,7:-:-	-	12	1	43	3	65	10	38	5	39	2	40	-	27	-	3	-	2
6,7:d:-	-	1	-	-	1	-	1	1	-	-	-	1	-	1	-	-	-	-
Agama	-	4	-	2	-	1	3	1	-	-	-	1	-	1	11	1	-	-
Agona	2	14	1	12	1	3	1	4	-	2	-	2	-	4	-	3	-	4
Anatum	-	4	-	7	-	1	2	2	-	-	-	1	-	2	1	-	-	1
Binza	-	8	1	23	6	54	-	6	-	1	-	-	-	-	1	2	-	1
Brandenburg	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-
Bredeney	-	52	-	6	-	12	1	10	-	-	-	-	-	-	-	-	-	-
Derby	-	-	-	3	-	3	1	-	-	-	-	1	-	-	-	-	-	-
Enteritidis 1	-	-	-	-	-	-	-	-	-	-	-	-	9	3	-	5	-	-
Enteritidis 6	1	-	-	-	-	2	1	2	-	-	-	-	-	-	-	-	-	-
Give	-	144	-	18	-	18	-	6	4	23	1	4	-	4	-	1	-	1
Goldcoast	-	-	-	1	2	8	-	6	-	-	1	-	-	-	-	-	-	-
Hadar	1	37	-	6	1	17	1	5	-	-	-	-	1	4	-	-	-	-
Heidelberg	-	62	-	50	1	26	-	1	-	-	-	-	-	-	-	1	-	-
Indiana	-	8	-	7	1	7	-	2	-	7	-	1	-	3	-	-	-	-
Infantis	-	-	1	1	-	2	2	3	4	13	-	4	-	1	-	1	-	-
Kedougou	2	79	4	38	2	62	4	32	10	21	4	29	2	27	-	14	-	7
Kentucky	-	11	-	10	-	2	-	-	3	2	-	1	-	1	2	3	-	-
Kottbus	5	-	2	-	-	1	1	1	-	4	1	3	-	2	1	1	-	-
Larochelle	1	15	-	2	-	2	-	-	-	-	-	1	-	-	-	-	-	-
Lexington	-	-	-	1	-	2	-	-	1	7	-	3	-	-	-	-	-	-
Liverpool	-	30	-	59	1	31	3	13	2	34	-	14	-	2	-	-	-	-
Livingstone	5	41	2	74	26	102	92	38	65	40	45	100	19	35	6	17	-	2
Mbandaka	2	40	6	51	2	51	5	27	4	14	5	12	-	10	7	6	5	4
Montevideo	2	68	5	49	3	53	1	12	4	9	1	12	-	9	-	-	-	1
Newport	-	13	-	4	-	8	2	3	3	6	-	2	-	1	-	-	-	-
Ohio	-	34	-	20	1	39	2	19	-	27	2	20	-	36	-	6	-	12
Orion	-	-	-	-	1	-	-	3	-	1	-	-	-	-	-	-	-	-
Rough	1	5	2	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Senftenberg	45	201	18	124	20	92	41	14	36	18	27	37	13	13	3	9	-	2
Tennessee	-	-	-	1	-	3	-	7	1	-	-	1	-	-	-	-	-	-
Thompson	-	69	-	58	-	31	-	11	-	35	-	31	-	14	-	1	1	-
Typhim. 104	-	24	1	28	-	26	1	4	-	2	-	5	1	2	-	-	-	-
Typhim. 120	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Typhim. unty*	-	3	1	4	-	2	-	-	-	-	-	-	-	1	1	-	-	-
Virchow	-	23	-	23	1	46	44	28	15	13	5	9	-	5	-	2	-	2
Yoruba	-	-	-	-	-	-	1	-	-	1	-	1	-	-	2	-	-	-
Total incidents	67	1019	47	757	77	776	224	306	160	325	98	341	45	208	38	76	6	39

*Did not react with any of the phages in the typing scheme

Data on *Salmonella* sero/phage types with incidents involving both broiler breeder and production flocks from 2000 to 2008, but not occurring in the same adjacent years is presented in Table 2. A total of 5 sero/phage types were identified in a total of 24 incidents.

Table 2. *Salmonella* sero/phage types with incidents involving both broiler breeder ('Bre') and production ('Bro') flocks, but <u>not</u> occurring in the same or adjacent years. GB, 2000-2008 (24 incidents, 5 sero/phage types).

	2000		2001		2002		2003		2004		2005		2006		2007		2008	
	Bre	Bro	Bre	Bro	Bre	Bro	Bre	Bro	Bre	Bro	Bre	Bro	Bre	Bro	Bre	Bro	Bre	Bro
Cubana	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Dublin	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
O rough:g,s,t:-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	2	-	-
Poona	-	-	-	1	-	-	-	-	-	-	-	-	-	-	2	-	-	-
Typhim. 104B	-	7	-	5	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Total incidents	1	7	-	7	-	-	1	-	-	-	1	2	-	-	2	2	1	-

During the period 2000 to 2008, there were 11 incidents involving sero/phage types <u>only</u> found in broiler breeder flocks. These comprised a total of 10 sero/phage types, which were: Enteritidis PT7a, PT9b, Lille, Meleagridis, O rough:i:l,w, Typhimurium DT12, DT40, DT41variant, DT193a and DT208.

There were 200 incidents involving sero/phage types <u>only</u> found in broiler production flocks. These comprised a total of 57 sero/phage types, which were: 3,10:-:-, 3,10:Y:-, 4,5,12:I:, 4,12:-:-, 6,7:-:1,5, 6,7:eh:-, 6,7:k:-, 6,7:z10:-, 6,7:rough:-, 6,8:-:-, 13,23:-:-, 61:K:1,5,7, Ajiobo, Braenderup, Carno, Cerro, Champaign, Durham, Ealing, Eimsbuettel, Enteritidis PT4, PT6a, PT8, PT11, PT12, not reactive with phages (1), Gloucester, Havana, Idikan, Manhattan, Menston, O rough:f,g:-, O rough:z:1,7, O rough:z4,z23:-, Oskarshamn, Panama, Pullorum, Reading, Rissen, Saintpaul, Schwarzengrund, Stanley, Stourbridge, Sundsvall, Taksony, Typhimurium DT2, DT8, DT41, DT85, DT193, DT195, U302, RDNC, Wangata, Worthington, 1 untypable (1), and 4 untyped (4).

Data on *Salmonella* sero/phage types with incidents involving both layer breeder and production flocks and occurring in the same or adjacent years are presented in Table 3. A total of 13 sero/phage types were identified in a total of 180 incidents.

Table 3. *Salmonella* sero/phage types with incidents involving both layer breeder ('Bre') and production ('Lay') flocks and occurring in the same or adjacent years. GB, 2000-2008 (13 sero/phage types, 180 incidents).

	2000		2001		2002		2003		2004		2005		2006		2007		2008	
	Bre	Lay	Bre	Lay	Bre	Lay	Bre	Lay	Bre	Lay	Bre	Lay	Bre	Lay	Bre	Lay	Bre	Lay
Agona	-	1	-	-	-	-	-	-	-	-	1	2	-	-	2	-	-	2
Brandenburg	-	-	-	-	-	-	9	5	14	3	-	-	-	-	-	-	-	-
Enteritidis 6	2	4	-	1	-	-	-	3	-	2	-	2	-	1	-	2	-	4
Enteritidis 6a	-	-	-	-	-	-	1	2	-	-	-	-	-	-	-	-	-	4
Gallinarum	-	-	-	-	-	-	-	-	-	-	-	4	1	4	-	6	-	-
Havana	-	-	-	-	-	-	1	1	-	-	-	-	2	-	-	-	-	-
Infantis	-	-	1	-	-	1	-	-	-	-	-	-	-	2	-	-	-	-
Livingstone	1	-	-	-	1	-	-	-	5	-	-	2	-	-	-	2	-	2
Mbandaka	-	-	-	-	-	-	1	-	-	1	-	3	-	-	-	1	-	-
Montevideo	2	1	-	1	2	-	2	28	-	-	1	1	-	-	-	1	-	-
Ohio	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-
Rissen	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	1
Senftenberg	9	-	-	-	1	-	-	1	3	-	-	1	1	2	-	5	-	4
Total incidents	14	6	1	2	4	1	14	41	22	6	4	16	4	9	2	17	0	17

Data on *Salmonella* sero/phage types with incidents involving both layer breeder and production flocks, but not occurring in the same or adjacent years are presented in Table 4. A total of 8 sero/phage types were identified in a total of 23 incidents.

Table 4. *Salmonella* sero/phage types (8) with incidents involving both layer breeder ('Bre') and production ('Lay') flocks, but not occurring in the same or adjacent years, GB 2000-2008

	2000		2001		2002		2003		2004		2005		2006		2007		2008	
	Bre	Lay	Bre	Lay	Bre	Lay	Bre	Lay	Bre	Lay	Bre	Lay	Bre	Lay	Bre	Lay	Bre	Lay
Indiana	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	1
Kedougou	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	3
Pullorum 1	-	1	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
Stourbridge	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-
Tennessee	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	1
Typhim. 40	-	-	-	-	-	-	-	1	-	-	-	-	2	-	-	-	-	-
Typhim. 208	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Typhim. unty*	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-
Totals	1	1	0	0	0	2	4	1	4	0	0	0	2	1	0	2	0	5

Total of 23 incidents. *Did not react with any of the phages in the typing scheme

From 2000-2008 there were nine incidents involving sero/phage types only found in layer breeder flocks. These comprised a total of 7 types, which were: 6,7,14:-:-, Dublin, Lexington, O rough:Z:1,6, Pullorum PT15, Pullorum not typed, Thompson and untypable (1).

There were 198 incidents involving sero/phage types only found in layer production flocks. These comprised a total of 46 types, which were: 6,7:-:-, 6,7:z10:-, 6,8:e:h, 18:z4,z32:-, Agama, Ajiobo, Anatum, Binza, Bovismorbificans, Braenderup, Bredeney, Derby, Durham, Enteritidis PT1, PT4, PT4b, PT5a, PT7, PT8, PT12, PT14b, PT21, PT22, PT28, PT35, RDNC, not reactive with phages (5), Hadar PT2, Kottbus, Liverpool, Meleagridis, Newport, O rough:g,m:-, Poona, Pullorum PT7, Saintpaul, Thomasville, Typhimurium DT12a, DT35, DT49, DT85, DT104, DT120, DT193, Virchow and Yoruba.

The analysis of temporal associations between isolation of *Salmonella* from breeders and production (broilers and layers) for targeted *Salmonella* serovars and other serovars is presented in Table 5 and Table 6. For broilers (Table 5), the overall increase in risk associated with the isolation of *Salmonella* from breeders was about 77% (RR=1.77), and was similar for regulated *Salmonella* serovars (2.14) and any other serovars (RR=1.70). For *S*. Enteritidis and *T*yphimurium, the risk was higher than for the other regulated serovars (2.57 (1.37-4.82) vs. 1.33 (1.0-1.77)). Because the confidence intervals of these estimates overlap it was not possible to confirm a statistically significant greater association between breeders and commercial flocks for any of the groups of *Salmonella*.

In the case of layers (Table 6) there was a similar increase in risk (RR=1.82, or 82% increase in risk) associated with the isolation of *Salmonella* from breeders. However for targeted serovars there was no significantly increased risk (1.07 [95%CI 0.32-3.57]) when these serovars were isolated from breeders. This compares with other *Salmonella* serovars, where an increase of 91% was observed in association with the isolation from breeders.

Table 5. Comparison of the risk (probability) of isolation of specific serovars/phage types from broilers in the same or subsequent year as isolation from breeders

	Years with isolation from breeders	Years without isolation from breeders	RR	95% CI	p-value
Targeted Serovars					
Enteritidis 1	1/1 (1.0)	1/8 (0.12)	NC	NC	NC
Enteritidis 6	1/2 (0.50)	1/7 (0.14)	NC	NC	NC
Typhimurium 104B	0/1 (0.0)	2/8 (0.25)	NC	NC	NC
Typhimurium 104	3/3 (1.0)	4/6 (0.67)	NC	NC	NC
Typhimurium 120	1/1 (1.0)	1/8 (0.12)	NC	NC	NC
Typhimurium unty	1/2 (0.50)	3/7 (0.43)	NC	NC	NC
Infantis	3/3 (1.0)	5/6 (0.83)	NC	NC	NC
Virchow	4/4 (1.0)	5/5 (1.0)	NC	NC	NC
Hadar	4/4 (1.0)	2/5 (0.40)	NC	NC	NC
Total Targeted serovars	18/21 (0.86)	24/60 (0.40)	2.14	1.50-3.06	<0.001
Other serovars	88/102 (0.86)	122/240 (0.51)	1.70	1.47-1.97	<0.001
Total *Salmonella* serovars	106/123 (0.86)	146/300 (0.49)	1.77	1.55-2.03	<0.001

NC=Not calculated; unty=Untypable; RR = Risk ratio

Table 6. Comparison of the risk (probability) of isolation of specific serovars/phage types from layers in the same or subsequent year as isolation from breeders.

	Years with isolation from breeders	Years without isolation from breeders	RR	95% CI	p-value
Targeted Serovars					
Enteritidis 6	1/1 (1.0)	8/8 (1.0)	NC	NC	NC
Enteritidis 6a	1/1 (1.0)	1/8 (0.12)	NC	NC	NC
Typhimurium 40	0/1 (0.0)	1/8 (0.12)	NC	NC	NC
Typhimurim 280	0/1 (0.0)	1/8 (0.12)	NC	NC	NC
Typhimurium unty	0/1 (0.0)	1/8 (0.12)	NC	NC	NC
Infantis	0/1 (0.0)	3/8 (0.37)	NC	NC	NC
Total targeted Serovars	2/6 (0.33)	15/48 (0.31)	1. 07	0.32-3.57	0.917
Other serovars	31/55 (0.56)	74/251 (0.29)	1.91	1.41-2.58	<0.001
Total *Salmonella* serovars	33/61 (0.54)	89/299 (0.29)	1.82	1.36-2.43	<0.001

NC=Not calculated; unty=Untypable; RR = Risk ratio

APPENDIX C. PREVALENCE DATA OF THE DIFFERENT *SALMONELLA* SEROVARS IN DIFFERENT POULTRY POPULATIONS IN THE EU MS

Data reported by the different EU MS (included only when reported) for the years 2004-2007 on results of prevalence of *Salmonella* spp. in poultry flocks (*Gallus gallus*) in parent, laying and broiler flocks during production, and on the results of typed serovars are presented in table 1 and 2.

When no results have been reported for a particular parameter, the value (-) is included in the corresponding cell.

Table 1. Reported prevalence values of *Salmonella* spp. in the different EU MS for the years 2004 to 2007, inclusive, both for parent breeding flocks for egg production line (during production period) and layer flocks.

Parent breeding flocks for egg production line

Country	Year	N	*Salmonella* spp.	S. Enteritidis or Typhimurium	S. Infantis, Hadar or Virchow	Other serovars	*Salmonella* unspecified
Austria	2007	11	0%	0%	0%	0%	-
	2006	11	0%	0%	-	-	-
	2005	14	0%	0%	-	-	-
	2004	11	9.1%	9.1%	-	-	-
Belgium	2007		-	-	-	-	-
	2006	32	0%	0%	-	-	-
	2005	46	0%	0%	-	-	-
	2004	-	-	-	-	-	-
Bulgaria	2007	140	0%	0%	-	-	-
	2006	-	-	-	-	-	-
	2005	-	-	-	-	-	-
	2004	-	-	-	-	-	-

Layers

Country	Year	N	*Salmonella* spp.	S. Enteritidis or Typhimurium	S. Infantis, Hadar or Virchow	Other serovars	*Salmonella* unspecified
Austria	2007	4965	3.0%	1.8%	0.7%	0.6%	-
	2006	4359	2.0%	1.3%	-	-	-
	2005	5096	1.3%	0.9%	-	-	-
	2004	2004	1.9%	1.0%	-	-	-
Belgium	2007	-	-	-	-	-	-
	2006	897	3.7%	0%	-	-	-
	2005	979	4.1%	0%	-	-	-
	2004	-	-	-	-	-	-
Bulgaria	2007	1552	0%	0%	-	-	-
	2006	-	-	-	-	-	-
	2005	-	-	-	-	-	-
	2004	-	-	-	-	-	-

Parent breeding flocks for egg production line

Country	Year	N	*Salmonella* spp.	S. Enteritidis or Typhimurium	S. Infantis, Hadar or Virchow	Other serovars	*Salmonella* unspecified
Czech Republic	2007	18	22.2%	5.6%	-	-	16.7%
	2006	11	0%	0%	-	-	-
	2005	-	-	-	-	-	-
	2004	-	-	-	-	-	-
Denmark	2007	12	0%	0%	-	-	-
	2006	11	0%	0%	-	-	-
	2005	16	0%	0%	-	-	-
	2004	-	-	-	-	-	-
Finland	2007	21	0%	0%	-	0%	-
	2006	22	0%	0%	-	-	-
	2005	72	0%	0%	-	-	-
	2004	-	-	-	-	-	-
France	2007	114	0.9%	0.9%	-	-	-
	2006	72	0%	0%	-	-	-
	2005	98	0%	0%	-	-	-
	2004	83	0%	0%	-	-	-
Germany	2007	23	17.4%	17.4%	-	0%	-
	2006	22	0%	0%	-	0%	-
	2005	18	0%	0%	-	-	-
	2004	-	-	-	-	-	-
Greece	2007	14	0%	0.0%	-	-	-
	2006	6	0%	0%	-	-	-
	2005	-	-	-	-	-	-
	2004	-	-	-	-	-	-

Layers

Country	Year	N	*Salmonella* spp.	S. Enteritidis or Typhimurium	S. Infantis, Hadar or Virchow	Other serovars	*Salmonella* unspecified
Czech Republic	2007	689	17.0%	15.8%	-	-	1.2%
	2006	458	0%	0%	-	-	-
	2005	-	-	-	-	-	-
	2004	-	-	-	-	-	-
Denmark	2007	836	0.6%	0.5%	-	-	-
	2006	854	0.4%	0.2%	-	-	-
	2005	913	1.4%	1.3%	-	-	-
	2004	-	-	-	-	-	-
Finland	2007	842	0.2%	0.1%	-	0.1%	-
	2006	1842	0%	0%	-	-	-
	2005	2303	0.0%	0.1%	-	-	-
	2004	-	-	-	-	-	-
France	2007	5075	2.5%	2.5%	-	-	-
	2006	11019	2.5%	2.5%	-	-	-
	2005	5456	1.6%	0.3%	-	-	-
	2004	5935	1.7%	1.7%	-	-	-
Germany	2007	5693	1.8%	0.8%	-	0.1%	-
	2006	2764	1.4%	0.8%	-	0.7%	-
	2005	5833	2.8%	2.1%	-	-	-
	2004	-	-	-	-	-	-
Greece	2007	61	3.3%	1.6%	-	-	-
	2006	81	3.7%	0.0%	-	-	-
	2005	-	-	-	-	-	-
	2004	-	-	-	-	-	-

Parent breeding flocks for egg production line

Country	Year	N	*Salmonella* spp.	S. Enteritidis or Typhimurium	S. Infantis, Hadar or Virchow	Other serovars	*Salmonella* unspecified
Ireland	2007	-	-	-	-	-	-
	2006	-	-	-	-	-	-
	2005	30	0%	0%	-	-	-
	2004	-	-	-	-	-	-
Latvia	2007	6	0%	0%	-	-	-
	2006	-	-	-	-	-	-
	2005	-	-	-	-	-	-
	2004	-	-	-	-	-	-
Netherlands	2007	175	1.1%	0%	-	-	-
	2006	126	0%	0%	-	-	-
	2005	-	-	-	-	-	-
	2004	-	-	-	-	-	-
Poland	2007	-	-	-	-	-	-
	2006	476	6.9%	6.30%	-	-	0.6%
	2005	136	9.6%	5.88%	-	-	3.7%
	2004	176	10.2%	6.25%	-	-	-
Slovakia	2007	47	0%	0%	0%	0%	-
	2006	219	0%	0%	-	-	-
	2005	-	-	-	-	-	-
	2004	-	-	-	-	-	-
Slovenia	2007	7	0%	0%	0%	-	-
	2006	3	0%	0%	-	-	-
	2005	9	22.2%	22.2%	-	-	-
	2004	-		-	-	-	-

Layers

Country	Year	N	*Salmonella* spp.	S. Enteritidis or Typhimurium	S. Infantis, Hadar or Virchow	Other serovars	*Salmonella* unspecified
Ireland	2007	-	-	-	-	-	-
	2006	-	-	-	-	-	-
	2005	217	2.8%	1.4%	-	-	-
	2004	-	-	-	-	-	-
Latvia	2007	73	20.5%	20.5%	-	-	-
	2006	-	-	-	-	-	-
	2005	-	-	-	-	-	-
	2004	-	-	-	-	-	-
Netherlands	2007	6877	3.4%	3.4%	-	-	-
	2006	5008	2.0%	2.0%	-	-	-
	2005	-	-	-	-	-	-
	2004	-	-	-	-	-	-
Poland	2007	-	-	-	-	-	-
	2006	2337	11.6%	5.5%		-	5.7%
	2005	3213	7.8%	3.9%	-	-	4.0%
	2004	3114	8.6%	3.7%	-	-	-
Slovakia	2007	1172	3.2%	2.2%	0.2%	0.8%	-
	2006	1298	2.2%	2.0%	-	-	-
	2005	-	-	-	-	-	-
	2004	-	-	-	-	-	-
Slovenia	2007	246	6.1%	4.5%	0.4%	-	-
	2006	205	1.5%	0.5%	-	-	-
	2005	130	6.2%	4.6%	-	-	-
	2004	-	-	-	-	-	-

Parent breeding flocks for egg production line

Country	Year	N	*Salmonella* spp.	S. Enteritidis or Typhimurium	S. Infantis, Hadar or Virchow	Other serovars	*Salmonella* unspecified
Spain	2007	98	0%	0%	-	-	-
	2006	71	0%	0%	-	-	-
	2005	-	-	-	-	-	-
	2004	-	-	-	-	-	-
Sweden	2007	24	0%	0%	-	-	-
	2006	21	0%	0%	-	-	-
	2005	22	0%	0%	-	-	-
	2004	-		-	-	-	-
Total EU	**2007**	**710**	**2%**	**0.3%**	**0%**	**0%**	**0%**
	2006	**1,103**	**3%**	**2.7%**	**-**	**0%**	**0%**
	2005	**461**	**0%**	**2.2%**	**-**	**-**	**1.1%**
	2004	**270**	**7%**	**4.4%**	**-**	**-**	**-**
Grand Total	**04-07**	**2,544**	**3%**	**2.1%**	**0%**	**0%**	**0.4%**

Layers

Country	Year	N	*Salmonella* spp.	S. Enteritidis or Typhimurium	S. Infantis, Hadar or Virchow	Other serovars	*Salmonella* unspecified
Spain	2007	771	27.1%	11.2%	-	-	-
	2006	1125	31.2%	13.2%	-	-	-
	2005	-	-	-	-	-	-
	2004	-	-	-	-	-	-
Sweden	2007	778	0.5%	0.4%	-	-	-
	2006	913	0.1%	0.1%	-	-	-
	2005	1109	0.1%	0.1%	-	-	-
	2004	-	-	-	-	-	-
Total EU	**2007**	**29,630**	**3%**	**2.8%**	**0.1%**	**0.1%**	**0.1%**
	2006	**33,160**	**4%**	**2.3%**	**-**	**0.1%**	**0.4%**
	2005	**25,249**	**3%**	**2.9%**	**-**	**-**	**1.1%**
	2004	**11,053**	**4%**	**2.1%**	**-**	**-**	**-**
Gand Total	**04-07**	**99,092**	**3%**	**2.6%**	**0.3%**	**0.3%**	**0.4%**

Table 2. **Reported prevalence values of *Salmonella* spp. in the different EU MS for the years 2004 to 2007, inclusive, both for parent breeding flocks for broiler production line (during production period) and broiler flocks.**

Broilers parent breeding flocks								Broilers							
Country	**Year**	**N**	***Salmonella* spp.**	**S. Enteritidis or Typhimurium**	**S. Infantis, Hadar or Virchow**	**Other serovars**	***Salmonella* unspecified**	**Country**	**Year**	**N**	***Salmonella* spp.**	**S. Enteritidis or Typhimurium**	**S. Infantis, Hadar or Virchow**	**Other serovars**	***Salmonella* unspecified**
Austria	2007	50	8.0%	0%	0%	8.0%	-	Austria	2007	5,123	1.9%	0.2%	0%	0%	-
	2006	50	0%	0%	-	-	-		2006	4,546	1.3%	0.1%	-	-	-
	2005	46	4.4%	4.3%	-	-	-		2005	6,021	3.3%	2.3%	-	-	-
	2004	-		-	-	-	-		2004	-		-	-	-	-
Belgium	2007	-		-	-	-	-	Belgium	2007	-		-	-	-	-
	2006	454	0%	0%	-	0%	-		2006	13,596	2.4%	0%	-	0%	-
	2005	567	2.8%	0.5%	-	-	-		2005	14,768	3.4%	0%	-	-	-
	2004	-		-	-	-	-		2004	-		-	-	-	-
Bulgaria	2007	108	0%	0%	0%	0%	-	Bulgaria	2007	771	0%	0%	0%	0%	-
	2006	-		-	-	-	-		2006	-		-	-	-	-
	2005	-		-	-	-	-		2005	-		-	-	-	-
	2004	-		-	-	-	-		2004	-		-	-	-	-
Denmark	2007	258	1.2%	1.2%	0%	0%	-	Denmark	2007	3,486	1.9%	0.2%	0.1%	0%	-
	2006	282	1.8%	0.7%	-	-	5.7%		2006	3,640	2.2%	0.4%	-	-	0.9%
	2005	60	0%	0%	-	-	-		2005	4,083	2.1%	0.7%	-	-	-
	2004	-		-	-	-	-		2004	-		-	-	-	-
Estonia	2007	-		-	-	-	-	Estonia	2007	-		-	-	-	-
	2006	10	60.0%	60.0%	-	-	-		2006	154	5.2%	5.2%	-	-	-
	2005	-		-	-	-	-		2005	-		-	-	-	-
	2004	-		-	-	-	-		2004	-		-	-	-	-
Finland	2007	142	0%	0%	0%	0%	-	Finland	2007	3,278	0.2%	0%	0.1%	0.2%	-
	2006	105	0%	0%	-	-	-		2006	3,020	0.3%	0%	-	-	-
	2005	138	0%	0%	-	-	-		2005	3,087	0.1%	0%	-	-	-
	2004	-		-	-	-	-		2004	-		-	-	-	-

Broilers parent breeding flocks

Country	Year	N	*Salmonella* spp.	S. Enteritidis or Typhimurium	S. Infantis, Hadar or Virchow	Other serovars	*Salmonella* unspecified
Germany	2007	2,329	0.8%	0.0%	0%	0%	-
	2006	2,201	0.8%	0.0%	-	0%	-
	2005	2,349	1.1%	0%	-	-	1.1%
	2004	-		-	-	-	-
Greece	2007	22	22.7%	9.1%	0%	0%	-
	2006	36	2.8%	-	-	2.8%	-
	2005	-		-	-	-	-
	2004	-		-	-	-	-
Italy	2007	-		-	-	-	-
	2006	-		-	-	-	-
	2005	-		-	-	-	-
	2004	68	1.5%	1.5%	-	-	-
Latvia	2007	15	0%	0%	0.7%	0%	-
	2006	-		-	-	-	-
	2005	-		-	-	-	-
	2004	-		-	-	-	-
Lithuania	2007	-		-	-	-	-
	2006	726	3.2%	2.8%	-	-	-
	2005	-		-	-	-	-
	2004	-		-	-	-	-
Netherlands	2007	997	1.3%	0.9%	0%	0%	0.1%
	2006	347	1.4%	1.4%	-	-	-
	2005	-		-	-	-	-
	2004	-		-	-	-	-
Norway	2007	135	0.7%	-	-	0.7%	-
	2006	-		-	-	-	-
	2005	-		-	-	-	-
	2004	-		-	-	-	-

Broilers

Country	Year	N	*Salmonella* spp.	S. Enteritidis or Typhimurium	S. Infantis, Hadar or Virchow	Other serovars	*Salmonella* unspecified
Germany	2007	1,552	7.0%	0.1%	0%	0.2%	-
	2006	1,566	11.9%	0.7%	-	11.2%	-
	2005	1,582	17.3%	2.0%	-	-	16.4%
	2004	-		-	-	-	-
Greece	2007	104	3.8%	0%	0%	0%	-
	2006	262	6.5%	-	-	4.6%	-
	2005	-		-	-	-	-
	2004	-		-	-	-	-
Italy	2007	-		-	-	-	-
	2006	-		-	-	-	-
	2005	-		-	-	-	-
	2004	714	8.7%	0.14%	-	-	-
Latvia	2007	150	5.3%	3.3%	0.7%	0%	-
	2006	-		-	-	-	-
	2005	-		-	-	-	-
	2004	-		-	-	-	-
Lithuania	2007	-		-	-	-	-
	2006	121	9.1%	7.4%	-	-	-
	2005	-		-	-	-	-
	2004	-		-	-	-	-
Netherlands	2007	56,263	1.6%	0.1%	0%	0%	1.6%
	2006	26,025	0.8%	0.1%	-	-	-
	2005	-		-	-	-	-
	2004	-		-	-	-	-
Norway	2007	4419	0.0%	-	-	0%	-
	2006	-		-	-	-	-
	2005	-		-	-	-	-
	2004	-		-	-	-	-

Broilers parent breeding flocks

Country	Year	N	*Salmonella* spp.	S. Enteritidis or Typhimurium	S. Infantis, Hadar or Virchow	Other serovars	*Salmonella* unspecified
Poland	2007	-		-	-	-	-
	2006	522	5.6%	2.7%	1.3%	-	1.5%
	2005	411	12.4%	8.8%	-	-	3.6%
	2004	722	6.0%	4.0%	-	-	-
Slovenia	2007	111	0%	0%	0%	0%	-
	2006	28	0%	0%	-	-	-
	2005	31	3.2%	3.2%	-	-	-
	2004	19	5.3%	5.3%	-	-	-
Spain	2007	741	2.6%	1.8%	0%	0%	0.1%
	2006	577	28.4%	15.9%	-	-	6.1%
	2005	-		-	-	-	-
	2004	-		-	-	-	-
Slovakia	2007	528	0.9%	0.8%	0%	0.2%	-
	2006	452	0.7%	0.4%	-	0.2%	-
	2005	-		-	-	-	-
	2004	-		-	-	-	-
Sweden	2007	-		-	-	-	-
	2006	63	0%	0%	-	-	-
	2005	64	0%	0%	-	-	-
	2004	-		-	-	-	-
Total EU	**2007**	**5,436**	**1.3%**	**0.6%**	**0%**	**0.5%**	**0.0%**
	2006	**5,853**	**4.3%**	**2.4%**	**0.1%**	**0.3%**	**0.7%**
	2005	**3,666**	**2.6%**	**1.1%**	**-**	**-**	**1.1%**
	2004	**809**	**5.6%**	**3.8%**	**-**	**-**	**-**
Grand Total	**04-07**	**15,764**	**2.9%**	**1.6%**	**0.8%**	**0.5%**	**0.6%**

Broilers

Country	Year	N	*Salmonella* spp.	S. Enteritidis or Typhimurium	S. Infantis, Hadar or Virchow	Other serovars	*Salmonella* unspecified
Poland	2007	-		-	-	-	-
	2006	10,260	17.6%	5.2%	0.1%		5.4%
	2005	33	9.4%	0%	-	-	6.4%
	2004	22,552	7.8%	3.7%	-	-	-
Slovenia	2007	2,491	1.8%	0.2%	0.6%	0%	-
	2006	1,800	0.5%	0.3%	-	-	-
	2005	321	2.2%	0.9%	-	-	-
	2004	1,146	1.0%	0.3%	-	-	-
Spain	2007	815	23.5%	14.0%	0%	0%	11.3%
	2006	776	41.2%	29.6%	-	-	11.6%
	2005	-		-	-	-	-
	2004	-		-	-	-	-
Slovakia	2007	4,539	4.0%	2.6%	0.2%	1.2%	-
	2006	4,430	2.1%	1.6%	-	0.5%	-
	2005	-		-	-	-	-
	2004	-		-	-	-	-
Sweden	2007	-		-	-	-	-
	2006	2,351	0.2%	0.1%	-	-	-
	2005	2,368	0%	0%	-	-	-
	2004	-		-	-	-	-
Total EU	**2007**	**82,991**	**2.0%**	**0.4%**	**0.0%**	**0.1%**	**1.2%**
	2006	**72,547**	**0.1%**	**1.2%**	**0.0%**	**0.3%**	**0.9%**
	2005	**32,263**	**9.2%**	**1.4%**	**-**	**-**	**4.8%**
	2004	**24,412**	**7.5%**	**3.4%**	**-**	**-**	**-**
Grand Total	**04-07**	**212,213**	**3.1%**	**1.2%**	**0.2%**	**1.5%**	**1.5%**

APPENDIX D. QUESTIONNAIRE CIRCULATED AMONG EU MS (PLUS NORWAY AND SWITZERLAND) ON *SALMONELLA* MONITORING AND CONTROLS

1. **Samples taken at the <u>rearing phase</u>**. Firstly indicate whether samples are taken by the official control authority or whether they are own checks by the operator. Then, the type of sample and the number or amount of samples that are taken.

Comments (*e.g.* any alternative method of *Salmonella* detection if different form 1003/2005 EU)

2. **Samples taken at the <u>adult breeding flock</u>.** Indicate both for official control and own checks the sampling frequency and whether samples are taken in the hatcheries or at farm level, indicating the type of sample and the number (or amount) of samples that are taken.

ADULT breeding flock	**Frequency or exact number of weeks of age**	**Type and number of samples**						
		In hatcheries			**At farm**			
		Basket liners	Broken egg shells	Other (please specify)	Boot swabs	Individual faeces (total grams)	Pooled faecal samples (total grams)	**Other?** (please specify)
Official checks								
Own checks								

Comments (*e.g.* on the frequency, serological tests performed, <u>differences between kept caged or on floor</u> breeding hens, etc)

3. ***Salmonella* vaccination in parent breeder flocks.** First tick the legal situation that applies. If permitted or Mandatory, indicate date since it was implemented, and if permitted or mandatory the details of the approved vaccines (*e.g. live or killed* type, company name, *Salmonella* serovar contained in the vaccine, vaccination strategies, etc).

***Salmonella* VACCINATION**	**Legal situation**			If permitted, since month and year?	If permitted, approved vaccines and **details**
	Mandatory	**Permitted**	**Prohibited**		

Comments (*e.g.* particular vaccination strategies – doses, vaccination schedule).

4. **Confirmatory testing after finding a positive result.** Indicate, both for own checks and official checks: If confirmatory testing is done and if yes the type of confirmatory testing.

		ALWAYS Confirmatory testing before reporting? Please indicate YES/NO and type	**Confirmatory testing before reporting ONLY IF FALSE POSITIVE SUSPECTED? Please indicate YES/NO and type**
ACTIONS in case of a positive result	**Serovars identified**	Confirmation with official control check (please specify method)	Confirmation with official control check (please specify method)
After positive result from operator (Own Checks) at the hatchery?	*S* Enteritidis or *S* Typhimurium		
	S Hadar, *S* Virchow or *S* Infantis		
After positive result from operator (Own Checks) at the farm?	*S* Enteritidis or *S* Typhimurium		
	S Hadar, *S* Virchow or *S* Infantis		
After positive result from Official Authority Controls?	*S* Enteritidis or *S* Typhimurium		
	S Hadar, *S* Virchow or *S* Infantis		

Comments (*e.g.* further details on confirmatory testing after positive result)