

Incidence of *Salmonella* spp. in Different Animal Species and Meat Products in Ecuador During the Period 2009-2019

Favian Bayas-Morejon^{1*} , Angelica Tigre¹, Ivonne Aldaz², Paulina Parra², Evelyn Ramos³, Roberto Remache⁴ and Carolina Zamora⁴

¹State University of Bolivar, Center for Biotechnology Research and Development, Faculty of Agricultural Sciences, Natural Resources and Environment, CP: 020150, Guaranda, Ecuador. ²Higher Polytechnic School of Chimborazo, CP: 060150, Riobamba-Ecuador. ³Capakñam, CP: 060150, Riobamba, Ecuador. ⁴Higher Technological Institute Federal Republic of Germany, CP: 060150, Riobamba, Ecuador.

Abstract

Salmonella is a gram-negative bacillus of the family Enterobacteraceae, is a pathogen of importance in public health. In Ecuador there is little information regarding this microorganism. So that the objective of this work was to determine the incidence of *Salmonella* spp. in the different animal species and meat products in through a documentary review. After the documentary study, have been registered a total of 1686 cases of salmonellosis in Ecuador, with a greater presence in the provinces of the Sierra (927 cases), followed by the provinces of the coast (729 cases) and finally the Amazon region with 30 cases. At the provincial level, the highest number of cases of salmonellosis occurs in the province of Pichincha with 805 cases, while, the highest incidence values it is in the province of Sto. Domingo with 85% of incidence. In relation to the level of incidence, the coastal region presents higher average percentage value (38.34%), the most part due to the presence of the pathogen in food, followed by the sierra (27.57), and Amazon region (22.23), however, in the Island region (Galapagos) no quantitative data was registered.

Keywords: Incidence, *Salmonella*, Ecuador, animal species, meat products.

*Correspondence: isba@doctor.upv.es; fbayas@ueb.edu.ec

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INTRODUCTION

The objective of this work was: to determine the incidence of the *Salmonella* spp. in the different animal species and meat products in Ecuador through the literature review in the period 2009-2019. *Salmonella* is a Gram-negative bacillus, belongs to the Enterobacteraceae family. Most of the serovarieties that have been isolated from human and from warm-blooded animals belong to the enteric subspecies I (subspecies I) and usually, their name is related to the geographical location where they were isolated for the first time (Grigar et al., 2017; Scallan et al., 2011).

There are more than 2.500 serovars or serotypes of *Salmonella*, the great majority belongs to the subspecies I, here find *Salmonella enteritidis* and *Salmonella typhimurium*, which are the most frequent in our environment (Ellermeier and Schlauch, 2006).

Epidemiology of Salmonellosis

According by Gyles et al. (2010), from the epidemiological point of view *Salmonella* spp. it can be classified into three groups:

a) Those that do not have a preference for any special host, so infect both human and animals. Most of the serovars responsible for salmonellosis are found in this group.

b) Those that infect only human: *Salmonella typhi*, *Salmonella paratyphi* A and *Salmonella paratyphi* C and that are transmitted directly or indirectly from one person to another.

c) Those adapted to a host in different animal species, such as *S. sbortusovis* in sheep; *S. abortusequi* in equines and *S. gallinarum* in birds.

Its wide distribution worldwide and other characteristics that make it resistant has caused a pandemic of *Salmonella enteritidis*, which first appeared in the eighties and is attributed to the contamination of eggs (Rodrigue et al., 1990). The number of *Salmonella* infections related to this serotype has been increasing over time. In 1995, there was 36% of *Salmonella enteritidis* in the world, compared to 65% in 2002 (Herikstad, et al., 2002).

The program WHO-Global *Salmonella* Survey confirmed that between 2000 and 2004 *Salmonella* enteric serovar *enteritidis*, was the most isolated in the world from human matrices; while, in animal samples, others are the *Salmonella* pathogens commonly founds (Yim et al., 2010).

Salmonella is a bacterium zoonotic that is transmitted through food and requires an adequate temperature for its development between 35 to 37°C. Once in your host organism triggers its toxicity that causes damage to the intestinal mucosa and sometimes the condition extends to a blood level.

The clinical picture usually emerges between the first day to the third day after the contamination, generating discomfort in the individual and symptoms such as dysentery, hyperthermia, pain at the nasogastric level, headaches and uncommon vomiting. When the bacteria reach the bloodstream, the individual is at risk of septicemia, osteomyelitis and meningitis (De Cesare, 2018).

Developing Incidence of *Salmonella* spp. Present in the Costa or Litoral Region of Ecuador Esmeraldas

In a study in the province of Esmeraldas on the prevalence of *Salmonella* in poultry farms, none of the two farms surveyed tested positive for the *Salmonella* prevalence test (Casart et al., 2018).

Los Rios

According to the research of Galiano et al. (2011), in the data of the National Directorate of Epidemiological Surveillance (DNVE) of the Ministry of Public Health (MSP). It has been reported that in the province of Los Rios, there were 47 cases of infections due to *Salmonella* spp. probably due to the ingestion of contaminated meat products, of which 39 cases were found in the city of Babahoyo.

Santo Domingo

In this province, 25 cases of salmonellosis have been evidenced in meat products that are contaminated during the process of raising transporting the animals, as considered by Rodriguez Merchan and Silva (2017). So also, Sanchez Chugchilon (2016), in their research where the authors detected higher *Salmonella* incidence during the process of slaughtering chicken skin before chilling with 85% incidence and 50% during the blind process in transport, said pathogen showed resistance to Quinolones.

Manabi

According to Rodriguez Merchan and Silva (2017), in the province of Manabi after microbiological analysis detected 15 cases of pigs

Table 1. Taxonomic classification of the *Salmonella* genus

Author/s	year	Salmonella	
		Specie	Origin
Borman	1957	<i>Salmonella arizonae</i>	
Le Minor	1985	<i>Salmonella bongori</i>	Gastrointestinal
Smith	1894	<i>Salmonella choleraesuis</i>	Feces
Borman	1957	<i>Salmonella choleraesuis</i> <i>subsp. arizonae</i>	Feces
Le Minor	1985	<i>Salmonella choleraesuis</i> <i>subsp. bongori</i>	Feces
Smith	1894	<i>Salmonella choleraesuis</i> <i>subsp. choleraesuis</i>	Feces
Le Minor	1985	<i>Salmonella choleraesuis</i> <i>subsp. diarizonae</i>	Feces
Le Minor	1985	<i>Salmonella choleraesuis</i> <i>subsp. houtenae</i>	Feces
Le Minor	1987	<i>Salmonella choleraesuis</i> <i>subsp. indica</i>	Feces
Le Minor	1985	<i>Salmonella choleraesuis</i> <i>subsp. salamae</i>	Feces
Kauffmann and Edwards	1952	<i>Salmonella enterica</i>	Feces
Borman	1957	<i>Salmonella enterica subsp.</i> <i>arizonae</i>	Gastrointestinal
Le Minor	1985	<i>Salmonella enterica subsp.</i> <i>bongori</i>	Gastrointestinal
Le Minor	1985	<i>Salmonella enterica subsp.</i> <i>diarizonae</i>	Gastrointestinal
Le Minor and Popoff	1987	<i>Salmonella enterica subsp.</i> <i>enterica</i>	Gastrointestinal
Le Minor and Popoff	1987	<i>Salmonella enterica subsp.</i> <i>houtenae</i>	Gastrointestinal
Le Minor and Popoff	1987	<i>Salmonella enterica subsp.</i> <i>indica</i>	Gastrointestinal
Le Minor and Popoff	1987	<i>Salmonella enterica subsp.</i> <i>salamae</i>	Gastrointestinal
Castellani and Chalmers	1919	<i>Salmonella enteritidis</i>	Gastrointestinal
Ezaki	2000	<i>Salmonella paratyphi</i>	Bowels and bloodstream
Shelobolina	2005	<i>Salmonella subterranea</i>	
Warren and Scott	1930	<i>Salmonella typhi</i>	Feces
Castellani and Chalmers	1919	<i>Salmonella typhimurium</i>	Bowels

LPSN (2019)

infected with *Salmonella*, which had white spots in the lungs, liver and intestines. On the other hand, in another study carried out in a processing plant in the city of Manta by Lvia and Trujillo (2013), the authors randomly selected 50 samples of fresh gutted prickly pear and 25 contact surface

samples, 150 pinchagua samples in the transport stage and 25 contact surface samples taken from the handlers in the fish market stage; of the total samples analyzed, 4 positive results were detected in the presence of *Salmonella* spp. on the contact surfaces.

Santa Elena

In this province studies were found on the prevalence of *Salmonella* in meat products in Planning Area 4, where Santa Elena was included. The results showed that, in total, 518 cases were reported for the last morbidity profile in 2016 (Rodríguez Merchan and Silva, 2017).

Guayas

In the province of Guayas the incidence of *Salmonella* is very wide since 120 cases of salmonellosis were found according to the research developed by Cedeño (2015), mostly present in poultry, domestic animals, sheep, bovines, among others, are usually the main origin of the contagion of this disease because they are the entity that these bacteria use as a reservoir. On the other hand, in another study carried out by Casart et al. (2018), registered an incidence in poultry farms by 11.1%. Also, in another study conducted by Plaza (2013), where he performed a microbiological analysis on cheeses that are sold in the city of Guayaquil, evidenced the presence of *Salmonella* spp. in 13.71% of the cheeses analyzed (8/51).

El Oro

Loayza (2011), carried out a study in the municipal market of the city of Piñas in the province of Oro, where they detected the presence of *Salmonella* in bovine meat by 66.66%. On the other hand, in the study carried out by Casart et al. (2018), detected *Salmonella* in 16.70% of the samples analyzed.

Incidence of *Salmonella* spp. Present in the Sierra or Interandina Region

Carchi

In a study developed by Campoverde (2014), in Tulcan province of Carchi, where 17 stalls selling artisan sausages were evaluated, and the presence of *Salmonella* 30.6% were identified in chorizo and 25% in black pudding. In contrast to the results obtained in commercial brands of chorizo where the results were negative for *Salmonella*.

Imbabura

In a study developed by Sanchez (2016), in a total of 299 samples collected of which: 177 corresponded to raw materials, 10 to finished food, 17 to papers of transport of chickens of 1 day, 51 to farms, 4 to blind, 20 to skin of chickens before and 20 after of the chiller. Resulting in 60

Table 2. Cases Susceptible to Avian Infectious Laryngotracheitis in 2014

Month	Province	Susceptible	Cases
January	Cotopaxi	127974	25
February	Cotopaxi	10500	25

Table 3. Summary of Incidence media values of *Salmonella* spp. in Ecuador by Regions

Region	Incidence (%)
Coast	38.34
Sierra region	27.57
Amazon region	22.23
Island region	—

Table 4. Cases and Incidence of *Salmonella* genus for provinces in Ecuador

Provinces	Cases	Incidence	Year
Los Rios	47	0.00	2011
Sto Domingo	25	85.00	2009; 2010
Manabi	19	0.00	2013; 2017
Sta Elena	518	0.00	2017
Guayas	120	12.35	2015; 2017; 2018
El Oro	0	41.00	2011; 2018
Carchi	0	27.80	2014
Imbabura	60	20.00	2016; 2018
Pichincha	805	28.36	2012; 2015; 2016; 2018
Cotopaxi	50	0.00	2014
Tungurahua	2	9.75	2013; 2018
Bolivar	0	35.67	2014; 2015; 2018
Loja	0	42.50	2014; 2018
Cañar	10	43.10	2016
Morona	8	0.00	2009
Santiago			
Napo	0	29.15	2015; 2018
Pastaza	22	15.30	2018
Total	1686		

positive samples for *Salmonella* after molecular analysis.

On the other hand, in the study by Casart et al. (2018), 42.9% of the samples analyzed were positive for *Salmonella*.

Pichincha

In 2011, 805 cases of salmonellosis were reported in the province of Pichincha, without

informing the origin (Dirección Provincial de Salud de Pichincha, 2012). On the other hand, Villagomez et al. (2015), carried out a field work in the poultry slaughtering industrial plant, located in the province of Pichincha, in the sector of Calderon belonging to the Quito. At the end of the sampling, of the 25 skin pools processed and analyzed during this investigation, 20 (80%) were positive for *Salmonella* spp. In the same way in the investigation, on fecal content of poultry slaughtered in industrial slaughterhouses in Pichincha has reported isolates of *Salmonella* spp. in 8.45% (n = 142) (Villagomez, 2015). So also, in the study by Casart et al. (2018), obtained a prevalence of *Salmonella* in 10% of the samples analyzed.

In another study conducted by Vinuesa-Burgos et al. (2016), indicated that 15.9% of the batches in the province of Pichincha are *Salmonella* positive.

Cotopaxi

Toaquiza (2017), conducted a study in 9 farms in the province of Cotopaxi in 2015, where it was confirmed that there were no outbreaks of salmonellosis.

In addition, according to the OIE, in its 2014 World Animal Health Information System, a total number of 278.444 birds were reported to have outbreaks of Avian Infectious Laryngotracheitis and Avian Mycoplasmosis in January and February, as detailed in Table 2.

Tungurahua

According to Rodriguez (2013), in his research, they selected 450 chicken eggs, distributed in 150 samples from 50 poultry farms. Of the total samples processed and analyzed, a prevalence of *Salmonella* enteritidis of 1.3% (2/150) was found. These samples were confirmed by biochemical tests and serotyping. So also, in the study by Casart et al. (2018), obtained a prevalence of *Salmonella* in 18.2% of the samples analyzed.

Chimborazo

In a study conducted by Jara (2016), he investigates the presence of microorganisms in the ground meat sold in the city of Riobamba, detecting for *Salmonella* presence / 25 g.

Bolivar

An investigation was carried out to determine the incidence of *Salmonella* types in chicken eggs sold in the markets of Guaranda,

Chimbo and San Miguel, 297 samples were analyzed in 99 eggs, being examined both in shell and content (yolk-clara), it was determined that the incidence of *Salmonella* types in Creole chicken eggs is low (Solano-Buñay, 2015). On the other hand, our research group carried out a study of susceptibility to natural extracts in 32 *Salmonella* isolates obtained from 100 consumer types of meat (beef, pork and chicken) in the city of Guaranda (Bayas-Morejon et al., 2018).

Loja

An investigation was carried out in the community of Oñacapac, where the inhabitants are 100% indigenous, in the Province of Loja, canton Saraguro. The objective of the research work was to determine the causes of mortality in guinea pigs, for which observations were made of the characteristic symptomatology present in the guinea pigs and the microbiological analysis, obtaining a prevalence of 35% (Guaman, 2014). So also, in the study conducted by Casart et al. (2018), obtained a prevalence of *Salmonella* in 50% of the samples analyzed.

Cañar

According to Vargas (2016), the main source of infection or transmission of salmonellosis is found in meat products derived from pigs, since 10 cases of salmonellosis were detected in pigs. This result shows that sales of pork are an important reservoir of this bacterium. and other products of porcine origin should be taken into account as a potential source of *Salmonella* infection. The results are mainly 43.1% of the total sales of pigs where it was used in the ELISA techniques that are commonly used for the serological diagnosis of porcine salmonellosis.

Azuay

Of some studies conducted on foods of meat products in the province of Azuay, the presence of *Salmonella* has not been detected (Paucar and Tenecora, 2013)

Incidence of *Salmonella* spp. Present in the Amazon Region

Sucumbios

No published data have been registered

Morona Santiago

In the canton Pablo VI, a study was carried out on 10 farms producing milk in the area, in which it was determined that 8 of them were

infected with *Salmonella*, through the tests taken on the milk, a very acute degree of *Salmonella* was determined in each one of the farms putting the milk-producing area in quarantine and under the protection of treatments for animals (Pelaez, 2009).

Napo

In the research carried out by Tena (2015), of the samples obtained in a free trade show, 75% resulted in a negative presence of *Salmonella* while 25% turned out to be positive out of a total of 12 samples taken. Concluding that the main pork focusses of infection for salmonellosis. So also, in the study by Casart et al. (2018), obtained a prevalence of *Salmonella* in 33.3% of the samples analyzed.

Pastaza

In a study conducted by Egas (2018), *Salmonella* was identified in 15.3% (n = 22/144) of the samples analyzed. The only serotype identified was *S. Infantis* (n = 5).

Orellana

No published data have been registered

Zamora

In the canton Panguí, a case of the loss of an establishment of broiler birds was detected where *Salmonella* spp. contamination had occurred in balanced feed, infecting the net population, resulting in the disease known as typhoid. The Agrocalidad department performed serological tests on the feed and on a batch of animals to determine the infection taken and the reaction of the batch to the same resulting in the involuntary slaughter of the animals in the growth

stage.

Incidence *Salmonella* spp. Present in Galapagos

Aquatic turtles or sea turtles and iguanas are frequently carriers of *Salmonella*, a bacterium that is lodged in the digestive tract of these animals and can be transmitted to humans with the danger that they will contract the disease of salmonellosis Franco et al. (2011).

Analysis of Data

According to the data investigated, have been registered a total of 1686 cases of salmonellosis in Ecuador, with a greater presence in the provinces of the Sierra (927 cases, followed by the provinces of the coast (729 cases) and finally the Amazon region with 30 cases.

At the provincial level, it can be seen that the highest number of cases of salmonellosis occurs in the province of Pichincha, while in the case of average incidence values it is in the province of Sto. Domingo, Table 4.

In relation to the level of incidence, the coastal region presents higher average percentage value the most part due to the presence of the pathogen in food, followed by the Sierra, and Amazon region, however, in the Island region (Galapagos) no quantitative data was registered. (Table 3).

The figure below shows the level of incidence by year of *Salmonella* in meat products

The figure shows that there is a higher incidence of *Salmonella* in relation to the number of studies conducted were in the years 2009, 2011 and 2018 with average data that exceed 40% of samples recorded.

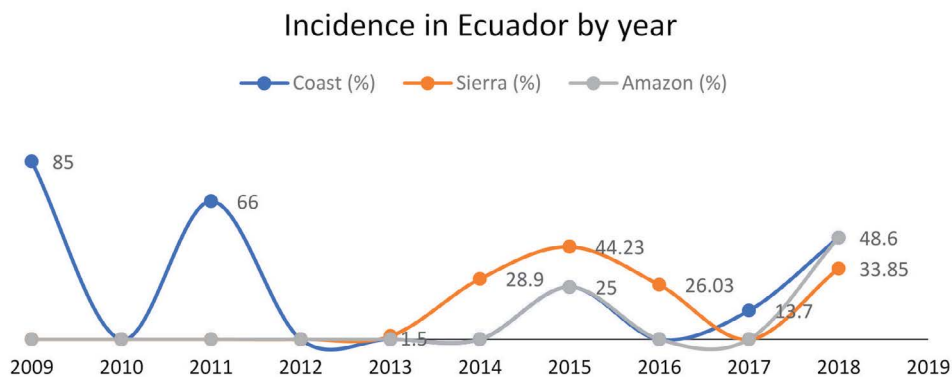


Fig. 1. *Salmonella* incidence level by year

CONCLUSION

With more than 1600 registered cases in Ecuador, where the Costa region presents the highest average for the presence of *Salmonella* and is generally related to food contamination, we can consider that environmental and sanitary conditions (overcrowding of animals in farm), may influence direct on the pathogen incidence.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORS' CONTRIBUTION

FB, AT, IA, PP drafted the manuscript. AT, IA and PP gathered information from the literature about data from the provinces of the coast, sierra and the amazon región respectively. FB compiled information from the literature, and designed the figures and tables. EM and RR supervised and reviewed the manuscript. CZ designed and did the final formatting of the figures and tables.

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DATA AVAILABILITY

All datasets generated or analyzed during this study are included in the manuscript and/or the Supplementary Files.

ETHICS STATEMENT

This article does not contain any studies with human participants or animals performed by any of the authors.

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