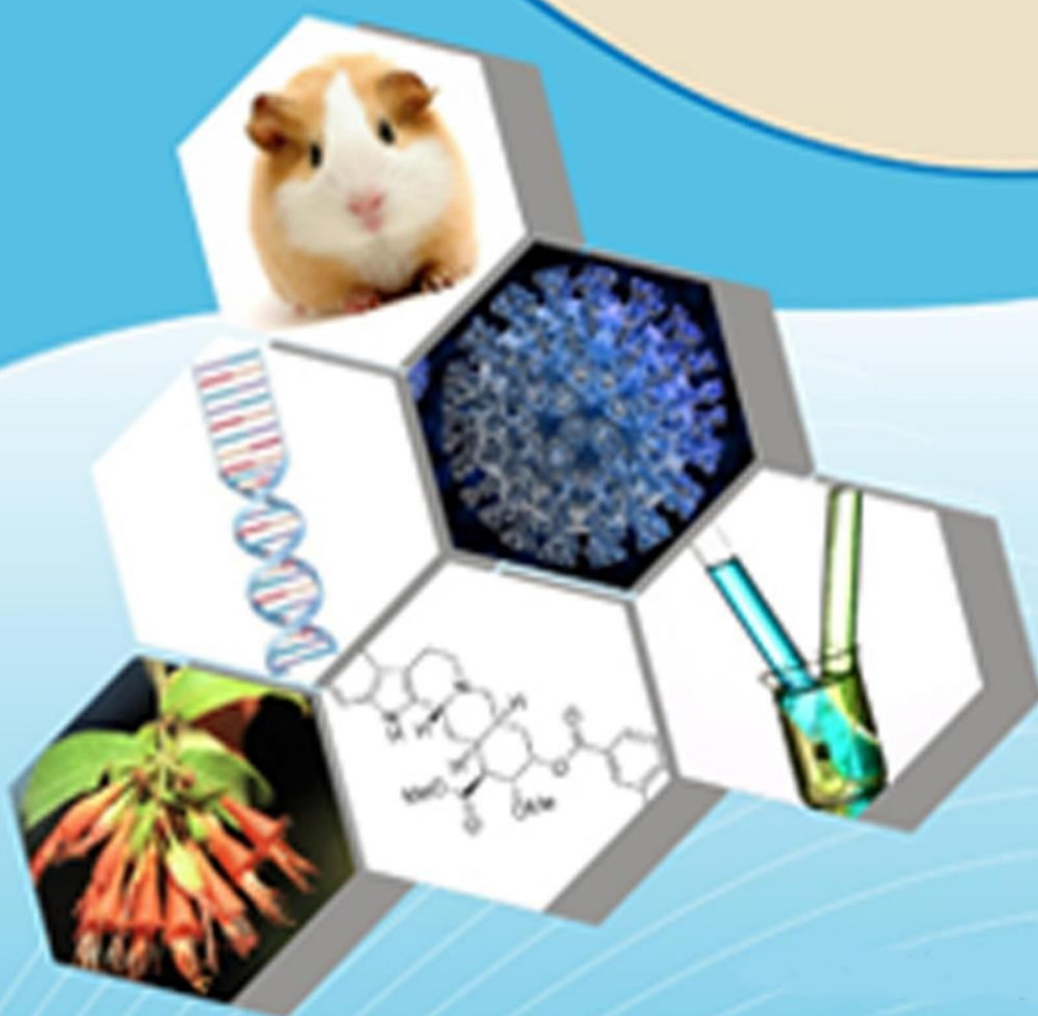




ISSN : 2347-2251

**Indo-American Journal of
Pharma and Bio Sciences**



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The frequency of *Salmonella gallinarum* (typhosis) in exotic and native chickens in the peri-urban districts of Bamako, Ségou, and Sikasso, Mali, as determined by bacteriological methods

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Abstract

In Mali, poultry farming is the main source of table eggs and broiler chickens. However, among the constraints to its development are those of a health nature in general and salmonellosis in particular. The objective of this study conducted in 2014-2015 was to assess the bacteriological prevalence of salmonellosis caused by *Salmonella gallinarum* in exotic and local hens in the peri-urban areas of Bamako, Ségou and Sikasso. 526 samples (515 cloacal swabs and 11 organ samples) from 182 chicken farms (exotic and local) collected and tested in culture. An overall bacteriological prevalence rate of 10.2% obtained with 9.7% in Bamako against 15.1% in Ségou and 8.0% in Sikasso. These rates varied according to the nature of the samples (9.5%, 14.2% and 6.2% for cloacal swabs against 25%, 100% and 50% for organ samples respectively in Bamako, Ségou and Sikasso) and the type of poultry (9.2% in exotic hens and 27.5% in local chickens). Statistical analysis revealed no significant variation ($p=0.128>0.05$ in Ségou, $p=0.335>0.05$ in Sikasso) in prevalence at the Ségou and Sikasso sites. On the other hand, it revealed a significant variation according to the types of samples and poultry ($p=0.003<0.05$). This study confirmed the persistence of avian salmonellosis in poultry farms located in peri-urban areas of Bamako, Ségou and Sikasso. 5% in local hens). Statistical analysis revealed no significant variation ($p=0.128>0.05$ in Ségou, $p=0.335>0.05$ in Sikasso) in prevalence at the Ségou and Sikasso sites. On the other hand, it revealed a significant variation according to the types of samples and poultry ($p=0.003<0.05$). This study confirmed the persistence of avian salmonellosis in poultry farms located in peri-urban areas of Bamako, Ségou and Sikasso. 5% in local hens). Statistical analysis revealed no significant variation ($p=0.128>0.05$ in Ségou, $p=0.335>0.05$ in Sikasso) in prevalence at the Ségou and Sikasso sites. On the other hand, it revealed a significant variation according to the types of samples and poultry ($p=0.003<0.05$). This study confirmed the persistence of avian salmonellosis in poultry farms located in peri-urban areas of Bamako, Ségou and Sikasso.

Keywords: Poultry farming; Bamako; Prevalence; Salmonellosis; Ségou; Sikasso

1. Introduction

An important part of Mali's economic, social, and cultural growth has been the poultry industry. Estimates put the total number of poultry in the country at around 55952026 in 2020, with 4961752 in the traditional sector accounting for 88.68% and 6,334,525 in the modern sector representing 11.32% (1). When compared to 2017, when there were over 450,04,600 subjects, this figure has grown substantially (2). Poultry farming is reportedly one of Mali's key cash crops and protein suppliers, according to many sources [2, 3, 4, 5]. The total value of all the business dealings involving chicken farms was projected to be about 5,019,232,000 CFA francs in the last year. Also, in 2019, the total amount of meat produced was anticipated to be 14,55% chicken, or 12,250,191 tons [1]. Therefore, it's clear that it helped alleviate poverty and ensure Malians have access to nutritious food. Even while the embryos of industrial facilities manufacturing day-old chicks locally are starting to appear, the majority of chicks are imported from other nations. Chick providers also provide poultry farms with prophylactic regimens. The use of these preventative measures does not always lead to acceptable death rates; for example, 20% or more in layers, compared to 5% during raising and 2% to 3% monthly throughout production [6]. Losses due to the many occurrences of salmonellosis are one example of the health-related limitations that have slowed the progress of modern chicken production [6]. In a diagnostic study conducted in Mali from 2003 to 2007, the main constraints in semi-industrial poultry farming were identified, and one of the dominant pathologies was salmonellosis, with typhosis accounting for 20.09% and cases of eggs infected with *Salmonella pullorum/gallinarum* for 19.53%. [6]. The study's findings are incomplete since they couldn't determine the disease's frequency based on locations or the kinds of hens (exotic and local). The technical team's diagnostic investigation on breeding in Mali found that conventional poultry farming was the outcome. Among

the most common diseases and infections in semi-industrial chicken farms in Mali between 2003 and 2007 was salmonellosis, which affected 19.53% of infected eggs and 20.09% of typhoid cases. [6]. The study's findings are incomplete since they couldn't determine the disease's frequency based on locations or the kinds of hens (exotic and local). [6]. The study's findings are incomplete since they couldn't determine the disease's frequency based on locations or the kinds of hens (exotic and local). Traditional chicken farming in Mali is plagued by salmonellosis, as shown in the diagnostic report on breeding in Mali by the Alive Technical Team. Typhosis accounts for 20.09% of cases, while 19.53% of cases include infection of eggs by *Salmonella pullorum/gallinarum*. [6] The research in question could not provide comprehensive data since it could not determine the illness prevalence based on location or the kind of chickens (exotic vs. local). Traditional chicken farming in Mali is plagued by salmonellosis, as shown in the diagnostic report on breeding in Mali by the Alive Technical Team. Typhosis accounts for 20.09% of cases, while 19.53% of cases include infection of eggs by *Salmonella pullorum/gallinarum*. [6]. The study's findings are incomplete since they couldn't determine the disease's frequency based on locations or the kinds of hens (exotic and local). The Alive Technical Team's diagnostic study on breeding in Mali states that conventional chicken farming, which has not been improved upon, suffers from very high disease and predator mortality rates (20% or more) (Team Alive Mali). [7]. *Salmonella gallinarum* is the causative agent of avian salmonellosis, hence any plan to manage the disease must center on preventing further contamination. Antibiotic treatment, immunization, biosecurity measures, and any other measures needed to ensure that food production is free of *Salmonella* are all part of the toolbox for on-farm control programs [8]. Inadequate biosecurity guarantees that vaccine protection against *Salmonella* infections will never be enough [9]. There were 182 mixed poultry farms infected with *Salmonella* in the peri-urban districts of the District of Bamako (96 farms) and the towns of Ségou (43) and Sikasso (43 farms) during the 2014–2015 research period. It allowed us to find out how common salmonellosis was in exotic laying hens compared to native breeds at each of the research locations.

2. Material and methods

The study was carried out during the period from August 2014 to December 31, 2015 in two essential phases: a phase of clinical-epidemiological monitoring and collection of appropriate samples and a phase of implementation of laboratory tests (isolation of strains in culture). Sampling by purposive choice was used to select the study areas, the farms and the subjects to be sampled (sick or recently dead laying hens having presented suspicious clinical signs of salmonellosis).

2.1. Type and area of study

This prospective study was carried out in the peri-urban areas of the District of Bamako and the cities of Ségou and Sikasso. The development and importance of modern poultry farming in these sites justified the choice of these sites. In the peri-urban area of Bamako, poultry farms have been chosen on 06 main axes including Bamako-Koulikoro, Bamako-Siby, Bamako-Kangaba, Bamako-Ségou, Bamako-Kati and Bamako-Bougouni. In Ségou, the farms chose on 03 axes including Ségou-Markala, Ségou-Cinzana and Ségou-Bamako. In Sikasso, they chose on 04 axes including Sikasso-Koutiala, Sikasso-Nièna, Sikasso-Bobo Dioulasso and Sikasso-Missiri Koro.

2.2. Choice of farms

The study covered 182 modern poultry farms located in peri-urban areas of Bamako, Sikasso and Ségou. Thus, the choice of farms made on the basis of objective criteria, such as the accessibility of the farm, the promoter's adherence to the spirit of the study, the frequency of suspected clinical cases of salmonellosis in poultry. 96 farms visited in Bamako, 43 in Ségou and 43 in Sikasso (Tables 3, 4 and 5).

2.3. Choice of poultry and collection of samples

As part of this study, fortnightly visits made during which cloacal swabs taken from sick laying hens showing signs of depression, anorexia, whitish diarrhea, dehydration and anemia and Cyanosis apparent on comb and wattles. Autopsies performed on sick or recently dead subjects. In the event of the presence of lesions specific to salmonellosis (discoloration of the liver, ovaritis or salpingitis, splenomegaly, enteritis, myopericarditis, pneumonia), samples of livers, ovarian clusters, spleen, intestines, heart and lungs. The various samples identified, kept under ice and sent to the Central Veterinary Laboratory for laboratory examinations.

2.4. Laboratory diagnostic methods

The samples collected were prepared before cultured for the selective search for Salmonella. To do this, the organs first crushed, while the swabs directly inoculated. Thus, all the samples subjected to prior pre-enrichment on peptone water followed by enrichment on tetrathionate broth or on Rappaport-Vassiliadis medium. *Salmonella* isolation performed on *Salmonella-Shigella* (SS) and Mac Conkey (MC) agars from the enrichment broth cultures. Salmonella suspect colonies subcultured onto soybean tryptose agars and incubated for 24 hours at 37°C to obtain pure Salmonella cultures.

2.5. Statistical analysis method

Data analyzed with Stata version 6.0 software. Logistic regression used to verify the existence of a significant difference in prevalence rates depending on the sites and types of samples.

3. Results

During this study, 526 samples including 515 cloacal swabs and 11 organ samples collected from 182 farms and subjected to laboratory examinations. Culture of the various samples made it possible to establish an overall bacteriological prevalence rate of 10.3% for *Salmonella gallinarum*. The prevalence rate did not vary significantly ($p>0.05$) depending on the study sites (9.7% in Bamako against 15.1% in Ségou and 8.0% Sikasso). On the other hand, it varied significantly ($p<0.05$) depending on the nature of the samples and the type of poultry. The results obtained are illustrated in Tables 3, 4, 5 and 6.

Table 1 Results by site of bacteriological examinations (Bamako)

Site	Farms visited	Specimens			
		Cloacal swabs		Organs	
		Tested	Positives	Tested	Positives
Dialakorobougou	01	03	01	01	0
Tabacoro	04	0	0	0	0
Baguineda	05	19	03	0	0
Kasela	02	12	04	0	0
Sadiouroubougou	03	05	01	0	0
Senou	01	03	0	0	0
Banankoroni	05	18	02	0	0
Sanankoroba	14	30	0	01	0
Sikulu	03	13	02	0	0
Missabougou	14	26	0	0	0
Morocco	03	0	0	01	0
Tiètiguibougou	02	0	0	0	0
Dogobala	02	11	01	0	0
Sebenikoro	01	03	01	0	0

Konobougou	01	03	01	0	0
Missala-Gouana	13	20	04	0	0
Soundougouba	01	10	01	01	01
Mountougoula	11	40	01	0	0
soro	01	09	02	0	0
Yayabougou	01	09	0	0	0
Dialakoroba	01	10	0	0	0
Samaya	02	12	0	0	0
Balandougou	05	17	02	0	0
Total	96	273	26	04	01

In the peri-urban area of the District of Bamako in the 96 farms visited, 277 samples were collected and cultured, of which 27 proved positive (i.e. 9.7%), including 26 cloacal swabs (26/273 i.e. 9.5%.) and 01 single organ (01/04 or 25.0%).

Table 2 Results by site of bacteriological examinations (Ségou)

Site	Farms visited	Specimens			
		Cloacal swabs		Organs	
		Tested	Positives	Tested	Positives
Kirangowere	03	04	0	0	0
Sekoro	01	03	0	0	0
Pelengana	05	10	01	0	0
Guerefebougou Road	01	04	0	0	0
Sebougou	07	14	04	0	0
Banankoro	01	05	01	0	0
Hamdallaye	02	01	0	01	01
Medina	07	13	03	0	0
Bagadadji	03	09	0	0	0
Sebougou	01	02	0	0	0
Hamdallaye	02	02	0	0	0
Emgoulem	02	04	01	0	0
Sakoiba (Missira)	04	17	04	0	0
City COMATEX	01	04	00	00	00
bamananking	01	01	00	00	00
millionking	01	03	00	00	00
Sokolakono	01	02	00	00	00
Total	43	98	14	01	01

In Ségou, in the 43 farms visited, 99 samples took, including one organ sample. Of which, 15 found to be positive (i.e. 15.1%), including 14 swabs (14/98 i.e. 14.2%) and 01 organ.

Table 3 Results by site of bacteriological examinations (Sikasso)

Site	Farms visited	Specimens			
		Cloacal swabs		Organs	
		Tested	Positives	Tested	Positives
Wayèrèma II	01	07	0	0	0
Sanoubougou	04	0	0	03	02
Kafela	04	11	0	0	0
Mamabougou	05	16	01	01	0
Ouahibera	01	02	0	0	0
Doniana	02	02	0	0	0
Zangaradougou	02	03	03	0	0
Manabougou	01	05	01	0	0
nankoundiassa	08	34	0	01	01
Zanso sirakoko	01	07	01	01	0
Zanblala	01	01	0	0	0
Sirakoro	04	23	02	00	00
Wayèrèma I	04	11	00	00	00
Farako Fenkolo	01	06	00	00	00
Medina	03	09	01	00	00
Koro dam	01	07	00	00	00
Total	43	144	09	06	03

Of the 526 samples, 44 found to be positive. This represents a bacteriological prevalence rate of 8.3%. No significant variation ($p>0.05$) in prevalence was demonstrated between the sites. On the other hand, there is a significant variation in prevalence according to the nature of the samples and the breeds of poultry ($p=0.003<0.05$).

Table 4 Results by type of poultry of bacteriological examinations

Site	Samples collected	Types of poultry					
		Exotics			local		
		Culture	Positives	%	Culture	Positives	%
Bamako	277	272	26	9.5	05	01	20.0
Segou	99	88	13	14.7	11	02	18.1
Sikasso	150	137	07	5.1	13	05	38.4
Total	526	497	46	9.2	29	08	27.5

The statistical analysis revealed a significant difference between the prevalence rates according to the types of samples (Chi2 (3) =13.62; $p=0.003<0.5$).

Table 5 Results of the statistical analyzes according to the site

Comments	526					
Chi2(3)	13.62					
prob	0.0035					
Nickname R2	0.0391					
					95% Confidence Interval	
Headings	Coefficients	standard error	Z	p	Terminal <	Terminal >
Segou	0.53	0.35	1.52	0.128	-0.15	1.22
Sikasso	-0.35	0.38	-0.93	0.335	-1.09	0.39
Organs	2.25	0.64	3.51	0.000	0.99	3.51
Constant	-2.29	0.21	-11.08	0.000	-2.7	-1.89

	Cloacal swabs			95% Confidence Interval		
Site (s)	Tested	Positives	Prevalence	Terminal<	Terminal>	Standard Deviation
Bamako	273	26	9.52	6.04	13	3.48
Sikasso	144	9	6.25	2.3	10.2	3.95
Segou	98	14	14.29	7.36	21.22	6.93
Total	515	49	9.51	6.98	12.04	2.53

Swabs: 9.52±3.48 % (Bamako), 6.25±3.95% (Sikasso), 14.29±6.93% (Ségou) withPrev. Overall: 9.51±2.53%

Table 6 Results of statistical analyzes on the link between the bacteriological prevalence of salmonellosis and the type of samples (organs)

	Organs			95% Confidence Interval		
Site (s)	Tested	Positives	Prevalence	Terminal<	Terminal>	Standard Deviation
Bamako	4	1	25	-17.44	67.44	42.44
Sikasso	6	3	50	10	90	40
Segou	1	1	100	-	-	-
Total	11	5	45.45	16.03	74.87	29.42

Organs: 25±42.44% (Bamako), 50±40% (Sikasso), 100% (Ségou) withPrev Global: 45.45±29.42%

4. Discussion

Worldwide, particularly in underdeveloped nations, *Salmonella pullorum/gallinarum* causes avian salmonellosis (10). Many studies have proved this to be true, and Mali is no different.

As a whole, this research found that *Salmonella gallinarum* was present in 10.2% of the population. Prevalences at the site level do not vary significantly ($p>0.05$) among Bamako (9.7%), Ségou (15.1%), and Sikasso (8.0%). However, in Bamako, Ségou, and Sikasso, the percentages for organ samples are 25%, 14.2%, and 6.2%, whereas in Sikasso, organ samples make up 100%, and there is a notable variation based on the species of chicken.

Similarly, the research found that exotic fowl had a much lower frequency of salmonellosis (9.2% vs. 27.5% of native breeds). In Bamako, the prevalence of exotic breed individuals was 9.5%, compared to 20% for local breed subjects; in Ségou, the prevalence of exotic breed people was 14.7%, compared to 18.1% for local breed subjects; and in Bamako, 5.1% of the poultry were exotic breed, compared to 38.4% of the local poultry. Because local hens, unlike foreign chickens, often do not benefit from proper care, this works in favor of the phenomenon's widespread occurrence. Modern chicken farms in Mali are not immune to *Salmonella gallinarum* infections, according to these data. It has been shown that avian salmonellosis is a significant limitation in Mali [6, 11] as well as in other sub-regional nations like Senegal [12, 13, 14, and 15] and Côte d'Ivoire [16]. *Salmonella* spp. frequency varies greatly by nation and direct debit type, according to many investigators. Analysis of cloacal swabs and organs in Mali revealed a bacteriological prevalence of 9.9%, as reported by Satigui and colleagues [17]. Prior to the aforementioned research, Sidibe and colleagues [6] found a bacteriological prevalence of 20.48 percent in the organs, with rates of 18.91 percent in Bamako, 50 percent in Sikasso, and 20 percent in Ségou. A 7.87% infection rate was also observed after analyzing Bamako eggs. *Salmonella pullorum/gallinarum* was successfully isolated from cloacal swabs by Sidibe et al. [6]. An investigation of the hazards associated with salmonella in improved-breeding eggs in the peri-urban region of the District of Bamako from 2008 to 2009 found an infection incidence of 11.79% for *Salmonella pullorum/gallinarum*. In the Niayes region of Senegal, Arbelot et al. [13] managed to extract 38% in layers. Among Somalia's intensive poultry farmers, Prosperi et al. [18] found a bacteriological prevalence of 74.2% and a serological prevalence of 54.8% for *Salmonella gallinarum* infection. According to the same authors, between 41% and 45% of laying hen batches infected with *Salmonella gallinarum/pullorum* during the rainy season. It is possible that the disparity in prevalence rates seen in swabs and organ samples is due to the smaller size of the former. Since the samples were so little, we can see why organs were so common. This prevalence estimate lacks the precision of one derived from a large-scale study. It is also impossible to make firm conclusions about bacteriological prevalence rates from the data at the Ségou and Sikasso locations since the samples were so tiny. On the one hand, the frequent cohabitation of laying hens with native poultry might explain why salmonellosis persists in exotic chickens from the research locations. It is difficult to draw a clear conclusion from the results relating to the bacteriological prevalence rates at the Ségou and Sikasso sites because of the small sample sizes, but the poultry houses are known to have very poor hygiene and biosecurity conditions, making them potential reservoirs of salmonellosis. Exotic chickens from the study sites still have salmonellosis. This could be due to two things: first, the poor hygiene and biosecurity conditions in poultry houses; and second, the frequent cohabitation of laying hens with local poultry, which are known to be potential reservoirs of salmonellosis.

Conclusion

The research shed light on the fact that salmonellosis is still an issue in contemporary chicken farms in the peri-urban regions of the District of Bamako, as well as in the towns of Ségou and Sikasso. There was a considerable difference in the total bacteriological prevalence rate between foreign and native fowl, as well as between swab and organ samples. The prevalences, however, did not differ much among the research locations.

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