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Original

Mortality Due to Colibacillosis and Salmonellosis in Sucklings and Pre-Fattening Pigs on a Swine Farm

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ABSTRACT

Background: Colibacillosis and salmonellosis are within the catastrophic diseases in swine production The aim of this research was to compare mortality caused by both diseases in sucklings and pre-fattening pigs on a swine farm.
Methods: Colibacillosis and salmonellosis-related death and sample data collected from a farm for three years (2017-2019), and sent to the laboratory, were studied. The research variables included enteropathies, (salmonellosis and colibacillosis), categories (pre-fattening animals and sucklings), and mortality. Comparison of two proportions was performed to compare mortality in all the combinations of etiology and categories.
Results: The proportion of total mortality due to colibacillosis was highly significant ($p<0.001$), even higher than salmonellosis. Particularly, this behavior was kept in sucklins and pre-fattening animals. The sucklings were more affected by the two diseases.
Conclusions: The high mortality caused by colibacillosis and salmonellosis might have been associated to the absence of a vaccination scheme, timely diagnosis, and the adoption of alternative measures to promote immune response and/or at least contribute to the establishment and stability of the intestinal microbiota of sucklings and pre-fattening pigs.
Key words: *Escherichia coli*, infections, *Salmonella*, pigs, (Source: *MeSH)*

INTRODUCTION

Swine production demands veterinary specialists with knowledge and practical skills to perform this job. Some farms, seeking higher yields, fail to meet the basic requirements. Accordingly, multiple enteropathogens to which the animals are exposed since they are born, find the breach to affect the most sensitive categories: suckling and pre-fattening pigs (Gui-Yan *et al.*, 2019; Rodríguez *et al.*, 2020). Two of the most commonly found bacterial agents involved are *Escherichia coli*, in its diverse pathotypes, some of which are zoonotic (Shah, Aziz, Zakaria, Lin, and Goni, 2018), and *Salmonella* (Barba-Vidal *et al.*, 2018).

The enterotoxigenic pathotype of *E. coli* (ETEC) causes enormous economic losses to the swine

industry, becoming the protagonist of the above-mentioned condition. Most ETECs involved in newborn colibacillosis express fimbriae F4, F5, F6 (formerly known as K88, K99, and 987P, respectively), or F41. Meanwhile, fimbriae F4 or F18ac are responsible for the syndrome in pre-fattening animals (Kanengoni *et al.*, 2017; Luppi, 2017). Nevertheless, other pathotypes take part in that condition, especially post-weaning diarrhea: Enteropathogenic *E. coli* (EPEC) and Shiga toxin-producing *E. coli* (STEC), also known as verotoxigenic *E. coli* (VTEC). The two pose serious challenges to public health due to their so low and ineffective dose (Gui-Yan *et al.*, 2019).

These pathotypes, like other three which are not mentioned (Shah *et al.*, 2018), have particular virulence and colonizing factors, so the methods to identify them are different. Hence, identification is increasingly complex, since the selective environmental pressure, and the collaborative actions of these populations inside *biofilms* to succeed at surviving (Barreto *et al.*, 2016a, b), have led to increasing isolation of hybrid strains ETEC/STEC, in both newborn and postweaning diarrhea (Gui-Yan *et al.*, 2019).

Septicemic salmonellosis in pigs are mostly caused by *Salmonella, serovar* Choleraesuis, and to a lesser extent, by *Salmonella,* serovar Typhimurium. In the presence of diarrheal events, their relevance is in the oposite order to the above mentioned. They are also an important cause of losses in swine production, as a result of treatments, and failure to meet the programmed sales of meat and subproducts. In the United States, the annual losses are approximately 100 million dollars. Other serovars causing diarrhea are Derby, Heidelberg, Dublin, and Enteritidis (Binh, Nghiem, and Giang, 2017). All are common causes of non-typhoidal salmonellosis in humans, with Typhimurium as the one posing the highest zoonotic risk due to its elevated invasiveness. In various industrial countries, they are the second cause of food-transmitted diseases (Rodríguez, Barreto, Bertot, and Vázquez, 2013; Campos, Mourão, Peixe, and Antunes, 2019).

Accordingly, the aim of this research was to compare the behavior of salmonellosis and colibacillosis in sucklings and pre-fattening animals, on a swine farm in Camagüey, Cuba.

MATERIALS AND METHODS

This study was conducted on a swine farm in Camagüey, and it relied on the data of deaths and the samples found in the laboratory records archived for three years (January 2014-December 2016). The variables included were enteropathies, (salmonellosis and colibacillosis), categories (sucklings and pre-fattening animals), and mortality. The proportions of mortality were compared in all the combinations of etiology, and categories, according to the two-proportion comparison technique, using the Minitab 16 (2013) software.

RESULTS AND DISCUSSION

During this period, there was a spike in swine mortality caused by colibacillosis and salmonellosis. The proportion of deaths due to the former was significantly ($p<0.001$) higher (Table 1).

Table 1. Proportion of total mortality due to colibacillosis and salmonellosis

Etiology	Deaths	N	Proportion	Difference	CI (95%)
Colibacillosis	2 863	3 813	0.751[a]	0.501	(0.482- 0.521)
Salmonellosis	950	3 813	0.249[b]		

Legend: unequal letters mean a significant difference (Z = 50.65 P-Value = 0.000)

As stated by the *Acquisition Services Directorate And Risk Management Agency* (2015), the two are among the catastrophic pig diseases in the United States. Regarding colibacillosis, they say that its etiological agent, besides diarrhea, can cause, edema in adult pigs. Multiple serotypes take part in diarrheal syndromes. The extent of reproductive losses, lethality, and delayed growth can vary. Salmonellosis due to *Salmonella serovar* Choleraesuis, and *S.* serovar Typhimurium, cause growth retardation and occasional mortality in growing animals. This assessment concludes that these two conditions are the typically caused by colibacillosis, as demonstrated in previous results.

Research done on the complexities of diarrhea in swine productions, and its causal agents reveals that the incidence of *E. coli.* generally is higher than *Salmonella,* both in the frequency of occurrence and mortality (Ruiz *et al.,* 2016). This result is perhaps conditioned by the fact that this species, in addition to the genetic arsenal common to gram-negative bacteria that conditions adaptability and environmental resistance, includes other pathogenic particularities that have promoted a differentiation of pathotypes, six of them enteric, as mentioned before (Bai *et al.,* 2019). All of them are highly versatile in colonizing the intestine of mammals and birds (Shah *et al.*, 2018).

In the two categories, colibacillosis had a significantly higher effect on mortality ($p<0.001$) than salmonellosis; in both instances, the sucklings underwent the strongest impact (Table 2).

Table 2. Deaths by categories and etiologies

Combinations	Deaths or events	N or trials	Proportion	Differences	CI (95%)	Z	P
Sucklings-colibacillosis	1 695	2 199	0.1771[a]	-0.542	(-0.566, -0517)	-42.73	0.000
Sucklings-salmonellosis	504		0.229[b]				
Pre-fattening animals-colibacillosis	1 168	1 614	0.724[a]	-0.447	(-0.478- 0.416)	-28.42	0.000
Pre-fattening animals-salmonellosis	446		0.276[b]				
Colibacillosis-sucklings	1 695	2 863	0.592[a]	0.184	(0.159- 0.021)	14.17	0.000
Colibacillosis-pre-fattening animals	1 168		0.408[b]				
Salmonellosis-sucklings	504	950	0.531[a]	0.061	(0.016- 0.106)	2.67	0.008
Salmonellosis-pre-fattening animals	446		0.469[b]				

Legend: unequal letters mean a significant difference ($p<0.001$)

In reference to this syndrome, multiple fimbriae (F4, F5, F6, and F41) facilitate the adhesion of ETEC strains to enterocyte receptors, whereas only two of them (F4, and F18ac) do the same in pre-fattening animals (Luppi, 2017). Hence, in addition to the immunological immaturity, this could explain why death proportion was higher in the animals only a few weeks old. Notwithstanding, this is a multi-factor issue, in which deficiencies in zootechnical management and other measures may account for 50% (Rodríguez *et al.,* 2020), or even more, of mortality in these categories (Gui-Yan *et al.,* 2019).

The uncertain elements in the previous paragraph are valid in terms of the proportion of deaths caused by salmonellosis. Although in general terms most affectations caused by this pathogen are assumed to take place after weaning, which are favored by stress, changes in the intestinal microbiota, quality of feedstuffs, and specific virulence factors of the etiological agent (Knetter *et al.*, 2015), and other factors that occur since the very first week of life, cannot be overlooked. In that sense, after a week, primiparous sows release 38.4% of *Salmonella* into the environment, which rises to 51.6% in sows with 2-5 farrowings. During the rainy season, the release values of that agent vary between 37.5% and 71.4%, which is an important source of infection to sucklings (Binh, Nghiem and Giang, 2017).

The control of both diseases lies in the application of sanitary control measures, and antibiotherapy in face of new outbreaks of diarrhea. More than a solution, this variant has also contributed to increased antibioresistance of the particular etiological agents (Barreto *et al.*, 2016b; Zhang *et al.,* 2019), and favors the selection of strains with augmented virulence (Barreto *et al.*, 2016a).

Unfortunately, these are the facts of enteropathies on swine farms, particularly where the animals are in pens (Barreto, Rodríguez, Bertot, and Delgado, 2015; Vega-Cañizares *et al.*, 2018), which rather than facing the cause, is an attempt to control the effects. The need to provide adequate microbiota during the first weeks of age or after weaning is totally disregarded. Furthermore, the utilization of foods that favor a quick reinstatement of the significantly damaged micro villi, is disregarded as well (Barreto *et al.,* 2015; Missotten, Michiels, Degroote, and de Smet, 2015; Dou *et al.,* 2017; Lépine *et al.,* 2019; Mukhopadhya, O'Doherty & Sweeney, 2019).

In the 80s and 90s, great emphasis was placed on the prevention and control of colibacillosis, particularly in Camagüey province. A vaccine developed under the name VACOLI was a significant step taken in the right direction, with outstanding application results on several farms. Another important moment was the development and application of AuBIODOT–ETEC, first of its kind, based on a set of monoclonal antibodies against fimbria F4, F5, F6, and F41, which could successfully detect ETEC from rectal swab samples collected on the farms, within 45 minutes (Campal, 2009). In salmonellosis, the establishment of a serovar from human, animal, and food isolates in the same decades, enabled a closer approximation to the real behavior of the

disease and epidemiology (Sedrés, Hernández, Barreto, and Mayo, 1993; Hernández, Barreto, and Guevara, 1994; Rodríguez**,** Barreto, Sedrés, Bertot, Martínez, and Guevara, 2011 a, b). As the new millennium advances, diagnostic of the two diseases follows clinical and anatomopathological criteria; the former inaccurate, the latter, delayed.

Although the literature does not refer to the limitations of their use, the truth is that though the traditional biochemical and serological studies were effective at a time, they were time-consuming and painstaking. The works based on fimbriae and enterotoxins were variable and aggressive to animals, and/or could only be performed in very specialized laboratories, respectively (Barreto, 2007; Campal, 2009).

Hence, though they have not enjoyed advanced technologies, other research should be taken into consideration. Besides the application of contemporary variants, the procedures to study diarrheal outbreaks have been simplified. For screening, the fresh stools on the ground are needed, which apart from simplifying and reducing time, contributes to a collective diagnosis of the situation. Aided by qPCR (Quantitative, Polymerase Chain Reaction), they amplify the virulent genes from enteropathogens present in those samples.

On top of that, in the absence of vaccines to prevent the two enteropathies and the lack of accurate and fast diagnostic methods, an alternative to reduce the negative impacts of salmonellosis and colibacillosis would be the utilization of techniques to achieve stability of the microbiota in the intestines of pigs during the two critical stages analyzed (Missotten *et al.,* 2015). Probiotic use has been very successful at national UEBs (basic production farms) (Vega-Cañizares *et al.,* 2018). Another simpler and more appropriate variant, depending on the swine production system, and as effective as the previous, is the use of multipurpose autochthonous organisms in the diet and drinking water of these animals (Rodríguez *et al*., 2013; Barreto *et al.,* 2015; Polyorach *et al.,* 2018).

CONCLUSIONS

Colibacillosis and Salmonellosis are significant and frequent causes of mortality of animals under intensive swine production. The proportion of deaths by colibacillosis was significantly greater ($p<0.001$) than that of salmonellosis in sucklings and pre-fattening animals, the former was more affected by enteropathogens. The high affectation observed may be associated to the absence of a vaccination scheme, timely diagnosis, and the adoption of preventive measures that promote an immune response by the animals, and also contribute to proper stability of intestinal microbiota.

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AUTHOR CONTRIBUTION

Conception and design of research: HRT, GBA, RVM, YJP; data analysis and interpretation: GBA, HRT, RVM; redaction of the manuscript: GBA, HRT.

CONFLICT OF INTERESTS

The authors declare no conflict of interests.