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REVIEW ARTICLE

A Review on *Salmonella* Characteristics, Taxonomy, Nomenclature with Special Reference to Non-Typhoidal and Typhoidal Salmonellosis

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Abstract

The genus *Salmonella* belongs to family *Enterobacteriaceae*. They possess interesting phenotypic/genotypic characteristics, history and peculiar nomenclature compared to other bacteria within and outside the family. The organism causes typhoidal salmonellosis (TS) and non-typhoidal salmonellosis (NTS), which exhibit different syndromes in man and animals and is of public health importance worldwide. This study reviewed the characteristics, taxonomy, nomenclature and nature of *Salmonella* in addition to the overview of NTS and TS. Baseline data/information published in peer reviewed journals, textbooks and bulletins/articles of international regulatory bodies were used for the study. The collective data of the present study revealed that *Salmonella* is a 2-3 X 0.4-0.6 µm sized, a Gram-negative rod, non-spore producing, oxidase, indole, urease, lactose and sucrose negative, facultative anaerobic and a motile organism. The two *Salmonella* species, that exist, only differ in their *16S rDNA* sequences although both species are related closely to *Shigella* and *E. coli* at *16S rDNA* and *32S rDNA* sequences. *Salmonella* species and genus names are italicized; while more recently, the first letter of the serotype's name is capitalized, but the word is not written in italics. *Salmonella* is the cause of NTS and TS in man and animals presenting enteritis, septicaemia, abortion and meningitis. Salmonellosis outbreaks had been reported from food, food products of animal origin and animal contact settings with cross infection between humans and animals. The disease in different parts of the world is among the public health challenges that are most common with reported increased incidence of many serotypes. The organism's role as a major aetiology of foodborne disease and septicaemia resulting in morbidity and mortality worldwide had been highlighted. Continuous research on *Salmonella* and salmonellosis should be carried out to contribute to the body of knowledge on the organism, disease and ultimately improvement of preventive/therapeutic strategies of the disease.

Keywords: *Salmonella*, characteristics, history, nomenclature, NTS/TS

Introduction

The ubiquitous nature of *Salmonella* species (spp.) in the environment is fuelled by their abundance in the intestinal tract of animals, which serve as major reservoirs of the organism [1]. The transmission of the bacteria to humans is usually through ingested food and water [2]. *Salmonella* was first observed in the 1800s [3]. The organism was cultured in 1888 by Salmon and Smith [3]. The first reported case and isolation in humans was also in 1888 by Gartner [4]. More than 2600

Salmonella serotypes had been reported by White Kauffmann-Le Minor, 1600 of which belong to the subspecies *enterica* [5]. Over 200 serotypes of the organism had been reported to be able to cause diseases in humans [6]. *Salmonella* spp. belong to the family *Enterobacteriaceae*. They are Gram-negative rod-shaped organisms [7]. Kauffmann-White scheme reported *Salmonella enterica* (*S. enterica*) and *S. bongori* as the two major species of the genus [8, 9]. Other reported forms of classification are based on biochemical characteristics (*S.* Cholerasuis, *S.* Typhi and *S.* Enteritidis) [10] and host predilection (*S.* Typhi and *S.* Paratyphi-adapted to humans, *Salmonella* spp. adapted to specific animals; *S.* Cholerasuis-swine, *S.* Pullorum/*S.* Gallinarum- poultry and *S.* Dublin-cattle and *Salmonella* spp. not adapted to any host) [11].

Worldwide, foodborne diseases caused by *Salmonella* have been of public health concern for over a century [12]. *Salmonella* diseases are grouped into typhoidal salmonellosis (TS, enteric fever) and non-typhoidal *Salmonella* (NTS) associated infections [13, 14]. *Salmonella enterica* serovar Typhi causes typhoid fever and *S.* Paratyphi A, B and C cause human host restricted paratyphoid fever [13]. The cause of NTS infections is a group of *S. enterica* serovars [14]. *Salmonella* Enteritidis, *S.* Cholerasuis and *S.* Typhimurium are some of the serovars that cause diseases in humans through contamination and ingestion of food and food products [15].While, invasive typhoidal salmonellosis causes enteric fever, gastroenteritis and bacteraemia [1]. Non-typhoidal salmonellosis presents majorly gastroenteritis, which is a condition that affects the ileum and colon with diarrhoea, abdominal cramp and vomiting as visible clinical signs/symptoms [16]. The aim of this study is to examine the characteristics, taxonomy, nomenclature and nature of *Salmonella* in addition to the overview of NTS and TS.

Materials and Methods

Baseline information on *Salmonella* characteristics, taxonomy, nomenclature and salmonellosis obtained from published work, textbooks and bulletins/articles of international regulatory bodies like Centre for disease Control (CDC) and World Health Organization (WHO) were collected by typing desired keywords into google search engine. Publications with relevant data and information were selected, saved and later retrieved for the study. Results were presented as texts, tables and figures.

General characteristics of *Salmonella*

Salmonella is one of the members of *Enterobacteriaceae* family. The organisms are negative to Gram stain and oxidase test and they are motile (due to the presence of peritrichous flagella), rod shaped, non-spore producing and facultative anaerobes [17]. *Salmonella* species are about 2-3 X 0.4-0.6µm in size [18-20]. *Salmonella* typically produces hydrogen sulphide, breaks down D-glucose to produce hydrogen and carbon dioxide, while nitrates are reduced to nitrites [20]. Except *Salmonella* serovar Typhimurium, which does not produce gas, almost all *Salmonella* serovars are aerogenic [21]. They test negative for both urease and indole (tryptophanase) production. *Salmonella* belongs to the Gamma proteobacteria class according to the sequence analyses of *16S rDNA* gene [21, 22].

The cell wall of *Salmonella* comprises lipids, lipopolysaccharide, proteins and lipoproteins [23]. The lipopolysaccharide and the lipid portion of the cell wall contain the endotoxin, which is responsible for the biological effects of the bacteria [23]. The common centre polysaccharides and monosaccharides of the endotoxin are also called the somatic O antigen [23]. The somatic 'O' antigen is the polysaccharide portion on the surface of the bacteria, which consists of many short oligosaccharide [24]. In *Salmonella,* about 60 somatic antigens exist [24]. Genotypic analysis suggests the acquisition of the antigens through gene transfer, which are interspecific within the bacteria. These antigens are represented by numbers (Figure 1) [24]. Based on these somatic antigens, *Salmonella* can be divided into groups with the use of specific antisera [23]. *Salmonella* also possesses the flagella

'H' antigens. These are represented by both letters and numbers [23]. There are about 114 recognized H antigens [25]. The flagella H antigens are proteins that are heat labile [18]. They present in 1 or 2 phases; the specific or/and non-specific phases otherwise referred to as phase I or/and II H antigen [23]. Some *Salmonella* serovars produce heat sensitive carbohydrates surface 'K' antigens. In addition, *Salmonella* Typhi has virulence/capsular antigen enveloping its cell wall [26]. Based on the somatic and flagella agglutination reactions, about 2,463 serotypes were described at year 2000 (Table 1) [27] and the number has reportedly risen to 3000 in 2017 [28].

Salmonella readily grows on blood and MacConkey`s agar [29]. Bismuth sulfate agar (BSA), *Salmonella Shigella* agar (SSA), xyline lysine deoxycholate (XLD) agar could also be used for *Salmonella* isolation. On these agars, they ferment glucose and mannose, but not lactose and sucrose (Figure 2) [30, 31]. *Salmonella* serotypes grow optimally at temperatures between 35˚C and 40˚C. Based on growth matrix and the serovars involved, they can grow within the temperature range of 2˚C - 54˚C [22]. Temperatures that are very low do not support the growth of *Salmonella* [32]. However, freezing does not always have destructive effect on the organism, because of its hardy nature [33]. Most *Salmonella* serovars are resistant to dehydration and thrive well in acidic media of pH 1- 4.6 [34]. The bacteria are heat stable and resistant to alcohol and dilute acid [20].

Salmonella as a genus only have two species; *S. enterica* and *S. bongori* (Table 2) with *S. enterica* being the most widely distributed in nature [8]. The sequence analysis of *16S rDNA* further distinguishes *S. enterica* and *S. bongori* and affirms their close relatedness to the *Shigella-E. coli* complex by both *23S* and *16S rDNA* sequence analyses [35].

Salmonella serovars possess peculiar and unique antigen combinations. This makes up the antigenic formula of each strain. The serotype name of each serovar is assigned based on the unique antigenic formula and the Kauffman – White scheme [36, 37]. Phage typing is another method used to differentiate and identify *Salmonella* serotypes [38], other established methods employed include PCR ribotyping, pulsed-field gel electrophoresis analysis, multilocus sequencing of DNA and patterns of antimicrobial resistance [39 - 42].

Kauffman-white classification shows that majority of the *Salmonella* involved in diseases in humans are from *Salmonella enterica* subspecies I, II, IIIa, IIIb, IV, VI or A, B, C, C_2, D and E [29, 43].

Most humans, domestic and wild animals harbour the bacteria in their gastrointestinal tract with no apparent signs of illness [44 - 46]. All over the world, *Salmonella* had been reported to be of significant economic and medical interest [47].

Taxonomy and nomenclature of *Salmonella*

Eberth first observed *Salmonella* in a patient that died due to tyhoid fever in the year 1880 [48]. The organism was identified from the sections of mesenteric/spleen lypmh nodes of the patient. At that time, the organism was known as *Typoid bacillus* [48]. The name *Bacillus choleraesuis* was thereafter given to the organism in the year 1884, when it was isolated from the intestine of pigs by D. E. Salmon, who was a bacteriologist from America [49, 50]. Lignieres subsequently changed the name of the organism to *Salmonella* Choraesuis in 1900 in honor of D. E. Salmon [40]. Kauffmann in 1966, proposed one serotype one specie concept for the genus *Salmonella* based on the identification of O and H antigens [51-53]. This made each serotype separate specie. The application of this conncept today will result in about 3000 species of *Salmonella*. Multiple *Salmonella* species thus existed and were taxonomically accepted before 1973 [54]. All these were however, classified under one type specie *Salmonella* Choleraesuis [55, 56]. The type specie was further divided into five subgroups based on genetic similarity. They are *Salmonella* Choleraesuis (type specie of the genus), *S.* Arizonae,which is now made up of *S.* Arizonae and *S.* Diarizonae, *S.* Enteritidis,

S. Typhi and *S*. Typhmurium [49, 57- 60]. This was published in 1980 in 'the approved list of bacteria names' [61].

Salmonella Choleraesuis in 'the approved list of bacteria names' appeared as 'the type species' of *Salmonella*. 'Choleraesuis' appearing on the list however, caused some confusion because it refered to a serotype and a specie at the same time [54, 56, 61]. The serotype is distinct in its biochemistry; it is arabinose and trehalose negative and does not represent the majority of the serotypes in the genus [54, 62].

In 1973, the defining moment in the taxonomy of *Salmonella* occurred in the work and report of Crosa *et al*. [55] who through the hybridization of DNA-DNA studies demostrated that *enterica*, *salamae*, *arizonae* and *houtenae* (subgenera I, II, III and IV) were related at the specie level and are from the same specie with the exception of *S. bongori*, which is a distinct specie on its own [24, 54, 55].

Kauffmann and Edwards came up with the name 'Enterica' in the year 1952, because it is not shared by any other serotype [54, 62]. At the 14th International Congress of Microbiology, the *Enterobacteriaceae* subcommittee of the International Committtee on Systemic Bacteriology unnanimously recommended that *S. enterica* can be used as the type specie name of *Salmonella* [63]. In 1986, the Centers for Disease Control and Prevention (CDC) adopted the reccomendation of the subcommittee. In 1987, LeMinor and Popoff of the World Health Organization (WHO) formally made a 'request for opinion' proposal to the Judicial Commission of the International Committee of Systemic Bacteriology [35, 64]. The request was however, not approved by the Judicial Commission due to concerns that the aetiology of typhoid fever, *Salmonella* Typhi, which causes a disease of utmost clinical importance, was not adequately addressed by the 'request for opinion' made by Popoff's and Le Minor [65].

Euzeby made an amended request to the opinion in 1999 for *S. enterica* to be used as the type specie name with the exception of "*S.* Typhi", which retains its specie name because of its clinical importance [65].

In 1987, LeMinor and Popoff proposed that the subgenera (subspecies) of *Salmonella* be refered to as *enterica* (I), *salamae* (II), *arizonae* (IIIa), *diarizonae* (IIIb), *houtenae* (IV), *indica* (VI) and *bongori* (VI) [35]. Based on biochemical reactions and antigenic relatedness, subspecies III was divided into 2 subspecies. *Salmonella enterica* subspecies Arizonae have serotypes with one phase, while *Salmonella enterica* subspecies Diarizonae have diphasic serotypes [54].

According to the recommendation of WHO Collaborating Center, the current system employed by the CDC recognized *S. enterica* and *S. bongori* as the 2 species in the genus *Salmonella*. Several serovars are named in the 2 species of *Salmonella* [35]. The WHO also described *Salmonella enterica* as consisting subspecies I, II, IIIa, IIIb, IV and VI, and V or *enterica*, *salamae*, *arizonae*, *diarizonae*, *houtenae* and *indica* respectively, while *Salmonella bongori* is subspecies V [35, 54]. The subspecies are represented by roman numerals or name [54].

Names are used for serotypes in subspecies I by the CDC, while antigenic formulars are used for serotypes that are not named within subspecies II, IIIa, IIIb, IV, VI, and V [54]. The names of serotypes in subspecies I are usually the geographical names of where the serovar was first isolated (Table 3). The first letter is usually capitalized and the word is not italicized, *S. enterica* subsp *enterica* serovar Zaria or *S. enterica* subsp *enterica* serovar London are possible examples. The names could also be summarily written as *Salmonella* Zaria or *Salmonella* London [8, 27, 66].

Serovars from subspecies II, IIIa, IIIb, IV, VI and V that have been given names before 1966 retain their names; e.g. *Salmonella* Marina (IV, 48: g, Z_{51}:-), while all others are identified with antigenic formula. The formula are designated as follows; subspecies identification I-VI, the designated number of the somatic 'O' antigen, colon, flagella 'H'

antigen phase I, colon, and flagella 'H' antigen phase II (if present). Example is *Salmonella* serotype IV 45: g, Z_{51}: - implies *Salmonella* Houtenae (subspecies IV), 'O' somatic antigen 45, 'H' flagella antigen phase I g and Z_{51}, while flagella 'H' antigen phase II is absent [24].

Table 1: Kauffmann-White scheme's *Salmonella* species, subspecies, serotypes and their usual habitats [27].

***Salmonella* species and subspecies**	**No. of serotypes within subspecies**	**Usual habitat**
S. enterica subspecies *enterica* (I)	1,454	Warm-blooded animals
S. enterica subspecies *salamae* (II)	489	Environment /Cold-blooded animals
S. enterica subspecies *arizonae* (IIIa)	94	Environment /Cold-blooded animals
S. enterica subspecies *diarizonae* (IIIb)	324	Environment /Cold-blooded animals
S. enterica subspecies *houtenae* (IV)	70	Environment /Cold-blooded animals
S. enterica subspecies *indica* (VI)	12	Environment /Cold-blooded animals
S. bongori (V)	20	Environment /Cold-blooded animals
Total	**2,463**	

Table 2: The nomenclature of *Salmonella* used at the CDC [66]

Position of taxonomy	**Nomenclature**
Genus (in italics)	• *Salmonella*
Species (in italics)	• *enterica* (subspecies I, II, IIIa, IIIb, IV and VI) • *bongori* (formerly subspecies V)
Serotype (Word not italicized, first letter capitalized)	• The name of a serotype should be preceded by the word "serotype" or "ser.", the first time it's mentioned in a text • Subspecies I serotypes are named, those in subspecies II to IV, VI and *S. bongori* are designated by antigenic formulae • Subspecies II, IV, VI and *S. bongori* members retain their names if named before 1966

CDC- Centers for Disease Control and Prevention

Table 3: The nomenclature of *Salmonella* in recent literature reflecting location of isolation [66].

Complete name	CDC designation	Older designation
S. enterica subsp. *enterica* ser. Typhi	*Salmonella* ser. Typhi	*Salmonella typhi*
S. enterica subsp. *enterica* ser. Typhimurium	*S.* ser. Typhimurium	*Salmonella typhimurium*
S. enterica subsp. *salamae* ser. Greenside	*S.* ser. Greenside	*S.* II 50:z:e,n,x, *S. greenside*
S. enterica subsp. *arizonae* ser. 18:z_4,z_{23}:-	*S.* IIIa 18:z_4,z_{23}:-	*Arizona hinshawii*" ser. 7a,7b:1,2,5:-
S. enterica subsp. *diarizonae* ser. 60:k:z	*S.* IIIb 60:k:z	"*A. hinshawii*" ser. 24:29:31
S. enterica subsp. *houtenae* ser. Marina	*S.* ser. Marina	*S.* IV 48:g,z_{51}:-, *S. marina*
S. bongori ser. Brookfield	*S.* ser. Brookfield	S. V 66:z_{41}:-, *S. brookfield*
S. enterica subsp. *indica* ser. Srinagar	*S.* ser. Srinagar	*S.* VI 11:b:e,n,x, *S. srinagar*

Figure 1:: A. Somatic O and Flagella H antigen of *S.* Typhimurium.
B. Structure of the flagellar attached to the basal body of the organism
C. Outermost portion of lipopolysaccharide (LPS) of the organism cell wall

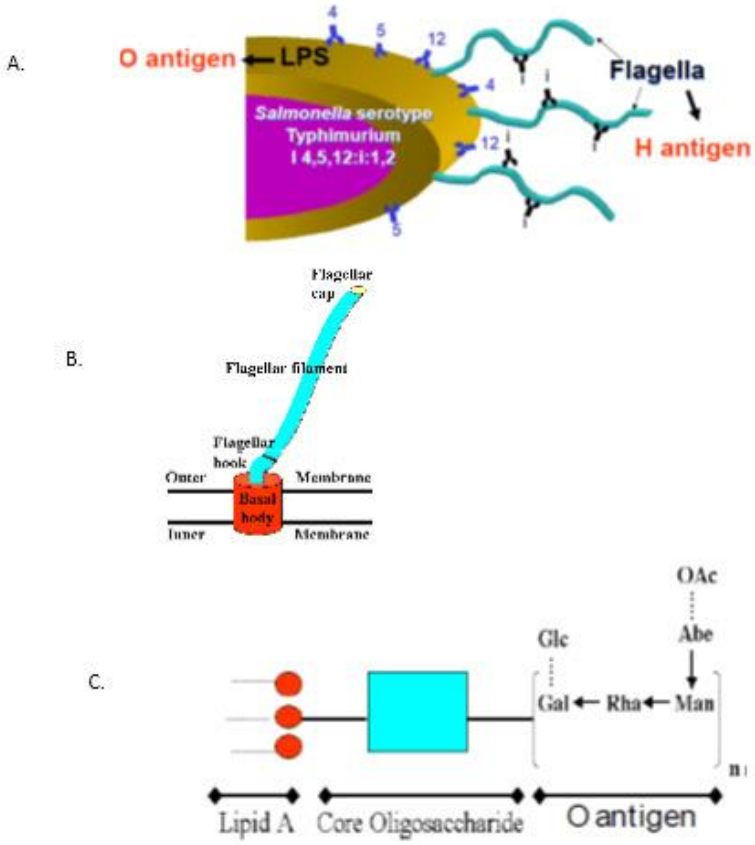
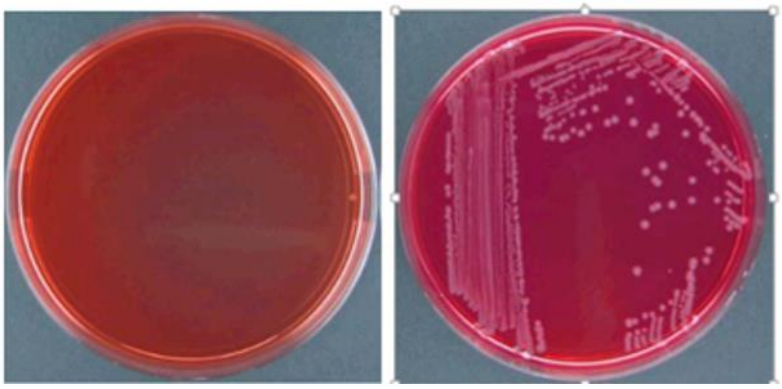


Figure 1: (A) Somatic O, flagella H antigen of *S*. Typhimurium, (B) structure of flagella attached to the basal body of the organism and (C) the outermost portion of lipopolysaccharide (LPS) of *Salmonella* cell wall

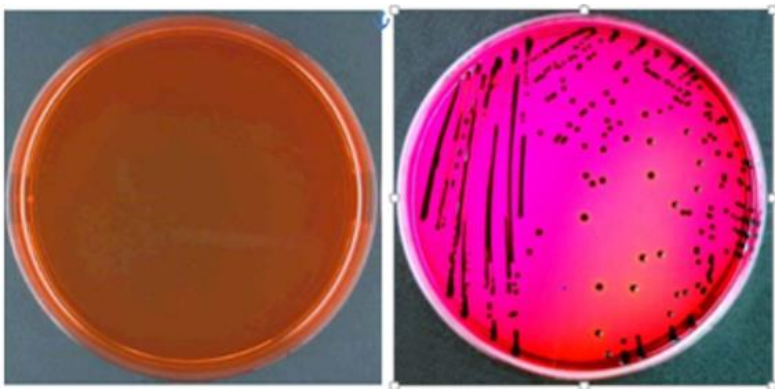
A.



Uninoculated BGA plate

BGA plate inoculated with *Salmonella* spp. The colonies are red because the bacterium does not ferment lactose or sucrose

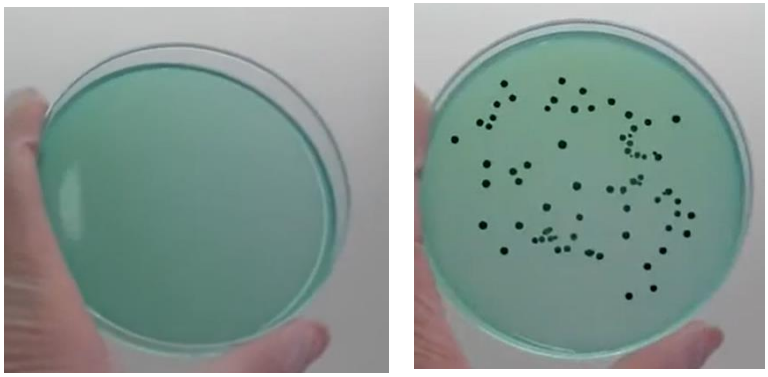
B.



Uninoculated XLD plate

XLD plate inoculated with *Salmonella* spp. The colonies are red with black center. Serovars Typhi and Paratyphi A may produce only clear colonies without H_2S. *E. coli* produce yellow colonies.

C.



Uninoculated BSA plates

Salmonella ser Typhi colonies on Bismuth sulphite (BS) agar

Figure 2: *Salmonella* growth on Brilliant Green Agar (BGA) (A), Xylose Lysine Deoxycholate (XLD) (B) and Bismuth sulfite Agar (BSA) (C) plates (WHO, 2010).

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Occurrence of salmonellosis

Salmonellosis incidence is defined as the identification of *Salmonella* from human, animal/group of animal-products or surroundings that can be specifically related to identifiable human, animal or animal's feed. The health authorities are to be notified in cases of *Salmonella* identification [67].

Salmonella causes different disease syndromes ranging from enteritis, septicaemia and abortion, while meningitis is a rare complication that is diagnosed in less than 1% of clinical salmonellosis [68, 69]. Most of the diseases caused by *Salmonella* show little specificity for their host specie [70, 71]. In many countries of the world, one of the most significant public health challenges is salmonellosis [17, 72, 73]. Outbreaks have been reported from eggs and poultry in southern Thailand [17], meat and beef in Europe and USA [23, 74], raw milk, pork meat, chocolate in many parts of Africa and Europe [74 - 76]. Outbreaks have also been reported from insects and wildlife in Africa, USA and Europe [75, 77, 78].

The incidence and severity of the disease is reported to be considerably on the increase [23, 79 -81]. Over 192,703 salmonellosis cases in humans were recorded in the European Union alone in 2004 [82]. In 1997, the most reported serovar associated with food contamination is *S.* Typhi, while the third most common serovar associated with food borne salmonellosis outbreak is *Salmonella* Newport [83]. *Salmonella* Seftenberg 775W in liquid culture media is notably heat-resistant [84, 85]. Higher thermal resistance is usually observed in *Salmonella* serovars that survived dryness and desiccation [86]. Although *Salmonella* has not been reported to grow in substrates whose water content is a_w<0.93 (less than 0.93), the organisms can however, stay alive for many months and grow during favourable conditions [85, 87]. Clinical isolation rates of known foodborne serotypes such as *S.* Enteritidis, are declining, while clinical isolation rates of serotypes whose transmission routes are not well defined such as *S.* Javiana and *S.* Muenchen are increasing [88]. Moreover, animal host species of these serotypes are not defined and may include animals that are not generally consumed by humans [89].

Between 55% and 95% of human salmonellosis cases are contracted through ingestion of food while about 9% are caused through direct contact with animals [90 - 93], salmonellosis that occur due to contact with pets are about 3% [94]. Veterinarians and physicians reported that after toxoplasmosis, the second most important zoonosis is salmonellosis [95]. The disease is potentially of risk to immunocompromised individuals, the elderly and children [96].

Non-typhoidal salmonellosis (NTS)

All over the world, the most prominent cause of acute bacterial gastroenteritis is non-typhoidal salmonellosis (NTS). It is estimated that in the United States, alone 1.4 million people fall ill annually due to salmonellosis [44]. Worldwide, NTS causes three million deaths and 1.3 billion gastroenteritis cases [20]. The United Kingdom in 2013 reported more than 7,500 cases of human salmonellosis [93]. Despite the self-limiting nature of the acute enteritis caused by *Salmonella* spp., complications may occur in infected humans due to severe systemic sequellae. The serovars involved in the infection and other host specific factors influence the severity of the infection [97, 98].

Typhoidal salmonellosis

Typhoidal salmonellosis is caused by *Salmonella* species. *Salmonella* Typhi is the aetiological agent of typhoid fever. *Salmonella* Paratyphi A, B and C are the causes of syndromes similar to typhoid fever. These organisms are usually transmitted directly from human-to-human [99 - 102]. Typhoid fever has been declared as endemic in tropical and sub-tropical countries [103]. Worldwide, there are estimated annual incidences of 540 per 100,000 or about 16 million including 600,000 deaths [20, 100, 104-106].

The symptoms presented by infected individuals include fever, headache, nausea, abdominal cramps, vomiting and diarrhoea. In severe or chronic cases, other symptoms like

arthritis may be experienced between 3 - 4 weeks after the onset of symptoms [107, 108].

Conclusion

The knowledge of the general characteristics of bacteria in the *Enterobacteriaceae* family and those specific to the genus *Salmonella* is essential for proper differentiation and identification of the organism from human and animal specimens. The division of members of the genus to only two general species compared to many other bacteria in and outside the family is a noteworthy peculiarity. Progressive research on the characteristics of *Salmonella* on the publication of their output contributed to the body of knowledge about the organism and identification of new isolates.

The history of *Salmonella* indicated isolation of the organism from humans and different types of animals since the 19th century thereby underscoring the ubiquitousness and multispecies-host nature of the organism and the diseases it causes.

Typhoidal and non-typhoidal salmonellosis is a notifiable disease with wide host range. The increasing severity and incidence of the disease all over the world especially Africa is however, of public health concern because of the incidence is mostly food associated. Food, especially those of animal origin and direct animal contact are responsible for 55-95% of human salmonellosis and are contributing to the increasing rate of the diseases in human and animals.

Conflict of interest

Authors declare, there is no conflict of interest.

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الملخص العربي

مراجعة لخصائص السالمونيلا ، التصنيف و التسمية مع إشارة خاصة إلى السالمونيلا غير التيفية والتيفية

ينتمى جنس السالمونيلا Yلى عائلة البكتريا المعوية. كما لديها خصائص نمطية / وراثية وتاريخ مثير للاهتمام. تتسم السالمونيلا بتسميات غريبة مقارنة بالبكتيريا الأخرى داخل وخارج العائلة. تعد البكتريا هى المسبب لداء السلمونيلات التيفوئيدية (TS) والسلمونيلات غير التيفية (NTS) ، والتي تظهر متلازمات مختلفة في الإنسان والحيوان بالإضافة إلى كونها ذات أهمية للصحة العامة في جميع أنحاء العالم. استعرضت هذه الدراسة خصائص السالمونيلا وتصنيفها وتسميتها وطبيعتها بالإضافة إلى نظرة عامة على NTS و TS. اعتمدت هذه الدراسة على البيانات والمعلومات الأساسية المنشورة في المجلات والكتب والنشرات / المقالات من الهيئات التنظيمية الدولية. أظهرت البيانات المجمعة للدراسة الحالية أن السالمونيلا يبلغ حجمها 2-3 × 0.4-0.6 ميكرومتر ، سالبة الجرام ، غير قادرة على التحوصل ،غير منتجة لكل من أوكسيديز ، إندول و يورياز ، سالبة لسكريات اللاكتوز والسكروز ، لاهوائية اختيارية و قادرة على الحركة. يختلف نوعا السالمونيلا الموجودان في تسلسل 16S rDNA على الرغم من أن كلا النوعين مرتبطان ارتباطًا وثيقًا بـ Shigella و E. coli في متواليات 16S, rDNA 32S rDNA. أنواع السالمونيلا وأسماء أجناسها تكتب مائلة ؛ بينما في الآونة الأخيرة ، تم كتابة الحرف الأول من اسم النمط المصلي بأحرف كبيرة ، ولكنه غير مكتوب بخط مائل. تعد السالمونيلا هي المسبب لـ NTS و TS في الإنسان والحيوان حيث تظهر التهاب الأمعاء وتسمم الدم والإجهاض والتهاب السحايا. تم تسجيل لتفشى داء السلمونيلات من الأغذية والمنتجات الغذائية من أصل حيواني وأماكن التلامس مع الحيوانات مع انتقال العدوى بين البشر والحيوانات. يعد المرض من بين تحديات الصحة العامة الأكثر شيوعًا في أجزاء مختلفة من العالم مع زيادة حدوث العديد من الأنماط المصلية. وقد تم تسليط الضوء على دور الميكروب باعتباره من المسببات الرئيسية للأمراض المنقولة عن طريق الأغذية وتسمم الدم مما يؤدي إلى المراضة والوفيات في جميع أنحاء العالم. يجب إجراء بحث مستمر حول السالمونيلا والامراض الناتجة عنها للمساهمة في تكوين معارف وتحسين الاستراتيجيات الوقائية / العلاجية للمرض في نهاية المطاف.