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Farm animal salmonellosis (ruminants and camel) with special reference to Egyptian situation: A review

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Salmonellosis is an infectious zoonosis that affects the public health and economic performance of industrialized as well as developing countries. In developing nations, salmonellosis is often a very common but neglected disease. The purpose of this review is to provide insight about salmonellosis in animal populations in Egypt and help to understand the situation from 1952 to 2019. A total of 69 national and international scientific publications on serological investigations, isolation, and biotyping studies from 1952 to 2019 were reviewed to verify the current status of salmonellosis in animal populations in Egypt (ruminants and camel). There is a gap of knowledge concerning the epidemiology of salmonellosis in cattle, buffaloes, sheep, goats, and camels in different localities in Egypt. Serologic testing for salmonellosis is a well-established procedure in Egypt but only at the research level. Salmonella spp. was recovered from apparently healthy and diarrheic neonatal calves, cattle, buffaloes, camel, sheep and goats. Infections among imported camels were considered as an additional source for salmonellosis in Egypt. Salmonellosis is prevalent nationwide in many Egyptian farm animal species. This review concluded that all seroprevalence data that present at local and international publication need to be applied at country level to design a strategy plan for Salmonella seroprevalence, isolation and identification. This will be helpful in drawing a geographical map for distribution of such zonootic disease in Egypt and finally these studies will be the nucleus for building an effective control program to minimize salmonellosis disease in animal and consequently in human.

Keywords: Salmonellosis, Farm animal, Egypt and Review

INTRODUCTION

Animal Salmonellosis is an infectious disease that caused by Salmonella, a genus of family Enterobacteriaceae that have two main species (S. enterica and S. bongori) (Kemal 2014). Daniel E. Salmon was the first scientist who isolated Salmonella microorganisms from a pig in 1885 and he named it Bacterium choleraesuis (currently named Salmonella enterica serovar Choleraesuis) (Rao 2004 and FDA 2008). There are 2500 different Salmonella serotypes and more all are considered potentially pathogenic to human and animal (Mead et al., 1999) young, pregnant and lactating animals are the most susceptible to the infection being capable of producing a serious of infections and have foodborne zoonotic importance (Kemal 2014). Many serotypes of Salmonella cause salmonellosis that clinically characterized by one or more of the three major syndromes; septicemia, acute and chronic enteritis (Davison, 2005). Salmonella enterica subspecies enterica serotype Dublin (S. dublin) and Salmonella enterica subspecies enterica serotype Typhimurium (S. typhimurium) are the most common serotypes that are associated with cattle (McEvoy, 2003). Septicemia, acute or chronic enteritis and abortion are the commonest clinical manifestations of animal salomonellosis (Venter et al., 1994). Gastroenteritis and typhoid fever are the two clinical manifestations of Salmonella infection (Fluit 2005). Salmonella is considered as one of the most wide spread foodborne zoonosis worldwide even though the incidences seems to vary (Bayleyegn et al., 2003). The most common cause of Salmonella infection in developed countries is the presence of S. typhimurium in cattle and the cross contamination of beef carcass tissue (Gomez et al.,1997). Antibiotic resistance in bacteria is one of the urgent threats to both public and global health. The Salmonella Typhimurium monophasic sequence type 34 (ST34) clone, with its rapid dissemination and resistance to numerous critical antimicrobials, has raised global concerns (Biswas et al 2019) Moreover, there is a great problem with antibiotics resistance is that the resistant organism may act as donor of resistance determinant to another facultative pathogen of the human commensal flora of intestinal tract that may later be associated with disease and, in turn, supply the resistance genes to other pathogen (Salyers 1995). Salmonellosis is a serious threat to human and animal health (Rehman et al., 2019) causing 16 million annual cases of typhoid fever, 1.3 billion cases of gastroenteritis, 1,000 deaths each year in USA due to food poisoning (Mead et al. 1999) and 3 million deaths worldwide (Kemal 2014). Therefore, the aim of this review is to provide insight regarding salmonellosis in Egypt over the last 67 years and to assist observers interested in salmonellosis to more fully understand the situation in Egypt and this have been covered through firstly, reviewing the disease history from 1952 until now. Secondly, describing isolated serotypes in relation to animal species. Thirdly, presenting the previous and current state of the disease in animal population especially ruminants and camel in different Egyptian governorates through reviewing the disease prevalence (percentage) from 1952 until now. Finally, a brief account on antibiotic resistance of Salmonella microorganisms isolated from above mentioned farm animal species was concluded.

General Overview of Farm Animal Salmonellosis Worldwide

General classification

CDC used the current nomenclature of the genus Salmonella that have been adopted worldwide through different publications based on the recommendations from the WHO collaborating center and it adequately addresses the concern and requirements of clinical and public health microbiologists (Table 1) (Deb and Kapoor 2005) Scientific Salmonella classification is described under:

Domain: Bacteria
Phylum: Protobacteria
Class: Gamma Protobacteria
Order: Enterobacteriales
Family: Enterobacteriaceae
Genus: Salmonella,
Species: Salmonella enterica and Salmonella bongori (Hafez 2005).

The species Salmonella enterica being divided into six subspecies (I–VI); S. enterica subsp. enterica (I), S. enterica subsp. salamae (II), S. enteric subsp. arizonae (IIIa), S. enterica subsp. diarizonae (IIIb), S. enterica subsp. houtenae (IV) and S. enterica subsp. indica (VI) (Brenner et al.2000) based on biochemical characteristics (biotype), differences observed in multilocus enzyme electrophoresis (MLEE), phylogenetic analysis using 16S rRNA or other sequences, or analyses using other molecular techniques such as amplified-fragment length polymorphism (AFLP). Members of Salmonella enterica subspecies I account for 99% of all human infections (Craig and James 2006). Kauffmann- White scheme used to classify Salmonella strains serologically. Nowadays the genus contains more than 2500 serotypes (Popoff et al., 2003, Popoff et al. 2001 and Tindall et al., 2005). However, Centre for Infectious Disease Research and Policy (CIDRAP) reported more than 2541 serotypes (serovars) that have been classified according to their somatic lipopolysaccharide (O), flagellar (H) antigens and at times capsular (Vi) antigen and most strains show diphasic variation of the flagellar antigns (CIDRAP 2006, Scott 2010). Recently, a number of 3000 Salmonella serotypes that able to cause disease in human have been suggested by

Dignostic Services of Monitoba (DSM) and new serotypes are identified continuously (DSM 2009). Salmonella enterica represents the most pathogenic specie and includes > 2600 serovars characterized (Jajere 2019).

General characters

Salmonella is a Gram-negative bacterium, distributed widely in such natural environments as soil, dust, or river water, causing food poisoning as well as oral infections such as Typhi or Paratyphi. Salmonella is highly tissue invasive, easily spreading throughout the whole body after initial growth in the phagocytic vesicles of macrophages as an intra-cellular parasite (Amano 2019). They are facultative anaerobic motile bacilli with peritrichous flagella (except S. pullorum and S. gallinarum) which are non-motile, they are glucose fermenter with or without production of gas (except S. typhi and S. dublin), but they are non-lactose, sucrose, salicin nor urea utilizers. They reduce nitrate to nitrite and most are phototropic (Lund et al., 2000 and Johnson et al., 2007). The optimal temperature for multiplication is from 35C to 37C with optimum PH of6.5-7.5 and water activity lies between 0.94-0.84. Salmonellae are chemo-organotrophic microorganisms (FRI 2010). They have the ability to multiply in the presence or absence of oxygen (European Commission 2000). The bacteria cannot resist temperature above 700C; so it is sensitive to pasteurization. However, it resist dryness even for years especially when organic materials such as feces, dust and food are present (Radostitis et al., 2007). Table (1).

Epidemiology:

The epidemiology of Salmonella is complex, which often makes control of disease difficult. Epidemiological pattern of prevalence of infection and incidences of disease differ greatly between geographical area depending on climate, population density, land use farming practice, food harvesting and processing technologies and consumer habits. In addition, the biology of serovar differs so widely that Salmonella infection or Salmonella contamination are inevitably complex (Radostitis et al., 2007). Salmonella genus represents the most common foodborne pathogens frequently isolated from food-producing animals that is responsible for zoonotic infections in humans and animal species including birds. Thus, Salmonella infections represent a major concern to public health, animals, and food industry worldwide (Jajere 2019).

Occurrences and Geographical distribution

The rate of infection in domestic animal has been estimated from 1-3%. In 1980, 16274 strains of 183 serotypes of Salmonella were isolated in USA from samples of meat obtained from slaughterhouse. In other examination of animals positive culture was obtained from 4.59% of 141, 827 bovine fecal samples. Epidemiological surveillance of animals including bird is of the most important since source of large majority of non-typhoidal salmonellosis cases are of food animal origin. There is scarce of data from developing countries in this regard (Acha and Szyfres 2001). Moreover 1229 salmonellae isolations were recorded by Gelaw et al., (2018) in South Africa during the period from 2007 to 2014. Around 108 different serotypes were recovered from nine different food and non-food animal host species (Gelaw et al., 2018). The most prevalent species is S. entritidis followed by S. typhimurium and both have worldwide distribution. Change in the relative frequency of serotypes can be observed over a short period. Some times within one or two years only limited number of serotypes is isolated from man or animals in a single region or country and the predominance of one or other can vary over a time. Some serotypes like S. entritidis and S. typhimurium are found worldwide in contrast to S. weltevreden, which seems to be confined to Asia (Acha and Szyfres 2001). Sibhat et al., (2011) found the serovars Newport, Anatum and Eastbourne to be the most prevalent in Ethiopia.

Morbidity and mortality

In a case control study of S. typhimurium DT 104 infection in cattle in Great Britain, Evans and Davies (1996) reported an overall case fatality rate of 44%. In the herd with outbreak of S. typhimurium DT 104 the case fatality rate was 51.2% in calves, 37.4% in adult cattle and 26.2% in fattening cattle (Evans and Davies 1996). In dairy sucker and mixed herd the case fatality rate was found 44% where in calf rearing unit and dealer herd was found 50%-100% (Richardson 1975). However, modern antibiotic therapy may have reduced this rate. In an outbreak of S. Dublin in calf rearing unit 29 (13.5%) of 214 calves died (Peters 1985). Mortality was significantly higher in group-reared calves (19.25%) than in calves in single pens (9.2%). Mortality and morbidity is usually highest in calves under 12 week of age. In all species case fatality rate often, reach 100% if treatment is not provided (Radostitis et al. 2007).

Economic importance

Salmonellosis is a significant cause of economic loss in farm animals because of the cost of clinical disease, which include death, diagnosis and treatment of clinical cases, diagnostic laboratory cost, the cost of cleaning and disinfection and cost of control and prevention. In addition, when the disease is diagnosed in the herd, it can create a considerable apprehension in the producer because of difficulty on identifying infected animals. An estimation of economic impact of an outbreak of S. Dublin infection in calf rearing unit indicate that the cost of disease represented a substantial proportion of gross margin of rearing calves (Radostitis et al., 2007). Estimated annual costs for salmonellosis have ranged from billions of dollars in United States to hundreds to millions of dollars in Canada and millions of pounds in United Kingdom. Analysis of five Salmonella outbreak due to manufactured food in North America gave direct cost with range from $36,400-$62 million, there have been few studies in to the cost and benefit of preventing Salmonella infection, but it has been suggested that for every £1 spent on investigation and curtailment of the outbreak there is a saving of £5 (Wray 1994). In Egypt there is no official data concerning economic losses because of Salmonella infection in farm animals, a further point that need more investigations.

Source of infection and transmission

Non-typhoidal Salmonella (NTS) infection is one of the major causes of diarrheal disease throughout the world (Mukherjee et al., 2019). Most Salmonella infection in farm animals are likely to acquire from animals of the same species, especially in the case of the host adapted serovars. In adult cattle there are important differences in the behavior of S. dublin and S. typhimurium. Those animals which recover from clinical S. dublin infection may become persistent excreters, shedding up to 106 organisms per gram of feaces daily. Other herd may harbor infection and excrete the organisms only when stressed particularly at parturition. Aerosol transmission has long been suggested as a means by which Salmonella may be transmitted and experimental infection of calves by aerosol has been reported recently. In addition pasture contamination results when flooding occurs and there are many reports of clinical case in adult cattle arising from grazing recently flooded pasture (Wray 1994) (Figure 1).

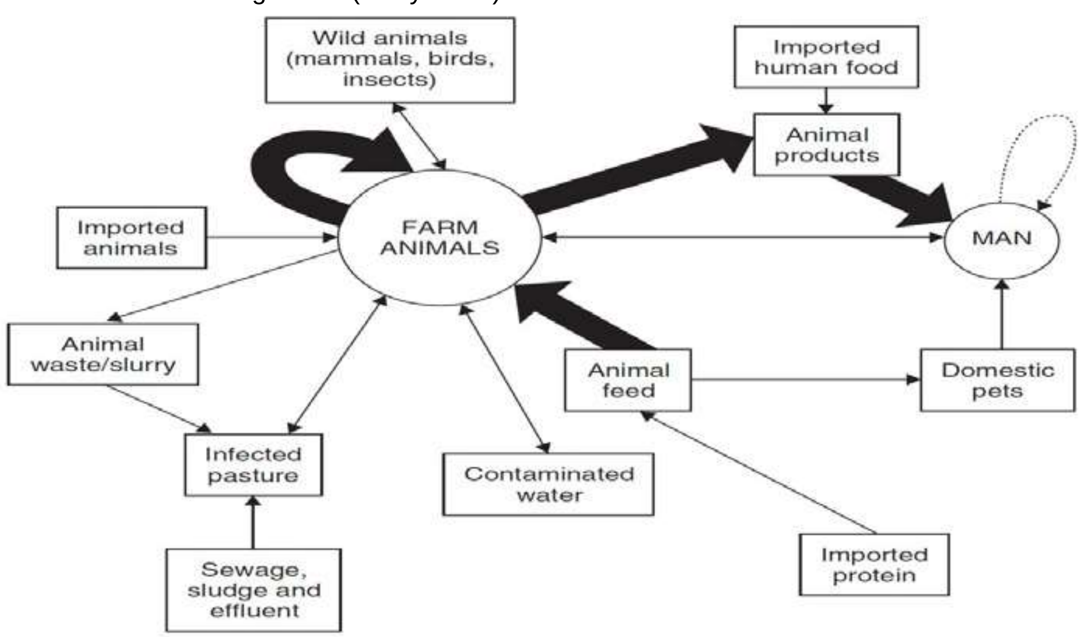

Figure 1: Sources of infection and transmission of *Salmonella* spp. in human and animals (Jones et al., 2007). Feed, water, pasture, wastes; wild animals etc can serve for the transmission of the pathogen *Salmonella* into farm animals, which in turn serve as a source for human.

Salmonella in Egypt

Egypt is located in the northeastern part of Africa connecting the three old-world continents Africa, Asia and Europe. Egypt has 27 governorates and over 90% of the population live in 10% of the whole area along the River Nile and Nile Delta in the northern part of the country. A number of zoonotic pathogens have been reported in Egypt. The highest incidence and prevalence of zoonotic diseases in Egypt may be attributed to the deficiency of suitable control mechanisms, inadequate infrastructure and lack of information on their significance and distribution (Helmy et al., 2017). In 1952, Salmonellosis was reported in a scientific report in Egypt for the first time by Kamel (1952). The disease was discovered in died 15 days old suckling buffalo calf. The isolated serotype was Salmonella Typhimurium. Since then, the disease has been detected at high levels among ruminants and camels, particularly in large intensive breeding farms (Table1). Lotfi and Kamel (1964) isolated Salmonella microorganisms from 900 apparently healthy buffalo calves at Cairo abattoir with an incidence of 1.67%, where S. bovis-morbificans and S. reading were isolated for the first time in Egypt. In 1965, Lotfi and Kamel described an outbreak of Salmonella among buffalo calves at a governmental breeding farm at Mehallet Mousa. Ramadan et al., (1965) isolated Salmonella Uganda from two (1-2 day old) dead buffalo calves. Moreover, a carrier state was detected among one of the calves attendants in one of the Egyptian farms. Different Salmonella serotypes were isolated with different isolation rates from examined apparently healthy, diarrheic and dead animal cases (ruminants and camel) throughout 12 Egyptian governorates Furthermore, Salmonella enterica was isolated from slaughterhouses in Egypt (Ahmed et al 2014). A study described the prevalence of Salmonella species in dairy handlers as well as milk and dairy products randomly collected from different dairy farms and supermarkets. Two stool specimens out of 40 apparently healthy dairy handlers were positive by PCR (Gweda et al., 2014). Moreover, Infection among imported camels were considered as an additional source for salmonellosis in Egypt (Ghoneim et al., 2017). Regarding to seroprevalence of Salmonellae in examined animal cases from 1952 to 2019 in Egypt, it was found that the most predominant serotypes in all previously mentioned animal species were Salmonella enterica subspecies enterica subspecies typhimurium (S. typhimurium), being the most frequent isolated serotype in Egypt especially among calves (Galal et al., 2008) who isolated S.typhimurium in a percentage of 19%, followed by S.enerititidis, S. Dublin, S. saintipoul, S.bovismorbificans, S.

Table 1: Currently recognized number of *Salmonella* serovars (Grimont and Weill 2007)

***Salmonella* species and subspecies**	**No. of serovars within subspecies**	**Usual habitat**
S. enterica	2557	
S.e. ssp. *enterica*	1531	Warm blooded animal
S.e. ssp. *salamae*	505	Cold blooded animals and environment
S.e. ssp. *arizonae*	99	Cold blooded animals and environment
S.e. ssp. *diarizonae*	336	Cold blooded animals and environment
S.e. ssp. *houtenae*	73	Cold blooded animals and environment
S.e. ssp. *Indica*	13	Cold blooded animals and environment
S. bongori	22	Cold blooded animals and environment
Total (genus *Salmonella*)	**2579**	

Newport and S reading, (figure 6). However, some serotypes founded to be species specific serotypes that could be isolated from a specific animal species but not from other animals according to table (2), for example S. newsland, S. chester, S. brazzavile, S.lokstedt, S.israel, S. Newport, S. goettingen could be isolated only from camel while S. newborunswick, S. montivideo, S. bonn, S. cerro and S. magherafelt found to be present only in cattle. S. gallinarum-pullorum, S. sofa, S. kaapstad, S. thomposon S. muenster, S. bovis, S. carrau, S. eastborn, S. tshiongwe, S. woryhington, S. oranieburg and S. infantis were specific only for buffalo. Regarding to sheep and goat it is found that S. muenchen, S. bloky, S.narashion, S. nanergou, S. abortis-ovis, S. paratyphi, S. bardo, S. Kentucky and S. braenderup were the specific serotypes for sheep and goats and they could not be isolated from other animal species. Although the collected data could not represent livestock size in Egypt, they provide insight about salmonellosis in farm animal populations in Egypt especially ruminants and camel, thus helping to understand the situation from 1952 to 2019. A comprehensive, evidence-based assessment of current literature and of officially available data on animal salmonellosis is missing for Egypt. Figure (2, 3. 4, 5 and 6) and table (2).

Figure 2: Geographical distribution of Salmonellae in Egypt from 1952 to 2019 according to available literature.

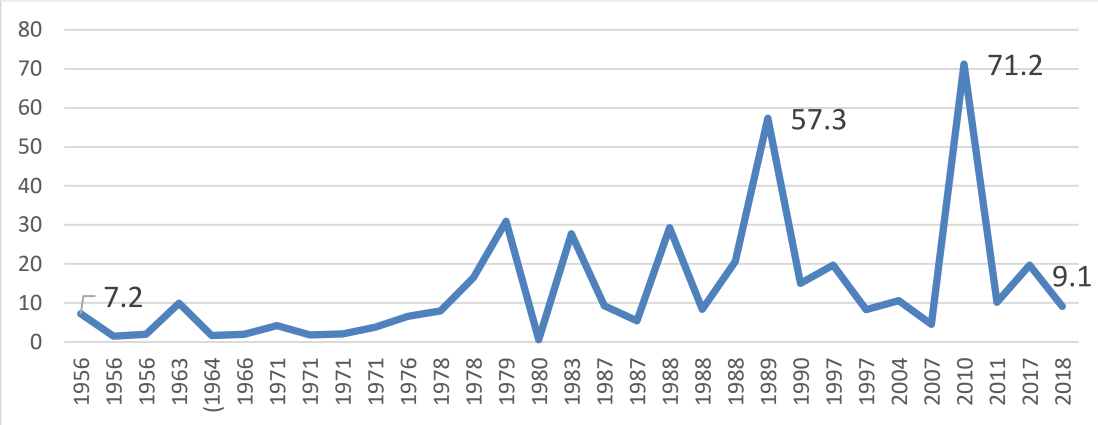

Figure 3: Prevalence of Salmonellosis in farm animals in Cairo Governorate according to available literatures.

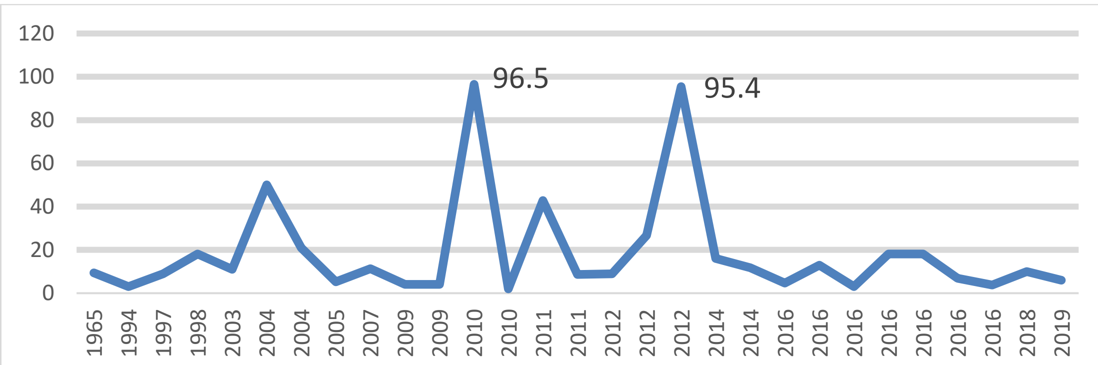

Figure 4: Prevalence of salmonellosis in cattle, buffaloes, Camel, sheep and goats in central Egypt according to available literature.

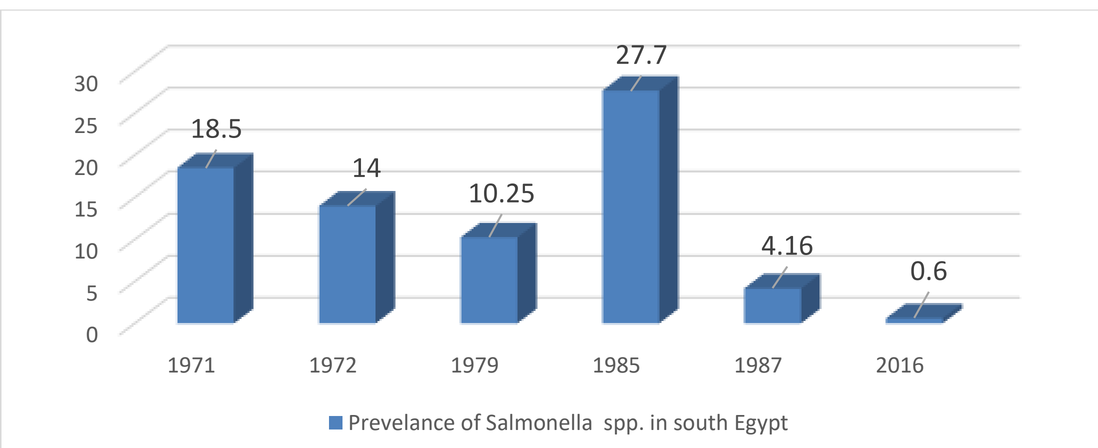

Figure 5: Prevalence of salmonellosis in cattle, buffaloes, Camel, sheep and goats in South Egypt according to available literature

Table 2: Status of farm animal salmonellosis in Egypt from 1952 - 2019

Area	No. of clinical samples	Animal	Clinical Cases	Overall incidence (%)	*Salmonella spp*	Isolation (%)	References
Cairo abattoir		Camel	Apparently	2	*S.paratyphi*	12.5	Floyd (1956)
	150	Cattle	healthy	5.2	*S.saintipoul*	12.5	
	96		App. healthy		*S.cholerasuis*	12.5	
					S.bovismorbificans	25	
					S.typhimurium	37.5	
		Camel		1.5			Zaki (1956)
	132	carcasses	Apparently	2	*S.typhimurium*	1.5	Farrag and
	Not given	Camel	healthy		*S.enterititidis*	2	Afifi (1956)
			Apparently	0			
		Cattle	healthy	1.01	*S.saintipoul, S.glostrup*	Not	Hamada et al.,
		Buffalos		8.9	*And S.dublin*	given	(1963)
	Not given	Camel	Apparently				
			healthy		*S. Typhimurium,*		
			Apparently	1.67	*S. Dublin*		
		Buffalo	healthy		*S. bovis-morbificans,*	0.77%	Lotfi and
	900	calves	Apparently	2	*S. reading*	0.44%	Kamel (1964)
			healthy			0.22%	
		Buffalos			*S. Typhimurium, S. Dublin,*	0.22%	
	200	Buffalos			*S. derby, S. Newport*		
	200			4.02	*and S.gallinarum-pullorum*	Not	Zein- el-
			Apparently			given	Abdeen et al.,
			healthy		*S. Typhimurium, S. Dublin, S. derby, S. Newport,*		(1966)
				1.8	*S.thompson, S.eastborn and S.saintipoul*		
		Cattle	Slaughtered			Not	
	1036		Apparently		*S. Typhimurium, S. reading*	given	Ramadan and
			healthy		*S. derby, S. Newport*		Sadik (1971)
		Buffalos			*S. bovis-morbificans S.uganda and S. gallinarum-*		
	1300			2.1	*pullorum*		
						Not	
					S. Typhimurium, S. reading, S. derby, S. Dublin, S.	given	
			Slaughtered		*bovis-morbificans S.eastborn and S. enterititidis*		Ramadan and
	1065	Camel		3.8			Sadik (1971)
					S. Typhimurium, S. reading, S. Thompson, S. Dublin,		
			Slaughtered		*S. bovis-morbificans S.eastborn and S. enterititidis*	Not	
						given	
	955	Sheep			*S.typhimurium*		Ramadan and
				6.6	*S.typhimurium*		Sadik (1971)
					S.carrau		
			Slaughtered			Not	
	150	Buffalo			*S. Typhimurium, S. bovis morbificans, S.dublin, S.*	given	
		calves		8%	*muenster, S. reading, S. enteritidis, S. east bourn,*		Ramadan and
					S.saintpaul and S. Thompson		Sadik (1971)

			Slaughtered		S. Typhimurium		
				14.37%	S. anatum,		
	300			2.08	S. sandigo,		
		Buffalo			S Alamo	1.3	
		calves	Apparently		S. Stanley	4	Abou-zeid
	95		healthy	30.9	Not given	1.3	(1976)
	48						
		Buffalo		0.59	S.sofa, S.kaapstad, S.thompson, S.eastborn, S.saint-		
		calves			poul, S,muenster,,S.entertitidis,S.typhimurium,	Not	
		Cow calves			S.dublin, S.bovis, S. morbificans and S.reading	given	Farid and
	110		Apparently				Lotfi (1978)
			healthy		S.tshiongwe, S.worthington and S.anatum	6.6	
	1850	Buffalo		27.7		20	
		calves			Not given	33.3	
			Dead	5.7	Not given	13.3	Saad (1978)
		Buffalo	Dead	3.6		26.6	
		calves			S.muenchen, S.blocky,S.belem and S.narashino		
	90			3.2 and		Not	
			Diarrheic	2.2		given	Abou-Zeid
	Not given			14			(1979)
	Not given		Apparently		S.typhimurium and S.oranieburg		
		Buffalo	healthy			Not	
	416	calves			S.typhimurium	given	Lotfi (1980)
	100				S.reading		
		Adult		4.8 and	S.saint paul		
	Not given	sheep		3.6	S.muenchen		
	Not given	Lambs	Apparently				
			healthy		S.typhimurium	Not	Saad (1983)
	250	Sheep and				given	
		goats	Apparently	20.6	S.typhimurium		Younis (1987)
		Sheep	healthy		S.newport	Not	
			Apparently			given	
	Not given	Sheep	healthy	8.3	Not given	Not	Abdel Ghani
		Sheep				given	et al., (1987)
			Apparently	0.32	S.abortis-ovis		
	Not given	Sheep and	healthy		S.typhimurium	Not	
		lambs	Slaughtered	5.8	S.abortis-ovis	given	
	Not given				S.typhimurium		
			Diarrheic	0.37	S.newport		Refaai et al.,
	Not given		Aborted				(1988)
		Buffalo		7.8			
	Not given	calves	Apparently		S.rissen	Not	
			healthy	6.7	S.bousso	given	Khalil (1988)
	Not given				S.hadar		
		Ewes			S.anatum	53.8	
	Not given			26.5	S.typhimurium	15.4	Nada (1988)
		Ewes	Apparently	19.4		15.4	
			healthy	11.4	S.heidelberg	7.7	
	300	She-Goats			S.newlands		

					S.chester	0.32	
		She-Goats	Diarrheic	15	*S.eastbourne*		
					S.goettingen	4.13	
		Ewes	Apparently		*S.typhimurium*	0.83	
	400		healthy		*S.brazzavile*		
		She-Goats			*S.lokstedt*	Not	
			Diarrheic		*S.israel*	given	
					S.newport		
		Cow calves	Apparently			4.7	
		Buffalo	healthy			3.13	Noverte
		calves			*S.newborunswick*	1.67	(1989)
		Cow calves	Aborted	15.68	*S.dublin, S.anatum, S.montevideo, S.meleagridis,*	1.67	
				4	*S.bonn and S.uganda*	1.67	
			Aborted				
		Camel			*S.typhimurium*		
	102				*S.anatum*	78.7	
	315		Apparently	8.3	*S.dublin*	10.6	
			healthy		*S.enterititidis*	4.2	Ilias (1990)
			Diarrheic		*S.meleagridis*	4.2	
			Diarrheic		*S.infantis*	2.1	
	393						
	198			10.6	*S.typhimurium, S.enteritidis, S.dublin and*	25	
			Apparently		*S.meleagridis*	23.4	
			healthy			20.3	
		Cattle			*S.heidelberg*	9.4	
	Not given	Cow calves		4.5	*S.paratyphi-A*	4.7	
					S.bardo	4.7	Sobhi (1997)
					S.kentucky	4.7	
					S.typhimurium	3.1	
	378	Buffalo			*S.Braenderup*	3.1	
		calves			*S.enterititidis*	3.1	
		Cow calves			*S.Agona*		Zaki (1997)
			Apparently	43.53	*S.typhimurium*	Not	
			healthy and		*S.enterititidis*	given	
		Calves	diarrheic	27.69	*S.typhimurium*		
					S.enterititidis		Salman and
	85						Tanios (2004)
				4.5	*S.typhimurium*	2.03	
	65	Sheep	Diarrheic		*S.enterititidis*	1.78	
			Diarrheic		*S.Agona*	1.5	
					S.dublin	1.22	
	290				*S.paratyphi*	1.0	
						0.76	Alhajeen
			Diarrheic	5.67	*S.typhimurium*		(2007)
					S.enterititidis	Not	
					S.heidelberg	given	
		Calves			*S.kentucky*		
	335		Diarrheic		*S.paratyphi-A*		

		Calves			*S.bardo*	1.1	
						0.79	Mousa et al.,
					S. Saintpaul	0.53	(2010)
		Cattle		12	*S. Cerro*	0.53	
				7.7	*S. Papuana*	0.26	
					S. Reading	0.26	
					S. Butantan	0.26	
	25		Diarrheic		*S. Anatum*	0.26	Aleslamboly
	181				*S. Chester*		(2011)
		Sheep	Apparently		*S. Typhimurium*	17.65	
			healthy		*S. enterica subsp.salamae*	11.76	
					Rough strain	15.38	
				9.1	*S. Wingrove*	7.69	
			Apparently		*S. Kottbus*		
			healthy			30.76	
Central and North Egypt						3076	
(Alexandria, Kafer El-	110				*S.typhimurium*	15.4	
Sheikh, Sueze Canal, El-		Camel			*S.enterititidis*	15.4	
Sharkia, Dakahliya,		Camel			*S.cerro*	7.7	
Menoufiya, Behira, El-					*S.anatum*		
Gharbia and El- Qalubiya			Apparently		*S.paratyphi*	26.3	
Governorates)			healthy	9.4	*S.virchow*	21.05	
					S.magherafelt	21.5	Ghoneim,
						15.8	(2017)
	845				*S.bovismorbificans*	10.5	
	108				*S.reading*	5.3	
	8	cattle and		3	*S.bovismorbificans*		
	5	calves				11.7	
				8.9		11.7	
	75		Local		*Not given*	5.9	
			slaughtered	18.2		11.7	
	206		imported		*S.montevideo, S.typhimurium and S.cerro*	5.9	
				11.1		5.9	El-Said (2018)
	66				*S.typhimurium*	11.7	
						11.7	
	45	Buffalo			*S.typhimurium*	5.9	
		calves			*S.dublin*	5.9	
		Buffalo		50	*S.enteritidis*	5.9	
		calves			*S.anatum*	5.9	
		Sheep	Feedlot	17.5	*S.paratyphi*		
	100	Cattle		3.4			Zein-El-
					S.typhimurium	30	Abdeen
	137	Calves		1.43%	*S.enteritidis*	20	(1965)
	116			3.85%		10	
		Calves			*S. typhimurium*	10	
	Not given			11.03	*S. dublin*	10	
		Calves			*S. enteritidis*	10	Hafiz (1994)
			Apparently	Not given	*S. anatum*	10	
	120	Sheep	healthy				Zaki, (1997)

			Dead		*Not given*	8.7	Riad et al.,
	Not given		Apparently	4.09		0.4	(1998)
			healthy		*S.typhimurium*	40	
			Dead		*S.enterititidis*		
	220	Sheep		4.09			Helmy and
			Diarrheic		*S.typhimurium*	Not	zaki (2003)
		Calves		6.9%		given	
	220	Calves	Septicemic		*S.typhimurium*		
				11.6%	*S.enteritidis*	Not	
	173	Dairy cattle	Diarrheic		*Non-type able serovare*	given	
		Dairy cattle		25%			El- Sebaaey
	68		Diarrheic		*S.typhimurium and S.enteritidi*	18.2	(2004)
		Buffalo and		53%			
	24	cow calves			*S. Dublin*	4.4	
		Calves			*S. Typhimurium*	2.2	Seleim et al
	15					0.0	(2004)
			Diarrheic		*S. Typhimurium*	2.2	
		Calves			*S. Arizona*	2.2	
			Diarrheic	2	*S. Typhimurium*		Hagagg et al.,
			Apparently		*S. Arizona*	35	(2005)
		Calves	healthy	5.6	*S. Typhimurium*	15	
	200			3.75	*S. Arizona*		
		Dairy cattle	Apparently	2	*S. Newport*		Moustafa et
	90		healthy	14.7		???	al., (2007)
	80	Dairy cattle	Diarrheic	9.2	*Not given*		
	100			7.6			Galal et al.,
	150	Calves	Diarrheic		*S.typhimurium*	Not	(2008)
	140			0.97	*S. Dublin*	given	
	210	Calves	Diarrheic	7.69%	*S.enteritidis*		Ahmed et al.,
					S.anatum	50	(2009)
	450					50	
			Diarrheic		*S.Typhimurium*		
					S. Montevideo	8.4-19.0	
				9	*S. Enteritidis*		Younis (2009)
		Calves	Diarrheic		*S. Anatum*	66.6	
					S. Concord	22.2	
	200	Cattle	App. Healthy	26.7	*S.Typhimurium*	11.1	
		Sheep			*S. Enteritidis*		
		Goats	Diarrheic			Not	Eid (2010)
	Not given	Cattle		18.66	*S.anatum*	given	
		Sheep	App. healthy	77.14	*S.concord*		
		Goats			*S.typhimurium*	1.2%	
	225		Diarrheic	14		0.6%	
	35	Dairy cattle		2	*Not given*		
		Dairy cattle				2.3%	
	100			5.26	*S.typhimurium*	4.7%	Nemer (2010)
	50			6.6	*S.enteritidis*	4.2%	
				0		4.2%	
	1200		Diarrheic		*Not given*	20%	Ali (2011)

	45	Calves			*Not given*	6.7	
	15		Apparently			20%	
			healthy		*S.typhimurium*		
		Calves	Apparently	4.7	*S.enteritidis*	Not	
			healthy		*Untypable Salmonella*	given	
			Apparently		*S. Virchow*		
	150	Calves	healthy			48.1	Osama et al.,
		Calves	Diarrheic	13	*S.Typhimurium*	22.2	(2011)
			Diarrheic	0	*S. Enteritidis*	14.8	
		Dairy cattle	Diarrheic		*S.saintpaul*	14.8	
	85	Dairy cattle			*S.langeveld*		
South Egypt	15		Apparently		*S.havana*	0.0	Elham et al.,
		Lambs	healthy			0.49	(2012)
		Cattle	Diarrheic			0.24	
		Cattle		3	*S.enteritidis*	0.0	
					S.typhimurium	0.24	Ghanim et al.,
				6.67	*S.kentuky*	2.56	(2012)
				11.43	*S.infantis*	0.0	
	250		Diarrheic		*S.tsevie*		Youssef and
		Calves		18.1	*S.magherafelt*	2.56	El-Haig (2012)
	30				*S.hadar*	2.56	
	70		Diarrheic			9	
				3.6	*S. Enteritidis*		
	127	Calves		3.3	*S. Montevideo*	Not	El-Leboudy et
		Calves	Diarrheic			given	al (2014)
			Dead	3.82	*S. Typhimurium*		
	55				*S. Anatum*	1.11	
	31		Apparently	10		3.11%	Nasr et al
			healthy		*S.typhimurium*		(2014)
	248		Apparently	6	*S.enteritidis*		
			healthy		*S.dublin*	Not	
	120	Cattle		Not given	*Not given*	given	
			App. Healthy		*Not given*	Not	
	50	Cattle	and diarrheic	9.3		given	
		Cattle	Diarrheic	1.6	*Not given*		Ashraf et al.,
	200			3		20	(2016)
		Calves			*S. Enteritidis, S. Typhimurium, S. Meleagridis, S.*	10	
	43			10.25	*Anatum and S. Lagos*	10	
	60				*Not given*	8.3	
	100	Lamb	Apparently				
		Goats kids	healthy	27.7%	*Not given*	14.3	Abd El-
	78				*S.typhimurium*	14.3	Rahman et al
		Sheep and		4.16%	*S.typhimurium*	14.3	(2016)
		goats			*S.typhimurium*	28.57	
	90		Diarrheic			28.57	
		Calves	Apparently	0.6	*S. abortis ovis*		
	600		healthy		*S.typhimurium*	16.6	
		Calves				16.6	
					S.tshiongwe, S.worthington and S.anatum	16.6	

	500	Calves Calves Sheep Cattle Sheep Buffalo calves Buffalo calves Cattle and buffaloes	Feedlot Apparently healthy Diarrheic Apparently healthy Diarrheic Diarrheic App. healthy and diarrheic Diarrheic Apparently healthy Diarrheic Diarrheic Diarrheic Apparently healthy Aborted Apparently healthy Apparently healthy Apparently healthy		*S.typhimurium, S.dublin, S.bovis-morbificans,S.reading, S.derby and S.enteritidis* *S.enteritidis*	8.3 8.3 8.3 16.6 66.6 33.3 28.6 71.4 30.4 60.9 8.7 Not given Not given Not given Not given Not given 18.5 9.3 1.6 62.5 12.5 Not given 9.3 1.6 3	El-Gamal and EL Bahi(2016) Haggag et al.(2016) El-Seedy et al., (2016) Rizk (2016) Tarabees et al. (2016) Shaaban et al.(2018) Elwaraqi et al (2019) El-Amrousi et al., (1971) Abdel-Galil et al., (1972) Oof and Abdel-Ghani (1979) Refai et al., (1985) Farid et al., (1987) Ahmed (2016)

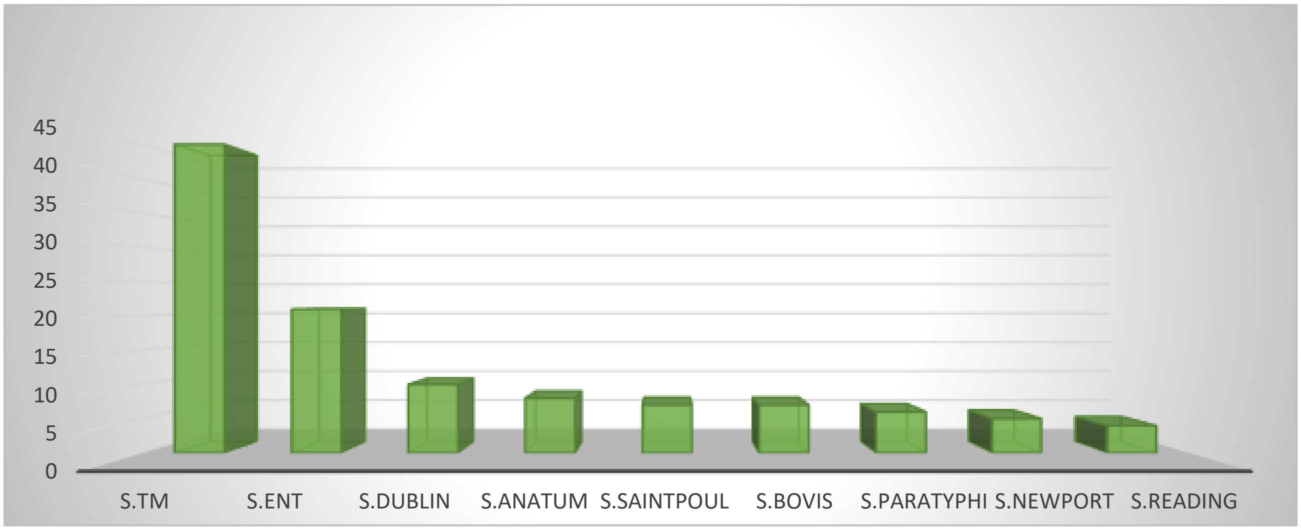

Figure 6: Frequencies of Salmonella serotypes in cattle, buffaloes. Camel, sheep and goats in Egypt from 1952 to 2019 according to available literature.

Literature search and data collection

National and international publications on prevalence, serological investigations and on typing studies of salmonellosis from 1956 to 2019 were obtained through PubMed, Science Direct, Google, and from Egyptian university libraries such as Cairo University Library, Zagazige University Library, Assuite University Library, Benha University library and University of Sadat City Library. The following search terms were used: Salmonella in Egypt, Salmonella infection in Egypt, Salmonella in animals in Egypt, and farm animal Salmonellosis in Egypt. Theses dealing with salmonellosis available from Egyptian universities were included in this study (1956–2019). The libraries were personally visited or contacted via e-mail. A full text analysis of each publication was done by at least two reviewers. Publications describing serological investigations were included even if statistical analyses were not sound to avoid loss of data. Publications on cultivation, bio- and genotyping or PCR analyses were included only if state-of-the-art techniques could be verified by the respective material, and if the methods sections and results were clear. To clarify ambiguities, the authors were first contacted by e-mail or phone. If the authors could resolve those ambiguities, the publications were accepted for further assessment. The following data were extracted from the manuscripts, reports, or theses: number of studied cases, type of studied cases, history of studied case (diseased, apparently healthy or died) seroprevalence for salmonellosis in host species populations and regional distribution, prevalence of Salmonella in animals and identification of isolates.

Data acquisition

Sixty nine scientific papers on isolation, seroprevalence, antibiotic sensitivity testing and molecular diagnosis of Salmonella species in different farm animal species (ruminants and camel) in different Egyptian provinces. 8 on isolation of Salmonella were identified by online search. 15 Local scientific papers and 22 theses were obtained from Egyptian universities; (No.) of them dealt with seroprevalence and (No.) dealt with isolation of Salmonelaa. (No.) publications on serology and (No.) on isolation of Salmonella were finally excluded from evaluation because ambiguities were identified within the materials and methods sections and the authors could not be contacted to resolve these ambiguities.

Diseases associated with Salmonella species in farm animals

Several salmonella serovars were incriminated in infection to different animals species causing different clinical illness syndromes. For examples, S. Dublin is considered the main cause of Salmonellosis in cattle which is usually endemic although, sporadic cases had been occurred. Moreover, the incidence of outbreaks usually rare but may occur under adverse stressful conditions such as severe nutritional deficiency and immunosuppression conditions. While in case of S. typhimurium single infection to an animal or a small groups of animals at the same time had been found. The clinical symptoms is often more severe in young calves and affected large numbers of animals groups La Ragione et al., 2013). However, other salmonella serovars such as S.muenster causing diarrhea and abortion in calves. Adult cattle after recovery become carriers and remain shed the microorganism in animal secretion (Wray & Davies, 2004). Septicemia is another disease form of salmonellosis in cattle, which is mostly prevalent in newborn calves under a few weeks of age. The main clinical findings were severe depression and toxemia in affected calves in addition to elevation of body temperature. In addition, nervous signs were also observed in some cases. The nervous symptoms begin as incoordination in calves gait and nystagmus may be occur (Mohler et al., 2009; Nielsen, 2013), although, diarrhea and dysentery are uncommon findings. In older calves and adults, acute enteritis, was more pronounced associated with abortion in pregnant cows and polyarthritis in calves. Dysentery is usually accompanied with sever bloody enteritis and severe painful reaction during fever, meanwhile agalactia was reported in the lactating cattle. Abdominal pain is observed as kicking at the abdomen, rolling, groaning and looking at the flanks are also predominant observed symptoms (McGuirk and Peek, 2003). Chronic enteritis was described clinically by complete in appetence, loses of body weight and commonly unthriftiness. The survive cattle usually suffered from abortion, especially by S. Dublin infection in cattle causing abortion with retained placenta. Other complications due to enteric salmonellosis includes the terminal dry gangrene which occur due to inflammation of the endarteritis of the peripheral extremities, including ear tips, tail tip, and the limbs from the fetlock down. This syndrome in calves characterized clinically by swelling of the hind limbs and lameness, below the fetlocks, and in severe complicated cases the separation of the skin above the fetlock was observed. By examination of the distal portion of the limb is found cool, not painful and the skin is dry or moist. Line of demarcation between the normal proximal skin and the distal necrotic tissue was observed with limb examination. In non-treated complicated cases, separation of the phalanges from the metatarsus has been reported. The ears tips was found more indurated and always deviated medially, while the distal portion of the tail may shriveled and dry (Radostitis 2007). Abortion due to S.dublin occurred naturally in cattle from days 124 to 270 of pregnancy with no previous clinical signs. The aborted cows suffered from fever, anorexia and retained placenta. In some circumstances, calves borne dead or stillbirth. The experimental infection of pregnant cattle by S. dublin reported variable signs from no clinical illness to fatal dysentery. Abortion was reported in some pregnant females and many cows suffer from pyrexia, anorexia, and mild diarrhea (Mohler et al., 2009; Nielsen, 2013). In other side, the experimental infection of calves by S. typhimurium, the severe general illness was achieved particularly in young calves. However, some chronic cases may be develop as bone lesions, including, osteomyelitis and osteoperiostitis with epiphyseal separation in some diseased cases (Hadimli et al., 2011). Concerning S. enteritidis, the experimental infection resulted in fever, profuse diarrhea of yellow color, subsequent dehydration and cough with a mucopurulent discharge were evident. Acute enteritis was the most recognized form in sheep flock. However, septicemic characters may be evident in the early period of the outbreak (Higgs et al., 1993). On describing the disease form in sheep, the experimental inoculation of sheep with S. dublin, it developed fever and diarrhea and abortion in pregnant ewes. Death of some aborted ewes may occurred and the lambs born usually die after few times. Meanwhile, the development of both Fever and diarrhea, followed by abortion were demonstrated in sheep after experimental infection by S. dublin. (Davies et al., 2001; Ferreras et al., 2007). Regarding the disease pattern in goats, natural infection is not often recorded. S. typhimurium is common cause of peracute septicemia, acute enteritis in newborn kids, which were also reported in a similar pattern in cattle (Radostitis 2007).

Diagnosis

Isolation of Salmonella is still the gold standard for diagnosis; however, culturing the organism is unreliable for various factors including the method used to collect samples, the amount of sample submitted, variation in the shedcling of the organism, and the bacteriological method used. Organism may be identified using a diversity of techniques that may include pre-enrichment to resuscitate sublethally damaged salmonellae, enrichment media that comprise inhibitory substances to inhibit competing organisms, and selective agars to differentiate salmonellae from other enterobacteria. Various biochemical, serological and molecular tests can be used to the pure culture to allow for a reliable verification of an isolated strain (Terrestrial 2008). A major complicating factor is the occurrence of apparently healthy carriers, which shed the organism intermittently in the feces, and silent carriers, which do not shed but harbor the organism in mesenteric lymph nodes or in the mucosa of the cecum and colon. The difficulty varies according to genotype. In cattle with S. dublin infections, the bacteria are present in the blood and milk for a very brief period during the bacteremic phase and before diarrhea commences (Warnick et al., 2003). Various biochemical, serological and molecular tests can be used to the pure culture to allow for a reliable verification of an isolated strain. Organism has antigens named somatic (O), flagellar (H) and virulence (Vi), which may be identified by special typing sera, and the serovar may be assignated by reference to the antigenic formulae in the Kauffman- White scheme. Many laboratories may require to send isolates to a reference laboratory to ensure the full serological identity and to verify the phage type and genotype of the strain,where suitable (Terrestrial 2008) Biochemical identification is an important diagnostic method following bacterial culturing whereas it revealed isolation of Salmonellae in the number of 22 out of 259 examined fecal samples from dairy cattle and 14 out of 39 examined fecal samples from calves (Eid 2010). Although various polymerase chain reaction (PCR) assays have been created to diagnose Salmonella, these assays are most useful when applied to DNA extracted from a positive culture (Warnick et al., 2003). Eid (2010) confirm diagnosis by PCR using invA primer sequence applied on Salomonella culture from apparently healthy and diarrheic cattle and calves, results showed PCR products at 243 bp. However conventional PCR and RT-PCR method were applied on clinical samples previously submitted to bacteriological examination, results showed higher percent of positive samples (11.8%) and (15.5)% compared with results obtained by bacteriological examination (9.1%) (El-Said 2018). The organism can be cultured from fecal samples, bulk tank milk, milk filters, water and feed sources, and environmental sites (Warnick et al. 2003). Testing environmental sample sources is more efficient for identifying infected premises than using individual cattle fecal samples. An antigen-capture ELISA with enrichment culture for detection of salmonellas from fecal samples is more rapid than routine culture techniques, with a test sensitivity of 69% and specificity of 97% (Radostitis et al. 2007).

Treatment and antibiotic resistance of Salmonellae isolated from Egyptian farm animals

Several antimicrobials exhibit high susceptibility and effectively used in salmonellosis in cattle such as ampicillin, ceftiofur, trimethoprim-sulfonamides , fluoroquinolones, and florfenicol. In addition, the supportive treatment is helpful for limiting the severity and disease course. It includes intravenous injection of fluids and electrolyte therapy and non-steroidal anti-inflammatory drugs (NSAIDs) (McGuirk and Peek, 2003). Moreover, Ceftiofur at dose of 5 mg/kg BW is used effectively for treatment of experimental salmonellosis by intramuscularly/ 24 hours in neonatal calves (Fecteau et al., 2003). In addition, the daily parenteral injection of trimethoprim-sulfadoxine, Ampicillin and amoxicillin are recommended antimicrobials for treatment of S. dublin in young calves until recovery. Oral antimicrobials dosing can be used satisfactory in calves but less effective. The synergism of trimethoprim and sulfadiazine are highly effective for parenteral and oral therapy the treatment of experimental salmonellosis in calves with S. dublin. Other antimicrobials such as Sulfadimidine and framycetin are widely applied and recommended for treatment of Salmonollosis. Chloramphenicole and Nitrofurazone are common antimicrobial agents used for salmonellosis but are forbidden for use in food-producing animals (Radostitis et al., 2007). Furthermore, (Rings, 1985) recommended that the treatment protocol of salmonellosis in cattle should base on compensation with electrolyte, and fluid therapy an acid-base balance, besides sanitation and management measures. The antibiotics usually provide effective and favorable benefit especially in uncomplicated cases of salmonellosis. The treatment should include correction of fluid and electrolyte imbalances in addition to the supportive care particular in calves' enteritis. Additionally both ampicillin and enrofloxacin has been recommended for treatment protocol. The using of nonsteroidal anti-inflammatory drugs was used to control of the endotoxemia (CFSPH, 2013). Antibiotics are common used with good response especially in acute cases for treatment of Salmonellosis in cattle and allowed the reduction of high mortalities if started in early stage in combination with supportive care. Also the earlier treatment with antimicrobial permit the less shedding of Salmonellae in animals secretion and thus help in reducing the cross infection (Fecteau et al., 2003; Fossler et al., 2005). In discrepancy, Warnick et al., (2003) found that antimicrobial treatment allowed no shedding of salmonella in calves meanwhile, heifers and cows were reported at higher risk of shedding. In outbreak, it is not recommended to use antibiotics as it may not effective and may be a cause of antimicrobial resistance problem but supportive therapy for the severely affected cases and vaccination may be benefit to prevent the high mortalities.. On the other side, the prophylactic use of antibiotics in animals feed may be appear of no value on shedding of Salmonellae in calves (Wray et al., 1987). In an outbreak, appropriate support therapy for severely affected animals and vaccination may be benefit and to prevent high mortalities. It is worth mentioning that typhoid fever is endemic in Egypt; and quinolones are the empirical treatment of choice. There are limited data reporting quinolone resistance among Egyptian typhoidal Salmonella isolates (Saleh et al., 2014 and Osman et al., 2013). However, 68% of Salmonella enterica isolates showed multidrug resistance phenotypes (Ahmed et al., 2014) particularly against chloramphenicol and trimethoprim-sulfamethoxazole, streptomycin, tetracycline, ampicillin and gentamicin (Ahmed et al., 2016), which is of great health significance (Ahmed et al., 2014). Many Salmonella isolates particularly S. typhimurium definitive type (DT) 104 in addition to causing infection they have developed a resistance to many types of antibiotics being resistant to ampicillin, chloramphinicol, streptomycin, sulfonamides and tetracycline (ACSUT) with increasing number of isolate showing resistance to trimethoprim and fluoroquinolones (Threlfall et al. 1997 and Piddock 2002). However, higher snsitivity to choloramphenicole still recorded in many international and local publications from Egypt (Abd El-Rahman et al. 2016 and Nasr et. al. 2014). A high resistance of Salmonella isolated from diarrheic and dead calves was recorded by Youssef and El-Haig (2012) where all Salmonella isolates (S. typhimurium and S. enterititid) were resistant to 138 of 216 antibiotic discs (63.88%). Moreover, three Typhimurium strains were resistant to all antibiotic discs used (Youssef and El-Haig 2012).

Control of salmonellosis in Farm Animals

Control and preventive measures of salmonellosis relies mainly on the breeding system. In free-living animals, the control program is of less and limited value and detection of carrier animals was very difficult. Although, many of hygienic measures may appear to provide some benefits. These include application biosecurity tools that help protection of infection and prevent environmental contamination. In addition, using of different disinfection types for hands, footwear, clothing, equipment and vehicles in houses of livestock may have a good effect. For examples, sodium hypochlorite 1%, ethanol 70%, glutaraldehyde 2%, iodine-components disinfectants, phenolics and formaldehyde. Some factors have an important effect on the control program of salmonellosis. These include hygiene and management and stress factors. In addition to, the hygienic disposal of sewage led to reduction of number of the bacteria into water sources. The ideal example for the management factors the densities level in which livestock are present that reduce the cycles of salmonella infection within animal populations. Furthermore, the closed breeding system is considered the most effective strategies in control of salmonellosis in young calves (Lanzas et al., 2008). In outbreaks, isolation of affected animals and applying of strict hygienic measures are described as the most important recommended procedures (Bender, 1994). To achieve a selective control program for certain disease, some intrinsic and extrinsic factors should be considered. Of these factors, the size and stocking density of livestock herd that may have an effect the risk of disease introduction, dissemination or persistence . However, other agents may also include such as geographical region, management, animal age and season. Although, some obstacles are facing the effective control program of salmonollosis, Carrier status, contamination of feedstuffs and environment are the major obstacles. The main principles lines in controlling bovine salmonellosis is to prevent the disease introduction and/or limitation of spread. Every effort must be made to prevent introduction of a carrier; ideally, animals should be purchased directly only from farms known to be free of the disease and should be isolated for ≥1 wk while their health status is monitored. Ensuring that feed supplies are free of salmonellae depends on the integrity of the source. Some countries also test for contamination of and regulate importation and home production of feedstuffs and feed components (Walter Gruenberg). In case of an outbreak of salmonellosis, the following steps should be recommended: 1)- identification of carrier animals and culled or isolated for treatment and confirmed that no shedding for the bacteria. 2) - Prophylactic use of antibiotics in animals feed or water supplies may be of value. 3) - restriction of animals movement to the limit level and avoided mixing of animals groups. 4) - Prevent contamination of food and water equipments. 5) - cleaning and disinfection of surroundings buildings and environment. 6) - Hygienic and carful disposal of contaminated materials. 7) - Vaccination might be recommended in this case by either killed bacterins or autogenous bacterins. 8) - prevent or minimizing the stresses factors (Walter Gruenberg). Several implemented control strategies for salmonellosis were constructed. These strategies should be focused on limiting the source of infection and enhancing the host immunity. (McGuirk and Peek, 2003). The Ten following points should be adopted. 1) - Maintain a close system for animals breeding and maintain the purchases of new animals at low level. 2) - Avoid the stress factors and infection of residents.3) - allow good nutritional status and adequate time and density in animals' pens. 4) - provide different facilities for pregnant cows and diseased cows. 5) - Avoid contact between diseased and healthy and isolated the infected calf.6) - Disinfection of all premises. 7) - Hygienic disposal of manure and organic debris and minimized the feedstuffs contamination. 8) - Feeding of colostrum and milk from immune cows to provide adequate immunity level. 9) - Control of rodents, birds and cat populations.10) - Vaccination that prevent infection and reduce the severity of infection and decrease the mortality rate.

Salmonella Vaccines

Vaccination is considered as an important process for prevention and control of many animals' infectious diseases. Live Salmonellae vaccines are expected to elicited optimal immune protection. However, inactivated bacterins may induce a lower level of protection. In several experiments, live attenuated Salmonella vaccines in pigs, cattle, and chickens produced a strong cell-mediated immunity response and prevent systemic infection and intestinal colonization of Salmonellae. A live attenuated S Choleraesuis vaccine was approved to be used in pigs under field conditions and the results reported reduction in colonization of pigs tissues after challenge with virulent serotype. Moreover, experimental challenge with S Dublin and serogroup C1 salmonellae allowed protection for calves against after intranasal or SC infection. Another prepared vaccine from live S Gallinarum serotype has described to elicited effective control of fowl typhoid and also in laying hens challenged with S Enteritidis (Walter Gruenberg,). In recent years, many of salmonella vaccines approved for commercial uses are inactivated-formalin vaccines with aluminum hydroxide adjuvant (McGuirk and Peek, 2003). (House et al., 2001) used an autogenous Salmonella bacterin vaccine in pregnant cows and the results reported that no effect on fecal shedding of salmonellae, meanwhile vaccination by a modified live S. Choleraesuis vaccine reduced the fecal shedding of serogroup C1 salmonellae during the peripartum period. The efficacy of Bacterins vaccines may be ineffective or good protection and occasional anaphylactic reactions may occur. Very few vaccines products for Salmonella are available. Although, autogenous bacterins are prepared and may have some benefit with some adverse reactions are frequently a common complication. Additionally, Modified live vaccines are genetically prepared , attenuated strains will provide more efficacy protection than bacterins, due to its ability to stimulate immune response (House et al., 2001). The Initial development of Salmonella vaccine began in late nineteenth century with Wright, (1997) for typhoid infection in human beings. Later, live attenuated vaccine prepared from Salmonella ssp. Enterica serovar Gallinarum (S.Gallinarum) for control of fowl typhoid. Subsequently, preparation of killed vaccines were successfully done with safety to control of salmonellosis in equines. After that , several different Salmonella serovars were used in killed bacterins for veterinary use such as S.Typhimurium (Mendel, et al., 1972, Nicholas and Andrews, 1991), S Abortusequi (Gupta et al., 1987), S.Dublin (Liberal,1989), S. Virchow (Ghosh, 1989), S. Gallinarum (Mohrah, I.M.; Zaki,,1995) and S.Enteritidis (Gast et al., 1993; , Barbour et al., 2001). Vaccination can reduce the level of colonization and shedding of the bacteria into the environment, as well as clinical disease. Vaccines are available for some serovars such as Salmonella dublin, S. typhimurium, S abortusequiand S. choleraesuis, in some countries

CONCLUSION AND RECOMENDATION

Salmonellosis is an infectious zoonosis that affects the public health and economic performance of industrialized as well as developing countries. There is a gap of knowledge concerning the epidemiology of salmonellosis in cattle, buffaloes, sheep, goats, and camels in different localities in Egypt. Serologic testing for salmonellosis is a well-established procedure in Egypt but only at the research level. There is a great demand for official seroprevalence data as well as for a nationwide survey to genotype circulating Salmonellae in different Egyptian provinces for drawing a geographical map for distribution of such zonootic disease in Egypt that will be effective in building an effective control program to minimize salmonellosis disease in animal and consequently in human. . The epidemiologic situation of salmonellosis in Egypt is unresolved and needs clarification.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

AUTHOR CONTRIBUTIONS

All listed authors have made substantial contributions to the research design, the acquisition, analysis, or interpretation of data; and to drafting the manuscript or revising it critically; and that all authors have approved the submitted version.

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