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Salmonella Infection Among farm Animals in Al Ain, United Arab Emirates.

Dalal Saeed Saeed Mansour Al Kaabi

United Arab Emirates University
Deanship of Graduate Studies
M.Sc. Program in Environmental Sciences

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A thesis submitted to
The United Arab Emirates University in partial fulfillment of the requirements for the Degree of M.Sc. in Environmental Sciences

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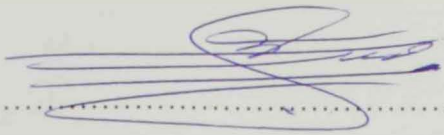
Dedication

To the memory of H.H. Sheikh Zayed bin Sultan Al Nahyan whose vision, intelligence, wisdom and sincerity enable us to reap considerable benefits in the form of a quality of life unimaginable a few short decades ago.....

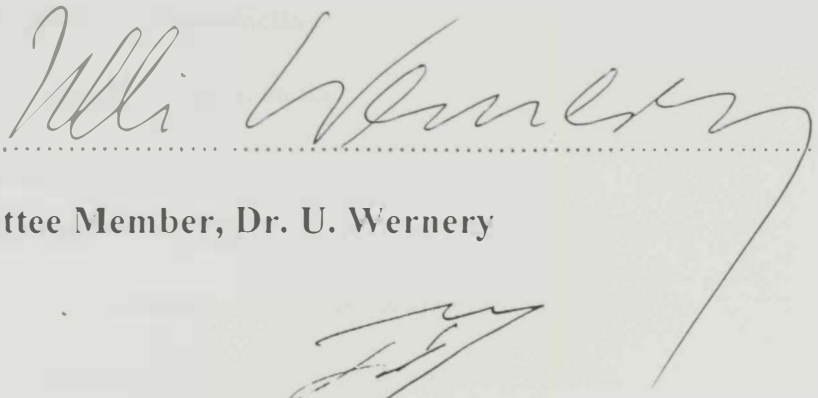
To my country and to my dear parents...

The Thesis of Dalal Saeed Al-Kaabi for the Degree of Master of Science in Environmental is approved.



Examining Committee Member, Dr. Abdulmajeed Saif M. Ammeen

Examining Committee Member, Dr. Oskar Ruger Kaaden



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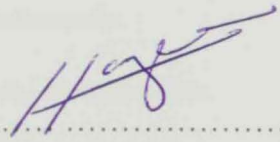

Director of the Program, Dr. Hazem A. H. Kataya

Dean of the Graduate Studies, Prof. James E. Fletcher

United Arab Emirates University
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ABSTRACT

Salmonellosis is considered one of the most economically significant diseases, affecting man and different animal species. The disease affects all ages of domesticated and wild living animals. Salmonellosis manifests a variety of clinical signs such as diarrhea, abortion, arthritis and respiratory problems. The natural habitat of Salmonella species is the intestinal tract of most animal species. Carrier animals represent a continuous source of shedding the bacteria in the surrounding environment. Salmonella infection spread among animals and then to man causing public health hazard.

In this study, a total of 882 samples were collected from different animal species in Al Ain area of Abu Dhabi Emirate in the United Arab Emirates (UAE). The fecal samples were aseptically collected from apparently healthy camels (266), cows (122), sheep (255) and goats (187). On the other hand, 52 samples were obtained from scouring and pyrexic camels (7), cows (10), sheep (6), goats (5), game animals (3) and avian species (17). Also samples were submitted from aborted foetus of a goat and fecal swab were obtained from aborting cow. All samples from apparently healthy and affected animals were subjected to Salmonella isolation and identification protocol. Each sample was inoculated into selenite broth medium and incubated at 37° C for 24 hours. A loopful from each broth was streaked on plates of blood agar, Salmonella Shigella agar and Hektoen enteric agar. The plates were incubated at 37° C for 24 hours. The yielded colonies were identified according to their cultural and biochemical properties. The isolated Salmonella were grouped (A-G) and partially serotyped using polyvalent and monovalent O and H antisera. Further and complete serotyping was carried out by Veterinary Laboratory Agency in Weybridge, U.K.

The present findings showed that, Salmonella infection is highly prevalent in cows and camels, whereas sheep and goats score the least incidence of the disease. To our best knowledge, no records are available to date of any isolation of Salmonella species in cows, sheep and goats nor serological evidence that exists in the UAE. This study reports the first isolation of Salmonella serotypes in cows, sheep and goats. Also, this study acknowledges the isolation of *S.* Indiana, *S.* Wien, *S.* Stanley, *S.* Haardt, *S.* Panama, *S.* Liverpool and *S.* Poona for the first time in camels of the UAE.

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I wish to express my great thank to UAE University for giving me this precious opportunity to continue my studies for a master degree. Many thanks to H.H. Sheikh Nahyan bin Mubarak Al-Nahyan, *the Minster of Higher Education and Supreme Chancellor of UAE University*, for his continuous support to the scientific research. Also I would like to thank Dr. Hadef bin Ju'aan Al-Dhaheri, *the Vice-Chancellor of UAE University*, for his support to graduate programms. Special thanks to the Graduate Studies Unit for its continuous help throughout the study. I wish to express my sincere appreciation to my supervisors, Dr. Abdulmajeed S. Al Khajah, *Assistant Professor of Medical Microbiology in UAE University*, and Dr. Tarq Mustafa, *Director of Veterinary Laboratory in Al-Ain City*, for their support, encouragement, guidance and experiences.

I specially want to thank the Department of Agriculture in Al-Ain City for giving me the chance to use the facilities of Veterinary Laboratory during the period of the study. I would like also to thank all veterinarians and people who helped me in collecting samples. Great thank and appreciation to my colleges in Bacteriology Unit, *Veterinary Laboratory*, Dr. Salwa Bassuony, Dr. Nawal Ali and Haifa Jamal for their help and support. Many thank to my college Dr. Elhag A. Omar, *Veterinary Laboratory*, for providing me with scientific articles and for his help, advice and encouragement.

All my love, thank and appreciation also to my family and friends for their support and encouragement.

in the stomach, so that fewer or no organisms enter the intestine (Inglis, 1996). Normal small intestinal motility also protects the bowel by sweeping ingested Salmonella through quickly (Shanson, 1999). The normal intestinal microflora protects against Salmonella, probably through anaerobes, which liberate short-chain fatty acids (SCFA) that are thought to be toxic to Salmonella (Lewis, 1997). In animal rumen, a period of starvation reduces the SCFA concentrations and growth of Salmonella occurs. The prevalence of Salmonella in the rumen increase from 4-30% when period of starvation increases from 24-72hours (McEvory et al., 2003). So alteration of the anaerobic intestinal flora by antibiotics renders the host more susceptible to Salmonellosis (van Immersell et al., 2003).

Salmonella invasion and survival mechanisms are linked to the function of two kind of type III secretion systems (T3SS) for virulence proteins (Hansen-Wester and Hensel, 2001). One T3SS is encoded by a cluster of virulence genes termed Salmonella Pathogenicity island 1(SPI). The SPI1-encoded system is activated by extracellular bacteria and mediates invasion (Marcus et al., 2000). The SPI1 T3SS plays a critical role in the invasion of non-phagocytic cells. The invasion is mediated via contact-dependent translocation of bacterial effectors that promote rearrangements of the host cell cytoskeleton (Coombes et al., 2003).

A further pathogenicity island, termed SPI2, encodes the second T3SS (Linehan and Holden, 2003). SPI2 genes are expressed by intracellular Salmonella and the gene products are required for the intracellular replication in macrophages, prevention of intracellular killing as well as for systemic pathogenesis of Salmonellosis (Rappl et al., 2003).

Salmonella is able to induce extensive membrane ruffling of the host cell surface and by means of this membrane ruffling it is subsequently enclosed and taken up into the host cell (Jebson and Clark, 2001).

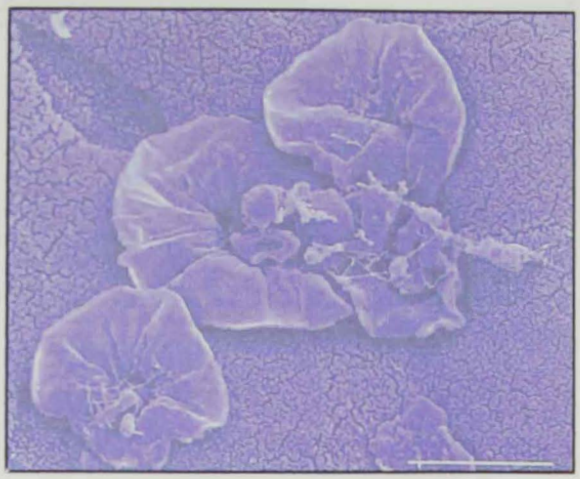

Figure (3): Scanning electron micrograph of murine Peyer's patch incubated for 60 min with wild-type *S.* Typhimurium suspended in PBS. The M cells in the center of the image exhibit Salmonella-induced rearrangement of their apical membranes, with the formation of prominent membrane ruffles. Bacteria can be seen associated with the lower, left-hand ruffle. The M cell in the upper left-hand corner of the image appears unaffected by Salmonella infection and possesses short irregular microvilli typical of M cells at this site (Jepson and Clark, 1998)

Invasion of mucosa causes the epithelial cells to synthesize and release various proinflammatory cytokines (Lewis, 1997). These evoke an acute inflammatory response and may also be responsible for damage to the intestine (Kramer et al., 2003). Because of the intestinal inflammatory reaction, symptoms of inflammation such as fever, chills, abdominal pain, leukocytosis and diarrhea are common. The stools may contain polymorphonuclear (PMNs) leukocytes, blood and mucus. During responding to infection, PMNs release prostaglandins, which cause inhibition of Na^+ uptake and Cl^- secretions, so that tissue loses water (Boyd and Hoerl, 1986). Diarrhea occurs as a result of the fluid and electrolytes secretions by the small and large intestine. Systemic spread of the organisms can occur, giving raise to enteric fever (Gillespie, 1994).

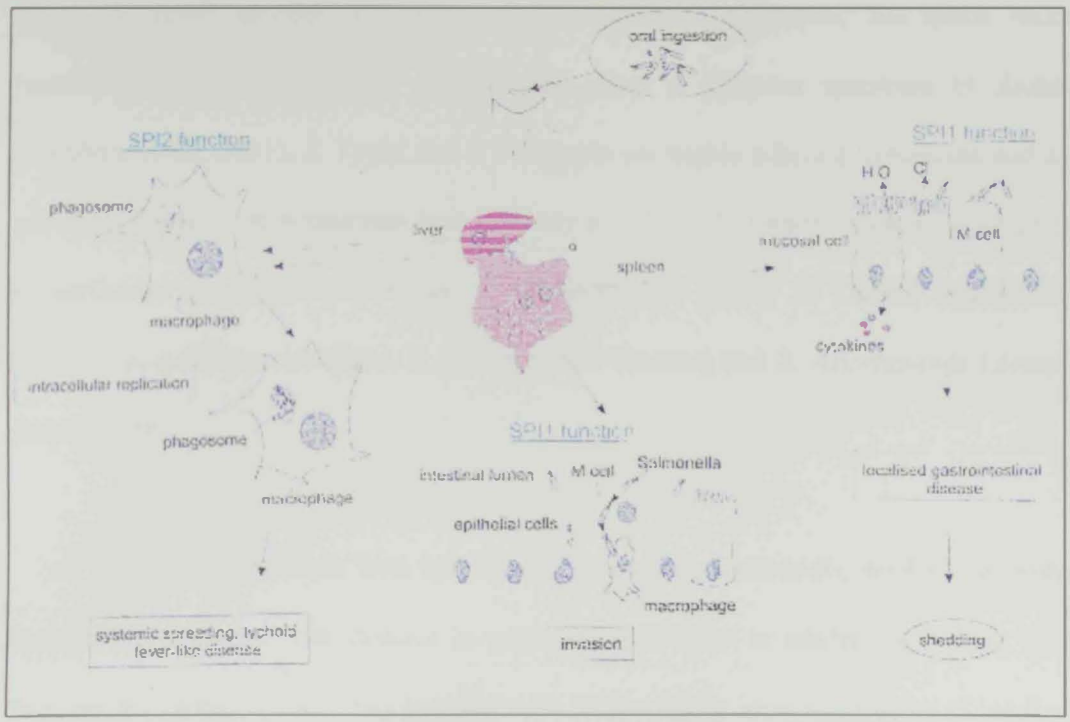

Figure (4): Schematic representation of host-pathogen interactions during pathogenesis of Salmonella infections (Hansen-Wester and Hensel, 2001).

1.3 Host range of Salmonella serovars

Salmonella species are widely distributed in nature (Losinger et al., 1995). They can colonize virtually all animals including poultry, reptiles, livestock, rodents, domestic animals, birds and humans (Wegener et al., 2003).

Many serotypes such as *S.* Typhimurium show a wide host range, and can be isolated from many different animal species such as cattle (Sojka and Field, 1970), pigs (Edwards and Bruner, 1943 and Davies et al., 2004), sheep (Sojka et al., 1983), horses (Wary et al., 1981), poultry (Sojka and Wary, 1975), falcons (Wernery and Joseph, 1996 and Zachariah, 1996), bustards (Bailey et al., 1998a and Bailey et al., 1998b) and rodents (Edwards and Bruner, 1943).

A small number of strains, the host-adapted serotypes, are much more restricted in the species they inhabit, and show a different spectrum of illness (Bispham et al., 2001). *S.* Typhi and *S.* Paratyphi are highly adapted to humans and do not cause diseases in nonhuman host (Murray et al., 2002). Other Salmonella adapted to particular animal hosts include *S.* Cholerae-suis (pigs), *S.* Dublin (cattle), *S.* Gallinarum-pullorum (poultry), *S.* Abortus-equi (horses) and *S.* Abortus-ovis (sheep) (Lewis, 1997).

Pathogens that lack host specificity, such as *S.* Enteritidis, tend to be more frequently associated with disease in young animals than in adults, suggesting that they are not optimally adapted to cope with fully mature immune system (Kingsley and Bäumler, 2000).

Serotypes that are host specific, on the other hand, have acquired the ability to breach defense mechanisms in full-growth animals, as shown by their association, at similar rates, with illness in all age groups. Furthermore, host-specific serotypes tend to be more virulent, as illustrated by the fact that they cause higher mortality rate (Bäumler et al., 1998).

The wide host range, the large number of convalescent and chronic healthy carriers and environmental sources in the communities increase the reservoir status of Salmonella infection and enhance its endemicity, especially in areas with low environmental hygiene (Orji et al., 2005).

1.4 Incidence of Salmonella infection in farm animals

1.4.1 Incidence of Salmonella infection in camels

Dromedary is one of the most important reservoirs for Salmonella and could, therefore, represent a health hazard for humans especially in countries where meat and milk of dromedaries are consumed. Food poisoning due to dromedary meat has been reported (Sandiford et al., 1943; Sandiford, 1944; Ramadan and Sadek, 1971 and El-Nawawi et al., 1982).

There are many studies regarding camel Salmonellosis published in different countries around the world. In Palestine, *S.* Kentuckey was isolated once from healthy camel (Olitzki, 1942) and once from camel had enteritis (Olitzki and Ellenbogen, 1943). However, in French North Africa, Salmonella were responsible for causing abortion, enteritis and septicaemia (Donatien and Boue, 1944).

In USA, Bruner and Moran (1949) isolated *S.* Typhimurium and *S.* Derby from camels had enteritis. On the other hand, many serotypes were isolated from healthy camel in India. These serotypes include *S.* Limete, *S.* Cerro, *S.* Anatum, *S.* Typhi, *S.* Paratyphi, *S.* Frintrop, *S.* Muenchen and *S.* Give (Malik et al., 1967 and Ambwani and Jatkar, 1973).

Two studies had reported Salmonella infection among sick and healthy camels in the Sudan (Curasson, 1918 and Saad and Hussein, 1975). On the other hand, *S.* Cholerae-suis was isolated from diarrheic camel case (Cheyne et al., 1977) and *S.* Bredeney was isolated from apparently healthy camel in Somalia (Andreani et al., 1978).

In Ethiopia, several studies had been published regarding camel Salmonellosis. Pegram and Tareke (1981) isolated *S.* Chester, *S.* Give, *S.* Eastborne and *S.* Saintpaul from camels having septicaemia. In 1981, Pegram and his colleges carried out another study to investigate the prevalence of Salmonella in domestic livestock and their by-products. Salmonella serovars isolated from camels were *S.* Chester, *S.* Eastbourne, *S.* Gaminara, *S.* Give, *S.* Muenchen and *S.* Saint-paul. In addition, Molla et al. (2004) carried out a study to determine the prevalence and distribution of Salmonella from apparently healthy slaughtered camels (*Camelus dromedarius*) in Eastern Ethiopia. *S.* Saintpaul and *S.* Braenderup were the most prevalent serovars followed by *S.* Muenchen, *S.* Kottbus and *S.* Havana. Other serotypes, including *S.* Typhimurium, *S.* Heidelberg and *S.* Enteritidis were also isolated.

During 1943-1990, several studies were carried out regarding camel Salmonellosis in Egypt. The isolated Salmonella serovars were *S.* Typhimurium, *S.* Typhi, *S.* Dublin, *S.* Saintpaul, *S.* Cholerae-suis, *S.* Anatum, *S.* Muenchen, *S.* Reading, *S.* Eastborne, *S.* Bovismorbificans, *S.* Muenster, *S.* Chester, *S.* Glostrup, *S.* Enteritidis, *S.* Uganda, *S.* Newport, *S.* Kottbus, *S.* Brandenburg, *S.* Shubra, *S.* Sandiego, *S.* Heidelberg, *S.* Newlands, *S.* Brazzaville, *S.* Goettingen, *S.* Lokstedt, *S.* Israel, *S.* Newbrunswik, *S.* Santiago, *S.* Thompson and *S.* Tshiongwe (Sandiford et al., 1943; Floyd, 1955; Farraq and El-Afify, 1956; Zaki, 1956; Hamada et al.,1963; Kamel and Lotfi, 1963; Ramadan and Sadek, 1971; El-Monla, 1978; Sayed, 1979; El-Nawawi et al., 1982; Refai et al., 1984 and Yassien, 1985).

In Eastern Sudan, fecal samples were collected from diarrheic camel-calves. They were examined for five types of bacteria reported to cause diarrhea. Fourteen

Salmonella species were obtained from the samples, but they were not typed (Salih et al., 1998). Moreover, Mohammed et al. (2003) carried out another study in Eastern Sudan. Fecal samples were collected from 1-3 months old diarrheic camel calves. Four Salmonella species were associated with diarrhea. On the other hand, Tadjbakhch et al. (1992) isolated *S.* Reading and *S.* Tesbiongowe from apparently healthy camels in Iran.

In the UAE, Wernery (1992) carried out a study regarding camel Salmonellosis. Fecal samples were collected from breeding and racing camels (*Camelus dromedarius*) of different ages and sex. Twenty eight different serotypes were identified with *S.* Saintpaul being the most frequent (69), followed by *S.* Frintrop (31), and *S.* Hindmarsh (15). Other serovars ordered as follow: *S.* Kottbus, *S.* Bovismorbificans, *S.* Kentucky, *S.* Cerro, *S.* Mbandaka, *S.* Reading, *S.* Nchanga, *S.* Oranienburg, *S.* Meleagridis, *S.* Derby, *S.* Havana, *S.* Infantis, *S.* Muenster, *S.* Senftenberg, *S.* Typhimurium, *S.* Anatum, *S.* Newport, *S.* Chaily, *S.* Livingstone, *S.* Amsterdam, *S.* Muenchen, *S.* Agona, *S.* Tarshyne, *S.* Johannesburg and *S.*II 42:b:enxz15.

In 1996, a comparative study on Salmonella serovars isolated from humans and camels in the UAE was conducted by Wernery and Makarem. A large number of identical Salmonella serotypes were identified in the stool of people afflicted with Salmonellosis and in the feces of dromedaries. Salmonella serovars isolated from camels were *S.* Frintrop, *S.* Hindmarsch, *S.* Kottbus, *S.* Kentucky, *S.* Mbandaka, *S.* Nchanga, *S.* Meleagridis, *S.* Muenster, *S.* Livingstone, *S.* Amsterdam and *S.* II: 42: ben + z 15.

Another study was conducted by Moore et al. (2002) in the UAE. Moore and his colleges examined 67 newborn calves of racing camels (*Camelus dromedarius*) to determine the prevalence of bacterial fecal pathogens from the local Emirati stock. All Salmonella species isolated from either symptomatic or asymptomatic animals were serotyped: six isolates of *S.* Hindmarsh and three non-typable Salmonella species Group C1, C2 and C3.

1.4.2 Incidence of Salmonella infection in cows

Salmonella affect mostly young cattle and may cause various clinical manifestations that range from per acute course with death within 24 hours of infection to a chronic asymptomatic infection. However, the most common clinical manifestation of the infection is an acute diarrheal disease (Santos et al., 2002).

In adult cattle there is profuse diarrhoea, sometimes with blood and often mixed with large pieces of fleshy mucus. This is the damaged lining of the gut being shed. Lactating cows completely stop milking, their eyes become dull and sunken due to dehydration. Pregnant animals may abort and death may occur during the following 2-3 days if not treated (blowey, 1993).

Zein-El-Abden et al. (1966) recovered Salmonella strains in 8 out of 400 examined buffaloes in Egypt. The isolated Salmonella serotypes were *S.* Derby (2), *S.* Typhimurium (2), *S.* Dublin (2), *S.* Gallinarum-Pullorum (1) and *S.* Newport (1).

In the Sudan, Salmonella serotypes were isolated from cattle: *S.* Chester, *S.* Amersfoort, *S.* Muenchen, *S.* Newport, *S.* Dublin, *S.* Muenster, *S.* Mishmar-haemek,

S. Berlin, *S.* Pomona, *S.* Adelaide and *S.* Poona (Khan, 1970a). On the other hand, Sojka and Wray (1977) isolated *S.* Dublin and *S.* Typhimurium from cattle during the period 1968-1974 in England and Wales.

In Egypt, 850 rectal swabs were collected from apparently healthy buffalo-calves and 59 swabs from calves suffering from diarrhea. Four isolates of *S.* Typhimurium were recovered from calves with diarrhea and six were recorded from 6 apparently healthy calves: two strains of *S.* Carrau and four strains of *S.* Typhimurium (Awad et al., 1980). However, Pegram et al. (1981) isolated *S.* Braenderup, *S.* Dublin and *S.* Typhimurium from bovine in Ethiopia.

An outbreak of diarrhea dysentery, abortion and death among N'Dama cattle is reported in Sierra Leone. Eight animals involved were examined and/ or postmortem yielding Salmonella belonging to three serotypes: *S.* Visby, *S.* Hadar and *S.* Taksong (Kamara and Noni, 1983).

In Ohio, USA, a study was conducted to estimate herd prevalence of Salmonella species. Fecal specimens were obtained for culture from neonatal calves of 47 Ohio dairy herds of the 452 calves tested, 10 calves from 7 farms were culture-positive. The isolated Salmonella serotypes were *S.* Dublin, *S.* Typhimurium, *S.* Enteritidis, *S.* Agona, *S.* Mbandaka and *S.* Montevideo (Lance et al., 1992). Another study in Ohio was carried out by Huston and his colleges (2002). A number of 105 dairy farms were tested to estimate prevalence of Salmonella species to identify potential risk factors for fecal shedding of Salmonella. In 31% of the study herd, at least 1 cow was shedding Salmonella species. Six percent of 7,776 fecal samples contained Salmonella organisms.

In Zambia, small scale outbreaks of Salmonella infection occurred repeatedly in these years from 1989-1991 among fattening calves on a dairy farm. The isolated Salmonella serotypes were *S.* Dublin and *S.* Typhimurium (Sato et al., 1993).

Across-sectional study was conducted on the Maltese island of Gozo to determine the prevalence of Salmonella excretion of adult cattle. Salmonella were found in 41.3% in the cattle investigated and seven animals yielded multiple Salmonella serovars. The isolated Salmonella serovars were *S.* Croft (55), *S.* Telaviv (29), *S.* Montevideo (17), *S.* Kpeme (7), *S.* Infantis (2) *S.* Abadina (1) and *S.* Gozo (Vella and Cuschierip, 1995).

The prevalence and antimicrobial resistance pattern of Salmonella isolates was determined from apparently healthy slaughtered cattle at Debre Zeit (Ethiopia). Salmonella were cultured from 23 out of 323 of the tested animals. Five different serovars were isolated: *S.* Mishmarhaemek (48%), *S.* Typhimurium (20%), *S.* Enteritidis (12%), *S.* Guildford (12%) and *S.* Dublin (48%). Both strains of Salmonella (*S.* Mishmarhaemek and *S.* Typhimurium) showed multiple resistances to ampicillin, sulfamethoxazole and ticarcillin (Alemayehu et al., 2003).

Davies et al. (2004) conducted a survey for Salmonella in healthy cattle at slaughter in Great Britain during 1999-2000. Two isolates were recovered from cattle, one each of *S.* Typhimurium DT193 and DT12.

Edrington et al. (2004) isolated different Salmonella serotype from healthy lactating dairy cattle in the southwestern United State. The most common serotypes are *S.* Montevideo, *S.* Senftenberg, *S.* Mbandaka and *S.* Kentucky.

1.4.3 Incidence of Salmonella infection in sheep

Abortion is the classical symptom of infection in pregnant animals with *S.* Abortus ovis. Susceptible ewes in the third trimester of pregnancy may abort or bear stillborn lambs. Affected ewes develop fever of 41-42 ℃, anorexia, depression and some, but not all, show diarrhea. A vaginal discharge may form a few days before and continue for few days after abortion. The vaginal discharge is often blood-stained or purulent (Jensen and Swift, 1982).

Deaths in lambs from *S.* Abortus ovis infection may occur during the first day after birth in those individuals which are born weak, or during the first 10 days of life in strong lambs which suddenly become acutely ill with diarrhea and dysentery. Sometimes, blood-splashed diarrhea with foul smell may develop (Henderson, 1990). However, in adults the symptoms are usually less acute, consisting of intermittent diarrhea, loss of weight, and areas of the fleece may fall out (Buxton and Fraser, 1977).

van Oye (1964) isolated different Salmonella serovars from sheep in Belgian Congo and Uranda Burundi. These serovars were *S.* Anatum, *S.* Bovis-morbificans, *S.* Infantis, *S.* Kisarawe, *S.* Moero, *S.* New port, *S.* Poona, *S.* Schwarzengrund, *S.* Typhimurium and *S.* Zanzibar

In the Sudan, 1,750 sheep were examined for Salmonella. The isolated serotypes were reported as follow: *S.* Eppendort var.27, *S.* Reading, *S.* San-diego, *S.* Amersfoort, *S.* Gombe, *S.* Braenderup, *S.* Muenchen, *S.* Muenster, *S.* London, *S.* Tuebingen, *S.* Aberdeen, *S.* Kisarawe, *S.* Poona, *S.* Mishmarhaemek, *S.* Havana, *S.* Salford, *S.* Berlin, *S.* Guildford, *S.* Leoben, *S.* Pomona, *S.* Adelaide, *S.* Alachua, *S.* Freetown, *S.* Johanesburg, *S.* Vleuten, *S.* Teshie and *S.* Utrecht (Khan, 1970b).

Bacteriological examination was investigated with 50 lambs, 143 aborted fetuses and 46 vaginal swabs in Khorassan Province, Mashad. *S.* Abortus ovis was isolated in 59.44% in aborted fetuses, 34% in lambs and 30.34% in vaginal swabs (Firuzi and Kita, 1981).

In Saudi Arabia, *S.* Typhimurium and *S.* Braenderup were isolated at Riyadh abattoir (Nabbutt and Al-Nakhli, 1982). On the other hand, *S.* Hindmarsh has been shown to be fatal in sheep in New Zealand. It was responsible for acute enteritis and death (Neilson et al., 1985).

Between 1980 and 1987, 1153 ovine fetuses and placentas were examined after abortion in the north Bavaria. In 68.5% of the cases of abortion, *S.* Abortus ovis was found in 10.7% (Plagemann, 1989). Moreover, *S.* Abortus ovis was isolated from sheep in England and Wales during the period 1968-1974 (Davies et al., 2004)

1.4.4 Incidence of Salmonella infection in goats

Infected goat shows symptoms similar to those in sheep (Sharma et al., 2001). There are few literatures regarding goat Salmonellosis over the world. van Oye (1964) isolated *S.* Abortus-equi, *S.* Dublin, *S.* Kibusi and *S.* Newport from goat in Belgian Congo and Uranda Burundi. In India, Nath et al. (1966) isolated *S.* Typhimurium from goat.

In the Sudan, only five of the 500 goat examined yielded Salmonella. These serovars include *S.* Amersfoort, *S.* Muenster, *S.* Pomona and two isolates *S.* Reading (Khan, 1970b). In Saudi Arabia, *S.* Kottbus and *S.* Anatum were isolated at Riyadh abattoir (Nabbutt and Al-Nakhli, 1982).

Fecal samples from diarrheic and non-diarrheic goat kids aged 1-45 days were examined for enteric pathogens in Spain. *S.* Arizonae was isolated from a diarrheic goat kid (Munoz et al., 1996).

1.5 Diagnosis of Salmonella

1.5.1 Cultural identification

The specimen is inoculated into Selenite F or Tetrathionate broth, which inhibit replication of normal intestinal bacteria and permit multiplication of Salmonella species. After incubation for 1-2 days, a loopful from the enriched broth is plated on differential media (e.g. MacConkey's) and selective media (e.g. Salmonella Shigella (SS) agar, Hektoen enteric, deoxycholate-citrate agar) and further incubated (Koneman et al, 1997). Colonies that are Gram-negative bacilli, non lactose fermentors are identified biochemically (Boyd and Hoerl, 1986).

1.5.2 Serological identification

Serological identification of Salmonella is based on detection of O-antigen, H-antigen and Vi-antigen (usually for *S.* Typhi). Preliminary rapid slide tests can be carried out using standard polyvalent O and polyvalent H (phase 1 and phase 2) antisera which composite sera containing antibodies to all the respective O and H antigens (Lewis, 1997). Monovalent O-antisera and H-antisera are used to identify the serotype by slide agglutination test which should be confirmed by tube agglutination test (Parker, 1983).

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variation (H-antigen loss) and reversible phase variations of flagellar antigens (Cruickshank et al., 1975).

1.6 Prevention and control

Infections caused by Salmonella in humans are increasingly frequent in developed and developing countries (Tauxe, 1997). The increasing rates of resistance to traditional antibiotics (chloramphenicol, ampicillin and trimethoprim-sulfamethoxazole) and extended-spectrum cephalosporins among these isolates have made treatment of invasive Salmonellosis a clinical issue (Lee et al., 1994; Angulo et al., 2000; Hsueh et al., 2002 and Yan et al., 2003). Of particular concern is the emergence of fluoroquinolones resistance among nontypoid Salmonella and the occurrence of outbreaks caused by some resistant strains, since this class of antimicrobial agent constitutes the drug choice for treating potentially life-threatening strains in adult persons (Threlfall et al., 2000 and Carnevale et al., 2000). Moreover, cases of treatment failure due to fluoroquinolones resistance in Salmonella strains have been reported (Piddock et al., 1993; Heisig et al., 1993 and Nakaya et al., 2003).

Researchers have increasingly reported that widespread use of fluoroquinolones in food animals leads to the rapid emergence and dissemination of resistant Salmonella infections to humans, particularly in developing countries (Angulo et al., 2000; Witte et al., 1998 and Baggesen et al., 2000).

Salmonellosis is difficult to control in livestock because of the ability of many serotypes to infect multiple animal species, survive in the environment, feed and water sources, and to be shed in the feces by apparently healthy animals (Warnick et

al., 2003). However, treatment of enteric Salmonellosis is chiefly aimed at maintaining fluid and electrolyte balance (Parker, 1983). Bacteremic or septicemic animals require systemic antibiotics. The control measures for Salmonellosis are based on sanitation and management. Individual hutchers or pens provide adequate isolation if sufficient spacing and good sanitation are maintained. The Salmonella vaccines are not recommended (Rings, 1985).

However, the use of antibiotics and live-attenuated vaccines to control Salmonella infection in chickens has been criticized because of the possible development of antibiotic resistant bacteria, the potential danger of antibiotic residues and because of residual attenuated vaccines strains in animal-derived food products for human consumption. Despite the use of antibiotics and vaccination, Salmonella infections are still widespread in poultry. Therefore, another alternative approach to control Salmonella infection in poultry is the enhancement of natural genetic resistance to Salmonella (Kramer et al., 2003).

Salmonella serology is used in some countries by the pig and poultry industries at slaughter to identify Salmonella infected herds and flocks as part of their food safety programs. Salmonella enzyme linked immunosorbent assay (ELISA) provides information about Salmonella infection status of an animal in the 30-120 days before sample collection. Repeated serological testing differentiates recently infected cattle (increasing titers) and convalescent cattle (decreasing titers) from Salmonella carriers, which would have relatively stave titers (Galland et al., 2000).

2. AIMS AND OBJECTIVES

The main objectives of this study were:

1. Investigate the prevalence of Salmonella infection in farm animals (camels, cows, sheep and goats) in Al-Ain area

2. Isolation and identification of Salmonella serovars

3. Updating the information about the different serovars exist in the area of study as well as give a better understanding about the magnitude of Salmonella infection problem at the area of study.

4. The obtained data would be a useful guide for planning prevention and control strategies of Salmonella infection at the area of study.

3. MATERIALS AND METHODS

3.1 MATERIALS

3.1.1 Area of study

Al Ain city was the core of this study. It lies about 170 Km to the east of Abu Dhabi Emirate, United Arab Emirates. It has extensive international borders with Sultanate of Oman towards the east. See Figure (5)

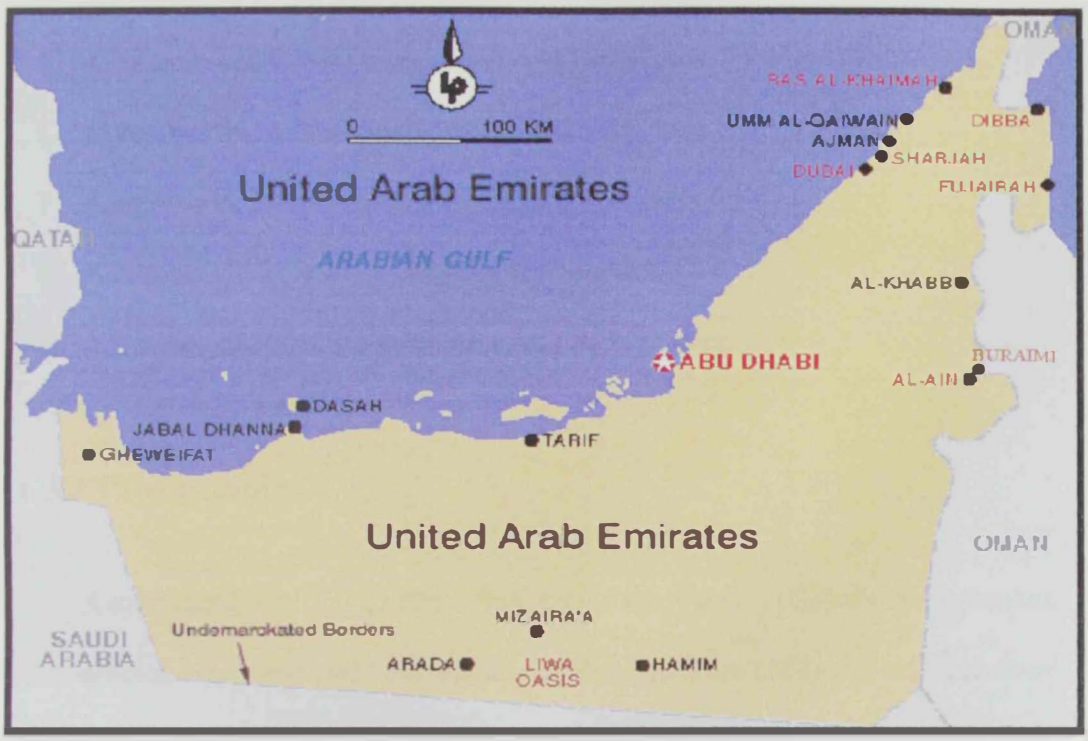

Figure (5): Map of the United Arab Emirates

3.1.2 Period of study

Samples were collected during the period of January 19th 2003 to June 31st 2004.

3.1.3 Samples

3.1.3.1 Camel samples

A total number of 273 samples from camel were tested for Salmonella infection. These samples were obtained from apparently healthy camels (266) and infected camels (7). Samples from apparently healthy camels were collected from the different geographic localities of Al Ain City. The samples were as following:

1. A number of 29 fecal swabs from Sewihan area.
2. A number of 30 fecal swabs from Masaken area.
3. A number of 27 fecal swabs from Al Shuwaib area.
4. A number of 32 fecal swabs from Al Niadat area.
5. A number of 38 fecal swabs from Al Maqam area.
6. A number of 23 fecal swabs from at Al Quaa area.
7. A number of 29 fecal swabs from Al Wagon area.
8. A number of 36 fecal swabs from Mazyad area.
9. A number of 22 fecal swabs from Abu Samrah area.

3.1.3.2 Cow samples

A total number of 133 samples from cow were tested for Salmonella infection. These samples were obtained from apparently healthy cows (122) and infected cows (11). It is noteworthy that one sample from affected animals was obtained from aborting cow. Samples from apparently healthy cows were obtained from two dairy farms as following:

a) Dairy farm number (1):

- A number of 20 out of 70 calves (less than 3 month's age) were randomly selected for the surveillance.

- A number of 54 out of 460 adult cows (more than 3 years) were randomly selected for the surveillance.

b) Dairy farm number (2):

- A number of 48 out of 150 adult cows were randomly selected for the surveillance.

3.1.3.3 Sheep samples

A total number of 263 samples from sheep were tested for Salmonella infection. These samples were obtained from apparently healthy sheep (255) and affected sheep (8). Samples from apparently healthy sheep were obtained from two sheep farms as following:

a) In sheep farm number (1):

- A number of 20 out of 200 fecal swabs were collected from young animals of Syrian breed.
- A number of 20 out of 90 fecal swabs were collected from adult animals of Syrian breed.
- A number of 21 out of 162 fecal swabs were collected from adult animals of Ramli breed.
- A number of 44 out of 380 fecal swabs were collected from young animals of Najdi breed.

b) In sheep farm number (2):

- A number of 150 out of 150 fecal swabs were collected from adult animals of Najdi breed.

- A number of 54 out of 460 adult cows (more than 3 years) were randomly selected for the surveillance.

b) Dairy farm number (2):

- A number of 48 out of 150 adult cows were randomly selected for the surveillance.

3.1.3.3 Sheep samples

A total number of 263 samples from sheep were tested for Salmonella infection. These samples were obtained from apparently healthy sheep (255) and affected sheep (8). Samples from apparently healthy sheep were obtained from two sheep farms as following:

a) In sheep farm number (1):

- A number of 20 out of 200 fecal swabs were collected from young animals of Syrian breed.
- A number of 20 out of 90 fecal swabs were collected from adult animals of Syrian breed.
- A number of 21 out of 162 fecal swabs were collected from adult animals of Ramli breed.
- A number of 44 out of 380 fecal swabs were collected from young animals of Najdi breed.

b) In sheep farm number (2):

- A number of 150 out of 150 fecal swabs were collected from adult animals of Najdi breed.

3.1.3.4 Goat samples

A total number of 193 samples from goats were tested for Salmonella infection. These samples were obtained from apparently healthy goats (187) and infected goats (6). It is noteworthy that one sample from affected animals was obtained from aborted foetus. Samples from apparently healthy goats were obtained from two goats' farms as following:

a) In goat farm number (1):

- A number of 10 out of 40 fecal swabs were collected from young animals of Wa'll breed.
- A number of 53 out of 470 fecal swabs were collected from adult animals of Wa'll breed.
- A number of 10 out of 140 fecal swabs were collected from young animals of Salalah breed.
- A number of 15 out of 70 fecal swabs were collected from adult animals of Salalah breed.
- A number of 35 out of 55 fecal swabs were collected from young animals of Pakistani breed.
- A number of 31 out of 374 fecal swabs were collected from adult animals of Pakistani breed.

b) In goat farm number (2):

- A number of 33 out of 600 fecal swabs were collected from adult animals of mixed breed.

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- A number of 15 out of 70 fecal swabs were collected from adult animals of Salalah breed.
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- A number of 31 out of 374 fecal swabs were collected from adult animals of Pakistani breed.

b) In goat farm number (2):

- A number of 33 out of 600 fecal swabs were collected from adult animals of mixed breed.

3.1.3.5 Samples from other animals

In order to have an idea about the spectrum of Salmonella serovars existed at the area of study, number of 20 diarrheic cases from different animal species submitted to Veterinary Laboratory in Al-Ain City were also included. These cases were obtained from game animals (3) and avian species (17).

3.1.4 Chemical reagents

- **Saline**

  It is prepared as 0.85 g of NaCl in 100ml of distilled water (Cruickshank et al., 1975).

- **Gram staining**

  It obtained from BioMérieux sa, France.

- **Swabs**

  Sterile bacteriological swabs obtained from Sterillin were used in the current study.

3.1.5 Cultural media

- **Trypcase Soy broth**

  Sterile ready made broth obtained from BioMérieux sa, France as 10 ml per tube.

- **Selenite broth base**

  This medium obtained from Oxoid (Catalog number CM395) and prepared as recommended by the manufacturer recommendation. Sodium biselenite (Oxoid L121) was added with the ratio advised by Oxoid.

- **Nutrient agar**

  The medium obtained from Oxoid (Catalog number CM3) and prepared as 28 g per liter of distilled water. The medium was sterilized by autoclaving at 121 °C for 15 minutes and kept at 4 °C until used.

- **Blood agar**

  Ready made Blood agar medium obtained from BioMérieux sa, France (Catalog number 43041).

- **Salmonella Shigella agar**

  This medium obtained from BBL (Catalog number 211597) and prepared as 60 g per liter of distilled water and heated for 1 minute. The prepared media was distributed as 15 ml per plate and kept at 4 °C until used.

- **Hektoen enteric agar**

  This medium obtained from BBL (Catalog number 212211) and prepared as 75 g per liter of distilled water and heated for 1 minute. The prepared media was distributed as 15 ml per plate and kept at 4 °C until used.

3.1.6 MUCAP Reagent

This reagent obtained from Biolife, Italy (Catalog number 191500) and used for presumptive identification of Salmonella species on the primary isolated plates using the chromogenic and fluorogenic characters of the reagent and the Wood's Lamb (wave length 366 nm).

3.1.7 Api 20E

The Api 20E panels obtained from BioMérieux sa, France (Catalog number 20100) and used for biochemical identification of the isolated strains.

3.1.8 Serological reagents

3.1.8.1 Wellcolex Colour Salmonella kit

The kit obtained from Remel, U.K and used for presumptive sero-group identification of Salmonella groups A-G.

3.1.8.2 Polyvalent and monovalent O-antigen

Different Salmonella O-antisera were obtained from Remel, UK. They are as following:

- Salmonella O factors 4 (group B)
- Salmonella O factors 5 (group B)
- Salmonella O factors27 (group B)
- Salmonella O factors 6, 7 (group C1)
- Salmonella O factors 8(group C2)
- Salmonella O factors 20 (group C2)
- Salmonella O factors 9 (group D)
- Salmonella O factors 3,10,15,19 (group E)
- Salmonella O factors 10 (group E1)
- Salmonella O factors 15 (group E2)
- Salmonella O factors 19 (group E4)
- Salmonella O factors 13, 22(group G)

3.1. 8.3 Polyvalent and monovalent H-antigen

Different Salmonella H-antisera were obtained from Remel, UK. They are as following:

- Salmonella H Polyvalent phases 1and 2
- Salmonella H rapid diagnostic1 (b,d,E,r)
- Salmonella H rapid diagnostic2 (b,E,k,L)

- Salmonella H rapid diagnostic3 (b,d,G,k)
- Salmonella H (1,2)
- Salmonella H (1,5)
- Salmonella H (1, 6)
- Salmonella H (1, 7)
- Salmonella H (a)
- Salmonella H (b)
- Salmonella H (c)
- Salmonella H (d)
- Salmonella H (e) polyvalent
- Salmonella H (eh)
- Salmonella H (enx)
- Salmonella H (enz15)
- Salmonella H (g) polyvalent
- Salmonella H (fg)
- Salmonella H (gm)
- Salmonella H (gp)
- Salmonella H (gq)
- Salmonella H (gst)
- Salmonella H (i)
- Salmonella H(k)
- Salmonella H (L) polyvalent
- Salmonella H (lv)
- Salmonella H (lw)
- Salmonella H (mt)
- Salmonella H (r)

- Salmonella H (y)
- Salmonella H (z)
- Salmonella H (z4, z23)
- Salmonella H (z6)
- Salmonella H (z10)
- Salmonella H (z27)
- Salmonella H (z29)
- Salmonella H (z36)
- Salmonella H (z38)

3.2 METHODS

3.2.1 Sample preparation

Each fecal swab was inoculated into tubes containing 5ml of selenite broth medium. The tubes were incubated for 24 hours at 37 °C. A loopful from each sample was streaked on Blood agar, Salmonella Shigella agar and Hektoen enteric agar. The inoculated plates were further incubated for 24 hours at 37°C. The yielded colonies were checked for cultural characteristics and Gram staining.

3.2.2 Bacterial identification

3.2.2.1 Cultural characteristics

All Gram negative, non lactose fermented and H_2S producing colonies were exposed to MUCAP Reagent and checked for fluorescent character under the Wood's lamb. All Gram negative, non lactose fermented and H_2S producing colonies that showed strong blue fluorescence were picked for biochemical identification.

3.2.2.2 Biochemical characteristics

All suspected isolates were purified on Blood agar medium and prepared for biochemical identification using Api 20E strips. The inoculated strips were incubated for 24 hours at 37 °C. All biochemical reactions were recorded using the Api results sheet. The computed numbers were compared with that obtained by the data management system supplied with Api system for Salmonella species.

3.2.2.3 Serological identification

3.2.2.3.1 Serogrouping of Salmonella isolates

The presumptively identified Salmonella isolates were grouped using Wellcolex Colour Salmonella test system. One or two suspected colonies were

emulsified in Latex reagent number 1 as well as Latex reagent number 2 following the procedures described by the manufacturer. The developed colour was compared with the identification panels supplied with the kit. The group of each isolate was determined and recorded.

3.2.2.3.2 Partial serotyping of Salmonella isolates

Previously grouped isolates were identified using individual monovalent O-antisera in a monopoly checkerboard way based on the data obtained concerning the group of each isolate. Several drops of smooth fairly dense suspension in saline were prepared from each tested isolates. To each drop (40µl) of tested isolates a drop of the required undiluted monovalent O-antiserum was added and mixed. The slides were shacked for 1 minute and observed for agglutination using indirect light against dark background. The positive reacted O-antiserum for each isolates was recorded. The same was applied using different individual H-antisera on 24 hours Trypcase Soy broth culture of each isolate. The applied individual H-antisera were selected according the data obtained in the last step using O-antisera.

3.2.2.3.3 Final identification of the isolates

Precise identification of each isolates needs reference laboratory due to the wide spectrum of Salmonella antisera needed. Consequently, all isolates were maintained on Nutrient agar just before submission of the isolates to the Salmonella Reference Laboratory, the Veterinary Laboratories Agency (VLA) in Weybridge, UK, to obtain a full identification of all isolates according to VLA standard operating procedures.

3.1.3.4 Goat samples

A total number of 193 samples from goats were tested for Salmonella infection. These samples were obtained from apparently healthy goats (187) and infected goats (6). It is noteworthy that one sample from affected animals was obtained from aborted foetus. Samples from apparently healthy goats were obtained from two goats' farms as following:

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- Salmonella H (1, 6)
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- Salmonella H (b)
- Salmonella H (c)
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- Salmonella H (eh)
- Salmonella H (enx)
- Salmonella H (enz15)
- Salmonella H (g) polyvalent
- Salmonella H (fg)
- Salmonella H (gm)
- Salmonella H (gp)
- Salmonella H (gq)
- Salmonella H (gst)
- Salmonella H (i)
- Salmonella H(k)
- Salmonella H (L) polyvalent
- Salmonella H (lv)
- Salmonella H (lw)
- Salmonella H (mt)
- Salmonella H (r)

- Salmonella H (y)
- Salmonella H (z)
- Salmonella H (z4, z23)
- Salmonella H (z6)
- Salmonella H (z10)
- Salmonella H (z27)
- Salmonella H (z29)
- Salmonella H (z36)
- Salmonella H (z38)

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Previously grouped isolates were identified using individual monovalent O-antisera in a monopoly checkerboard way based on the data obtained concerning the group of each isolate. Several drops of smooth fairly dense suspension in saline were prepared from each tested isolates. To each drop (40µl) of tested isolates a drop of the required undiluted monovalent O-antiserum was added and mixed. The slides were shacked for 1 minute and observed for agglutination using indirect light against dark background. The positive reacted O-antiserum for each isolates was recorded. The same was applied using different individual H-antisera on 24 hours Trypcase Soy broth culture of each isolate. The applied individual H-antisera were selected according the data obtained in the last step using O-antisera.

3.2.2.3.3 Final identification of the isolates

Precise identification of each isolates needs reference laboratory due to the wide spectrum of Salmonella antisera needed. Consequently, all isolates were maintained on Nutrient agar just before submission of the isolates to the Salmonella Reference Laboratory, the Veterinary Laboratories Agency (VLA) in Weybridge, UK, to obtain a full identification of all isolates according to VLA standard operating procedures.

4. RESULTS

4.1 Surveillance of Salmonella infection among apparently healthy animal species

In the present study, a number of 830 samples were assayed for Salmonella isolation. The samples were distributed as 266 (camels), 122 (cows), 255 (sheep) and 187 (goats). The number of positive cases among the different studied species was shown in Table (4).

Table (4): Total number of samples collected from apparently healthy animal species

Animal species	Total number of samples	Number of positive cases	Percentage of positive cases
Camel	266	21	7.89%
Cow	122	12	9.83%
Sheep	255	None	0%
Goat	187	None	0%

4.2 Surveillance of Salmonella infection among infected animal species

In order to obtain a better idea about the different Salmonella serovars existed in Al-Ain area, a number of 52 samples obtained from affected animal species were included. The number of positive cases among these animal species was shown in Table (5).

Table (5): Total number of samples from different animal species with diarrhea symptoms

Animal species	Total number of samples	Number of positive cases	Percentage of positive cases
Camel	7	7	100%
Cow	11	11*	100%
Sheep	8	8	100%
Goat	6	6**	100%
Avian	17	17	100%
Game animal	3	3	100%

* One sample from aborting cow
** One sample from aborted foetus

4.3 Surveillance of Salmonella infection among different camel flocks

Table (6) illustrated the incidence of Salmonella infection among different camel flocks at different geographic localities of Al-Ain area. The obtained data showed that the highest percentage of positive cases (28%) was recorded in Sewihan followed by Masaken (17%). An approximate equivocal incidence was recorded at Al Shuwaib and Al Niadat (6-7%). An incidence of 5%, 4% and 3% were recorded in Al Maqam, Al Quaa and Al Wagon in descending order. On the other hand, no positive cases were recorded from samples collected from Mazyed and Abu Samrah.

Table (6): Surveillance of Salmonella infection among apparently healthy camel flocks raised at different geographic localities of Al-Ain area

Locality	Total number of samples	Number of positive samples	Percentage of positive cases
Sewihan	29	8	28%
Masaken	30	5	17%
Al Shuwaib	27	2	7%
Al Niadat	32	2	6%
Al Maqam	38	2	5%
Al Quaa	23	1	4%
Al Wagon	29	1	3%
Mazyed	36	0	0%
Abu Samrah	22	0	0%
Total	266	21	-

4.4 Surveillance of Salmonella infection among the selected dairy farms

With regard to samples collected from the selected dairy farms, the data showed that the incidence of positive cases among newly born calves was as high as 25% compared with that obtained from adult cows (11%) in farm number (1). However, in dairy farm number (2); the recorded incidence of positive cases was as low as 2%. Table (7)

Table (7): Surveillance of Salmonella infection among the selected dairy farms

Dairy farm	Age	Total number of animals	Number of tested samples	Number of positive samples	Percentage of positive cases
Farm (1)	Young	70	20	5	25%
	Adult	460	54	6	11.10%
Farm (2)	Young	150	48	1	2.10%

4.5 Surveillance of Salmonella infection among the selected sheep farms

Two sheep farms were selected randomly in this study. All the 255 collected samples regardless the selected age or breed gave negative isolation for Salmonella in both farms. Table (8)

Table (8): Surveillance of Salmonella infection among the selected sheep farms

Farm	Breed	Age	Number of animals	Number of tested animals	Number of positive cases	Percentage of positive cases
Farm (1)	Syrian	Young	200	20	None	0%
		Adult	90	20	None	0%
	Ramli	Adult	162	21	None	0%
	Najdi	Young	380	44	None	0%
Farm (2)	Najdi	Adult	150	150	None	0%

4.6 Surveillance of Salmonella infection among the selected goat farms

No Salmonella isolates was obtained from the all 187 samples collected from goat farms regardless the selected age or breed. Table (9)

Table (9): Surveillance of Salmonella infection among the selected goat farms

Farm	Breed	Age	Number of animals	Number of tested animals	Number of positive cases	Percentage of positive cases
Farm (1)	Wa'll	Young	40	10	None	0%
		Adult	470	53	None	0%
	Salalah	Young	140	10	None	0%
		Adult	70	15	None	0%
	Pakistani	Young	55	35	None	0%
		Adult	374	31	None	0%
Farm (2)	Mixed	Adult	600	33	None	0%

4.7 Salmonella serovars isolated in the study

4.7.1 Salmonella serovars isolated among different animal species

A list of the 85 isolates including those obtained during the animal surveillance as well as those obtained from suspected cases were exposed to serotyping and mentioned in Table (10). The data showed that *S.* Typhimurium is the most frequently isolated serovar (20x) followed by *S.* Anatum (13), *S.* Frintrop (7), *S.*

Bovismorbificans (6), *S.* Infantis (4), *S.* Havana (4), *S.* Poona (3), *S.* Haardt (3), *S.* Reading (3), *S.* Hindmarsh (2), *S.* Blockley (2), *S.* Agona (2) and *S.* Kottbus (2). The achieved data reveled that *S.* Newport, *S.* Muenster, *S.* Montevideo, *S.* Meleagridis, *S.* Liverpool, *S.* Indiana, *S.* Give, *S.* Dublin, *S.* Butantan, *S.* Panama, *S.* Wien, *S.* Stanley, *S.* Hadar and an O rough:e,h:1,6 were isolated once each.

Table (10): List of the different Salmonella serovars isolated in the present study

Group	Serovar	Frequency of isolation *
B	*S.* Typhimurium	20
E	*S.* Anatum **	13
D	*S.* Frintrop	7
C	*S.* Bovismorbificans	6
C	*S.* Infantis	4
G	*S.* Havana	4
G	*S.* Poona	3
C	*S.* Haardt	3
B	*S.* Reading	3
C	*S.* Hindmarsh	2
C	*S.* Blockley	2
B	*S.* Agona	2
C	*S.* Kottbus	2
C	*S.* Newport	1
E	*S.* Muenster	1
C	*S.* Montevideo	1
E	*S.* Meleagridis	1
E	*S.* Liverpool	1
B	*S.* Indiana	1
E	*S.* Give	1
D	*S.* Dublin ***	1
E	*S.* Butantan	1
D	*S.* Panama	1
B	*S.* Wien	1
B	*S.* Stanley	1
C	*S.* Hadar	1
E	O rough:e,h:1,6	1

* A number of 85 isolates were exposed to serotyping
** One was isolated from aborted foetus of a goat
***One was isolated from aborting cow

4.7.2 Salmonella serovars isolated from camels

With regard to isolates obtained from camels; *S.* Frintrop was the most frequently isolated serovar (7x) followed by *S.* Bovismorbificans (6x), *S.* Poona (3x) and *S.* Typhimurium (2x). *S.* Agona, *S.* Indiana, *S.* Wien, *S.* Stanley, *S.* Hindmarsh, *S.* Haardt, *S.* Panama, *S.* Muenster, *S.* Liverpool and *S.* Meleagridis were isolated once each. The isolates obtained from infected camels were *S.* Frintrop, *S.* Typhimurium, *S.* Stanley, *S.* Hindmarsh, *S.* Haardt and *S.* Meleagridis. Table (11)

On the other hand, Table (12) showed the different Salmonella serovars isolated from the different camel flocks raised at different geographic localities of Al-Ain area.

Table (11): List of the different Salmonella serovars isolated from apparently healthy and sick camels

Serovar	Number of isolates obtained from healthy camels	Number of isolates obtained from sick camels	Frequency of isolation*
S. Frintrop	6	1	7
S. Bovismorbificans	6	0	6
S. Poona	3	0	3
S. Typhimurium	0	2	2
S. Agona	1	0	1
S. Indiana	1	0	1
S. Wien	1	0	1
S. Stanley	0	1	1
S. Hindmarsh	0	1	1
S. Haardt	0	1	1
S. Panama	1	0	1
S. Muenster	1	0	1
S. Liverpool	1	0	1
S. Meleagridis	0	1	1

* A number of 28 isolates were exposed to serotyping

Table (12): List of the different Salmonella serovars isolated from camel flocks raised at different geographic localities of Al-Ain area

Locality	Serovar	Frequency of isolation
Sewihan	*S.* Bovismorbificans	5
	S. Frintrop	2
	S. Liverpool	1
Masaken	*S.* Poona	3
	S. Frintrop	2
Al Shuwaib	*S.* Muenster	1
	S. Panama	1
Al Niadat	*S.* Frintrop	1
	S. Indiana	1
Al Maqam	*S.* Frintrop	1
	S. Agona	1
Al Quaa	*S.* Wien	1
Al Wagon	*S.* Bovismorbificans	1

4.7.3 Salmonella serovars isolated from cows

Table (13) showed the different Salmonella serovars isolated from cows. *S.* Anatum was the most frequently isolated serovar (12x) followed by *S.* Havana (4x). However, *S.* Typhimurium, *S.* Montevideo, *S.* Dublin, *S.* Give, *S.* Butantan, *S.* Haardt and an O rough:e,h:1,6 were isolated once each. The isolated serovars from infected cows were *S.* Anatum, *S.* Havana, *S.* Typhimurium, *S.* Butantan and *S.* Haardt. However, *S.* Dublin was isolated from an aborting cow.

Table (13): List of the different Salmonella serovars isolated from apparently healthy and sick cows

Serovar	Number of isolates obtained from healthy cows	Number of isolates obtained affected cows	Frequency of isolation *
S. Anatum	8	4	12
S. Havana	1	3	4
S. Typhimurium	0	1	1
S. Montevideo	1	0	1
S. Dublin	0	1**	1
S. Give	1	0	1
S. Butantan	0	1	1
S. Haardt	0	1	1
O rough:e,h:1,6	1	0	1

* A number of 23 isolates were exposed to serotyping
** Aborting cow

4.7.4 Salmonella serovars isolated from sheep and goats

No Salmonella isolates were obtained from the monitored sheep and goats samples regardless the age or the breed. However, Table (14) showed a list of Salmonella serovars isolated from the diarrheic sheep and goats cases. *S.* Typhimurium was the most frequently isolated serovar obtained from both sheep (7x) and goats (4x) samples. *S.* Newport was isolated from sheep and *S.* Blockley from goat once each. *S.* Anatum was isolated from an aborted foetus.

Table (14): List of the different Salmonella serovars isolated from infected sheep and goat

Animal species	Serovar	Frequency of isolation *
Sheep	*S.* Typhimurium	7
	S. Newport	1
Goat	*S.* Typhimurium	4
	S. Blockley	1
	S. Anatum **	1

* A number of 8 and 6 isolate from sheep and goat
** Aborted foetus

4.7.5 Salmonella serovars isolated from different avian species

Unfortunately, no survey applied for poultry farms in this study, but Table (15) illustrated the different Salmonella serovars isolated from the different avian species. *S.* Kottbus, *S.* Agona and *S.* Blockley were isolated from bustards species. *S.* Hindmarsh and *S.* Haardt were isolated from Pheasant species. *S.* Infantis was isolated four times from domestic chicken. *S.* Hadar was isolated from Quail species while *S.* Typhimurium was isolated from Sandgrouse species as well as pigeon species.

Table (15): List of the different Salmonella serovars isolated from the different avian species

Animal species	Serovar	Frequency of isolation
Bustards species	*S.* Kottbus	2
	S. Agona	1
	S. Blockley	1
Sandgrouse species	*S.* Typhimurium	2
Pheasant species	*S.* Hindmarsh	1
	S. Haardt	1
Domestic chicken	*S.* Infantis	4
Quail species	*S.* Hadar	1
Pigeon species	*S.* Typhimurium	4

4.7.6 Salmonella serovars isolated from Al-Ain Zoo

S. Reading was isolated once from White beared Gnu and isolated twice from Cheetah in Al-Ain Zoo. Table (16)

Table (16): List of the different Salmonella serovars isolated from Al-Ain Zoo

Animal species	Serovar	Frequency
White beared Gnu	*S.* Reading	1
Cheetah	*S.* Reading	2

5. DISCUSSION

There is a limited data concerning farm animals' Salmonellosis in the Untied Arab Emirates. The current study is the first survey of the prevalence of the different *Salmonella* serovars among different farm animals in Al-Ain City.

Salmonella is a primary aetiologic agent of infectious diarrhoea, and its high morbidity and mortality rates make it one of the most economically significant pathogens in livestock production (Fairbrother, 1999). Animal species appear non-symptomatic while shedding this bacterium into the environment (Gansheroff and O'Brien, 2000). Although shedding is intermittent and often difficult to detect, the pathogen has been isolated from different animal species at all ages (Fedorka-Gray et al., 1998; Hancock et al., 1998 and Elder et al., 2000).

The present findings showed that Salmonella infection is highly prevalent in cows and camels, whereas sheep and goat score the least incidence of the disease. In Table (4), the highest percentage of Salmonella infection prevalence was among cows (9.83%) followed by camels (7.89%). On the other hand, no positive cases were recorded among sheep and goats samples. This result agreed with Chamers (1977) and Pegram et al. (1981) who stated that sheep and goats are often the least infected of food animals. As shown in Table (5), all affected cases were recorded positive to Salmonella. Our results can be attributed to the fact that these cases were suffered from acute diarrhea.

In this study, differences in geographical distribution of Salmonella infection have been observed between camel flocks at the different localities in the area of the study. As shown in Table (6), the high prevalence of positive cases was in Sewihan followed by Masaken. Other localities showed negative cases of Salmonella infection such as Mazyed and Abu Samrah. This variation can be attributed to the level of hygiene practice or stresses that may increase infection. Blood et al. (1990) believed that stressful situation such as transport, inter-current diseases, malnutrition, crowding, surgery, parturition and administration of some drugs increase the risk of Salmonella infection. Our results also showed difference between Salmonella serovars isolated in these localities as illustrated in Table (12). These findings agreed with Besser et al. (2000) who reported that geographical differences can be observed for serotype diversity and also for season of highest prevalence.

Our survey of dairy farms showed that incidence of Salmonella infection was higher in dairy farm (1) than in farm (2). In farm (1), the percentage of positive cases was higher in young calves (25%) than in adult cows (11.10%) as shown in Table (7). This result agreed with the fact that young animals are more susceptible to Salmonella infection than adults due to less developed immunity (Pacer et al., 1989). The infection among cows occurs more commonly in the calving season than at other times where prolonged carriage and shedding of the pathogen may occur (Poppe et al., 1998). Only one positive case was recorded in dairy farm (2) while eleven positive cases were recorded in dairy farm (1). Dairy farm (1) seems to be in risk for Salmonella infection than the other farm. Many authors described different risk factors such as large herd-size (Wray and Sojka, 1977), movement of animals subclinically infected with Salmonella, access of vermin to dairy feeds (Smith and House, 1992), free-stall housing (Fedaka-Cray et al., 1998), prolonged intensive

feeding (Wray and Davies, 1996), occurrence of enteric conditions such as Johne's disease, Bovine Viral Diarrhea Virus, fascioliasis (Evans, 1996) and contaminated feed (Krytenburg et al., 1998 and Davis et al., 2003). In the present study, one diarrheic cow case was positive to Salmonella infection and Bovine viral diarrhea virus. This result agreed with Evans (1996) and Wary and Roeder (1987) who pointed to the aetiological relationship between Bovine Viral Diarrhea Virus and Salmonella infection.

In the present study, none of the selected sheep and goat farms showed positive cases of Salmonella infection even among different breeds at different ages as shown in Tables (8) and (9). These farms belong to ruler families where proper hygiene practices and adequate feeding are applied to prevent such infectious disease and this explains our results. Although there were no positive cases in the selected sheep and goat farms, risk factors facing these populations are existed. Jensen and Swift (1982) described many factors such as shipment over long distances and fasting for long periods. Inclement weather may add to the ill effects of travel and hunger. Crowding and inadequate feeding during times of shearing and dipping may expose these animals to large number of Salmonella in feed or water and result in disease outbreaks.

Our findings showed that *S.* Typhimurium was the most frequently isolated serovar (Table (10)). It was isolated from different animal species such as camels, cows, goat, sheep and avian species. The obtained result agreed with the fact that *S.* Typhimurium is ubiquitous among different animal species and it is possible for infection by this serovar to originate from disease in another animal species (Buxton and Fraser, 1977). In this study, *S.* Typhimurium was isolated only from sick animals.

Our results disagreed with other studies where *S.* Typhimurium could be isolated from healthy (Zaki, 1956; Nath et al., 1966; Zein-El-Abden et al., 1966; Ramadan and Sadek, 1971 and Lance et al., 1992) and sick animals (Sandiford, 1944; Nabbutt and Al-Nakhli, 1982 and Sato et al., 1993).

In this study, differences between Salmonella serovars isolated from apparently healthy animals and those isolated from clinically affected animals have been observed among camel and cow populations as shown in Tables (11) and (13). In contrast, no differences could be observed among sheep and goat populations because no Salmonella infection was recorded from healthy animals. Among camels, only *S.* Frintrop was isolated from both healthy and sick camels. Our result agreed with Malik et al. (1967) and Wernery (1992) who reported that *S.* Frintrop is one of the most frequently isolated serovars among camels and can be isolated from both healthy and sick camels. However, other serovars seem to be isolated only from healthy camels such as *S.* Poona, *S.* Agona and *S.* Indiana while *S.* Typhimurium, *S.* Stanly and *S.* Haardt were isolated only from diarrheic cases. The same result was observed among cows. *S.* Anatum and *S.* Havana, which were the most frequently isolated serovars in the study, seem to be isolated from both cases while *S.* Montevideo was isolated from healthy cow and *S.* Dublin was isolated from affected cow. These differences may be attributed to two reasons. The first reason is the period of sample collection. Galland et al. (2001) and Troutt et al. (2001) reported that Salmonella prevalence and serotype diversity can be different during winter and summer seasons. The other reason is the virulence of Salmonella serovars. Serovars isolated from affected animals could be more virulent than those isolated from apparently healthy animals.

Our results showed that *S.* Indiana, *S.* Wien, *S.* Stanley, *S.* Haardt, *S.* Panama, *S.* Liverpool and *S.* Poona were isolated for the first time among local camel flock in the country. On the other hand, *S.* Frintrop and *S.* Bovismorbificans were still among the most frequently isolated serovars in UAE in comparison with the study of Wernary (1992) regarding camel Salmonellosis. This study also showed that flock infection was not restricted to certain serovar. For example, two different serovars, *S.* Frintrop and *S.* Bovismorbificans, were isolated from camels from the same flock and their mothers were negative for Salmonella. The reason of this could be introduction of a new camel into the flock, infected wild birds and rates or contaminated feed.

In the present study, *S.* Anatum was isolated eight times from apparently healthy young and adult cows in dairy farm (1), which means that *S.* Anatum persisted in the farm. Our result agreed with other studies concerning Salmonella persistence in cow herds (McLaren and Wray, 1991; Gay and Hunsaker, 1993 and Warnick et al., 2001). Giles et al. (1989) reported that Salmonella can persist in herds for periods ranging from several months to 3.5 years following the occurrence of clinical disease. Persistence in the herd more commonly results from multiple, temporary infections of individual animals (Gay and Hunsaker, 1993). Blowey (1993), Kabagambe et al. (2000) and Daniels et al. (2003) reported that an increased incidence of a particular serotype among animals in a district may result in the wild rodents of that area becoming infected with the predominant serotype. So rats and mice in the farm may become infected with that organism for a period of time, and contaminate water supplies and food. On the other hand, we found other serovars isolated in the same dairy farm (1) which means that there are other sources of infection such as contaminated food and water supplies or introduction of new cattle. Warnick et al.

(2003) reported that bringing purchased cattle to the farm is typically considered as a risk factor for Salmonella transmission to uninfected herds.

During this study, two abortion cases were recorded. *S.* Anatum was isolated from aborted foetus of a goat and *S.* Dublin was isolated from aborting cow. Our finding conforms to Montagne et al. (2001) who stated that *S.* Dublin is adapted to cattle and can cause abortion rather than enteric pathogens.

Our study included Salmonella serovars isolated from different avian species. Our results showed a variety of serovars between the different avian species as shown in Table (15). *S.* Infantis appears to be isolated from domestic chickens. Al-Nakhli et al (1999) considered this serovar as widely distributed and encountered in poultry and poultry environment in Saudi Arabia. On the other hand, *S.* Hadar was isolated from quail species. This result agreed with Sander et al. (2001) who stated that 94% of Salmonella isolated from quails belonging to *S.* Hadar. Because birds considered one of the most important vectors for Salmonella infection among different animal species, our findings showed that there is similarity between serotypes isolated from birds and farm animals. For instance, *S.* Typhimurium was isolated from camels, cows, sheep and goat and also isolated from Sandgrouse and pigeon species. *S.* Blocky was isolated from both Bustards species and goat.

Regarding Salmonella serovars isolated from affected cases of Al-Ain Zoo, *S.* Reading appeared to be dominant serovar among zoo animals as shown in Table (16). These results can be attributed to the contaminated food and water supplies, movement of infected wild rodent between animal cages or improper management of animal manure.

As a conclusion, our study showed that Salmonella infection in Al-Ain area is highly prevalent in cows and camels, whereas sheep and goat score the least incidence of the disease. This study considered the first report of Salmonella serovars isolation among cows, sheep and goats populations in the country. *S.* Indiana, *S.* Wien, *S.* Stanley, *S.* Haardt, *S.* Panama, *S.* Liverpool and *S.* Poona were isolated for the first time in local camel flocks in the UAE. The study also showed similarity between Salmonella serovars isolated from both different avian species and farm animals confirming the important role played by birds in Salmonella infection distribution.

6. RECOMENDATIONS

Preventive measures must take into account that inadequate treatment can lead to unapparent subclinical cases or carriers that may then persist in the stock. These chronic carriers are not only a threat to the remaining animals, but also present a human health hazard though consuming meat and contacting with contaminated animal products.

Shedding of Salmonella in feaces is a serious problem in controlling the disease and without reliable tests to detect carriers; we suggest that control of this infection in farms must be based on prevention and improved hygiene such as:

1. Adequate feeding
2. Ensuring that there is no contamination of food or water supplies.
3. Animals showing symptoms of enteritis should be isolated immediately and treated.
4. Avoiding crowding of sheep into pens or small areas of pasture for lambing, shearing or transport as much as possible, particularly when there is a history of subclinical infection in a flock
5. Control population of wild rats and mice, and attempt to eliminate faecal execrators, since these animals can act as reservoirs of the infection on farm premises.
6. Avoiding large herd size and intensive management which may provide an environment conducive to Salmonella shedding and chronic infection.

7. Avoiding introduction of animal from an infected area to a clean area.
8. Isolation of aborting animals and destruction of contaminated bedding and of all products of abortion in order to reduce contamination.
9. Preventive precautions should be given to the purchased animals since these are a source of introducing Salmonella infection into the herd or flock especially in dairy farms, sheep and goats farms.
10. Proper management of animal manure
11. Routine monitoring of feed, water sources and farm environment especially if there is a history of the disease.
12. Molecular typing of *S.* Typhimurium is required to have an idea about the different stains of this serovar in the country.

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الملخص

يُعتَبر السالمونيلوسيس أحد أكثر أمراض أهمية اقتصاديًا، فهو يؤثر على الإنسان وأنواع الحيوانات المختلفة. يؤثر المرض على الحيوانات المستأنسة و غير المستأنسة في مختلف الأعمار. يظهر السالمونيلوسيس بصور إكلينيكيّة متعددة مثل الإسهال و الإجهاض و الرّوماتيزم ومشاكل تنفسية. يعتبر الجهاز المعويّ لمعظم أنواع الحيوانات البيئة الطبيعية لأنواع السالمونيلا . تمثل الحيوانات الناقلة مصدرًا مستمرًا لنشر البكتيريا في البيئة المحيطة. إن عدوى السالمونيلا تمثل خطرا على الصحّةالعامة حيث أنها تنتشر بين الحيوانات و من ثم للإنسان.

في هذه الدّراسة، جمع عدد (882) عيّنة من حيوانات مختلفة في منطقة العين بإمارة أبوظبي في دولة الإمارات العربيّة المتّحدة . لقد تم جمع عيّنات برازية من جمال سليمة (266)، بقر (122)، غنم (255) و جديان (187) و من ناحية أخرى، تم جمع 52 عيّنة من جمال تعاني اسعال وحمى (7)، بقر (10)، غنم (6)، جديان (5)، حيوانات برية (3) و طيور (17) . أيضًا لقد تم أخذ عينة من جنين غنم مجهض و عينة برازية من بقرة مجهضة . أُخضِعَتْ كلّ العيّنات من الحيوانات السّليمة و المريضة لبروتوكول عزل السالمونيلا و التّعرّف عليها . حقنت كل عينة في وسط السيليناىت و حضنت في درجة 37º سيليزية لمدّة 24 ساعة . لقد تم بعدها أخذ لوبفول من كلّ وسط سيليناىت و تم زرعها على أطباق البلاد آجار، السالمونيلا- شيجيلا آجار و هيكتوين إنترك آجار ثم حضنت الأطباق في درجة 37º سيليزية لمدّة 24 ساعة. تم التعرف على المستعمرات النامية طبقا لخواصّها الزراعية و الكيميائيّة الحيويّة. قسمت السالمونيلا المعزولة تبعا للمجموعات (أ-ج) وعرفت جزئيًا باستخدام مونوفيلنت وبولي فيلنت أو و إتش أنتيسيرا. التعريف الكامل للعزلات تم في وكالة المعمل البيطري في وايبريدج بالمملكة المتّحدة .

تظهر النّتائج أن عدوى السالمونيلا منتشرة بدرجة كبيرة في البقر و الجمال، بينما الغنم و الجديان تسجّل التكرار الأقل للإصابة . لا توجد سجلات متاحة حتّى الآن لأيّ عزلة لأنواع السالمونيلا في البقرو الغنم و الجديان ولاتوجد دلائل سيرولوجية في دولة الإمارات العربيّة المتّحدة . هذه الدّراسة تعتبر الأولى من حيث عزل أنواع السالمونيلا في البقرو الغنم و الجديان . إضافة إلى ذلك، تم في هذه الدّراسة عزل س.إنديانا، س.وين، س.ستانلي، س.هاردت، س.باناما، س.ليفربول و س.بونا للمرة الأولى في جمال دولة الإمارات العربيّة المتّحدة .

إهداء

إلى ذكرى صاحب السمو الشيخ زايد بن سلطان آل نهيان(رحمه الله) الذي استطاع بفضل رؤيته، ذكائه، حكمته وإخلاصه أن يقود مسيرة نهضتنا لننعم بحياة كريمة لم يُحلم بها قبل بضع عقود من الزمن...

إلى وطني و إلى والدي العزيزين.

جامعة الإمارات العربية المتحدة
عمادة الدراسات العليا
برنامج ماجستير علوم البيئة

عدوى السالمونيلا بين حيوانات المزرعة بمدينة العين في دولة الإمارات العربية المتحدة

رسالة مقدمة من الطالبة/
دلال سعيد سعيد منصور الكعبي

إلى

جامعة الإمارات العربية المتحدة
استكمالاً لمتطلبات الحصول على درجة الماجستير في علوم البيئة

لجنة الإشراف

د. عبدالمجيد الخاجة أستاذ مساعد قسم الميكروبيولوجي الطبية جامعة الإمارات العربية المتحدة	د. طارق مصطفى مسؤول المختبر البيطري مدينة العين الإمارات العربية المتحدة

٢٠٠٥/٢٠٠٤

جامعة الإمارات العربية المتحدة
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