

Isolation and Identification of Bacteria from House Hold Cockroaches (*Blattella germanica*)

Arwa Hashim M. A. Musa ., Eltaib, S. A. Lina ., Yassir Mohamed ., Amina, E. M

Sudan academy of science, SAS, Biological Science, New Technologies and Environmental Council, Sudan

Corresponding author: Eltaib, S. A. Lina
B. pharm., M. pharm., PhD (Pharmaceutics)
Email: linasalaheldin@gmail.com

Department of pharmaceutics, Faculty of Pharmacy, Northern Border University, P.O. Box 840, Rafha, 91911, Kingdom of Saudi Arabia

Abstract

Most insects carry bacteria, viruses and parasites on their bodies. When these insects come into contact with people or when they bite/sting, they leave behind many types of germs. Some of these germs cause diseases. Cockroaches are one of the common household invaders which known to transmit bacteria. The aim of this work was to isolate and identify the bacteria from the German cockroaches (*Blattella germanica*) in Khartoum state (Khartoum, Khartoum north and Omdurman) city.

In this study 60 samples were collected from cities (20 samples from each city). Biochemical tests were used for microbial identification. In total, 15 different bacterial species were isolated from three cities. The bacterial species detected in Khartoum city were: *Staphylococcus* spp. (3) (13.04%), *Streptococcus* spp. (13.04%), *E. coli* (1) (4.35%), *Klebsiella* spp. (4) (17.39%), *Shigella* spp. (1) (4.35%), *Salmonella* spp. (1) (4.35%), *Salmonella paratyphi .A* (1) (4.35%), *Morganella* spp. (1) (4.35%), *Serratia* spp. (1) (4.35%), *Enterobacter* spp. (1) (4.35%), *Alcaligenes* spp. (1) (4.35%) and *Bacillus* spp. (5) (21.74%). Bacterial species isolated from Khartoum north city were: *Staphylococcus* spp. (13) (46.43%), *Shigella* spp. (3) (10.71%) and *Bacillus* spp. (12) (42.85%); while species isolated from Omdurman city were: *Staphylococcus* spp. (10) (40.00%), *Streptococcus* spp. (1) (4.00%), *Micrococcus* spp. (1) (4.00%), *Klebsiella* spp. (3) (12.00%), *Proteus* spp. 2(8.00%), *Pseudomonas* spp. (1) (4.00%), *Morganella* spp. (1) (4.00%), *Serratia* spp. (2) (8.00%), *Enterobacter* spp. (1) (4.00%), *Bacillus* spp. (3) (12.00%).

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Introduction

Cockroaches have become most vital pest commonly found in association with man in areas where food is prepared and stored such as restaurants, kitchens, bakeries, and grocery stores (Rivault et al; 1993; Vythilingam et al. 1997). These insects live in different environments, like sewage pipes, latrines, garbage, wall slits, baseboards and filthy places, as they are attracted by food, organic waste and fluids regularly discharged in such site (Graczyk et al, 2001; Bell et al.2007;Allotey et al, 2009).The cockroach poses one of the greatest health hazards of all households' pests. Millions of them live in our homes, hotels, restaurant kitchens, shops, supermarkets and bars, spreading diseases which can prove fatal to humans. Many cases of food poisoning are known to be as a result of cockroach contamination.

Cockroaches have survived on the earth for more than 300 million years virtually without change (Zurek and Schal, 2004). There are approximately 3500 species of cockroaches worldwide (Kopanic, 1994). 50 species of them have been reported living in or around human structures (Kinfua and Erkob, 2008). The majority of these species live in tropical and subtropical area but are not pests (Vazirianzadeh et al., 2009), so they found in abundance near areas where there is frequently standing water or areas where continued moist is usually available such as toilets, kitchen and drainages water frequently serve as a migration routes from place to place (Siachua et al., 2008). Cockroaches frequently feed on human feces, garbage and sewage, therefore they have copious opportunity to disseminate pathogenic agents (Uckay et al., 2009). They are known as one of the most important agents in transmission and distribution of many different bacteria, viruses, protozoa and fungi to human life, and they are intermediate host for some pathogenic intestinal worms (Cloarec et al., 1992). In addition to the presence of some bacteria, parasites and fungi in external surfaces of cockroaches they have been found in internal parts of their body, therefore these insects are considered important diseases vectors transmitted by both mechanical and biological routes (Thyssen et al., 2004).

Houseflies and cockroaches have been shown to carry multi-drug resistant clonal lineages of bacteria identical to those found in animal manure. Furthermore, several studies demonstrated proliferation of bacteria and horizontal transfer of resistance genes in the insect digestive tract as well as transmission of resistant bacteria by insects to new substrates. (Zurek and Ghosh, 2014).

At least 32 species of bacteria have been isolated from cockroaches in domestic environments (Yiu et al., 2006).

For example:

- *Aeromonas* spp., cause wound and other infections, diarrhea.
- *Alcaligenes faecalis*, causes of gastroenteritis, urinary tract infections.
- *Bacillus cereus*, causes food poisoning.
- *Bacillus subtilis*, causes conjunctivitis.
- *Campylobacter jejuni*, causes enteritis.
- *Clostridium perfringens*, causes food poisoning, gas gangrene.

- *Enterobacter* spp., causes bacteremia (temporary presence of bacteria in the blood, which is commonly followed by the development of various infections including abscesses).
- *Enterococcus* spp., cause urinary tract and wound infections.
- *Escherichia coli*, causes diarrhea, wound infections.
- *Klebsiella* spp., cause pneumonia and urinary tract infections.
- *Mycobacterium leprae*, causes leprosy.
- *Morganella morganii*, causes wound infections.

Rationale

Several studies indicated that cockroaches are responsible of transmitting many infectious diseases and its being domestic insect in household (bathrooms, kitchens and gardens) may harm the human health. Thus, this study aimed to isolate and identify bacteria carried by cockroaches from households in Khartoum state.

Objectives

To isolate possible pathogenic bacteria from the surface of German cockroach (*Blattella germanica*) and to identify these isolates by biochemical test.

Literature Review

1.1 Cockroaches:

1.1.1 Background:

Cockroaches are some of the most important pests in urban environments. They are frequently found in large multi-family dwellings where it is difficult to get rid of them completely. Their presence can cause many problems as it reduces people's perception of their well-being and the satisfaction they derive from their own personal environment. In flats, cockroaches are found mainly in kitchens, bathrooms, toilets and cupboards used for storing food. Cockroaches are able to move from one part of a building to another. In large blocks sanitary conditions as well as cockroach population size are highly variable between flats, although the variations of these two factors are not always related. In addition, cockroaches are omnivorous, and their feeding habits are such that they are in contact with many kinds of stored food used by people, as well as with different kinds of biological waste or detritus, garbage and sewage, dead insects, feces, etc... . They are known to carry passively many microorganisms such as bacteria, viruses, helminthes and fungi. (Roth et al., 1957). Cockroaches have always been associated with different sites of domestic environments, by food, organic waste and fluids that are regularly discharged in such sites (Mpuchane et al., 2005).

1.1.2 Classification:

Cockroaches are insects, flattened from top to bottom, usually with two pairs of wings folded flat over the back. Most species rarely fly but they walk very fast. The color usually varies from light brown to black. The species vary from 2–3 mm to over 80 mm in length.

Of over 3500 identified species only a few are of importance to people because they have adapted to living in buildings. The most common species commonly found infesting in domestic area are:

Periplaneta americana:

The American cockroach, which occurs around the world. It is common around the home and associated with water drainage systems and water pipes. It is 35–40 mm in length and is a shiny reddish to chocolate brown color. The egg case measures 8–10 mm and contains 16 eggs (Bell et al; 2007).



Fig 1. American cockroach (*Periplaneta americana*)

Blattella germanica:

The German cockroach, found in most parts of the world. It is more prevalent inside the home, light yellowish brown and 10–15 mm in length, making it one of the smallest domestic cockroaches. The female usually carries the eggcase until shortly before the young come out. The egg case is light in colour, about 7–9 mm long and contains about 40 eggs (Bell et al; 2007).



Fig 2. The German cockroach (*Blattella germanica*)

1.1.3. Distribution and habitat:

German cockroaches, believed to have originated in Southeast Asia, are the most widely distributed urban pests. They have been introduced to all parts of the globe including North America, Australia, Africa, and the Oceanic Islands. This ubiquity makes German cockroaches cosmopolitan, with the only deterrent being cold temperatures. (Jacobs, 2007). They live in temperate or tropical environments and prefer warm, humid weather and are solely terrestrial. They inhabit a variety of habitats, from very moist areas, such as rainforests and scrub forests, to somewhat drier areas such as taigas and chaparrals. They are also found in sylvatic areas, such as forests and caves, as well as in urban, suburban, and rural settings. Cold is one of the major factors limiting the habitat of German cockroaches. On average, they are found at elevations of 1200 m, and, due to cold temperatures and dryness, they usually do not reside above 2000 m. (Jacobs, 2007; Valles, 2008).

Recently more than 40% of cockroach populations are found in domestic areas, because of uncontrolled of domestic sewage, poor sanitation and environment pollution which makes ideal environment for increase the cockroaches. Furthermore, their feeding mechanisms and filthy breeding habits make them ideal carriers of various pathogenic microorganisms (Graczyk et al., 2005).

1.2 Cockroaches as vectors of pathogens:

Cockroaches, *Blattodea* order insects, act as an important mechanical vector for lots of pathogenic microorganism agents, including bacteria, protozoa, worms, fungi, and viruses amongst humans and animals. However, they are very prepared to carry the bacteria very readily than the other pathogen microorganisms. The population of cockroaches transmit the disease agents by means of different parts of their bodies (body hairs, appendages and mouth parts) and secretions (regurgitates and feces). Cockroaches enter to the several places, including contaminated premises because of their own biologic habits for feeding. Thus, the presence of cockroaches in urban areas is a potential hazard to human health. Cockroaches can cause 2 potentially serious health problems. First, they may provoke allergic reactions. (Tungtrongchitr., et al.2004). Second, they have been suggested as possible vectors of multidrug-resistant pathogens. In particular, cockroaches that live and breed in hospitals have higher bacterial loads than cockroaches in the community. (Paul et al., 1992) and (Salehzadeh et al., 2007) .

98% of “nosocomial” cockroaches may carry medically important microorganisms on their external surfaces or in their alimentary tracts.(Paul S.et al., 1992 ; Elgderi et al., 2006) and may disseminate these microorganisms by fecal–oral transmission.(Paul et al., 1992).Cockroaches are capable of harboring *Escherichia coli* (Salehzadeh .,et al 2007 ; Pai HH, et al;2004), *Enterobacter* spp. (Salehzadeh ., et al 2007 ; Lemos et al ., 2005 ; Elgderi et al., 2006), *Klebsiella* spp. (Salehzadeh et al., 2007; Pai et al.,2004 ; Elgderi et al., 2006), *Pseudomonas aeruginosa* (Salehzadeh et al., 2007 ; Elgderi R et al., 2006), other non fermentative bacteria and *Serratia marcescens* (. Pai et al., 2004 ; Elgderi et al.,2006), *Shigella* spp. (Salehzadeh et al., 2007), *Staphylococcus aureus* and *Enterococcus* spp. (Salehzadeh et al., 2007 ., Pai et al., 2004), group A streptococci (Pai et al.,2004 , Elgderi et al.,2006), *Bacillus* spp. (Pai et al.,2004), various fungi (Salehzadeh et al., 2007 ; Lemos et al .,2005), and parasites and their cysts (Salehzadeh et al., 2007).

More than 100 species of bacteria have been isolated from or passed through cockroaches, which were carried on their rough body parts, cuticle, gut, vomits and feces (Allotey et al., 2009).Cockroaches are mechanical carriers or perfect vector for harboring and transmitting

virulent bacteria associated with food born infections. Some of them demonstrate resistance to antibiotics (Mpuchane et al., 2005; Cruden and Markovetz, 1987).

Transmission could occur by cockroach regurgitation or fecal pellet deposition into human foodstuffs (Bell et al. 2007). Although recently several studies of cockroaches in domestic environments have shown the presence of microorganisms spread on their external surfaces, such as *Enterobacter* spp., *E.coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumonia* and several other potential pathogens (Saitou et al, 2009).

Although studies with *Bl. Germanica* showed that when *Ps. aeruginosa* has been demonstrated to multiply in the gut and excretion of the bacteria continued up to 114 days (Fotadar et al, 1993), also *Salmonella typhi*, *Shigella dysenteriae* and toxigenic strains of *E. coli* can be retained in the gut of cockroaches for up to several days (Stek, 1982).

The domestic pollution and poor sanitation gives the favorable condition to growth and development of population of cockroaches in food preparation areas and multi-family dwellings, the diversity of micro-organisms that they are associated and the fact that some of these bacteria highly resistance to recent antibiotics, which is indicates one of the positive health risk for the human beings (Prado et al, 2002).

The high population density with poor disposal of left-over's, lack of proper sanitation and ideal temperature conditions could serve as a source of cockroaches' infestation. Bacteria were isolated from Cockroaches trapped from food dispensing areas (kitchens) including the pathogenic and potentially pathogenic species *Shigella boydii*, *S. dysenteriae*, *Salmonella typhimurium*, *Klebsiella oxytoca*, *K. ozaena* and *Serratia marcescens* (Oothuman et al., 1989). Many studies found that cockroaches, in food-related environments, carry many species of bacteria listed in European Union regulations, such as *Salmonella* spp., *Enterobacter sakazakii* (*Cronobacter* spp.), and *Escherichia coli*. A wide variety of species were isolated, some belonging to different genera that have a significant impact on public health and hygiene, such as *Enterobacter* and *Klebsiella* (Ponce et al, 2005).

In hospitals, cockroaches have been considered to be a possible carrier of nosocomial infections, especially the transmission of drug-resistant bacteria, also they play a critical role in transmitting food-borne diseases; such as diarrhea, dysentery, cholera, tuberculosis, and typhoid fever (Saitou et al, 2009).

Cockroaches are possible vectors for carrying TEM-type beta-lactamases producing Gram negative bacteria, most often found in *E.coli* and *Kl. pneumonia*, which showed ampicillin and penicillin resistance (Cotton et al., 2000).

The transmission and storage of *Salmonella* by synanthropic cockroaches is a major risk factor for enterobacteria dissemination in hospitals, houses, and restaurants (Devi et al. 1991).

A total of 25 species of bacteria was isolated from cockroaches in the storage rooms and kitchens. Antibiotic resistance was found in *Staphylococcus aureus*, *Enterococcus* spp., *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *Escherichia coli*, *Serratia marcescens*, and *Proteus* spp. isolated from cockroaches (Hsiu-HuaPai et al.; 2005). In addition to these bacteria, non-tuberculous mycobacteria were isolated from hospital cockroaches (Pai et al., 2003).

Moreover, cockroaches in hospitals may harbor bacteria with resistance to antibiotics and those carrying *Klebsiella* spp. with antibiotic resistance has been suggested to play a role in nosocomial infections (Fotadar et al; 1991). Cockroaches have been suggested to be possible

vectors for an outbreak of nosocomial beta-lactamase-producing *Klebsiellapneumoniae* infections in a neonatal unit with heavy cockroach infestation (Cotton et al., 2000). Over 4% of cockroaches collected from hospitals, houses, animal sheds, grocery stores, and restaurants in India harboured multiple drug resistant *Salmonella* (Devi and Murray 1991). It has been reported that 70% of cockroaches collected from hospitals in Iran yielded *Salmonella spp.* and some of the isolates were resistant to antimicrobial drugs (Fathpour et al. 2003). Various food-borne pathogens were isolated from cockroaches collected from kitchens in Ghana (Agbodaze and Owusu 1989) and in Nigeria (Umunnabuike and Irokamulo 1986). In Bangladesh, *Salmonella*, *Shigella*, *S. aureus*, *B. cereus*, and *E. coli* were isolated from cockroaches (Paul et al. 1992). Survival of pathogens in experimentally infected cockroaches was reported by (Fotedar et al. 1993) and (Imamura et al. 2003). Isolates of pathogenic bacteria from medical centers have been reported to have high prevalence of resistance to commonly used antimicrobial agents (Chang et al., 2001).

1.2.1 American cockroaches (*Periplaneta americana*):

The American cockroach comes in contact with human sewage through sewer systems where they can live, and from there also are able to get into bathrooms and basements.

In Morocco, pathogenic bacteria have been isolated from American cockroaches and houseflies collected in urban areas (Bouamama et al., 2010).

American cockroaches are often found in intimate association with human beings and are present in large numbers in and around houses or hospitals and in urban areas and villages with poor sanitation and insalubrious conditions (Oothuman et al., 1989 ; Bouamama et al., 2010). Various bacteria may simply be carried on the insect's cuticle or be ingested and, sometime later, regurgitated or excreted. Moreover, several species of bacteria of public health significance have been isolated, or have passed through, cockroaches (*Periplaneta americana*) and their digestive tract, such as *Staphylococcus aureus*, *Streptococcus spp.*, *Enterobacteriaceae*, *Pseudomonas aeruginosa*, etc. (Fotedar et al., 1991 ; Pai et al., 2005).

Bacteria was isolated from the whole body of these insects *Periplaneta Americanain* residential areas of different districts in Cairo, Kafr Al-Sheikh and Sharqiya governorates (Cotton et al., 2000).

Cockroaches collected in hospitals and households have been found to harbor multi-drug resistant bacteria and hospital cockroaches with drug-resistant *Klebsiella spp.* have been suggested to play a role in the epidemiology of nosocomial infections. In addition, a neonatal unit infested with cockroaches suffered an outbreak of nosocomial disease due to extended-spectrum β -lactamase-producing *Klebsiella pneumoniae* .(Bouamama et al., 2010).

1.3.2 German cockroach (*Blattella germanica*):

German cockroaches (*Blattella germanica*) have become a significant domestic pest that are not only repugnant because of their association with dirt, but because of their possible health risks in spreading diseases, causing allergies, tainting food odors and contaminating food and food processing environments. Increased infestation of the German cockroach in buildings has increased with urbanization. (Tanaka and Motoki., 1993). Poor management of urban refuse has been linked with the increase in the population of cockroaches in urban areas (Boase , 1999). German cockroaches have also been isolated from various environments including hospitals, food industries and landfill sites. (Rivault et al., 1994) .They are also

common pests in bakeries, food processing facilities and kitchens.(Adler et al.,2002) and (Pellegrini et al., 1992) .While the causal relationship between cockroaches and disease still needs to be established, they also pose danger in the dairy industry since they carry microorganisms including *Salmonella*, *Pseudomonads*, *E.coli*, *Listeria monocytogenes*, and conidia of mycotoxigenic fungi (Bennet, 1993; Paul et al .,1992; Onuegbu, 1994). 98.5 % of cockroaches from hospitals and residences were carriers of microorganisms and involved in the etiology of nosocomial infections. (Fotedar and Banerjee,1992;Marty, 1998;Branscone , 2002).

At the household level, a relationship has been established between cockroach infestation and standards of hygiene. (Shah , 1996). Various studies have revealed that cockroaches aggregate in corners in kitchens, especially around the refrigerators and in the bathrooms around chests, around plumbing connections within or between rooms and/or flats. . (Tanaka and Motoki,1993; Rivault et al., 1993;Bennett et al., 1984). As cockroaches are engaged in their nocturnal forages, they drop off shed skins, nymphal shed skins and fecal pellets. Most of the Gram positive bacteria isolated from the cuticle were coagulase negative *staphylococci*. (Sramova et al., 1992). It is possible that the antimicrobial agents that are present in these creations produced by the male accessory glands may have a role in selecting against certain types of bacteria. (Gilliot, 2003). Cockroaches are possible vectors of pathogenic bacteria in hospital environments (Kim et al., 1995;Cotton et al., 2000 ; Gliniewicz A, et al ;2003).Up to 54 % of isolates from hospital environments were found to be human pathogens (Devi and Murray, 1991).

More than 33.3 % of cockroach isolates were resistant to more than three antimicrobials (some to 6 or more). (Sramova et al ., 1992). Resistance covered a large diversity of microbes including *Salmonella*, *enterobacteria* and *coagulase negative staphylococci* .(Prado et al., 2002). There has been great concern about cockroaches carrying and spreading micro organisms as they forage in the houses, and at the same time on to foodstuffs and working areas in the kitchen, which could result in allergic reactions from consumers.(Cloarec et al.,1992; Brenner ,1992).

Although important pathogenic microorganisms such as *P. aeruginosa*, *Staphylococcus aureus*, and *Streptococcus faecalis* have been isolated from *Blattellagermanica* collected in hospitals, these species were not found in the corresponding residential areas (Fotedar et al., 1989.).

Carriage of multiple-antibiotic-resistant bacteria that are potentially pathogenic to human by the German cockroach (*Blattella germanica*) was investigated in hospitals and households surrounding hospitals in Tripoli (Elgderi et al., 2006).

Material and Method

Study area:

Khartoum state (Khartoum, Khartoum north and Omdurman city).

Duration of study:

From August 2014 to October 2014

Study design:

Cross-sectional descriptive study.

Sample size:

60 samples (20 from each city).

Sample collection:

Samples were collected by covering cockroach by oblong box containing pore on the top surface with the same diameter of container. The container was opened and placed upside down in the hole so the cockroach spontaneously enter the container. Then the container back and 1 ml of normal saline was added.

Cultivation of samples:

From the normal saline containing a sample (cockroach), 1ml was transferred to the Petri dish containing blood agar medium incubated for 24 hours at 37°C, and sub cultured in nutrient agar medium for 24 hours at 37 °C. Then Gram staining was performed.

Biochemical tests:**Catalase test:**

The test was used to differentiate between the bacteria that produce the enzyme catalase such as *staphylococci* from non-producing bacteria such as *streptococci* (catalase act as catalyst in the breakdown of hydrogen peroxide to oxygen and water).

-A good growth of the test organism was picked by sterile wooden stick and immersed into 2-3 ml of hydrogen peroxide in test tube.

-Bubbles of oxygen were released in positive result. (cheesbrough, 1984).

Indole test:

Test was used to differentiate *enterobacteria* species which break down the amino acid tryptophan by releasing of indole (e.g. *E.coli*) from the others, the test organism detected indole production by Kovac's reagent (dimethyl aminopenzaldehyde) which reacts with indole to produce red color (red ring) (cheesbrough, 1984). Test organism was inoculated in peptone water containing tryptophan (tryptone water) then a drop of kovac's reagent was added and result was read.

Urease test:

Test for urease enzyme is important to differentiate enterobacteria (e.g. *Proteus spp.* strong urease producer) from non-urease produce like *salmonella spp.* (cheesbrough, 1984). Changing in the medium color to the pink indicates positive result.

Citrate test:

Used to differentiate enterobacteria species. Simmon's citrate agar test the ability of organisms to utilize citrate as only source of carbon, Simmon's citrate agar contain sodium citrate as the sole source of carbon, and ammonium dihydrogen phosphate as sole source of nitrogen.

-Test organism was inoculated in media contains citrate and incubated over night.

- Positive result was appeared as bright blue color and the negative result appeared as a green color (Cheesbrough, 1984).

Kligler iron agar test:

Kligler iron agar (KIA) slope medium used to assist in the identification of *Salmonella*, *Shigella*, and other enteric bacteria. KIA reaction is based on the fermentation of lactose and glucose (dextrose) and the production of hydrogen sulphide.

- A yellow butt (acid production) and red- pink slope indicate the fermentation of glucose only. The slope is pink-red due to reversion of of the acid reaction under aerobic conditions. This reaction is seen with *salmonella* and *shigella* species and other enteric pathogens.

Cracks and bubbles in the medium indicates gas production from glucose fermentation. Gas is produced by *Salmonella paratyphi* and some feecal commensals.

-A yellow slope and a yellow butt indicate the fermentation of lactose and possibly glucose.

-This occurs with *Escherichia coli* and other *enterobacteria*.

A red pink slope and yellow butt indicate no fermentation of glucose or lactose. This is seen in most strains of *Pseudomonas aeruginosa*.

-Blackening along the stab line or throughout the medium indicates hydrogen sulphide (H₂S) production. For example *Salmonella typhi* produces a small amount of blackening whereas *Salmonella typhenerium* produces extensive amount of blackening.(cheesbrough,1984).

Results

3.1 Isolation and identification of bacteria from cockroaches from households

in Khartoum city

The bacterial species detected in khartoum city were *Staphylococcus spp.* (13.04%), *Streptococcus spp* (13.04%), *E.coli* (4.35%), *Klebsiella spp* (17.35%), *Shigella spp* (4.35%), *Salmonella spp* (4.35%), *Salmonella para typhi.A* (4.35%), *Morganella spp* (4.35%), *Serratia spp* (4.35%), *Enreobacter spp* (4.35%), *Alcaligenes spp* (4.35%) and *Bacillus spp* (21.74 %).

3.2. Isolation and identification of bacteria from cockoroaches from households

in Khartoum north city.

The bacterial species detected in Khartoum north city were: *Staphylococusspp spp* (46.43%), *Shigella spp.*(10.71%) and *Bacillus spp.*(42.85%) and from Omdurman were *Staphylococcus spp.* (40.00%), *Streptococcus spp.*(4.00%), *Micrococcus spp* (4.00%), *Klebsiella spp.*(12.00%), *Proteus spp.*(8.00%), *Pseudomonas spp.* (4.00%), *Morganella spp.* (4.00%), *Serratia spp.* (8.00%),*Enterobacter spp.* (4.00%), *Bacillus spp.*(12.00%).

3.3. Isolation and identification of bacteria from cockroaches from households

in Omdurman city.

The bacterial species isolated from Omdurman city were: *Staphylococcus spp.* (10) (40.00%), *Streptococcus spp.* (4.00%), *Micrococcus spp.* (4.00%), *Klebsiella spp.* (12.00%),

Proteus spp. (8.00%), *Pseudomonas spp.* (4.00%), *Morganella spp.* (4.00%), *Serratia spp.* (8.00%), *Enterobacter spp.* (4.00%), *Bacillus spp.* (12.00%).

Table (1) Bacterial species isolated from household in Khartoum city

Type of Bacteria	Number	Percentage %
Staph spo	3	13.04
Strep sp	3	13.04
Micrococcus sp	0	0
E.coli	1	4.35
Klebsiella	4	17.39
Shigella	1	4.35
Salmonella	1	4.35
S.para.A	1	4.35
Proteus	0	0
Pseudomonas	0	0
Morganella	1	4.35
Serratia	1	4.35
Enterobacter	1	4.35
Alaligenes	1	4.35
Bacillus sp	5	21.74
Total	23	

Table (2) Bacterial species isolated from households in Khartoum north city

Type of Bacteria	Number	Percentage %
Staph sp	13	46.42857
Strep sp	0	0
Micrococcus sp	0	0
E.coli	0	0
Klebsiella	0	0
Shigella	3	10.71429
Salmonella	0	0
S.para.A	0	0
Proteus	0	0
Pseudomonas	0	0
Morganella	0	0
Serratia	0	0
Enterobacter	0	0
Alcaligenes	0	0
Bacillus sp	12	42.85714
Total		

Table (3) Bacterial species isolated from households in Omdurman city

Type of Bacteria	Number	Percentage %
Staph sp	10	40
Strep sp	1	4
Micrococcus sp	1	4
E.coli	1	4
Klebsiella	3	12
Shigella	0	0
Salmonella	0	0
S.para.A	0	0
Proteus	2	8
Pseudomonas	1	4
Morganella	1	4
Serratia	2	8
Enterobacter	1	4
Alaligenes	0	0
Bacillus sp	3	12
Total	25	

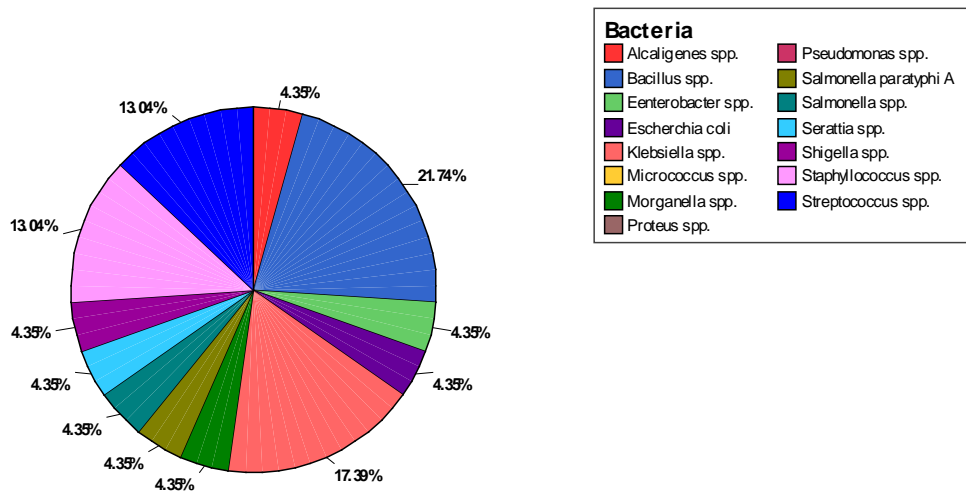


Figure (1) Percentage of different bacterial species isolated from households in Khartoum city.



Figure (2) Percentage of different bacterial species isolated from households in Khartoum north city.

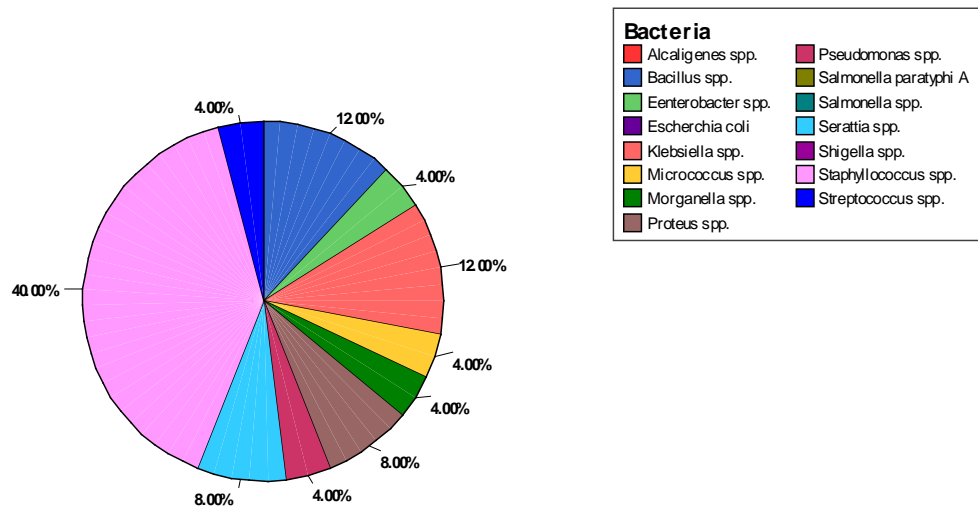


Figure (3) Percentage of different bacterial species isolated from households in Omdurman city.

Discussion

This study found that some bacterial species carried by household cockroaches (*Blattella germanica*) trapped in kitchens from three different cities Khartoum, Khartoum north and Omdurman. Fifteen bacterial species were isolated from the three cities. Two species (*Staphylococcus spp.* and *Bacillus spp.*) were isolated from all cities which indicate that they are the most common in these cities. In Khartoum city, the most prevalent species was *Klebsiella spp.* (17.39%) while in Khartoum north city and Omdurman city, the most prevalent species were: *Staphylococcus spp.* (46.43%) and (40%), respectively. Cockroaches carry micro-organisms on their surfaces and fecal pellets. They carry food-borne pathogens and food spoilage organisms wherever they crawl or forage in the home. Their presence in homes compromises the best practices in food safety and quality. These are of major concern for human health due to their capacity to act as a potential mechanical vector for transmitting more than 50 disease causing microorganisms (Cloarec et al., 1992; Rivault et al., 1993a, William et al. 2007; Kopanic 1994, Czajka et al., 2003).

The bacterial species were most frequently in food-handling establishments, however few bacterial species were identified from samples in households. Among these bacterial pathogens, four bacterial species appeared frequently, isolated in highest numbers from cockroaches trapped around the food-handling establishments, as compared with the households. These bacteria were and *Enterobacter cloacae*, which are potential pathogens. (Wannigama., 2014)

Bacterial isolates from *B. germanica* collected from the hospitals, human dwellings and canteens / restaurants were Gram negative and Gram positive bacteria. Bacteriological examination of the external body washes of

P. americana and *B. germanica* revealed that they were carriers of *Salmonella spp*, *Shigella spp*, *Staphylococcus aureus*, *coagulase negative Staphylococcus spp*, *Bacillus cereus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *Citrobacter freundii*, *Morganella morganii*, *Proteus vulgaris*, *Proteus mirabilis*, *Enterobacter cloacae* and *Providencia spp*. (Akinjogunla et al., 2012).

It has been reported that cockroaches may play a role as vectors of microorganisms involved in food poisoning (Rueger and Olson, 1969). Moreover, association of cockroaches with an outbreak of dysentery has also been established (Burgess and Chetwyn, 1981).

Conclusion

These study findings suggest the importance of this species of cockroaches in the transmission of several bacteria which may be linked to many health problems.

Recommendations

- Utmost efforts must be taken to drive cockroaches out by controlling their population at the household level.
- Being aware of the potential role of cockroaches as carrier of pathogens, people at the household level should strive to keep their kitchens and toilets clean and prevent cockroach infestation.

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