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Original article

Cockroaches (*periplaneta americana* and *blattella germanica*): reservoirs of multi drug resistant (MDR) bacteria in Uyo, Akwa Ibom State

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A B S T R A C T

Bacteriological examination of external surfaces and internal guts of *Periplaneta americana* and *Blattela germanica* were carried out using standard method and antibiotics susceptibility profiles of the isolates were determined using disc diffusion methods. Of the 317 bacteria isolated from the external surfaces and internal guts of *P. americana*, 275 (86.8%) were Gram-negative bacilli, while 42 (13.2%) were Gram-positive bacteria. Of the 204 bacterial isolates from *B. germanica,* 175 (85.8%) were Gram negative, while 29 (14.2%) were Gram positive bacteria. The bacteria isolated were *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. Among the Gram positive bacteria, only 75.8% *S. aureus* and 76.5% *B. cereus* were sensitive to Streptomycin and Gentamycin, while their resistance profiles to antibiotics in decreasing order were as follows: Chloramphenicol (41.7%), Amoxicillin (40.3%), Streptomycin (36.1%), Tetracycline (36.0%), Erythromycin (35.5%), Gentamicin (34.0%), Penicillin (34.6%), Cephalothin (27.8%), Sulfamethoxazole (23.4%), Ciprofloxacin (18.4%) and Levofloxacin (17.7%). Less than 50% of *E. cloacae* and *Providencia* spp were resistant to Streptomycin, while < 40% of *P. vulgaris, K. pneumoniae*, and *P. aeruginosa* were resistant to Chloramphenicol. Of the 353 (67.8%) multi drug resistant bacteria, 121 (23.2%) were resistant to 3 antibiotics, 232 (65.7%) were resistant to 4-10 antibiotics. The antibiotic resistant *Salmonella* spp. and *P. mirabilis* had Multiple Antibiotic Resistance (MAR) indexes ranging from 0.27 to 0.82. These findings suggest cockroaches in Uyo as potential vectors of medically important multiple drug-resistant bacteria.

1. Introduction

The American cockroach, *Periplaneta americana* L. (Dictyoptera; Blattidae), is the largest shiny reddish brown peridomestic cockroaches measuring on average 4-5 cm in length, while the German cockroach*, Blattella germanica* L. (Dictyoptera; Blattellidae) is light yellowish brown with length ranging from 1.0–2.5 cm (Rust *et al*., 1991). *Blattella germanica* are the most abundantly distributed cockroach species (Kwon and Chon, 1991; Tachbele *et al*., 2006). Cockroaches are among the varieties of medically important insects found in urban and rural environments that cause serious public health problems (Sramova *et al*., 1992; Graczyk *et al*., 2001, 2005). Cockroaches are often found in intimate association with human beings and are present in large numbers in and around houses, hospitals and in areas with unsanitary and insalubrious conditions (Oothuman *et al*., 1989; Boase, 1999). They have been found to harbour diverse pathogenic bacteria, different protozoan, pathogenic worms, fungi, and viruses on either the cuticle or in the gut (Cloarec *et al*., 1992; Khrustalyova, 1994). Cockroaches can carry up to 14 million bacteria on the body and 7 million in each of their faecal droppings (Bennett, 1993). *Salmonella typhi*, *Shigella dysenteriae* and toxigenic strains of *Escherichia coli* can be retained in the gut of cockroaches for up to several days (Stek, 1982).

The ranges of problems caused by cockroaches vary between hospitals, food-handling establishments, public institutions, and multi-family dwellings (Rivault *et al*., 1993). At the household level, a relationship has been established between cockroaches' infestation and standards of hygiene (Shah *et al*., 1996). Various studies have also revealed the aggregation of cockroaches in corners, kitchens, bathrooms and around plumbing connections within or between rooms (Rivault *et al*., 1993; Tanaka and Motoki, 1993). In hospitals, cockroaches can act as potential vectors in the epidemiology of nosocomial infections, especially the transmission of drug-resistant *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiella* spp and several other potential pathogens (Oothuman *et al*., 1989; Fotedar *et al*., 1991; Cotton *et al*., 2000). Studies have shown that of the 25 different species of medically important bacteria isolated from *Blattella germanica* and *Periplaneta americana* collected from public hospitals and a residential house in central Tehran, Iran, *Klebsiella* spp was the predominant bacteria (Tilahun *et al*., 2012).

Blattella germanica are repugnant because of their association with dirt, possible health risks in spreading diseases, tainting food odours, contaminating food and food processing environments (Mpuchane *et al*., 2006). Studies showed that many patients in China were allergic to *Blattella germanica* (Tsai and Chen, 1999). As cockroaches are engaged in their nocturnal forages, they drop off shed skins, nymphal shed skins and faecal pellets, thus, dissemination of infections is via faecal-oral route (Rivault *et al*., 1993; Pai *et al*., 2003, 2005). Cockroaches have been associated with an outbreak of dysentery (Burgess and Chetwyn, 1981). The aim of this study was to determine the prevalence of multidrug resistant bacteria isolated from external surfaces and internal guts of cockroaches (*Periplaneta americana* and *Blattella germanica*) collected in Uyo, Akwa Ibom State.

2. Material and methods

2.1. Study area

This study was carried out in Uyo. Uyo is a city in South-Southern Nigeria and the capital of Akwa Ibom State. The population is estimated to be about 451,128 and its geographic coordinates are latitudes 5° 02' 37" North and longitudes 7° 54' 06" East.

2.2. Collection and identification of cockroaches

One hundred and five cockroaches were captured during eight consecutive weeks from hospitals, human dwellings and canteens/restaurants using sterile hand-gloves and containers. These containers had been previously decontaminated using water and soap, then dried and disinfected with 70% alcohol. Only cockroaches caught whole and alive were considered in this study and the cockroaches were immobilized by freezing at 0^oC for 5mins. Identification of cockroaches was performed in accordance with a standard taxonomic key.

2.3. Isolation of surface-adhering bacteria

Isolation of surface-adhering bacterial isolates of the cockroaches was carried out by adding 5 ml of sterile normal saline (0.9%) into each sterile universal container with a cockroach and was shaken for 2mins. Aliquots (0.1ml) of the washing (external body homogenate sample) was inoculated onto plates of Blood Agar (BA) , Deoxycholate citrate agar (DCA), MacConkey Agar (MCA) , and Eosin methylene blue agar (EMB) and incubated for 18-24hrs at 37^oC. After overnight incubation, the colonies on the positive plates were sub cultured on Petri dishes containing freshly prepared nutrient media to obtain pure culture and incubated aerobically at 37^oC for 18-24hrs. Characteristics such as colour and colony shape were all noted in the typical appearance of bacteria on solid agar. Routine conventional laboratory techniques including Gram staining, motility, coagulase, catalase, oxidase , indole, urease production, citrate utilization, methyl red, Vogues Proskauer, spore formation, and carbohydrate fermentation tests such as mannitol, sucrose, glucose and lactose were all carried out using the methods described by Holt *et al* (1994); Cowan, (1999); Cheesbrough (2006).

2.4. Isolation of bacteria in the guts

After external body washing, decontamination of the external surfaces of the cockroaches was carried out by soaking in 90% ethanol for 5 mins. The cockroaches were further re-washed using sterile normal saline to remove the possible traces of ethanol. Digestive tract (gut) of each of the cockroaches was then removed using sterilized entomological instruments and the whole gut was homogenized in sterile normal saline and aliquot obtained. Zero point one (0.1) ml of the aliquot was then cultured onto plates of Blood agar, MacConkey Agar, Deoxycholate citrate agar and Eosin methylene blue agar and incubated aerobically for 18-24hrs at 37^oC. After overnight incubation, the colonies on the positive plates were subcultured onto Petri dishes containing freshly prepared nutrient media to obtain pure culture and incubated aerobically at 37^oC for 24hrs. Characteristics such as colour and colony shape were all noted in the typical appearance of bacteria on solid agar and routine conventional laboratory techniques described above were also carried out.

2.5. Antibiotic susceptibility testing

In vitro susceptibility of the bacterial isolates to twelve different antibiotics was determined using Kirby-Bauer disk-diffusion technique (Bauer *et al*., 1996). Sterile Petri – dishes of Mueller Hinton agar were prepared according to manufacturer's specification. Zero point one (0.1) ml of each morphologically identified bacterial isolates prepared directly from an overnight agar plate, equilibrated to match 0.5 McFarland Standard was inoculated onto each of the Petri dishes containing Mueller-Hinton agar and were allowed to stand for 30 mins to enable the inoculated organisms to pre-diffuse. The commercially available discs containing the following antibiotics: Penicillin (Pen, 10µg), Streptomycin (Stp, 10µg), Amoxicillin (Amx,10µg), Cephalothin (Cep,30µg), Ciprofloxacin (Cip, 5µg), Levofloxacin (Lev, 5µg) Sulfamethoxazole (Smx,25 µg); Chloramphenicol (Chl, 30 µg); Gentamicin (Gen,10 µg); Tetracycline (Tet, 30 µg) and Erythromycin (Ery, 15 µg) (Oxoid, UK) were aseptically placed onto the surfaces of the sensitivity agar plates with a sterile forceps and gently pressed to ensure even contact. The plates were incubated at 37°C over night and zones of inhibition after incubation were observed and the diameters of inhibition zones were measured in millimeters (mm) using a ruler. The interpretation of the measurement as sensitive and resistant was made according to the manufacturer's standard zone size interpretative manual. The intermediate readings were considered as sensitive for the assessment of the data. Percentage resistance was calculated using the formula $PR=a/b\times100$, *where 'PR'* was percentage resistance, '*a*' was the number of resistant isolates and '*b*' was the number of isolates tested with the antibiotic. The percentage sensitivity was calculated using the formula $PS=c/d\times100$, *where 'PS'* was percentage sensitivity, '*c*' was the number of sensitive isolates and '*d*' was the number of isolates tested with the antibiotic (Akinjogunla and Enabulele, 2010).

2.6. Determination of multiple antibiotic resistances (MAR) index

Multiple antibiotic resistance (MAR) index was determined using the formula $MAR=x/y$, where x was the number of antibiotics to which test isolate displayed resistance and y is the total number of antibiotics to which the test organism has been evaluated for sensitivity. Isolates that were resistant to three or more antibiotics were taken to be multiple antibiotics resistant.

3. Results

Fourteen (14) medically important bacterial species belonging to 12 genera were isolated from external surfaces and internal guts of one hundred and five (105) cockroaches consisting of sixty (60) *Periplaneta americana* and forty-five (45) *Blattela germanica* collected from the hospitals, human dwellings and canteens / restaurants. Of the 317 bacteria isolated from the external surfaces and internal guts of *P. americana*, 275 (86.8%) belonged to the group of Gram-negative bacilli, while 42 (13.2%) were Gram-positive bacteria (Table 1). Of the 204 bacterial isolates from *B. germanica,* 175 (85.8%) were Gram negative, while 29 (14.2%) were Gram positive bacteria (Table 2). 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 (Tables 1 and 2).

The results showed that < 9% *P. americana* and < 5% *B. germanica* harboured more than one bacterial isolate on their external surfaces. The most frequently isolated Gram negative bacterial isolate from both the external surfaces and internal guts of *P. americana* and *B. germanica* was *E. coli,* followed by *P. aeruginosa, K. pneumoniae* and *Salmonella* spp. Twenty-one *S. aureus* (6.6%), 12 (3.8%) Coagulase negative *Staphylococcus* spp and 9 (2.8%) *B. cereuses were* obtained from *P. americana. B. cereus,* the bacteria associated with food poisoning, was not isolated from *P. americana* and *B. germanica* collected from the hospitals, while between 1.8% to 3.1% *B. cereus* were found on the external surfaces of *P. americana* collected from human dwellings and canteen / restaurants (Tables 1 and 2). Highest numbers of the bacterial isolates were found in internal guts of *P. americana* and *B. germanica* collected from human dwellings, while the lowest numbers of the bacteria were found on the internal guts of *P. americana* and *B. germanica* collected from the hospitals (Tables 1 and 2).

Five hundred and twenty-one (521) bacteria from *P. americana* and *B. germanica* were evaluated for their susceptibility to antibiotics and between 72.2% to 82.3% bacterial isolates were sensitive to Cephalothin, Ciprofloxacin and Levofloxacin. Among the Gram positive bacteria isolated, only 75.8% *S. aureus* and 76.5% *B. cereus* were sensitive to Streptomycin and Gentamycin (Table 3). The bacteria resistance profiles to antibiotics in decreasing order were as follows: Chloramphenicol (41.7%), Amoxicillin (40.3%), Streptomycin (36.1%), Tetracycline (36.0%), Erythromycin (35.5%), Gentamicin (34.0%), Penicillin (34.6%), Cephalothin (27.8%), Sulfamethoxazole (23.4%), Ciprofloxacin (18.4%) and Levofloxacin (17.7%) (Table 4). The results showed that >50% of *E. cloacae* and *Providencia* spp were resistant to Streptomycin, while < 40% of *P. vulgaris, K. pneumoniae*, *P. mirabilis, P. aeruginosa* and Coagulase negative *Staphylococcus* spp were resistant to both Chloramphenicol and Sulfamethoxazole (Table 4). Overall, 353 (67.8%) of the bacterial isolates from *P. americana* and *B. germanica* demonstrated a multi drug resistant phenotype. Fifty-six (56) were single drug resistant, 76 (14.6%) were resistant to 2 antibiotics. Of the 353 multi drug resistant bacteria, 121 (23.2%) were resistant to three antibiotics, 232 (65.7%) were resistant to 4-10 antibiotics. The antibiotic resistant *Salmonella* spp., *Shigella* spp., *K. pneumoniae, C. freundii* and *P. mirabilis* had MAR indexes ranging from 0.27 to 0.82, while 2 (2.2%) *E. coli* had the highest MAR index of 0.91 (Table 5).

4. Discussion

Cockroaches are among the most notorious pests of premises, which do not only contaminate food by leaving droppings and cause food poisoning but also transmit bacteria and other pathogenic microorganisms in infested areas (Kopanic, 1994; Czajka *et al*., 2003). Cockroaches feed indiscriminately on garbage and sewage and so have copious opportunity to disseminate human pathogens (Cotton *et al*. 2000, Pai *et al*., 2005) In this study all the *P. americana* and *B. germanica* collected from the hospitals, human dwellings and canteens / restaurants were found to carry various bacterial isolates of medical importance in their external surfaces and internal guts and this is in agreement with Fotedar *et al*. (1991) who reported the array of pathogenic microorganisms carried by the cockroaches collected from domestic, hospital and restaurants. Cockroaches' nocturnal and filthy habits make them ideal carriers of various pathogenic microorganisms (Graczyk *et al*., 2005).

Table 1
Distribution of Bacteria Isolated from *Periplaneta Americana.*

	Hospitals		Human Dwellings		Canteens / Restaurants		
Bacterial	**External**	**Gut**	**External**	**Gut**	**External**	**Gut**	**Total**
Isolates	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)
Salmonella spp	5 (12.8)	5 (9.4)	4 (7.0)	9 (13.8)	5 (11.4)	7(11.9)	35 (11.0)
Shigella spp	2 (5.1)	4 (7.5)	3 (5.3)	5 (7.7)	2 (4.5)	2 (3.4)	18 (5.7)
Staphylococcus aureus	6 (15.4)	1 (1.9)	5 (8.8)	3 (4.6)	4 (9.1)	2 (3.4)	21 (6.6)
CoN *Staphylococcus* spp	2 (5.1)	1 (1.9)	3 (5.3)	2 (3.1)	2 (4.5)	2 (3.4)	12 (3.8)
Bacillus cereus	0 (0.0)	0 (0.0)	1 (1.8)	2 (3.1)	1 (2.3)	5 (8.5)	9 (2.8)
Escherichia coli	9 (23.1)	11 (20.8)	9 (15.8)	13(20.0)	8 (18.2)	8 (13.6)	58 (18.3)
Pseudomonas aeruginosa	3 (7.7)	5 (9.4)	6 (10.5)	6 (9.2)	4 (9.1)	6 (10.2)	30 (9.5)
Klebsiella pneumoniae	4 (10.3)	7 (13.2)	7 (12.3)	6 (9.2)	4 (9.1)	6 (10.2)	34 (10.7)
Citrobacter freundii	2 (5.1)	4 (7.5)	5 (8.8)	4 (6.2)	7 (15.9)	4 (6.8)	26 (8.2)
Morganella morganii	0 (0.0)	2 (3.8)	1 (1.8)	2 (3.1)	1 (2.3)	2 (3.4)	8 (2.5)
Proteus vulgaris	4 (10.3)	5 (9.4)	6 (10.5)	4 (6.2)	3 (6.8)	6 (10.2)	28 (8.8)
Proteus mirabilis	2 (5.1)	5 (9.4)	4 (7.0)	4 (6.2)	2 (4.5)	4 (6.8)	21 (6.6)
Enterobacter cloacae	0 (0.0)	1 (1.9)	1 (1.8)	2 (3.1)	0 (0.0)	3 (5.1)	7 (2.2)
Providencia spp	0 (0.0)	2 (3.8)	2 (3.5)	3 (4.6)	1 (2.3)	2 (3.4)	10 (3.2)
Total	39 (100)	53 (100)	57 (100)	65 (100)	44 (100)	59 (100)	317 (100)

CoN: Coagulase negative; Values in parenthesis are percentages.

Table 2
Distribution of Bacteria Isolated from *Blattela germanica.*

Bacterial Isolates	Hospitals External No. (%)	Hospitals Gut No. (%)	Human Dwellings External No. (%)	Human Dwellings Gut No. (%)	Canteens / Restaurants External No. (%)	Canteens / Restaurants Gut No. (%)	Total No. (%)
Salmonella spp	2 (10.5)	3 (8.6)	0 (0.0)	2 (4.4)	0 (0.0)	4 (9.5)	11 (5.4)
Shigella spp	0 (0.0)	2 (5.7)	2 (5.4)	4 (8.9)	2 (7.7)	2 (4.8)	12 (5.9)
Staphylococcus aureus	2 (10.5)	0 (0.0)	3 (8.1)	2 (4.4)	4 (15.4)	1 (2.4)	12 (5.9)
CoN *Staphylococcus* spp	3 (15.8)	2 (5.7)	2 (5.4)	0 (0.0)	2 (7.7)	0 (0.0)	9 (4.4)
Bacillus cereus	0 (0.0)	0 (0.0)	1 (2.7)	2 (4.4)	1 (3.8)	4 (9.5)	8 (3.9)
Escherichia coli	4 (21.1)	7 (20.0)	4 (10.8)	9 (20.0)	5 (19.2)	5 (11.9)	34 (16.7)
Pseudomonas aeruginosa	2 (10.5)	5 (14.3)	4 (10.8)	6 (13.3)	3 (11.5)	6 (14.3)	26 (12.7)
Klebsiella pneumoniae	3 (15.8)	5 (14.3)	5 (13.5)	2 (4.4)	3 (11.5)	6 (14.3)	24 (11.8)
Citrobacter freundii	2 (10.5)	4 (11.4)	5 (13.5)	4 (8.9)	0 (0.0)	2 (4.8)	17 (8.3)
Morganella morganii	0 (0.0)	1 (2.9)	1 (2.7)	2 (4.4)	0 (0.0)	1 (2.4)	5 (2.5)
Proteus vulgaris	0 (0.0)	2 (5.7)	4 (10.8)	4 (8.9)	3 (11.5)	4 (9.5)	17 (8.3)
Proteus mirabilis	1 (5.3)	3 (8.6)	4 (10.8)	4 (8.9)	2 (7.7)	4 (9.5)	18 (8.8)
Enterobacter cloacae	0 (0.0)	1 (2.9)	1 (2.7)	2 (4.4)	0 (0.0)	3 (7.1)	7 (3.4)
Providencia spp	0 (0.0)	0 (0.0)	1 (2.7)	2 (4.4)	1 (3.8)	0 (0.0)	4 (2.0)
Total	19 (100)	35 (100)	37 (100)	45 (100)	26 (100)	42 (100)	204 (100)

CoN: Coagulase negative; Values in parenthesis are percentages

Table 3
Antibiotic Sensitivity Profiles of Bacterial Isolates obtained from Cockroaches (*P. americana* and *B. germanica*).

Bacterial Isolates	**No. of Isolates**	**Pen No. (%)**	**Stp No. (%)**	**Gen No. (%)**	**Chl No. (%)**	**Tet No. (%)**	**Sxt No. (%)**	**Amy No. (%)**	**Ery No. (%)**	**Cep No. (%)**	**Cip No. (%)**	**Lev No. (%)**
Salmonella spp	46	29(63.0)	29(63.0)	31(67.4)	22 (47.8)	27(58.7)	34(74.0)	26(56.5)	28(60.9)	34(73.9)	37(80.4)	39(84.8)
Shigella spp	30	19(63.3)	22(73.3)	22(73.3)	15 (50.0)	20(66.7)	24(80.0)	18(60.0)	14(46.7)	24(80.0)	27(90.0)	25(83.3)
Staphylococcus aureus	33	24(72.7)	25(75.8)	25(75.8)	18 (54.5)	25(75.8)	26(78.8)	21(63.6)	24(72.7)	25(75.8)	30(90.9)	26(78.8)
CoN *Staphylococcus* spp	21	16(76.2)	12(57.1)	10(47.6)	14 (66.7)	14(66.7)	18(85.7)	15(71.4)	18(85.7)	12(57.1)	17(81.0)	18(85.7)
Bacillus cereus	17	10(58.8)	13(76.5)	13(76.5)	7 (41.2)	11(64.7)	14(82.4)	9(52.9)	7(41.2)	14(82.4)	15(88.2)	14(82.4)
Escherichia coli	92	68(73.9)	65(70.6)	65(70.6)	53 (57.6)	65(70.6)	77(83.7)	60(65.2)	70(76.1)	71(77.2)	84(91.3)	84(91.3)
Pseudomonas aeruginosa	56	38(67.9)	34(60.7)	32(57.1)	35 (62.5)	39(69.6)	47(83.9)	33(58.9)	40(71.4)	33(58.9)	44(78.6)	46(82.1)
Klebsiella pneumoniae	58	43(74.1)	40(69.0)	38(65.5)	38 (65.5)	32(55.2)	43(74.1)	33(56.9)	39(67.2)	42(72.4)	42(72.4)	42(72.4)
Citrobacter freundii	43	24(55.8)	20(46.5)	28(65.1)	22 (51.1)	25(58.1)	30(69.8)	27(62.8)	23(53.4)	23(53.4)	32(74.4)	32(74.4)
Morganella morganii	13	8(61.5)	9(69.2)	6(46.2)	6 (46.2)	6(46.2)	9(69.2)	6(46.2)	8(61.5)	10(76.9)	8(61.5)	10(76.9)
Proteus vulgaris	45	27(60.0)	23(51.1)	32(71.1)	27 (60.0)	22(48.9)	30(66.7)	29(64.4)	29(64.4)	34(75.6)	39(86.7)	39(86.7)
Proteus mirabilis	39	24(61.5)	27(69.2)	24(61.5)	30 (76.9)	27(69.2)	29(74.4)	21(53.8)	19(48.7)	33(84.6)	30(76.9)	32(82.1)
Enterobacter cloacae	14	7(50.0)	7(50.0)	10(71.4)	9 (64.3)	11(78.6)	9(64.3)	6(42.9)	7(50.0)	10(71.4)	10(71.4)	12(85.7)
Providencia spp	14	9(64.3)	7(50.0)	8(57.1)	8 (57.1)	10(71.4)	9(64.3)	7(50.0)	10(71.4)	11(78.6)	10(71.4)	10(71.4)
Total	521	346(66.4)	333(63.9)	344(66.0)	304 (58.3)	334(64.0)	399(76.6)	311(59.7)	336(64.5)	376(72.2)	425(81.6)	429(82.3)

Penicillin: Pen; Streptomycin: Stp; Gentamicin: Gen; Chloramphenicol: Chl; Tetracycline: Tet; Sulfamethoxazole: Sxt; Amoxicillin: Amy; Erythromycin: Ery; Cephalothin: Cep; Ciprofloxacin: Cip; Levofloxacin: Lev; Values in parenthesis are percentages

Table 4
Antibiotic Resistance Profiles of Bacterial Isolates obtained from Cockroaches (*P. americana* and *B. germanica*).

Bacterial Isolates	No. of Isolates	Pen No. (%)	Stp No. (%)	Gen No. (%)	Chl No. (%)	Tet No. (%)	Sxt No. (%)	Amy No. (%)	Ery No. (%)	Cep No. (%)	Cip No. (%)	Lev No. (%)
Salmonella spp	46	17(37.0)	17(37.0)	15(32.6)	24 (52.2)	19(41.3)	12(26.0)	20(43.5)	18(39.1)	12(26.1)	9(19.6)	7(15.2)
Shigella spp	30	11(36.7)	8(26.7)	8(26.7)	15 (50.0)	10(33.3)	6(20.0)	12(40.0)	16(53.3)	6(20.0)	3(10.0)	5(16.7)
Staphylococcus aureus	33	9(27.3)	8(24.2)	8(24.2)	15 (45.5)	8(24.2)	7(21.2)	12(36.4)	9(27.3)	8(24.2)	3(9.1)	7(21.2)
CoN *Staphylococcus* spp	21	5(23.8)	9(42.9)	11(52.4)	7 (33.3)	7(33.3)	3(14.3)	6(28.6)	3(14.3)	9(42.9)	4(19.0)	3(14.3)
Bacillus cereus	17	7(41.2)	4(23.5)	4(23.5)	10(58.8)	6(35.3)	3(17.6)	8(47.1)	10(58.8)	3(17.6)	2(11.8)	3(17.6)
Escherichia coli	92	24(26.1)	27(29.4)	27(29.4)	39 (42.4)	27(29.4)	15(16.3)	32(34.8)	22(23.9)	21(22.8)	8(8.7)	8(8.7)
Pseudomonas aeruginosa	56	18(32.1)	22(39.3)	24(42.9)	21(37.5)	17(30.4)	9(16.1)	23(41.1)	16(28.6)	23(41.1)	12(21.4)	10(17.9)
Klebsiella pneumoniae	58	15(25.9)	18(31.0)	20(34.5)	20(34.5)	26(44.8)	15(25.9)	25(43.1)	19(32.8)	16(27.6)	16(27.6)	16(27.6)
Citrobacter freundii	43	19(44.2)	23(53.5)	15(34.9)	21(48.9)	18(41.9)	13(30.2)	16(37.2)	20(46.6)	20(46.6)	11(25.6)	32(74.4)
Morganella morganii	13	5(38.5)	4(30.8)	7(53.8)	7(53.8)	7(53.8)	4(30.8)	7(53.8)	5(38.5)	3(23.1)	5(38.5)	3(23.1)
Proteus vulgaris	45	18(40.0)	22(48.9)	13(28.9)	18(40.0)	23(51.1)	15(33.3)	16(35.6)	16(35.6)	11(24.4)	6(13.3)	6(13.3)
Proteus mirabilis	39	15(38.5)	12(30.8)	15(38.5)	9(23.1)	12(30.8)	10(25.6)	18(46.2)	20(51.3)	6(15.4)	9(23.1)	7(17.9)
Enterobacter cloacae	14	7(50.0)	7(50.0)	4(28.6)	5(35.7)	3(21.4)	5(35.7)	8(57.1)	7(50.0)	4(28.6)	4(28.6)	2(14.3)
Providencia spp	14	5(35.7)	7(50.0)	6(42.9)	6(42.9)	4(28.6)	5(35.7)	7(50.0)	4(28.6)	3(21.4)	4(28.6)	4(28.6)
Total	521	175(33.6)	188(36.1)	177(34.0)	217(41.7)	187(36.0)	122(23.4)	210(40.3)	185(35.5)	145(27.8)	96(18.4)	92(17.7)

Penicillin: Pen; Streptomycin: Stp; Gentamicin: Gen; Chloramphenicol: Chl; Tetracycline: Tet; Sulfamethoxazole: Sxt; Amoxicillin: Amy; Erythromycin: Ery; Cephalothin: Cep; Ciprofloxacin: Cip; Levofloxacin: Lev; Values in parenthesis are percentages

Table 5
Multidrug Resistant Resistance (MAR) Index of Bacterial Isolates obtained from Cockroaches (*P. americana* and *B. germanica*).

MAR	**Number / Percentage (%)**														
INDEX	**SS**	**SH**	**EC**	**CN**	**BC**	**SA**	**PA**	**KP**	**CF**	**MM**	**PV**	**PM**	**EN**	**PS**	**Total (%)**
0.0	9(19.6)	1(3.3)	15(16.3)	3(14.3)	1(5.9)	2(6.1)	1(1.8)	1(1.7)	-	-	-	1(2.6)	1(7.1)	1(7.1)	36(6.9)
0.09	5(10.9)	4(13.3)	19(20.7)	1(4.8)	1(5.9)	8(24.2)	7(12.5)	2(3.4)	1(2.3)	-	1(2.2)	5(12.8)	1(7.1)	1(7.1)	56(10.7)
0.18	4(8.7)	8(26.7)	10(10.9)	2(9.5)	3(17.6)	3(9.1)	10(17.6)	11(19.0)	4(9.3)	2(15.4)	6(13.3)	12(30.8)	-	1(7.1)	76(14.6)
0.27	6(13.0)	6(20.0)	15(16.3)	6(28.6)	5(29.4)	9(27.3)	14(25.0)	20(34.5)	9(20.9)	2(15.4)	19(42.2)	2(5.1)	5(35.7)	3(21.4)	121(23.2)
0.36	4(8.7)	4(13.3)	15(16.3)	4(19.0)	2(11.8)	6(18.2)	6(10.7)	13(22.4)	13(30.2)	2(15.4)	8(17.8)	7(17.9)	1(7.1)	1(7.1)	86(16.5)
0.45	4(8.7)	2(6.7)	6(6.5)	3(14.3)	2(11.8)	3(9.1)	10(17.6)	5(8.6)	6(14.0)	5(38.5)	7(15.6)	5(12.8)	2(14.3)	3(21.4)	63(12.1)
0.54	7(15.2)	1(3.3)	6(6.5)	1(4.8)	1(5.9)	1(3.0)	5(8.9)	3(5.2)	5(11.6)	1(7.7)	1(2.2)	5(12.8)	2(14.3)	4(28.6)	43(8.3)
0.64	1(2.2)	3(10.0)	2(2.2)	1(4.8)	2(11.8)	-	2(3.6)	1(1.7)	2(4.7)	-	2(4.4)	1(2.6)	2(14.3)	-	19(3.4)
0.73	2(4.3)	-	2(2.2)	-	-	1(3.0)	1(3.0)	1(1.7)	2(4.7)	1(7.7)	1(2.2)	-	-	-	11(2.1)
0.82	4(8.7)	1(3.3)	-	-	-	-	-	1(1.7)	1(2.3)	-	-	1(2.6)	-	-	8(1.5)
0.91	-	-	2(2.2)	-	-	-	-	-	-	-	-	-	-	-	2(0.4)

SS: *Salmonella* spp; SH: *Shigella* spp; EC: *Escherichia coli* ; CN: CON *Staphylococcus* spp; BC: *Bacillus cereus*; SA: *Staphylococcus aureus ;* PA: *Pseudomonas aeruginosa* ; KP*: Klebsiella pneumoniae*; CF: *Citrobacter freundii;* MM*: Morganella morganii;* PV: *Proteus vulgaris;* PM: *Proteus mirabilis;* EN: *Enterobacter cloacae;* PS: *Providencia* spp.

Isolation of Gram-negative bacilli such as *Salmonella* spp, *Shigella* spp, *E. coli, P. aeruginosa, K. pneumoniae, E. cloacae* and *Providencia* spp from the external surfaces and internal guts of *P. americana* in this study agrees with Fotedar *et al*, (1991); Cloarec *et al*, (1992); Rivault *et al*, (1993). The occurrence of *Salmonella* spp in the cockroaches collected in this study also confirms the reports of Agbodaze and Owusu (1989); Devi and Murray (1991). *Salmonella* has also been isolated from different species of cockroaches found in hospitals, restaurants, residents, schools, animal shelters throughout the world (Cotton *et al*., 2000; Prado *et al*., 2002; Fathpouer *et al*., 2003). The isolation of *Salmonella* spp in the internal gut of cockroach intestine suggested them as a major reservoir of *Salmonella*. Paul (1992) reported the presence of *Shigella* spp. in cockroaches found in hospitals, restaurants and a residence indicating their importance in the dissemination of the bacterium and this study confirms it. Various bacteria were obtained in cockroaches collected from the hospitals and this shows that the hospital environments provide them with suitable temperature, humidity and food. *Klebsiella pneumoniae* were isolated from *P. americana* and *B. germanica* collected in the hospitals and this is in conformity with Cotton *et al. (*2000) who suggested that cockroaches are possible vectors of *Klebsiella pneumoniae* in the hospital environment.

The results of the antibiotics susceptibility in this study showed that bacterial isolates were highly sensitive to ciprofloxacin and this is in agreement with Tilahun *et al*. (2012). Low resistance of *P. aeruginosa* to Ciprofloxacin agrees with Tilahun *et al*. (2012). *Staphylococcus* aureus and Coagulase negative *Staphylococcus* spp from cockroaches showed significantly sensitivity to Gentamicin and Erythromycin and this is in contrary to Bouamama *et al*. (2010). The bacterial isolates from *P. americana* and *B. germanica* demonstrated a multi drug resistant phenotype. Multidrug resistant *C. freundii, M. morganii, Salmonella* spp. and *Enterobacter cloacae* with MAR index ranging from 0.27 to 0.82 were obtained in this study. Isolation of multi-drug resistant *Salmonella* spp from cockroaches has been reported by Prado *et al. (*2002) and this study confirmed it, while Khadka *et al.* (2011) reported the occurrence of multi-drug resistant *Citrobacter freundii* in cockroaches.

5. Conclusion

In conclusion, areas containing waste refuse and excreta of humans and domestic animals might provide ideal conditions for the breeding and multiplication of these synanthropic insects, thus, pest control regulations, elimination of cockroaches from sensitive areas, such as hospitals, food-handling establishments and human dwellings should be adopted.

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