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BACTERIA INFESTATION OF COCKROACHES IN BALI METROPOLIS, TARABA STATE, NIGERIA

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ABSTRACT

A research was undertaken between June and September 2023 in Bali metropolis, Taraba State, Nigeria, aiming to explore the bacterial species harboured by cockroaches. This investigation involved the isolation and identification of microorganisms from the outer surfaces and digestive systems of cockroaches captured from various households across the study area. Of the 100 cockroaches (*Periplaneta americana*) captured, 64 were found to be contaminated with bacteria, resulting in an overall prevalence rate of 56%. Notably, cockroaches captured from toilets exhibited a higher contamination prevalence (64.86%) compared to those from kitchens (58.06%), bedrooms (50.00%), and parlors (33.33%). Moreover, bacterial contamination was more pronounced in the alimentary canals (54.69%) than on the external body surfaces (45.31%), although no statistically significant difference in contamination was observed between the body surfaces ($p>0.05$). The identified bacterial species included *Escherichia coli*, *Klebsiella pneumoniae*, *Proteus* sp., *Pseudomonas aeruginosa*, *Salmonella* sp., and *Staphylococcus aureus*, with *E. coli* being the predominant isolate (25%) on both external and internal body surfaces of cockroaches, followed by *Klebsiella* sp. (23.44%), while *Staphylococcus aureus* exhibited the lowest occurrence (7.81%). Furthermore, cockroaches captured from toilets had a higher mean bacterial load (51.7 $x10^4$ cfu/ml) compared to those from kitchens (39.3 $x10^4$ cfu/ml), parlors (22.1 $x10^4$ cfu/ml), and bedrooms (19.9 $x10^4$ cfu/ml). These findings underscore the role of cockroaches as carriers of bacterial pathogens, emphasizing the necessity for control measures to mitigate cockroach-related infections.

Keywords: Bacteria, Bali metropolis, Cockroaches, Contamination, Pathogens.

INTRODUCTION

Cockroaches, classified under the order Blattodea, represent one of the most prevalent household pests, posing both psychological and health-related concerns for humans (Tyagi, 2003). These insects are characterized by their flattened, oval bodies, equipped with two pairs of wings, antennae, and typically range in colour from light brown to black, with sizes varying from 2-3 mm to exceeding 80 mm in length. Known for their swift movement, cockroaches possess six robust legs adorned with spines (Tyagi, 2003). Their presence spans across the globe (Ojiezeh and Ogundipe, 2015), with an estimated 3500 species, out of which approximately 30 inhabit human dwellings (Kinfu and Erko, 2008), with less than 1% considered as widespread pests (El-Sherbini and El-Sherbini, 2001). Certain species, such as the American (*Periplaneta americana*), German (*Blattella germanica*), Asian (*Blattella asahinai*), and oriental cockroaches (*Blatta orientalis*), have successfully adapted to human

environments (Pai *et al*., 2003), proliferating as pests in residences and other structures where food sources are abundant (Bell *et al*., 2007).

They primarily inhabit buildings, favouring warm, dark, and humid environments, particularly areas like kitchens, toilets, drainage systems, and even sewage facilities. These conditions provide ideal habitats for cockroaches, which coincidentally also create favourable environments for pathogens such as bacteria and parasites (Isaac *et al*., 2014; Nasirian, 2017). Cockroaches are omnivorous, consuming a variety of substances including garbage, decomposing food, organic matter in various stages of decay, human waste, and even faecal matter from other cockroaches (Jeffery *et al*., 2012; Feleke *et al*., 2016). Throughout the day, these insects seek refuge in secluded spots like gaps or cracks in walls and other dark crevices, becoming active at night when they can scavenge for food without detection (Lihoreau *et al*., 2012).

The American cockroach (*P. americana*) is the predominant species associated with household infestations in Nigeria, followed by the German cockroach (*B. germanica*) (Etim *et al*., 2013). Particularly in Bali town, Taraba State, Nigeria, *Periplaneta americana* is the prevalent insect pest found in metropolitan areas due to its frequent sightings in various household locations such as kitchens, toilets, bedrooms, parlors, sewage systems, and waste disposal sites (Elijah and Lamidi, 2023).

Due to their nocturnal and unsanitary behaviours, cockroaches serve as efficient carriers of pathogens, particularly bacteria, including *Klebsiella pneumonia, Enterobacter cloacae, Enterobacter aerogenes, Salmonella* spp., *Shigella* spp., *Vibrio cholerae, and Citrobacter freundii* (Iboh *et al*., 2014). Research by Pai *et al*. (2005) and Nwankwo *et al*. (2016), has documented the isolation of various bacterial species such as *Staphylococcus aureus, Streptococcus* spp., *Enterobacteriaceae, Pseudomonas aeruginosa, Bacillus* spp., *Escherichia coli, Klebsiella* spp., *Proteus vulgaris, Proteus mirabilis, Shigella* spp., and *Salmonella* spp. from cockroaches, both externally and internally. Studies conducted in Gondar Town, Ethiopia, by Feleke *et al*. (2016), similarly identified a range of bacterial species including *S. aureus, E. coli, Citrobacter* spp., *Enterobacter* spp., *K. pneumoniae*, other *Klebsiella* spp., *Shigella* spp., *Providencia* spp., *Serratia* spp., *Proteus* spp., and *Salmonella* spp.

Furthermore, investigations in Iran by Fathpour *et al*. (2003), found that 70% of cockroaches collected from hospitals harboured *Salmonella* spp., with some isolates demonstrating resistance to antimicrobial drugs.

Cockroaches have been explored as a viable source of nutrition for humans and as a suitable dietary option for livestock (Sikkema, 2015). Among cockroach species, the American cockroach is notably considered edible, particularly in countries like China, where they are bred in controlled environments, marketed to farmers for animal feed, and sold to the public for consumption, medicinal purposes, or as a tonic (Sikkema, 2015; Demick, 2013; Malcolm, 2013). However, despite their potential as a food source, the presence of cockroaches poses significant health risks to humans, livestock, and the surrounding environment (Alzain, 2013). Therefore, the aim of this study was to investigate and identify the bacterial species carried by cockroaches in Bali metropolis, Taraba State, Nigeria.

MATERIALS AND METHODS

Study Area

Bali local government area of Taraba State lies between latitude 7°46 N and 7°54 N of the equator and longitude 10°30 E and 11° 00 E of the prime meridian (Bureau for land and survey Jalingo, 1968). It is found in dry guinea savannah. It is the largest local Government in Taraba State, with an estimated land area of 11,540 km2. It has some mountains like Gazabu, Dakka, Maihula, Bagoni, among others. Bali local Government had a population of about 211,024 persons (NPC, 2006). It has a tropical climate marked by two seasons; dry and rainy seasons. The rainy season starts around April and ends November occasionally, with 1350 – 1500mm rainfall annually. The dry season is from December to March. Daily temperature varies from 37 to 40°C during the hottest months of March/April. It also varies from 32 to 37oC during the coldest months of December/January. The relative humidity is about 23.00 % during the hot dry weather and can reach 80.00 % during the peak of wet season in July/August (Dammo *et al*., 2015; Wikipedia, 2015). The major ethnic groups in the area include; Jibawa, Tiv, Chamba, Fulani, Hausa, Itchen etc. The major occupation of the inhabitants is farming, fishing and nomadism. In addition, Public servants, traders and artisans also inhabit the area. Their water sources for domestic and agricultural uses are River Taraba, Borehole, ponds and wells.

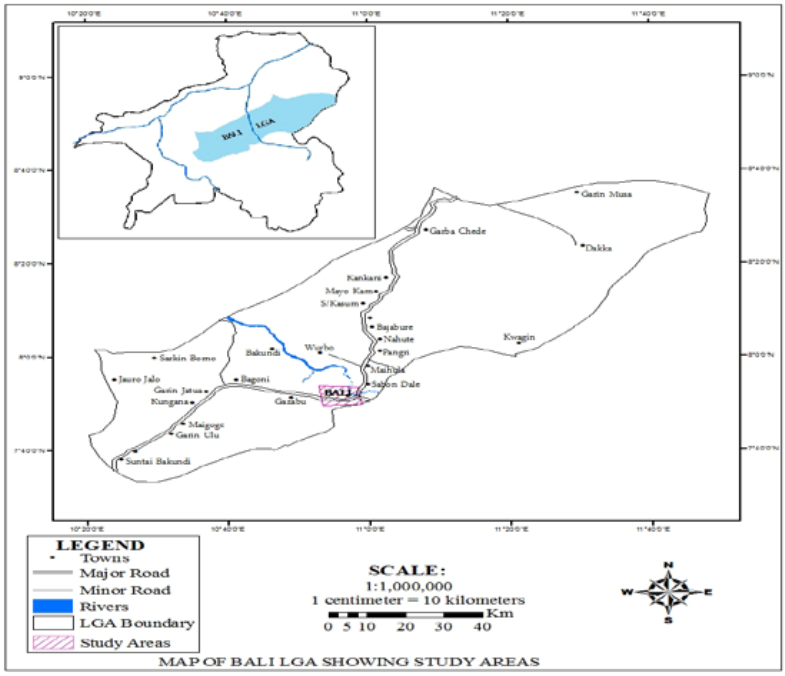

Figure 1: Map of the study Area
(Source: Bureau for land and survey Jalingo, Taraba State, 2019)

Cockroach Sampling

One hundred (100) adult cockroaches were randomly captured from various areas within households, including bedrooms, parlors, kitchens, and toilets, utilizing a combination of sticky traps and manual catch methods with sterile hand gloves, following the techniques outlined by Jirage (2018) and Sosan *et al*. (2019). The collections occurred once monthly from June to September 2023, during the time frame of 6:00 pm to 7:00 am, until the desired sample size

was attained. Each cockroach was individually placed in a sterile, labelled plastic container containing a killing agent (cotton wool soaked in 10% chloroform) and then transported to the Biology laboratory, Department of Science Laboratory Technology, Federal Polytechnic Bali, Taraba State, Nigeria, for subsequent sorting and bacteriological examination.

Culture, Isolation and Identification of Bacteria from External Body Surface and Gut Content of Cockroaches

External Body Surface

To each sterile universal container containing a cockroach, 5 ml of sterile normal saline was introduced and vigorously agitated. Subsequently, the cockroaches were extracted from the washing solutions using sterile forceps and left to air-dry at ambient room temperature. A loopful of each suspension was then inoculated onto various culture media including Mac Conkey agar, Eosin Methylene Blue agar, blood agar, deoxycholate citrate agar (DCA), and Salmonella Shigella agar (SSA), following the methodology outlined by Tatfeng *et al*. (2005). The inoculated plates were then incubated at 37°C for 24 hours. Bacterial colonies grown on the selective media were further purified and characterized through microscopic examination, observation of colonial morphology, Gram staining, and some biochemical tests including oxidase, catalase, coagulase, indole, methyl red (MR), and Voges–Proskauer (VP), as described by Cheesbrough (2006).

Gut Content

Following external washing, the cockroaches underwent a 5-minute rinse with 70% alcohol in a sterile container to disinfect their surfaces. Subsequently, they were transferred to a sterile petri dish and allowed to air-dry under sterile conditions at room temperature. Once dried, they were rinsed with normal saline for 3 minutes to eliminate any residual alcohol. The cockroaches were then dissected, and the entire gut contents were transferred into 5 ml of sterile normal saline, where they were aseptically macerated using a sterile pestle and mortar, as described by Brown and Alhassan (2015). A loopful of each macerated saline was then streaked onto the surfaces of various agar media including MacConkey agar, Eosin Methylene Blue agar, blood agar, deoxycholate citrate agar (DCA), and Salmonella Shigella agar (SSA), following the procedures outlined by Tatfeng *et al*. (2005) and Moges *et al*. (2016). The inoculated plates were subsequently incubated at 37°C for 24 hours. Bacterial colonies grown on the media were further purified and characterized through microscopic examination, observation of colonial morphology, Gram staining, and a series of biochemical tests including oxidase, catalase, coagulase, indole, methyl red (MR), and Voges–Proskauer (VP), as detailed by Cheesbrough (2006).

Total viable count

Each previous suspension of the external body surface and internal gut content of cockroaches underwent a ten-fold serial dilution to ascertain the total viable count of each cockroach on Nutrient agar, employing the pour plate technique. Enumeration was performed on plates exhibiting distinct and evenly dispersed colonies, using a colony counter (Model No.AVI659).

Statistical Analysis

Descriptive statistics were used to analyse the prevalence of bacteria species on cockroaches obtained from various locations within the household while chi-square ($\chi 2$) test was used to analysed the differences in the distribution of bacteria between the external body surface and gut content of cockroaches. $P < 0.05$ was considered statistically significant.

RESULTS AND DISCUSSION

Results

Table 1: Prevalence and distribution of bacterial contamination of cockroaches in relation to captured sites

Sites	No. of cockroach examined	No. of cockroach contaminated (%)
Parlor	12	4 (33.33)
bedroom	20	10 (50.00)
Kitchen	31	18 (58.06)
Toilet	37	24 (64.86)
Total	100	56 (56)

Table 2: Distribution of bacterial isolate identified from external body surface and gut content of cockroaches (n=100)

Bacteria Isolate	Gut Content	External Body Surface	Total No. of Bacteria Isolated (%)
	No. of Bacteria Isolated (%)	No. of Bacteria Isolated (%)	
Escherichia coli	12 (75.00)	4 (25.00)	16 (25.00)
Klebsiella pneumoniae	10 (66.67)	5 (33.33)	15 (23.44)
***Proteus* sp.**	3 (42.86)	4 (57.14)	7 (10.94)
Pseudomonas aeruginosa	3 (25.00)	9 (75.00)	12 (18.75)
***Salmonella* sp.**	4 (50.00)	5 (62.50)	9 (14.06)
Staphylococcus aureus	3 (60.00)	2 (40.00)	5 (7.81)
Total	35 (54.69)	29 (45.31)	64 (100)
	*	*	

χ^2 calculated = 8.65; χ^2 tabulated = 11.07, df= 5, p>0.05, ***** = Statistically insignificant

Table 3: Mean bacterial load of cockroaches in relation to captured sites

Sites	Mean bacteria load (cfu/ml)
Parlor	22.1 x10^4
bedroom	19.9 x10^4
Kitchen	39.3 x10^4
Toilet	51.7 x10^4

A total of one hundred (100) cockroaches were captured from various locations within households in the study area for bacteriological assessment. Our findings indicated that 64 cockroaches were contaminated with pathogenic bacteria, resulting in an overall prevalence rate of 56% (Table 1). Cockroaches captured from toilets exhibited a higher contamination prevalence (64.86%) compared to those caught from kitchens (58.06%), bedrooms (50.00%), and parlors (33.33%) (Table 1). Table 2 illustrates the diverse pathogens isolated from both the external body surface and alimentary canals of the examined cockroaches. It was observed that a greater number of pathogens were isolated from the alimentary canal (gut content) of cockroaches (54.69%) compared to the external body surface (45.31%). However, there was

no statistically significant difference in contamination between the body surfaces ($p>0.05$). Additionally, a total of six bacterial species, including *Escherichia coli, Klebsiella pneumoniae*, *Proteus* sp., *Pseudomonas aeruginosa*, *Salmonella* sp., and *Staphylococcus aureus*, were isolated from both external and internal body surfaces of the examined cockroaches. *E. coli* (25%) emerged as the predominant bacterial isolate from both external and internal body surfaces of cockroaches, followed by *Klebsiella* sp. (23.44%), with *Staphylococcus aureus* being the least prevalent (7.81%) (Table 2).

The average heterotrophic bacterial load of cockroaches varied depending on their capture sites. Cockroaches captured from toilets exhibited a higher bacterial load, averaging 51.7×10^4 cfu/ml, whereas those collected from bedrooms had the lowest load, averaging 19.9×10^4 cfu/ml (Table 3).

Discussion

The six (6) bacterial species identified in our study closely resemble those reported by Nwankwo *et al*. (2016) in Umuahia, Abia State, Nigeria, with the exception of *Bacillus* sp., which was absent in our findings. This similarity may stem from the fact that, regardless of their species or location, cockroaches tend to exhibit consistent behavioral patterns (Tatfeng *et al*., 2005). Tilahun *et al*. (2012) and Nagham *et al*. (2011) have emphasized that such organisms have the potential to cause urinary tract infections, sepsis, gastroenteritis, as well as infections in the biliary and peritoneal areas. *E. coli* and *S. aureus* have been implicated in causing diarrhea and hospital-acquired infections, respectively (Bouamama *et al*., 2010; Akindele *et al*., 2012). Our findings revealed that *E. coli* was the predominant bacterium (25%) on both internal and external body surfaces, followed by *Klebsiella* sp. (23.44%). This differs from the previous report by Feleke *et al*. (2016), who found *Klebsiella pneumoniae* (17.7%) to be the primary isolate from cockroach surfaces, followed by *E. coli* (16%). Nonetheless, these are all similar bacterial species. Moreover, six bacterial species isolated in our studies, conflicts with the report by Isaac *et al*. (2014) in Edo State, Nigeria, who identified ten species of bacteria. This inconsistency suggests varying sanitary conditions in these areas, as observed by Isaac *et al*. (2014), who noted inadequate waste disposal agencies and facilities in Benin City, leading to prolonged stays of waste bins at collection points, allowing cockroaches to feast on garbage and become infested with various pathogens that may contaminate nearby households' food items.

The higher bacterial load observed in cockroaches trapped from toilets aligns with the findings of Nwankwo *et al*. (2016), who suggested that bacterial isolates obtained from toilet areas are more abundant compared to those from residential areas. This could be attributed to the behavioral tendencies of cockroaches, as toilets (whether pit latrines or water systems) provide more favorable and accessible habitats for cockroaches, serving as hiding places during the day. At night, they venture into households, potentially contaminating household items with bacterial pathogens (Tatfeng *et al*., 2005).

CONCLUSION

The findings of this study highlight the presence of disease-causing pathogens carried by cockroaches in Bali town. Consequently, it is imperative to implement suitable control measures to mitigate the transmission of diseases by these insect vectors in the study area.

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REFERENCES

Akindele, A.A., Adewuyi, I.K., Adefioye, O.A., Kassiri, H., Kazemi, S.A., Adedokun, S.A. (2012). Antibiogram and beta-lactamase production of Dictyoptera (Blattidae) as carriers of bacterial *Staphylococcus aureus* isolates from different human pathogens in Ile-ife, Nigeria. *American-Eurasian J. Sci. Res.*, 5: 230-233.

Alzain, B. (2013). Cockroaches: transmission of medically important parasites. *ARPN Journal of Science and Technology*, 3(5): 533 – 537.

Bell, W.S., Roth, L.M., Nalepa, C.A. (2007). Cockroaches: Ecology, Behavior and Natural History. Baltimore: John Hopkins University Press; Pp. 56-9.

Bouamama, L., Sorlozano, A., Laglaoui, A., Lebbadi, M., Aarab, A., Gutierrez, J. (2010). Antibiotic resistance patterns of bacterial strains isolated from *Periplaneta americana* and *Musca domestica* in Tangier, Morocco. *J Infect Dev Ctries*, 4: 194-201.

Cheesbrough, M. 2006. District laboratory practice in tropical countries. Cambridge University Press, New York, NY.

Demick, B. (2013). Cockroach farms multiplying in China. Los Angeles Times; 2013. Available:https://www.latimes.com/la-fg-c1-china-cockroach-20131015-dto=htmlstory.html

Elijah, M.I. and Lamidi, B.T. (2023). Species Composition and Seasonal Distribution of Cockroaches in Bali Town, Taraba State, Nigeria. *International Journal of Current Researches in Sciences, Social Sciences and Languages*, 4(1): 1-7.

El-Sherbini, G.T. and El-Sherbini, G.A. (2001). The Role of cockroach and flies in mechanical transmission of medical important parasites. *J. Entomol. and Nematology*, 3(7): 98-104.

Etim, S.E., Okon, O.E., Akpan, P.A., Ukpong, G.I. and Oku, E.E. (2013). Prevalence of cockroaches (*Periplaneta americana*) in households in calabar: public health implications. *Journal of Public Health and Epidemiology*, 5(3):149–152.

Fathpour, H., Emtiazi, G. and Ghasemi, E. (2003). Cockroaches as reservoirs and vectors of drug resistant *Salmonella* spp. *Iranian Biomedical Journal*, 7(1):35-38.

Feleke, M., Setegn, E., Mengistu, E., Kahsay, H., Dagnachew, M., Tigist, F. *et al*., (2016). Cockroaches as a Source of High Bacterial Pathogens with Multidrug Resistant Strains in Gondar Town, Ethiopia. *BioMed Research International*, 1-6.

Isaac, C., Orue, P.O., Iyamu, M.I., Ehiaghe, J.I. and Isaac, O. (2014). Comparative analysis of pathogenic organisms in cockroaches' form different community settings in Edo state, Nigeria. *Korean journal of Parasitology*, 52(2): 177-181.

Isaac, C., Orue, P.O., Iyamu, M.I., Ehiaghe, J.I. and Isaac, O. (2014). Comparative analysis of pathogenic organisms in cockroaches' form different community settings in Edo state, Ngeria. *Korean journal of Parasitology*, 52(2): 177-181.

Jeffery, J., Sulaiman, S. and Oothuman, P. (2012). Domiciliary Cockroaches found in restaurants in five zones of Kuala lumpur Federal Territory Peninsular Malaysia. *Journal of Tropical Biomedicine*, 29:180-186.

Kinfu, A. and Erko, B. (2008). Cockroaches as carriers of human intestinal parasites in two localities in Ethiopia. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 102(11): 1143 –1147.

Lihoreau, M., Costa, J.J. and Rivault, C. (2012). The social biology of domiciliary cockroaches: Colony structure, kin, recognition and collective decisions. *Journal of Insect Sociology*, 59:445-452.

Malcolm, M. (2013). Not for taste but medicinal value; 2013. Available:www.telegraph.co.uk

Nagham, Y.A., Anfal, S.A. and Israa, K.A. (2011). Risks associated with cockroach *Periplaneta americana* as a transmitter of pathogen agents, *Diyala Journal of Medicine*, 1(1): 91–97.

Nasirian, H. (2017). Infestation of cockroaches (Insecta: Blattaria) in the human dwelling environments: A systematic review and meta-anlysis. *Acta Trop*., 13, 86-98.

Nwankwo, E.O., Onusiriuka, K. N., Elesho, B.J. and Pipi, O.G. (2016). Isolation and Identification of Some Microbial Pathogens Associated with the External Body Surface of Periplaneta americana in Umuahia, Abia State. *International Journal of Tropical Disease and Health*, 13(3): 1-8.

Ojiezeh, T. I. and Ogundipe, O. O. (2015). Microbiology of cockroaches - a public health concern. *International Journal of Scientific Research*, 4(4): 484 – 488.

Pai, H.H., Chen, W.C and Peng, C.F. (2005). Isolation of bacteria with antibiotic resistance from household cockroaches (*Periplaneta americana* and *Blattella germanica*). *Acta Tropica*, vol. 93, no. 3, 259–265.

Pai, H.H., Ko, Y.C., Chen, E.R. (2003). Cockroaches as potential mechanical disseminators of *Entamoeba histolytica*. *Acta Trop.,* 87: 355-9.

Sikkema, A. (2015). Insects make animal feed sustainable. Resource for everyone at Wegeningen University Research.

Tatfenga, Y. M., Usuanleleb, M.U., Orukpeb, A., Digbana, A.K., Okoduac, M., Oviasogied, F. and Turayc, A.A. (2005). Mechanical transmission of pathogenic organisms: The role of cockroaches. *Journal of Vector Borne Diseases*, 42(4):129–134.

Tilahun, B., Worku, B., Tachbele, E., Terefe, S., Kloos, H., Legesse, W. (2012). High load of multi-drug resistance nosocomial neonatal pathogens carried by cockroaches in a

neonatal intensive care unit at Tikur Anbessa specialized hospital, Addis Ababa, Ethiopia. *Antimicriobial Resistance and Infection control,* 1: 12.

Tyagi, B.K. (2003). Medical entomology: A hand book of medically important insects and other arthropods, Scientific publishers, Jodhpur, India, Pp. 44-58.