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Full Length Research Paper

Comparative Analysis of the Prevalence of Bacteria Pathogens Obtained from Rat and Cockroach Faeces

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The study was aimed at comparatively analyzing the bacteria pathogens presence in rat faeces (RF) and cockroach faeces (CF) so as to ascertain their implication as potential vectors of disease transmission. Samples of RF and CF were examined for total heterotrophic bacteria counts (THBC) and total coliform bacteria counts (TCBC). Results obtained indicated that RF had THBC that ranged from 5.0×10^4 CFU/g to 6.1×10^4 CFU/g, while CF recorded THBC which ranged between 6.0×10^5 CFU/g and 8.4×10^4 CFU/g respectively. CF had high THBC of Log_{10} 4.9 when compared to that of RF which gave Log_{10} THBC of 4.8. Results further shown that RF had TCBC which ranged from 1.3×10^5 CFU/g to 1.6×10^5 CFU/g, while CF gave TCBC ranging from 1.6×10^5 CFU/g to 1.9×10^5 CFU/g. The highest prevalent bacterium in RF was *Bacillus* sp. 33 (23.9%). This was followed by *Klebsiella* sp. 32 (23.2%), *Serratia* sp. 27 (19.6%), *Escherichia* sp. 17 (12.3%) and then *Proteus* sp. 16 (11.6%) while the least prevalent was *Pseudomonas* sp. 13 (9.4%). CF contained a significantly ($p<0.05$) higher prevalence of bacteria than RF and with low total heterotrophic bacteria population when compared to its total coliform bacteria counterpart in both rat and cockroach feaces. The presence of these bacteria in the feaces of rats and cockroaches indicates possible presence of pathogens of public health risk. Businesses and households handling food should adhere to basic food hygiene to help ensure that food and beverage products prepared and consumed at homes are free from rat and cockroach infestation to prevent outbreak of foodborne illnesses.

Keywords: Rat, cockroach, faeces, vectors, pathogens, food hygiene, foodborne illnesses

INTRODUCTION

Rats and cockroaches are synonymous with filth and poor hygiene. Their feeding and nesting habits mean they can accumulate a range of pathogenic organisms which they transmit to food and surfaces where they feed and crawl. For businesses this can affect both customer and staff health. In addition, for businesses handling and processing food it could result in a breach of food safety laws and costs for eradication, cleaning and loss of stock (Atlas, 1995; Ayres *et al.,* 1980). The presence of cockroaches and rats in homes pose a serious health risk to you and your family. Cockroaches are known to spread the bacteria which cause foodborne illnesses and contribute to the contamination of food products (Aminigo and Okoro, 2002). The common bacteria spread by cockroaches are *Salmonella* sp., *Escherichia coli* and *Listeria monocytogenes.* Cockroaches aid in the spread of food borne diseases through contamination – primarily through their feeding habits (Brooks, 2001). Rats and cockroaches are known to spread food borne illnesses and are among the medically important pests in urban environments that cause serious public health problems (Brooks *et al.,* 2004; Creager *et al.,* 1990). Their feaces habours intestinal bacterial pathogens which when contributed to food, water or domestic material could results to the spread of disease-causing microorganisms and associated infectious diseases (Karlson, 1965; Atlas,

1995; Betsy and Keogh, 2005; Duguid *et al.,* 1978; Nester *et al.,* 1998). Bacteria living within rats and cockroaches digestive system are deposited through their faeces and in turn could contaminate anything it touches such as raw ingredients, cooking utensils and food processing machinery. As outlined in the Codex Alimentarius, pest prevention is a vital procedure to ensure food safety and hygiene. Rats and cockroaches can be prevented through (i) establishing effecting procedures and methods to ensure food production areas equipment and waste management areas are kept clean and hygienic, (ii) storing food in pest-proof containers, (iii) ensuring an efficient waste management system is in place, (iv) regularly inspecting and maintaining the facility to prevent cockroaches gaining access through windows, drains, vents, piping and (v) carrying out inspections of incoming ingredients, equipment, packaging, containers and vehicles for the presence of cockroaches and rats (ICMSF, 1986).

An integrated pest management programme is an effective solution to control cockroaches, helping to reduce the potential for food borne illnesses spreading and complying with food safety legislation. An integrated pest management programme can manage cockroaches by (i) setting action thresholds designed to support your business needs, enabling faster interventions, (ii) providing 24/7 wireless, remote pest monitoring, (iii) practicing good sanitation to prevent and exclude pests along the entire supply chain and (iv) offering a range of pest control solutions from baiting to our Entotherm heat treatment solution to exterminate rats and cockroaches from your business. There are many different illnesses and diseases that can infect a human from substances contaminated from rats droppings (feaces). The study, therefore, was aimed at comparatively analyzing the prevalence of bacteria from rat and Cockroach faeces.

MATERIALS AND METHODS

Sample collection

Samples of rat faeces (Plate 1) as well as Cockroach feaces (Plate 2) were obtained from a dilapidated building in Captain Elechi Amadi Polytechnic and transported via clean polythene bag to the Biology/Microbiology laboratory of the institution for analysis. They were analyzed for total heterotrophic bacteria counts (THBC) and total coliform bacteria counts (TCBC) using nutrient and MacConkey agar media respectively using standard microbiological procedures earlier reported by Betsy and Keogh (2005) and Cheesbrough, (2004).

Sterilization of materials and media preparation

Glassware used were washed, dried and placed in the appropriate can. All glass ware used including media were sterilised by autoclaving at 121°C for 15 min and 15 psi (pounds per square inch unit of pressure). Plastic containers were sterilised by rinsing the inside with 95% ethanol and rinsed using distilled water to the remove smell of ethanol (Atlas, 1995). Media was prepared according to manufacturer's instructions on the container. Nutrient agar is composed of the following ingredients (g/l); Agar 15, peptone 5, sodium chloride 5, beef extract 1.500, yeast extract 1.500 and pH 7.4±0.2 at 25 ^{o}C. Twenty eight grammes (28g) of the powder nutrient agar was weighed and dissolved in one litre (1000 ml) of distilled water. It was then gently heated to dissolve completely. The solution was then sterilized by autoclaving at 121°C for 15 min and 15 psi (Cheesbrough, 2004). MacConkey agar was prepared and used for coliform bacteria enumeration. It is composed of the following ingredients (g/l); peptone digest of animal tissue 20, Agar 12, lactose 10, bile salts 5, neutral red 0.075 and pH 7.5±0.2 at 25°C. Media was prepared according to manufacturer's instructions on the container (Creager *et al.,* 1990). Fourty seven grammes (47g) of the powder agar was weighed and dissolved in 1000 ml of distilled water in a conical flask. The solution containing the medium was then gently heated to dissolve completely. The solution was then sterilized by autoclaving at 121 ^{o}C for 15 min and 15 psi (Cheesbrough, 2004).

Physiological Saline was prepared and 8.5gm of analytical salt was obtained and weighed using a standard automated balance and dissolved in 1000 ml of distilled water in a 1500 ml conical flask. Sample was prepared by adding 1 ml of it to 9 ml sterile physiological saline (0.85 % w/v) as diluents (Cheesbrough, 2004). The content was shaken to homogenize (mix) evenly and 9 ml of the homogenate was dispensed into a set of already prepare dilution blanks. The conical flask and dilution blanks were properly capped with cotton wool plug before they were sterilized by autoclaving at 121 °C for 15 min and 15 psi (Cheesbrough, 2004).

The sterilized physiological saline was cooled before used. The procedure previously described by Ogugbue *et al.* (2015) was adapted for plate inoculation and 0.1 ml of each dilution was spread-plated on already prepared nutrient agar plates. This was done in duplicates for greater accuracy of plate count. Plates were then incubated in an inverted position at 28±2°C for 24h. Colony forming unit per gramme (CFU/g) was calculated as earlier expressed by other researchers (Atlas, 1995; Brooks *et al.,* 2004; Creager *et al.,* 1990; Solomon and Ibe, 2012).

Characterization and identification of bacterial isolates

The bacterial isolates were characterized and identified based on their motility, microscopic morphology, colonial

morphology and biochemical characteristics as described in Medical Laboratory Manual for Tropical Countries (Cheesbrough, 2004) and with reference to the Bergey's Manual of Systematic Bacteriology (Krieg and Holt, 1994) and Manual of Microbiology: Tools and Technique by Kanika (2011).

Statistical analysis

The data generated in the study were subjected to statistical analysis to determine level of significance using chi-square (x^2). A value of $p<0.05$ was accepted as significant and $p>0.05$ was considered not significant.

RESULTS AND DISCUSSION

Results of the total heterotrophic bacterial counts (THBC) for rat faeces (RF) and cockroach feaces (CF) samples obtained on nutrient agar plates respectively. THBC of 6.1×10^4 CFU/g, 5.8×10^4 CFU/g and 5.0×10^4 CFU/g was obtained for RF1, RF2 and RF3 respectively thus representing Log_{10} THBC of 4.8, 4.8 and 4.7. On the other hand, CF had THBC that ranged between 6.0×10^4 CFU/g, 8.0×10^4 CFU/g and 8.4×10^4 CFU/g. Again, this represented Log_{10} THBC of 4.8, 4.9 and 4.9 respectively for CF1, CF2 and CF3. Results of total coliform bacterial counts (TCBC) for rat faeces and cockroach feaces samples obtained on nutrient agar plates. THBC of 1.6×10^5 CFU/g, 1.3×10^5 CFU/g and 1.3×10^5 CFU/g was obtained for RF1, RF2 and RF3 respectively. The obtained total coliform bacterial counts gave Log_{10} TCBC of 5.2, 5.1 and 5.1 for CF1, CF2 and CF3. Furthermore, CF1, CF2 and CF3 indicated THBC values which ranged from 1.9×10^5 CFU/g, 1.6×10^5 CFU/g and 1.6×10^5 CFU/g respectively. Again, this corresponded to Log_{10} TCBC of 5.3, 5.2 and 5.2 for CF1, CF2 and CF3 respectively. These results indicated that rat faeces had total heterotrophic bacterial counts which ranged from 5.0×10^4 CFU/g, giving Log_{10} THBC of 4.7 to 6.1×10^4 CFU/g, thus representing Log_{10} THBC of 4.8 while cockroach faeces had THBC ranging between 6.0×10^5 CFU/g and 8.4×10^4 CFU/g, giving Log_{10} THBC of 4.8 and 4.9.

This shows that cockroach faeces with THBC counts of Log_{10} 4.9 was slightly higher in when compared to that of rat faeces which gave lesser Log_{10} THBC count of 4.8. On the other hand, RF had total coliform bacterial counts (TCBC) in the range of 1.3×10^5 CFU/g, giving Log_{10} THBC of 5.1 to 1.6×10^5 CFU/g, thus representing Log_{10} THBC of 5.2 while cockroach feaces recorded TCBC that ranged from 1.6×10^5 to 1.9×10^5 CFU/g, giving Log_{10} THBC of 5.2 to 5.3. Table 1 shows the percentage prevalence of bacterial isolates from rat feaces. Six (6) bacterial isolates were characterized. Out of these six (6) isolates, results indicated 13 *Pseudomonas* sp. (9.4%), 32 *Klebsiella* sp. (23.2%) and 27 *Serratia* sp. (19.6%) were seen on rat faeces. Others are 17 *Arthrobacter* sp. (12.3%), 33 *Bacillus* sp. (23.3%) and 16 *Proteus* sp. (11.6%) were obtained.

Table 2 indicated the results of the percentage prevalence of bacterial isolates from cockroach feaces. The percentage prevalence of bacterial isolates from cockroach feaces indicated the following; 11 (10.9%), 22 (21.8%), 18 (17.8%) for *Pseudomonas* sp., *Klebsiella* sp. and *Serratia* sp. respectively. *Arthrobacter* sp., *Bacillus* sp. and *Proteus* sp. recorded 12 (11.9%), 24 (23.8%) and 14 (13.9%) respectively (Table 2). Members of these two bacteria groups (coliforms and total heterotrophic bacteria) are often used as indicators of possible sewage contamination because they are commonly found in human and animal feces (Atlas, 1995). Although they are generally not harmful themselves, they indicate the possible presence of pathogenic **(**disease-causing) bacteria that also live in human and animal digestive systems (Betsy and Keogh, 2005). Therefore, the presence of these disease-causing bacteria in faeces of rat and cockroach suggests their pathogenicity and might be a health risk (Atlas, 1995). These microorganisms isolated from the feaces of rats and cockroaches have been obtained from seafood and are known to be involved in food poisoning and gastroenteritis (Solomon and Ibe, 2012). Sources of fecal contamination to food and other domestic products include vectors (Block, 2001). In addition to the possible health risk associated with the presence of elevated levels of fecal bacteria, they can also cause cloudy water, unpleasant odors, and an increased oxygen demand (Nicklin *et al.,* 2002; Pommerville, 2004). According to ICMSF (1986), total coliforms are a group of bacteria that are widespread in nature.

All members of the total coliform group can occur in human feces, but some can also be present in animal manure, soil, and submerged wood (Nester *et al.,* 1998; Prescott and Harley, 2005). Thus, the usefulness of total coliforms as an indicator of fecal contamination depends on the extent to which the bacteria species found are fecal and human in origin (Talaro and Talaro, 2002; Atlas, 1995)**.** Feaces of rats and cockroaches contained enteric microorganisms that are pathogenic in nature and have been implicated to cause major food borne illness (Nester *et al.,* 1998; Prescott and Harley, 2005). Cockroaches can transmit the following diseases namely; Salmonellosis, Campylobacteriosis, Listeriosis, *E. coli* infections, Typhoid fever, Cholera, Dysentery, Leprosy, Plague and Asthma (Deguid *et al.,* 1978; Nester *et al.,* 1998). Some of the diseases are discussed thus:

Cockroach Feaces/Droppings

Due to their unsanitary eating habits, cockroaches can pass harmful pathogens through their droppings. When a cockroach feasts on something contaminated, such as a

Table 1. Percentage prevalence of bacterial pathogens in rat feaces.

Bacterial Isolates	Frequency of occurrence of bacterial isolates	Percentage (%) frequency of occurrence of bacterial isolates
Pseudomonas sp.	13	9.4
Klebsiella sp.	32	23.2
Serratia sp.	27	19.6
Arthrobacter sp.	17	12.3
Bacillus sp.	33	23.9
Proteus sp.	16	11.6
Total	138	100

Table 2. Percentage prevalence of bacterial pathogens in cockroach feaces.

Microbial Isolates	Frequency of occurrence of bacterial isolates	Percentage (%) frequency of occurrence of bacterial isolates
Pseudomonas sp.	11	10.9
Klebsiella sp.	22	21.8
Serratia sp.	18	17.8
Arthrobacter sp.	12	11.9
Bacillus sp.	24	23.8
Proteus sp.	14	13.9
Total	101	100

raw piece of chicken or animal faeces, the organism will enter, and may lay dormant in their digestive system. The pathogen will then be excreted in cockroach droppings and will contaminate surfaces and food (Nicklin *et al.,* 2002).

Cockroach saliva

Cockroach saliva is also responsible for spreading a range of diseases. Similar to droppings, saliva can harbour pathogens accumulated from eating contaminated items (Block, 2001).

Mechanical transfer

Cockroaches can be found living in sewers, cesspits, drains and rubbish bins where they come into contact with a range of organisms, which can become attached to cockroaches' bodies (Betsy and Keogh, 2005). The legs of a cockroach, for example, have spines that are sensitive to touch and provide a very large surface area to pick up pathogens. Anything a cockroach touches or rubs past may then become contaminated. These diseases include:

Hantavirus

Hantavirus is a potentially life-threatening disease transmitted to humans by rodents—primarily, the white-footed deer mouse. People become infected through exposure or inhalation of infected rodent urine, droppings or saliva, and the chances increase when people are near spaces where rodents are actively living.

Bubonic plague

Although it is regarded as a rodent-borne disease, cockroaches are also suspected of spreading the *Yersinia pestis* bacterium which causes plague. Common symptoms of plague include, but are not limited to swollen and painful lymph nodes, chills, muscle cramps and high fever. People infected by the plague need to receive urgent treatment and should be given antibiotics 24 h after infection to avoid severe consequences. It is estimated that the bubonic plague was responsible for around 50 million deaths in the fourteenth century.

Salmonellosis

Salmonellosis is a type of food poisoning spread by rodent feces, especially through the consumption of contaminated food. Consuming food or water that is contaminated by rat feces bacteria can cause this disease. Symptoms include diarrhea, fever and abdominal pain (Cheesbrough, 2004). Similar to rodents, cockroaches are known to transmit the *Salmonella* bacterium which can cause salmonellosis, a disease in humans with symptoms similar to food poisoning. Cockroaches accumulate the bacteria by crawling in filth and feeding on contaminated food materials (Prescott *et al.,* 2005). The *Salmonella* remains in their digestive system for a month or more and is deposited through their vomit and faeces. Human symptoms, which typically show 12 to 72 h after infection, include diarrhoea, fever,

and vomiting. Recovery usually occurs after four to seven days, with little to no medical treatment need, besides replenishing fluids (Pommerville, 2004).

Rat-bite fever

Rat-bite fever (RBF) is an infectious disease transmitted by the rats and possibly mice. It can be caused by two different bacteria: *Streptobacillus moniliformis* and *Spirillum minue. Streptobacillary* rat-bite fever is caused by Streptobacillus moniliformis in Europe and North America. Sodoku (spirillary RBF) is caused by spirillum minus and occurs primarily in Africa and Asia. As a rule, humans get the illness through the bite or scratch wound from infected rats and mice. Besides, consuming contaminated water or food causes Haverhill fever. Symptoms of *streptobacillary* RBF are fever, muscle and joint pain, headache, vomiting and rash. Symptoms usually occur 3-10 days after the bite or scratch wound or exposure to an infected rodent. Within 2-4 days after fever onset, a maculopapular rash appears on the feet and hands. In addition, joints may then become swollen, red, or painful.

Campylobacteriosis

Campylobacteriosis is an infection caused by the *Campylobacter* bacterium. It is one the most common bacterial infections in humans, and is a common food borne illness (Stanier *et al.,* 1987). Researchers have isolated a *Campylobacter jejuni* subspecies in the gut contents and on the external surface of both American cockroaches and Oriental cockroaches. Transmission occurs through ingesting contaminated food and drinks such as unpasteurized milk and undercooked and poorly handled poultry. It can also be transmitted through sexual contact. Symptoms of campylobacteriosis include bloody diarrhoea as well as cramps, abdominal pain and fever. The disease usually lasts for 2-10 days and requires little to no medical treatment. However, as with any occurrence of diarrhoea, it is important to replenish fluids to avoid dehydration (ICMSF, 1986; Jablonski and Bohach, 2001).

Listeriosis

Listeriosis is a serious infection caused by the bacterium *Listeria monocytogenes*. It is usually contracted by consuming contaminated food and drink. According to the Centers for Disease Control (CDC) it is an important public health problem in the United States. Listeriosis primarily affects people with weakened immune systems such as pregnant women, newborns and the elderly. Although rare, people with strong immune systems can also be affected (Russell *et al.,* 1999). Symptoms of listeriosis are usually a fever, muscle aches and diarrhoea. However, if the disease spreads beyond the gastrointestinal tract, symptoms can also include headaches, a stiff neck, confusion, loss of balance and convulsions. For pregnant women, contracting listeriosis can sometimes lead to miscarriage, stillbirth or premature delivery (Iwamoto *et al.,* 2010).

***Escherichia coli* infections**

Escherichia coli is a bacterium commonly found in the gut of an intestinal tract of humans. Although most strains of the bacteria are harmless, some can cause serious food poisoning (Solomon and Ibe, 2012). Symptoms usually last three weeks and require little to no medical support. Common symptoms of an *E. coli* infection are watery diarrhoea and abdominal cramping. Less common symptoms include fever, chills, nausea and muscle aches (Brooks and Brooks, 1978).

Typhoid fever

Typhoid fever is a bacterial infection caused by the *Salmonella typhimurum* bacterium and is a highly infectious disease. It is believed that cockroaches accumulate this disease by consuming faeces contaminated with the bacterium. According to the UK National Health Services (NHS) Typhoid fever is most common in developing countries where there is poor sanitation and limited access to clean water (Teter *et al.,* 1977). Children and the elderly are thought to be most at risk due to their immunocompromised states. The symptoms of typhoid fever include high temperature, head and muscle aches, constipation or diarrhea, exhaustion and stomach pain. You should seek medical attention if you experience any of the symptoms for typhoid fever. With treatment, this disease will quickly improve within three to five days.

Cholera

Cholera is an acute diarrhoeal infection caused by the *Vibrio cholerae* bacterium. It is most common in developing countries and areas that have inadequate environmental management. Infection occurs through ingestion of food and drink contaminated with the bacterium. If exposed to the bacterium, cockroaches can spread the organism through their faeces and vomit, contaminating surfaces and food (Talaro and Talaro, 2002). Researchers from the WHO have estimated that worldwide there are roughly 1.4 million to 4.3 million cases of cholera per year resulting in 28,000 to 142,000 deaths. Around 80% of people infected with cholera do

not develop any symptoms, although the bacterium is present in their faeces for 1-10 days after infection. Among the small percentage that do develop symptoms, 80% have mild to moderate symptoms with around 20% developing acute watery diarrhoea resulting in severe dehydration (Pommerville, 2004; Nicklin *et al.,* 2002).

Dysentery

Dysentery is a type of gastroenteritis that results in diarrhoea with blood. Generally, most people suffer from mild symptoms and recover within a week or so without medical attention. There are two types of dysentery. They are (i) bacillary dysentery — sometimes referred to as shigellosis. It is caused by the *Shigella* bacteria (Talaro and Talaro, 2002) and (2) Amoebic dysentery — is caused by a single-celled parasite called Entamoeba. It is usually found in tropical areas (Talaro and Talaro, 2002). Dysentery is usually spread through poor hand hygiene and consuming contaminated food and drink. Symptoms are diarrhoea containing blood and mucus, painful stomach cramps, nausea and vomiting, and a high temperature.

Leprosy

Cockroaches, along with other insects, are suspected of being carriers of the bacillus *Mycobacterium leprae* which causes the disease leprosy (Talaro and Talaro, 2002). Cockroaches are believed to spread the disease through their faeces. Whilst the bacteria are not highly infectious, if left untreated, it can cause permanent damage to the skin, nerves, eyes and skin which can lead to disfigurement and deformities. Leprosy has an incubation period of around five years but symptoms may take as long as 20 years to appear (Pommerville, 2004; Nicklin *et al.,* 2002). Treatment is possible using multidrug therapy (Stanier *et al.,* 1987).

***Staphylococcus aureus* infection**

Staphylococcus aureus is a gram-positive cocci bacterium. This organism is generally harmless, but can cause serious infections. Infection can occur in many forms ranging from minor skin infections, such as boils, to infections of the blood, lungs and heart. Cockroaches are known to carry the bacterium on their exoskeletons or in their digestive tracts (Talaro and Talaro, 2002). Like *Staphylococcus aureus*, *Streptococcus* infections come in many different forms, from mild throat infections to life-threatening infections of the blood or organs (Betsy and Keogh, 2005).

Asthma

Cockroaches can trigger asthma because they certain proteins in their bodies which can be an allergen for certain people (Stanier *et al.,* 1987). When tiny particles from cockroach bodies are spread through the air in buildings, these proteins are inhaled and an asthma attack can be triggered in sensitive people (Talaro and Talaro, 2002). The American College of Allergy, Asthma and Immunology reports that the saliva, faeces and shed skin of cockroaches can trigger both asthma and other allergic responses (Betsy and Keogh, 2005). Frequent hospital visits of children living in cities suffering from asthma can often be as a result to contact with cockroaches.

Conclusion

The highest prevalent bacteria obtained from Rat faeces was *Bacillus* sp. 33 (23.9%). This was followed by *Klebsiella* sp. 32 (23.2%), *Serratia* sp. 27 (19.6%), *Escherichia* sp. 17 (12.3%) and then *Proteus* sp. 16 (11.6%) while the least prevalence of all the six (6) bacterial characterized was *Pseudomonas* sp. 13 (9.4%). Results obtained in this study indicated that cockroach faeces had significantly ($p<0.05$) high prevalence of pathogenic bacteria that rat faeces; thus, the total heterotrophic bacterial counts were lesser in number when compared to that of total coliform bacterial counts in both faeces samples. The presence of pathogenic bacteria in faeces of rats and cockroaches suggests their health risk and hence, call for proper house-keeping and hygiene. The ultimate solution remains with provision of adequate portable water, teaching of good-hygiene practices, including hand washing and enforceable legislation on water-processing and environmental sanitation may improve environmental situation. These would, however, go a long way to reduce the prevailing morbidity that could result due to rats and cockroaches borne gastroenteritis in the polytechnic community (Teter *et al.,* 1977).

Recommendations

The following recommendations could help in preventing food-borne diseases:

(i) In food handling establishments the potential of rats and cockroaches to transmit food-borne diseases should not be ignored or simply rejected without further investigation. Preventing rats and cockroaches is a necessary precaution to help reduce the spread of food-borne or vector-borne illnesses.
(ii) Microbiological control of drinking water should be the priority to curtail the incidence of Cockroach and Rat-borne diseases and so routine microbiological analysis of drinking water should be carried out by assaying the presence of these pathogens by culture methods.
(iii) The Government affected nations should devote part of her financial resources to research and implement

recommendations emanating from them in other to reduce morbidity and mortality resulting from human and animal fecal contamination of drinking water sources.
(iv) For businesses handling food, adhering to necessary food safety regulations and standards is imperative to help ensure the food and beverage products produced are safe to eat and free from food borne illnesses such as Salmonella and *Escherichia coli*.

To avoid bacterial rat-borne diseases, you should keep you food-stuffs away from rodents and make everything possible to protect your home and yard from rat infestations. Moreover, be careful and take measures when cleaning up areas where you regularly see rodents.

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Conflicting of interests

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