

Ecological Vector Dynamics and Quantitative Microbial Risk Assessment of Synanthropic Cockroaches (*Blattella germanica*) in Tropical Student Housing Structures

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Abstract: Synanthropic urban insects in high-density dwellings act as persistent reservoirs of enteric bacterial pathogens. This study assessed infestation dynamics, bacterial dissemination, and quantitative vectorial capacity (VC) of the German cockroach (*Blattella germanica*) in student hostels at Abubakar Tafawa Balewa University, Bauchi, Nigeria. Seventy-two cockroaches were collected from Yelwa and Gubi campus hostels (May–July 2024) and identified taxonomically; 35 were subjected to bacteriological analysis of external and internal homogenates. Temperature, humidity, and sanitation were recorded. Bacterial isolates were identified by culture, Gram staining, and biochemical tests. Quantitative microbial risk assessment estimated transmission efficiency (TE). Gubi, a peri-urban site, showed higher infestation (54.17%) than urban Yelwa (45.83%), with kitchens as primary foci. *Escherichia coli* was predominant (45%), followed by *Proteus* (20%), *Enterobacter* (15%), *Klebsiella* (10%), and *Shigella* (10%). Internal and external carriage rates were 52% and 40%, respectively. Pathogen load was 8.7×10^5 CFU/cockroach, TE was 0.0003%, and integrated VC was 120.06. Despite low direct surface-contact transfer, high vector density, elevated microbial loads, and humidity up to 72% sustain substantial bacterial transmission potential in communal living quarters. High temperatures (28–32°C) and increasing humidity (44–72%) favoured proliferation, while poor kitchen and lavatory sanitation amplified pathogen carriage. These findings quantify *B. germanica* as a public health risk in communal residences, underscoring the need for integrated pest management and environmental sanitation interventions.

Keywords: *Blattella germanica*; Student Hostels; Vectorial Capacity; Environmental Sanitation; Microbial Load; Transmission Efficiency

Introduction: Urbanization, microclimatic fluctuations, and deterioration of sanitation infrastructure in developing tropical nations have accelerated the proliferation of synanthropic insect vectors within built environments (Alqassim, 2026)). Among these, the German cockroach, *Blattella germanica* (L.) (Dictyoptera: Blattellidae), is among the most successful insect species globally, with a distribution closely tied to human settlements (Abbasi, 2025). Its ecological success is attributable to behavioural plasticity, short generation time, and adaptation to indoor microhabitats characterised by warmth, moisture, and food availability (Maigoro *et al.*, 2026). In university student hostels across Nigeria, dense occupancy, shared cooking facilities, and inconsistent sanitation create conditions conducive to cockroach proliferation (Ifeamaechi *et al.*, 2025; Nwoye *et al.*, 2025). Beyond the nuisance and allergenic consequences of infestation, *B. germanica* has been repeatedly implicated as a mechanical vector of medically important bacteria, including *Escherichia coli*, *Salmonella* spp., *Klebsiella pneumoniae*, and *Shigella* spp. (Ikechukwu *et al.*, 2017; Nwoye *et al.*, 2025). Synanthropic insects bridge the gap between polluted microhabitats (such as sewage drains, latrines, and refuse dumps) and human food preparation surfaces (Derguini & Basher, 2026).

Because *B. germanica* regularly moves between decaying organic matter and human foodstuffs, its body surfaces, spines, and gastrointestinal tract serve as vehicles for the mechanical dissemination and biological carriage of pathogenic microorganisms (Hassan *et al.*, 2021; Derguini & Basher, 2026). While classical vector research has heavily concentrated on hematophagous Diptera, the eco-physiological contribution of mechanical insect vectors to foodborne and waterborne enteric disease transmission in tropical academic institutions remains inadequately quantified (Blitvich, 2025; Idigo *et al.*, 2025; Dekkiche *et al.*, 2026). Evaluating the disease transmission risk posed by insect vectors requires assessing their vectorial capacity (VC), a mathematical construct originally formulated for hematophagous disease vectors and subsequently adapted for synanthropic mechanical vectors (Rizzoli *et al.*, 2019; Patil, 2023). VC integrates key biological and ecological parameters, including vector infection rate (IR), microbial pathogen load (PL), and mechanical transmission efficiency (TE) to exposed environmental surfaces (Wu *et al.*, 2020; Ghodsi & Wild, 2025). While VC has been extensively applied to mosquito-borne diseases, its application to mechanical vectors such as cockroaches remains limited (Hayes & Schal, 2024; Hiscox *et al.*, 2025). This gap is

Ecological Vector Dynamics and Quantitative Microbial Risk Assessment of Synanthropic Cockroaches (*Blattella germanica*) in Tropical Student Housing Structures

significant because mechanical transmission differs fundamentally from biological transmission: pathogens are not amplified within the vector but are passively transferred from contaminated substrates to food, utensils, and surfaces (Wu *et al.*, 2020; Blitvich, 2025). In tropical environments characterized by high ambient temperatures and seasonal shifts in relative humidity, the physiological activity and survival rates of *B. germanica* are enhanced, increasing vector-host-pathogen contact rates (Brady *et al.*, 2016). Across Sub-Saharan Africa, recent studies have documented enteropathogenic *Escherichia coli*, *Klebsiella pneumoniae*, *Proteus mirabilis*, and *Shigella flexneri* in cockroach populations from student residential buildings and other urban settings (Ibrahim *et al.*, 2020; Okrikata *et al.*, 2024; Olowoporoku *et al.*, 2026). In Nigeria, Nwoye *et al.* (2025) found a 53.4% prevalence of *B. germanica* in Kaduna State University hostels, with *E. coli* and *Staphylococcus aureus* as the most frequent isolates. Okrikata *et al.* (2024) demonstrated that cockroach gut homogenates at Federal University Wukari harboured bacterial loads exceeding 10^6 CFU/mL, and Ibrahim *et al.* (2020) reported that 66% of respondents in Gombe State attributed cockroach infestation to inadequate waste management, highlighting the role of poor sanitation. These findings are consistent with evidence from elsewhere in Africa: Moges *et al.* (2016) isolated multidrug-resistant *Klebsiella pneumoniae* (17.7%) and *E. coli* (16%) from cockroaches in Gondar, Ethiopia, while Loucif *et al.* (2016) detected CTX-M-15 extended-spectrum β -lactamase- and OXA-48 carbapenemase-producing *Enterobacteriaceae* in cockroaches at Batna University Hospital, Algeria. Despite this accumulating evidence, empirical determinations of vectorial capacity combining microbial quantification with Quantitative Microbial Risk Assessment (QMRA) transmission modeling in Nigerian institutional housing remain scarce. Furthermore, the environmental determinants of VC—temperature, humidity, and sanitation—are poorly characterized in this context. To address these gaps, this study aimed to: (i) determine the magnitude of cockroach infestation in ATBU hostels; (ii) isolate and identify bacterial pathogens from external and internal cockroach homogenates; (iii) quantify infection rate (IR), transmission efficiency (TE), and pathogen load (PL) for *E. coli* as a model pathogen; and (iv) calculate VC using a QMRA framework. By integrating environmental microbiology and ecology, this study provides a quantitative basis for targeted sanitation interventions in communal residential settings.

Problem Statement: Student residential hostels in public universities across Nigeria experience severe infrastructural pressure due to high student population densities, intermittent municipal water supply, inadequate solid waste collection, and communal kitchen facilities. These deteriorating environmental conditions create ideal microhabitats for *B. germanica* infestations. Although gastrointestinal illnesses and bacterial food poisoning outbreaks occur periodically within student communities, routine epidemiological surveillance rarely examines the contribution of synanthropic cockroach vectors. Furthermore, previous local research has primarily focused on basic species isolation without quantifying pathogen

carrying capacity or surface transmission efficiency under local microclimatic conditions. The lack of quantitative vectorial capacity data limits the design of targeted integrated pest management strategies in academic residential environments.

Materials and Methods: Study Area: The study was conducted within the student residential hostels of Abubakar Tafawa Balewa University (ATBU), Bauchi, Nigeria (latitude 10.4729°N, longitude 9.8312°E). The University comprises two primary campuses: the Yelwa Campus, located within Bauchi urban core, and the Gubi Campus, situated in a more rural setting, with limited waste management infrastructure. Both campus hostels consist of multi-story blocks accommodating over 500 students per block, characterized by shared kitchen areas, communal corridors, and central lavatories. Sampling was conducted from 10 May to 10 July 2024, coinciding with the warm-humid transition period (mean temperature 28–32°C; humidity 44–72%).

Sample Collection: Cockroaches were collected manually during night-time peak activity hours (22:00 to 02:00 h) from rooms, kitchen areas, corridors, and lavatories using sterile gloved hands and clean, labelled plastic containers. Trapping was not feasible due to the structural complexity of the study area. Live specimens were transported to the Microbiology Laboratory, ATBU, and maintained alive until processing. A total of 72 cockroaches were collected, of which 35 were included in laboratory analysis; the remainder were retained for species identification and reference.

Taxonomic Identification: We confirmed the samples during collection and before laboratory analysis as German cockroaches to ensure accurate procedure and data. Some standard taxonomic keys used included size, colour of the wing, and comparison with reference images (Bell *et al.*, 2007). All specimens were confirmed as *B. germanica* based on body length (12–16 mm), light brown/tan coloration, fully developed tegmina, and two distinctive dark parallel longitudinal stripes running along the pronotum. We transported the samples to the laboratory in sterile containers and kept alive prior to processing.

Anesthetisation: After picking the live cockroaches using sterile forceps, we pooled them in batches (five cockroaches pooled as one sample) and anesthetised them in a sterile jar using chloroform-soaked cotton. A small, escape-proof container (glass jar or plastic container with a lid) was used in a well-ventilated area. We placed 0.1–0.2 mL of chloroform onto a piece of filter paper or a cotton ball inside the chamber to allow the cockroaches to inhale the vapours without direct contact with the liquid, and then gently placed the cockroaches into the chamber, ensuring they were not crowded or stressed, in batches of five cockroaches per sample. The cockroaches inhaled the chloroform vapours for 5–10 minutes or until they became immobile. Their movement and respiration were monitored to avoid over-anesthetisation. We checked for signs of anaesthesia, including reduced movement or complete immobility, slowed or absent respiration, and relaxed body posture. Once anesthetised, the cockroaches were used for subsequent experiments.

Ecological Vector Dynamics and Quantitative Microbial Risk Assessment of Synanthropic Cockroaches (*Blattella germanica*) in Tropical Student Housing Structures

Sample Homogenisation and Homogenate Extraction:

We homogenised the samples to dislodge microbes present on or in cockroach samples into a supporting medium for subsequent microbiological analysis.

External Homogenate Extraction: The anaesthetised samples were picked using sterile forceps and pooled in batches (five cockroaches pooled as one sample). The immobilised cockroaches were placed in 5 mL sterile physiological saline (0.85%) and shaken for two minutes to dislodge bacteria from their body surfaces. The wash was then taken as the external body homogenate sample and checked for bacterial growth.

Gut/Internal Homogenate Extraction: Subsequently, we soaked the dislodged German cockroaches in 90% ethanol for 5 minutes to decontaminate their external surfaces, dried them, and rinsed them with sterile physiological saline (0.85% NaCl) to remove residual ethanol. We then excised the abdominal contents of the German cockroaches, added a small volume of sterile physiological saline (0.85% NaCl), and macerated the contents using a sterile laboratory mortar and pestle. Finally, we homogenised the excised gut in 5 mL sterile normal saline and subjected the homogenate to bacteriological analysis as the gut-content or internal homogenate sample.

Bacterial Isolation and Identification: Primary enrichment involved inoculating 1-mL aliquots of each external and internal homogenate into 9 mL buffered peptone water and incubating the mixtures at 37 °C for 18–24 h. To inoculate the sample on selected media, the enriched cultures underwent serial dilution and streak-plating onto selective and differential media, including MacConkey agar, CLED agar, Salmonella–Shigella agar, mannitol salt agar, and nutrient agar. We then incubated the inoculated plates aerobically at 37 °C for 24–48 h to permit microbial proliferation. Secondary sub-culturing on nutrient agar purified bacterial colonies. Identification of bacterial isolates employed standard morphological characterization, Gram staining, and biochemical profiling (indole production, methyl red, Voges–Proskauer, citrate utilization, urease production, triple sugar iron agar tests, and catalase/oxidase assays) following Microbiological Manual Guidelines (Cheesbrough, 2006).

Determination of Infection Rate (IR): Infection rate was calculated as the proportion of examined cockroaches from which *E. coli* was isolated, and expressed as a percentage:

$$IR \% = \frac{\text{Number of Infected Cockroach samples}}{\text{Total Number of Samples Examined}} \times 100$$

Determination of Pathogen Load (PL): Bacterial load carried per cockroach was determined by serial ten-fold dilutions (10^{-1} to 10^{-5}) of internal homogenates that were plated on MacConkey agar and incubated at 37°C for 24–48 h. Plates exhibiting 30–300 colony forming units (CFUs) were counted, and pathogen load (CFU per individual cockroach) was calculated as:

Pathogen Load (PL)

$$= \frac{\text{Number of Colonies} \times \text{Dilution Factor} \times \text{Volume of Diluent}}{\text{Volume Plated}}$$

Determination of Transmission Efficiency (TE): To quantify the mechanical transfer efficiency of *E. coli* from cockroach bodies to environmental surfaces, a QMRA-based experimental design was used (Campbell *et al.*, 2020; Capone *et al.*, 2023). Cockroaches ($n = 5$) were starved for 24 h and then exposed to a surface contaminated with *E. coli* at 10^8 CFU/mL for 1 h. They were then transferred to a clean chamber with sterile surfaces and allowed to roam for 2 h. Afterwards, the receiving surfaces were swabbed with sterile cotton swabs moistened with normal saline, plated onto Nutrient Agar, and incubated at 37°C for 24 h to enumerate transferred CFUs. Transmission efficiency (TE) was calculated as:

Transmission Efficiency (TE, %)

$$= \frac{\text{Number of CFUs on Surface after Cockroach Exposure}}{\text{Initial Number of CFUs in Innoculum}} \times 100$$

Vectorial Capacity (VC) Calculation: VC was calculated as the product of IR (expressed as a proportion), TE (as a proportion), and PL (CFU/cockroach):

$$VC = IR \times TE \times PL$$

Results: Cockroach Abundance and Micro-Habitat

Infestation Rates: A total of 72 cockroaches were collected, all identified as *B. germanica*. Yelwa hostel accounted for 45.83% of collections and Gubi 54.17%. Kitchen areas were the primary infestation foci in both hostels (Yelwa: 36.36%; Gubi: 46.15%) (Table 1). Student bedrooms constituted the second most infested micro-habitat (Yelwa: 30.30%; Gubi: 23.08%), followed by lavatories (Yelwa: 15.15%; Gubi: 17.95%) and communal corridors (Yelwa: 18.18%; Gubi: 12.82%) (Table 1).

Bacterial Pathogen Carriage: Bacteriological analysis of 10 pooled external body washes ($n = 5$) and internal gut homogenates ($n = 5$) yielded 20 distinct bacterial isolates belonging to five genera. Enteropathogenic *E. coli* was predominant (45%, $n = 9$), followed by *Proteus* (20%, $n = 4$), *Enterobacter* (15%, $n = 3$), *Klebsiella* (10%, $n = 2$), and *Shigella* (10%, $n = 2$) (Table 2).

Environmental Determinants: Temperature and humidity data (Table 3) show mean temperatures of 28–32°C and relative humidity increasing from 44% (May) to 72% (July). These conditions are optimal for *B. germanica* development and reproduction, with the species' thermal optimum generally between 25–33°C (Okrikata *et al.*, 2024). The correlation between increasing humidity and infestation intensity was evident in the higher capture rates from lavatories and kitchen areas—microhabitats with sustained moisture. Sanitation assessment revealed that kitchen areas with visible food debris, grease accumulation, and irregular cleaning had the highest cockroach densities, corroborating the strong association between poor sanitation and infestation.

Vectorial Capacity Components: Infection Rate (IR): Of the 25 pooled cockroaches subjected to specific *E. coli* screening, 13 internal gut homogenate pools tested positive, giving an internal infection rate of 52% (13/25 x 100); while 10 external body homogenates tested positive, giving an external surface infection rate of 40% (10/25 x 100). The overall combined mean infection rate (IR) for *B. germanica* was computed as:

$$\text{Mean IR} = \frac{52\% + 40\%}{2} = 46\% \text{ or } 0.46$$

Bacterial Pathogen Load (PL): Colony counts from serial dilutions yielded an average of 87 CFU on MacConkey plates at a 10^{-3} dilution factor using 1.0 mL initial diluent and 0.2 mL plated volume. The pathogen load per cockroach was calculated as:

$$\begin{aligned} \text{Pathogen Load (PL)} \\ &= \frac{87 \text{ colonies} \times 1000 (\text{dilution Factor}) \times 1.0 \text{ mL}}{0.1 \text{ mL}} \\ &= 8.7 \times 10^5 \text{ CFU/Cockroach} \end{aligned}$$

Transmission Efficiency (TE): In the QMRA exposure chamber, exposure to an initial inoculum of 1.0×10^8 CFU/mL resulted in a recovery of 300 CFU transferred to clean secondary contact surfaces following 2 h of mechanical activity.

$$TE (\%) = \left(\frac{300}{10^8} \right) \times 100 = 0.0003\% \text{ or } 3.0 \times 10^{-6}$$

Integrated Vectorial Capacity (VC): Substituting IR (0.46), TE (0.0003), and PL (8.7×10^5) into the integrated vectorial capacity model yields:

$$VC = 0.46 \times 0.0003 \times (8.7 \times 10^5) = 120.06$$

A VC value of 120.06 indicates a substantial overall capacity for *B. germanica* to maintain and mechanically disseminate bacterial pathogens across high-density student residential environments.

Discussion: Ecological Distribution and Microclimatic Drivers: The higher infestation in Gubi likely reflects its more rural setting, poorer waste management infrastructure, structural defects, unsealed drainage pipes, and accumulated solid waste that provide extensive outdoor-indoor corridors and greater proximity to outdoor breeding sites (Ibrahim *et al.*, 2020; Maigoro *et al.*, 2026). These findings align with Nwoye *et al.* (2025) who reported a 53.4% prevalence of *B. germanica* in Kaduna State University hostels, and with studies in Gombe linking poor sanitation to increased infestation (Ibrahim *et al.*, 2020).

Across both campuses, kitchen areas emerged as the primary locus of infestation (36.36% - 46.15%). This localized concentration is directly explained by the insect's physiological requirements; *B. germanica* exhibits strong affinity for warm, moist microhabitats with accessible food sources (Okrikata *et al.*, 2024). These findings align with broad eco-entomological assessments in African urban

dwellings where unwashed culinary utensils, open refuse bins, and stagnant water in student kitchenettes create optimal feeding and breeding niches (Mwang'onde *et al.*, 2023).

The climatic progression from May to July 2024 in Bauchi State, Nigeria, further underscores the thermal ecophysiology of *B. germanica* (Wu *et al.*, 2017; Kamal *et al.*, 2025). During this period, the region experienced the transition into the rainy season, with temperatures typically ranging from 22 °C to 38 °C and increasing humidity from 44% to 72% that elevates indoor moisture levels in poorly ventilated lavatories and kitchen areas. High relative humidity reduces desiccation stress in adult cockroaches and nymphs, accelerating egg capsule development and nymphal maturation rates (Lopina, 2026). All these conditions align with the known thermal preferences of *B. germanica*, which exhibits optimal development around 30 °C and a lower developmental threshold of approximately 16.2 °C (Wu *et al.*, 2017; Kamal *et al.*, 2025). Consequently, seasonal shifts in microclimate modulate vector population density and exacerbate mechanical transmission risks in communal housing structures.

Microbiological Profile and Public Health Implications: The spectrum of bacterial pathogens isolated in this study—dominated by *Escherichia coli*, alongside *Proteus* spp., *Enterobacter* spp., *Klebsiella* spp., and *Shigella* spp.—demonstrates that *B. germanica* acts as a significant reservoir for enteropathogenic bacteria (Derguini & Basher, 2026). The dominance of *E. coli* is consistent with its role as a faecal indicator organism and its frequent isolation from cockroaches in Nigerian institutional settings (Ikechukwu *et al.*, 2017; Ogunde *et al.*, 2017; Okrikata *et al.*, 2024; Irabor, 2025; Oarhe, 2026). Cockroaches acquire these organisms while foraging in sanitary sewer lines, overflowing latrines, or contaminated refuse disposal sites. The presence of *Shigella* associated with dysentery and *Proteus* associated with opportunistic infections is particularly concerning (Kotloff *et al.*, 2023; Chakkour *et al.*, 2024). Comparable studies from Ethiopia have reported *Klebsiella pneumoniae* (17.7%) and *E. coli* (16%) as predominant isolates (Moges *et al.*, 2016), while Algerian studies have documented ESBL-producing Enterobacteriaceae in hospital cockroaches (Loucif *et al.*, 2016). The isolation of multiple enteric pathogens from both external and internal homogenates confirms that *B. germanica* acts as both a surface contaminant and an internal reservoir of pathogenic bacteria.

Infection Rate and Bacterial Pathogen Load Dynamics: The internal gut infection rate (52.0%) exceeded the external body surface infection rate (40.0%), yielding a combined infection rate of 46.0%. The higher internal carriage rate reflects the physiological role of the insect digestive tract as a protected microbial microenvironment (Lanan *et al.*, 2016). While external surface-bound bacteria are subject to desiccation, grooming behavior, and environmental mortality, bacteria ingested during coprophagous or necrophagous feeding survive within the alimentary canal (Niaz *et al.*, 2017). Ingested pathogens can subsequently be excreted via fecal pellets or regurgitated during feeding, facilitating indirect transmission (Tachbele *et al.*, 2006).

Ecological Vector Dynamics and Quantitative Microbial Risk Assessment of Synanthropic Cockroaches (*Blattella germanica*) in Tropical Student Housing Structures

The estimated bacterial pathogen load (8.7×10^5 CFU/cockroach) demonstrates that an individual insect carries a substantial microbial burden. This value aligns with quantitative assessments by studies that reported bacterial loads ranging between 10^5 and 10^7 CFU per insect in synanthropic cockroach populations sampled from public facilities (Mpuchane *et al.*, 2006; Menasria *et al.*, 2014, 2015). A high microbial load ensures that even brief contact events dislodge sufficient bacterial inoculum to exceed infectious thresholds for human hosts (Donkor, 2020).

Quantitative Vectorial Capacity (VC) and Transmission

Dynamics: A key finding of this study is that integrating empirical parameters into a quantitative vectorial capacity model yielded a VC value of 120.06. This estimate reflects a low direct transfer efficiency, consistent with Pai *et al.* (2003), who reported TE values of 0.0001–0.001% for *Salmonella* and *E. coli* transfer by cockroaches in various urban environments. Although the experimental surface TE determined in this study was numerically low (0.0003%), the overall vectorial capacity remained elevated because of the multiplicative effects of a high infection rate (46%) and a high pathogen load (8.7×10^5 CFU/cockroach). These values are comparable to the high cockroach-associated microbial burdens reported by Tilahun *et al.* (2012) and Menasria *et al.* (2014). Therefore, the public health significance of this seemingly low efficiency should be interpreted in the context of high cockroach population densities and frequent surface contacts. Cumulative contamination through repeated contacts, fecal deposition, and shedding of body fragments can substantially amplify transmission risk (Kopanic *et al.*, 1994).

Mechanical TE measures direct contact transfer during brief movement. However, in real-world institutional settings, *B. germanica* individuals exhibit repetitive nocturnal crawling behaviors over human food items, cutlery, and kitchen counters (Tilahun *et al.*, 2012). When coupled with cumulative contamination via defecation and regurgitation, low mechanical transfer rates per individual contact accumulate into substantial environmental contamination (Donkor, 2020; Tilahun *et al.*, 2012). Quantitative vectorial capacity modeling thus confirms that *B. germanica* is a potent mechanical vector of enteric bacterial pathogens in high-density student residences (Pai *et al.*, 2003).

From an environmental microbiology perspective, the persistence of *E. coli* and other enteric pathogens in cockroach gut and surface homogenates underscores the role of indoor microenvironments as reservoirs of faecal contamination. From ecological perspective, the distribution of *B. germanica* across hostels reflects resource-driven habitat selection: kitchen areas and lavatories provide the warmth, moisture, and organic matter that sustain populations. Understanding these ecological drivers is essential for designing targeted control strategies that address root causes rather than symptoms.

Conclusion and Recommendations: This study demonstrates that *B. germanica* in ATBU student hostels carries a substantial load of pathogenic bacteria, with *E. coli* as the predominant isolate. The calculated vectorial capacity of 120.06 indicates a moderate but non-negligible

transmission risk, driven by high infection rates, appreciable pathogen loads, and favourable environmental conditions. Kitchen areas and lavatories were the primary infestation foci, reflecting the species' ecological requirements for warmth, moisture, and food. Poor sanitation practices amplified both infestation intensity and pathogen carriage. These findings establish a quantitative basis for environmental health interventions in Nigerian university hostels and contribute to the broader discourse on mechanical vector-borne disease transmission in developing-country residential settings.

Recommendations: Based on the findings of this study, we propose the following actionable recommendations:

Integrated Pest Management (IPM): Implement routine monitoring using sticky traps and gel baits, with targeted insecticide application in kitchenettes and lavatories. Coordinate with campus facilities management for quarterly professional pest control. **Sanitation**

Infrastructure Upgrade: Install covered waste bins in all kitchen areas, repair leaking pipes to eliminate moisture sources, and schedule daily cleaning of food preparation surfaces with hospital-grade disinfectants. **Student Awareness and Engagement:** Conduct orientation programmes on food storage hygiene, waste disposal, and the health risks of cockroach infestation. Establish student-led sanitation committees for peer monitoring.

Environmental Monitoring: Maintain quarterly records of temperature, humidity, and infestation indices to enable predictive modelling of cockroach population dynamics and pre-emptive interventions. **Further Research:** Extend VC assessments to other cockroach species (*P. americana*, *S. longipalpa*) and to antibiotic-resistant bacterial strains. Apply the QMRA framework to quantify actual infection risks from surface contamination events.

References

- Abbasi, E. (2025). Cockroaches as urban pests: Challenges, public health implications, and management strategies. *International Journal of Infectious Diseases One Health*, 9(1):e2949.
- Alqassim, A. Y. (2026). Climate Change, Urbanization, and the Emerging Urban Threat of Rift Valley Fever in Tropical and Subtropical Cities: A Narrative Review. *Tropical Medicine and Infectious Disease*, 11(8), 226.
- Bell, W. J., Roth, L. M., & Nalepa, C. A. (2007). *Cockroaches: Ecology, behavior, and natural history*. Johns Hopkins University Press.
- Blitvich, B. J. (2025). The Role of Hematophagous Arthropods, Other than Mosquitoes and Ticks, in Arbovirus Transmission. *Viruses*, 17(7), 932.
- Brady, O. J., et al. (2016). Vectorial capacity and vector control: reconsidering sensitivity to parameters for malaria elimination. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 110(2), 107–117.
- Campbell, P. M., Stork, R. J., & Hug, A. G. (2020). The common feeder cockroach *Blattella germanica* shows increased transmission distance based on mode of acquisition of environmental bacteria. *Journal of the Arkansas Academy of Science*, 74(7).
- Capone, D., Adriano, Z., Cummings, O., Viegas, E., & Brown, J. (2023). Urban onsite sanitation upgrades and synanthropic flies in Maputo, Mozambique: Effects on enteric pathogen infection risks. *Environmental Science & Technology*, 57(2), 1075–1085.

Ecological Vector Dynamics and Quantitative Microbial Risk Assessment of Synanthropic Cockroaches (*Blattella germanica*) in Tropical Student Housing Structures

Chakkour, M., Hammoud, Z., Farhat, S., El Roz, A., Ezzeddine, Z., & Ghasein, G. (2024). Overview of *Proteus mirabilis* pathogenicity and virulence: Insights into the role of metals. *Frontiers in Microbiology*, 15(1383618).

Hayes, C.C., Schal, C. (2024) Review on the impacts of indoor vector control on domiciliary pests: good intentions challenged by harsh realities. *Proceedings of the Royal Society B*, (291): 20240609.

Ifeamaechi, N. Z., Saidu, A., Samaila, M., & Hafsat, A. (2025). Prevalence and species composition of cockroaches in male and female hostels of Kaduna State University, Nigeria. *International Journal of Emerging Multidisciplinaries: Biomedical and Clinical Research*, 3(1), Article 07.

Ikechukwu, O., Ifeanyichukwu, E., David, I., Agwu, E., & Ogbonnaya, O. (2017). Antibiotic resistance and beta-lactamase genes detection among extended-spectrum beta-lactamase (ESBL)-producing *Escherichia coli* and *Salmonella* species isolated from cockroaches (*Periplaneta americana*) in Abakaliki, South-East Nigeria. *International Journal of Microbiology and Applied Sciences*, 4(1), 1–8.

Irabor, B. (2025). Bacteriological screening for *Escherichia coli* in female hostel drains/wastewater from University of Benin, Ugbowo Campus, Nigeria [Unpublished bachelor's thesis]. University of Benin.

Kamal, A., Omar, A. A., Shamsudden, A., Auwal, L. M., Mohammed, U. A., Yusuf, A. S., Aliyu, U., & Ya'u, F. Z. (2025). Survey of medically important protozoans infested on cockroaches collected from student hostel in Sa'adu Zungur University, Bauchi State. *FUDMA Journal of Sciences*, 9(2), 61–65.

Okrikata, E., Bozdoğan, H., & Luka, B.-E. (2024). Cockroaches (*Periplaneta americana* Linnaeus [Dictyoptera: Blattellidae]) as potential vectors of bacteria in Federal University Wukari, Nigeria. *Egyptian Academic Journal of Biological Sciences. A, Entomology*, 17(3), 1–11.

Olowoporoku, J. O., Agbo, M., Alabi, E. D., Abdullahi, K., Adesoji, A. T., & Johnson, S. I. (2026). Household insect pests as transient vectors of multidrug-resistant Gram-negative bacteria in Dutsin-Ma, Nigeria: A cross-sectional study. *Pan African Medical Journal*, 55, 1-7.

Pai, H. H., Ko, Y. C., & Chen, E. R. (2003). Cockroaches (*Periplaneta americana* and *Blattella germanica*) as potential mechanical disseminators of *Entamoeba histolytica*. *Acta Tropica*, 87(3), 355–359.

Patil, A. J. (2023). Evaluation of transmission capacity of houseflies and cockroaches for pathogenic human intestinal parasites. *International Journal of Community Medicine And Public Health*, 10(4), 1464–1468.

Table 1: Magnitude of German cockroach (*Blattella germanica*) Infestation in Yelwa and Gubi Campus Hostels, ATBU, Bauchi, Nigeria (10 May – 10 July 2024)

Hostel	Trapping Area	Number of Samples	Percentage of Hostel Samples	Percentage of Total Samples
Yelwa	Kitchenettes	12	36.36%	16.67%
Yelwa	Lavatory	5	15.15%	6.94%
Yelwa	Bedroom	10	30.30%	13.89%
Yelwa	Corridor	6	18.18%	8.33%
Sub-Total: Yelwa		33	45.83%	45.83%
Gubi	Kitchenettes	18	46.15%	25.00%
Gubi	Lavatory	7	17.95%	9.72%
Gubi	Bedroom	9	23.08%	12.50%
Gubi	Corridor	5	12.82%	6.94%
Sub-Total: Gubi		39	54.17%	54.17%
Grand Total		72	100.00%	100.00%

Table 2: Bacteria Pathogens Isolated from German cockroach (*Blattella germanica*) in Yelwa and Gubi Campus Hostels, ATBU, Bauchi, Nigeria (May–July 2024)

Bacterial Isolate Identified	Total Number of Isolates (n)	Percentage (%)	Primary Clinical Significance
<i>Escherichia coli</i>	9	45.00	Gastroenteritis, Urinary Tract Infections, Food Poisoning
<i>Proteus</i> spp.	4	20.00	Wound Infections, Urinary Tract Infections
<i>Enterobacter</i> spp.	3	15.00	Opportunistic Nosocomial & Respiratory Infections
<i>Klebsiella</i> spp.	2	10.00	Pneumonia, Septicemia, Enteric Infections
<i>Shigella</i> spp.	2	10.00	Bacillary Dysentery, Severe Abdominal Cramps
Total	20	100.00	—

Table 3: Ambient Microclimatic Data for Abubakar Tafawa Balewa University Hostel Environs, Bauchi, Nigeria (May to July 2024)

Month	Average High Temp (°C)	Average Low Temp (°C)	Mean Temp (°C)	Precipitation (inches)	Humidity (%)
May	38	26	32	1.71	44%
June	35	25	30	1.88	59%
July	32	23	28	5.18	72%

Source: ATBU, Bauchi, Nigeria- Agro-Meteorological Data Centre

Ecological Vector Dynamics and Quantitative Microbial Risk Assessment of Synanthropic Cockroaches (*Blattella germanica*) in Tropical Student Housing Structures