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Assessment of Bedbug (*Cimex Hemipterus* Fabricius, 1803) Infestation in Households and Tsangaya Schools in the Sudan Savanna Zone of Nigeria: Prevalence, Distribution, and Control Practices

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ABSTRACT
Bedbug infestation remains a persistent public health challenge in many developing regions. This study assessed the prevalence, distribution, and control practices of bedbugs in households and Tsangaya schools across Kaduna, Kano, and Katsina States in the Sudan savanna zone of Nigeria. A cross-sectional design was adopted, involving field inspection and questionnaire-based data collection from 300 respondents. Bedbug infestation was recorded in 59.2% of examined locations, with Kaduna showing the highest prevalence. Infestation levels were significantly higher in Tsangaya schools compared to households ($p \leq 0.05$). Walls were identified as the primary harboring sites, supporting the highest populations of bedbugs across all developmental stages. Although 78% of respondents were aware of bedbugs, exposure was widespread. Chemical control methods were more commonly used than traditional methods; however, sanitation practices were generally poor. Analysis of variance (ANOVA) revealed significant differences across states, materials, and settlement types, while Duncan's Multiple Range Test separated group means. The findings highlight the need for targeted interventions, improved sanitation, and integrated pest management strategies, particularly in communal living environments such as Tsangaya sschools.

Keywords: Bedbugs, Households, Infestations, Tsangaya schools

INTRODUCTION

Bedbugs (*Cimex hemipterus*) are hematophagous ectoparasites that have re-emerged globally as significant public health pests due to increased urbanization, insecticide resistance, and inadequate pest management strategies (Doggett and Lee, 2023). Bedbugs have long been associated with human habitation. The global resurgence of bedbugs poses threat to the pest management industry and a public health concern globally over the last two decades (Doggett *et al*., 2018). Bedbug infestations are no longer limited to homes, hotels, and motels; these days, infestations also are found in commercial buildings, health care facilities (Sheele *et al*., 2017), offices (Sked *et al*., 2019), libraries (Salter, 2019), and mass transportation including trains (Anders *et al*., 2010), ships (Lilly and Jones, 2018), and airplanes (Juson and Juson, 2018). Bedbugs' bite cause skin irritation and allergic reactions (Hwang *et al*., 2018). Scratching may often lead to secondary bacterial infections in some individuals. The bites may result in psychological disturbance (Wang *et al*., 2016), insomnia, anxiety, and social stigma, significantly affecting quality of life (Harlan *et al*., 2021). A host of other health impacts, including blood loss and respiratory issues due to exposure to bedbug allergens were reported (Doggett, 2018). The increasing prevalence of insecticide-resistant bedbug populations has further complicated control efforts, making infestations more persistent and difficult to manage (Dang *et al*., 2021).

In sub-Saharan Africa, the burden of bedbug infestation remains high due to overcrowding, poor housing conditions, and limited awareness of effective control measures (Gbakima *et al*., 2020). In northern Nigeria, the Tsangaya school system—characterized by communal living and shared sleeping arrangements—provides an environment conducive to rapid bedbug transmission. Socio-economic factors also play a critical role in the distribution and intensity of bedbug infestation. Low-income households, overcrowded living conditions, and limited awareness of effective control methods have been identified as major drivers of infestation (Mbuta *et al*., 2022). In northern Nigeria, the Tsangaya school system represents a unique socio-cultural setting characterized by communal living, shared bedding, and limited resources. These conditions are likely to enhance the transmission and persistence of bedbugs, yet there is limited empirical data examining infestation patterns in such environments.

Despite the growing recognition of bedbugs as a public health concern, there remains a paucity of detailed studies on their distribution across different habitat types, particularly in the Sudan savanna zone of Nigeria. Existing studies have largely focused on isolated environments such as households or hostels, with limited comparative analysis between different settlement types. Furthermore, there is insufficient information on the distribution of bedbugs across various materials and developmental stages, as well as the effectiveness of current control practices. More so, despite increasing reports of infestation, there is limited empirical data comparing infestation patterns between households and Tsangaya schools, particularly in the Sudan savanna zone. Furthermore, the distribution of bedbugs across different materials and the effectiveness of control practices remain underexplored. This study therefore investigates bedbug infestation in households and Tsangaya schools across Kaduna, Kano, and Katsina states in the Sudan savanna zone of Nigeria, with the aim of providing evidence-based insights for improved pest management and public health interventions.

MATERIALS AND METHODS

Study Area

The study was conducted in the Sudan savanna ecological zone of northern Nigeria, covering three states: Kaduna (northern Kaduna), Kano, and Katsina. The Sudan savanna is characterized by a tropical climate with annual rainfall ranging from 500–1000 mm, a prolonged dry season, and mean temperatures between 25–35°C. Vegetation consists mainly of short grasses with scattered drought-resistant trees. These climatic and ecological conditions, combined with increasing urbanization and housing challenges, provide suitable environments for bedbug survival and reproduction (Wang *et al*., 2020). Kaduna, Kano, and Katsina were selected due to their socio-economic importance and the widespread presence of both conventional households and Tsangaya (Islamic boarding) school systems. These states also exhibit varying population densities and sanitation conditions, which are relevant factors influencing bedbug infestation dynamics. Respondents were assured of confidentiality, anonymity, and voluntary participation. Data were used strictly for academic and research purposes.

Research Design

A cross-sectional descriptive and analytical study design was adopted. This design enabled the assessment of bedbug infestation prevalence, distribution, and associated socio-demographic and environmental factors at a single point in time. The study integrated entomological inspection with structured questionnaire administration, allowing for both observational and perception-based data collection (Parola and Izri, 2020).

Study Population

The study population comprised individuals residing in selected households and occupants of '*Tsangaya schools*' within the three states.

Sample Size Determination

The sample size (N = 300) was determined using a standard proportion-based sampling approach suitable for cross-sectional studies. The sample was proportionally allocated across the three states to ensure representativeness. Equal representation of settlement types (households and Tsangaya schools) was considered to facilitate comparative analysis.

Sampling Technique

A multistage sampling technique was employed: Stage I (State Selection): Kaduna, Kano, and Katsina states were purposively selected based on their location within the Sudan savanna zone. Stage II (Stratification): Each state was stratified into two settlement categories: Households and Tsangaya schools. Stage III (Selection of Units): Within each stratum, sampling units were selected using simple random sampling to minimize bias and Stage IV (Respondent Selection): Eligible respondents were randomly selected within each sampled unit. This approach ensured adequate representation across geographical and socio-cultural contexts.

Instrument for Data Collection

A validated self-designed structured questionnaire was used to obtain data from respondents. The questionnaire contained both closed-ended and limited open-ended questions to allow for quantifiable responses while capturing contextual insights.

Field Procedure and Entomological Assessment

Field inspections were conducted to determine the presence and distribution of bedbugs. Standardized inspection protocols were applied across all sampling sites. The following materials were systematically examined: Walls (cracks and crevices), Mattresses, Pillows and Clothes. Bedbugs were identified based on morphological characteristics and categorized into developmental stages: Eggs, Nymphs, Adult males and Adult females. Counts were recorded for each category to assess infestation intensity and distribution patterns (Reinhardt & Siva-Jothy, 2019).

Statistical Analysis

Descriptive statistics were computed, while ANOVA was used to test for significant differences. Significant means were separated using Duncan's Multiple Range Test (DNMRT) at $p \leq 0.05$.

RESULTS AND DISCUSSION

Prevalence of Bedbug Infestation across Study Areas

A total of 300 locations were examined across the Sudan savanna zone of Nigeria, of which 178 (59.2%) were infested with bedbugs (Table 1). Infestation was highest in Kaduna (78 cases), followed by Kano (53 cases) and Katsina (47 cases), indicating spatial variability in infestation intensity. Kaduna contributed the largest proportion of infested sites, suggesting a relatively higher burden in this location.

Table 1: Infestation of Bedbug in Settlements within Sudan Savanna Zone of Nigeria

Selected Zones	No. Examined	No. Infested (%)
Kaduna	100	78(26)
Kano	100	53(17.6)
Katsina	100	47(15.6)
Total	300	178(59.2)

Comparison of infestation between households and Tsangaya schools

Marked differences were observed in infestation levels between households and Tsangaya schools (Table 2). Across all states, Tsangaya schools recorded substantially higher infestation counts compared to households. Kaduna had the highest infestation in both households (1379) and Tsangaya schools (3946), followed by Kano and Katsina. These differences were statistically significant ($p \leq 0.05$), indicating that institutional settings such as Tsangaya schools are more prone to bedbug infestation than household environments.

Table 2: Comparison between Households and Tsangaya Schools' Infestation by Bedbugs

STATES	HOUSE HOLDS	TSANGAYA	*P*-Value
Kaduna	1379[a]	3946[a]	0.00
Kano	1019[b]	2624[b]	0.00

STATES	HOUSE HOLDS	TSANGAYA	*P*-Value
Katsina	731[c]	2111[c]	0.00
MEAN	1043	2893.7	

Values with the same superscripts down a column are NOT significantly different at P≤0.05

Distribution of Bedbugs on Different Materials

The distribution of bedbugs across materials in Kaduna (Table 3) showed that walls harbored the highest populations across all life stages, including males (172.00), females (284.00), nymphs (249.00), and eggs (1871.00). Mattresses and pillows also supported considerable infestations, whereas clothes recorded the lowest counts. Statistical analysis indicated significant differences among materials for all developmental stages (p≤0.05), with walls forming a distinct group with consistently higher infestation levels.

Table 3: Distribution of Bedbugs on Materials Found in Kaduna

Materials	Male	Females	Nymph	Eggs
Walls	172.00[a]	284.00[a]	249.00[a]	1871.00
Mattresses	136.00[b]	117.00[d]	152.00[b]	842.00[b]
Pillows	95.00[c]	230.00[b]	75.00[d]	554.00[c]
Clothes	80.00[d]	159.00[cd]	126.00[c]	183.00[d]
Mean	120.75	197.50	150.50	862.50
SE±	08.00	02.11	01.63	03.69
p-value	0.02	0.05	0.00	0.00

Values with the same superscripts down a column are NOT significantly different at p≤0.05

A similar pattern was observed in Kano (Table 4), where walls recorded the highest counts for males (287), females (402), nymphs (310), and eggs (843). Mattresses and clothes showed moderate infestation, while pillows generally had lower counts. Differences among materials were statistically significant for all life stages (p≤0.05), reinforcing the importance of material type in determining infestation levels.

Table 4: Distribution of Bedbugs on Different Materials Found in Kano

Materials	Male (%)	Females (%)	Nymph (%)	Eggs (%)
Walls	287[a]	402[a]	310[a]	843[a]
Mattresses	101[b]	117[c]	268[b]	249[b]
Pillows	83[c]	130[c]	193[c]	124[c]
Clothes	80[c]	148[b]	62[d]	246[b]
Mean	137.75	199.25	208.25	365.50
SE±	03.27	08.79	07.13	09.13
p-value	0.00	0.00	0.00	0.00

Values with the same superscripts down a column are NOT significantly different at p≤0.05

In Katsina (Table 5), walls also exhibited the highest infestation across most life stages, particularly females (429.00) and eggs (482.00). Mattresses showed comparable egg counts but lower values for other stages. Clothes and pillows consistently recorded lower infestation levels. The observed variation among materials was statistically significant (p≤0.05), indicating consistent habitat preference patterns across locations.

When aggregated across the study area (Table 6), walls remained the most heavily infested material, with the highest mean counts of males (184.67), females (371.67), nymphs (257.33), and eggs (1065.3). Mattresses ranked second, followed by pillows and clothes. This pattern highlights walls as the primary harbor for bedbugs in the Sudan savanna zone.

Table 5: Distribution of Bedbugs Based on Different Materials Found in Katsina

Materials	Male (%)	Females (%)	Nymph (%)	Eggs (%)
Walls	95.00[a]	429.00[a]	213.00[a]	482.00[a]
Mattresses	84.00[b]	117.00[b]	109.00[c]	468.00[a]
Pillows	72.00[c]	82.00[c]	21.00[d]	276.00[b]
Clothes	52.00[d]	56.00[d]	183.00[b]	103.00[c]
Mean	75.75	171.00	131.50	332.25
SE±	0.97	0.26	0.09	0.69
p-value	0.00	0.00	0.00	0.00

Values with the same superscripts down a column are NOT significantly different at p≤0.05

Table 6: Distribution of Bedbugs on Materials Found in Sudan Savanna Zone of Nigeria

Materials	Males	Females	Nymphs	Eggs
Walls	184.67[a]	371.67[a]	257.33[a]	1065.3[a]
Mattresses	107.00[b]	117.00[d]	176.33[b]	519.7[b]
Pillows	83.33[c]	147.33[b]	96.33[d]	318.0[c]

Materials	Males	Females	Nymphs	Eggs
Clothes	70.67[d]	121.00[c]	123.67[c]	177.3[d]
Mean	111.42	189.25	163.71	520.08
S.E±	1.07	0.92	1.71	6.82

Values with the same superscripts down a column are NOT significantly different at p≤0.05

Demographic characteristics of respondents

The demographic profile of respondents (Table 7) revealed that, majority were within the age group 15–19 years (29.33%), followed by 10–14 years (24.67%), indicating a predominantly young population. Males constituted 59.67% of respondents, while females accounted for 40.33%. Educational attainment was generally low, with 66.00% having non-formal education, and only 19.00% attaining tertiary education. Most respondents were single (62.33%), followed by married individuals (26.00%). The sample is characterized by young, predominantly male subjects with limited formal education.

Table 7: Demographic Status of the Respondents

Status	Parameter	Frequency	Percentage (%)
Age	10 – 14	74	24.67
	15-19	88	29.33
	20-24	48	16.00
	25-29	45	15.00
	30-34	20	6.67
	35-39	18	6.00
	40 above	7	2.33
	Total	300	100
Gender	Male	179	59.67
	Female	121	40.33
	Total	300	100
Education	Non-formal	198	66.00
	Primary	17	5.67
	Secondary	21	7.00
	Tertiary	57	19.00
	Any other	7	2.33
	Total	300	100
Marital Status	Single	187	62.33
	Married	78	26.00
	Divorced	13	4.33
	Widow/widower	22	7.33
	Total	300	100

Control Practices

Findings on control measures to bedbugs are summarized in Figure 1. A majority of respondents viewed chemical control methods (51.33%) as the most commonly used and effective method of control than traditional methods (37.33%), although 11.33% reported no control measures.

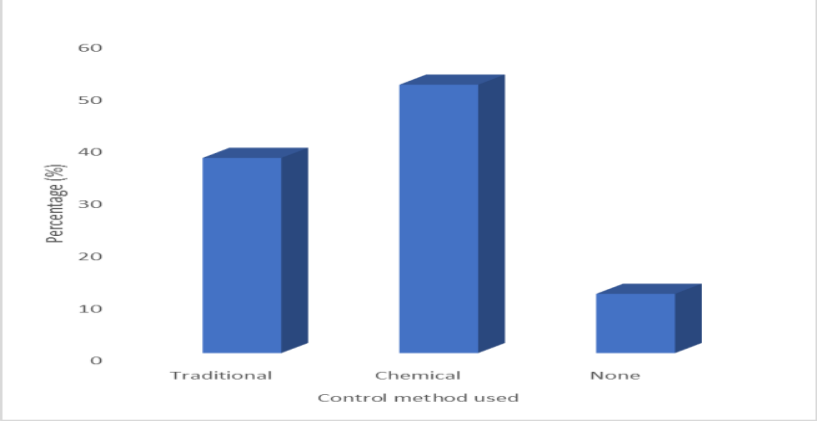

Figure 1: Control measures of bedbugs in Sudano-sahelian zone of Nigeria

Discussion

The present study reveals a high prevalence (59.2%) of bedbug infestation across the Sudan savanna zone of Nigeria, confirming that bedbugs remain a significant public health and socio-environmental concern in the region suggesting the needs for more orientation and public enlightenment campaign on bedbug identification among the public as reported by Oduola *et al*. (2017). This prevalence is consistent

with recent reports from sub-Saharan Africa, where infestation rates remain elevated due to overcrowding, poor housing conditions, and limited access to effective pest control interventions as reported by previous findings of Doggett *et al*. (2018) and Tiffin and Curnow (2020). The infestation rate is higher than that (53.3%) reported by Shire *et al*. (2020) from households in Nakuru town, Kenya.

The higher infestation observed in Kaduna compared to Kano and Katsina suggests spatial heterogeneity, which may be attributed to differences in population density, housing structures, and sanitation practices. A key finding of this study is the significantly higher infestation levels recorded in Tsangaya schools compared to households. This aligns with previous finding of Aultman (2019) reported that institutional and communal living environments are particularly vulnerable to bedbug proliferation due to high human traffic, shared sleeping spaces, and limited pest management practices. The significantly higher infestation in Tsangaya schools highlights the role of overcrowding and communal living in facilitating transmission. Similar findings have been reported by Deku *et al*. (2021) in Cape Coast, Ghana.

The distribution of bedbugs across materials consistently showed that walls had the highest populations across all life stages. This finding corroborates earlier studies by Oduola *et al*. (2017) who posited that bedbugs' infestation were more pronounced in walls with identified cracks, crevices, and wall surfaces served as primary refugia for bedbugs due to their proximity to hosts and protection from disturbance as stressed by Reinhardt and Siva-Jothy (2019) and Wang *et al*. (2020). The relatively high infestation observed in mattresses further reflects their role as secondary harborages, given their direct contact with hosts. In contrast, lower counts on clothes and pillows may be due to more frequent movement and disturbance, reducing the suitability of these materials as stable habitats. Across all study locations, the consistency in material-based distribution suggests that bedbug habitat preference is largely influenced by ecological and behavioral factors rather than geographic location alone. The aggregated data further reinforce walls as the dominant harboring sites, indicating that control strategies focusing solely on bedding materials may be insufficient. Integrated pest management approaches targeting structural components of buildings are therefore essential.

The demographic characteristics of respondents indicate that the affected population is predominantly young, male, and with low levels of formal education. This demographic pattern is typical of Tsangaya school populations and other vulnerable groups in northern Nigeria. Limited education may contribute to poor awareness of effective control measures and hinder the adoption of preventive practices as reported by Gbakima *et al*. (2020). Although a majority of respondents reported awareness of bedbugs, this knowledge did not appear to translate into effective control, suggesting a gap between awareness and practice as reported by Harlan *et al*. (2021).

Control practices among respondents were generally inadequate. Although chemical methods were the most commonly used, the reliance on a limited range of insecticides raises concerns about potential resistance development, which has been widely documented in bedbug populations globally as stressed by previous findings of Romero *et al*. (2019) and Dang *et al*. (2021). The substantial proportion of respondents using traditional methods or no control at all further underscores the lack of access to effective pest management solutions. Additionally, the infrequent cleaning practices reported by most respondents likely contribute to the persistence and spread of infestation. Effective bedbug management in the study area will require a combination of community education, improved sanitation, structural modifications, and access to safe and effective insecticides. Special attention should be given to high-risk environments such as Tsangaya schools, where targeted interventions could significantly reduce infestation levels.

CONCLUSION

This study demonstrates that bedbug infestation is highly prevalent in the Sudan savanna zone of Nigeria, with significant variation across locations and living environments. Walls were identified as the primary harbor, and infestation levels were significantly higher in communal living settings such as Tsangaya schools. Despite relatively high awareness, control practices remain inadequate, contributing to persistent exposure and infestation. The study therefore recommends that, targeted pest control interventions in Tsangaya schools should be given priority and integrated pest management strategies ought to be adopted in combating the menace of bedbug infestation.

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