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Incidence of pathogenic bacteria associated with non-biting flies collected in some selected locations within Maiduguri Metropolis, Borno State, Nigeria

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Abstract

Musca domestica (house fly), *Fannia spp*. (lesser house flies), and *Lucilia spp*. (green bottle flies) are significant mechanical vectors of pathogenic bacteria due to their synanthropic behavior and association with contaminated environments like waste, feces, and decaying organic matter. This study investigated the incidence and antibiotic resistance profiles of pathogenic bacteria associated with flying insects collected from five major markets within Maiduguri Metropolis. A total of 757 flies comprising *Musca domestica, Fannia spp*., and *Lucilia spp*. were sampled from different stands, including meat, fish, and vegetable sections, across Monday, Tashan Bama, Gamboru, Ngomari Airport, and Bolori markets. Standard microbiological and biochemical methods were used. The study revealed a high prevalence of bacterial contamination among the sampled flies. *Klebsiella spp*. (41%) exhibited the highest frequency, followed by *Proteus spp*. (24%), *Escherichia coli* (15%), *Staphylococcus aureus* (13%), and *Pseudomonas spp*. (7%). Gamboru market recorded the highest bacterial load, while Bolori market showed the least. Antibiotic susceptibility testing demonstrated marked resistance of Gram-negative isolates to Amoxicillin, Augmentin, and Sparfloxacin. The predominance of multidrug-resistant *Klebsiella spp*. and *Proteus spp*. suggests a growing environmental reservoir of resistance determinants that could complicate infection control within food-handlers and healthcare settings. In conclusion, the study underscores the public health significance of flying insects in the epidemiology of pathogenic and drug-resistant bacteria within Maiduguri metropolis. Enhanced market sanitation, improved waste management, and the adoption of One Health-based antimicrobial surveillance strategies are recommended to mitigate bacterial transmission risks and safeguard community health.

Keywords: *Non-biting flies, Pathogenic bacteria, Mechanical vectors, Maiduguri, Antibiotic*

1. Introduction

Flying insects such as *Musca domestica* (house fly), *Fannia spp*. (lesser house flies), and *Lucilia spp*. (green bottle

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flies) are significant mechanical vectors of pathogenic bacteria due to their synanthropic behavior and association with contaminated environments. These flies exploit environment rich in organic matter such as garbage, feaces, carrions and wounds where they acquire pathogens and transfer them to food, water, surfaces or clinical settings through contacts, regurgitation or defecation (Khamesipour *et al.*, 2018). Their global distribution, high reproductive rate and adaptability to diverse habitats amplify their role in disseminating bacteria responsible for food borne illnesses, nosocomial infections and antimicrobial resistance (Monyama *et al.*, 2022). Flies acquire and harbor microbial communities residing in habitation where they feed and can potentially disseminate microbes to neighboring farms or communities. Flies play a major role in spreading AMR bacteria from animal production operations to human habitation, causing major concern to public and animal health (Nayduch *et al.*, 2023). Moreover, house flies also harbor and disseminate Antimicrobial Resistant (AMR) pathogenic and nonpathogenic bacteria containing Antimicrobial Resistance Genes (ARG) that can be horizontally transferred among bacteria (Neupane *et al.*, 2020).

Antimicrobial Resistance (AMR) is a global crisis affecting multiple facets of human life, from food security and global economics, to increasing mortality and morbidity caused by Drug-Resistant Infections (DRIs). The one health approach to AMR mitigation requires an understanding of the dynamics between human, animal and environmental systems. In clinical settings, the spread of AMR is a major concern as its results in limited treatment options for patients with DRIs, with attendant increase in morbidity, mortality and cost of care. Flies are of particular concern due to their vast abundance and synanthropic nature. The involvement of flies in the environmental AMR landscape has been demonstrated in various locations including clinical settings, residential dwellings, food production and preparation areas, farms and open markets (Khamesipour *et al.*, 2018).

In view of this, hence the research work aims at investigating the incidence of bacterial pathogen associated with flying insects collected in some selected location within Maiduguri metropolis, which pose a great challenge in the clinical settings.

2. Materials and methods

2.1. *Study area*

This research work was conducted in Maiduguri the capital of Borno State Nigeria, which lies within Latitude 11°50 and 14°N and Longitude 11°09'E and 15'E and an area of 61435 sq km (Legit, 2023). Borne state is situated in the north eastern region of the country with over 6,111,500 million people population, bordered with three states, Yobe to the west, Adamawa to the south, and Gombe to the southwest as well as sizeable number across the borders of Cameroon to the east, Chad ta the northeast and Niger Republic to the north (Wikipedia, 2023).

2.2. *Sample size determination*

The minimum sample size was calculated from a standard formula for calculation of minimum sample size. The formula is as shown below,

$$n = \frac{(Z)^2 (p)(1-p)}{d^2}$$

Where:

n = minimum sample size.

Z = the value of standard normal deviation which at 95% confidence intervals has been found to be 1.96.

p = the estimate of the people prevalence obtained from literature review 39% 0.39 (Balla and Usman, 2014).

d = the degree of precision (error margin) 5%= (0.05).

At prevalence rate of 39%. Using 5% degree of precision at 95% confidence level, the minimum sample size (n) for this study was calculated as follows:

$$n = \frac{(Z)^2 (p)(1-p)}{d^2}$$

$$n = \frac{(1.96)^2 (0.39)(1-0.39)}{0.05^2}$$

n = 142.57

n = 143 sample size.

Due to the predisposing factors and abundances of the flies in study population and to obtain fair distribution in the selected location, a total of 757 flies was used in the study.

2.3. Study design

The study design adopts across sectional study to determine the incidence of pathogenic bacteria associated with flying insects collected from Monday market, Tashan bama market, Gamboru market, Ngomari airport market and Bolori market which will include the following (meat stand, fish stand and vegetable stand).

2.4. Ethical consideration

The ethical clearance letter was collected from ministry of health Maiduguri Borno state for the study with a research number RHREC. NO 54/2025.

2.5. Sample collection and preparation

2.5.1. Sample collection

A total of 757 flying insects was collected from Monday market, Tashan bama market, Gamboru market, Bolori market, and Ngomari airport market from different sites which include (meat stand, fish stand, vegetables stand) within Maiduguri metropolis. An average of 143 flying insects from three species was collected between the hours of 8: 00 am to 2:00 pm. The collected flying insects was preserved in universal sterile container and transported to microbiology, department of medical laboratory science, university of Maiduguri teaching hospital for laboratory analysis. Their external and internal surfaces were processed by standard microbiological procedures and screened for bacteria.

2.5.2. Preparation of phosphate buffered saline

A tablets of phosphates buffer saline containing 500 mg was dissolved in 1 liter of distilled water and sterilized using an autoclaved for 15 minutes at 121 ^{o}C.

2.6. Extraction of external bacteria

The collected flying insects was sorted out based on the types which include (*Fannia spp, lucilia spp and Musca domestica*), each type was aseptically transferred into sterile universal container containing 15 mls of sterile physiological saline and washed to remove all the external bacteria. The homogenate was serially dilute into five fold in other to reduce bacterial load in the sample. All other samples were treated as such before inoculation.

2.7. Extraction of internal bacteria

The collected flying insects were sorted out based on the types and location which include (*Fannia spp, lucilia spp and Musca domestica*), each type was aseptically dissected to remove the internal content and sterile physiological saline was used to wash out the internal content which was transferred into sterile tube, serial dilution was perform on the solution to obtained fivefold concentration to reduce the bacterial load. All other samples from different sites were treated as such before inoculation.

2.8. Media preparation

Various culture media such as Blood agar, MacConkey, chocolate agar, Muller Hinton and peptone water were prepared according to the manufacturer's instructions (Cheesbrough, 2006).

2.9. Sample analysis

The Inoculation of fivefold concentration of the samples was seeded on enriched and differential media, a loop full from each sample was inoculated on Blood agar, Chocolate agar, MacConkey agar. The plates were

incubated for 24 hours at 37° under aerobic and anaerobic condition after which bacterial colonies were identified.

2.10. Biochemical test

Gram stain was conducted on the isolates followed by biochemical test which include the; Motility, indole, citrate and urease for gram negative organisms. Catalase and coagulase for gram positive organisms.

2.11. Antibiotics susceptibility testing

The antibiotic susceptibility of the isolates was tested against the following antibiotics: Cefoxtaxin (10 ug), Rocephine (25 ug), Ceftriazone (10 ug), pefloxacin (30 ug), Ofloxacin (10 ug), Spefloxacin (20 ug), Azithromycin (20 ug), Amoxicillin (10 ug), Erythromycin (10 ug), Gentamycin (10 ug), Cefotaxim (10 ug), Ciprofloxacin (10 ug), Sparfloxacin (10 ug), Augumentin (30 ug). Antibiotic sensitivity pattern was determined by disc diffusion method. A colony of the test organism was picked with sterile wire loop and emulsified in peptone water. The turbidity of the suspension was compared against a reference 0.5 MacFarland standard tube. The suspension was poured onto the entire plates of Muller Hinton agar excess was drained and the antibiotics disc was placed on the plate using forceps. The plates were incubated at 37 °C for 24 hours, sensitivity pattern was determined by measuring the diameter of the zones of inhibition with a calibrated ruler and interpreted according to standard guidelines for clinical and laboratory standards institutes criteria (Clinical and Laboratory Standards Institute (CLSI), 2025).

2.12. Data analysis

Bacteria incidence was determined as percentage of flying insects carrying specific bacteria. The antibiotics resistant pattern was analyzed and compared across different sample based on percentage.

3. Results

A total of 757 non-biting flies were analysed and presented in the following figures and tables. Figure 1 shows the distribution of flying insects obtained from five market locations with respect to flies' species. Gamboru market has: *M. domestica* (127), *Fannia spp.* (47) and *Lucillia spp.* (59). Monday market has: *M. domestica* (92), *Fannia spp.* (5) and *Lucillia spp.* (48). Tashan bama market has*: M. domestica* (112), *Fannia spp.* (33) and *Lucillia spp.* (44). Ngomari airportmarket has: *M. domestica* (69), *Fannia spp.* (26) and *Lucillia spp.* (17).

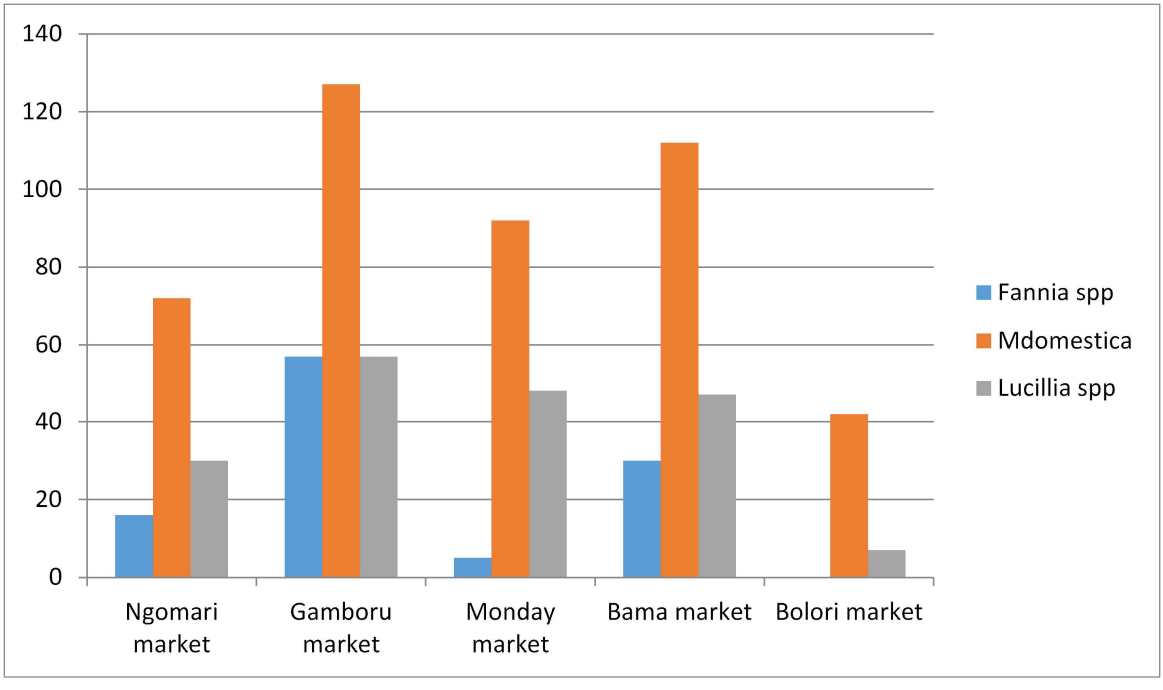

Figure 1: Distribution of different flying insects obtained from different five (5) markets within Maiduguri metropolis

Table 1: Number of flying insects caught and the number of isolated organisms from different market location within Maiduguri metropolis

Market's location	Number of flies	Number of isolated organisms
Ngomari airport	140	13
Tashan bama	188	17
Monday	145	15
Gamboru	233	18
Bolori	51	5
Total	757	68

Table 1 shows the total number (757) of flies caught and the number of isolated organisms (68) with respect to market locations, Gamboru have the highest number of flies (233) and the number of bacteria isolates (18) while Bolori have the least number of flies (51) and bacteria isolates (5).

Table 2 shows the distribution of isolated organism across different stands with respect to flies' species obtained in tashan bama market. Meat stands (5) fish stands (5) vegetables stands (7) from both internal and external surfaces of *M. domestica, Fannia spp.* and *Lucillia spp.*

Table 2: Distribution of isolated organisms across different stands with respect to flies species in Tashan bama market

Location	Flies types	Extract types	Organism types				
			S. aureus	*E. coli*	*Klebsiella spp.*	*Protues spp.*	*Pseudomonas spp.*
Meat stand	*M. domestica*	External	+	-	+	-	-
		Internal	-	-	-	-	+
	Fannia spp.	External	-	-	-	+	-
		Internal	-	+	-	-	-
	Lucillia spp.	External	-	-	-	-	-
		Internal	-	-	-	-	-
Fish stand	*M. domestica*	External	-	+	-	-	-
		Internal	-	-	+	-	-
	Fannia spp.	External	-	-	+	-	-
		Internal	-	-	-	+	-
	Lucillia spp.	External	-	-	-	-	+
		Internal	-	+	-	-	-
Vegetables stand	*M. domestica*	External	-	-	-	+	-
		Internal	+	-	-	+	-
	Fannia spp.	External	-	-	+	-	-
		Internal	-	-	-	-	-
	Lucillia spp.	External	-	-	-	-	+
		Internal	-	+	-	-	-

Note: + = positive; **- =** negative.

Table 3 shows the distribution of isolated organism across different stands with respect to flies' species obatined in monday market. Meat stands (5) fish stands (6) vegetables stands (5) from both internal and external surfaces of *M. domestica, Fannia spp.* and *Lucillia spp.*

Tables 3: Distribution of isolated organisms across different location with respect to flies species in Monday market

Location	Flies types	Extract types	Isolated organisms				
			S. aureus	*E. coli*	*Klebsiella spp.*	*Protues spp.*	*Pseudomonas spp.*
Meat stand	*M. domestica*	External	-	-	+	-	-
		Internal	-	-	+	-	-
	Faniina spp.	External	-	-	-	+	-
		Internal	-	+	-	-	-
	Lucillia spp.	External	-	-	+	-	-
		Internal	-	-		-	-
Fish stand	*M. domestica*	External	-	-	+	-	-
		Internal	+	-	+	-	-
	Fannia spp.	External	-	-	+	-	-
		Internal	-	-	-	+	-
	Lucillia spp.	External	-	+	-	-	-
		Internal	-	-	-	-	-
Vegetables stand	*M. domestica*	External	-	-	+	-	-
		Internal	-	-	-	+	-
	Fannia spp.	External	-	-	+	-	-
		Internal	-	-	-	-	-
	Lucillia spp.	External	-	+	-	-	-
		Internal	-	-	+	-	-

Note: + = positive; **- =** negative.

Table 4 shows the distribution of isolated organism across different stands with respect to flies' species obatined in Ngomari airport market. Meat stands (7) fish stands (4) vegetables stands (2) from both internal and external surfaces of *M. domestica, Fannia spp.* and *Lucillia spp.*

Table 4: Distributions of isolated across different location with respect to flies species in Ngomari Airport markets

Location	Flies types	Extract types	Isolated organism				
			S. aureus	*E. coli*	*Klebsialla spp.*	*Protues spp.*	*Pseudomonas spp.*
Meat stand	*M. domestica*	External	-	-	-	-	+
		Internal	+	-	-	+	-
	Fannia spp.	External	-	-	-	+	-
		Internal	-	-	+	-	-
	Lucillia spp.	External	-	-	+	-	-
		Internal	-	+	-	-	-
Fish stand	*M. domestica*	External	-	-	-	-	-
		Internal	-	-	-	+	-
	Faniina spp.	External	-	-	-	-	-
		Internal	-	-	-	+	-
	Lucillia spp.	External	+	-	+	-	-
		Internal	-	-	+	-	-
Vegetables stand	*M. domestica*	External	-	-	+	-	-
		Internal	-	-	+	-	-
	Fannia spp.	External	-	-	-	-	-
		Internal	-	-	-	-	-

Note: + = positive; **- =** negative.

Table 5 shows the distribution of isolated organism across different stands with respect to flies' species obatined in Gamboru market. Meat stands (7) fish stands (4) vegetables stands (7) from both internal and external surfaces of *M. domestica, Fannia spp.* and *Lucillia spp.*

Table 5: Distribution of isolated organisms across different locations with respect to flies species in Gamboru markets

Location	Flies types	Extract types	Isolated organism				
			Staph spp.	***E. coli***	***Klebsialla spp.***	***Protues spp.***	***Pseudomonas spp.***
Meat stand	*M. domestica*	External	+	-	-	-	+
		Internal	-	+	-	-	-
	Fannia spp.	External	-	-	-	+	-
		Internal	-	-	-	+	-
	Lucillia spp.	External	+	-	-	-	+
		Internal	-	-	-	-	-
Fish stand	*M. domestica*	External	-	+	-	-	-
		Internal	-	+	-	-	-
	Fannia spp.	External	-	-	+	-	-
		Internal	-	-	-	-	-
	Lucillia spp.	External	-	-	+	-	-
		Internal	-	-	-	-	-
Vegetables stand	*M. domestica*	External	-	+	-	-	-
		Internal	-	+	-	-	-
	Fannia spp.	External	+	-	+	-	-
		Internal	-	-	-	+	-
	Lucillia spp.	External	-	-	+	-	-
		Internal	-	-	-	+	-

Note: + = positive; **- =** negative.

Table 6 shows the distribution of isolated organism across different stands with respect to flies' species obatined in Bolori market. Meat stands (5) fish stands (0) vegetables stands (0) from both internal and external surfaces of *M. domestica, Fannia spp.* and *Lucillia spp.*

Table 6: Distribution of isolated organisms across different location with respect to different species in Bolori markets

	Flies types	Extracts types	Isolated organisms				
			S. aureus	***E. coli***	***Klebsialla spp.***	***Proteus spp.***	***Pseudomonas spp.***
Meat stand	*M. domestica*	External	-	+	-	-	-
		Internal	-	+	-	-	-
	Fannia spp.	External	-	-	-	-	-
		Internal	-	-	-	-	-
	Lucillia spp.	External	+	-	+	-	-
		Internal	-	-	+	-	-

Note: + = positive; **- =** negative.

Table 7 shows the frequency the bacteria isolates from *M. domestica* across all market. A total of 16 bacteria isolate was obtained from the internal surface and 14 bacteria isolates from the external surface.

Figure 2 shows the prevalence of bacteria isolates in *M. domestica* across the five (5) market locations within Maiduguri metropolis, with *Klebsiella spp.* having the highest prevalence (32%) and *Proteus spp.* and *Pseudomonas spp.* having the least (13%).

Table 7: Frequency of bacteria isolates from *M. domestica* across all markets		
Organisms	**% of internal isolates N(16)**	**% external isolates N(14)**
Staph spp.	3(18.7%)	2(14.2%)
E coli	3(18.7%)	4(28.5%)
Proteus spp.	3(18.7%)	1(7.1%)
Klebsialla spp.	5(31.2%)	5(35.7%)
Psuedomonas spp.	2(12.5%)	2(14.2%)
Total %	99.8%	99.7%

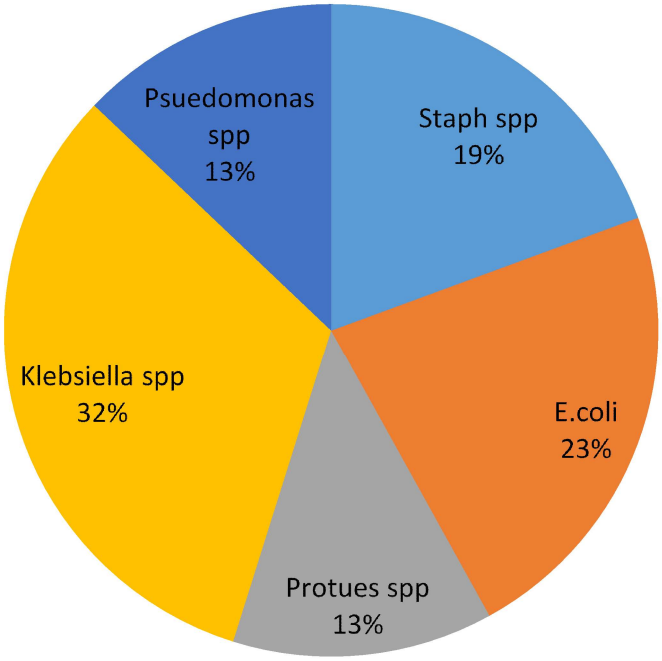

Figure 2: Total % of *M. domestica*

Table 8 shows the frequency the bacteria isolates from *Fannia spp.* across all market. A total of 10 bacteria isolate was obtained from the internal surface and 10 bacteria isolates from the external surface.

Table 8: Frequency of bacteria isolates from *Fannia spp.* across all markets		
Organisms	**% of internal isolates N (10)**	**% of external isolates N (10)**
Staph aureus	1(10%)	1(10%)
E. coli	0 (0%)	0(0%)
Proteus spp.	3(30%)	5(50%)
Klebsialla spp.	6(60%)	4(40%)
Pseudomonas spp.	0(0%)	0(0%)
Total %	100%	100%

Figure 3 shows the prevalence of bacteria isolates from *Fannia spp.* across different markets location within Maiduguri metropolis,with *Klebsiella spp.* with the highest percentage (50%), *Proteus spp.* (40%) *Staph spp.* (10%) *E. coli* and *Psuedomonas spp.* (0%).

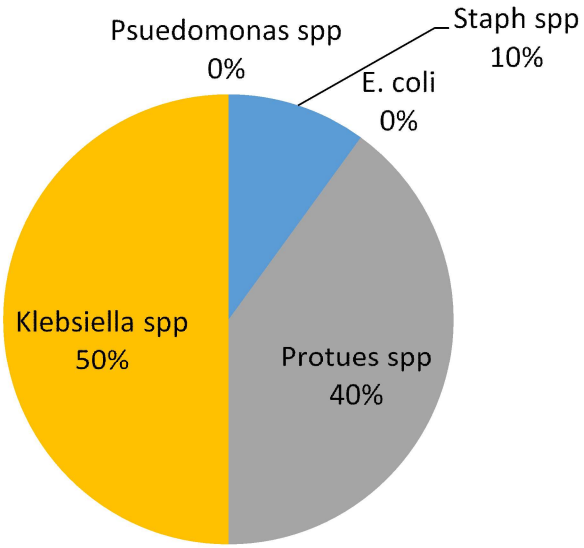

Figure 3: Total % of *Fannina spp.*

Table 9 shows the frequency the bacteria isolates from *Lucillia spp.* across all market. A total of 11 bacteria isolate was obtained from the internal surface and 7 bacteria isolates from the external surface.

Table 9: Distribution of bacteria isolates in *Lucillia spp.* across all markets

Organisms	% of internal isolates N(11)	% of external isolates N(7)
Staph spp.	2(18.1%)	0(0%)
E. coli	1(9.0%)	2(28.5%)
Proteus spp.	1(9.0%)	3(42.8%)
Klebsialla spp.	6(54.5%)	2(28.5%)
Psuedomonas spp.	1(9.0%)	0(0%)
Total %	99.6%	99.8%

Figure 4 shows the prevalence of bacteria isolates across five market location within Maiduguri metropolis, with *Klebsiella spp.* (44%) having the highest percentage, *Protues spp.* (22%), *E. coli* (17%), *Staph spp.* (11%) and *Psuodomonas spp.* (6%).

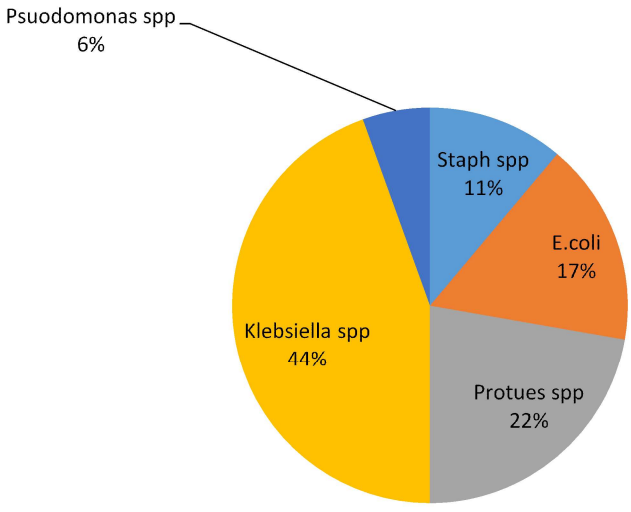

Figure 4: Total % of *Lucillia spp.*

Figure 5 shows the prevalence of bacteria isolates obtained from three species of flying insects across five markets location in Maiduguri metropolis, *Klebsiella spp.* (41%) having the highest percentage, *Protues spp.* (24%), *E. coli* (15%), *Staph spp.* (13%) and *Psuedomonas spp.* (7%).

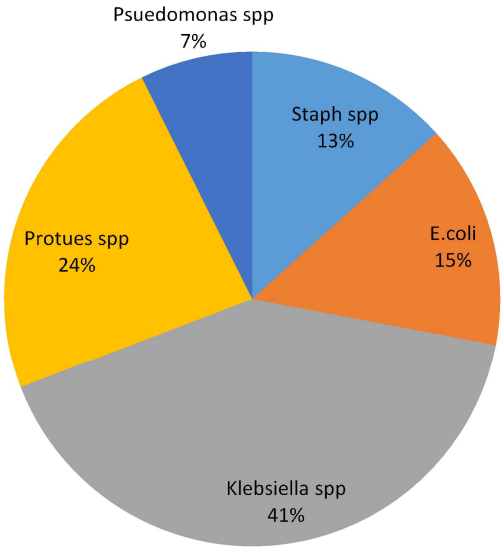

Figure 5: Prevalence of bacteria isolates obtained from three species of flying insects

Table 10 shows the antibiotic subceptibility testing of gram positive organisms shows that levofloxacin, ceftriaxone, erythromycin, gentamycincefoxtaxin have > 50% sensitivity, rocephine, azithromycin, amoxacin and spefloxacin have <50% sensitivity for *Staph aureus*. However cefoxtaxin, ceftriaxone, amoxacin, ciprofloxacin, erythromycin, gentamycin and levofloxacin have 100% sensitivity while spefloxacin and azithromycin have 50% sensitivity and rocephine is 0% in case of staph

Table 10: The antibiotic subceptibility testing of gram positive organisms

Antibiotics	Conc.	*Staph aureus* (7)		*Constaph* (2)	
		Sens	Res	Sens	Res
Cefotaxin	10 ug	4(57.14%)	3(42.85%)	2(100%)	0(0%)
Rocephine	25 ug	3(42.85%)	4(57.14%)	0(0%)	2(100%)
Ceftriazone	10 ug	4(57.14%)	3(42.85%)	2(100%)	0(0%)
Spefloxacin	20 ug	2(28.57%)	5(71.42%)	1(50%)	1(50%)
Azithromycin	20 ug	3(42.85%)	4(57.14%)	1(50%)	1(50%)
Amoxacilin	10 ug	3(42.85%)	4(57.14%)	2(100%)	0(0%)
Ciprofloxacin	10 ug	4(57.14%)	3(42.85%)	2(100%)	0(0%)
Erythromycin	10 ug	6(85.71%)	1(14.28%)	2(100%)	0(0%)
Gentamycin	10 ug	6(85.71%)	1(14.28%)	2(100%)	0(0%)
Levofloxacin	10 ug	7(100%)	0(0%)	2(100%)	0(0%)

Table 11 shows the antibiotic subceptibility testing of gram negative or organisms, levofloxacin have >50% sensitivity across a *E. coli, Klebsiella spp., Protues spp.* and *Psuedomonas spp.* cefotaxim have >50% sensitivity on *E. coli* and *Klebsiella spp.* sparfloxacin have 50% sensitivity in *Klebsiella spp.* and <50% in *E. coli, Protues spp.* and *Psuedomonas spp.* ciprofloxacin have >50% sensitivity except in *Psuedomonas spp.* have 20%. Augimentin have 50% sensitivity *Klebsiella spp.* and *Psuedomonas spp.* gentamycin have >50% sensitivity except in *Psuedomonas spp.* pefloxacin and ofloxacin have >50% sensitivity in all the isolated *Enterobacteriacea.* Azithromycin have >50% sensitivity in *Klebsiella spp.* and *Psuedomonas spp.* while <50% in *E. coli* and *Protues spp.*

Table 11: The antibiotic subceptibility testing of gram negative organisms

Antibiotics	Conc.	*E. coli* (10)		*Klebsialla pneumoni* (28)		*Protues spp.* (16)		*Psuedomonas spp.* (5)	
		Sens	Res	Sens	Res	Sens	Res	Sens	Res
Levofloxacin	20 ug	10(100%)	0(0%)	25(89.28%)	3(10.71%)	14(87.5%)	2(12.5%)	3(60%)	2(40%)
Cefotaxim	10 ug	7(70%)	3(30%)	14(50%)	14(50%)	5(31.25%)	11(68.75)	1(20%)	4(80%)
Sparfloxacin	10 ug	5(50%)	5(50%)	5(17.85)	23(82.14%)	4(25%)	12(75%)	0(0%)	5(100%)
Ciprofloxacin	10 ug	9(90%)	1(10%)	15(53.57%)	13(46.42%)	8(50%)	8(50%)	1(20%)	4(80%)
Amoxacilin	30 ug	4(40%)	6(60%)	10(35.71%)	18(64.28%)	5(31.25%)	11(68.75%)	2(40%)	3(60%)
Augumentin	30 ug	4(40%)	6(60%)	17(60.71%)	11(39.28%)	4(25%)	12(75%)	5(100%)	0(0%)
Gentamycin	10 ug	10(100%)	0(0%)	27(96.42%)	1(3.57%)	15(93.75%)	1(6.25%)	2(40%)	3(60%)
Pefloxacin	30 ug	2(20%)	8(80%)	4(14.28%)	24(85.71%)	3(18.75%)	13(81.25%)	1(20%)	4(80%)
Ofloxacin	10 ug	3(30%)	7(70%)	3(10.71%)	25(89.28%)	7(43.75%)	9(56.25%)	2(40%)	3(60%)
Azithromycin	12 ug	5(50%)	5(50%)	4(14.28%)	24(85.28%)	9(56.25%)	7(43.75%)	0(0%)	5(100%)

4. Discussion

This study investigated the incidence of pathogenic bacteria associated with flying insects collected in selected markets within Maiduguri Metropolis, with emphasis on *Musca domestica, Fannia spp*. and *Lucilia spp*. The findings revealed a high prevalence of bacterial isolates including *Klebsiella spp., Proteus spp., Escherichia coli, Staphylococcus aureus*, and *Pseudomonas spp*. across all five market locations: Gamboru, Monday, Tashan Bama, Ngomari Airport, and Bolori marketsA total of 757 flies were examined, and 68 bacterial isolates were recovered, with *Klebsiella spp*. accounting for the highest proportion (41%), followed by *Proteus spp.* (24%), *E. coli* (15%), *Staphylococcus spp*. (13%), and *Pseudomonas spp.* (7%).

These results corroborate earlier findings by Monyama *et al.* (2022) and Clinical and Laboratory Standards Institute (CLSI) (2025), who also reported a predominance of Gram-negative enteric bacteria on houseflies and blowflies collected from Nigerian markets and hospitals. Similarly, Odo *et al.* (2021) and Silva *et al.* (2022) documented that *Musca domestica* and *Lucilia spp*. serve as key mechanical vectors of enteropathogenic and multidrug-resistant bacteria in urban and clinical environments. The predominance of *Klebsiella spp.* in this study is particularly concerning as it aligns with (Cheesbrough, 2006), who found that over 60% of *Klebsiella spp.* isolates recovered from hospital-associated flies in Libya exhibited multidrug resistance.

The relative abundance of bacterial isolates varied among markets, with Gamboru market recording the highest number (18 isolates) and Bolori market the least (5 isolates). This variation may be attributed to environmental sanitation differences and the presence of high microbial loads in densely populated markets, similar to reports by Ogunleye *et al.* (2022) and Dehghani and Kassiri (2020), who associated fly-borne bacterial contamination with poor waste management and proximity to decomposing materials.

The antibiotics susceptibility results revealed that most Gram-negative isolates were highly sensitive to Levofloxacin (89-100%) and Gentamycin (93-100%), but showed marked resistance to Amoxicillin, Sparfloxacin, and Augmentin. Gram-positive organisms, notably Staphylococcus aureus, exhibited >50% sensitivity to Levofloxacin, Ceftriaxone, and Gentamycin but less than 50% sensitivity to Amoxicillin and Azithromycin. These findings agree with Wikipedia. (2023) and Eger *et al.* (2021), who noted similar resistance patterns among bacteria isolated from M. domestica in hospital and market environments. The high prevalence of Antimicrobial Resistance (AMR) suggests horizontal gene transfer of resistance determinants among bacteria residing in the gut and body surfaces of flies (Neupane *et al.*, 2020). Interestingly, *Lucilia spp*. exhibited higher internal bacterial loads (54% *Klebsiella spp.*) thanexternal loads (28%), indicating that these flies may serve not only as passive carriers but as biological reservoirs capable of sustaining bacterial populations. This supports findings by Sobur *et al.* (2022) that *Lucilia sericata* and *L. cuprina* maintain persistent bacterial communities across developmental stages. Similarly, *Fannia spp*. showed significant carriage of *Proteus* and *Klebsiella species,* in line with reports by Monyama *et al.* (2022) who identified Fannia canicularis as an important vector in poultry and livestock environments.

The overall distribution pattern from this study reinforces the ecological role of synanthropic flies as vectors bridging environmental, animal, and human microbial communities. The findings highlight the need for One Health approaches in AMR surveillance and control. In comparison with international data, similar high carriage rates of multidrug-resistant *E. coli* and *Klebsiella spp.* were reported in India (Kumar *et al.*, 2021) and Brazil (Sobur *et al.*, 2022), underscoring that the phenomenon is global and exacerbated by environmental contamination and antimicrobial misuse.

Finally, the study demonstrates that the flying insects sampled within Maiduguri markets are heavily contaminated with clinically significant bacteria that exhibit resistance to multiple antibiotics. These findings have major public health implications, particularly for food safety, hospital hygiene, and antimicrobial stewardship in urban environments.

5. Conclusion

The present study established that flying insects within Maiduguri metropolis, particularly *Musca domestica, Fannia spp.* and *Lucilia spp*., harbor diverse pathogenic and antibiotic-resistant bacteria. Among the identified isolates, *Klebsiella spp.* recorded the highest prevalence, followed by *Proteus spp.* and *Escherichia coli*. The bacterial contamination was most prominent in Gamboru and Tashan Bama markets, reflecting the influence of hygiene and waste management practices. The antibiotic susceptibility patterns reveal emerging resistance to commonly used antibiotics such as Amoxicillin, Augmentin, and Sparfloxacin, which poses a threat to public health and infection control measures.

This study underscores the epidemiological importance of flying insects as reservoirs and transmitters of multidrug-resistant bacteria within the human environment, emphasizing their role in the persistence and spread of AMR within the One Health framework.

Recommendations

1. **Enhanced sanitation and waste management:** Proper waste disposal systems and market sanitation should be enforced to reduce breeding sites for flies, especially in food-handling areas.
2. **Regular vector surveillance:** Routine monitoring of flies in markets, hospitals, and abattoirs should be incorporated into public health surveillance programs to detect emerging AMR threats.
3. **Antimicrobial stewardship:** Judicious use of antibiotics in both human and veterinary settings should be promoted through education, regulation, and antimicrobial policies.
4. **Public health education:** Awareness campaigns should emphasize personal hygiene, proper food covering, and vector control practices among food vendors and the general public.
5. **Further research:** Molecular and genomic studies should be conducted to identify resistance genes and characterize bacterial strains associated with flying insects in different ecological zones.
6. **Implementation of one health approach:** Collaborative interventions involving human, animal, and environmental health sectors are essential to curb the transmission of antimicrobial-resistant pathogens.

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