**Dipteran (Fly) Species Assemblage Comparison Across Taverns and Eateries in Edo State, Nigeria, using Palm-Wine-Baited Bottle-Trap and Sweepnet captures.**

**Comparative Assemblage of Dipteran Species in Taverns and Eateries of Edo State, Nigeria, Using Palm-Wine-Baited Bottle Traps and Sweep Netting**

**INTRODUCION**

Insects of the order *Diptera* (true flies) are particularly dominant in urban environments and thrive in anthropogenic landscapes such as taverns, eateries, open markets, and waste disposal sites—environments typified by the accumulation of organic waste and continuous human activities (Bahrndorff et al., 2020; Dhamorikar, 2017). Dipterans, such as the common housefly (*Musca domestica*), and many other synanthropic fly species, are mechanical vectors of disease-causing agents, including bacteria, protozoa, and viruses (Chakrabarti et al., 2010; Bahrndorff et al., 2020; Park et al., 2019; Omoregie et al., 2025). Their widespread presence in human-dominated areas poses considerable public health risks, particularly in densely populated urban centres where food hygiene and waste management are often inadequate (Suntaravitun, 2012).

Despite the ecological and epidemiological significance of Dipteran insects, there exists a paucity of published research documenting the diversity, abundance, and spatial distribution of flies within Nigerian urban centres. However, insect assemblages are influenced by latitude, habitat structure, land use, and the degree of urbanization (Bahrndorff et al., 2020; Omonona et al., 2021; Cheke et al., 2024), although this varies by taxa (Andrew & Hughes, 2005). Understanding this locally is important for many reasons: If significant variation exists in fly assemblages across different urban and peri-urban locations, it would have implications for designing effective monitoring and control strategies (Cohnstaedt et al., 2012; Montgomery et al., 2021). Knowledge of spatial and co-occurrence patterns of fly species is particularly relevant for anticipating the transmission dynamics of fly-borne diseases, many of which rely heavily on these vectors for dispersal (Chakrabarti et al., 2010; Kehinde et al., 2014; Cheke et al., 2024).

Effective monitoring of insect populations requires methods adaptable to the complex, heterogeneous, and often unpredictable nature of urban microhabitats (Montgomery et al., 2021). For public health entomologists, the focus is frequently on synanthropic species due to their potential to transmit pathogens (Spielman et al., 2001). As such, identifying optimal sampling techniques is crucial for assessing public health risks and informing mitigation efforts. This is especially critical in low-income and developing countries, where there is a pressing need for affordable, efficient, and sustainable approaches to insect surveillance (Chandrasekhar et al., 2012; Cohnstaedt et al., 2012; Abraham et al., 2023). In this context, simple, cost-effective traps have garnered increasing attention. For example, Egbon & Omoruwa (2022) evaluated a range of fruit-baiting strategies for the collection of *Drosophila melanogaster* (fruit fly) and found that pineapple was especially effective, even in olfactorily complex environments like fruit markets. Their study also underscored the practical utility of low-cost trapping methods as viable alternatives to more technologically advanced and expensive equipment in managing insect populations. Simple attractant-based trapping systems have a broader potential in urban insect monitoring.

Flies such as Bottle flies (Calliphoridae) and houseflies (Muscidae) are known for their roles as mechanical vectors of disease and their observed affinity for sugary beverages such as palm wine and beer, commonly found in these settings (Ewuim et al., 2010; Khamesipour et al., 2018; Abraham et al., 2023). Palm wine—a locally available, sugary alcoholic beverage—may serve as an attractive bait in environments where it is widely consumed, such as taverns and informal eateries. Given this chemical complexity, palm wine presents a potentially effective and low-cost alternative to synthetic or fruit-based baits (Abraham et al., 2023). Despite its promise, the use of palm wine in fly traps remains underexplored compared to conventional sampling techniques such as sweep netting.

The present study will investigate the composition of dipteran communities inhabiting urban and peri-urban taverns and eateries across Edo State, Nigeria—locations where food and drink are routinely consumed, providing ample opportunities for fly gathering. We would employ two complementary sampling techniques: palm-wine-baited bottle traps and sweep netting to capture flies. These methods were selected based on their practicality, cost-effectiveness, and potential for differential species capture. The objectives of this study are to: [1] compare the community level structure of flies captured by palm-wine-baited bottle traps and sweep nets; [2] assess whether geographic distance between sampling sites correlates with (dis)similarity in fly community composition and [3] evaluate the potential selectivity of each method in terms of species and sex.

**MATERIALS AND METHODS**

**Statistical Analysis**

Diptera data were recorded in Excel spreadsheets and analyzed using R version 4.4.0. To compare the abundance of each fly species captured using both collection methods, we used the data collected from taverns, since it included captures for both sweep nets and bottle traps. Specifically, we applied a G-test for independence using the ‘GTest()’ function from the “DescTools” package (Signorell, 2025). Also, Fisher's exact tests were used to assess whether sex ratios varied by collection method, while Chi-squared goodness-of-fit tests evaluated whether each species deviated from an expected 1:1 male-to-female ratio.

We examined geographic distance decay in fly community composition across all collection sites (taverns and eateries) using a Jaccard similarity index matrix. A Mantel test was used to assess whether (changes in) community compositional similarity were significantly associated with geographic distance. Community dissimilarities based on the Jaccard index were calculated using the ‘vegdist()’ function from the “vegan” package (Oksanen et al., 2025). Geographic distances (latitude and longitude) between sampling sites were computed using the ‘dist()’ function.

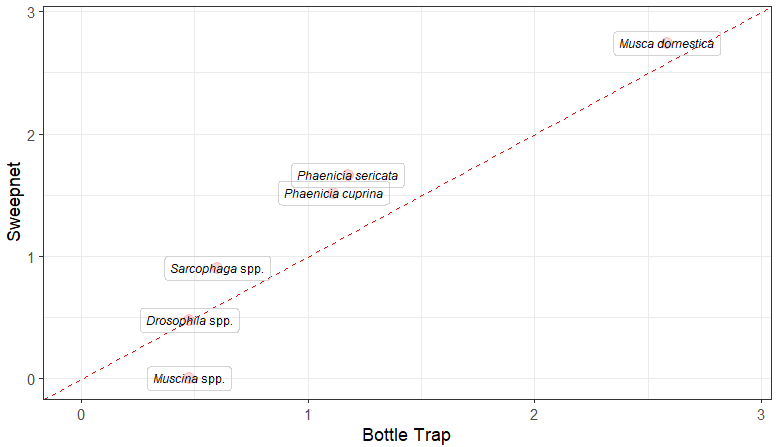
To assess and visualize differences in fly community composition between eateries and taverns based on abundance data, we performed a Non-metric Multidimensional Scaling (NMDS) analysis using Bray-Curtis dissimilarities. Before analysis, a Hellinger transformation was applied to the abundance matrix to mitigate the influence of double zeros. A two-dimensional NMDS solution sufficiently captured the structure in the data. To test for significant differences in community composition between site types, we conducted a Permutational Multivariate Analysis of Variance (PERMANOVA) using 9,999 permutations via the adonis2() function from the “vegan” package. We also tested for homogeneity of multivariate dispersion (PERMDISP) using the betadisper() function to ensure that any observed group differences were not driven by unequal within-group variability (Anderson et al., 2013).

Since differences in sampling effort can strongly influence abundance data, and only one collection method was used at eateries, we conducted an additional set of community-level analyses based on presence–absence data using the Jaccard similarity index. This included NMDS ordination, as well as PERMANOVA and PERMDISP to compare fly communities across eateries, tavern kitchens, and tavern parlors. Jaccard-based metrics were also used to compare community similarity of flies captured using sweep nets and bottle traps, to minimize bias due to varying trapping efficiencies and unequal sampling efforts. Post hoc pairwise comparisons between groups were performed using the pairwise.adonis() function from the “pairwiseAdonis” package, with significance evaluated at α = 0.05.

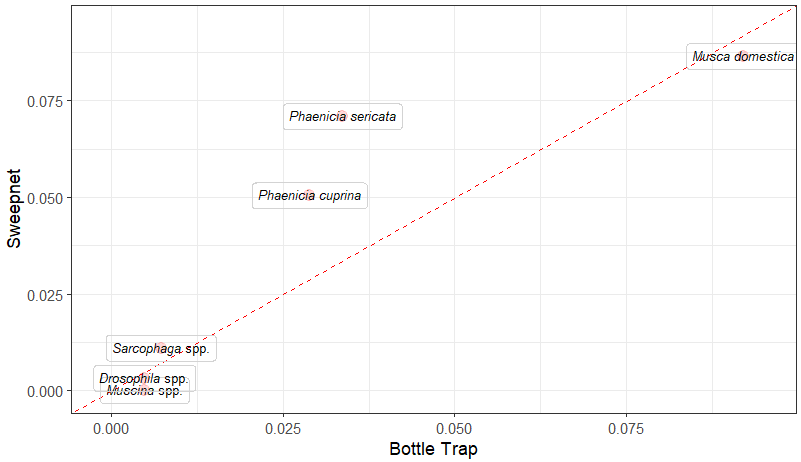
**RESULT**

A total of 2,813 individual dipterans (flies), representing seven distinct taxa across six genera, were collected during this study. These included Musca domestica, Muscina spp., Phaenicia cuprina, Phaenicia sericata, Drosophila spp., Fannia canicularis, and Sarcophaga spp. Among them, M. domestica was the most dominant species in collections from bottle traps and sweep nets, with recorded abundances of 383 and 1,901 individuals, respectively. Following in abundance were P. sericata and P. cuprina, while F. canicularis was notably rare, with only a single individual collected throughout the entire survey. Overall, seven fly species were identified across the two collection methods, with sweep nets capturing (significantly) higher numbers of most species. For instance, P. sericata was more abundant in sweep net samples (270) than in bottle trap samples (14), and similar trends were observed for P. cuprina (113 vs. 12), Sarcophaga spp. (82 vs. 3), and Muscina spp. (28 vs. 2). F. canicularis occurred solely in sweep net samples (from eateries), while Drosophila spp. were found in equal numbers (2 individuals) across both methods.

In tavern sites, 635 individual flies were collected using sweep nets, while 416 were captured using bottle traps. Notably, several fly species showed marked differences in abundance between the two collection methods (Figures 1 and 2). There was a statistically significant difference in the abundance of fly species collected between both methods (G(6):14.742; *p* = 0.02), indicating that the method of collection influenced sample abundance. This pattern is particularly evident for species such as P. sericata, P. cuprina, M. domestica, and Muscina spp., which deviate strongly from the diagonal in Figure 1. Figure 1 illustrates the proportion of species collected based on raw abundance, highlighting that M. domestica was more frequently captured using sweep nets (549 individuals) than bottle traps (383 individuals). However, when assessed by relative abundance within each trap type, M. domestica accounted for a higher proportion of the bottle trap captures (92%) compared to the sweep net captures (86%), as shown in Figure 2. Despite the differences in absolute and relative abundance, both perspectives produce similar patterns in species rankings and dichotomous groupings, suggesting consistency in the comparative effectiveness of the two methods across taxa.



**Figure 1**: Scatterplot comparing fly species abundance collected using sweepnets and bottle traps from tarvans. Abundances were log-transformed using log₁₀ (X + 1) data to aid visibility while preserving rank order. The red dashed diagonal line represents the 1:1 ratio, where species falling on the line had equal abundance in both collection methods. Species above the line were more abundant in Sweepnet samples, while those below were more abundant in bottle trap samples. *F. canicularis* was excluded due to insufficient sample size (n < 2).



**Figure 2.** Comparison of species relative abundances between Sweepnet and bottle trap collections. Relative abundance values (scaled 0–1) are plotted for each species, with a red dashed diagonal line indicating a 1:1 ratio between methods. To improve visual clarity and preserve monotonicity, Musca domestica values were downscaled by 0.1 due to their disproportionately high abundance in both methods. Species located on the (red) diagonal line have equal relative abundance in both collection methods, while deviations indicate method-specific differences. F. canicularis was excluded due to a low total sample size (n < 2).

Across the sampled fly species, sex ratios varied between species and collection methods (Table 1). Most species exhibited female-biased sex ratios, particularly in *M. domestica*, which was the most abundant species. For *M. domestica*, a significant deviation from a 1:1 sex ratio was observed under both bottle trap and sweepnet methods (χ² = 19.76 and 38.29, respectively; P < 0.001), with females consistently more abundant. In contrast, other species showed no significant deviation from a 1:1 ratio or had counts too low for reliable inference. For example, *P. cuprina* and *P. sericata* showed slight female biases, though these differences were not statistically significant. Fisher’s exact tests assessing the independence of sex distribution between collection methods yielded non-significant results across all species, suggesting that the relative proportions of males and females did not differ substantially (P>0.05) between bottle traps and sweep nets.

**Table 1:** Comparison of sex ratios of fly species in the taverns collected using bottle traps and sweep nets.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Species** | **Method** | **Female** | **Male** | **Sex ratio** | **Chi-Square (Sig.)** | **P-value**  **(Fisher's exact)** |
| *Drosophila* spp. | Bottle trap | 2 | 0 | 1:0 | 2 | *1* |
| Sweepnet | 2 | 0 | 1:0 | 2 |
| *F. canicularis* | Bottle trap | 0 | 0 | NA | - | *1* |
| Sweepnet | 0 | 0 | NA | - |
| *M. domestica* | Bottle trap | 235 | 148 | 1:0.63 | 19.762\*\*\* | *0.583* |
| Sweepnet | 347 | 202 | 1:0.58 | 38.29\*\*\* |
| *Muscina* spp. | Bottle trap | 2 | 4 | 1:2 | 0.667 | *1* |
| Sweepnet | 0 | 0 | NA | - |
| *P. cuprina* | Bottle trap | 6 | 4 | 1:0.67 | 0.40 | *1* |
| Sweepnet | 7 | 5 | 1:0.71 | 0.333 |
| *P. sericata* | Bottle trap | 5 | 10 | 1:2 | 1.667 | *0.162* |
| Sweepnet | 36 | 30 | 1:0.83 | 0.545 |
| *Sarcophaga* spp. | Bottle trap | 3 | 1 | 1:0.3 | 1 | *0.571* |
| Sweepnet | 3 | 3 | 1:1 | 0 |

N.B.: Female and male counts are shown alongside observed sex ratios and results of chi-square (χ²) goodness-of-fit tests (expected ratio = 1:1). Fisher’s exact test was used to assess the independence of sex proportions between collection methods for each species. Significant p-values are indicated: \*\*\**P* < 0.001; \*\**P* < 0.01; P < 0.05. NA = Not available/ not computable.

Mantel test revealed that across geographic distance, the fly community composition did not change significantly with increasing distance (Mantel statistic r: 0.047, p=0.089). Longitudinally, there was a negative relationship between the community similarity and longitudinal distance. Communities become slightly dissimilar with increasing longitudinal distance-- and this was not statistically significant (Mantel statistic: r= -0.071, p= 0.977).

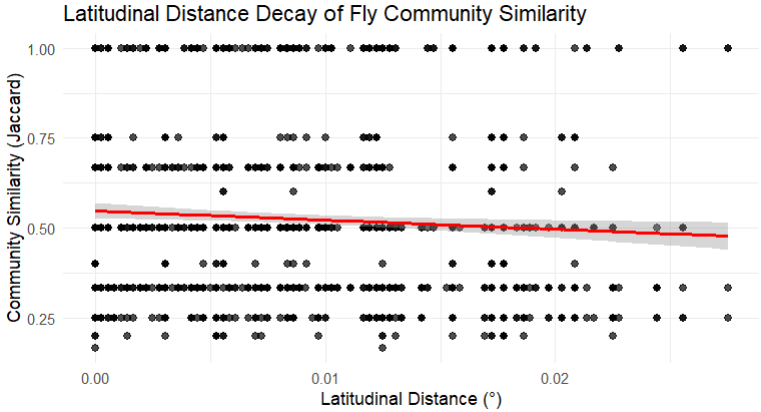
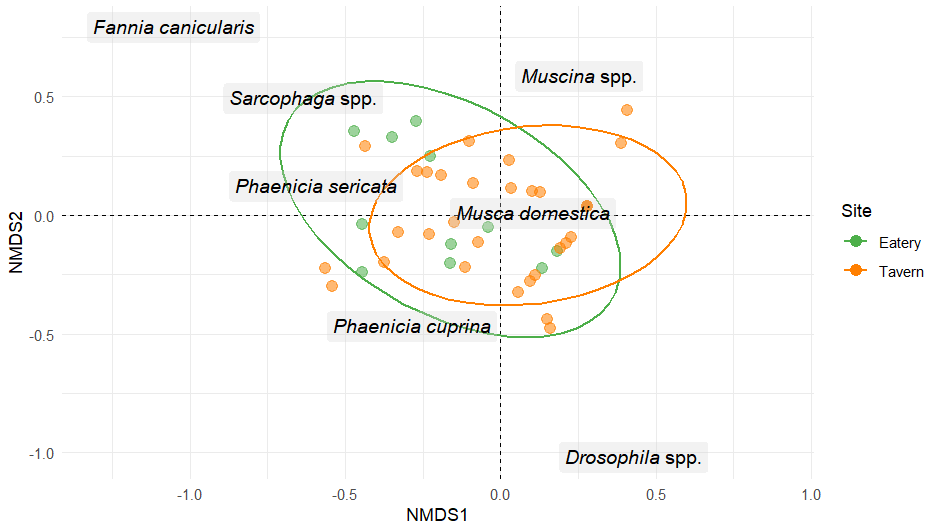


Figure 3: Latitudinal distance decay of fly community (Jaccard) similarity across eateries and taverns. The red line shows the trend line with 95% confidence intervals.

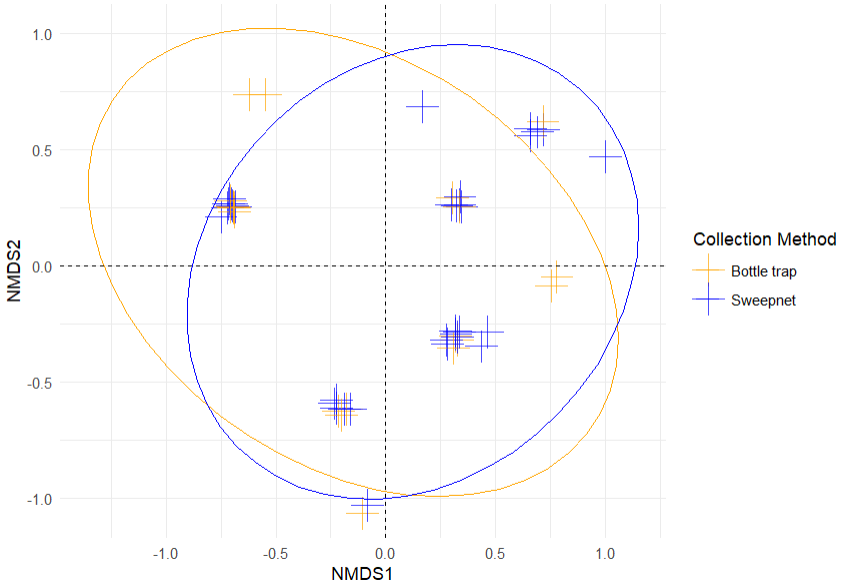
Fly community composition differed significantly across sampling locations categorised by site (Eatery and Tavern). PERMANOVA indicated a highly significant effect (p < 0.001), with site accounting for approximately 30.5% of the total variation in community composition. The non-significant result from the test for homogeneity of group dispersions (PERMDISP; F=0.1068, p = 0.75) suggests that this difference is unlikely to be influenced by variation in within-group dispersion. Additionally, the NMDS plot (Figure 4) reveals a visible spread of species across the ordination space. However, species abundances were highly skewed, with M. domestica and the two Phaenicia species overwhelmingly dominating the samples. This pronounced dominance may compromise the interpretability of the positions of Drosophila spp. and F. canicularis in the plot, as their distant placement may not accurately reflect true co-occurrence patterns due to their extremely low abundances in this study.



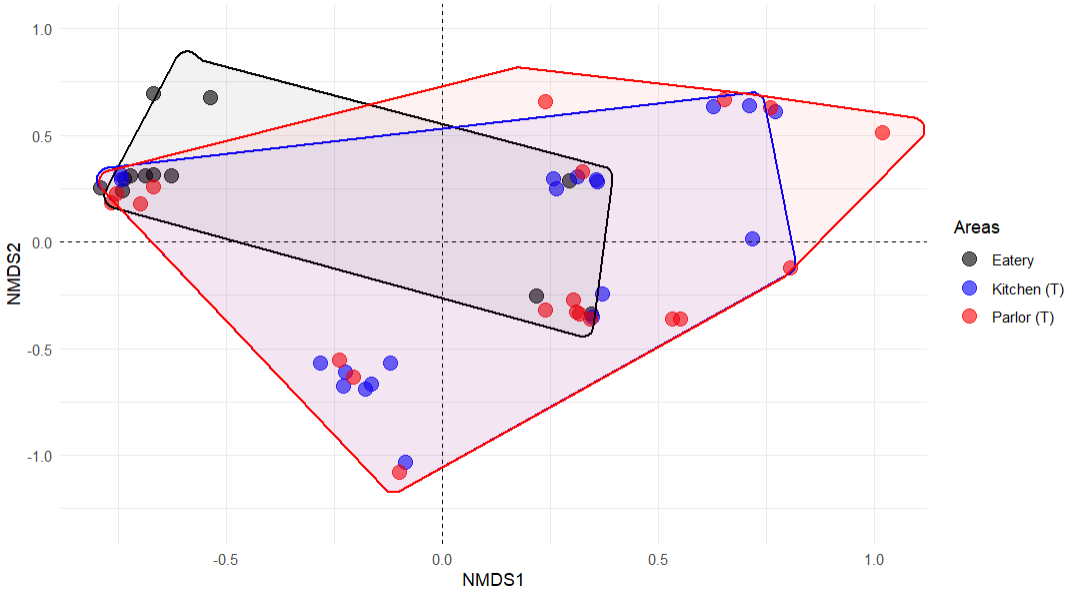
**Figure 4**: NMDS ordination of fly species assemblages based on two eating areas (Eatery and Tavern), using Bray-Curtis similarity (stress = 0.12; 9999 permutations). Ellipses represent 90% confidence intervals around groupings by collection method. Each point corresponds to a sampling location (N = 52; Tavern: 40, Eatery: 12). Species are represented according to their NMDS score, with similarly occurring species occurring closely in the NMDS ordination.

Fly community composition differed significantly between collection methods (Bottle trap vs Sweep net), as revealed by PERMANOVA (F=8.296, p < 0.001), with method accounting for approximately 14.2% of the variation in community structure. The test for homogeneity of multivariate dispersions (PERMDISP) was not significant (F= 0.006, p = 0.94), indicating that this result is not confounded by differences in within-group variability.

Fly community composition did not differ significantly among sampling areas (Eatery, Kitchen, and Parlor) based on Jaccard dissimilarity (PERMANOVA: F = 1.50, p = 0.192), with areas explaining approximately 5.8% of the total variation. This is represented in the NMDS ordination plot (of Figure 6). The assumption of homogeneity of multivariate dispersions was met (PERMDISP: p = 0.678), indicating that within-group variation was comparable across sites. Pairwise comparisons revealed a marginally significant difference in community composition between Eatery and Kitchen (p = 0.049), though this was not significant after adjusting for multiple testing with Bonferroni correction (p.adj = 0.146). No significant differences (p> 0.05) were detected between other areas.



**Figure 5:** NMDS ordination of hover fly species assemblages based on two collection methods (Bottle traps and Sweep nets), using Jaccard similarity (stress = 0.05; 9,999 permutations). Ellipses represent 90% confidence intervals around groupings by collection method. Each point corresponds to a sampling location (N = 52), with points jittered by 0.04 (NMDS unit) on both axes to improve visual clarity.



**Figure 6:** NMDS ordination of hover fly species assemblages across three sites (Eatery, Kitchen and Parlor of Taverns), based on Jaccard similarity (stress = 0.05; 9999 permutations). Polygons outline groupings of assemblages by site, while individual scatter points represent samples (N = 52). Points have been jittered by 0.09 (NMDS unit) along both axes.

**DISCUSSION**

This study surveyed fly communities within taverns and eateries using two different sampling methods—sweep nets and bottle traps baited with palm wine. The research advances our current understanding in two main areas: (1) it provides empirical evidence on the effectiveness of palm wine as an attractant for synanthropic fly collection, and (2) it offers insight into the structure and similarity of fly communities across various food-serving venues in Edo State, a region where public health entomology remains underexplored. By applying a suite of community similarity indices, this study delivers one of the most detailed analyses of urban-associated fly assemblages in the region.

Our findings indicate that the kind of food eating venues and the sampling approach can shape observed community patterns, including species abundance and sex distribution. Notably, sweep nets consistently yielded higher total captures than bottle traps. Nonetheless, when analysing relative species abundance, the rankings remained generally consistent across both sampling methods. However, *P. sericata* was seen to be higher in relative abundance in Sweepnets than in baited bottle traps, but this was not statistically significant (p> 0.05). This suggests that, although there are differences in the number of flies collected, both methods produce similar insights regarding community composition and dominant species. Thus, while absolute abundance metrics favoured sweep nets, the overall ecological patterns identified appear near-robust across both collection techniques.

The dominance of *M. domestica* across both sampling methods and all site types aligns with its known generalist and synanthropic behaviour, reaffirming its status as a pervasive inhabitant of anthropogenic settings (Chaiwong et al., 2012; Scott et al., 2014). The significant female bias in *M. domestica* across both collection methods is consistent with previous observations that females may be more strongly attracted to nutrient-rich environments suitable for oviposition. This sexual asymmetry has been reported in multiple studies in and outside Nigeria (REF). For example, Chaiwong et al. (2012) conducted their survey using beef that had been left at room temperature for 24 hours to attract synanthropic flies in human-inhabited areas of Ubon Ratchathani Province, Northeast Thailand. Their findings on sex ratio aligned with ours, showing a higher number of females compared to males for almost all fly species they observed. For other taxa, sample sizes were frequently low, which limits inferences on sex ratios and potential biases introduced by trap type. Nonetheless, the lack of significant differences in sex ratios between sweep net and bottle trap collections suggests that, while abundance may vary by method, the sex composition of captured flies remains relatively stable across methods.

Differences in community composition between taverns and. eateries were statistically significant as revealed by PERMANOVA. This may reflect underlying differences in environmental conditions, hygiene practices, or food availability, which can influence fly attraction and persistence. Eateries in this study were in open areas compared to the completely- or quasi-indoor nature of most taverns. This may account for the higher amount of fly captures in the eateries as compared to the taverns. Furthermore, eateries were surveyed solely using Sweepnets, and these generally had higher captures than bottle-traps in this study.

Contrary to expectations, spatial distance had minimal influence on fly community similarity across sites, as indicated by the non-significant (P>0.05) Mantel test results. Although there was a slight negative association with longitudinal distance (Figure 3), this pattern lacked statistical support. The limited geographic extent of sampling within Benin City may account for the weak distance-decay signal, as urban fly communities may be homogenised by high human mobility and the ubiquity of suitable habitats, which facilitate species dispersal. It is also possible that a significant effect of distance on fly community composition would be observed on a broader spatial sampling area.

When community data were analysed using presence–absence metrics, differences in fly composition between collection methods remained non-significant. This underscores that while sweep nets may capture more individuals, the core community of species detected by each method is broadly similar. The NMDS plot (Figure 5) supports this, showing overlapping clusters by method. These findings suggest that while both methods are suitable for community assessment, especially in studies prioritising species richness.

Interestingly, fly community composition did not show significant differences among eateries, tavern kitchens, and tavern parlors when based on species presence–absence data. This indicates that while broader site categories (such as taverns versus eateries) shape overall community patterns, more localised divisions within taverns do not strongly influence the types of flies present. A marginally significant difference was noted between eateries and kitchens, but this did not hold after adjusting for multiple comparisons. These findings imply that similar fly species occurred across all types of sampling areas. Notably, even though eateries were sampled using sweep nets alone, there was no significant discrepancy in community composition compared to eateries where both sweep nets and bottle traps were used. The higher fly abundance recorded in eateries may be related to their outdoor setting, in contrast to the more enclosed environments typical of taverns.

In Edo state, disease transmitted by flies, such as those observed in this study, has been well pronounced. *M. domestica*, for example, is a mechanical transmitter of Salmonella spp that causes salmonellosis (Ugbogu et al., 2006; Khamesipour et al., 2018), and Escherichia coli that causes gastrointestinal disturbance in humans (Omoregie et al., 2025).

**CONCLUSION**

This study provides novel insights into the structure and dynamics of dipteran fly communities across food-related environments in Benin City, Nigeria. By comparing fly assemblages in eateries and taverns using both sweep nets and bottle traps baited with palm wine, we revealed clear differences in community composition driven primarily by broad site type. The results highlight the greater efficiency of sweep nets in capturing higher counts per fly species, especially in more open, outdoor environments like eateries. Despite differences in sampling methods and site characteristics, relative abundance data suggested a consistent species ranking across methods, reinforcing the robustness of observed community patterns. Importantly, this work underscores the potential of palm wine as an effective bait in bottle-trap surveys and expands the limited baseline data available for public health entomology in Edo State. The consistent presence of medically relevant fly species across all sampling categories reinforces the need for improved sanitation and vector surveillance in urban food spaces.

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