**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**

Urban insect biodiversity remains largely understudied in many regions of Nigeria, despite the ecological and public health importance of these organisms. Insects of the order Diptera (true flies) are particularly abundant in urban environments, attracted by readily available food sources, breeding habitats, and human activity. These flies frequently inhabit anthropogenic environments such as taverns, eateries, open markets, and waste disposal areas—settings where organic waste accumulates and human disturbance is constant.

Among the most prevalent dipterans is the common housefly (*Musca domestica*), a species commonly found in households and commercial food establishments. Far from being harmless, houseflies and other synanthropic species are well-established mechanical vectors of disease-causing agents, including bacteria, protozoa, and viruses. Their presence in urban areas poses significant public health risks, particularly in densely populated communities. Despite this, there is a marked lack of published data documenting the diversity, abundance, and spatial distribution of flies in urban centres across Nigeria. In Edo State specifically, there is little information on how fly community composition changes across geographic space. Studies from around the world have demonstrated that insect communities vary by latitude, habitat, and land use and urbanization level. This is important for many reasons. If there is evidence of variation in fly community with geographic distance, then this would need to be factored into monitoring and control efforts and strategies. Also, dynamical spread and (co-)occurrence of flies may determine the kind and spread of fly-transmitted disease---especially those that are well dependent on fly for transmission.

A central challenge in urban entomological studies is determining how best to sample these insects. Effective insect monitoring depends on carefully timed, standardized, and methodologically sound sampling strategies. Urban environments complicate this effort due to their mosaic of microhabitats and the unpredictability of human-related disturbances. Public health entomologists, in particular, are concerned with synanthropic fly species due to their role in disease transmission. Understanding their diversity and the most effective collection methods is crucial for assessing health risks and implementing control measures. In low-income and developing countries, there is a critical need for affordable, efficient, and sustainable tools for biomonitoring insect populations. For example, Egbon and Omoruwa (2022) examined various baiting strategies for collecting *Drosophila melanogaster* (Fruit fly) and found that organic fruits such as pineapple were particularly effective, even in complex olfactory environments like fruit markets where competing odours can interfere with bait efficacy. Their work also emphasized the value of simple, low-cost traps that can serve as viable alternatives to more expensive equipment in managing pest populations. In this context, it is valuable to assess the cost-effectiveness and efficiency of simple bait-based traps relative to more established collection methods such as sweep netting, which is widely used to capture medically significant flies like bottle flies (Calliphoridae) and houseflies. Key metrics in comparing collection methods include species richness, species selectivity, sex and morphometric bias in capture, and the total number of individuals collected. Traps using a variety of bait types have shown high effectiveness in previous studies, and palm wine—a locally available sugary alcoholic beverage—may serve as a particularly attractive bait in taverns and other locations where such drinks are consumed.

Palm-wine has been used as bait to capture insects in not-so-many studies around the world. However, there is little evidence of its efficacy for collecting fly. Palm wine is biochemically rich, containing sugars, alcohols, acids, esters, amino acids, minerals, and phytonutrients beneficial to human health. Fermentation of its sugars at ambient temperature produces volatile compounds such as higher alcohols, aldehydes, and ketones, which contribute to its distinct odour. It supports the growth of various microorganisms, particularly yeasts. These biochemical and microbial activities result in a complex array of volatile compounds, including semiochemicals. Despite this richness, no study has investigated how mosquitoes respond to the odourants emitted by palm wine, presenting a gap in understanding its potential role in vector attraction or repellency.

This study aims to investigate the composition of fly communities in urban and peri-urban taverns and eateries across Edo State, Nigeria—environments where food is frequently served and discarded, and where flies are commonly observed feeding on leftovers and decaying organic matter. In particular, bottle flies and houseflies are known to be effective mechanical vectors of disease due to their feeding and breeding behaviours. These flies are also drawn to sugary beverages such as palm wine and beer, which are commonly available in taverns and informal eateries. To better understand these communities, we employ two complementary sampling techniques: palm-wine-baited bottle traps and sweep netting. We expect that geographic distance would affect the compositional similarity between sites we surved, and also, Sweepnets would significantly preferentially select for some species of fly over bottle trap (and vice versa). Our objectives are to compare the diversity and abundance of dipteran species captured by each method, evaluate the potential selectivity of the techniques, and assess whether geographic distance between sampling sites correlates with community dissimilarity. The findings from this study will provide valuable insight into urban fly assemblages in an understudied region, while also evaluating practical and cost-effective approaches to insect biodiversity monitoring.

**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.

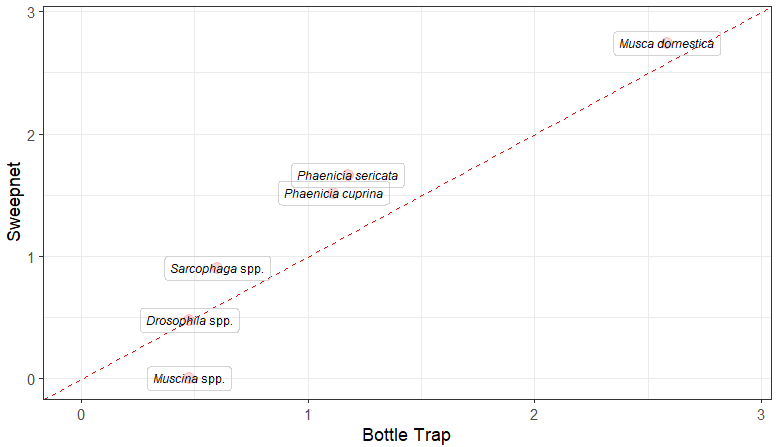
To assess and visualize differences in fly community composition between eateries and taverns based on abundance data, we performed a Non-metric Multidimensional Scaling (NMDS) analysis using Bray-Curtis dissimilarities. Before analysis, a Hellinger transformation was applied to the abundance matrix 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.

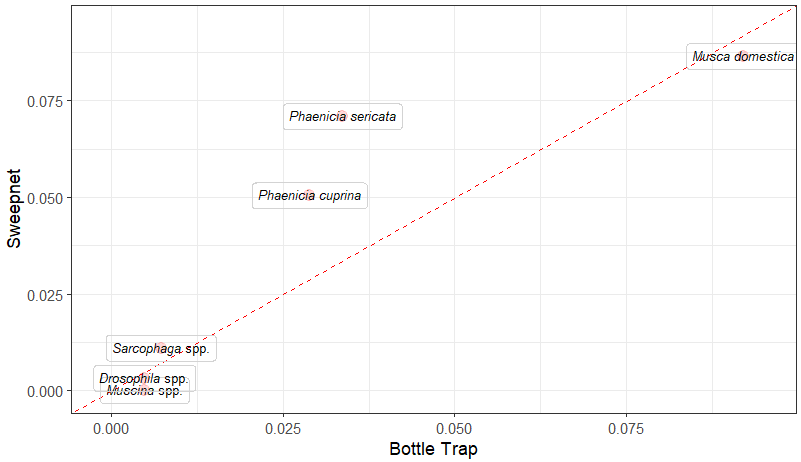
**RESULT**

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 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).

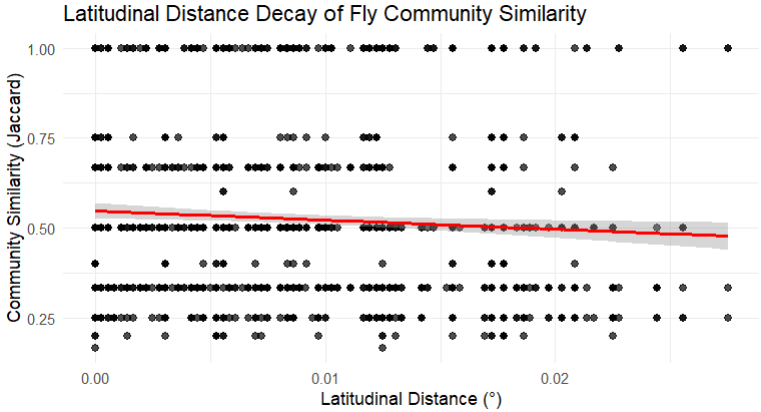
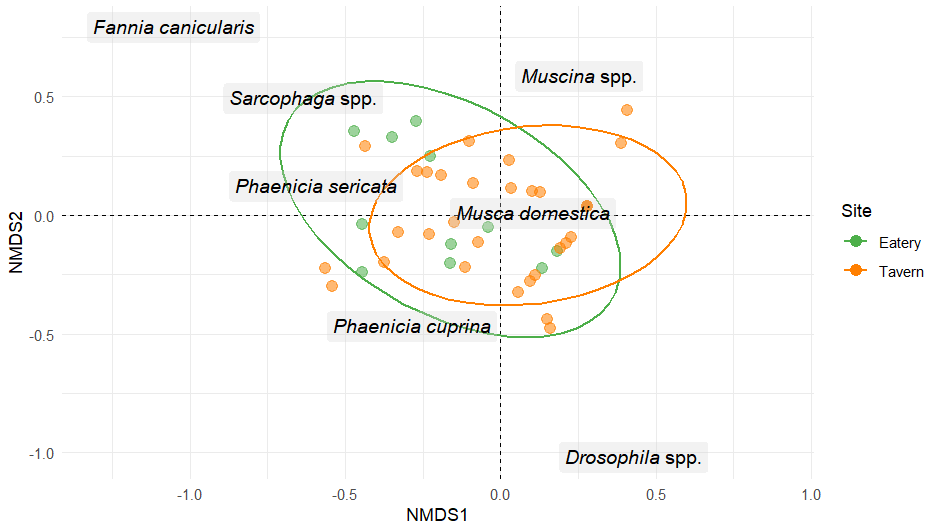


Figure 3: Latitudinal distance decay of fly community (Jaccard) similarity across eateries and taverns. The red line shows the trend line with 95% confidence intervals.

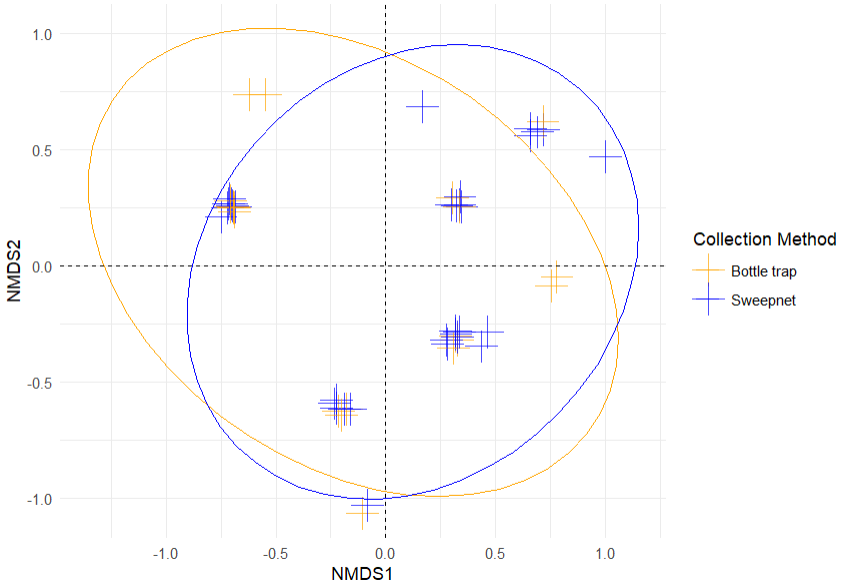
Fly community composition differed significantly across sampling locations categorised by site (Eatery and Tavern). PERMANOVA indicated a highly significant effect (p < 0.001), with site accounting for approximately 30.5% of the total variation in community composition. The non-significant result from 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.



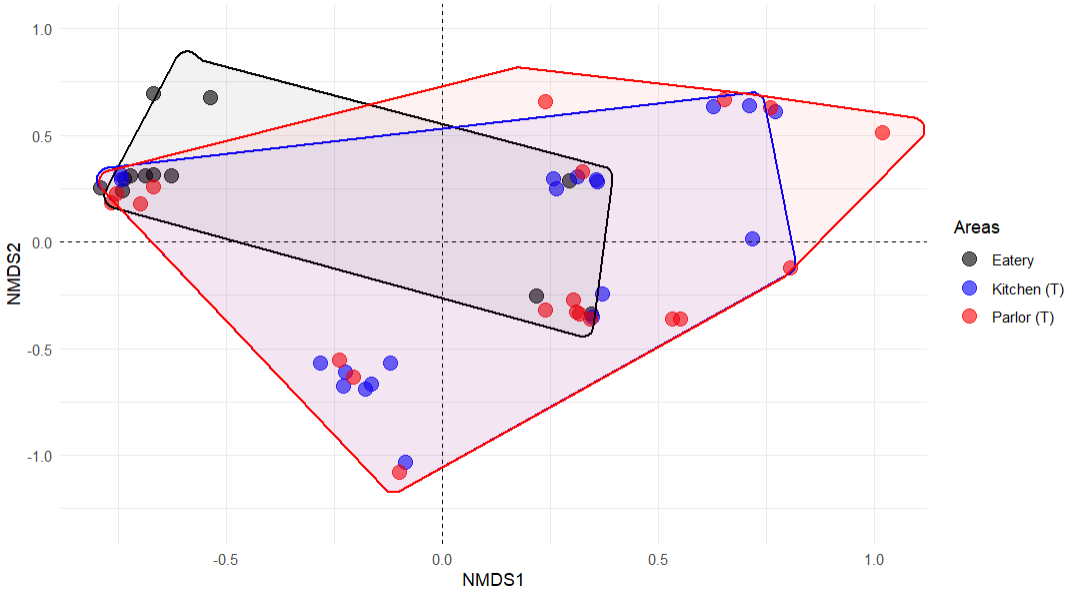
**Figure 4**: NMDS ordination of fly species assemblages based on two eating areas (Eatery and Tavern), using Bray-Curtis similarity (stress = 0.12; 9999 permutations). Ellipses represent 90% confidence intervals around groupings by collection method. Each point corresponds to a sampling location (N = 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 units 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 sampling locations (N = 52). To enhance visibility, points have been jittered by 0.09 NMDS units along both axes.

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