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# Insect Abundance in Soils Contaminated with Palm Oil Mill and Spent Engine Oil Effluents and Their Relationship to Ambient Microclimate

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

This study investigates the effects of microclimates, specifically temperature and relative humidity, on the abundance of insects in Abakaliki, Ebonyi State, Nigeria. The study divided Ebonyi State University's Presco Campus into two habitat zones, employing quantitative methods like handheld sweep nets and pitfall traps. Six transect walks were conducted along 0.23-kilometer lines, sampling ground-level vegetation twice a week. Twelve pitfall traps with a soap-water solution were deployed in each habitat. Euthanized insects were preserved with ethyl acetate, and data analysis involved descriptive statistics, One-Way ANOVA, and diversity indices to assess species diversity and distribution. Results indicate variations in temperature, relative humidity and insect abundance

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across different sites, with the Palm Oil Mill Effluent (POME) site exhibiting the highest mean insect abundance (10.79). The relationship between environmental variables and insect abundance reveals a positive correlation with temperature (r = 0.361; P = 0.03) and a negative association with relative humidity (r = -0.0741; P = 0.667). These findings underscore the nuanced interplay between microclimates and insect abundance, emphasizing the importance of context-specific analyses in understanding ecological relationships. The research findings have implications for agriculture, public health, and ecosystem management in Abakaliki and similar regions, highlighting the need for targeted interventions considering the unique microclimatic conditions of the area.

*Keywords: Insects; relationship; temperature; relative humidity.*

## 1. INTRODUCTION

Microclimates, defined as localized climate conditions that differ from the surrounding areas, play a crucial role in shaping the abundance and distribution of insects. Two key factors within microclimates—temperature and relative humidity—exert significant influence on the behavior, development, and survival of insects, ultimately impacting their overall abundance [1]. Temperature serves as a crucial determinant in the life cycles of insects. Each insect species has a preferred temperature range for optimal development, and microclimates can either facilitate or impede their growth [2]. In warmer microclimates, insects may experience accelerated development rates, leading to increased reproductive success and population growth. Conversely, cooler microclimates may slow down development, potentially limiting the abundance of certain insect species. Temperature variations can also affect the metabolic rates of insects, influencing their feeding patterns, energy expenditure, and overall activity levels [3].

Relative humidity, the ratio of water vapor in the air to the maximum amount the air could hold at a given temperature, is equally instrumental in shaping insect populations. Insects exhibit diverse adaptations to humidity levels, with some species thriving in high humidity environments while others prefer drier conditions [4]. Microclimates with elevated humidity provide a conducive environment for certain insects, particularly those with aquatic or semi-aquatic life stages. Conversely, arid microclimates may pose challenges to insects adapted to moist conditions, potentially limiting their abundance. The interaction between temperature and relative humidity further refines the conditions suitable for specific insect species [5]. For instance, tropical microclimates often exhibit both high temperatures and high humidity, creating favorable habitats for a plethora of insect species. In contrast, temperate microclimates may experience seasonal fluctuations, influencing the prevalence of insects at different times of the year [6].

Microclimatic conditions also impact the geographical distribution of insects. Mountainous regions, with their varied elevations and microclimates, provide a diverse range of habitats for insects [7]. As one ascends a mountain, temperature and humidity levels change, leading to distinct ecological zones that host different insect communities. This phenomenon, known as altitudinal zonation, underscores the sensitivity of insect abundance to microclimatic variations [8]. Human-induced changes to microclimates, such as urbanization and deforestation, can significantly alter insect populations. Urban areas, characterized by the urban heat island effect, often experience elevated temperatures compared to their surrounding rural landscapes [9]. This can create microclimates that favor certain heat-tolerant insect species, potentially leading to shifts in insect abundance and community composition.

Furthermore, climate change amplifies the impact of microclimates on insects. As global temperatures rise, microclimates become increasingly variable and unpredictable. Insects, with their finely tuned adaptations to specific environmental conditions, may face challenges in adjusting to rapid changes [10,11]. This could result in altered phenology, distribution patterns, and, ultimately, abundance. The interplay between these factors shapes the ecological niches available to different insect species, influencing their life cycles, behaviors, and overall populations [12]. Understanding these dynamics is essential for predicting and mitigating the consequences of environmental changes on insect communities, with broader implications for ecosystem health and biodiversity.

The need for the study therefore becomes very urgent due to the recognition of the pivotal role that local climatic conditions play in shaping ecological dynamics. The motivation for this study is deeply rooted in the unique environmental context of Abakaliki and the broader implications for agriculture, public health, and ecosystem stability. Abakaliki, located in Ebonyi State, Nigeria, is characterized by a tropical climate, with distinct wet and dry seasons [13,14]. This region is agriculturally significant, relying heavily on crops for sustenance and economic activities. Understanding the microclimatic factors influencing insect abundance is vital for agricultural planning and pest management. However, the existing literature on the subject often lacks specificity concerning the microclimates of Abakaliki and their direct impact on local insect populations.

A comprehensive review of literature reveals a gap in the understanding of the intricate relationship between microclimates and insect abundance in the specific context of Abakaliki. While broader studies discuss the impact of climate on insect populations [15,16], the localized factors unique to Abakaliki, such as its topography and vegetation, are often overlooked. Consequently, there is a need for a study that delves into the microclimatic nuances of Abakaliki to provide a more accurate and context-specific understanding of how temperature and relative humidity influence insect abundance. Furthermore, the agricultural landscape of Abakaliki is diverse, featuring crops with varying susceptibility to insect pests [17]. The motivation for this study is intensified by the potential agricultural consequences of an imbalance in insect populations. For example, staple crops like cassava and yams are crucial to the local economy, and their vulnerability to specific insect pests can have cascading effects on food security and economic stability. The existing literature provides generalized insights into the impact of climate on agriculture [18,19], but fails to offer a granular examination of how microclimates in Abakaliki contribute to insect-related challenges in specific crops.

Public health is another critical dimension driving the motivation for this study. Insects, particularly those that serve as vectors for diseases, are sensitive to climatic conditions [20,21]. Abakaliki, like many tropical regions, faces health challenges associated with insect-borne diseases such as malaria and dengue fever. Understanding how microclimates influence the abundance and distribution of disease-carrying insects is imperative for developing targeted public health interventions. The existing literature provides a global perspective on climate change and its implications for vector-borne diseases [22,23], but a focused study on Abakaliki is necessary to tailor interventions to the local context. Rapid urbanization alters local microclimates, creating pockets of heat and humidity that can significantly affect insect populations. This study aims to fill this gap by exploring how the unique combination of urban development and microclimate influences the abundance and distribution of insects in Abakaliki.

## 2. METHODS

The research was conducted at Ebonyi State University's Presco Campus in the Abakaliki capital territory of Ebonyi State, Southeast Nigeria. Positioned in the Guinea Savannah zone, the campus experiences distinct precipitation phases in June and September, with an annual rainfall ranging from 1000 mm to 1500 mm. The climate is characterized by a mean annual temperature of 29°C to 30°C and relative humidity varying from 60% to 80%. The terrain comprises undulating plains with irregular river valleys and steep ridges, featuring a dendritic drainage pattern. The open savannah woodland environment is rich in biodiversity, hosting various plant species.

The research site was divided into two habitat zones, and quantitative assessment methods, including handheld sweep nets and pitfall traps, were employed to evaluate insect populations. Line transects of 0.23 kilometers were established at each site, with six transect walks conducted in the two habitats. Insect sampling using handheld sweep nets occurred twice a week along predetermined transect routes, targeting ground-level vegetation.

Twelve pitfall traps were deployed in each habitat, filled with a soap and water solution. Insects were euthanized and preserved using ethyl acetate, with identification carried out in the laboratory using relevant keys.

Descriptive statistics and One-Way ANOVA were employed for data analysis, assessing variances in orders, families, and species. Diversity indices, including species diversity, richness, and evenness, were used to evaluate species diversity and distribution

## 3. RESULTS

In this section, the result of the monthly mean abundance of insects alongside key environmental variables — temperature and relative humidity were presented.

### 3.1 Monthly Mean Abundance of Insects, Temperature and Relative Humidity

The summary of the result on the mean abundance of insect and environmental variables (temperature and relative humidity) is presented in Table 1. The result showed that the highest mean temperature was recorded in the POME site (24.82±0.725) while the least was in the control site (24.33±0.666). The relative humidity was higher (60.82%±4.499) in the site exposed to spent engine effluent while least in the control site (58.93%±4.191). The result also revealed that the highest mean number of insects (10.79±1.250) was recorded in the POME site while the least was recorded in the spent engine effluent site (2.95±0.344).

### 3.2 Relationship between the Abundance of Insects Associated with Sites and Environmental Variables (Temperature and Relative Humidity)

The relationship existing between some environmental variables and insect abundance in the study area is presented in Table 2. The result in Table 2 indicates that mean abundance of insects was positively associated with mean temperature (r = 0.361; P = 0.03). This indicates that insect abundance increased simultaneously with increase in temperature. However, the mean abundance of insects was negatively associated with mean relative humidity (r = -0.0741; P = 0.667). This indicates that insect abundance decreased simultaneously with increase in relative humidity.

## 4. DISCUSSION

Table 1 summarizes the results of a study examining the mean abundance of insects and associated environmental variables, namely temperature and relative humidity, across different sites. The POME site exhibited the highest mean temperature, in contrast to the control site with the lowest. This finding aligns with previous research indicating temperature variations across different ecological niches [24,25]. Additionally, the site exposed to spent engine effluent demonstrated higher relative humidity, contrasting with the control site where it was least, indicative of potential environmental stressors influencing humidity levels. Regarding insect abundance, the POME site recorded the highest mean number, while the spent engine effluent site had the least. This observation

**Table 1. Summary of insect abundance, temperature and relative humidity of the study sites**

| Sites | Mean abundance ± SEM | Mean Temperature ± SEM | Mean relative humidity ± SEM |
|---|---|---|---|
| Palm Oil Mill Effluent | $10.79^{b}$±1.250 | $24.82^{a}$ ±0.725 | $59.78^{a}$±3.969 |
| Spent Engine Effluent | $2.95^{a}$±0.344 | $24.57^{a}$±0.681 | $60.82^{a}$±4.499 |
| Control | $5.47^{a}$±0.461 | $24.33^{a}$±0.666 | $58.93^{a}$±4.191 |
| P-value | 0.00 | 0.882 | 0.951 |

*Columns sharing similar superscripts are not significantly different at P>0.05*

**Table 2. Relationship between environmental variables and insect abundance in the study area**

| | | Mean abundance | Mean Temperature | Mean relative humidity |
|---|---|---|---|---|
| Mean abundance | Pearson Correlation | 1 | | |
| | Sig. (2-tailed) | | | |
| Mean Temperature | Pearson Correlation | $.361^{*}$ | 1 | |
| | Sig. (2-tailed) | .030 | | |
| Mean relative humidity | Pearson Correlation | -.074 | $.544^{**}$ | 1 |
| | Sig. (2-tailed) | .667 | .001 | |

**. Correlation is significant at the 0.05 level (2-tailed)*
***. Correlation is significant at the 0.01 level (2-tailed)*

supports the notion that different pollutants can impact insect populations differently [26], this was also highlighted in a related study on the effects of industrial effluents on insect communities [27]. The variations in insect abundance across sites could be attributed to the specific ecological responses to pollutants and temperature, as noted in studies exploring similar ecosystems [11]. In summary, the study emphasizes the complex interplay between environmental variables and insect abundance, warranting further investigation into the specific mechanisms underlying these observations.

Table 2 presents the relationship between environmental variables and insect abundance in the study area, revealing contrasting associations. The mean abundance of insects exhibited a positive correlation with mean temperature, indicating that as temperature increased, insect abundance also increased. This finding aligns with previous studies highlighting the impact of temperature on insect populations [19]. In contrast, the mean abundance of insects showed a negative association with mean relative humidity. This suggests that insect abundance decreased as relative humidity increased, opposing the positive relationship observed with temperature [21]. The observed negative correlation between insect abundance and relative humidity is in agreement with findings from a related study on insect responses to varying humidity levels [28]. However, the lack of a significant correlation in this study emphasizes the context-dependent nature of these relationships, underscoring the need for considering specific environmental contexts [29]. The study highlights the nuanced interplay between temperature, relative humidity, and insect abundance, emphasizing the importance of context-specific analyses in understanding ecological relationships.

## 5. CONCLUSION

The exploration into the impact of microclimates, specifically focusing on temperature and relative humidity on insect abundance in Abakaliki, Ebonyi State has yielded significant findings. Through meticulous data collection and analysis, we have unraveled compelling associations that underscore the intricate interdependence between environmental variables and insect populations. This study elucidates the critical role that temperature and relative humidity play as determinants shaping the distribution and abundance of insects. The observed correlations highlight the sensitivity of insect life cycles and behaviors to variations in these microclimatic conditions, emphasizing the need for a nuanced understanding of ecological dynamics.

The practical implications of our research extend beyond academic curiosity, offering valuable insights for pest management, agriculture, and conservation efforts in the region. As global climate change continues to exert its influence, a thorough comprehension of how microclimates influence insect communities becomes paramount for devising informed strategies and sustainable environmental practices. Looking ahead, it is imperative to recognize the dynamic nature of microclimates and their potential ramifications on insect populations. Ongoing research in this field will not only contribute to our broader understanding of ecological processes but will also aid in developing adaptive strategies to mitigate the effects of environmental changes on insect biodiversity. In essence, this study contributes a crucial piece to the puzzle of ecosystem dynamics in Abakaliki, Ebonyi State. By shedding light on the intricate relationships between microclimates and insect abundance, this study provides a foundation for future investigations, inspire further inquiry, and facilitate the development of strategies that safeguard the delicate equilibrium between environmental variables and insect communities in the face of a changing climate.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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