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Influence of environmental conditions (temperature and humidity) on the population density and distribution of domestic insects in Kirkuk City

Rafal Muthana Hassan *

Republic of Iraq, Ministry of Education, Salah al-Din Education Directorate-Samarra Education Department

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Abstract

The objective of this study was to determine the impact of environment variables such as temperature and relative humidity on insect population density and distribution in households. The field analysis was carried out between May and September 2025 in various residential areas with varying population densities. Insect sampling was done using sticky traps, light traps, and hand-picked, and the temperatures and humidity levels were recorded daily.

Results showed that there was a definite variation in environmental factors and insect populations based on time and location. The temperature factor steadily increased until the mid-summer when it reached its peak value. However, humidity had the exact opposite relationship with time. 3250 insects were captured, where the most common insects were cockroaches, followed by flies and ants.

There was an observable seasonality effect, where the insect density increased during warm seasons. There was a statistically significant positive relationship between temperature and insect density ($r = 0.72$, $p < 0.01$) and a statistically significant inverse relationship between humidity and insect density ($r = -0.48$, $p < 0.05$). There were also statistically significant differences among study sites and months according to ANOVA results. These results emphasize the crucial importance of environmental variables in regulating the insect population dynamics in urban environments.

Keywords. Environmental Factors; Temperature; Humidity; Household Insects; Urban Environment; Insect Density; Distribution

1. Introduction

The urban environment is an example of an ecological system characterized by constant interactions between human activities, environmental conditions, and living organisms. The organisms that are commonly found within the urban ecosystem are household insects that have managed to adapt well to living alongside humans [1]. This type of organism is usually classified as synanthropic insects and includes the likes of cockroaches, flies, and ants [2].

Insects and their abundance in homes are not a coincidence and are heavily affected by the environment. Some of the environmental aspects that have been found to be key for the life of insects include temperature and humidity. Ectotherms such as insects require an environmental stimulus to maintain their biological processes [3]. Temperature fluctuations have an impact on the metabolic rate, developmental rate, and rate of population increase. Humidity impacts water balance and the ability to resist drying [4].

These environmental variables in an urban environment are often subject to change depending on the seasons and microclimate within the neighborhood. Variables like buildings, human activity, ventilation, and sanitation are just some

* Corresponding author: Rafal Muthana Hassan

of the elements that lead to the creation of microhabitats, which may either favor or hinder insects. In effect, insect densities and their dispersion would differ widely in an urban setting [5].

It is important to understand the effect of temperature and humidity on household insects because of several reasons. Publicly, household insects may be regarded as carriers of infectious agents since they are mechanical vectors of diseases [6]. Ecologically, it helps one to learn how organisms cope with the fast-changing environment due to the rapid development of urban areas. Furthermore, it becomes necessary to create an environmentally friendly and efficient way of pest elimination. [7].

Although this subject matter holds great significance, much work remains to be done in the form of field studies that would precisely measure the effect of environmental conditions on insect populations [8]. The purpose of this study is to assess the impact of temperature and relative humidity on the abundance and distribution of household insects in Kirkuk city.

2. Materials and Methods

2.1. Study Design

A Field Analytical Study was conducted from May to September 2025 in Kirkuk city to investigate the influence of environmental conditions (temperature and humidity) on the density and distribution of domestic insect populations. The study area covered several residential districts selected based on varying environmental and socio-demographic criteria, including population density, sanitation levels, and housing types (apartments vs. standalone buildings). These districts were divided into 3–5 primary zones, with each zone containing 5–10 randomly selected residential units, totaling 20–40 sampling sites. To assess temporal variations in insect density, weekly sampling was performed using insect traps set directly in the fields, while environmental factors were measured simultaneously. Furthermore, sampling conditions and trap placements were strictly standardized across all locations to ensure accurate comparative data analysis.

2.2. Insect Sampling

Insects from houses were collected using standard techniques in order to ensure that both crawling and flying insects were adequately represented. The following techniques were used:

2.2.1. Sticky traps

Deployed within residential spaces at locations that are prone to insect infestation, including kitchens, bathrooms, and waste disposal sites, for the collection of crawling insects.

2.2.2. Light traps

Employed to trap insects like flies and placed in suitable indoor places where there was an assurance of trapping those insects.

2.2.3. Manual trapping

Carried out by using simple methods like forceps or collecting the insects in containers if the insects could not be trapped in traps.

The traps were left set for 24 to 48 hours after which they were collected and brought into the lab. The sampling process took place every week for 8 to 12 weeks.

Standardization was ensured through the use of consistent numbers and placement of the traps in all residential units, along with the accurate recording of trapping periods.

2.3. Measurement of Environmental Factors

Environmental factors were measured at all the sites under study at the same time when insects were being collected to correlate their presence with environmental conditions.

Measurements included:

- **Temperature (°C):** Measured using a digital thermometer calibrated to ensure precision in each area**.**
- **Humidity (%):** Determined through measurement by a hygrometer in each home setting.

Data were collected twice a day (in the morning and evening) during the duration of the experiment. The daily mean for temperature and humidity was computed for each site and later subjected to statistical analysis.

2.4. Identification and Classification of Insects

Identifying of collected insects was done in the laboratory through their physical structure such as the body shape, wings, legs, and mouthparts.

The most common household insect groups identified included: flies, cockroaches, and ants.

For quantitative analysis, two measures were considered:

- Insect Density: The number of insects found at each point to identify the level of infestation.
- Frequency of occurrence: The percentage of the number of insects that occurred at each point based on the total number of points.

From these observations, the dominant insects were identified as well as how they related to various environmental factors like temperature and humidity.

Figure 1 Laboratory presentation and classification of collected household insects using Petri dish method

2.5. Statistical Analysis

Data were analyzed using SPSS. Mean ± SD, Pearson correlation, and one-way ANOVA were applied. A p-value < 0.05 was considered significant.

3. Results

3.1. Environmental Conditions During the Study Period

Table (1) illustrates the monthly average values of temperature and relative humidity that were recorded during the experiment period (May – September 2025).

The results indicate an increasing pattern in temperature values from May through July, when the maximum value is achieved during July and August. At the same time, relative humidity demonstrates a reverse trend, when the minimum values are recorded during July and August, while the increasing values are evident in September.

Differences in the values of standard deviations are also identified throughout the experiment period. The aforementioned trends are represented graphically in Figure (1).

Table 1 Temperature and Humidity During Study Period

Month	Temperature (°C) Mean ± SD	Relative Humidity (%) Mean ± SD
May	28.5 ± 2.1	55.3 ± 4.2
June	34.7 ± 2.5	48.6 ± 3.8
July	41.2 ± 2.8	36.1 ± 3.2
August	40.8 ± 2.6	34.7 ± 3.5
September	35.6 ± 2.3	42.5 ± 3.9

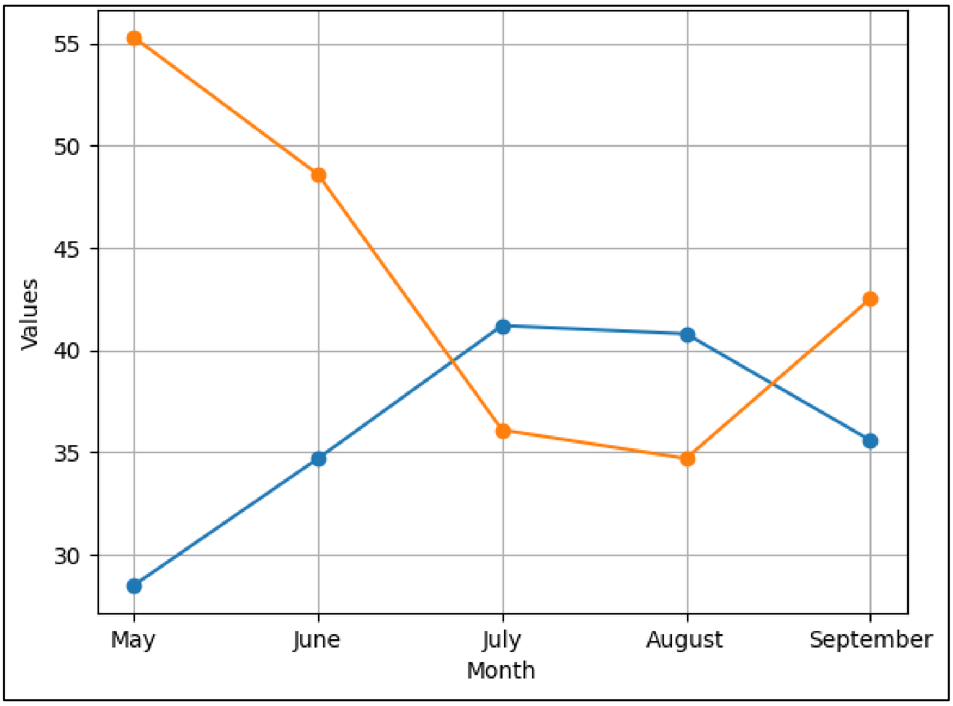

Figure 2 Monthly Trends of Ambient Temperature and Relative Humidity

3.2. Overall Insect Density

Table (2) depicts the total number of insects collected and their percentage distribution in the different categories. From the above findings, there is a difference in the number of insects for the three groups studied. Cockroaches had the highest number, then flies, while ants were the least in number. The percentages represent the relative distribution of the groups compared to the total number of insects collected. The total number represents the sum total of all insects collected in the different locations.

This distribution is well depicted in Figure (2).

Table 2 Distribution of Household Insects

Insect Type	Number	Percentage (%)
Cockroaches	1365	42%
Flies	1138	35%
Ants	747	23%
Total	3250	100%

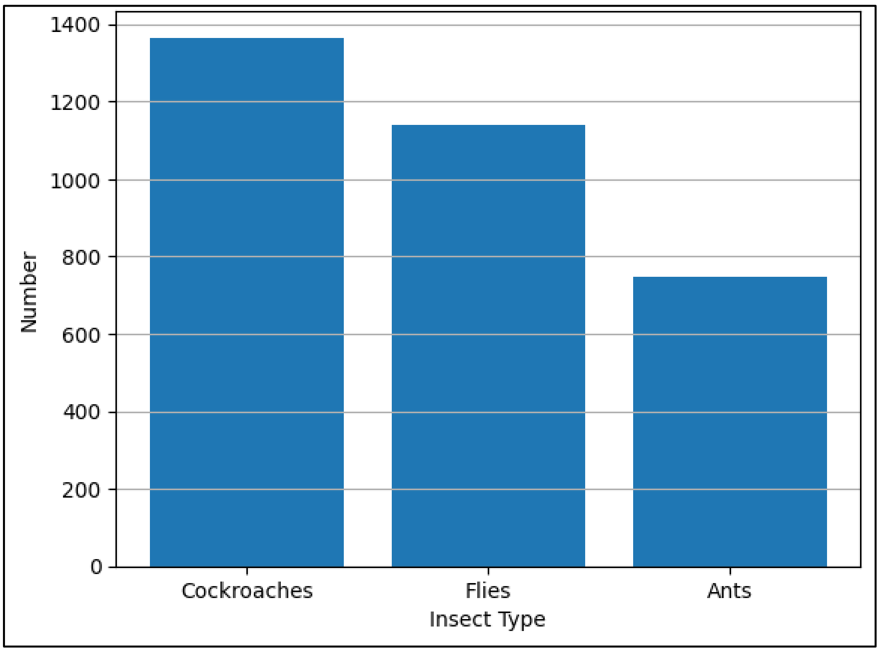

Figure 3 Distribution of Household Insect Types Based on Abundance

3.3. Spatial Distribution of Insects

Figure 3 represents the average insect density (insects/site) and standard deviations in various study areas. The results show variations in insect density among the classified areas as high, medium, and low population density. The variation is shown by changes in mean values and standard deviations, which are due to variations in insects' numbers in the classified areas. The spatial variations have been captured in Table (3) below.

Table 3 Insect Density by Study Area

Area Type	Density (Mean ± SD) insects/site
High population density	95.6 ± 12.3
Moderate density	78.4 ± 10.7
Low population density	60.2 ± 8.9

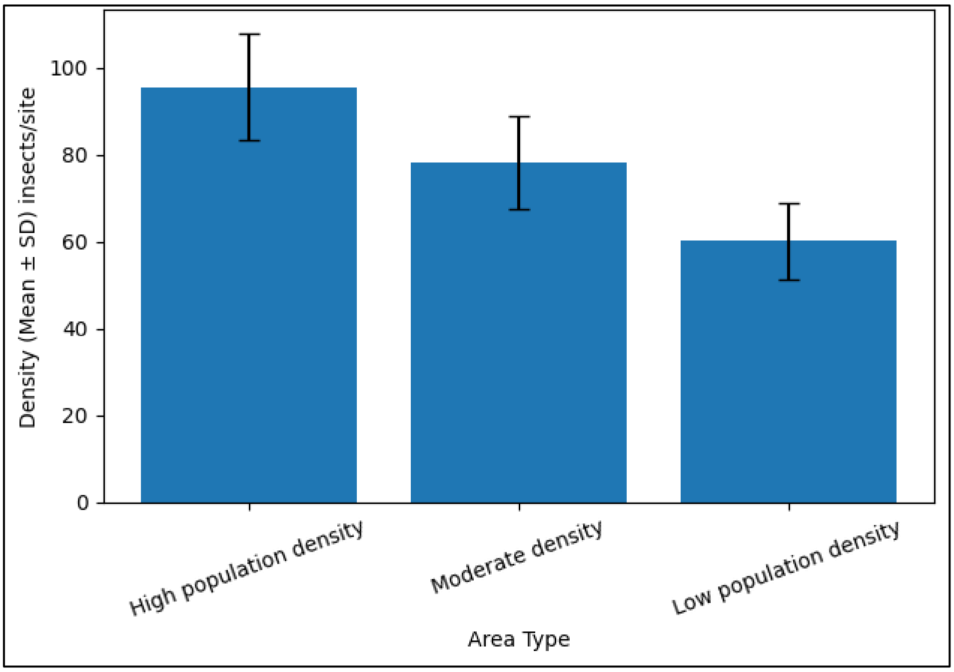

Figure 4 Variation in Insect Density Across Different Population Density Areas

3.4. Temporal Variation in Insect Density

Table (4): Monthly fluctuations in mean insect population

The data reveals an increasing trend in insect population from May through July, with highest figures occurring in July and August, after which there was a decline in September. Standard deviation figures reveal the variations in insect numbers per month.

Graphical representation of the temporal trend of insect population can be seen in Figure (4).

Table 4 Monthly Variation in Insect Density

Month	Density (Mean ± SD) insects/site
May	60.5 ± 9.8
June	75.3 ± 11.2
July	102.5 ± 14.6
August	100.8 ± 13.9
September	85.4 ± 12.1

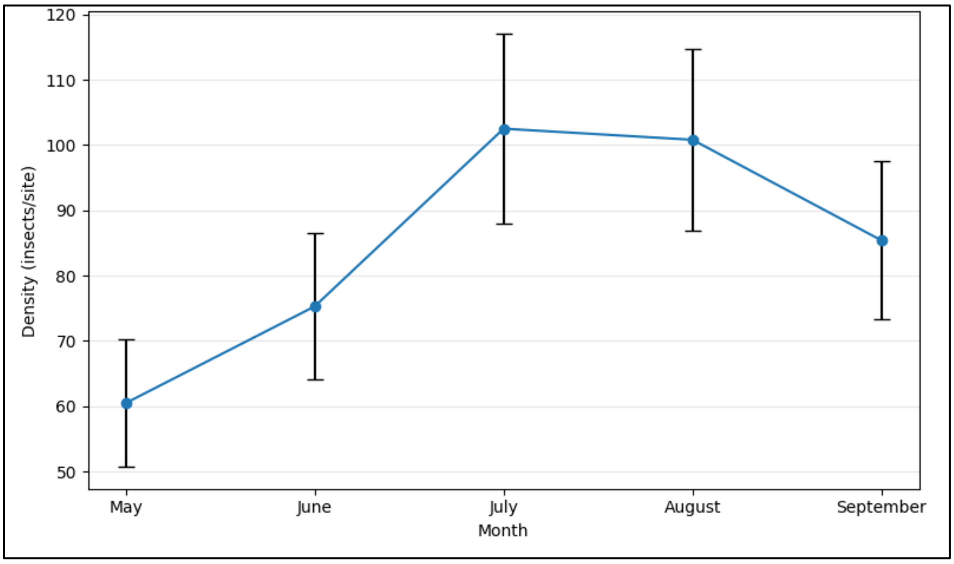

Figure 5 Monthly insect density (Mean ± SD) per site

3.5. Correlation Between Environmental Factors and Insect Density

Table (5) contains the findings obtained from the correlation analysis between environmental factors and insect density.

Correlation coefficient values (r) along with corresponding p-values showing the relation between temperature and insect density, as well as humidity and insect density, are displayed in the table.

Table 5 Correlation Analysis

Variable	Correlation Coefficient (r)	p-value
Temperature vs Density	0.72	<0.01
Humidity vs Density	-0.48	<0.05

3.6. Frequency of Occurrence

Table (6) indicates the percentage (%) occurrence of each insect category in all field locations.

The figures indicate the occurrence of the percentage of each insect category relative to the total number of sites from where samples were collected. This table suggests that there is variation in the spatial occurrence of insects belonging to different categories.

Table 6 Frequency of Occurrence

Insect Type	Frequency (%)
Cockroaches	85%
Flies	78%
Ants	65%

3.7. Statistical Analysis (ANOVA Results)

The following table (7) shows the output from one-way ANOVA used to examine any difference in insect density between different study sites and months.

Table (7) displays F-values and their p-values for all factors. The values reveal the statistical comparison among groups.

Table 7 ANOVA Results

Factor	F-value	p-value
Study Area	5.87	<0.05
Month	8.21	<0.01

4. Discussion

Environmental variables have been found to be important determinants for the ecology, behavior, and demography of insects in urban areas [9]. Some of the environmental variables that significantly affect the physiology, reproduction, and survival of domesticated insects include temperature and relative humidity [10].

Insect development is significantly influenced by temperature which is often regarded as an abiotic factor with the greatest importance for their lives [11]. Being poikilothermic animals, insects require an adequate temperature regime for regulation of their metabolism [12]. Higher temperatures usually favor rapid enzyme action, faster feeding and reduced time taken for development, and thus favor their proliferation and activity [13]. Several urban entomological studies have shown the relationship between higher temperatures and high population numbers of synanthropic insects, especially insects that live indoors, like cockroaches and flies [14].

Relative humidity has an important impact on insect survival and prevalence as well, but their effects can be different from one insect to another because of species-specific physiological limitations [15]. Humidity plays an important role in water balance, resistance to desiccation, and even reproduction in insects [16]. There are some insects that show tolerance to dryness as a result of adaptive traits; others rely on high levels of humidity for survival [17]. The link between humidity and temperature is thus quite complicated [18].

Urban settings offer an exceptional ecological setting that is distinguished by diverse microhabitat types, different sanitation status, and constant human activity [19]. These factors provide favorable habitats for domestic insects by guaranteeing their supply of food, shelter, and breeding grounds [20]. In addition, population density and the type of dwellings have been found to increase environmental heterogeneity, which affects the distribution of insects in various residential settings [21]. Urban areas that feature high population densities are usually associated with more insect populations [22].

Seasonality is another key determinant affecting insect populations. The changes in climate throughout the year affect insect behavior, reproduction, and distribution [23]. Warming climates often promote increased insect activity because of favorable temperatures, while cooling periods restrict movement and hinder population expansion [24]. This aspect has been extensively studied in ecology and is regarded as an essential element in comprehending insect population dynamics [25].

The variations in species distribution and prevalence between different domestic environments can be explained on the basis of the adaptability and behavioral features of the insects [26]. Some types of insects have higher resistance to environmental challenges and also possess certain abilities, which help them take advantage of the wide variety of environments inside homes [27]. These include factors such as nocturnal behavior, opportunistic diets, and capacity to hide in tiny spaces [28]. On the other hand, there are certain other insects that show limited distribution due to environmental preferences [29].

The spatial distribution of insects within urban settings is also determined by human interventions such as waste management systems, water availability, and the structural characteristics of buildings [30]. Poor sanitation, accumulation of organic waste, and poor ventilation facilitate the growth of insects. These human elements are often associated with environmental factors, adding another layer of complexity to the dynamic nature of insect populations [31;32].

Based on an ecological approach, the link between environmental parameters and insect numbers may be viewed as a system wherein various parameters are interconnected at the same time [33]. The most important elements in this interaction may be seen as temperature and humidity; however, the impacts of both may be affected by other considerations such as habitats [34;35].

5. Conclusions

This paper shows that there is a direct connection between the environment conditions, including temperature and humidity, and the number of insect pests found in households. High temperatures contribute to greater pest activity and reproduction, whereas low humidity can further facilitate the growth of insect populations.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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