# Behavioral Responses of the American Cockroach (*Periplaneta americana*) to Environmental Stressors in Residential and Agricultural Areas

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## Abstract

This study aimed to evaluate the behavioral responses of the American cockroach Periplaneta americana to several major environmental stressors including temperature light intensity, and humidity. A total of 90 adult cockroaches were collected, comprising 45 individuals from residential environments and 45 individuals from agricultural environments in Karbala Province the results revealed a clear variation in behavioral responses according to the insects original habitat, reflecting the remarkable adaptability of the American cockroach to diverse environmental conditions Cockroaches collected from agricultural environments exhibited a stronger preference for the warm zone 35°C with an attraction rate of 62.21% whereas those collected from residential environments showed a greater preference for the moderate zone 25°C with an attraction rate of 57.77% the overall effect rates of temperature treatments were 18.88% 39.99% and 42.21% for the cool moderate and warm zones respectively for the cool, moderate and warm zones respectively in response to light conditions the American cockroach exhibited a pronounced negative phototactic behavior individuals collected from residential environments showed a stronger preference for dark areas than those from agricultural environments with environmental effect rates of 74.43% and 24.44% respectively this finding is consistent with the well-documented nocturnal behavior of this species.

Regarding humidity preference the results demonstrated a significant attraction toward environments with high relative humidity (70%) this preference was more evident among individuals originating from agricultural environments which exhibited an effect rate of 51.10% compared with 49.99% for those collected from residential environments furthermore the overall effect rate of humidity reached 71.10% in the humid environment compared with 29.99% in the dry environment these findings indicate that *Periplaneta americana* possesses considerable behavioral plasticity enabling it to adjust its responses to environmental conditions according to habitat-specific selective pressures such adaptability may contribute substantially to its ecological success and widespread distribution across both residential and agricultural environments.

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**Keywords:** *Periplaneta americana* , Thermal Response , Light Aversion Response , Humidity Preference.

## Introduction

Insects are among the most adaptable living organisms to environmental changes and the American cockroach (*Periplaneta americana*) is considered one of the most successful species in adapting to a wide range of environmental conditions the American cockroach (*Periplaneta americana*) is a widely distributed species that has successfully adapted to and thrived in both residential and agricultural environments this species belongs to the order Blattodea and is considered a medically important pest that poses significant public health concerns due to its role in the mechanical transmission of numerous pathogenic microorganisms, including bacteria, fungi and parasites, thereby constituting a potential threat to human health [1] .

american cockroaches exhibit a distinct nocturnal lifestyle (Nocturnal behavior) as their activity follows a daily rhythm: they are active at night, engaging in foraging, exploration, and reproduction, while they tend to hide in dark, damp places during the day (Coby Schal & Ayako Wada-Katsumata, 2015)

Negative phototaxis is one of the most important behavioral adaptations that helps cockroaches avoid environmental hazards such as predation and dehydration [3] the behavioral responses of the American cockroach are significantly influenced by environmental factors such as temperature, humidity, food availability, and light intensity, as these factors affect locomotor activity, feeding rates, and reproduction [4,5]

A recent study demonstrated that the American cockroach (*Periplaneta americana*) exhibits distinct behavioral responses depending on the wavelength of light, with both short- and long-wavelength light exerting direct effects on its activity patterns and locomotory orientation [6].

Similarly in residential environments cockroaches benefit from the availability of food resources and suitable harborages such as kitchens and sewage systems which contribute to increasing their population density and facilitating their widespread distribution [1] .

In agricultural environments the presence of organic matter and crop residues provides favorable conditions for the survival and proliferation of cockroach populations However exposure to pesticides and environmental fluctuations may induce adaptive behavioral changes that enhance their ability to cope with these stressors [7].

Moreover the American cockroach possesses highly developed sensory systems including olfactory tactile and visual receptors which enable it to perceive environmental changes and respond to them with remarkable efficiency studies have shown that alterations in chemical cues particularly those associated with food sources can induce adaptive behavioral modifications such as the avoidance of toxic baits glucose aversion this adaptive behavior represents a significant challenge

to cockroach control and management programs [8].

Understanding these behavioral responses is essential for the development of effective strategies within Integrated Pest Management (IPM) programs accordingly the present study aims to investigate the behavioral responses of the American cockroach (*Periplaneta americana*) to environmental stressors in residential and agricultural environments Periplaneta americana the study focuses on evaluating the effects of various environmental factors on the activity and distribution of this species, thereby contributing to the improvement of control strategies and the mitigation of the public health risks associated with its presence

Behavioral responses in this species are also influenced by chemical factors with pheromones serving as one of the primary regulators of social behavior Previous studies have demonstrated that the sensory neurons of nymphs exhibit specialized responses to aggregation and sex pheromones thereby contributing to the regulation of social interactions and group organization within cockroach populations [9] .

Furthermore the environmental degradation of cuticular hydrocarbons results in the production of volatile pheromonal compounds that play a pivotal role in mediating social and aggregative behaviors in cockroaches thereby influencing group formation and population dynamics [10] in addition the feeding behavior of the American cockroach is influenced by both the availability and quality of food resources Recent studies have revealed distinct dietary preferences that may be exploited in the development of effective non-chemical bait-based control strategies [11] . Furthermore these feeding behaviors are associated with complex neural mechanisms recent molecular investigations have highlighted the crucial role of the cephalic ganglia in regulating behavioral responses and sensory processing of environmental stimuli, thereby contributing to the adaptation of this species to changing environmental conditions [12] .

## Materials and Methods

This study targeted adult specimens of the American cockroach (*Periplaneta americana*) to compare and evaluate the behavioral responses of this species across different habitats. Particular emphasis was placed on assessing the effects of temperature, humidity and light on adults collected from residential and agricultural environments a total of 90 adult cockroaches were collected from two locations within Karbala Regardless of whether they were males or females Province Iraq comprising 45 individuals from the agricultural area of Al-Hussainiya and 45 individuals from the residential area of Hayy Al-Tahadi.

Cockroaches were collected from sewer drains and kitchens using the hand collection method and were picked up directly with forceps or by hand while wearing gloves this is considered one of the primary methods for collecting insects making it suitable for such studies to preserve them intact and undamaged [13] a transparent plastic box (40 × 30 cm) was prepared along with a lamp a small heater with a thermostat moist and dry materials (moistened cotton/silica gel), food items, paper, and a pen for recording behavior after transferring the specimens the american cockroaches (Periplaneta americana) were identified using the [14] identification key the insects

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behaviors were then monitored under the influence of the variables.

**Experiment 1: Thermal Response (Temperature Gradient).**

Comparison of the preferred temperature of cockroaches in each area within a thermal gradient the experimental arena was longitudinally divided into three zones: a cold zone (18 °C) a moderate zone (25 °C), and a warm zone (35 °C) Ice was used at one end and a heater at the opposite end to establish the gradient while temperature was continuously monitored using a thermometer Each experimental trial lasted for 30 minutes for each group.

Fifteen cockroaches collected from the agricultural area were introduced into the thermally neutral (moderate) zone at the center of the apparatus the distribution of individuals across the three temperature zones (cold, moderate and warm) was then recorded. Observations were initiated from minute 1 to 30, and counts were repeated at two-minute intervals the same procedure was applied to cockroaches collected from the residential area.

**Experiment 2: Light Aversion Response**.

Comparison of light avoidance or attraction behavior in the american cockroach (*Periplaneta americana*) collected from residential and agricultural areas the experimental arena was prepared by covering one half of the box with opaque black cardboard to create a dark zone while the other half was illuminated using an LED light source fifteen cockroaches were introduced at the center along the boundary between the light and dark zones observations were recorded from minute 10 to 30, and at two-minute intervals the number of individuals present in the light versus dark zones was documented for both populations.

**Experiment 3: Humidity Preference (Humidity Choice).**

The experimental arena was prepared by placing moist cotton (70% relative humidity) on one side of the box while the opposite side contained silica gel or dry cotton to create low humidity conditions (30% relative humidity) a low barrier was placed in the center to prevent mixing of the two conditions fifteen cockroaches were then introduced into the central region of the arena.

Observations were recorded from minute 10 to 30, with counts taken every two minutes to determine the number of individuals present in the humid and dry zones the experiment was repeated for cockroaches collected from both agricultural and residential areas each population tested separately under the same conditions.

The thermal light and humidity preference experiments were designed based on behavioral principles commonly used in cockroach ecology and behavioral studies as described by [3] . The percentage of attraction was calculated using the following formula:

Percentage of attraction (%) = (Number of attracted individuals / Total number of individuals) × 100

The data were analyzed using a Completely Randomized Design (CRD)

**Results and Discussion**

The results of the study revealed significant differences in the behavioral responses of

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the american cockroach (*Periplaneta americana*) depending on the environment from which the specimens were collected whether residential or agricultural the behavior of the insects was markedly influenced by variations in temperature, humidity, and light conditions these findings reflect the high behavioral adaptability of this species to diverse environmental conditions a well-documented characteristic of domiciliary cockroaches of medical and ecological importance.

The results of the thermal preference test (Table 1) indicated that cockroaches collected from the agricultural environment exhibited a higher attraction toward the warm zone (35 °C), with a zone effect rate of 33.33. In contrast cockroaches collected from the residential environment showed a preference for the moderate zone (25 °C) with a zone effect rate of 34.07 the mean effect of temperature across the two sampling locations was 18.88°C under cold conditions, 39.99°C under moderate conditions, and 42.21°C under warm conditions.

This may be explained by the fact that cockroaches inhabiting agricultural areas are continuously exposed to greater thermal fluctuations compared to those in residential environments, leading to the development of adaptive responses that enable them to tolerate higher temperatures [6] these findings are consistent with previous reports indicating that the locomotor activity of the american cockroach is closely temperature-dependent with increased movement and foraging activity occurring within optimal thermal ranges that support metabolic processes.

Recent studies have shown that temperature directly affects the neural and sensory processes regulating insect behavior consequently variation in environmental conditions leads to differences in the preferred thermal threshold of the species the preference of residential cockroaches for moderate temperatures can also be explained by the relatively stable thermal conditions provided within human dwellings due to the insulating effects of buildings water availability and sewage systems which reduce the need for movement toward higher-temperature environments [6] further reported that environmental factors including temperature influence locomotor orientation and the nocturnal activity of the American cockroach (*Periplaneta americana*).

Several studies have demonstrated that, in the American cockroach, activation of thermosensitive transient receptor potential (TRP) channels by capsaicin induces the release of the neurotransmitter octopamine. This neurotransmitter plays a key role in modulating the thermal threshold and behavioral responses of the American cockroach (*Periplaneta americana*) [16] .

In another study [17] reported that cockroaches exhibited a stable thermal preference, with a mean preferred temperature of **30 ± 1°C** during both daytime and nighttime periods these findings suggest that habitat conditions and lifestyle characteristics, whether solitary or social can influence the preferred thermal threshold of insects nevertheless cockroaches appear to maintain a relatively stable thermal preference reflecting their ability to regulate behavioral responses within an optimal temperature range.

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**Table 1. Percentage of thermal preference (%) of Periplaneta americana collected from agricultural and residential habitats under different temperature treatments**

| Mean effect of region | Warm (35 °C) | Moderate (25 °C) | Cold (18 °C) | Temperature / Region |
|---|---|---|---|---|
| 33.33 | 62.21 | 22.22 | 15.55 | Agricultural |
| 34.07 | 22.22 | 57.77 | 22.22 | Residential |
| | 42.21 | 39.99 | 18.88 | Mean effect of temperature |

| Region *Temperature | Temperature | Region | L.S.D 0.05 |
|---|---|---|---|
| 2.6448 | 1.928 | 0.7202 | |

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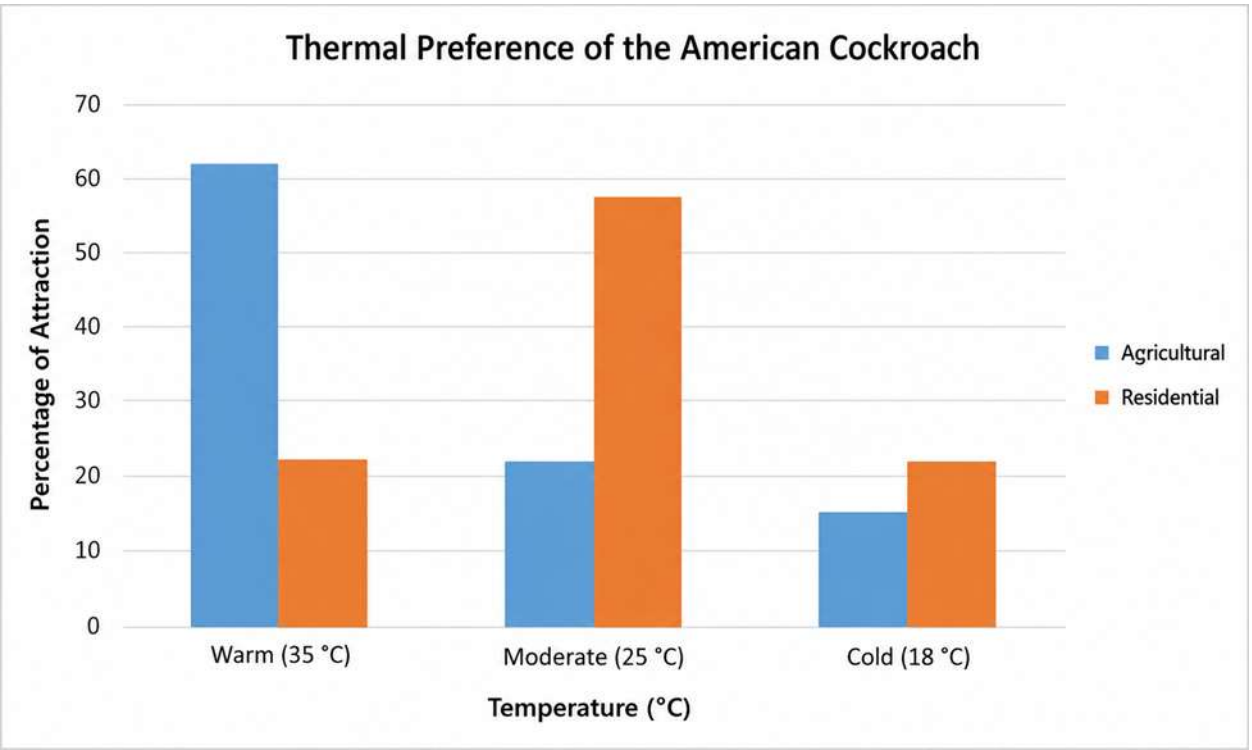


In the phototactic preference assay (Table 2) the cockroaches exhibited a clear preference for dark areas over illuminated ones particularly those collected from residential environments the mean response value recorded for individuals from the agricultural area was 24.44, whereas a substantially higher mean response value of 74.43 was observed for individuals from the residential area these findings are consistent with the nocturnal behavior of the American cockroach *Periplaneta americana*, which is characterized by negative phototaxis a behavioral trait that causes individuals to avoid light and preferentially seek dark habitats.

These findings are consistent with those reported by [3] who indicated that cockroaches exhibit pronounced nocturnal activity and preferentially occupy dark humid environments while light acts as an inhibitory factor that suppresses their locomotor activity in contrast cockroaches collected from the agricultural area exhibited a less pronounced response to light this may be attributed to their natural exposure to relatively longer periods of illumination compared with residential populations resulting in a reduced sensitivity to negative phototaxis.

Chronic exposure to light has been shown to fundamentally alter the behavioral responses of cockroaches complete immobility a characteristic indicator of the inactive phase was observed in groups maintained under continuous illumination and subsequently tested in darkness these findings suggest that prolonged light exposure in open environments such as agricultural habitats may subsequently reduce insect sensitivity to light stimuli [18] Both visual systems contribute to the regulation of photophobic behavior, and simultaneous stimulation of both has been shown to produce an additive effect furthermore studies have revealed a complex and integrated role of the

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compound eyes and ocelli in controlling leg movements and antennal activity suggesting that the visual system of cockroaches is more sophisticated than a simple light-detection mechanism Consequently behavioral variations may be attributed to differences in the processing and integration of photic signals within the nervous system [19]

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**Table 2. Phototactic preference of the American cockroach, Periplaneta americana**

| Mean effect of the region | Dark | Light | Lighting / Area |
|---|---|---|---|
| 24.44 | 33.33 | 15.55 | Agricultural |
| 74.43 | 62.21 | 86.66 | Residential |
| | 47.77 | 51.10 | Mean effect of illumination |
| Area × Illumination | Illumination | region | L.S.D 0.05 |
| 3.6127 | 1.8845 | 1.7282 | |

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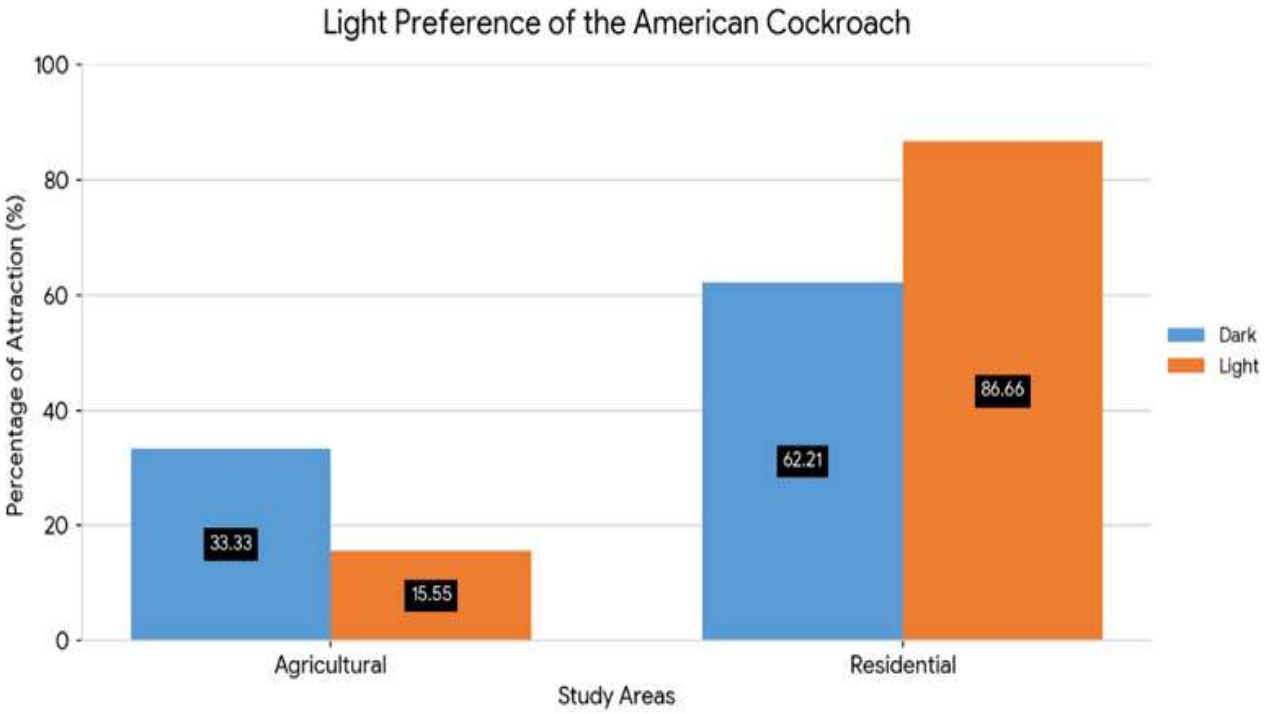


Table (3) presents the thermal preference results which demonstrated that *Periplaneta americana* exhibited a distinct preference for humid environments this preference was more pronounced among individuals collected from the agricultural area the mean effect value recorded for the agricultural area was 51.10 compared with 49.99 for the residential area indicating a slightly stronger affinity for humid conditions among cockroaches inhabiting agricultural habitats.

These findings are consistent with previous studies demonstrating that humidity exerts a direct influence on cockroach behavior including shelter-seeking feeding and reproductive activities [5] reported that humidity is a critical environmental factor regulating several physiological and behavioral responses in cockroach populations furthermore reduced humidity levels have been associated with increased escape behavior and intensified searching for water sources other studies have suggested that cockroaches possess highly sensitive hygroreceptors capable of detecting subtle changes in ambient humidity and directing movement toward environments that provide more favorable moisture conditions [15] these adaptations likely enhance survival and contribute to the successful colonization of diverse habitats.

This result can be attributed to the critical role of humidity in cockroach survival as it reduces water loss through the cuticle and helps maintain physiological homeostasis Cockroaches particularly larger-bodied individuals require environments with adequate moisture levels to sustain metabolic efficiency and normal behavioral activity furthermore, agricultural habitats generally exhibit higher humidity levels due to irrigation practices and the accumulation of plant debris creating favorable microclimatic conditions. Consequently cockroaches adapted to agricultural environments are likely to display a stronger attraction to humid conditions than those inhabiting residential areas where moisture

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availability is often more variable and limited.

**Table 3. Humidity Preference of the American Cockroach (Periplaneta americana)**.

| Regional Effect Mean | Dry %30 | Moderate %70 | Moderate / Region |
|---|---|---|---|
| 51.10 | 15.55 | 86.66 | Agricultural |
| 49.99 | 44.44 | 55.55 | Residential |
| | 29.99 | 71.10 | Mean Effect of Humidity |
| Region * Moderate | Moderate | Region | L.S.D 0.05 |
| 2.1364 | 1.0212 | 1.1152 | |

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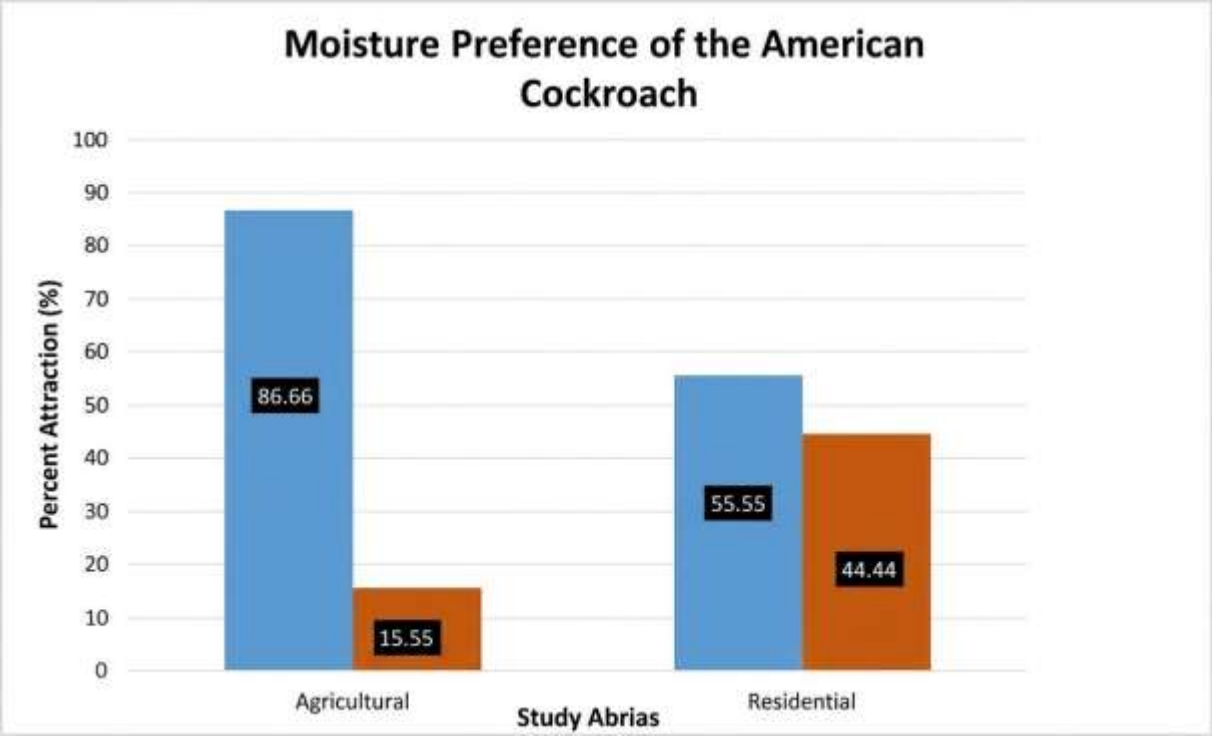


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