DETERMINATION OF BEHAVIOURAL RESPONSE OF COCHROACHES (*periplaneta Americana L)* TO LIGHT EMITTING DIODES (LEDs) AT SAMARU, ZARIA.

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ABSTRACT

This study focuses on phototactic behavioural response of American cockroach (Periplaneta americana Linnaeus, 1758) to light emitting diodes (LEDs) was carried out with different light wavelengths (red, blue, white and dark as control) was conducted at Entomology Laboratory, Pest Management Technology Programmes, Samaru College of Agriculture, Division of Agricultural Colleges, Ahmadu Bello University, Zaria, Nigeria. Objectives are to determine the repulsion rate of red, blue and white LED light on cockroaches and to evaluate light-based barriers as a non-chemical method in the management of cockroaches in Samaru, Zaria, Nigeria. Experiment was carried out in a box having two chambers, A and B, where chamber A is the part with LEDs light while Chamber B is the dark side (as Control). Cockroaches were observed for three LED light red, blue and white. Each LED light was repeated three times at an interval of 10 min, 20 min, and 30 min. However, the highest repulsion rate was recorded against the dark (control) chamber in all trials. In this research, red light showed to have the lowest repulsion rate when compared to blue and white LEDs lights with the cockroaches been more attractive to the dark sides (chamber B). Overall, red light is more attractive than blue light and less attractive than darkness. Investigation on the potential use of LEDs in integrated pest management (IPM) strategies on other pests should be carried out. Further research should be carried out to identify the optimal LED wavelength and intensity for cockroach repellency. Investigate the impact of LEDs on cockroach behaviour in combination with other control methods (e.g., traps, insecticides).

***Keywords*:** Phototactic, American cockroach, *Periplaneta americana* L., LEDs, Repulsion and Attraction.

INTRODUCTION

Cockroaches are one of the oldest inhabitants of earth, dating back as far as the Carboniferous period, over 250 million years ago (Donkor, 2019). They lack special adaptations like the sucking mouthparts in some insects such as the aphids and other true bugs (Abdullah *et al.,* 2023). Over 4500 species of cockroaches have been identified, of which 40 species are associated with human habitants while four species are well known as pests (Neupane, 2022).

Cockroaches have chewing mouthparts and feed on varieties of materials (Omnivorous) aiding in the mechanical transmission of various pathogenic viruses, bacteria, and protozoans to humans (Neupane, 2022; Ojiezeh *et al.,* 2015). Cockroaches have a worldwide distribution especially in the tropical and subtropical areas and can tolerate a wide range of environments from Arctic cold to tropical heat (Neupane, 2022; *Ojiezeh et al.,* 2015). Their population increases in hot and humid places especially with the availability of food and water. Common indoor cockroaches found

in Nigeria include, *Blattella germanica*, *Blatta orientalis* and *Periplaneta americana* (Otu-Bassey *et al*., 2019).

They are considered pests in various environments, including homes, restaurants, hospitals, warehouses, offices, and food processing facilities. Their spread is primarily facilitated by human movement and trade. Cockroaches are known to cause allergic reactions in humans and capable of carrying numerous pathogenic organisms (Ahmad *et al*., 2011). They can transmit nearly 150 species of, 60 types of fungi, 45 species of parasitic worms, and 90 protozoan species to humans, either biologically or mechanically (Jahan *et al*., 2019; Etim *et al*., 2013). Common species like the American cockroach (*Periplaneta americana*) and the German cockroach (*Blattella germanica*) are found globally. Most of the insecticides used for cockroach management had led to the developed resistance to these substances, which can also have adverse effects on human health and the environment.

Cockroaches carry micro-organisms on their surfaces and fecal pellets. They carry food-borne pathogens and food spoilage organisms wherever they crawl or forage in the home. Their presence in homes compromises the best practices in food safety and quality. Cockroaches spread a range of disease-producing organisms to humans including salmonella, staphylococcus and streptococcus. Cockroaches prefer warm, humid conditions with a ready food source. The bacteria carried by the cockroaches display multiple antibiotic resistances (Ojiezeh *et al.,* 2015).

Typically, cockroaches are nocturnal, engaging in exploration, feeding, and mating while avoiding light (Uluca *et al*., 2016). One of their notable behaviors is their quick escape response to sudden light, as they seek refuge in the nearest dark spot.

Artificial lighting can play a significant role in pest management, particularly in integrated pest management strategies or greenhouse (Johansen *et al*., 2011). Certain nocturnal species are attracted to UV light sources (Shimoda *et al.,* 2013), leading to the creation of various UV traps for monitoring insect populations and capturing them in masses (Shimoda *et al.,* 2013). Different colors of light can elicit varying effects—such as mortality, attraction, and behavioural changes—across different insect species. For instance, blue light has been shown to be lethal to *Drosophila melanogaster* (Hori *et al*., 2014). Research has found that the most commonly captured insects in light traps belong to the orders Diptera, Coleoptera, and Lepidop (Ashfaq *et al*., 2005). Additionally, lighting has been shown to influence the activities of beneficial organisms, such as predators, as demonstrated in studies involving Oriuseri (Wang *et al*., 2013).

The rise of LED bulb production has led to an increased application of lighting in pest control (Shimoda *et al*., 2013). Studies have shown that different wavelengths of light can produce lethal, attractive, or repellent effects on insects (Van Langevelde *et al*., 2011; Shimoda *et al*., 2013; Hori *et al*., 2014). In Turkey research on the orientation of cockroaches toward light is scarce. However, Uluca *et al*. (2016) examined the of ultrasonic pest repellents on Turkestan cockroaches.

This research offers important insights into the factors influencing cockroach behaviour which can inform the development of effective pest management strategies. Furthermore, the availability of food and water sources plays a significant role in shaping their movement patterns. However, this study has certain limitations, as the experiments were conducted in a controlled laboratory environment, which may not entirely reflect natural conditions. Future studies should investigate the effects of lighting and other environmental factors in real-

world settings. Overall, this research enhances our understanding of pest management and provides a foundation for formulating more effective strategies for controlling cockroach populations.

OBJECTIVE OF RESEARCH

1. To determine the repulsion rate of blue, red and white LED on cockroaches
2. To evaluate light-based barriers as a non-chemical method in the management of cockroaches.

Research Area

This research was carried out in Entomology Laboratory of Pest Management Technology Programmes, Samara College of Agriculture, Division of Agricultural Colleges, ABU Zaria which is located in Sabon Gari local Government Area, Kaduna State, Nigeria. This research was conducted during the period of September to October, 2024.

Insect Collection

Insect used for this research was collected from three locations which are, the female hostel of Samaru College of Agriculture, Down Hostel of Samaru College of Agriculture and Area BZ staff quarters, ABU Zaria.

Design of Phototactic Test Chamber

One rectangular cardboard box with a dimension of 298 X 198 X 238mm was partition into two smaller compartments or chambers (A and B). Compartment A was the side with the LEDs light while compartment B was the dark side which also serve as the control. Live cockroaches, where inserted into the chamber. Small entrances in both compartments were made so that cockroaches can enter whichever compartment they like. The box was closed and LEDs light was turned on for a minimum of ten, twenty and thirty minutes. Then the box was opened and the cockroaches on each compartment were count. More preference for compartment A indicates that they are photopositive. They are photonegative if they lean more toward the dark side. This was repeated three times (Yadav *et al.,* 2024).

Testing for Repulsive and Attractiveness of LEDs

The LEDs was turn on, the cockroaches ten (10) was introduced into chamber to observe if they move away from or avoid the areas where the LEDs light (i.e. chamber A) or to where the LED light is not (i.e. chamber B). This was recorded as repulsive. When the insect pest moves towards the light source and there is increased activity, it was recorded as attractive (Park and Lee 2017; Yadav *et al.,* 2024).

Data Collection

Data collected includes, insect phototactic responses to blue, green and red LEDs light and repulsion rate at different wavelength.

RESULTS

Table 1. Response of Cockroach (*Periplaneta americana* L.) to Red, Blue and White Light

LEDs Light	Total no. cockroach	No. of Cockroaches in Dark Side		
		10min	20 min	30 min
Red	10	7	8	8
Blue	10	8	10	10
White	10	8	10	10

Table 2. Repulsion Rate of Red, Blue and White Led Light

LEDs Light	Repulsion Rate (%)		
	10min	20min	30min
Red	70	80	90
Blue	80	100	100
White	80	100	100

Response of Cockroach (*Periplaneta americana* L.) to Red Light

Table 1 shows that after 10mins 7, 8, and 8 cockroaches were repulsive to red, blue and white respectively with 8, 10 and 10 cockroaches were also repulsive to red, blue and white respectively at 20mins and after 30mins.

Repulsion Rate of Cockroach (*Periplaneta americana* L.) to Red, Blue and White Led Light

Result of repulsive rate as presented in the table 2 above shows that, after 10min, 70% of the cockroach where repulsive to red led light, 80% where repulsive to both blue and white light. At 20mins, red light shows about 80% of the cockroaches were repulsive with 100% repulsion to both blue and white LED light. Also 100% repulsion was recorded for both blue and white light with red LED light having **90**% repulsion rate.

DISCUSSIONS

In this research, red light showed to have the lowest repulsion rate when compared to blue and white LEDs lights with the cockroaches been more attractive to the dark sides (chamber B). This research is in line with the study of *Okada et al.,* (1998) which showed that *P. americana* where more oriented towards the dark chamber with average number of adult insects under dim light was statistically less than the number of adults in the chamber illuminated by red LED light. Overall, red light is more attractive than dim light and less attractive than darkness. In contrast to this study, Dean (2017) found that red light repels a greater number of Dublin cockroaches than yellow, blue, white, green, black and no light control (dark). Also, in contrast to this study, Dean (2017) reported that blue light was the most attractive to Dublin cockroaches. Yellow and green light showed the least attraction after blue. Dean (2017) studies, in different insect groups, green LEDs were attractive for adults of *Plutella xylostella* (Linnaeus, 1758) (Lepidoptera: Plutellidae) and *Frankliniella occidentalis* (Pergande, 1895) (Thysanoptera: Thripidae) (Park *et al*., 2014; Yang *et al*., 2015).

Furthermore, blue and white LEDs light shows to have a similar result with 80%, 100% and 100% repulsion rate after ten, twenty and thirty minutes respectively. This research agreed with the research of (Burhan *et al*., 2020) where they determined that blue light may have a repellent effect on cockroaches, and red light may be more attractive than other wavelengths. In the experiment where blue light of 2500 lux intensity was applied, the cockroach orientation was the lowest at 0.9% and 1.8%, respectively. In general, the highest orientation was against the dark (control) chamber in all trials. In addition, under all lux values, the orientation to red light was higher than with green, yellow, blue and white light (Burhan *et al*., 2020).

This research is agreement with the study of (Yadav *et al*., 2024). Cockroaches were photonegative since it was observed that they moved away from the light source. Cockroaches are more prevalent in that specific compartment were photonegative. Cockroach populations in

a given chamber are lower and they are photopositive. The fact that the cockroaches are avoiding the light suggests that their behavioural is photonegative.

Various results have been obtained in studies with other insect species on this subject. In addition, Shibuya *et al*. (2018) reported that blue light has lethal effects on different stages of vinegar fly, (*D. melanogaster*). Also, Hori *et al*. (2014) examined the lethal effects of visible light with short wavelength on insects. They found that short wavelength visible (blue) light had lethal effects on the vinegar fly eggs, larvae, pupae and adults. In the same study, they found that blue light had a lethal effect for mosquitoes and flour beetles, but that the effective wavelength at which death occurs differed between insect species. Findings in the same study also shows that high toxic wavelengths of visible light are species-specific in insects and that shorter wavelengths are not always more lethal. For some organisms, such as insects, blue light appears to be more harmful than UV light. Our study confirms the results of, Hori *et al*. (2014). Orientation of adult cockroaches tends to vary with light wavelength. In our study, especially blue light showed the least attraction. In this regard, light sources with storage insects were studied. Similar to our study, Kim *et al*. (2013) found repellent effect of the blue light to *Lasioderma serricorne* (F.). In contrast to our study, Jeon & Lee (2016) reported that blue light is the most attractive to *Sitotroga cerealella* (Olivier). Also, in contrast to our study, Jeon *et al*. (2012) reported blue light attraction in *Sitophilus oryzae* (L.). Similar to our study, Wang *et al*. (2013), determined that red light was attractive to *O. sauteri* and the research found the blue and red light had a negative impact on the development of this predator species. Lee *et al*. (2015) also found the repellent effect of the blue light on *Tyrophagus putrescentiae* (Schrank.).

CONCLUSIONS

Cockroaches are photonegative since it was observed that they moved away from the light source. Cockroaches are more prevalent in that specific compartment and are photonegative. Cockroach populations in a given chamber were lower and they were photopositive. Fact that the cockroaches are avoiding the light suggests that their behaviors is photonegative. This study demonstrates that certain LED wavelengths and intensities can effectively repel or attract cockroaches. LEDs offer a promising alternative to traditional pest control methods, with potential benefits including reduced chemical use and increased efficacy. Findings of this study will contribute to the development of innovative, LED-based pest control solutions. Further research is needed to fully understand the mechanisms underlying cockroach behavioural responses to LEDs.

RECOMMENDATIONS

Further research should be carried out to identify the optimal LED wavelength and intensity for cockroach repellency. Explorations on the potential use of LEDs as a non-toxic, environmentally friendly alternative to traditional pest control methods should be investigated. Investigate the impact of LEDs on cockroach behaviour in combination with other control methods (e.g., traps, insecticides). Research should be conducted on field trials to assess the efficacy of LEDs in reducing cockroach populations in various settings (e.g., homes, restaurants, hospitals). Development of LED-based traps or repellent devices should be considered for practical applications. Investigation on the potential use of LEDs in integrated pest management (IPM) strategies on other pests should be carried out.

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APPENDIX

Plate 1: Phototactic Test Chamber

Plate 2: Phototactic Test Chamber showing blue LEDs light.

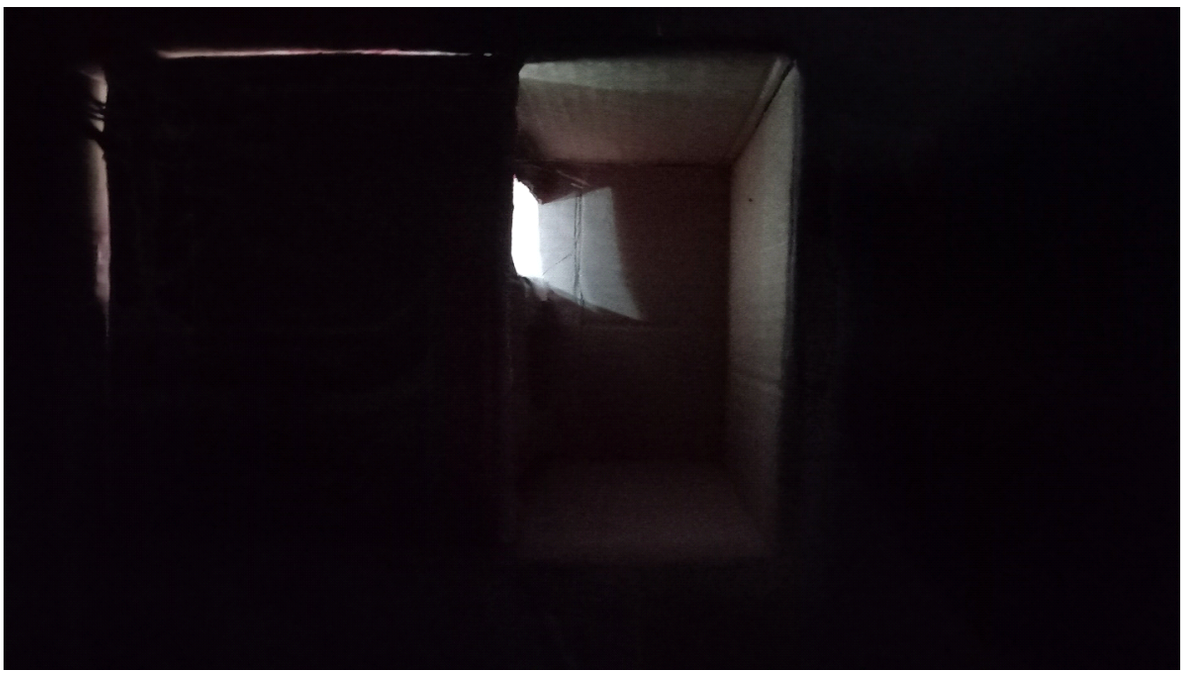

Plate 3: Phototactic Test Chamber showing White LEDs light.

Plate 4: Phototactic Test Chamber showing red LEDs light.