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Research Article

Identification of Intestinal Helminths in Cockroaches found in Selected Public Market of Davao City

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ABSTRACT

Cockroaches are resilient insects that thrive in various environments, including public markets. These creatures can act as mechanical vectors for intestinal helminths, posing a risk to human health. This study aimed to identify and measure the infestation rate of intestinal helminths in cockroaches from Bankerohan Public Market and Agdao Public Market in Davao City. Cockroaches were collected using specialized traps via the "catch-and-release" method, and the presence of intestinal parasites on their external surfaces was determined. The study found that cockroaches from both markets harbored Hookworm and *Ascaris lumbricoides*, with *Ascaris lumbricoides* having the highest frequency and infestation rate among the entire population of cockroaches gathered from both markets. The infestation rate of *Ascaris lumbricoides* was higher in the Bankerohan public market compared to the Agdao public market; however, the findings reveal that there is no correlation between the frequency of the parasites and the public market studied, indicating that the occurrence of the parasites cannot be attributed to the location of the public markets. The study highlights the need for improved sanitation practices and awareness to control parasite transmission through cockroaches, which can serve as vectors for these pathogens.

Keywords: *Ascaris lumbricoides, Cockroaches, Davao City, External surface, Hookworm, Parasites, Public Market*

Introduction

Cockroaches, with their exceptional resilience and tenacity, are masters of survival in the face of adversity. They are insects that have flat body structures with limited flying abilities but are highly agile on their legs. These creatures are primarily active at night and possess an omnivorous diet, feeding on various sources such as garbage, decaying food, and even fecal matter (Mohammed, 2022). They are common insects seen in many places in households and other public areas, and it has been noted that their prevalence is high amongst places where the exchange of wet and dry goods happens due

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to the availability of homes to breed in and sources of food (Nasirian, 2019). In metropolitan settings, cockroaches are a significant public health pest and can inflict serious adverse effects on human health (Adenusi et al., 2018). They possess the potential to serve as mechanical vectors for a range of intestinal helminths such as Hookworm, *Ascaris lumbricoides*, *Strongyloides stercoralis*, *Trichuris trichiura*, as well as *Moniliformes dubius* (Amawulu et al, 2019).

Public markets provide an optimal environment, such as abundance of warmth and humidity that are essential for the survival of cockroaches (Vizon et al., 2019). These environmental conditions provide a conducive habitat for cockroaches to thrive and expose them to various pathogenic microorganisms (Research Square, -). Fruits and vegetables sold in public markets have the potential to be contaminated with various microorganisms, and cockroaches can come into contact with these pathogens disseminating their spread from one product to another. Human infection can occur when individuals consume vegetables, fruits, or other plant-based food items contaminated with embryonated eggs of these pathogens[44].

Several observational studies conducted globally to explore the microbial carriage of cockroaches have identified various microorganisms, including bacteria, parasites, fungi, and viruses in cockroaches. A noteworthy revelation from these studies is that around a quarter of the microorganisms reported are foodborne pathogens. Among the foodborne bacterial pathogens isolated from cockroaches are Shigella spp., Salmonella spp., *Escherichia coli* O157:H7, *Staphylococcus aureus*, and *Bacillus cereus* (WHO, 2023). Different countries have also reported a considerable frequency of human diseases transmitted by cockroaches. A compelling study conducted in Lokoja State, Nigeria, provided substantial evidence implicating cockroaches as vectors for the transmission of parasitic worms, cysts, and ova. The study found that species of cockroaches with large areas of the body, such as *Periplaneta americana*, have more opportunities to contaminate themselves with parasitic organisms. Particularly, Strongyloides spp. and Ascaris spp., known to cause strongyloidiasis and ascaris in humans, were found to be the most prevalent helminth parasites recovered from the bodies of captured cockroaches (Amawulu et al., 2019). In the Philippines, a study conducted in three randomly selected areas of Metro Manila, namely Manila, Pasay, and Quezon City provided valuable insight on the prevalence of parasites on cockroaches in urban settings. Ascaris spp., Hookworm, *Enterobius vermicularis*, and *Trichuris trichiura* are found to be abundant on the external surface of cockroaches obtained in different areas of Metro Manila (Sia et al., 2016).

The inadequate communication efforts regarding the dangers associated with cockroaches left the public uninformed about the potential health implications they present. Consequently, this knowledge gap exacerbates the likelihood of disease-causing microorganisms being transmitted to humans. Moreover, public markets, being a primary location that offers the consumers a diverse range of food options, also served as an ideal habitat for cockroaches to thrive. The presence of cockroaches in such environments also increases the risk of people contracting foodborne pathogens carried by these pests.

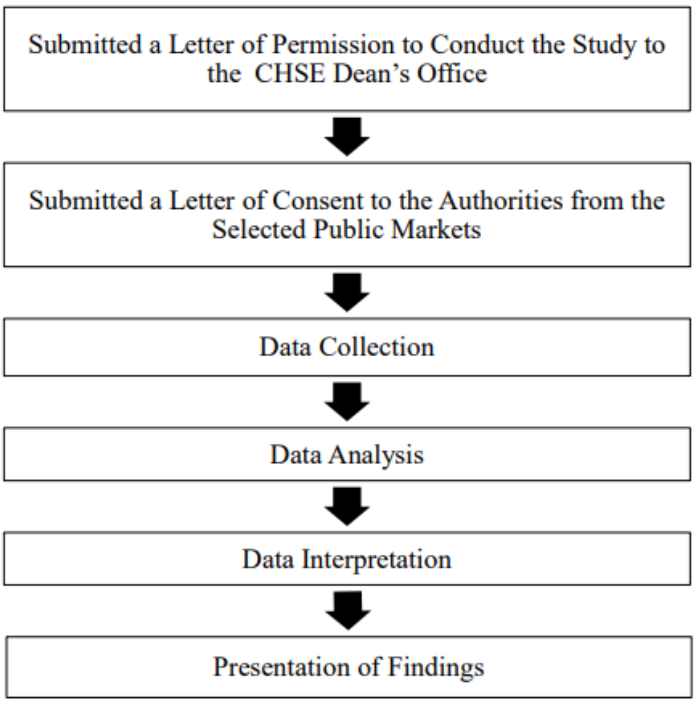
In line with the problem, this study aims to identify and measure the infestation rate of intestinal helminths amongst the caught cockroaches in Bankerohan Public Market and Agdao Public Market, Davao City. It specifically aims to answer the following:

1. What are the intestinal parasites found on the external surfaces of cockroaches?
2. What is the frequency of all the identified intestinal parasites in cockroaches?
3. What is the infestation rate of each identified intestinal parasite in the cockroaches?
4. Is there a significant association between the infestation rate of intestinal parasites among the selected public markets in Davao?

This study will focus on collecting cockroaches to determine the intestinal parasite's presence and the intestinal parasite's infestation rate in the cockroaches. To ascertain the potential of the cockroaches as mechanical vectors of these parasites, the researchers have collected the cockroaches from two public markets: the Bankerohan Public Market and Agdao

Public Market. Consistent with the research protocol described by Etim, S.E et al. (2013), 35 cockroaches were collected from each market, resulting in a total sample of 70 cockroaches from the specified markets. Notably, the investigation will not extend to other markets beyond the scope of this study.

Methods



General workflow of the study

Research Design

This study employed a quantitative descriptive study design to describe a population or phenomenon accurately and systematically. The researchers followed a systematic process throughout the research period to maintain the integrity of the study. Understanding that the goal of the study is to identify the infestation rate of intestinal parasites in cockroaches from Agdao and Bankerohan Public Markets, it was necessary to employ this type of research design to provide and establish not just a description of the data findings but to provide an in-depth discussion about the acquired data, which allowed the researchers to provide deeper context from the surface variables gathered. Additionally, quantitative descriptive design allowed the researchers to establish, collect, interpret numerical values, and summarize findings in a systematical method (H et al., 2019). Moreover, convenience sampling is a form of non-probability sampling that involves selecting individuals or subjects for a study based on their convenient availability and willingness to participate without following a specific sampling plan or probability-based selection method (AMA, 2021). Following the study conducted by Etim S. E et al., 2013, a total of thirty-five (35) cockroaches were caught from each selected public market using specialized traps that were placed randomly within the market premises overnight. Live and whole cockroaches that were conveniently available from the specialized traps were selected and used in the study.

Research Locale

The researchers procured the cockroaches used for this study from two public markets in Davao City, Philippines. Davao City, encompassing a vast land area of 2,444 sq. km, is the largest city in the Philippines in terms of land area. It attained widespread recognition as the biggest and most highly urbanized city outside

the National Capital Region. The study encompassed the collection of cockroaches from Bankerohan and Agdao Public Market, recognized as among the largest in the city.

Bankerohan Public Market, situated in Barangay 5-A Davao City, is a large public market where vendors and dealers actively offer various products, including fresh produce, meat, fish, fruits, spices, and other essential commodities. Given its extensive size and bustling environment, Bankerohan public market was an ideal setting for investigating the dynamics of cockroach infestations and the potential transmission of intestinal helminths through cockroaches acting as vectors.

Agdao Public Market, located at Barangay Agdao, is a farmer's market where vendors offer a myriad of goods, from meat, fish, rice, and vegetables to a variety of food like kakanin. Partial closure of the market has been implemented to address sanitation concerns and construction-related problems that have prompted the need for reconstruction. The sanitation problem was evident in the market, which made it an enticing research setting. During the process of sample collection, the presence of cockroaches was conspicuously observed within the market premises. The empty stalls served as pathways where these pests could crawl freely, while others found breeding grounds behind unoccupied tables, especially in dark and secluded spaces.

Cockroaches are resilient creatures that can thrive and adapt to various habitats, particularly in warm, dimly lit, and humid environments with abundant organic sources. Bothpublic markets are ideal locales for the study because of poor sanitation and the significant exchangeof wet and dry goods, which offers an excellent breeding place for cockroaches.

Data Collection

Following the study conducted by Etim S. E et al., 2013, the researchers have utilized the following procedures indicated below to obtain the necessary data for the research:

The researchers began their study by collecting a total of 70 cockroaches, with 35 specimens obtained from each of the selected public markets. Protective equipment was worn during this process to avoid possible infections. In pursuit of identifying parasites present on the external surface of the cockroaches, the live cockroaches were trapped using specialized cockroach traps. Concerning the nocturnal characteristics of cockroaches, the traps were placed every evening in spots like wet goods stalls and food-handling establishments where the insects thrived. To ensure the cockroaches were alive upon collection, the researchers used a catch-and-release method. Each captured cockroach was placed into a sterile container individually to prevent any potential cross-contamination. The researchers utilized forceps to gently transfer the cockroaches into the container and prevent any damage to the insects. Deceased cockroaches and specimens with incomplete body parts were excluded from laboratory analysis.

Upon arrival at the laboratory, the cockroaches were euthanized via freezing below 4 degrees Celsius for 15 minutes. After euthanization, 5 mL of normal saline solution (NSS) was added to the universal container housing the cockroaches. The researchers shook the container vigorously to dislodge parasites from the cockroaches' external surface. They then subjected 5 mL of the washing fluid to centrifugation to separate its contents effectively. After the centrifugation process, the transparent liquid portion was gently decanted, leaving behind the sediment at the bottom of the test tube. The sediment was stained using a 1% Lugol's iodine solution and placed on a slide for examination. To detect intestinal parasites, Olympus cx23 compound microscope with a high power objective (HPO) was utilized. Taxonomical keys were used to detect and analyze intestinal parasites, and the researchers counted the detected parasites to determine their frequency.

Once the analysis was completed, the cockroaches used in the study were disposed of following guidelines set by Vanderbilt University (V.U.) and its Medical Center (VUMC). To prevent contact with other insects, the cockroaches were safely contained and sealed back in their original container before being disposed before being disposed of in the same way as solid, non-sharp biohazardous garbage.

Statistical Tools

The researchers used statistical tools to acknowledge and understand the purpose of the study. Frequency distribution tools, cross-tabulations, and measures of associations are all used in the study.

Frequency distribution tools such as the frequency table are used in understanding the prevalence of parasites in each identified market. With the assistance of the frequency distribution tool, the researchers were able to gain greater insight in terms of prevalence as well as infestation rate of the parasites identified from the Agdao and Bankerohan Public Market. Cross tabulations and measures of associations, such as the chi-square test, also partake a significant role in this study in examining the relationship between the two categorical variables (H et al, 2019).

Result and Discussion

Table 1. Intestinal Parasites found on the external surfaces of cockroaches

Agdao Public Market	
Sample No.	Parasite Seen
6	Hookworm
12	Hookworm
19	*Ascaris lumbricoides*
22	*Ascaris lumbricoides*
31	Hookworm
35	*Ascaris lumbricoides*
Bankerohan Public Market	
Sample No.	Parasite Seen
1	*Ascaris lumbricoides*
2	*Ascaris lumbricoides*
5	*Ascaris lumbricoides*
11	*Ascaris lumbricoides*
14	*Ascaris lumbricoides* Hookworm
17	Hookworm
19	Hookworm
22	*Ascaris lumbricoides*
23	Hookworm *Ascaris lumbricoides*
29	*Ascaris lumbricoides*
31	*Ascaris lumbricoides*

Based on Table 1, out of the 35 samples collected from Agdao public market, six cockroaches tested positive for harboring intestinal parasites. In contrast, out of 35 cockroaches caught from Bankerohan public market, 11 were positive for harboring intestinal parasites. The researchers have discovered the presence of Hookworm and *Ascaris lumbricoides* on the external surfaces of the cockroaches isolated in both public markets. These findings are in congruence with the study conducted by Belema et al. in Port Harcourt, Rivers State-Nigeria, in which *Ascaris lumbricoides* and Hookworms, which are known to cause Ascariasis and Hookworm infections, respectively, were the most abundant

species recovered from the external body surface of 52 cockroaches (Jourdan et al., 2018). The study by Ngwamah et al. in Kogi State, Nigeria, also reported similar results in which *Ascaris lumbricoides* are one of the most prevalent parasites encountered on the body surface of adult cockroaches (Amawulu et al., 2019). The study findings revealed a close linkage between the intensity of parasite infestation and the level of hygiene and sanitation within the habitat of the cockroaches (Vizon et al., 2019). In the public markets where the researchers procured the cockroaches, inadequate sanitation practices and the absence of effective waste disposal methods actively contribute to the thriving population of cockroaches. This condition creates a favorable environment where they can directly feed on the abundant waste and rotten food within the market premises. Also, certain cockroaches harbor more than one parasite species, attributed to their large body surface area and heightened activity levels in search of food and suitable egg-laying sites (Amawulu et al., 2019).

Moreover, poor sanitation and inadequate waste management also create a conducive environment that favors the proliferation and survival of intestinal parasites. *Ascaris lumbricoides* and Hookworms are collectively known as soil-transmitted helminths, implying that they prefer soil with high organic matter content or contaminated with human feces. The movement and trade of animals, fruits, vegetables, and other products within the market premises allow the introduction and dissemination of these parasites. In a study conducted by Amawulu et al. in Yenagoa Metropolis, Nigeria, the researchers found that helminth eggs contaminate the fruits purchased in public markets, with *Ascaris lumbricoides* being one of the intestinal parasite species recovered on fruits (Kobayashi et al., 2020). This aligns with the study conducted by Vizon et al. in 2019, which revealed that *Ascaris lumbricoides* and Hookworm contaminate green-leafy vegetables such as cabbage, lettuce, and Chinese cabbage sold in public markets in Nueva Ecija, Philippines. Contaminated soil and water present during cultivation, transportation, and handling by vendors are among the possible sources of this parasites (Belema et al., 2020). Indiscriminately deposited on these products, the intestinal parasites can come into contact with cockroaches, which can then serve as hosts or vectors, facilitating the spread of these parasites. Furthermore, Ascaris and Trichuris are the most common coexisting geohelminths; however, Trichuris was not recovered from the external body surfaces of the cockroaches. This could be a result of environmental conditions that were less favorable for the development of eggs of Trichuris. To successfully develop into infectious larvae, the eggs must remain for around three weeks in the soil at optimal circumstances, such as shady, warm, and wet soil. Eggs do not thrive in direct sunlight and require proper temperature within 9-52 degrees Celsius for appropriate development (Research Methodology, -). Considering these factors, the absence of ideal soil conditions, exposure to sunlight, and potential temperature fluctuations in public markets make it an unfavorable habitat for Trichuris to flourish.

Table 2. Frequency of intestinal parasites in cockroaches

Agdao Public Market	
Parasite Seen	**Frequency**
Hookworm	3
Ascaris lumbricoides	3
	N= 6
Bankerohan Public Market	
Parasite Seen	**Frequency**
Ascaris lumbricoides	9
Hookworm	4
	N= 13

N= Total Number of Infected Cockroaches

Table 2 reflects the frequency of all the identified intestinal parasites in cockroaches, which suggests that the cockroach population at the Bankerohan public market has a greater total frequency of intestinal parasite infestation. Notably, *Ascaris lumbricoides* has the highest frequency of 9 in the Bankerohan public market and 3 in the Agdao public market. The abundance of *Ascaris lumbricoides* can be associated with their ability to withstand and survive adverse environmental conditions. They possess an innermost shell layer with a lipoprotein nature that facilitates this resilience and enables them to be airborne. Also, female Ascaris worms could lay about 200,00 eggs in a day (Jourdan et al., 2018). Furthermore, in a book by Selendy in 2019, hookworms are found to tolerate greater temperatures but cannot survive desiccation. Their transmission requires a minimum amount of rainfall, and in some endemic areas, it follows a seasonal pattern, explaining why they are lesser in numbers than *Ascaris lumbricoides* (Ngwamah, 2021). Also, although hookworms are sensitive to freezing temperatures, fully developed eggs, and newly hatched larvae can survive for a few days if kept below 6° to 8° C (Nweze et al., 2019). Considering this trait, the researchers only exposed the cockroaches to freezing conditions for 15 minutes, therefore, the killing method of the cockroaches did not influence the frequency of the hookworms.

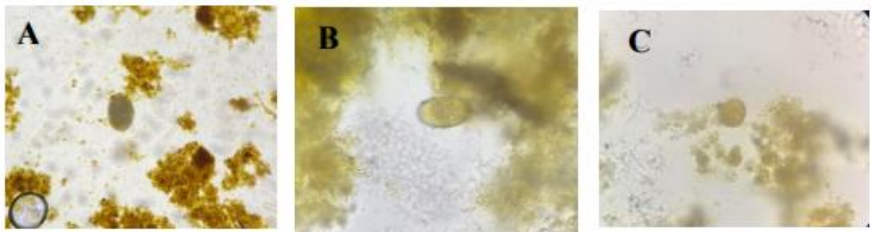


Figure 1. Ova seen on External Surfaces of Cockroaches in Lugol's Iodine: A. Hookworm B. Hookworm C. Ascaris lumbcricoides

Figure 2. Helminth Larvae seen on External Surfaces of Cockroaches in Lugol's Iodine

Table 3. Infestation rate of Intestinal Parasites Found on the External Surface of Cockroaches in Agdao and Bankerohan Public Market

AGDAO (N = 35)		
Parasite	**F**	**%**
Ascaris lumbricoides	3	8.57
Hookworm	3	8.57
BANKEROHAN (N=35)		
Parasite	**F**	**%**
Ascaris lumbricoides	9	25.71
Hookworm	4	11.42
TOTAL (N= 70)		
Ascaris lumbricoides	12	17.14
Hookworm	7	10.00

N = total number of cockroaches; f = number of positive cockroaches; % = infestation percentage

In table 3, the parasite infestation rate was calculated using: F/N x 100 to acquire the percentage. Regarding parasite infestation percentage, *Ascaris lumbricoides* shows the highest infestation rate amongst the total number of cockroaches collected, with up to 17% infestation rate. Hookworm then follows it with 10%

Similarly, various studies provide the same results of parasite infestation rate in cockroaches. Kinfu and Erko's study in 2008 about cockroaches acquired from two localities in Ethiopia being the carrier of parasites also provides identical results, with *Ascaris lumbricoides* and Hookworm being the most prevalent parasites that use cockroaches as vectors for transmission. Furthermore, Dokmaikaw A. and Suntarayitun P. (2020) reported similar findings of *Ascaris lumbricoides* and Hookworm in cockroaches acquired from fresh markets in Chachoengsao Province, Thailand.

Understanding human parasite infection can be hard to cure, even with repeated chemotherapy and drug usage (Mohammed, 2022). However, parasite prevalence can be controlled with appropriate sanitation and food handling that could be a source of infestation for cockroaches, which are considered vectors of the parasites.

The two isolated parasites can be classified under the group of soil-transmitted helminths (STH) (Fenta et al., 2020). STHs are the causative agents for parasite infections in more than a quarter of the world's population, with *Ascaris lumbricoides* accounting for the highest number of cases. STHs are identified as the cause of soil-transmitted helminthiasis, a group of diseases prevalent in human infections. According to the World Health Organization (WHO) studies, a recent update on the decline of STH infections has been reported globally. Despite the decline, the continuous threat of transmission is still subject to awareness.

Cockroaches have been known to carry internal and external parasites in a global disposition (Kinfu & Erko, 2008). These parasites are transmitted externally through the cockroaches' external skeleton and its other parts, such as the legs, body, and antennae. Despite the update on the decline in the cases of STH human infections globally, it is still endemic in poor areas with poor sanitation. Humans cannot discern these parasites with the naked eye; therefore, awareness is necessary, especially in places like Davao City, which are thriving regions not just for the human population but also for cockroach infestation.

Table 4. Association Between the Infestation Rate of Intestinal Parasites in Agdao and Bankerohan Public Market

4-A. Infesttaion Rate of *Ascaris lumbricoides*

Public Market	**Prevalence of *Ascaris lumbricoides***		
	Negative	Positive	Total
Agdao	32	3	35
Bangkerohan	26	9	35
Total	58	12	70
Chi-Square Value: 3.621		p-value: 0.057	

$p < 0.05$*

4-B. Infestation Rate of Hookworm

Public Market	**Prevalence of Hookworm**		
	Negative	Positive	Total
Agdao	31	3	35
Bangkerohan	32	4	35
Total	63	7	70
Chi-Square Value: 0.159		Significance: 0.690	

$p < 0.05$*

Table 4-A shows the association between the infestation rate of *Ascaris lumbricoides* and the two public marketplaces, Agdao and Bangkerohan. Since the chi-square value is 3.621 and the p-value is 0.057, there is no significant association between the prevalence of *Ascaris lumbricoides* and the two public markets. The location of the public market has no bearing on how common the aforementioned parasite is. It can be inferred that the variables are unrelated and that there is little statistical difference between parasite prevalence and the public market.

Table 4-B, on the other hand, also shows the association between the second identified parasite, Hookworm, and the two markets highlighted in the study. The results show that the chi-square value is 0.159 and the p-value is 0.690; therefore, the researchers have concluded that there is no significant association between the infestation rate of Hookworms from Agdao and Bankerohan Public Market.

Based on the statistical data analyzed and quantified in Table 4, it is notable that intervention programs to counter the growth of the parasite population and the increase of infection do not necessarily need to focus on one of the public markets. Considering that none of the highlighted research locales have a significant difference in parasite infestation, it is recommended that the local government must focus on parasite control and eradication simultaneously. The two identified parasites do not present a significant difference between the infestation rate to the public markets highlighted, so it is safe to conclude that there is also no direct association between how prevalent parasite infections are found. The location of the public markets also does not play a significant role in the prevalence of the parasites. Furthermore, the researchers have concluded that the variables and data acquired from each public market are independent, and the statistical relationship between the prevalence of the parasites between the two public markets is negligible. Understanding the crucial data set gathered from the experiment, the researchers also identified that using the public markets as a measure of parameters in analyzing the prevalence of parasites is ineffective, considering the low and insignificant difference between the infestation rate of the two parasites.

Similarly, in a study conducted by Susan Tanner in 2014, along with her study team in Bolivia, where they explored the relation between parasitic infections, child nutrition status, and markets, it was discovered that individuals who are staying in distant places from the urban communities are more likely to acquire soil-transmitted helminthiasis while those who live in the urban community and near the markets themselves are at lower risk for infection. This relates to the researchers' study in that the results also revealed no significant association between the infestation rate of *Ascaris lumbricoides* and Hookworm to the public markets included in the study.

Conclusion

The findings of the study conclude that cockroaches can act as hosts and vectors of intestinal helminths, including *Ascaris lumbricoides* and hookworm, which are found to be present on their external surfaces. Based on the result of the frequency, cockroach infestation is more common among the cockroach population at Bankerohan public market. Also, applying statistical tools, such as chi-square and p-value, reveals no significant correlation between the frequency of parasites and the public market studied, which suggests that the market location does not influence the occurrence of parasites. Despite the report on the global decline of STH infections, areas with poor sanitation and hygiene remain vulnerable to contracting parasitic infections and this underscores the need for education and preventive measures, particularly in public markets that are not only inhabited by people but also susceptible to cockroach infestation.

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