



Factors That Trigger Cockroach Density: A Literature Review

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ABSTRACT

Cockroaches are mechanical vectors classified as domestic or peridomestic. In addition to being nuisance pests, there are important medical implications associated with cockroach infestations. For example, cockroaches can transport human pathogenic microorganisms on their bodies and physically or mechanically transfer them to food and food handling surfaces. This study aims to collect the results of previous studies related to the influence of the environment on cockroach infestation density and look at factors that affect cockroach density and population, distribution, infestation levels, and the influence of several parameters that trigger cockroach population dynamics density. This study uses the Literature review method, to summarize the results of previous studies to see the factors that trigger cockroach density. From the results of several studies, it is known that the triggering factors are poor sanitation and pest control practices, old and unmaintained building conditions, poorly managed food availability, socioeconomic status, food handler behavior, incorrect insecticide use and physical environmental conditions including temperature, humidity and lighting.



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Kata kunci:

Faktor Pemicu
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ABSTRAK

Kecoa merupakan vektor mekanik yang diklasifikasikan sebagai domestik atau peridomestik. Selain menjadi hama pengganggu, ada implikasi medis penting terkait infestasi kecoa. Misalnya, kecoa dapat mengangkut mikroorganisme patogen manusia pada tubuhnya dan secara fisik atau mekanis memindahkannya ke makanan dan permukaan penanganan makanan. Penelitian ini bertujuan mengumpulkan hasil-hasil penelitian sebelumnya yang berkaitan dengan pengaruh lingkungan terhadap infestasi kepadatan kecoa serta melihat faktor yang mempengaruhi kepadatan dan populasi kecoa, distribusi, tingkat infestasi, dan pengaruh beberapa parameter pemicu densitas dinamika populasi kecoa. Penelitian ini menggunakan metode Literature review, untuk merangkum hasil-hasil penelitian sebelumnya untuk melihat faktor pemicu densitas kepadatan kecoa. Dari hasil beberapa penelitian diketahui bahwa faktor pemicu adalah faktor praktik sanitasi dan pengendalian hama yang buruk, kondisi bangunan tua dan tidak terawat, ketersediaan pangan yang tidak dikelola dengan baik, status sosial ekonomi, perilaku penjamah makanan, penggunaan insektisida yang salah serta kondisi lingkungan fisik baik itu suhu, kelembaban dan pencahayaan.



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INTRODUCTION

Cockroaches are one of the insects with the longest history in the world, distinguished by very high endurance and adaptability. Some species have a synanthropic way of life and a very wide, ubiquitous distribution, in close biological association with humans, animals and foodstuffs (Valeva et al., 2022).

Cockroaches are distributed worldwide and are one of the most common pests on ships, airplanes and trucks especially in food storage areas. Some cockroach species commonly found in the human environment include *Periplaneta australasiae*, *Blattella germanica*, *Periplaneta brunnea*, *Neostylophaga rhombifolia*, *Supella longipalpa*, *Blatta orientalis*, *Periplaneta americana* (Muhadir, 2014).

Cockroaches are insects that live in homes, restaurants, hotels, hospitals, conveyances, warehouses, offices, libraries, and others. This insect is very close to humans, likes buildings that are warm, humid and have lots of food, lives in groups, can fly actively at night such as in kitchens, food storage, garbage, dirty water channels. Generally avoiding light, during the day hide in dark places and often hide in cracks. These insects are said to be a nuisance because they usually live in dirty places with poor sanitation and under certain circumstances emit a liquid that smells bad. The factors that play the most role in cockroach survival are food, water availability and shelter. Cockroaches are most fond of foods that contain carbohydrates and protein. In addition, cockroaches are also attracted to strong odors (Depkes, 2002).

Their filthy breeding habits, feeding mechanisms, and indiscriminate passage between feces and food make them serious vectors of human enteric parasites they multiply and spread very quickly. This is because they secrete pheromones in their droppings that attract other cockroaches with the resultant buildup in unsanitary conditions, which cockroaches prefer are places where there is a lot of organic matter such as food, paper, textiles, wool and fatty materials. Cockroaches need nutrients to survive and reproduce such as carbohydrates, proteins and fats (Cahyani et al., 2018). Based on their habitat, cockroach pests can be classified as domestic or peridomestic. While domestic cockroach infestations are mainly found in indoor environments, peridomestic species live around man-made structures and enter indoors in search of nutrient sources and shelter. In addition to being a nuisance pest, there are important medical implications associated with cockroach infestations. For example, cockroaches can transport human pathogenic microorganisms on their bodies and physically or mechanically transfer them to food and food handling surfaces (Valeva et al., 2022).

As hardy insects most cockroach species can survive for long periods without food and water. For example, *Periplaneta americana* can survive for approximately 1 month without food or water (Willis & Lewis, 1957). Cockroaches, like other insects, can become cannibals when nutrients are scarce, but cannibalism is not observed exclusively during starvation: some female cockroaches eat males after copulation in a similar way to grasshoppers (Richardson et al., 2010) Cockroaches can also reproduce by parthenogenesis, although fewer eggs are produced compared to sexual reproduction (Wharton, 1957).

The rapid spread of cockroach populations in the human environment has resulted in many health and economic problems. Cockroaches, as is well known, can be important mechanical spreaders of a wide spectrum of infections across geographical boundaries (Saipollizan et al., 2021). Cockroaches as mechanical vectors can spread disease by

contaminating human food with many important pathogenic microorganisms such as: bacteria, viruses, protozoa and fungi. German and American cockroaches are pests that threaten human health due to their filthy habits, foul odor, and body composition properties. Also, they secrete an oily liquid that has a pungent and sickening odor that can spoil food (Baz & Hegazy, 2021). Even in hospitals, in neonatal intensive care units, the presence of cockroaches can be a source of nosocomial infections in newborns, due to pathogenic bacteria found in the bodies and intestines of cockroaches (Dimitriadou et al., 2021). In the United States, asthma and allergies are common problems associated with cockroach infestations. Sensitization and exposure to cockroach allergens contribute to an increased incidence of asthma, especially among low-income groups. Early exposure to cockroach allergens can lead to the onset of asthma symptoms. Although a sustained reduction in cockroach allergen levels is difficult, it can be achieved with the use of professional insecticides, as well as thorough house cleaning (Arruda et al., 2001).

In Hospitals Factors such as temperature, humidity, food, and adequate shelter can create optimal conditions for cockroach growth. In urban areas, factors contributing to increased cockroach infestations in apartments include ineffective sanitation and pest control practices, lack of adequate maintenance of apartments, and the natural dispersal of cockroaches between dwelling units in multi-storey buildings (Dimitriadou et al., 2021).

Existing research states that there is a very strong relationship between kitchen sanitation and cockroach density, as well as food raft room and warehouse sanitation with cockroach density on ships in the Kendari Port area (Firmansyah, 2017). Furthermore, based on the results of other studies, there is evidence that environmental temperature and humidity are associated with density (Baz & Hegazy, 2019). Based on this description, this study aims to gather the results of previous research to answer a series of research questions that include: "how does the environment affect cockroach infestation density and what are the factors that trigger cockroach density?".

METHODS

This research uses the Literature review method, which is a series of processes to collect, review, and analyze written sources relevant to the research topic intended to understand previous research, identify knowledge gaps, and build a theoretical basis for further research. This method is used to answer the research questions, namely, how does the environment affect cockroach density infestation and what are the factors that trigger cockroach density? Data sources came from national and international journals. Journal searches used as review material were conducted using the keywords 'Environmental factors and cockroach density' and 'food sources and cockroach density' for Indonesian-language journals, while for English-language journals the keywords 'factors and cockroach density' were used. International journal searches were conducted through databases; PubMed 105 Articles, Scopus 95 Articles, Science Direct 87 Articles and ProQuest 68 Articles. National journal searches were conducted through Google Scholar 122 Articles, Garuda Indonesia Portal 61 Articles. The selection of articles is also based on the research design used, which is observational.

The sorting of articles begins with a glance at the title, then reviewing abstracts that are relevant to the research topic.

From a total of 538 articles, 6 suitable articles were obtained, the findings were selected using inclusion and exclusion

criteria. The inclusion and exclusion criteria are presented in table 1.

Table 1.
Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Research results in the form of primary research articles, where the author directly conducts research, published from 2017-2022	Research articles in the form of theses and theses not in the form of published articles
Articles are full-text articles that are free and accessible	Articles used are paid
Articles with observational research type	The research article uses a research design other than cross sectional quantitative
The article uses a cross-sectional type of quantitative research method that examines the relationship between the independent variable and the dependent variable	

Table 2.
Article findings

Title	First Author, Year & Location	Methods	Results
Overview of Factors Associated with Cockroach Density in Traditional Market Food and Food Stalls in Semarang (Cahyani et. al., 2018).	Cahyani LK, Semarang City Traditional Market	Descriptive Observational Research Type with cross sectional design	- The highest percentage of cockroach density status was classified as ready-to-eat food (26.9%). - The temperature and humidity of the air where food and food ingredients are sold in Semarang City's traditional markets ranged from 30.28-32.410C and 54.65%- 64.33%, respectively.
Reduction of Cockroach Density and Spread in Benha University Hospital (Egypt) in 2019 Compared to 2014 (Baz & Hegazy, 2021).	Baz M M, (2021), Benha University Hospital (Egypt)	Analytic Observational Research Type with cross sectional design	- Residential areas and hospitals were heavily infested by <i>Blattella germanica</i> , followed by <i>P. americana</i> , which spread according to the availability of food sources and climatic conditions. - In the current study, temperature affected the number of cockroaches caught in the selected sites, while relative humidity was not significant.
Relationship between Sanitation Condition and Cockroach Density on Ships in Kendari Port Area (Supardin, 2021).	Supardin S, (2021), Kendari Port Area	Observational research with a Cross Sectional approach	- There is a very strong relationship between kitchen sanitation and cockroach density on ships in the Kendari Port area in 2020. - Temperature and humidity are factors that favor the presence of cockroaches, manipulating the temperature to cool below 200C in the location of the kitchen or food storage warehouse can reduce cockroach density, especially <i>Americana</i> species.
Relationship between Temperature, Humidity and Lighting on Cockroach Density on Passenger Boats at Semayang Port Balikpapan 2017 (Firmansyah, 2017).	Firmansyah M, (2017), Balikpapan Semayang Port in 2017	Analytical Observational Research with Cross Sectional approach	- The highest cockroach density was found in rooms with 75%-78% humidity. - From the measurement results, cockroaches were most often found in the passenger kitchen with a temperature range of 250C-300C.
A First Insight Into the Occurrence of Cockroaches in the Urban City of Thessaloniki (Greece)-Identifying Hot Spots (Dimitriadou et. al., 2021)	Ioanna Dimitriadou, (2021), City of Thessaloniki, Greece	Methods mapping spatial mapping method using QGIS Version 3.18.3	This preliminary mapping of data distribution clearly shows that areas with high density of evacuees are located near Hospital facilities. In addition, areas with high crowd density are found in highly congested and older parts of the city. In urban networks there are many parameters that contribute to the high proportion of apartments with cockroach infestation. Some apartments have poor sanitation and pest control practices poor sanitation and pest control practices, lack of proper apartment maintenance and the natural spread of robots between apartments in multi-unit dwellings.
Cockroach Infestation and Their Perceived Importance in Yenagoa Metropolis of Bayelsa State, Nigeria (Ukoroiye et. al., 2019)	Ukoroiye, Rosemary Boate, (2019), Yenagoa metropolis Bayelsa State Nigeria	Observational Research with Cross Sectional approach	On the frequency of cockroach infestation in their habitats, fifty-two (52) respondents reported 20.40% infestation in private homes, twenty (20) reported 7.80% infestation in schools, fifteen (15) reported 5.90% infestation in offices, thirty-one (31) reported 12.20% infestation in hospitals, forty-seven (47) reported 18.40% infestation in restrooms, forty (40) reported 15.70% infestation in trash bins and fifty (50) reported 19.60% infestation in restaurants.

Analysis of Environmental Sanitation and Food Handler Behavior on Cockroach Density in the Dumai Port Canteen (Tanjung Dwi Yanti et. al., 2020)	Dwi Yanti Tanjung, (2020), Dumai Port	Observational Research with Cross Sectional approach	Cockroach density in the Dumai Port Canteen is in the medium and high categories, measurements taken at the location of the toilet, kitchen and trash can. While behavior in the good category is still more dominant, amounting to 23 respondents out of 48 respondents who were interviewed.
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RESULTS AND DISCUSSION

The research locations of all the articles reviewed were in the countries of Greece, Egypt and Nigeria, while four studies were in Indonesia. The majority of the research locations of the articles reviewed were developing countries. The type of research in the articles reviewed was 1 spatial study and 6 observational studies with a cross sectional design (table 2).

Cockroaches are one of the insects with the longest history in the world, distinguished by very high endurance and adaptability. Some species have a synanthropic way of life and a very wide, ubiquitous distribution, in close biological association with humans, animals and foodstuffs. Due to their specific way of life and global distribution, cockroaches produce and spread chemicals, pathogenic microorganisms and parasites that pose serious risks to animal health, food safety and public health. Their year-round polyphagia and propensity for intensive migration increase the likelihood of cockroach contact with sources of various human and animal infections and invasions (Valeva et. al., 2022).

There are many reasons to eliminate indoor cockroach infestations, but chief among them is the central role cockroaches play as etiologic agents in allergic diseases and asthma. Cockroaches move freely between waste and food, they can acquire, carry and spread pathogenic bacteria, digestive system worms. Thus, the presence of cockroaches in the home poses a significant health risk to humans.

In a study conducted in Owo city Nigeria, a total of 105 cockroach samples were collected from toilets, shops and kitchens of different households in Owo, with 35 cockroaches per each group. Bacteria were successfully isolated from a total of 89(84.8%) cockroach samples collected, of which 32(91.4%) cockroaches from toilets, 29(82.9%) cockroaches from shops, 28(80%) cockroaches from kitchens. The main bacteria isolated on the outer surface of cockroaches included, *Kleb. pneumoniae*, *E. coli*, *Proteus vulgaris*, *Pseudomonas aeruginosa*, and *Kleb. oxytoca*. *E. coli* with the highest frequencies of 12 and 8 was most commonly isolated from the external surfaces of cockroaches collected in toilets and kitchens respectively and *Pseudomonas aeruginosa* with the highest frequency of 14 was most commonly isolated from the external surfaces of cockroaches collected in stores. *Proteus mirabilis*, *Staphylococcus epididymis*, *Haemophilus influenza*, *Citrobacter freundii*, *Shigella* spp. were less isolated from the external surfaces of cockroaches collected in the toilet. *Salmonella typhii*, *Strept. pneumoniae*, *Proteus mirabilis* were not isolated from cockroaches collected from stores, *Staphylococcus*, *Staphylococcus aureus*, *epididymis*, *Shigella* spp. were poorly isolated (Hassan O Abdulwasii, 2022).

Research conducted in the Greek city of Thessaloniki shows that areas with high cockroach density are near hospital facilities. This fact concerns a large area of the city center. Similar studies, have shown that cockroaches are often a common pest within hospital facilities. At Tikur Anbessa Hospital, Addis Ababa, a total of 400 cockroaches were collected from the neonatal intensive care unit. Findings showed that pathogenic bacteria isolated from the body and intestines of cockroaches were responsible for neonatal

nosocomials. Hospital internal conditions such as temperature, humidity, sufficient food and shelter seem to create an ideal environment for cockroach infestation. In addition, areas with high cockroach density are found in densely populated and old parts of the city. In urban networks there are many parameters that contribute to the high percentage of apartments with cockroach infestation. Some of these are poor sanitation and pest control practices, lack of proper apartment maintenance and the natural spread of cockroaches between apartments in multi-unit dwellings. In addition, socioeconomic status plays an important role in cockroach treatment. Peers living in urban environments and experiencing high levels of material hardship showed a positive correlation with increased exposure to cockroach allergens. Also, factors such as substandard housing and multi-unit buildings are thought to be the cause of cockroach infestation, while two large studies conducted in the United States confirmed that low family income and living in multi-family houses make up a high population density area with higher occupancy rates per room associated with increased cockroach allergens and lower dust mite allergen concentrations (Dimitriadou et. al., 2021).

Most studies show a positive correlation between qualitative (i.e., good, moderate and poor) or quantitative (i.e., based on numerical ratings) assessments of sanitation levels in human dwellings and the presence of cockroach infestations. In a survey conducted in the United States of seven buildings, apartments with poor sanitation ratings were almost three times more likely to have active German cockroach infestations. Therefore, the elimination of certain conducive conditions such as access to food and moisture sources and the availability of ideal hiding places, collectively referred to as 'sanitation', is an important component of an Integrated Pest Management program for German cockroaches (Gondhalekar et. al., 2021).

Another parameter related to cockroach infestation is the age of the building which was looked at in the study as one hundred and forty houses were ten years old and above while one hundred and fifteen houses were between one and ten years old. All houses surveyed in Yenagoa metropolis reported cockroach infestation, although the prevalence of cockroach infestation was higher in older houses compared to newer ones. Older houses reported a total of 71.40% while newer houses reported 53.90% cockroach infestation each. This supports the results of the study which stated that the age of the building is also strongly associated with cockroach infestation. They reported that buildings over ten years old tend to be infested more than new buildings, the reason being a lot of damages such as leaking roofs, broken walls, cracks, broken pipes (especially in toilet and kitchen areas) and also the nature of the building whether painted, unpainted or even unplastered. It was found that cockroach infestation was higher in dilapidated buildings that were ten years old and above (Ukoroiye et. al., 2019).

Thus, low-cost interventions that reduce cockroach burdens in high human population areas have great potential public health benefits. The results reported here support our hypothesis and confirm that well-designed anti-insect shields

can prevent cockroach access to pet food as a source of nutrition (Hayward et. al., 2021).

The key to controlling cockroaches is to remove their access to food. In this case, one very important food source for cockroaches in and around human dwellings is human or pet food, especially dog and cat food usually left in bowls on the ground outside or on the kitchen floor for pets where cockroaches can and easily access pet food (6) (Figure 4). Thus, pet food can spawn large colonies of cockroaches both inside and outside the home. The cockroaches contaminate pet food with their feces and secretions and thus transmit bacterial, parasitic, and viral diseases to pets and human pet owners. Due to excess food, cockroaches can multiply colonies and numbers of cockroaches, causing larger infestations locally and cockroach colonies can develop both inside and outside the home and then invade preventing the intrusion of insects, especially ants, into the food bowl. One solution for adjoining properties (Hayward et. al., 2021).

The behavior of food handlers has a relationship with the presence of cockroaches, as illustrated in the study conducted at the Dumai Port Canteen, out of 48 respondents there were 8 respondents (16.67%) behaving poorly, 17 respondents (35.42%) behaving quite well and 23 respondents (47.91%) behaving well. Based on observations in the field that most of the food handlers do not seem to care about the surrounding conditions, for respondents income is more important than cleanliness, when the cleanliness supervision officer comes, the respondent will clean the canteen area and return to the habit of not caring when the officer has left. This shows that there is still a lack of awareness of food handlers towards cockroach control and eradication. Research conducted by Pulungan (2012) The habit factor is a difficult thing to change the behavior of a food handler because it is used to things that act badly. behavior is expressed in the form of actions or actions and is a real form that is based on the knowledge and attitudes that have been possessed. It can be concluded that the behavior of food handlers is determined by the knowledge, attitudes, actions of food handlers. In addition, the availability of facilities, the canteen environment, and the behavior of food handlers towards the control and eradication of cockroach vectors will also support and strengthen the formation of behavior (Tanjung Dwi Yanti et. al., 2020).

Study to show the relationship between temperature, humidity and lighting factors on cockroach density on passenger ships. The results showed that temperature, humidity and lighting had a correlation with the density of movement on board. Temperature has a not very strong correlation, this is probably because the minimum room temperature on the ship reaches -30OC, and the maximum temperature is 30OC. While the optimal temperature for intruders to live is 25 - 30OC. So there are some places where intruders are not found. Humidity has a very strong correlation with vibration density. This is because the humidity found on the ship ranges from 50% - 78%, which is good humidity as a breeding ground for cockroaches. Feeling has a relationship that is not too strong. In the study, the most cockroaches were found in lighting below 100 lux. The average lighting on board the measured vessels ranged from 37 lux to 75 lux. So the presence of cockroaches was still found in measurements taken during the day (Firmansyah, 2017).

As this study observed *P. americana*, the most common cockroach in Esfahan sewers, *P. americana* is the most common insect pest in urban sewers²⁶ in tropical and subtropical regions. Large-scale *P. americana* cockroaches can invade human apartments through respiratory drain holes. Unlike *P. americana* as the most important sewer pest, it should be noted that the German cockroach (*Blattella*

germanica) is the species that most commonly attacks humans. An important factor reported to affect bait performance against the American cockroach is sanitation. Although sanitation has no direct relationship with the infestation level of domiciliary cockroaches, its role on bait performance against American cockroaches is unknown. A reasonable strategy is to use a combination of integrated pest control strategies with strong vector control management such as sanitation, spraying and baiting (Nasirian & Abedin, 2021).

Insecticide formulations are considered effective when more than 90% reduction in cockroach population density is achieved. There are many problems in cockroach control with the use of pesticides. Commonly used insecticides can cause cockroaches to become resistant. It takes between 4-12 months to complete the life cycle of the American cockroach. There are not as many generations of American cockroaches per year as other cockroach species, therefore the expression of resistant genes may take longer. Many pesticides are cockroach repellents. Chemical control only provides temporary control and should be accompanied by other control measures (Nasirian & Abedin, 2021).

It is also known that the efficacy and persistence of insecticides in sewers depends on several factors such as the amount of organic matter, climatic conditions, cockroach population, the presence of cockroach-resistant populations, and the type of active ingredient and its formulation. It seems that emerging resistance to insecticides is the factor that causes the most efficacy and persistence of insecticides. Although insecticide resistance in German cockroaches has been well studied and emerged to a variety of old and new insecticides including organophosphates, carbamates, pyrethroids, phenyl pyrazoles, spinosads, neonicotinoids and oxadiazines whereas in American cockroaches it is less studied. Recently, the cockroach *P. americana* has been found to be resistant to malathion (Nasirian & Abedin, 2021).

LIMITATION OF THE STUDY

In this literature review research, there are limitations in the number of articles reviewed, only 7 articles were the focus of our research. Despite the limited number, we still tried to present relevant and important information to help understand the topic we covered.

CONCLUSION AND RECOMMENDATION

Based on existing research, it can be seen that the triggers of cockroach density are influenced by several factors, namely poor sanitation and pest control practices, socioeconomic status, poorly maintained old buildings, poorly managed food availability, food handler behavior in restaurants and ships, incorrect use of insecticides and physical environmental conditions including temperature, humidity and lighting. It is necessary to conduct further research on the factors that influence the triggering of cockroach density

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Conflict of Interest statement

The authors declare that they have no involvement with any external parties and this paper is purely from the sources listed in the bibliography and does not contain plagiarism from any journal article. All sources of writing have been listed in the bibliography

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