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Unexpected Urban Inhabitant Shelfordella Lateralis in Sangihe Island

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A study conducted on Sangihe Island identified the presence of Shelfordella lateralis, an unexpected cockroach species in the region. DNA extraction, PCR amplification, and sequencing analysis of specimens revealed a 100% match to S. lateralis using BLAST, confirming its species identity. This discovery suggests potential changes in local biodiversity and urban ecological dynamics, as S. lateralis may compete with native species for resources. Understanding the adaptability of S. lateralis in urban settings is crucial, as it may influence species interactions, competition, and ecological health. Further research is needed to assess the long-term ecological and public health impacts of S. lateralis in the area.
Keywords: Urban biodiversity, DNA identification, Shelfordella lateralis, ecological impact, urban ecosystems, Sangihe Island, species competition.

1. Introduction

Urban biodiversity encompasses the variety of living organisms, including insects, invertebrates, plants, and animals, that inhabit urban areas. This biodiversity is increasingly recognized for its significant contribution to the natural world within cities and towns (Marselle et al., 2021; Faraniza, 2021). Urban biodiversity plays a vital role in influencing the stability of urban ecosystems. For example, many urban plants rely on insects and other animals to transfer pollen, which is essential for plant reproduction and the production of fruits and seeds. Additionally, predatory species, such as birds and insects, help control populations of pests, reducing the need for chemical pest management.

Decomposers, comprising diverse fungi, bacteria, and invertebrates such as earthworms and cockroaches, play a vital role in breaking down organic matter and recycling nutrients back into the soil, thereby promoting plant growth. The intricate interactions among these species contribute to the overall balance and resilience of urban ecosystems, enabling them to withstand and recover from environmental stresses. Through these mechanisms, urban biodiversity not only supports cities' ecological health but also enhances their human inhabitants' quality of life (Sun et al., 2023). Urban biodiversity, therefore, not only supports the ecological health of cities but also enhances the quality of life for urban residents by providing ecosystem services that are essential for human well-being.

Understanding urban green spaces and their ecological roles is vital as cities grow. Urban gardens and farms, despite urban sprawl's negative effects, can host diverse insect populations that influence ecosystem balance. While insects like herbivores are crucial for food webs, they can also damage plants if their numbers grow unchecked. Natural predators help regulate these pests, providing key ecosystem services in urban settings where chemical pesticides are often limited. The effectiveness of these natural controls depends on local and landscape factors, making it important to study how various environmental conditions affect these populations to support urban ecosystem health (Liere and Cowal, 2024).

Sangihe Island is located north of Sulawesi Island, with the coordinates 03°00′N 125°30′E, covering 736.98 km², and a population of 139,262 as of the 2020 census. This island has long been recognized in global fisheries constellations as an area with diverse marine habitats, particularly those supporting high-value fish species (Turuis et al., 2021). The economic value of a region is often correlated with its biodiversity index (Paul et al., 2020). This relationship suggests that Sangihe Island, with its rich marine and terrestrial ecosystems, may also host a wide range of terrestrial species, including various types of cockroaches.

Given Sangihe Island’s location within the North Sulawesi province, it was initially hypothesized that Periplaneta americana, the most commonly found cockroach species in the region, would also be the predominant species on the island (Kundera et al., 2020; Rondonuwu et al., 2019). P. americana is well-known for its widespread distribution across urban areas in Southeast Asia, particularly in regions with tropical climates. This species has been extensively documented as a pervasive urban pest, thriving in various environmental conditions and often coexisting with human populations.

However, contrary to expectations, our study identified the presence of S. lateralis, a species not previously reported in this region, within the urban areas of Sangihe Island. S. lateralis is typically found in Southeast Asia, particularly in regions with a tropical climate, but its presence in Sangihe Island was unexpected. This discovery challenges the prevailing assumptions about the distribution of cockroach species in the region and suggests that S. lateralis may have successfully established itself in the island’s urban ecosystem. The presence of this species in a new geographical area raises important questions about its impact on local biodiversity, interspecies interactions, and the ecological dynamics of urban environments.

The discovery of S. lateralis on Sangihe Island underscores the need for further research to understand the ecological implications of this species in the region. The study aims to explore the potential impact of S. lateralis on the local urban ecosystem, particularly its interactions with native species and its influence on urban ecological dynamics. By examining the ecological role of S. lateralis and its adaptation strategies in a new environment, this research contributes to a broader understanding of urban biodiversity in the northeast region of Indonesia.

2. Research Methodology

Four cockroaches were randomly collected from various urban areas on Sangihe Island (3.5303° N, 125.5439° E), Indonesia. The collection sites were chosen to represent different urban environments, such as residential areas, markets, and public spaces, where cockroach populations are typically found. The specimens were captured using hand-held nets and were immediately preserved in 95% ethanol to prevent DNA degradation.

Before proceeding to molecular analysis, a preliminary morphological examination was conducted to identify the cockroach specimens to the genus level. This step involved examining key morphological features such as body size, coloration, wing structure, and antenna length, which are commonly used for cockroach identification. The specimen that showed distinct characteristics, differing from the commonly found Periplaneta americana, was selected for DNA analysis to confirm its species.

The DNA extraction was performed using a leg from the selected cockroach specimen. The extraction process was carried out with the Genomic DNA Mini Kit (Geneaid, catalog number GT100), following the manufacturer's protocol. The tissue sample was first homogenized to break down the cells, and then the DNA was isolated using a series of chemical and mechanical processes. The quality and quantity of the extracted DNA were assessed using a Nanodrop spectrophotometer to ensure it was suitable for subsequent PCR amplification.

Polymerase chain reaction (PCR) was carried out on the extracted DNA to amplify a target region of the mitochondrial cytochrome c oxidase subunit I (COI) gene, a common marker in insect barcoding due to its significant variability across species. Each PCR reaction was prepared in a total volume of 40 µl, incorporating 1x MyTaq™ HS Red Mix (Bioline), 1.5 nmol of each primer, and 2 µl of the DNA sample. The primers LCO1490 (5'-GGT CAA CAA ATC ATA AAG ATA TTG G-3') and HC02198 (5'-TAA ACT TCA GGG TGA CCA AAA AAT CA-3'), as outlined by Folmer et al. (1994), were utilized for amplification. The thermal cycling protocol was tailored for optimal amplification, starting with an initial denaturation at 95°C for 3 minutes, followed by 35 cycles comprising a denaturation step at 95°C for 20 seconds, an annealing phase at 50°C for 20 seconds, and an extension at 72°C for 20 seconds. A final extension at 72°C for 5 minutes was conducted to finalize the PCR products.

PCR products were subjected to analysis through 0.8% agarose gel electrophoresis. The gel, stained with ethidium bromide, displayed a distinct single band around 710 base pairs under UV illumination, confirming successful amplification. Following this, the PCR products were purified using a Qiagen PCR purification kit to eliminate residual primers, nucleotides, and other contaminants that might hinder the sequencing process.

Sequencing was carried out bidirectionally using the PCR primers at First Base C.O. (Malaysia). The resulting chromatograms were carefully edited and assembled using

Geneious Primer v2024.0.5. To accurately identify sequence variations, the MUSCLE algorithm was utilized for sequence alignment. The aligned sequences were subsequently compared against the GenBank database with the help of the Basic Local Alignment Search Tool (BLAST) to ascertain species identity.The sequences were matched with 100% similarity to Shelfordella lateralis (accession number NC_030003.1) and Periplaneta lateralis (accession number MT465995.1), confirming the identification of the cockroach species as Shelfordella lateralis.

The molecular data obtained from the DNA sequencing were further analyzed to explore the phylogenetic relationships of the identified species with other related cockroach species. Phylogenetic trees were constructed using maximum likelihood methods to visualize these relationships and to assess the evolutionary significance of the identified species within the urban environment of Sangihe Island.

3. Results and Discussion

DNA analysis was conducted to confirm the species identity of cockroach specimens collected from various urban areas on Sangihe Island. Figure 1 presents the DNA sequencing chromatogram of the mitochondrial cytochrome c oxidase subunit I (COI) gene from a representative specimen. The chromatogram displays well-defined, non-overlapping peaks corresponding to the specific nucleotides (adenine, cytosine, guanine, and thymine), indicating high-quality sequencing results. The clarity and consistency of the peaks confirm that the DNA extraction and PCR amplification were successfully performed without contamination or errors. The observed sequence was then subjected to further analysis for species identification.

Following the chromatogram analysis, the obtained sequence was matched against the GenBank database using the Basic Local Alignment Search Tool (BLAST). Figure 2 shows the BLAST results, which revealed a 100% similarity (with 100% query coverage) to Shelfordella lateralis (accession number NC_030003.1) and Periplaneta lateralis (accession number MT465995.1). This unequivocally confirmed the identity of the collected specimens as Shelfordella lateralis. The identification of S. lateralis is significant, as this species has not been previously reported in Sangihe Island. The results highlight the precision and reliability of molecular methods in distinguishing morphologically similar species, which might otherwise be misidentified through traditional taxonomic methods (Li et al., 2020).

The detection of S. lateralis on Sangihe Island suggests potential ecological shifts within the local urban ecosystem. S. lateralis is known for its adaptability to diverse environmental conditions and its ability to thrive in urban settings, as reported in previous studies from Europe and parts of Asia (Kamran et al., 2021; Davranoglou et al., 2020). This adaptability may allow it to outcompete native or previously established species like Periplaneta americana, which has been the dominant species in the region (Kundera et al., 2020; Rondonuwu et al., 2019). Such shifts in species dominance could disrupt existing ecological dynamics, as S. lateralis competes for resources like food and habitat (Davranoglou et al., 2020).

Human activities, particularly trade and travel, have been recognized as key factors facilitating the spread of non-native species (Brown et al., 2021). Sangihe Island, with its high connectivity and visitation rates, is particularly vulnerable to biological invasions. The establishment of S. lateralis in this region could be attributed to increased human movement, further supporting the role of anthropogenic factors in species distribution (Arruda and Pomés, 2013). The successful establishment of S. lateralis also underscores its resilience and potential to become a dominant species in the urban ecosystems of Sangihe Island.

Comparative morphological studies have shown that S. lateralis and P. americana share many visual characteristics, complicating identification without genetic analysis (Li et al., 2020). The accurate identification of S. lateralis through DNA barcoding techniques highlights the importance of using molecular methods to distinguish between closely related or visually similar species. Moreover, the ability of S. lateralis to establish itself in new environments suggests that it may possess unique ecological traits that contribute to its survival and adaptability.

The discovery of S. lateralis on Sangihe Island raises important questions about its ecological impact on local biodiversity and its potential interactions with native species. Further research is needed to understand its influence on species composition, resource competition, and overall urban ecosystem health. As an adaptable species, S. lateralis may pose a risk to native insect populations and could alter ecological dynamics, leading to long-term shifts in species interactions (Belluco et al., 2023).

A study by Diabate et al. (2024) highlighted the critical role of predatory species, such as Coccinella septempunctata and Harmonia dimidiata, in regulating pest populations and maintaining ecological balance within agricultural ecosystems. Similarly, in the urban ecosystem of Sangihe Island, the unexpected presence of Shelfordella lateralis raises questions about its potential interactions with both native and introduced species. Although S. lateralis is not a predator like C. septempunctata or H. dimidiata, its adaptability and potential to compete with native species for resources could disrupt existing ecological dynamics. Understanding the role of species such as S. lateralis in urban settings is crucial, as it may indirectly influence the abundance and effectiveness of predatory species by altering the availability of prey or by competing for shelter and food resources. This highlights the importance of studying the complex interplay between predatory and non-predatory species to assess the overall impact on urban biodiversity and ecological health

The adaptability of S. lateralis also makes it a potential bioindicator species for monitoring environmental changes, such as pollution levels and habitat degradation, in urban settings (Sun et al., 2023). The use of S. lateralis as a bioindicator could provide valuable insights into the health of urban ecosystems and the impacts of anthropogenic activities on biodiversity (Liere and Cowal, 2024).

Given the unexpected presence of S. lateralis on Sangihe Island, future studies should focus on its reproductive strategies, habitat preferences, and survival mechanisms in urban settings. Comparative studies between S. lateralis and P. americana could elucidate their ecological roles and interactions, which would inform pest management strategies and contribute to the broader understanding of urban biodiversity dynamics (Davranoglou et al., 2020; Kamran et al., 2021).

In conclusion, the identification of S. lateralis on Sangihe Island provides new insights into the urban biodiversity of this region. The adaptability and resilience of S. lateralis highlight its potential to become a dominant species in local urban ecosystems, necessitating ongoing monitoring and research to assess its long-term ecological impact.

4. Conclusion

The identification of Shelfordella lateralis in Sangihe Island represents a significant discovery, challenging the assumption that Periplaneta americana is the predominant urban cockroach species in the region. The unexpected presence of S. lateralis suggests potential shifts in local biodiversity and raises important questions about its ecological role and adaptability in this new environment. As a species not previously documented in the area, S. lateralis may compete with native species for resources, potentially altering existing ecological dynamics and impacting the overall health of the urban ecosystem. This finding underscores the need for continued monitoring and research to understand the long-term ecological implications of S. lateralis in Sangihe Island. Future studies should focus on the potential interactions between S. lateralis and other species, its influence on urban biodiversity, and the environmental factors facilitating its establishment. By expanding our knowledge of S. lateralis, we can better manage and preserve the ecological balance and health of urban ecosystems in the region.

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