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Evaluating entomological measures and cypermethrin use in pest control

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Abstract

Purpose: This study aims to analyze entomological indicators and the susceptibility status of the Aedes aegypti mosquito to cypermethrin in the Tanjung Balai Karimun Port Health Office area. **Methods:** This type of study is observational, using a cross-sectional design approach. Entomology indicator data collection is carried out routinely every month by observing containers in each building both inside and outside. The susceptibility test uses the WHO susceptibility test method. **Results:** The results of entomological indicators in the perimeter area showed no density of Aedes aegypti mosquito larvae. In contrast, the density of larvae in the buffer area was low to moderate. A susceptibility test showed that 0.05% cypermethrin was still susceptible to Aedes aegypti mosquitoes. **Conclusion:** These findings underscore the efficacy of the current control measures implemented in the study area and emphasize the critical need for continuous monitoring and surveillance. Maintaining such efforts is paramount for sustaining effective mosquito control initiatives and mitigating the potential risks posed by Aedes aegypti mosquitoes, thereby reducing the threat of vector-borne disease.

Keywords: Aedes aegypti; cypermethrin; susceptibility; Tanjung Balai Karimun Port

INTRODUCTION

Aedes aegypti or Aedes albopictus mosquito vectors transmit the dengue virus, which causes dengue hemorrhagic fever (DHF), an infectious disease. Until now, DHF has had a significant public health problem. Based on data from the Indonesian Health Profile, 73,518 dengue cases were reported in 2021, with 705 deaths. This figure has decreased compared to the previous year, with 108,303 cases and 747 deaths [1]. The number of sufferers and the distribution area are increasing, along with increasing mobility and population density. All provinces in Indonesia reported cases of DHF, not only in urban areas; DHF cases began to spread to rural areas. The Riau Islands Province contributed the highest DHF cases in 2021, with a DHF incidence rate (IR) of 80.9 per 100,000 population, while the province with the lowest IR was Papua Province.

Nationally, DHF IR in 2021 is below the national target rate of 27 per 100,000 population (≤ 49 per 100,000 population) [1]. Numerous factors, including the quick development of transportation technology, which makes distances between regions closer due to shorter travel times so that the mobility of people and goods is faster than the incubation period of infectious diseases, influence the growth, spread, and expansion of communicable diseases (especially DHF). Transportation is essential in spreading DHF between regions, especially for those who routinely move between regions and come into contact with mosquito vectors [2,3]. The impact of advances in transportation technology resulted in the carrying of disease-transmitting vectors between regions so that they could quickly spread from the entry points of an area, including ports [4]. Ports are meeting points or activities for incoming and outgoing ships, goods, and people, as well as gateways for transforming the spread of disease, and are a global threat to public health due to new emerging diseases and re-emerging diseases [5].

As a Technical Implementation Unit (UPT) of the Ministry of Health of the Republic of Indonesia, the Class II Port Health Office Tanjung Balai Karimun has duties and tasks that must be carried out in line with Regulation No. 33 of 2021 from the Minister of Health of the Republic of Indonesia. These include preventing the entry and exit of quarantine diseases and potentially infectious disease outbreaks, as well as providing limited health services in ports, airports, and across borders. One of the efforts to prevent DHF and other vector-borne diseases such as yellow fever and Zika, is to free the port/airport area from Aedes sp. mosquitoes, following Annex 5 of the 2005 International Health Regulation (IHR). Each port and perimeter area of an airport/port must be vector-free to minimize the risk of disease transmission. High vector density affects the high transmission of cases [6]. The indicators used are the House Index (HI) and Container Index (CI), namely 0 for the perimeter area and the buffer area ≤ 1. According to these indicators, the perimeter area must be free of Aedes sp. [5].

Controlling mosquito populations by eliminating breeding sources is vital for reducing their numbers. Although community involvement in habitat management is crucial; completely eradicating all breeding sites remains challenging. A systematic review found that certain interventions significantly reduce dengue risk. House screening and community-based environmental management with water container covers both significantly reduced the risk of getting dengue (OR 0.22, 95% CI 0.05–0.93, p = 0.04 and OR 0.22, 95% CI 0.15-0.32, p<0.0001, respectively), showing that they are effective at stopping the spread of the disease [7].

In outbreak seasons, insecticides are commonly employed to curb disease transmission rapidly [8]. Well-executed insecticide spraying can effectively decrease mosquito numbers during outbreaks. To date, the Port of Tanjung Balai Karimun has implemented routine mosquito control measures, including using Cypermethrin insecticide for fogging purposes since 2012.

The lack of insecticide rotation, incorrect dosing, and timing can lead to decreased susceptibility among insects and mosquitoes, fostering the development of resistance within the target population. Prolonged insecticide use spanning 2–20 years can exacerbate this resistance issue [9]. The WHO report highlights insecticide resistance in vector mosquitoes in various regions of Indonesia, particularly in Central Java, DI Yogyakarta, and Central Sulawesi [10], where cypermethrin insecticides have shown regional resistance. While there's no available evaluation of mosquito resistance status at Tanjung Balai Karimun port, this study aims to assess the entomological indicators of DHF vectors and identify the susceptibility status of Aedes aegypti mosquitoes. This information is important for formulating effective control strategies and adopting appropriate policies, especially in the study locations.

METHODS

This type of study is observational, using a cross-sectional design approach. The study location is in the perimeter and buffer areas of the Tanjung Balai Karimun Port Health Office, Riau Islands. Entomological survey activities occurred from January to December 2022, while testing for resistance status took place from September to October 2022.

Data collection to determine entomological indicators is carried out routinely every month by observing containers inside and outside the buildings in the study area. The presence of Aedes sp. larvae is recorded in a form (positive or negative) based on the location of the containers in the buildings, which are buffer areas and perimeters. The entomological index was recorded based on survey time, building, and the presence of larvae. In addition, efforts to control the DHF vector, namely participation and fogging, were recorded.

The resistance status test activity involved gathering test insects, surveying Aedes aegypti in the perimeter and buffer areas, and taking all the larvae found. They were collecting larvae from containers using pipettes and flashlights as lighting devices. The collected larvae were taken to the Tanjung Balai Karimun KKP Laboratory to continue the rearing process; the larvae that had become pupae were transferred to the mosquito cage until they became adult mosquitoes. Aedes aegypti adults in the cage are given a supplement of sugar water solution using long gauze rolled up to resemble a small stick so that mosquitoes can land and suck the sugar solution. Aedes aegypti adult females aged 3-5 days were caught using an aspirator in preparation for a susceptibility test and placed in a coded paper cup. In addition, the entomological index was also measured in this data collection, namely the Container Index (CI), which is the number of positive larvae per total number of containers surveyed, and the House Index (HI), which is the number of positive houses per total number of houses surveyed. These indicators are used to determine the risk of transmission based on density figures: low category (1), medium (2–5), and high (> 5) [11]. The HI, CI, and BI formulas are as follows:

$$HI = \frac{Number\ of\ houses\ (buildings)\ positive\ for\ larvae}{Number\ of\ houses (buildings)\ examined} x\ 100\%$$

$$CI = \frac{number\ of\ positive\ larvae\ containers}{Number\ of\ containers\ checked} x\ 100\%$$

$$BI = \frac{Number\ of\ positive\ larvae\ containers}{Number\ of\ houses(buildings)\ examined} x\ 100\%$$

The procedure for testing susceptibility status uses the Susceptibility Test (WHO) method, which uses tubes and insecticidal material in the form of impregnated paper, namely 0.05% Cypermethrin. The susceptibility test stage was to provide four green spot tubes in which 0.05% cypermethrin-impregnated paper had been inserted. In comparison, two green spot tubes were used as controls, using only paper without insecticide. As many as 22 adult Aedes aegypti mosquitoes aged 3-5 days were included with the same conditions when they were full of sugar solution by blowing slowly into a green tube that had been coated with 0.05% cypermethrin impregnated paper insecticide and the same treatment into the red tube without insecticides as a control. Mosquitoes were allowed to contact 0.05% Cipermethrin-impregnated paper insecticide for one hour, as well as with controls. After one hour, the mosquito is in contact with Cypermethrin insecticide. It is transferred to a storage tube (holding), given a 10% sugar water solution, and allowed to be stored for 24 hours. The air's minimum and maximum temperature and relative humidity at the test site were recorded during storage. After 24 hours of observation, the mosquitoes were examined and counted to determine how many were dead and still alive. The results of the susceptibility test and observations are recorded in the observation form. In this test, if the mosquito mortality is >10%, it is considered a failure and must be repeated. The ABBOTS formula correction variable is used if it is less than 10%.

$$Abbotts = \frac{(\%\ mortality\ of\ uiji\ mosquitoes - \%\ mortality\ of\ control\ mosquitoes)}{100 - \%\ control\ mosquito\ mortality} x\ 100\%$$

The criteria for grouping the results of the mosquito susceptibility test to insecticides are as follows:

- Percentage of deaths in the 98–100% susceptible category
- Percentage of death: 80–98% tolerance category
- Percentage of deaths: <80% resistant category

RESULTS

The port perimeter area is the leading land area at the port, where ships dock, load, and unload goods and passengers. In this perimeter area are warehouses and offices of government and private agencies. The buffer area is around the port, with residential areas and supporting infrastructure, including schools and other public facilities. Residential areas dominate the buffer area at Tanjung Balai Karimun Harbor; buildings in the buffer area directly adjacent to the perimeter area are offices and hotels.

Entomological indicators in the form of Aedes aegypti larvae density in settlements or areas examined are considered for carrying out appropriate control efforts. In this study, the entomological indicators measured were HI, CI, and BI in the perimeter area and buffer area of Tanjung Balai Karimun Port.

Based on field observations conducted in the perimeter area in 2022, it was noted that no Aedes aegypti mosquito larvae were detected. This outcome can likely be attributed to the area's composition, predominantly consisting of offices, warehouses, and public spaces like passenger waiting rooms. In these environments, containers are regularly cleaned daily by maintenance staff, and the presence of water containers is minimal.

Figure 1 shows a one-year field observation of HI and CI in the study area. The HI value of the buffer area in 2022 was 11.01, with the lowest HI in June of 2.80 and the highest HI in December of 20. The CI of the buffer area in 2022 is 4.21, with a CI value. The lowest was 0.85 in June, while the highest CI was 8.73 in March. The BI buffer area value in 2022 is 13.81, with the lowest HI value in June and July at 2.86, while the highest BI occurs in March at 34.38. Based on the HI, CI, and BI values, the density figure of the buffer area in 2022 is between 1 and 4, so it can be concluded that the density of larvae in the buffer area is low to moderate.

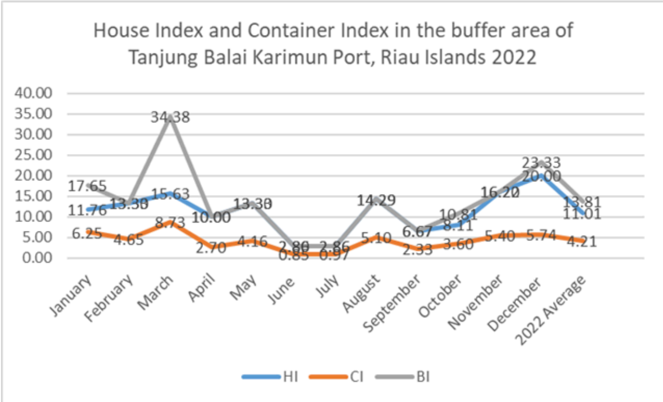

Figure 1. House Index, container index, and Breateau index in the port Tanjung Balai Karimun perimeter and buffer area.

Since 2012, the Tanjung Balai Karimun KKP has implemented this insecticide quarterly to combat the Aedes aegypti mosquito. Periodic assessments of cypermethrin's effectiveness are essential. The tests utilized F1 generations from field mosquitoes collected in the buffer zone, as no larvae were detected in the perimeter area during this study's data collection phase.

Table 1 presents the outcomes of susceptibility testing for Aedes aegypti mosquitoes to 0.05% cypermethrin insecticide. The results show that 100% of the test mosquitoes died at the time of contact with the test insecticide, both at 1 hour of contact and after 24 hours of holding. These findings place the 0.05% cypermethrin used by the Tanjung Balai Karimun KKP for vector control in the susceptible category.

Table 1. The results of the Aedes aegypti mosquito susceptibility test to 0.05% cypermethrin insecticide for 24 hours of observation

Mosquito Mortality	Number of test mosquitoes	Average Death of Test Mosquitoes		Susceptibility Status
		Total	Percentage	
Knockdown 1 hour	22	22	100 %	Susceptible
Holding 24 Hours	22	22	100 %	

* Air temperature during testing 24-25 0C, Air humidity during testing 74 - 76 %

DISCUSSION

Aedes aegypti density in the buffer area typically ranges from low to moderate, depending on factors like community control behaviors, breeding site availability, microclimate, mosquito flight distance, and insecticide susceptibility [12]. Despite this, the larval-free rate (ABJ) in the Tanjung Balai Karimun port buffer area falls below the standard of ≥ 95%, posing a risk for DHF transmission. However, studies show inconsistent correlations between mosquito density and dengue fever cases, with some suggesting that population density, rather than entomological indicators, is more closely linked to dengue incidence [13,14]. While some research emphasizes the importance of the House Index (HI) in dengue transmission, others argue that vector density alone cannot accurately depict transmission risk [15]. Nevertheless, vector control efforts in the port area, including mosquito nest eradication campaigns, remain crucial. Human movement plays a significant role in dengue virus transmission to Aedes aegypti mosquitoes and susceptible individuals, highlighting the importance of increasing awareness about disease transmission through vector control measures. Research in Sudan suggests a correlation between vector control factors and dengue transmission, further emphasizing the necessity of proactive vector control strategies [16].

The widespread use of insecticides, particularly cypermethrin, for mosquito control carries significant social implications, particularly in areas where diseases like dengue fever are prevalent. From natural sources, cypermethrin has extensive applications in agriculture, plantations, and disease vector control programs [17]. Despite its efficacy against Aedes aegypti mosquitoes, emerging studies raise concerns about cypermethrin resistance, echoing trends seen with other insecticides [18,19]. The observed susceptibility of mosquitoes to cypermethrin suggests that selective restriction of its use within the port perimeter may be insufficient. Moreover, given cypermethrin's common use in household insecticides [20,21], its resistance poses challenges for ongoing mosquito control efforts [22], potentially undermining the effectiveness of insecticide-based interventions.

In regions such as Semarang and Bengkulu in Indonesia [18,19] and Brazil [21], resistance to cypermethrin has been documented, highlighting the urgent need for regular evaluation and adaptive strategies in vector control programs. Furthermore, studies across Southeast Asian countries indicate a growing resistance to pyrethroid-class insecticides, including cypermethrin, among Aedes mosquitoes [23]. This underscores the importance of vigilance and proactive measures to mitigate resistance development.

To address this effectively, stakeholders must embrace integrated approaches that actively involve the community and prioritize moderation, saturation, and multiple attacks in insecticide applications [24]. These strategies are designed to alleviate selective pressure on mosquitoes while maximizing the efficiency of control measures. Furthermore, fostering community engagement and collaboration among stakeholders is essential for bolstering mosquito control endeavors, decreasing reliance on insecticides, and mitigating the negative repercussions of resistance emergence. By implementing adaptable and sustainable vector control strategies, communities can safeguard public health, mitigate environmental impacts, and uphold the enduring efficacy of insecticides over the long term.

CONCLUSION

During the activity, no Aedes aegypti mosquito larvae were detected in the perimeter area, while the density in the buffer area ranged from low to moderate. The susceptibility of Aedes aegypti mosquitoes to 0.05% cypermethrin insecticide falls within the susceptible category. To effectively control Aedes aegypti larvae in the buffer area of Tanjung Balai Karimun Port, more intensive control efforts are necessary. By working together to reduce the larval density to zero, the community and relevant institutions, such as neighborhood health centers, can achieve this. Implementing robust vector control measures significantly reduces the transmission of dengue cases in the area.

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