Brief report: Diversity of mosquito in East Surabaya

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Abstract. Mosquitoes are insects that are detrimental to human health because they act as disease vectors, such as dengue fever. Surabaya was known for its high risk of dengue fever. This study aims to describe the diversity of mosquitoes and breeding site distribution in Eastern Surabaya. The study was conducted in 2021 during the end of the wet season in different habitat types in the eastern Surabaya (residential, city park, bamboo forest, and mangrove forest). Eggs, larval, and adult-stage mosquitoes were collected and stored in the Entomology Laboratory for morphological identification. Adult mosquito was collected by using a sweep net and light trap method, while the larva and egg were collected incidentally from breeding sites. The diversity of mosquitoes in the Eastern Surabaya was determined by using the Shannon-Wiener diversity index (H'), dominance, species richness (R), and breeding site distribution. Eleven species were obtained in this study, namely *Aedes aegypti*, *Aedes albopictus*, *Aedes annandalei*, *Anopheles subpictus*, *Anopheles vagus*, *Anopheles barbirostris*, *Culex bitaeniorhynchus*, *Culex pseudovishnui*, *Culex quinquefasciatus, Mansonia uniformis*, and *Malaya genurostris*. The H' index of 1.63 indicates the mosquito community was at a moderate level. The R-value of 1.56 indicates a low level of mosquito species richness. The most abundant species was *Cx. quinquefasciatus* (37.2%). Most of the breeding sites with mosquito larval infested were found in open areas (79.3%). These numbers mean the total of individuals of each species tends to be low and its dominance shows no effect on other species. The data on mosquito species and their distribution in Surabaya could be used as base information for vector control strategies.

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1 Introduction

Biodiversity in recent years has been influenced by urban activities. The changes in the diversity of urban areas are affected by anthropogenic activity. Some groups of animals have declined such as birds and the specialist group which tends to adapt to specific habitat types. However, there are groups of animals that increasing due to anthropogenic activity. Mosquitoes are a group of animals that become more abundant [1]. A drastic change in the environment has affected the number of breeding sites, especially the artificial habitat for mosquito larvae [2]. On the other hand, the decrease in mosquito predator population and the availability of food sources become the factors that support the widespread of mosquitoes in urban areas.

Mosquitoes belong to the family of Culicidae, are responsible for the transmission of several viruses, microbes, and protozoa to the human population, and lead to infectious diseases in tropical countries such as Indonesia. The pathogen is transmitted when a mosquito sucks blood from its host, and this could lead to severe illness and death, moreover, some of the diseases transmitted have not been found in effective vaccines or medicine. The risk of an outbreak might increase as the population.

Mosquito breeding sites could vary in many forms. Mosquitoes, in general, lay their eggs on each site that contains water. Some species of mosquitoes have different preferences in choosing the place to lay their eggs. *Mansonia* sp. lay their eggs near the aquatic plant, *Aedes* sp. stuck the eggs on the side of the container near the water surface, while *Culex* sp. and *Anopheles* sp. lay their eggs on the water surface of brackish water.

Surabaya was one of the cities where most of the habitat has changed. The high mobility of people and the high number of populations in this city probably enhance the spread of mosquitoes from one house to another. Dengue fever was an endemic disease in Surabaya, and other vector-borne diseases such as malaria probably happened due to the existence of habitat for *Anopheles* sp. (mangrove area). The study of mosquito diversity and distribution in the Eastern Surabaya has never been conducted nor reported. The diversity and distribution of mosquitoes contribute to further analysis of the risk of pathogens that are probably transmitted by the species. In this case, we observed and collected mosquito samples in Eastern Surabaya to analyze the diversity and distribution of mosquito species and their breeding sites for being new reference mosquito biodiversity research at Surabaya and adding information in vector control strategies to suppress the risk of pathogen transmission by the mosquitoes.

2 Method

Sample collection was carried out during the end of the wet season in March 2021. Mosquito samples were collected in several ecological settings in Eastern Surabaya: residential areas, bamboo forests, city parks, and mangrove forests each located in Mulyorejo, Keputih, and Rungkut subdistrict (Fig 1). Sampling of adult mosquitoes was carried out by using a sweep net and a light trap. Larvae and eggs were collected incidentally in the area. Collected samples were carried to the Institute of Tropical Disease (ITD) Entomology Laboratory for rearing the eggs and larvae samples. Morphological identification of larvae and adult mosquitoes was based on the illustrated mosquito of Java identification key book and the illustrated key of mosquito species in Thailand. Identified species and the number of each species were analyzed to determine the diversity of mosquitoes in the Eastern Surabaya area by using the Shannon-Wiener

diversity index (1) and Margalef species richness index (2). The location of the mosquito breeding sites was grouped into closed and open areas based on the sampling point.

$$H' = -\sum_{i=1}^{S} \quad pi\ ln\ ln\ pi \tag{1}$$

$$R = \frac{(S-1)}{lnln\ (n)} \tag{2}$$

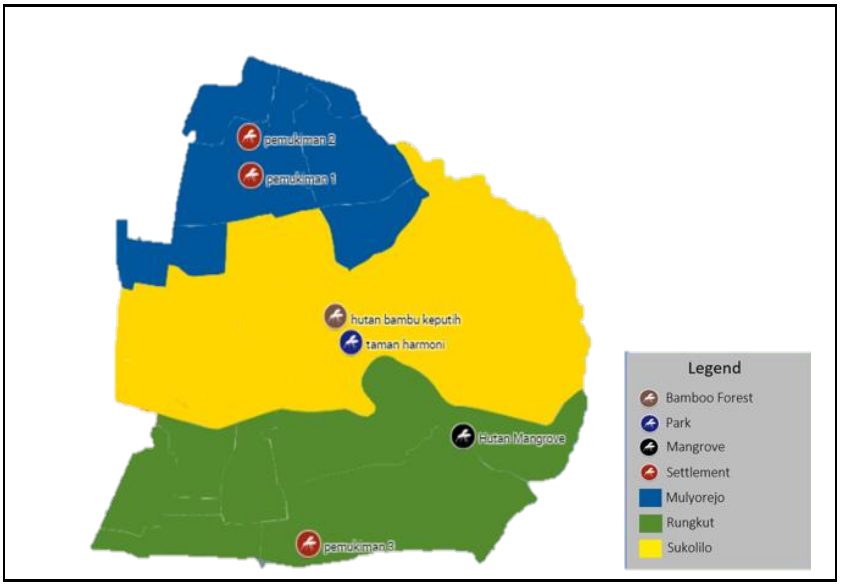

Fig.1. Map of sample collection

Table 1. Location of mosquito collection

No.	Location	Subdistrict	Latitude	Longitude
1	Mangrove Forest	Rungkut	E -7.3120001	S 112.8240965
2	Bamboo Forest	Sukolilo	E -7.2940387	S 112.8027746
3	Residential Area	Mulyorejo	E -7.2695397	S 112.7861482
4	Residential Area	Mulyorejo	E -7.2632471	S 112.7857682
5	Residential Area	Rungkut	E -7.3295531	S 112.7963933
6	City Park	Sukolilo	E -7.2952211	S 112.8043496
7	Residential Area	Sukolilo	E -7.2909989	S 112. 7973192

3 Results

A total of 602 individuals of mosquitoes were collected from all sampling sites. These were *Aedes aegypti*, *Ae. albopictus*, *Ae. Annandalei*, *Anopheles vagus*, *An. subpictus*, *An. barbirostris*, *Culex quinquefasciatus*, *Cx. bitaeniorhynchus*, *Cx. pseudovishnui*, *Mansonia uniformis*, and *Malaya genurostris*. Table 2 shows the distribution of mosquito species in each habitat type. Based on Table 1, three species were collected in all sampling points, *Culex quinquefasciatus*, *Aedes aegypti,* and *Ae. albopictus*. These species have a wide

range of distribution. While *Anopheles barbirostris* was caught by a sweeping method in the city park *Malaya genurostris* appeared in the leaf axils of colocasia. *Aedes annandalei* collected from the larval stage in Bamboo Forest. *Anopheles vagus* and *An. subpictus* collected from a mangrove forest in the larvae stage. *Mansonia uniformis* were collected at the adult stage in residential areas and bamboo forests by sweeping and trapping methods. *Culex pseudovishnui* was found in bamboo forests and *Culex bitaeniorhynchus* was found in residential areas. The species composition of mosquitoes (Diptera: Culicidae) is shown in Table 3

Table 2. Distribution of mosquito species in study site

Species	Type of habitat			
	Residential	**City Park**	**Bamboo Forest**	**Mangrove Forest**
Ae. aegypti	+	+	+	+
Ae. albopictus	+	+	+	+
Ae. annandalei	-	-	+	-
An. vagus	-	-	-	+
An. subpictus	-	-	-	+
An. barbirostris	-	+	-	-
Cx. quinquefasciatus	+	+	+	+
Cx. bitaeniorhynchus	+	-	-	-
Cx. pseudovishnui	-	-	+	-
M. uniformis	+	-	+	-
M. genurostris	-	+	-	-
Aedes sp.	-	-	+	-

Culex quinquefasciatus was the most abundant species (37.2%). This species was collected from all stages (eggs, larvae, and adults). Eggs and larvae stages were collected from mangrove forests (fish ponds). At the same area, larvae and adult stage of *Ae. albopictus* were infesting the barrel containing fresh water which was located near the fish pond.

The diversity value (H') of 1.63 showed that the mosquito's diversity at a moderate level indicated the distribution of each species is moderate. A moderate level of diversity means that it has sufficient productivity, fairly balanced ecosystem conditions, and moderate ecological pressure [3]. The dominance (C) value of 0.25 indicated a low level of dominance among the species. The species richness value (R) of 1.56 indicated a low level of species richness in the study area. These values range in a moderate level of diversity due to various ecological settings or habitats, and the low level of dominance is correlated where none of the species are significantly abundant.

Table 3. Mosquito species composition and diversity indices

Species	f	%	H'	C	R
Ae. aegypti	50	8.3	1.63	0.249	1.56
Ae. albopictus	160	26.6			
Ae. annandalei	20	3.3			
An. vagus	12	2.0			
An. subpictus	2	0.3			
An. barbirostris	1	0.2			
Cx. quinquefasciatus	224	37.2			
Cx. bitaeniorhynchus	3	0.5			
Cx. pseudovishnui	1	0.2			
M. uniformis	19	3.2			
M. genurostris	4	0.7			

Species	f	%	H'	C	R
Aedes sp.	106	17.6			
	602				

Tables 4 and 5 show the breeding site data in the study site. The breeding sites recorded were natural breeding sites and artificial breeding sites. The natural breeding sites were mostly collected from bamboo forests, while the artificial breeding site was recorded in residential areas. The majority use of bathroom containers has led to the high risk of *Aedes* laying their eggs in household containers. Mangrove forest has shrimp pawns and the barrel as the breeding site. Shrimp pawns were infested with various species of *Culex* and *Anopheles*. During the sample collection, *Culex* larvae were found in ponds with water temperature parameters of 28°C. Unlike the *Culex* larvae, *Anopheles* larvae are found in different ponds, with water temperature parameters of 33.9°C, and wind speed of 1.2. In these ponds there is green algae and above this pond is shaded by trees. This alga serves an important function in *Anopheles* larvae circulation. The measured pH of the water is 8. This indicates that *Anopheles* tend to be more selective in choosing their area.

Table 4. Breeding sites and species of larvae collected

Location	Name/type of breeding site	Species of mosquitoes collected
Mangrove	Shrimp pawn	Eggs dan larvae *Culex* sp.; Larvae *Anopheles* sp.
	barrel	Larvae *Ae. albopictus*
Bamboo Forest and City Park	Bamboo hole,	Larvae *Ae. albopictus* Larvae *Ae. annandalei*
	colocasia leaf axil	Larvae *M. genurostris*
	Discarded tires	Larvae *Ae.aegypti*, *Ae. albopictus*
	tree hole	Larvae *Ae. albopictus*
Residential	Bathroom container Aquatic plant-vas	Larvae *Ae. albopictus*

Several species were found in the same breeding site. *Ae. albopictus* and *Ae. annandalei* were found in bamboo groves (Fig. 2(c)), and the other coexistence was between *Anopheles* sp. and *Culex* sp. in the fish pond (Fig. 2(a)). *Anopheles vagus, An. subpictus*, and *Culex* sp. were commonly found in the same type of breeding site. Non-biting mosquitoes *M. genurostris* infesting leaf axil of colocasia (Fig. 2(b)).

(a) (b) (c)

(d)

(e,f)

Fig. 2. Study sites and breeding sites; (a) fish pond in mangrove forest; (b) leaf axil of colocasia in city park; (c) bamboo forest; (d) bamboo grove; (e) and (f) residential area

Table 5. Frequency distribution of mosquito breeding sites

Area	Presence of mosquito larvae				Total	
	Positive		Negative			
	f	%	f	%	f	%
Open area	11	37.9%	12	41.4%	23	79.3%
Close area	1	3.4%	5	17.3%	6	20.7%

Most of the mosquitoes from Bamboo Forest were *Aedes*. Three species of *Aedes* were identified, *Ae. aegypti*, *Ae. albopictus*, and *Ae. annandalei*. As many as 106 *Aedes* sp. have not been identified at the species level because some morphological characters that guide species were no longer observable. In the holes of bamboo stems found mosquito larvae from the genus *Aedes*, namely *Ae. albopictus* and *Ae. annandalei*. It is known that the larvae of *Ae. annandalei* associate with the larvae of other mosquitoes, such as the larvae of *Ae. aegypti* and *Toxorhynchites*. *Ae. annandalei* larvae could live in coexistence with *Aedes* species at a low density [4], such as *Ae. albopictus* and *Armigeres subalbatus* [5]. *Culex quinquefasciatus*, and *M. uniformis* were also found in the residential area through sweep net methods. *Anopheles barbirostris* only found in city park areas in adult stages. Breeding sites in open areas have greater potential as breeding places for larvae of various types of mosquitoes than closed areas. But it does not rule out the possibility that closed areas have the potential as a breeding ground for mosquitoes, especially *Ae. aegypti* and *Ae. albopictus*.

4 Discussion

Urban mosquito diversity could be different among the species. Mosquito density may be positively or negatively associated with vegetational complexity and the resulting habitat structure it provides. The results showed some species in high density, while others were only found in a few numbers. *Ae. aegypti*, *Ae. albopictus*, *and Cx. quinquefasciatus* were found in the highest individual number compared to other species. Therefore, these species were considered as invasive species. Immature forms *of Ae. aegypti* were more abundantly found in artificial breeding sites than natural ones. Ratnasari et al. [6] showed that mosquitos breed in many types of water containers neglected by people. East Surabaya was the region of the city that still has various ecological settings. A wide area

of mangrove forest and the presence of fishpond near the forest become a favorable site for *Anopheles* and *Culex* species to develop the immature stages whereas the forest was the place for resting and blood-seeking activity. City Park and bamboo forests become habitats for some species that were rarely found, such as *Ae. annandalei*, *An. barbirostris*, and the non-biting mosquito *M. genurostris*. However, it is supposed to be an early warning for those species that could adapt to the urban environment and their prevalence of transmiting pathogens are still unknown. Due to the study period, which was conducted during the transition between the wet and dry seasons, when the rain density is low and many places are flooded with water, the plant holes such as bamboo groves and leaf axils of plants are infested by immature mosquitoes. another finding of this study was the occurrence of *An. barbirostris* mosquito in the city park area.

Surabaya is known as a dengue-endemic area. Mulyatno et al. [7] reported the dengue virus (DENV) in *Ae. aegypti* and *Ae. albopictus* in Surabaya. The Public Health Office of Surabaya has a larva monitoring program for vectors of dengue control by checking the household containers. An improvement of larvae monitoring in the opened area is essential to control *Aedes* sp. population in its natural habitat. *Culex quinquefasciatus* transmit urban *Wuchereria bancrofti* nocturnally to humans. The high abundance of *Cx. quinquefasciatus* was caused by the high population density and habitat conditions that support its developmental stages. *Culex quinquefasciatus* mosquitoes are considered intelligent vectors because they have the ability to thrive and survive in a wide range of environmental conditions [8].

Anopheles barbirostris is known as a vector of filariasis in the limited area of Eastern Indonesia [8]. Recent studies mention the expansion of the spread of *An. barbirostris* in Indonesia. The status of this species as a vector is different in several regions in Indonesia [9]. The discovery *An. barbirostris* in this study need to be highlighted for the area functioned as a public place. *Anopheles vagus*, *An. barbirostris, An. subpictus*, and *Anopheles sundaicus* from Indonesia have been reported to be positively infectious considering the presence of salivary gland sporozoites [10,11]. The use of repellents during outdoor activities is necessary to prevent mosquito bites due to that phenomenon.

5 Conclusion

Eleven species of mosquitoes belong to the genera *Aedes*, *Culex*, *Anopheles*, *Mansonia*, and *Malaya*. *Aedes aegypti*, *Ae. albopictus*, *Ae. annandalei*, *An. barbirostris*, *An. subpictus*, *An. vagus*, *Cx. bitaeniorhynchus*, *Cx. quinquefasciatus*, *Cx. pseudovishnui,* and *M. uniformis*. The level of mosquito diversity (H') in the Eastern Surabaya is 1.63 which is included in the medium category. Species richness value of 1.56 which is included in the low category and a dominance value (D) of 0.25. Measurement of environmental parameters needs to be carried out in all sampling areas to determine the relationship between environmental factors and mosquito distribution.

Acknowledgments

Our sincere thanks to the house owners in Keputih, Mulyorejo, and Rungkut subdistrict. We also thank the volunteers who were willing to become mosquito collectors the team that was helping to identify mosquitoes in the field, and all the staff in the Entomology Laboratory of the Institute of Tropical Disease Airlangga University. This research was supported by a grant

from Airlangga University through the “HIBAH RISET MANDAT 2022” research scheme with contract number 212/UN3.15/PT/2022.

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