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Research Article

Entomological Risk Stratification of Malaria in the Urban Ecosystem of Havana, Cuba: Descriptive Study

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- Cuba

Abstract

Background and aims: Malaria is confined mainly to the tropical and subtropical regions where Cuba is located. The objective of this work was to establish an entomological risk stratification of malaria from indicators related with *Anopheles albimanus* main vector of this disease in Cuba.

Methods: Havana is the capital of Cuba located in the northwestern region of Cuba, between 22° 58', 23°10' N and 82° 30', 82° 06' longitude W. It is divided administratively in 15 municipalities. The data collection was conducted from January 2015 to December 2017. Open natural and artificial water bodies were selected randomly from each municipality and sampled each month. All larva samples collected during this monitoring program were included in the analysis, even the samples from species other than *Aedes aegypti* and *Aedes albopictus* to highlight the presence or absence of *Anopheles* species.

Results: Of the six species of *Anopheles* reported for Cuba, five are present in the province of Havana. *Anopheles albimanus* has been reported in each municipality of Havana. The majority of the larvae samples were obtained from natural permanent and temporary breeding sites. A total of 20 different artificial containers were found with *An. albimanus* larvae during the sampling. *An. albimanus* was present throughout the year and increased during the rainy season. The municipalities with high and low risk of malaria transmission were identified.

Conclusions: This is the first study to build an entomological risk stratification of malaria in Havana, Cuba.

ABBREVIATIONS

PAHO: Pan-American Health Organization; WHO: World Health Organization

INTRODUCTION

The incidence of malaria is estimated to have decreased globally by 18%, from 76 to 63 cases per 1 000 population at risk, between 2010 and 2016. In South-east Asia region the World Health Organization (WHO) recorded the largest decline (48%) followed by the Americas (22%) and African region (20%). Despite this reduction, between 2014 and 2016, the incidence increased substantially in the Americas, and marginally in the South-east Asia, Western Pacific and African regions [1].

In 2016, 91 countries reported a total of 216 million cases of malaria, an increase of 5 million cases over the previous year. The global tally of deaths from malaria reached 445 000, about the same number reported in 2015. Although malaria case incidence has fallen globally since 2010, the rate of decline has stalled and even reversed in some regions since 2014. Mortality rates have followed a similar pattern [1].

In the region of the Americas, the Pan-American Health Organization (PAHO) warns that the achievements made towards the elimination of the disease could be compromised if the surveillance and control actions throughout the region are not maintained or strengthened. The organization mentioned that although the member states of PAHO made efforts in response to this alert, the increase in cases during 2017 indicates the persistence of the conditions and gaps in the response [2].

The existence of conditions of vulnerability and poverty in populations that inhabit areas with the vector and high transmission of the disease, the predominance of labor and economic activities such as, mining, extraction of natural products, agriculture, high rates of poor and vulnerable populations inhabiting high risk areas for malaria transmission and the unplanned massive migration are some of the determinants that explain the increase in cases, besides the migrant populations are

particularly vulnerable groups due to the lack of social protection in which they live [2].

PAHO report also draws attention to countries that last year, although they are malaria-free or have very few cases, have reported autochthonous local transmission of malaria. Cuba and Costa Rica reported autochthonous cases in 2017 and Honduras recorded cases in an area where they thought there was not malaria. Similarly, in countries such as Ecuador and Mexico, where transmission had decreased significantly in recent years, showed increases in cases in 2017. In Ecuador, 1,279 cases were reported last year and 926 cases in 2016. Mexico reported 704 cases in 2017 and 514 in the previous period [2]. At present, malaria is confined mainly to tropical and subtropical regions like Cuba where higher temperature or increases in precipitation increase the possibility of transmission. In addition, in countries free of the disease for many years, such as Cuba, the populations lack protective immunity and are prone to the occurrence of outbreaks when the meteorological and entomo-epidemiological conditions favor it. Cuba eradicated malaria in 1967 and received the PAHO/WHO certificate in 1972 [3] but the main vector of this disease is found all over the country [4-6] Faced with this situation in the Americas and the warning launched by PAHO the objective of this study was to establish an entomological risk stratification of Malaria using indicators related to *Anopheles albimanus* the main vector of this disease in Havana, Cuba.

MATERIALS AND METHODS

Havana is located in the western region of Cuba, between 22° 58', 23°10' N and 82° 30', 82° 06' longitude W. The province of Havana is divided administratively into 15 municipalities. For this study the authors used the records of the larval samples of mosquitoes from the provincial entomology laboratory in Havana that functions as a reference laboratory for the whole city.

The data collection was conducted from January 2015 to December 2017. Breeding sites in all municipalities of Havana were sampled each month. Open natural and artificial water bodies were selected to sample randomly in each municipality and with the main objective to determine the presence or absence of *Anopheles* mosquito larvae. The entomological white dipper of 250 cm3 was submerged 10 times every 10 meters in an area of 1m2 following the recommended WHO standard procedures [7]. The permanent natural breeding sites included: 1) dams, 2) natural lagoons, 3) oxidation lagoons, 4) ditches, 5) concrete canals, 6) streams, 7) rivers, 8) and small lagoons, and temporary sites included: puddles, holes in the ground, tracks, animals footprints and coconut shells.It should be mentioned that larval samples obtained in one hundred percent of the residential areas during *Aedes aegypti* and *Aedes albopictus* monitoring program also were collected followed the methodology established by the National Control program of these species [8]. The houses inspection was carried out in all the reservoirs containing water in the premises, as well as, in the courtyards present in the urban and peri-urban areas of each municipality that makes up the province of Havana.

Classification of mosquito samples

A sample was taken from each container or natural breeding site positive for the mosquito and placed in vials with a label including the necessary information about its location, collection date and breeding sites types. The larvae were identified using morphological keys [9,10]. The specimens collected were recorded in each municipality and then sent to the provincial entomology laboratory for the quality control of the larvae identification.

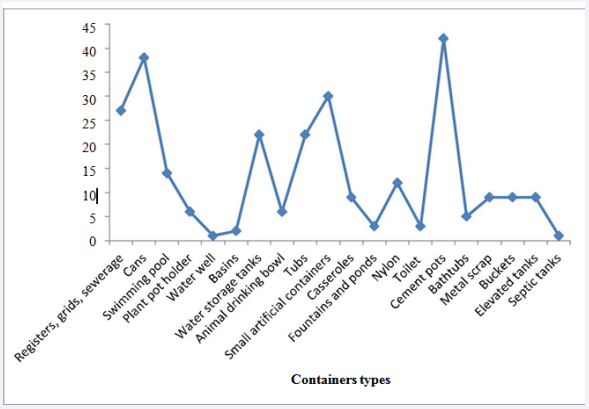

Figure 1 Totals of artificial containers containing *Anopheles albimanus* in Habana, Cuba, 2015-2017.

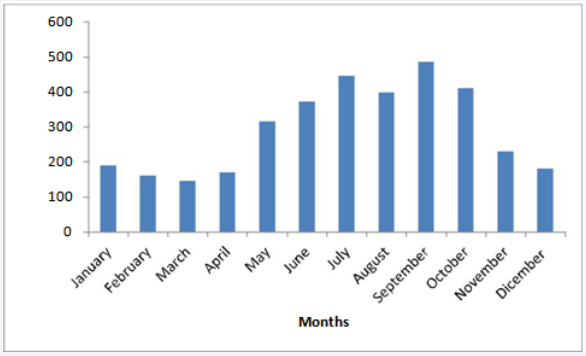

Figure 2 Average of *Anopheles albimanus* larval samples in Habana, Cuba by months 2015-2017.

Figure 3 Entomological risk stratification of malaria in Havana, Cuba.

Aspects taken into account for the entomological risk stratification of malaria

- Location of the municipalities (urban or peri-urban area) due to the preference of the *Anopheles* mosquito for peri

urban and rural areas.

- Presence of abundant vegetation
- Presence of permanent natural breeding sites
- Breeding sites with *Anopheles albimanus* at the courtyards
- Number of samples collected

RESULTS AND DISCUSSION

Of the six species of *Anopheles* reported in Cuba; five are present in the province of Havana. *Anopheles albimanus*, the main vector of malaria in Cuba, was registered in the 15 municipalities, although only the adult phase was found in the Centro Habana municipality. *Anopheles vestitipennis* was recorded in eight of the municipalities in Havana (Arroyo Naranjo, Boyeros, Cotorro, Guanabacoa, Habana del Este, La Lisa, Marianao and Playa). *Anopheles crucians* was recorded in four municipalities (Arroyo Naranjo, Boyeros, Habana del Este and Playa). *Anopheles atropos* and *Anopheles grabhamii* were found in two municipalities (Boyeros and Habana del Este. It is necessary to explain that for the entomological risk stratification only used the *An. albimanus* samples.

A total of 3 631 *An. albimanus* samples were received in the laboratory. 3 361 (92,6%) from natural permanent and temporal breeding sites and 270 (7,4%) from artificial containers in the houses and courtyards (Table 1). Natural lagoons, ditches, puddles and holes in ground were much more likely to contain larvae than other habitats. From artificial containers cement pots in construction areas, cans, small artificial container, sewerage, water storage tanks, and tubs were the most used by the mosquito (Table 2). A total of 20 different types of artificial containers were used by *An. albimanus* to breed which favors its proliferation in densely populated urban areas (Figure1).

An. albimanus was present throughout the year but the samples number increased in the May-October (rainy season) favored by the proliferation of natural and artificial breeding sites at this time Figure 2.

Taking into account the aspects for the entomological risk stratification of malaria and the analysis of our results, we can state that the municipalities with the highest risk were: Boyeros, Cotorro, Habana del Este and La Lisa. But the presence of natural breeding sites, in the peri urban areas of the municipalities 10 de Octubre, Guanabacoa, Regla, San Miguel del Padrón and Arroyo Naranjo should not be disregarded. The municipalities with the lowest risk of transmission were Habana Vieja, Centro Habana and Plaza de la Revolución (Table 1; Figure 3). Despite having high risk ecological characteristics, the municipalities Marianao, Playa, and San Miguel del Padrón reported low number of *Anopheles* samples but this was probably due to inconsistent sample collection during the routine surveillance

The important role of artificial containers in mosquito proliferation in courtyards and houses, closely related to lack of environmental sanitation and community participation, emphasizes the need to continue working on both aspects since it is not only important in the proliferation of mosquito vectors of arboviruses, but also in the proliferation of vectors for malaria in the urban ecosystem of Havana.

It is necessary to increase the monitoring of *An. albimanus* in general and in particular at construction sites. In 2017 these places contained artificial breeding sites with the highest presence of *An. albimanus* in the urban ecosystem of Havana.

In some municipalities, such as, Marianao, San Miguel del Padrón, and Playa was detected scanty surveillance in general on this mosquito vector due to problem with the capacity human resource for carried out the sampling. On the other hand, Boyeros

Table 1: Larval samples of *An. albimanus* in natural and artificial containers by municipalities, Havana province 2015-2017.

Municipalities	Total larval samples in natural breeding sites			Totals	Total larval sample in artificial containers			Totals
	2015	2016	2017		2015	2016	2017	
Arroyo Naranjo	15	18	15	48	3	7	9	19
Boyeros	766	834	854	2 454	20	18	25	63
Cerro	-	2	1	3	-	2	1	3
Cotorro	88	109	126	323	23	17	28	68
Centro Habana	-	-	-	-	-	-	-	-
10 de Octubre	45	16	14	75	1	1	-	2
Guanabacoa	11	11	4	26	4	3	5	12
Habana del Este	56	64	63	183	18	12	20	50
Habana Vieja	2	-	-	2	-	-	-	-
La Lisa	61	49	76	186	10	12	16	38
Marianao	-	1	1	2	2	1	1	4
Playa	2	5	11	18	2	1	2	5
Plaza de la Revolución	-	-	2	2	-	-	2	2
Regla	4	5	13	22	-	-	2	2
San Miguel del Padrón	-	1	16	17	-	1	1	2
Totals	**1 050**	**1 115**	**1 196**	**3 361**	**83**	**75**	**112**	**270**

Table 2: *An. albimanus* larval samples collected at permanent and temporary natural breeding sites sampled in Havana, 2015-2017.

Types of Permanent Natural Breeding Sites Sampled	Total larval samples		
	2015	2016	2017
Oxidation ponds	23	12	36
Natural Lagoons	535	533	579
Small lagoons	18	28	30
Drains	262	188	231
Streams	8	18	25
Dams	6	9	12
Concrete Channels	2	-	10
Rivers backwater	2	2	-
Marshy areas	-	32	39
Totals	**856**	**903**	**962**
Types of Temporary Natural Breeding Sites Sampled	**Total larval samples**		
	2015	2016	2017
Puddles	186	180	217
Holes in ground	5	23	21
Tire tracks of vehicles	1	-	2
Footprints of Animals	3	-	-
Coconut shells	1	1	-
Totals	**196**	**204**	**240**

and Habana del Este need special attention. This is due to during the last two years the numbers of national and international flights have increased which entails an increase in visitors from different parts of the world who enter through the international and national airport located in the Boyeros municipality. While in Habana del Este are located different beaches with a large number the national and international visitors in months of high presence of mosquitoes (May-October). In addition in both municipalities 5 species of *Anopheles* mosquito are registered.

It is known that in countries free of malaria for many years, such as Cuba, the populations lack protective immunity and are susceptible outbreaks when the meteorological and entomo-epidemiological conditions favor it [11]. Therefore, the monitoring and knowledge of the entomological aspects of *An. albimanus* constitutes practical and convenient information for the planning of activities related to malaria control at the time of a transmission of this disease in Havana.

Although in Cuba there is a great epidemiological surveillance system established nationally, the possibility of re-introduction of this disease in the country is possible because the migration of Cuban personnel from endemic areas has increased in the couple of years [12]. Studies on *An. albimanus* at this time in the country are very important for the prevention of the disease.

An example of re- introduction of malaria occurred in Jamaica. This country had also eradicated this disease a just few years before Cuba [13]. However, at the end of 2006 there was a report of cases from Haiti that led to a prolonged transmission of the disease mainly in the capital, due to the lack of human resources with the necessary training to deal with the outbreak, together with the low perception of risk in the population about the disease due to the time since its elimination and the appearance of transmission again [14].

CONCLUSION

These results can be used for communication and education to the human population about the prevention and control of this disease in case of occurrence of outbreaks leaded to a part of the generations born in the last 50 years after the eradication of the disease in Cuba that they do not know about it, to migrants and health personnel in general.

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