Larval Development of Mosquitoes and pH of Different Reservoirs in the City of Cartagena de Indias (Colombia)

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***Abstract*— This study aimed to determine the effect of water pH on the development of larvae of *Aedes aegypti, Anopheles albimanus* and *Culex* mosquitoes. Quarterly samplings from March 2012 until June 2013 were made. Mosquito larvae in three different zones of the city of Cartagena de Indias (Colombia) were collected and classified. The water where those were deposited, it was acidified with lemon juice and alkalized with sodium bicarbonate. The larvae were fed with poultry feed once a day during its development. The larvae of *A. albimanus* and *Culex* were better adapted in acidic media and those of *A. aegypti* in basic media. The ideal pH for larval growth was between 6.5 and 7.5.**

Keyword - pH, *Aedes aegypti, Anopheles albimanus, Culex*, Mosquito, Larval development.

I. INTRODUCTION

Diseases such as dengue, malaria, yellow fever, encephalitis, cholera and leishmaniasis, among others, entirely or partially incapacitate people who suffer from it. Its vectors are effective in reproducing and transporting viruses, without adequate control of them is prone to cause an epidemic. Epidemiology has among its purposes to describe and explain the dynamics of population health, identify the elements that compose it and understand the forces that govern it, to intervene during its natural development. Entomological surveillance is undoubtedly the most critical part of establishing early detection systems to anticipate possible arboviral diseases [1]. The study of mosquitoes transmitting vectors of dengue fever and yellow fever (*Aedes aegypti*), malaria (*Anopheles albimanus*) and viral encephalitis and West Nile fever (*Culex*) is a priority for reducing the risk of contracting them, through actions that increase environmental safety and reduce contact with vectors [1], [2].

Malaria is the most important parasitic disease for global health; it is caused by one of the five species of the *Plasmodium* genus: *P. falciparum*, *P. vivax*, *P. ovale*, *P. malariae* and recently described the effect of *P. knowlesi* as a causal agent of malaria infection in humans [3]. Historically, malaria has been responsible for the deaths of more people than any other parasitic disease and still has high rates of morbidity and mortality [4]. It is estimated that more than 2.7 million people, mainly children, die from malaria each year, and a population of more than 2 billion lives in endemic malaria regions [5].

Dengue fever is currently the most important arbovirus disease in humans, with an estimated between 50 and 100 million cases of dengue fever annually and between 250 000 and 500 000 cases of its most severe forms, dengue hemorrhagic fever and dengue shock syndrome. Nearly four million people are at risk in 128 countries worldwide [6]. *A. aegypti* is the primary vector of dengue and other diseases such as chikungunya and yellow fever [7]. However, current control interventions are not sufficiently efficient or sustainable, and more cost-effective strategies are needed [2], [8]–[10].

Other authors have been commissioned to study the incidence of factors in larval growth [1], [2], [11], [12], finding that control mechanisms may exist for these factors, and thus be able to reduce biological risk. The identification of critical points, suitable for directing immediate control actions, can be a way to make control programs more efficient [11], [12]. Spatial propitiators may be exogenous, such as pH, generated by factors or processes that are not directly related to the variable under study [2].

The lifespan of adult mosquitoes is affected by climatic conditions, mainly humidity and temperature, as they condition its feeding, reproduction and resting activities. During the rainy season, densities increase as a result of the availability of more nurseries [13]. Currently, it is necessary to use new vector control techniques at all stages in order to ensure the efficiency of the methods, while minimizing undesirable effects on the environment and public health. Spatial analysis has gained an important role in epidemiology in the last two decades [14]; therefore this study analysed the effect of water pH on the development of larvae of *Aedes aegypti, Anopheles albimanus* and *Culex* mosquitoes to identify its importance as an external factor in larval growth.

II. Materials and Methods

This paper corresponds to a cross-sectional, descriptive and observational study, such as other authors have done in the past in similar studies [15]–[17]. The observation units correspond to the number of larvae that pupate at each pH level of the habitat. *A. albimanus* larvae were collected in the Colombiatón neighbourhood, *Culex* and *A. aegypti* in the Cielo Mar neighbourhood. Both neighbourhoods were located in Cartagena de Indias (Colombia). The water where they were deposited was acidified with lemon juice and alkalinised with sodium bicarbonate. An LCD digital pH meter was used for pH measurement.

Larvae were collected in March 2012, June 2012, September 2012, December 2012, March 2013 and June 2013 between 6:00 AM and 7:00 AM. In the laboratory, the larvae were separated and counted, keeping 250 mL of water in glass containers. In each of them, between 20 and 40 mosquito larvae were added, being September and March when the most significant number of larvae were found. Each container had water with controlled pH from 4.5 to 10.5. The larvae were fed in the morning with chicken concentrate. The initial time in each case was the moment when the mosquito larvae were transferred to the vessels with different pH. From that moment on, the mosquito larvae were counted in each of the containers every 24 h. Then the amount that had passed into its next phase was calculated. The determinations were made by triplicate, and the results were expressed as the mean ± standard deviation. For this, Statgraphics Centurion XVI statistical package (Statgraphics Centurion Version 16.1.15, Chicago, EE. UU) was used [18]. The mean and standard deviation of the results were calculated in the analyses performed. The t-student test was applied for data analysis. The significance level was set at $p < 0.05$.

III. Results and discussions

Fig. 1 shows the larvae index at different pH. From the results, it can be seen that at pH of 4.5, the development of *A. aegypti* larvae was more affected than *A. albimanus* larvae ($p < 0.05$). *Culex* and *A. albimanus* larvae did not survive at pH 10.5, while almost 25 % of *A. aegypti* larvae passed into their adult state under the same conditions.

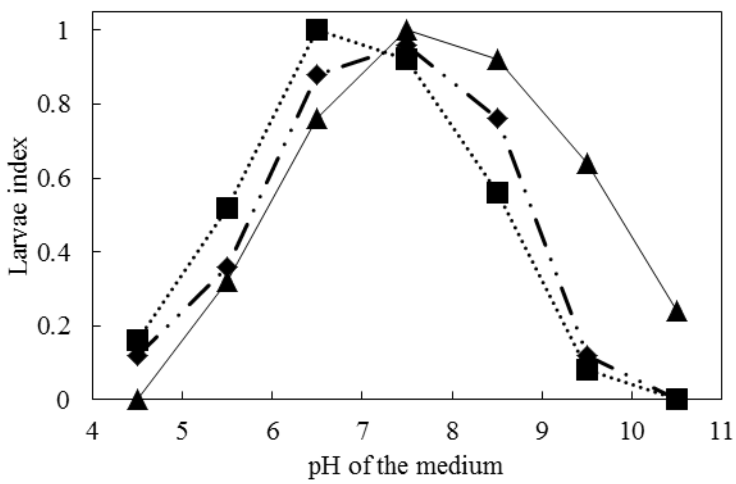

Fig. 1. The average percentage of larvae that passed to Adult relative to pH. Larvae of *Culex* ( ), *Anopheles albimanus* ( ) and *Aedes aegypti* ( )

The ideal pH for the development of *A. albimanus* larvae was around 6.5, meanwhile, for *A. aegypti* larvae it was around 7.5 and between 6.5 and 7.5 for *Culex* larvae. Furthermore, during the rainy periods (between September and March) the highest amount of embryonic development occurred in the city of Cartagena de Indias. In this city, the highest number of cases of dengue fever happens in the first and third semesters of each year according to DADIS [19]. In Cartagena, mosquito classes are found in areas of different socioeconomic strata, as reported by other authors in other tropical cities [1]. Similar results were obtained in the study reported by Honório *et al.*, [15], who conducted a longitudinal entomological survey with weekly egg collections in three neighbourhoods of Rio de Janeiro, Brazil, between September 2006 and March 2008 to determine the association between the meteorological and mosquito density variables, measured by ovitramps and sticky traps. The authors demonstrated that the mosquito density was positively and nonlinearly linked to the mean air temperature in three neighbourhoods. This reflects the importance of having external factors (pH, temperature, among others) in the growth of the larvae studied [1].

IV. CONCLUSIONS

By analysing spatial patterns of disease incidence and/or vector emergence and abundance could provide insight into the processes that determine disease risk and to identify areas where control actions are most needed. The larval index of mosquitoes as a risk factor for disease development and as an entomological indicator should be taken into account in epidemiological surveillance actions in the city. Adequate control must be maintained at all stages of the vectors. Vector control must be integral, combining the different types of methods with rationality, safety, efficacy, adaptability and acceptability criteria, aimed at the stages of the life cycle of the vectors.

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