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SPATIAL DISTRIBUTION OF THE Aedes aegypti MOSQUITO IN A MUNICIPALITY WITH A HIGH INCIDENCE OF DENGUE CASES IN MINAS GERAIS

Distribuição espacial do mosquito Aedes aegypti em município com alta incidência de casos de dengue em Minas Gerais

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ABSTRACT

Dengue is an arbovirus whose main vector is the *Aedes aegypti* mosquito. This disease has nonspecific symptoms and can lead to the death of the infected individual. The high incidence of cases of the disease has been a major challenge for public health in Brazil and in the world, especially in tropical regions where rainfall is higher. The objective of this study was to evaluate the spatial distribution of the egg positivity index (IPO) of the Aedes aegypti mosquito. The entomological investigation method was based on the ovitrap trap, which were distributed throughout the urban area of the municipality, in a total of 241 residences and 5,543 ovitraps in all months of the year 2019. verification of the spatial distribution of the mosquito infestation. Of the 5,543 ovitraps installed, the IPO obtained was 25% (1,410/5,543) and positive ovitraps were identified in all areas, with the highest IPO observed in area 6 with 44.62% (195/437), which has the highest incidence of cases of dengue. In the period corresponding to the rains, the highest frequency of positive ovitraps was observed in the months of March 55% (133/241), April 44% (216/482) and January 40% (196/482). The spatial distribution of the mosquito presents a homogeneous behavior in the neighborhoods, and in only one of them it was not verified positivity of the ovitraps. The highest IPO verified in the rainy months suggests the association between the factors rainfall index and positivity of the ovitraps.

Keywords: Trap. Oviposition. Geoprocessing.

INTRODUTION

Dengue is a disease transmitted to humans through the bites of *Aedes aegypti* mosquitoes infected by an arbovirus belonging to the *Flaviviridae* family (PEREIRA et al., 2017). This disease has nonspecific symptoms, since when infected the individual can present symptoms such as high fever, intense headache, pain behind the eyes, muscle pain and joint pain, nausea, vomiting and rashes, even bleeding and shock, which can progress to death (WHO, 2012). This vector is also a transmitter of yellow fever, *chikungunya* and *zika*, both diseases with characteristics similar to dengue (BRASIL, 2015).

In recent decades, dengue has become a huge obstacle to public health in Brazil and in the world, due to the problems it causes to the health of the population. The World Health Organization (WHO) estimates that 2.5 billion people – 2/5 of the world's population – are at risk of contracting dengue and that about 50 million cases occur annually (PAHO/WHO). In an epidemiological bulletin from the Ministry of Health, reported that Brazil registered 1,530,940 probable cases of dengue in 2023, between epidemiological weeks 01 to 35. Compared to the same period in 2022, there were 1,313,805 probable cases of dengue fever recorded. As for deaths, in 2023 there were 946, and in the same period of 2022 there were 960, however, until the publication of the bulletin there were 279 deaths under investigation due to the disease (BRASIL, 2023).

The abundance of domestic water reservoirs is one of the likely causes of the success of the dengue epidemic. Climatic factors, such as temperature, precipitation and humidity, can cause seasonality in transmission, with epidemic peaks in warmer and wetter seasons (DONALÍSIO & GLASSER, 2002). Other factors that favor the proliferation of mosquitoes carrying the disease agent may be associated with the irrational use of the environment and the lack of basic sanitation conditions for the population (CATÂO, 2012).

To intervene in the proliferation of the mosquito, the National Campaign for the Eradication of the *Aedes aegypti* mosquito was developed, an epidemiological surveillance system, which is responsible for monitoring and disseminating data in addition to reporting on the behavior of the disease (BRASIL, 2008). Assistance in the municipality must be structured and capable of notifying and adequately treating the patient, preventing deaths (BRASIL, 2008).

Controlling *Aedes aegypti* is a major challenge, especially in developing countries. Available technology includes physical, chemical and biological control measures, with the first two groups being most intensively used (DONALÍSIO & GLASSER, 2002). The use of egg collection traps is of great importance for defining population density indicators, based on the assumption that the number of eggs deposited reflects the abundance of mated and fed females, therefore actively reproducing, present in the environment. The evaluation of this tool proved to be capable not only of detecting the presence of the mosquito, but also of indirectly estimating the density of females present in the environment (ACIOLI, 2006).

Applied to public health issues, geoprocessing allows disease mapping and risk assessment, helping to identify, locate and monitor populations. The analysis of the spatial distribution of cases of a given disease or condition in municipalities supports studies on transmissibility in regions and areas of coverage, allowing rapid access to the information needed to monitor cases. It also creates conditions for analyzing where the population is most affected, facilitating the work of professionals and ongoing education actions (BARCELLOS & RAMALHO 2002).

Costa (2011) reported that the use of geoprocessing can be an effective method for identifying priority areas where control actions are needed to interrupt disease transmission and reduce its incidence. Therefore, the aim of this study was to evaluate the spatial distribution of the *Aedes aegypti* mosquito egg positivity rate in a municipality with a high incidence of dengue cases in Minas Gerais, Brazil.

MATERIAL AND METHODS

The research was carried out from January to December 2019, in the municipality of Patos de Minas, located in the Alto Paranaíba region of the state of Minas Gerais, Brazil. The municipality has an area of 3,190.187 km², an average altitude of 833 meters, with a territorial extension of 1,197.78 km², including the 50 km² of the urban area, and has a population of approximately 152,488 inhabitants (IBGE, 2020), has a climate called Tropical de altitude, characterized by an average maximum temperature of 27.6ºC and an average minimum of 16.6ºC, relative humidity of 72% and average annual precipitation: 1,473.75 mm. The months with the highest rainfall are between the months of October to April with an average of 192 mm and the dry months between May to September, with an average of 20 mm (Climate-Data.Org, 2019).

To investigate mosquito oviposition, the neighborhoods were grouped into 11 health areas (Figure 1) pre-established by the Municipal Dengue Control Program of the Municipal Health Department of the Municipality. Area 1 is composed of the neighborhoods Alto Limoeiro, Morada do Sol, Alto Colina, Alto da Boa Vista, Alto da Colina, Moradas, Terra Nova, Jardim Esperança, Residencial Monjolo and Alto da Serra; area 2 composed of neighborhoods Bela Vista, Nova Floresta, Jardim Califórnia, Novo Horizonte and Valparaíso; area 3 composed of neighborhoods Caiçaras, Alto dos Caiçaras, Jardim Floresta, Vila Garcia, Aurélio Caixeta, São Francisco, Jardim Centro, Jardim Paraíso and Abner Afonso; area 4 by neighborhoods Alvorada, Nossa Senhora de Fátima, Santa Helena, Residencial Sorriso, Residencial Barreiro, Jardim Quebec, Jardim Itamarati and Coração Eucarístico; area 5 composed of neighborhoods Padre Eustáquio, Caramuru, Cerrado, Nossa Senhora das Graças, Laranjeiras, Queiroz de Melo, Alto dos Caiçaras and Caiçaras; area 6 composed of neighborhoods Jardim América, Rosário, Copacabana, Guanabara, Lagoinha, Sobradinho and Centro; area 7 composed of neighborhoods Santa Terezinha, Brasil, Várzea, Brasília, Santo Antônio, Nossa Senhora Aparecida and São José Operário; area 8 composed of neighborhoods Lagoa Grande, Cônego Getúlio, Vila Rosa, Jardim Paulistano, Santa Luzia, Cristo Redentor, Cidade Nova and Santa Terezinha; area 9 composed of neighborhoods Jardim dos Andradas, Jardim Peluzzo, Jardim Céu Azul, Ipanema, Planalto, Distrito Industrial I-II, Residencial Gramado and Campos Elíseos; area 10 composed of neighborhoods Eldorado, Boa Vista, Antônio Caixeta, Jardim Recanto, Cidade Jardim and Sebastião Amorim, and area 11 composed of neighborhoods Jardim Panorâmico, Jardim Vitória, Morada da Serra, Belvedere and Afonso Queiroz.

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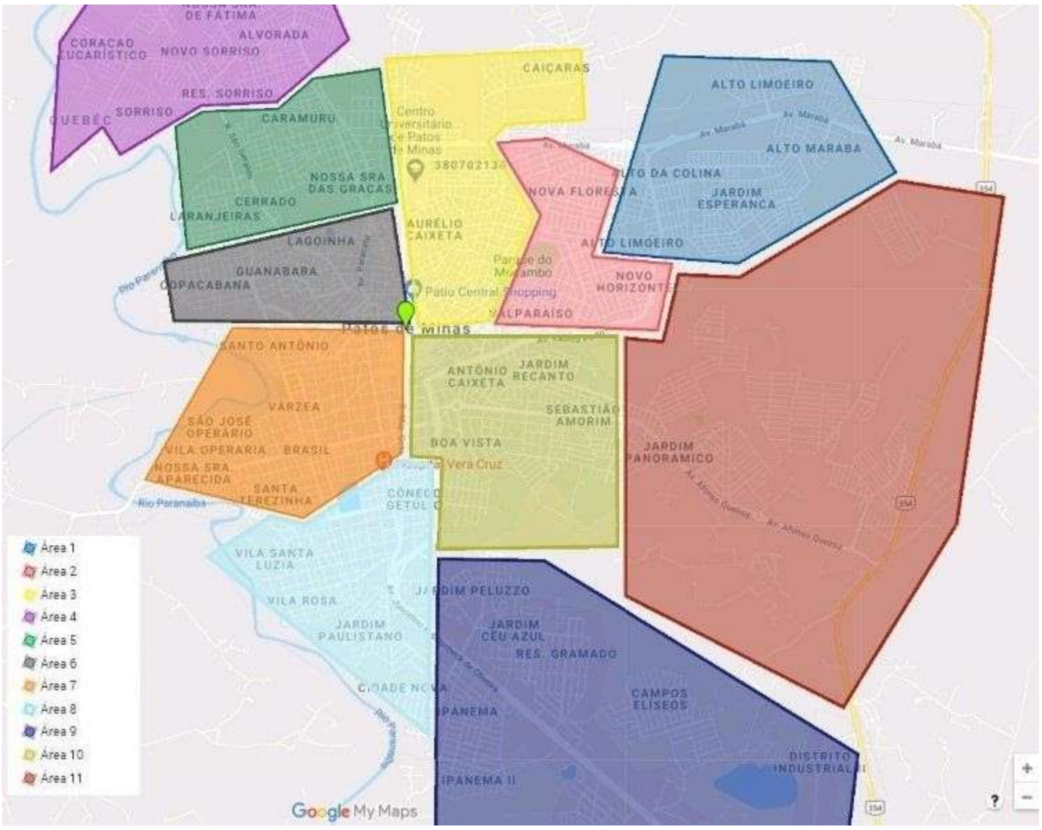


Figure 1. Map of the municipality of Patos de Minas – MG with the identification of the 11 health areas established by the Municipal Program to Combat Dengue, Patos de Minas – MG 2020

The entomological investigation method was based on an ovitrap trap, consisting of a black plastic container measuring 9 cm in height and 12 cm in diameter, with a capacity of 580 mL, and a 13.5 cm long and 2.5 cm wide Eucatex straw. The rough part faces outwards from the container for oviposition, plus 250 mL of water and 1 mL of yeast infusion. Each straw was identified by a code that was then recorded on a field form.

The ovitraps were distributed by the endemic agents of the Municipal Dengue Control Program throughout the urban area of the municipality, to a total of 241 residences from 77 neighborhoods, spread out within a 200 meter radius of each other. The homes selected for distribution of the traps were based on the availability of the residents, as verified through contact made by the agents. The traps were installed during all months of 2019, twice a month (482 installations per month), except in the months of March and December when only 1 installation was installed (241/month), and in July with 3 installations (723), for a total of 23 collections per residence, totaling 5,543 ovitraps in the year. The traps were installed in the morning in the outdoor area of each residence, in covered areas, at a height of 80 cm to 150 cm, removed after 7 days and reinstalled the following week. The straws were collected in a vertical position, attached with paper clips to cardboard boxes and sent to the Dengue Control Program Laboratory.

The egg count was performed using a stereoscopic magnifying glass and a manual counter. The Egg Positivity Index (EPI) was determined by the presence or absence of mosquito eggs. For counts greater than 200 eggs, a special vector survey (SVS) was carried out, which consisted of reviewing and spraying all properties on the block and the sides of the blocks around the residence that had a high number of eggs. To verify the spatial distribution of the infestation by the *Aedes aegypti* mosquito, the geographic coordinates of all residences were identified using the Terra View program, which generates data using the TerraLib geoprocessing library (https://www.dpi.inpe.br/cursos/ser301/softwares.html). Spatial analysis was performed using Kernel density. The basic analysis is done based on the specific location of the occurrence of each variable investigated in the georeferenced study region, using the Environmental Analysis by Geoprocessing methodology according to Xavier-da-Silva & Carvalho-Filho (1993).

RESULTS AND DISCUSSION

Of the 5,543 ovitraps installed in 2019, the EPI obtained was 25% (1,410/5,543). Among the 77 neighborhoods analyzed, the only one that did not present positivity was Jardim Floresta, identified in area 3. The other neighborhoods presented positivity at some point in the year. Positivity rates greater than 200 eggs were identified in 42.85% (33/77) of the neighborhoods, which came from sanitary areas 1 to 10. The only one that did not present an EPI greater than 200 eggs was 11. In all of them, positive ovitraps were identified, with the highest EPI observed in areas 6 with 44.62% (195/437), 7 with 33.91% (156/460) and 5 with 32.21% (163/506) (Figure 2 and Table 1).

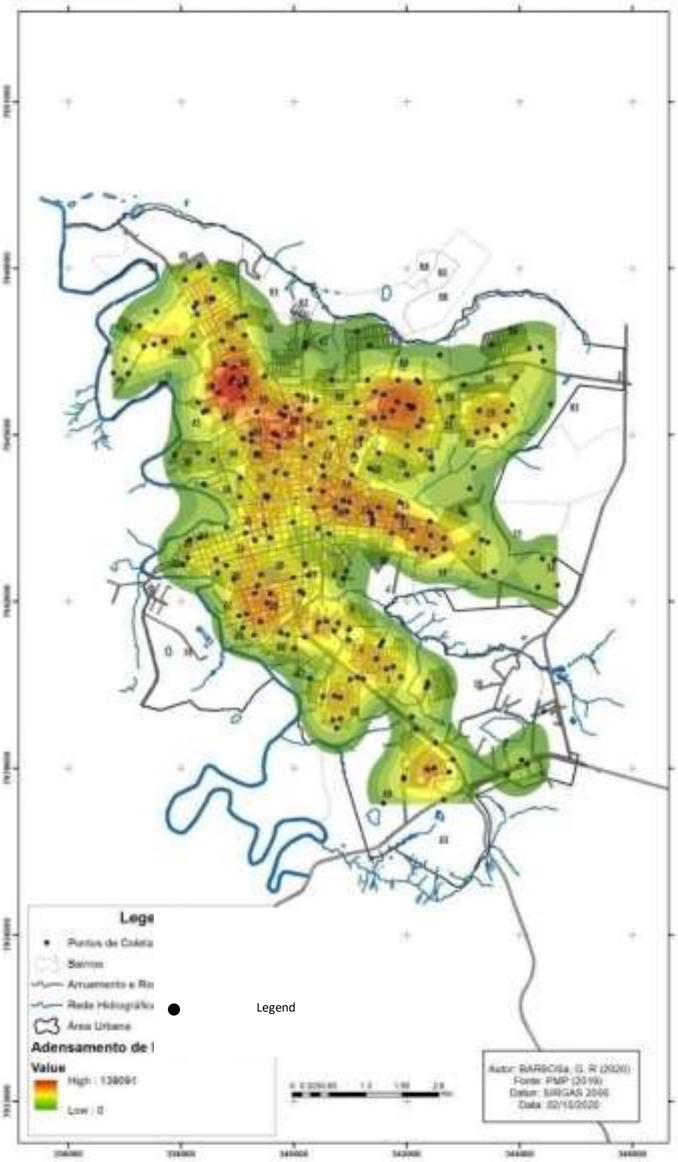


Figure 2. Map of the spatial distribution of the *Aedes aegypti* mosquito egg positivity index measured by ovitraps in the municipality of Patos de Minas – MG, 2019 (Source: PMP, 2019)

Table 1. Neighborhoods of the municipality of Patos de Minas -MG listed according to the map in Figure 2

ID	Neighborhoods	ID	Neighborhoods	ID	Neighborhoods
1	Distrito Industrial I	27	Santa Luzia	56	Rosário
2	Distrito Industrial II	28	Conego Getúlio	57	Aurélio Caixeta
3	Resid. Gramado	29	Cristo Redentor	59	Abner Afonso
4	Jardim Céu Azul	30	Lagoa Grande	60	Caiçaras
5	Jardim dos Andradas	31	Brasília	61	Jardim Itamarati II
6	Jardim Peluzzo	32	Nossa Senhora Aparecida	62	Jardim Itamarati I
7	Centro	33	Brasil	63	Queiroz de Melo
8	Eldorado	34	São José Operário	66	Das Palmeiras Alto
9	Jardim Panorâmico	35	Várzea	67	Caiçaras
10	Boa Vista	36	Santo Antônio	68	Valparaíso
11	Afonso Queiroz	37	Sobradinho	69	Vila Garcia
12	Morada da Serra	38	Jardim América	70	Jardim Califórnia
13	Cidade Jardim	39	Copacabana	71	Jardim Floresta
14	Belvedere	40	Guanabara	72	São Frascisco
15	Jardim Recanto	41	Laranjeiras	73	Jardim Paraíso
16	Antônio Caixeta	45	Redidencial Barreiro	74	Jardim Centro
17	Sebastião Amorim	46	Jardim Quebec	75	Novo Horizonte
18	Campos Elíseos	47	Coração Eucarístico	76	Alto da Colina
19	Distrito Industrial III	48	Residencial Sorriso	77	Jardim Aquarius
20	Ipanema	49	Alvorada	78	Nova Floresta
21	Cidade Nova	50	Nossa Senhora de Fátima	79	Jardim Esperança
22	Jardim Paulistano	51	Padre Eustáquio	80	Residencial Monjolo
23	Novo Planalto	52	Caramuru	81	Alto da Serra
24	Planalto	53	Cerrado	82	Morada do Sol
25	Vila Rosa	54	Lagoinha	83	Bela Vista
26	Santa Terezinha	55	Nossa Senhora das Graças	84	Alto Limoeiro

The highest incidence of the Aedes aegypti mosquito was recorded in sanitary unit 6, where the Centro neighborhood is located. This region had the highest number of dengue cases in the city, confirming that the populations most exposed to mosquitoes are at greater risk of acquiring the infection (Costa et al., 2008).

According to the Minas Gerais State Health Department through the epidemiological bulletin, 6,699 cases of dengue were identified in Patos de Minas in

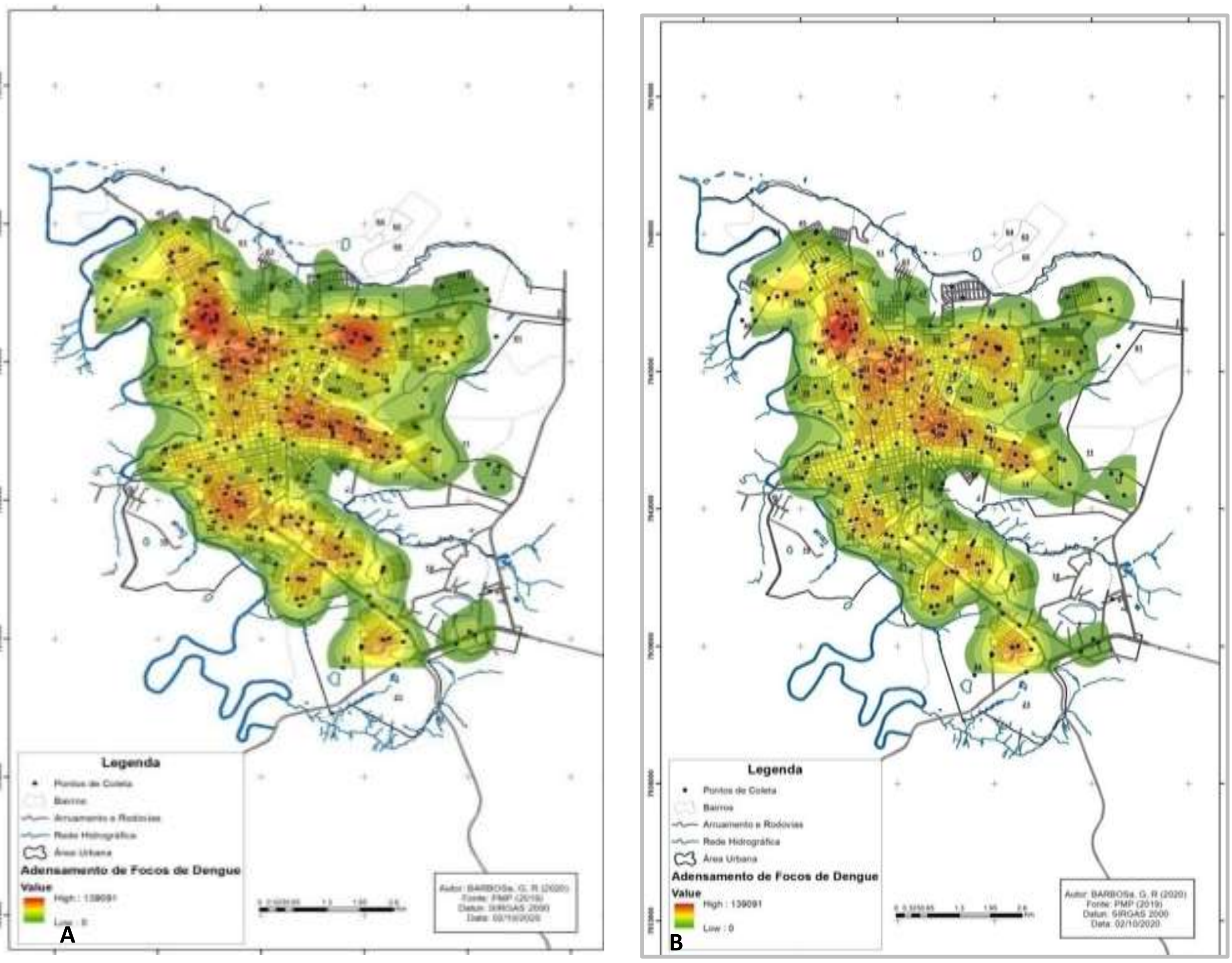
2019, which is considered a high incidence (BRASIL, 2020). According to experts, this increase was related to the new increase in the circulation of dengue serotype 2, which had not occurred since 2008, and also due to the summer, which presented high temperatures and rains that favored the reproduction of the mosquito (ANAHP, 2020).

In the study carried out by Nunes et al., (2010), in the city of Santana, state of Amapá, 30 blocks of a neighborhood were selected for the installation of ovitraps. The blocks were divided into 4 blocks, A $_{(1-9)}$, B $_{(10-18)}$, C $_{(19-26)}$ and D $_{(27-32)}$. They were collected from the ovitraps 9,820 *Aedes aegypti* eggs, with an EPI of 36.6% and an Egg Density Index (EDI), which is the result of dividing the number of eggs by EPI, of 89.2%. The EDI found in blocks A, B, C and D was 20.3%, 13%, 2.3% and 1%, respectively. The EDI found was: A = 117.7; B = 62.8; C = 10.8 and in D = 36.6. The highest egg laying rates were concentrated in block A, with the others decreasing as they moved away from this block. It was found that the traps installed in the region closest to the city center, where the largest number of residences, commercial establishments and a school are located, were those that presented the highest number of eggs collected.

In the research carried out by Acioli (2006) in Recife – PE, 464 ovitraps were distributed among the five selected neighborhoods and 4,695,593 eggs were counted. The largest absolute number of *Aedes* spp. eggs came from the area located closer to the city center, but the area with the highest intensity of mosquito infestation was on the outskirts. A comparison with other studies showed a correlation between precipitation and the EPI, which suggests that the rains certainly promoted the hatching of eggs present in the environment (MARQUES et al., 1993; DIBO et al., 2008; COSTA et al., 2008).

Marques et al (1993), demonstrated that egg traps, in addition to their greater capacity to attract females to oviposit – even in the presence of natural breeding sites – are more efficient than larvitraps. They also observed that the use of ovitraps is a sensitive method for evaluating the effects of thermal fogging (application of chemical adulticides through spatial spraying), as these traps showed a significant reduction in the average number of eggs deposited in them, detecting a rapid decrease in the vector population. The trap can also be used to determine the presence or absence of *Aedes aegypti* populations in areas where control measures are being applied (REITER et al., 1991).

The EPI observed in the rainy season was 36% (1053/2892) and in the dry season 14% (394/2651). In the period corresponding to the rains, the highest frequency of positive ovitraps was observed in areas 2, 5 and 6, in the months of March 55%, (133/241), April 44% (216/482) and January 40% (196/482) (Figure 3). Also, in the month of April, the highest positivity rate was observed considering counts above 200 eggs 6% (29/482). In the months corresponding to the dry season (May to September), it was observed that despite the climatic conditions, areas 5 and 6 maintained a high positivity rate, with 40% (196/482) in May, 12% (60/482) in June, 7% (56/723) in July, 9% (44/482) in August and 7% (36/482) in September (Figure 4). On the other hand, the other areas 2, 7, 8, 9 and 10 showed a reduction in



the EPI compared to the rainy season.

Figure 3. Map of the spatial distribution of the positivity index of *Aedes aegypti* mosquito eggs measured by ovitraps in Patos de Minas - MG, 2019. **A**. Referring to the rainy season (October to April); **B**. Referring to the dry season (May to September).
Fonte: PMP, 2019

When analyzing the coldest and driest periods of the year (conditions less favorable to the development of the mosquito), Costa et al (2008) observed a sharp reduction in the adult population of the vector and, although to a lesser extent, the mosquito was also present in the coldest and driest months of the year. The study also indicates that between March 2003 and February 2005 in the municipality of Uberlândia-MG, temperature and rainfall significantly influenced the increase in the number of breeding sites and the population dynamics of *Aedes aegypti*. Similar results were also observed by Dibo et al (2008), in the municipality of Mirassol, SP, Southeast region of the country, between November 2004 and November 2005. Through weekly collections of eggs and larvae, the results already described on the proliferation of *Aedes aegypti* were confirmed, showing that the number of eggs, larvae and mosquitoes is more frequent in periods of higher temperatures and rainfall. In the study conducted by Costa et al (2008) in Uberlândia, Minas Gerais, from March 2003 to February 2005, ovitraps were distributed biweekly in three neighborhoods in the city center and two in the outskirts. Of the 1,428 traps exposed, 303 tested positive over the 24 months sampled. 13.5% of the positive traps were identified in the dry season and 86.5% in the rainy season. It was observed, therefore, that rainfall contributed to the multiplication of the mosquito, due to the increase in its breeding sites.

The maintenance of egg positivity, even in dry months, may be associated with the presence of environments favorable to the multiplication of the vector. Donalíso & Glasser (2002) state that the main larval environment in tropical countries corresponds to water storage deposits, such as old tires, water tanks, tanks, wells, cisterns, gutters, swimming pools, among others, which generally do not depend on rain to contain water. Places where rainfall is irregular have water deposits close to homes, facilitating the breeding of the *Aedes aegypti* mosquito, increasing the infestation rate even in dry months. In Brazil, studies identify that plant pots, tires, water tanks, flower boxes in cemeteries, in addition to the inadequate disposal and collection of these materials and household waste, make these efficient breeding sites for *Aedes aegypti* (CATÃO, 2012).

In regions identified with positivity above 200 eggs, specific measures to combat the vector were adopted, including spraying all properties on the block and the sides of the blocks around the residence. The egg stage is difficult to control, with no available or recommended products with ovicidal action for use in public health. In the immature stages (larvae), biological or chemical products can be used.

Currently available as alternatives for mosquito control, in addition to methoprene, one of the oldest juvenile hormone analogues developed, pyriproxyfen, also chemically related to natural juvenile hormone (JH), is highly effective. Both are recommended by the World Health Organization (WHO) for controlling *Aedes* spp. in drinking water (BRAGA & VALLE, 2007).

According to the Ministry of Health (2009), for the control of adult mosquitoes, the spatial application of Ultra Low Volume (ULV) has the specific function of eliminating female *Aedes aegypti* and should only be used to block transmission and control outbreaks or epidemics (BRAZIL, 2009). This action is part of the set of emergency activities adopted in these situations and its use must be concomitant with all other control actions, especially the reduction of mosquito sources. For this, it is necessary to verify routine activities, with priority being given to controlling focal actions (BRASIL, 2009).

CONCLUSION

The egg positivity rate (EPI) observed in 2019 in Patos de Minas, MG, was 25%. The spatial distribution of the mosquito shows homogeneous behavior in the neighborhoods, and in only one neighborhood, positivity of the ovitraps was not observed. The higher EPI observed in the rainy months suggests an association between the factors of rainfall index and positivity of the ovitraps.

The observation of the high frequency of positivity also in the dry season suggests that health education measures be carried out throughout the year, by trained health agents, in order to raise awareness among the population about the environments favorable to the multiplication of the vector and the main sanitation measures..

AUTHORS' CONTRIBUTION

Leandro Vieira de Oliveira- Methodology, formal analysis, validation, research and writing
Guilherme Nascimento Cunha- Review and editing formal analysis
Daniele Cristine Nunes- Review, editing and formal analysis
Mariana Assunção de Souza- Supervision, project administration, validation, review
Camila de Fátima Nascimento - Proofreading, editing and writing

DECLARATION OF CONFLICTS OF INTEREST

None.

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