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Environmental factors associated to dengue fever occurrence in the Chapecó municipality, Santa Catarina State

Fatores ambientais associados à ocorrência de dengue no município de Chapecó, Estado de Santa Catarina

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Abstract

This study aimed to evaluate the influence of environmental factors on the occurrence of dengue and the spatial distribution of the cases in the municipality of Chapecó, Santa Catarina State. Dengue cases were obtained from the Epidemiological Surveillance Department of Santa Catarina and Epidemiological Surveillance of Chapecó. The data of positive containers for *Aedes aegypti* were obtained from the Environmental Health Surveillance of the municipality. In 2015 and 2016, Chapecó registered 819 autochthonous cases of dengue. It showed a significant relationship between the number of foci of the vector and the minimum and maximum temperatures, as well as the cases of dengue and the population size of the neighborhoods evaluated. This study indicated a multifactorial influence on mosquito proliferation and the occurrence of viral transmission of dengue in the municipality of Chapecó. It reinforces the need of an interdisciplinary approach to prevent and control this endemic disease.
Key words: *Aedes aegypti*. Foci. Temperature. Arboviruses infections.

Resumo

Este estudo objetivou avaliar a influência de fatores do ambiente para a ocorrência de dengue e a distribuição espacial dos casos no município de Chapecó, Estado de Santa Catarina. Os casos de dengue foram obtidos junto à Diretoria de Vigilância Epidemiológica de Santa Catarina e Vigilância

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Epidemiológica de Chapecó. Os dados de recipientes positivos para *Aedes aegypti* na Vigilância em Saúde Ambiental do município. Em 2015 e 2016 Chapecó registrou 819 casos autóctones de dengue. Apresentou relação significativa entre o número de focos do vetor e as temperaturas mínimas e máximas, assim como os casos de dengue com o tamanho populacional dos bairros avaliados. Este estudo indicou influência multifatorial sobre a proliferação do mosquito e a ocorrência da transmissão viral de dengue no município de Chapecó. Reforça a necessidade de uma abordagem interdisciplinar de ações de prevenção e controle desta endemia.
Palavras chave: *Aedes aegypti*. Focos. Temperatura. Infecções por arbovírus.

Introduction

Dengue fever is currently the most prevalent arboviruses worldwide, and around 40% of population is at risk(1). Risk in Brazil is becoming more widespread once the main vector of transmission, *A. aegypti* mosquito (Linnaeus, 1762) (Diptera: Culicidae), has dispersed all over the country and epidemics have been recurrent. The *A. aegypti* (Diptera: Culicidae) has evidencing fast ecologic adaptation to urban environments(2) and its reproduction has been benefited from the lack of basic sanitation as well as the poor infrastructure in cities(3). That vector is adapted to the anthropic urban environment, which provides the necessary contribution to the adult mosquito to survive and a variety of habitats for the immature ones. Some factors contribute for the mosquito to develop, such as inadequate discarded materials, which become potential breeding sites, as well as temperature variations and rainfall.

Dengue fever is caused by a virus of *Flavivirus* genus. Nowadays, four virus serotypes are known (DENV-1, DENV-2, DENV-3 and DENV-4)(4) and the transmission occurs through the female mosquito's bite during man-mosquito-man cycle. After repasting of infected blood, the mosquito is able to transmit the virus after eight to twelve days of intrinsic incubation.

In the year of 2016, 1.500.535 cases of dengue were registered in Brazil. In 2017, 249.056 cases(5). Santa Catarina was the last state of the country to register a dengue viral transmission. First epidemic occurred in 2015 in the municipality of Itajaí. In that year, 3.605 cases were registered in the state and the number of cases increased to 4.376 in 2016. In Chapecó, the biggest city (213.000 inhabitants)(6) of the west region of Santa Catarina, autochthonous transmission of dengue was registered in 2013 (15 cases), 2015 (34 cases), and 2016 (785 cases) (7-8). Considering that scenario, our study aimed to 1) describe spatial distribution of dengue cases in Chapecó, 2) evaluate the influence of environmental factors to the proliferation of *A. aegypti* and, by consequence, dengue occurrence.

Material and Methods

Data collection

The study was carried out based on the data from the municipality of Chapecó, Santa Catarina State, Brazil, referring to the cases of dengue and positive containers for *A. aegypti* (number of focuses - LIRa) from January 2015 to December 2016. The assessment of the relationship between dengue confirmed cases and the environmental associated factors with vector proliferation allows for an understanding of the risks and the basis of management and prevention plans of new outbreaks or epidemics. Dengue cases were obtained from data of the Epidemiological Surveillance Office of Santa Catarina(8) and the Department of Health in the Epidemiological Surveillance of Chapecó(9). The foci data were obtained from the Environmental Health Surveillance Department of the municipality and considered only those identified at strategic areas. Climatic data on temperature (minimum, average and maximum monthly), rainfall and relative humidity were obtained from the Environmental and Hydrometeorology Information Center of Santa Catarina[10], station of the studied area.

In this work, the presence of larvae of the *A. aegypti* mosquito found at strategic areas was considered "focuses". According to the National Program for Dengue Control (PNCD), a strategic area is characterized as that property where several potential breeding sites are found for the vector[11]. Breeding sites are considered all the containers which contain water stored at the time of inspection by endemic Agents to Combat Endemic diseases, being classified in water tank, cisterns, small reservoirs, swimming pools, tires, garbage and natural reservoirs aquariums, ornamental fonts, drains, vases, and other natural reservoirs[11]. The search for the outbreaks was done by the municipality environmental services, by the Agents to Combat Endemic diseases. All residences and commercial facilities were visited, according to the recommendation of the PNCD.

From the recorded dengue cases obtained in the Epidemiological Surveillance, a map of the spatial distribution was built, in which, for each dengue case address, a point was inserted, using the program Google Earth Pro 7.1.7 2600.

Data analyzes

Results of foci were initially explored in a descriptive way in terms of frequency. Next, the weather data with *A*. *aegypti* foci were related to strategic areas by the Pearson correlation index. Correlation tests were performed in the PAST program version 3.14 14 and those with a *p value* <0.05 were considered significant.

The monthly number of dengue cases was also correlated (Pearson) to the climatic data and to the population and the number of strategic areas registered by the Municipal Dengue Control Program, by neighborhood.

A Principal Component Analysis (PCA) was used to assess the relationship between climatic variables and the number of dengue fever cases and the number of monthly focuses. For this, the PAST software was used. The data were previously transformed into Log (x + 1).

Ethical aspects

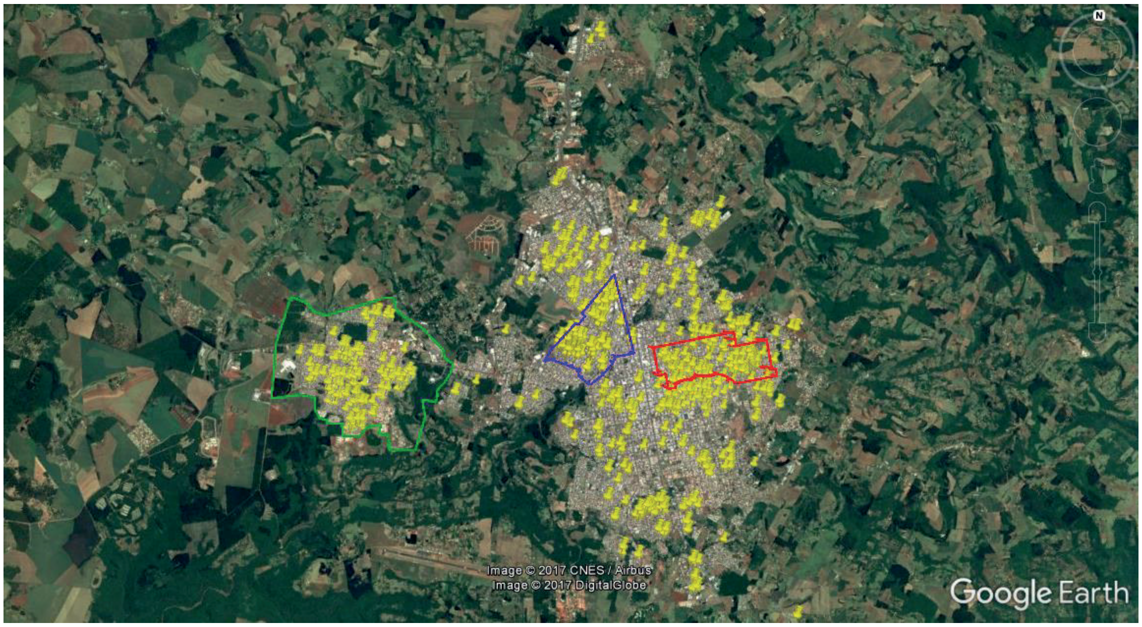
An authorization was obtained from the Health Department of the municipality of Chapecó to access the records of dengue cases that occurred in the period. The study followed the regulations set in Resolution 466/2012 of the National Health Council.

Results

In 2015 and 2016, Chapecó-SC recorded 819 cases of autochthonous dengue, being 34 in 2015 and 785 in 2016, that occurred in 36 of the 39 neighborhoods. Three neighborhoods were responsible for 35.80% of the cases.

The spatial distribution of dengue cases in 2016, the year in which there was the highest incidence of cases indicates two central districts and a peripheral one, such as those with the highest rate of viral transmission. Presidente Médici District (highlighted in red) is characterized as being residential. São Cristóvão district (highlighted in blue) is a commercial district that concentrates 45 of the 300 strategic points registered by the Environmental Health Surveillance Department. Efapi District (highlighted in green) is a residential and commercial one with more than 40.000 inhabitants, located in the middle of the two largest industries and the two largest universities in the city, which are regions with a large population flow (Figure 1).

Figure 1 - Spatial distribution of dengue cases in Chapecó-SC, Brazil, 2016, evidencing the three neighborhoods with the highest number of cases from January 2015 to December 2016.



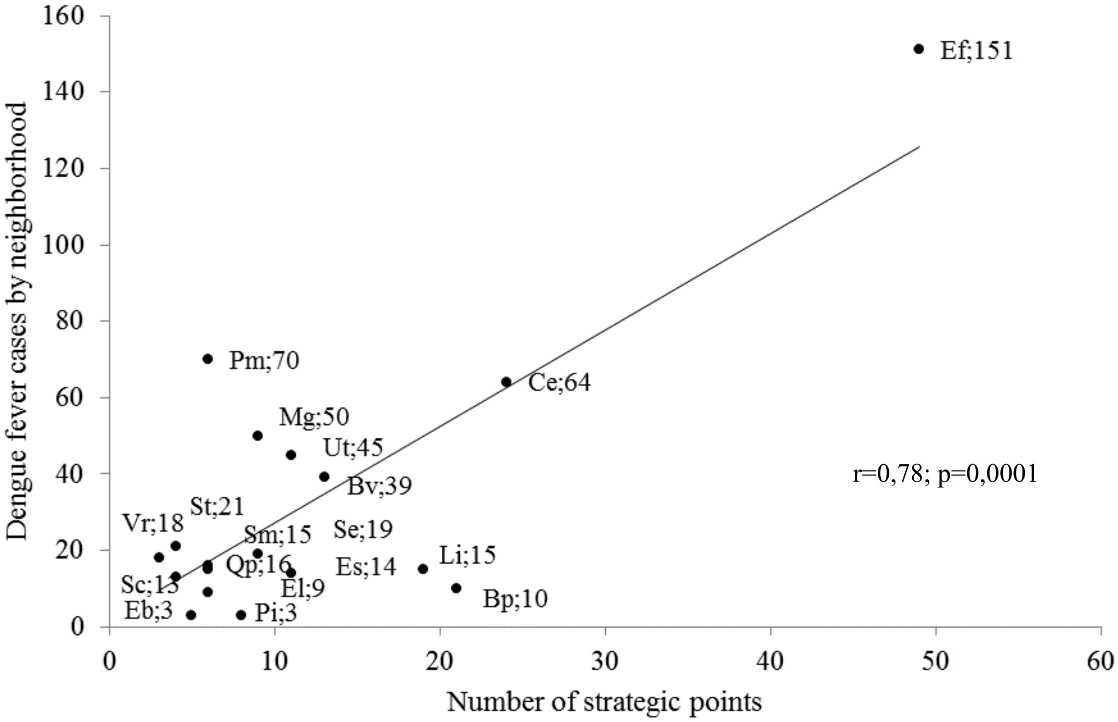
The monitoring of the strategic areas identified the presence of positive containers for *A. aegypti* in all neighborhoods. The strategic areas are understood by the places where there is great concentration of preferential containers for the oviposition of the female mosquito *A. aegypti.* The types of containers considered were water boxes, cisterns, small reservoirs, swimming pools, tires, garbage and natural reservoirs (Table 1). One of the neighborhoods with the highest infestation (Efapi) in the city was among those with the highest number of dengue cases during the 2016 epidemic. In other districts, this relationship was not evident (Figure 2).

Table 1 – Main *A. aegypti* positive recipient types in Chapecó-SC from January 2015 to December 2016.

Year	Month	Cisterns	Small ponds	Tires	Garbage
	Jan	23	19	15	43
	Feb	6	23	14	51
	Mar	14	14	14	52
	Apr	16	16	16	49
	May	4	27	11	54
	Jun	8	16	20	56
2015	Jul	0	0	0	60
	Aug	0	25	0	25
	Sep	24	0	29	47
	Oct	6	0	11	84
	Nov	25	9	27	39
	Dec	14	2	14	68
	Jan	3	15	19	51
	Fev	7	7	13	66
	Mar	10	7	8	57
	Apr	16	0	11	68
	May	0	12,5	12,5	75
	Jun	0	0	0	0
2016	Jul	0	0	0	0
	Aug	0	0	0	0
	Sep	0	0	0	0
	Oct	0	33	0	67
	Nov	0	25	67	0
	Dec	50	50	0	0

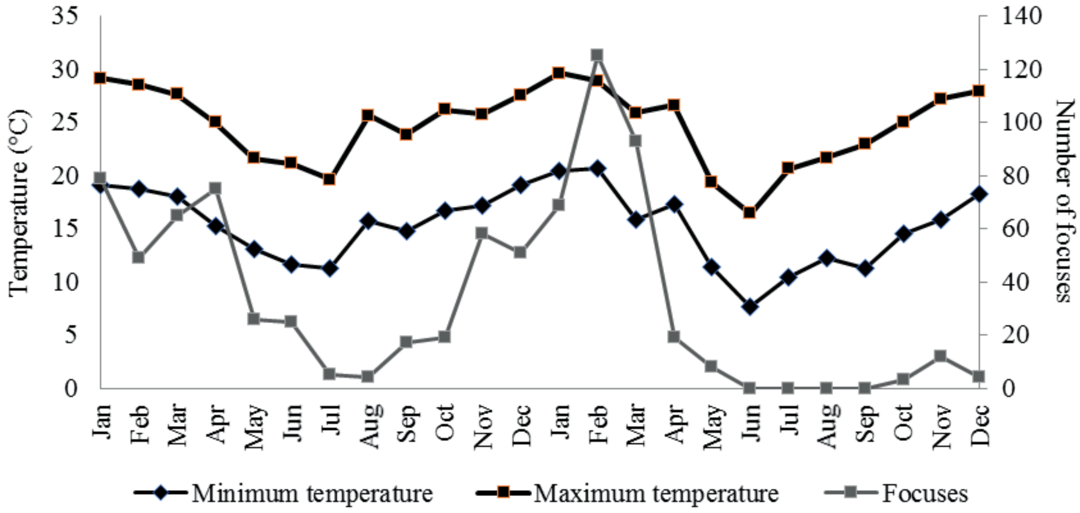
There was no association between the number of dengue cases and the environmental variables evaluated, both in 2015 and 2016, ($p > 0.05$). The dengue cases recorded in 2015 and 2016 presented a positive correlation with the population size of the evaluated neighborhoods ($r = 0.93$, $p < 0.0001$). The frequency of dengue cases per district also showed a positive correlation with the number of facilities registered as strategic points by the Municipal Dengue Control Program ($r = 0.78$, $p = 0.0001$) (Figure 2).

Figure 2 – Pearson correlation between dengue cases in the neighborhoods of Chapecó-SC, from January 2015 to December 2016, and the number of strategic points registered by the Municipal Dengue Control Program. Bv: Bela Vista, Bp: Bom Pastor, Ce: Centro, Ef: Efapi, El: Eldorado, Eb: Engenho Braum; Es: Esplanada; Li: Líder; Mg: Maria Goretti; Pi: Pinheirinho; Pm: Presidente Médici; Qp: Quedas do Palmital; Sc: Saic; Sm: Santa Maria; St: Santo Antonio; Se: Seminário; Ut: Universitário; Vr: Vila Real.



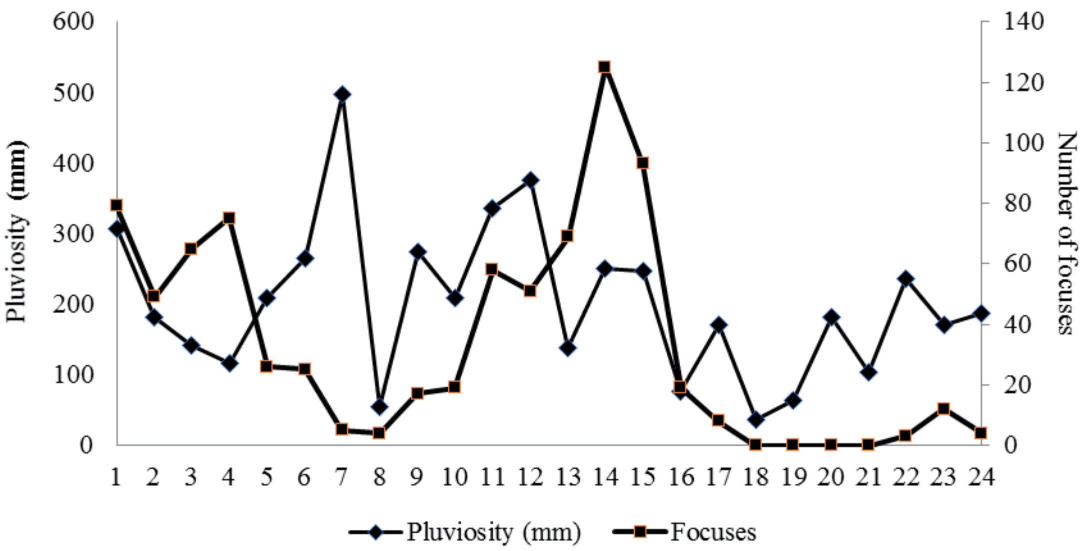
The average maximum temperature recorded in 2015 was 29.2°C in January, and the lowest average of 11.3 in June. In 2016 the average maximum temperature was 29.6°C in January and the average minimum was 7.7°C in June (Figure 3). It is observed an increase in the number of positive reservoirs for *A. aegypti* in November, December, January, February, March and April, coinciding with the higher temperatures (Figure 3). A significant relationship was observed between the number of foci of the vector and the minimum and maximum temperatures ($r = 0.60$ $p < 0.002$ and $r = 0.68$ $p = 0.0003$, respectively).

Figure 3 – Relationship between monthly maximum and minimum temperatures and the focuses of *A. aegypti* in strategic points of Chapecó from January 2015 to December 2016.



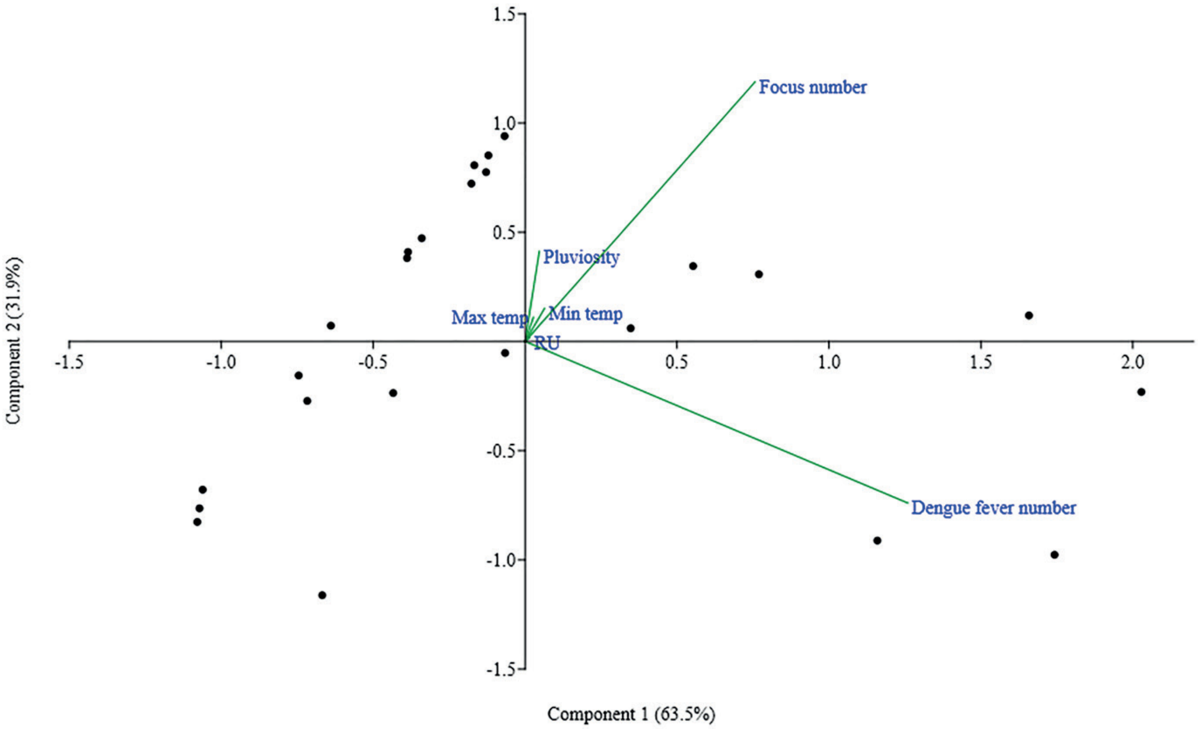
The maximum rainfall recorded in 2015 was 498 mm in July (17% of annual precipitation) and the minimum of 54 mm in August (2% of annual precipitation). In 2016, the maximum rainfall occurred in February, 251 mm (13.4% annual precipitation) and the minimum of 36 mm in June (2% of annual precipitation) (Figure 4). No significant relationship ($p > 0.05$) was observed between the number of foci with rainfall, which is also not evident in Figure 3, as well as with Relative Humidity.

Figure 4 – Monthly relative pluviosity in 2015 and 2016 and the presence of *A. aegypti* focuses in Chapecó – SC, from January 2015 to December 2016.



A total of 95.3% of climatic variation, focuses and monthly dengue fever cases were explained by PCA. The relationship between climatic variables and the number of focuses was observed, however, no relation was recorded with the monthly frequency of dengue fever cases (Figure 5).

Figure 5 - Relationship, by Principal Component Analysis, among climatic variables, number of focuses and monthly dengue fever cases in Chapecó - SC, from January 2015 to December 2016. RU: Relative humidity; Max temp: Maximum temperature; Min temp: Minimum temperature.



Discussion

The rate for the municipality was 374.6% per 100.000 inhabitants being considered an epidemic situation. The World Health Organization defines as level of epidemic transmission when the incidence rate of dengue cases is greater than 300 cases per 100 thousand inhabitants. The state of Santa Catarina presented a rate of 63.32% per 100 thousand inhabitants, which indicates that the municipality recorded 5.91 times more than the incidence rate of the state[8]. In this context it can be considered that there has been a greater demand for health services in Chapecó, a recurrent situation when symptoms of the disease occur[12].

The preference of the vector *A. aegypti* by central regions of the city shown here may be related to the population density of the neighborhoods, demonstrating its relationship with urbanized environments[13]. The preference of Culicidae by these areas was investigated by Cox and collaborators[14] in different landscapes and verified that *A. aegypti* predominated in urbanized areas, which was also observed in a study carried out in the central region of Porto Alegre - RS[15]. This study also found a higher incidence of cases in the urban region. The rural area accounted only 0.038% of the incidence rate. These indices should be relativized considering that 91% of the population lives in the urban area[7].

The high number of cases, especially in 2016, may be related to the presence of *A. aegypti* foci at strategic areas that were positive during the study period, especially in tires, garbage, cisterns and small reservoirs. These environments showed positivity of foci in practically all the months of the period, except for the period from June to September of 2016, which coincided with the months of the lowest average temperatures of the whole period. In these places, according to the Ministry of Health[11], there is a large accumulation of preferential deposits for the oviposition of *A. aegypti* mosquito due to the concentration of containers, which may become potential breeding grounds for the dengue vector. Although the Ministry of Health warns, the strategic areas have been positive in most of them.

It should be noted that the main containers that were positive for the presence of the vector were tires, cups, plastics bags, bottles and organic waste. Lutinski et al.[16] describe that among the factors that constrain the development of the vector are inadequate housing conditions, incorrect destination of solid urban waste, intermittent water supply, poor urban infrastructure conditions, and incorrect waste management. In Chapecó, these areas have been repeatedly the most positive. It is considered that garbage is still a problem that the population does not give the correct destination, leaving it open, being a behavior that contributes to the creation and dispersal of the vector.

Rainfall fluctuation influences the availability of breeding sites, especially the small ones, located outdoor due to the increase in the number of artificial and natural containers with water at strategic points[17]. The fluctuation of rainfall recorded during the period of this study did not influence significantly in the proliferation of the vector in the municipality. This result may be associated to the fact that the foci sample considered only strategic areas where the availability of breeding sites is large and available throughout the year. The incidence of dengue cases also fluctuates according to the weather conditions and is associated to the increase of temperature and precipitation, conditions that favor the increasing of number of available breeding sites and also the development of the vector[18].

Temperature influences on the life cycle of *A. aegypti*, because when it is high, it accelerates the passage from one stage of development to another, reducing the duration of the extrinsic incubation period of the virus within the vector[19].

The favorable temperature for development of *A. aegypti* is between 21°C and 29°C, and for the longevity and fecundity of adults is between 22°C and 30°C[20]. Several studies corroborate the assertion of the influence of temperature and rainfall under the life cycle of the main dengue vector, such as Lopez-Velez and Moreno[21] in Spain, Souza, Dantas and Limeira[22], in the states of Alagoas and Paraíba, Fernandes et al.[13] in Tangará da Serra, which emphasize the influence, on the density of vector as in vector efficiency. According to these authors, temperature and rainfall can increase or decrease vector survival, determining the growth rate of their populations, changing the incubation period of the agent in the vector and changing the activity and pattern of transmission between seasons.

In this study it was observed that the foci were more frequent from November 2015 to May 2016, coinciding with the high temperatures of the summer months, presenting a statistically significant relation with the average of the maximum temperatures ($r = 0.60$ $p < 0.002$). In this scenario, it is possible to to detect the influence of temperature on longevity, fecundity and hematophageal activity of the vector. According to Costa et al.[23], at 25°C the females survived twice as much and produced 40% more eggs. In order for the eggs to mature, the mosquito needs to perform the blood repellent and this can be done in several people in a single day, meaning that an infected vector can transmit the virus to several people and this can transmit the virus to a vector uninfected during the viremia period when repotting. In this sense, the increase of temperature are associated with the increase in the reproductive cycle of *A. aegypti* in the municipality of Chapecó in 2015 and 2016, leading to greater larval development, culminating in a larger mosquito population.[20] In the year 2016 this factor culminated in an increase in the incidence of dengue. Dengue transmission is considered to be complex because it involves contact that include vector, virus and man, and this interaction is associated to favorable environmental and weather conditions that also determine the occurrence of the disease[24].

The foci had a heterogeneous distribution, having a higher incidence in the months from November to May, coinciding with the hotter seasons, corroborating with the studies carried out by Ribeiro et al.[25] in the city of São Sebastião - SP and Câmara et al.[26] in Rio de Janeiro, where epidemics coincided with high temperatures. Among the factors that contributed to the epidemics in the country, the following stand out: the fast demographic growth associated to the intense and disordered urbanization; inadequate urban infrastructure; increased production of non-organic waste; the ways of life in the city; the weakness in public health services and campaigns, as well as the population's neglect to control the vector[27].

Conclusion

This study showed that dengue was present in 2015 and 2016, as a seasonal disease, having a higher incidence of cases in the first three months of each year. Regarding weather data, a relation between temperature and number of foci was observed.

The correlation of disease cases to the population size is an expected result as it reflects a larger number of exposed people and indicates a generalized transmission in the city during the epidemic period. The correlation of the number of cases of the disease to the number of strategic areas registered by neighborhood shows the importance of facilities of this nature in the maintenance and the annual re-infestation of *A. aegypti* mosquito in the city. This finding characterizes as an alert to health authorities to introduce actions focused on vector control in these establishments.

This study indicates a multifactorial influence on *A. aegypti* mosquito proliferation and the occurrence of viral transmission of dengue in the municipality of Chapecó. It reinforces the need of an interdisciplinary approach in proposing actions to prevent and control this endemic disease.

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