*Rev Soc Bras Med Trop* 51(1):71-76, January-February, 2018
doi: 10.1590/0037-8682-0228-2017

Short Communication

# Building Infestation Index for *Aedes aegypti* and occurrence of dengue fever in the municipality of Foz do Iguaçu, Paraná, Brazil, from 2001 to 2016

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## Abstract

**Introduction:** the Building Infestation Index (BII) uses the Rapid Assay of the Larval Index for *Aedes aegypti* (LIRAa) to express the relationship between positive and surveyed properties. We evaluated LIRAa and the relationship between the BII and climate variables for dengue cases in Foz do Iguaçu municipality, Paraná. **Methods:** Spearman's correlations for mean precipitation, mean temperature, BII, and dengue cases (time lag). **Results:** positive correlations between BII and cases, and mean temperature and cases at two months. Weak correlation between precipitation and cases at three months. **Conclusions:** LIRAa and climate variables correlate with dengue cases.

**Keywords:** LIRAa. Dengue. Epidemiology.

The Dengue, Chikungunya, and Zika viruses are mainly transmitted to humans by *Aedes aegypti*[1], a mosquito with a wide geographical distribution, particularly in tropical and subtropical areas[2]. Dengue fever is an acute febrile disease, which may have a moderate or severe course. The transmission period for dengue has two cycles: an intrinsic one, which occurs in humans, where the viremia period begins one day before the onset of fever and continues until the sixth day; and one extrinsic, occurring in the vector, where the viremia period occurs after 8 to 12 days[3].

*Aedes aegypti* monitoring is guided by control programs that utilize the Building Infestation Index (BII), which uses the Larval Index Rapid Assay for *Aedes aegypti* (LIRAa) to express the difference between the number of positive properties and the number surveyed. This method, recommended by the Ministry of Health, aims to identify the mosquito breeding sites and the situational diagnosis of the municipality, which, based on its results, directs control actions to the most critical areas[4].

However, the BII is not good for measuring adult abundance because of the distance between the life cycle phases and the fact that it does not consider the productivity of the containers[5]. Therefore, it is poor at estimating transmission risk, although it is used for this purpose[6]. The hypothesis that the BII does not reflect the situation in the municipality led to this study, which aimed to evaluate rapid vector assessment methodology as a risk area indicator for dengue and investigate associations between the BII, temperature, rainfall, and dengue cases in Foz do Iguaçu, Paraná.

Foz do Iguaçu is located to the west of the State of Paraná, Brazil (**Figure 1**) at 25°32′49″S and 54°35′18″W. It has an altitude of 164 m, a total area of 618,352 km$^2$, and 256,089 inhabitants[7]. The climate is subtropical humid mesothermic, with a mean annual temperature of 20.4°C and mean annual rainfall of 1,800mm[8].

The urban area was divided into 11 strata (**Figure 2**) that represent socio-environmental characteristics in order to obtain homogeneity. The strata contained 8,100 to 12,000 buildings. In total, 20% of the properties were surveyed and immature forms were collected during the LIRAa[9]. The Center for Zoonosis Control (CZC) in Foz do Iguaçu collects and identifies the immature forms to calculate the BII index. It requires considerable effort to inspect a sufficient number of

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**Received** 1 June 2017
**Accepted** 12 September 2017

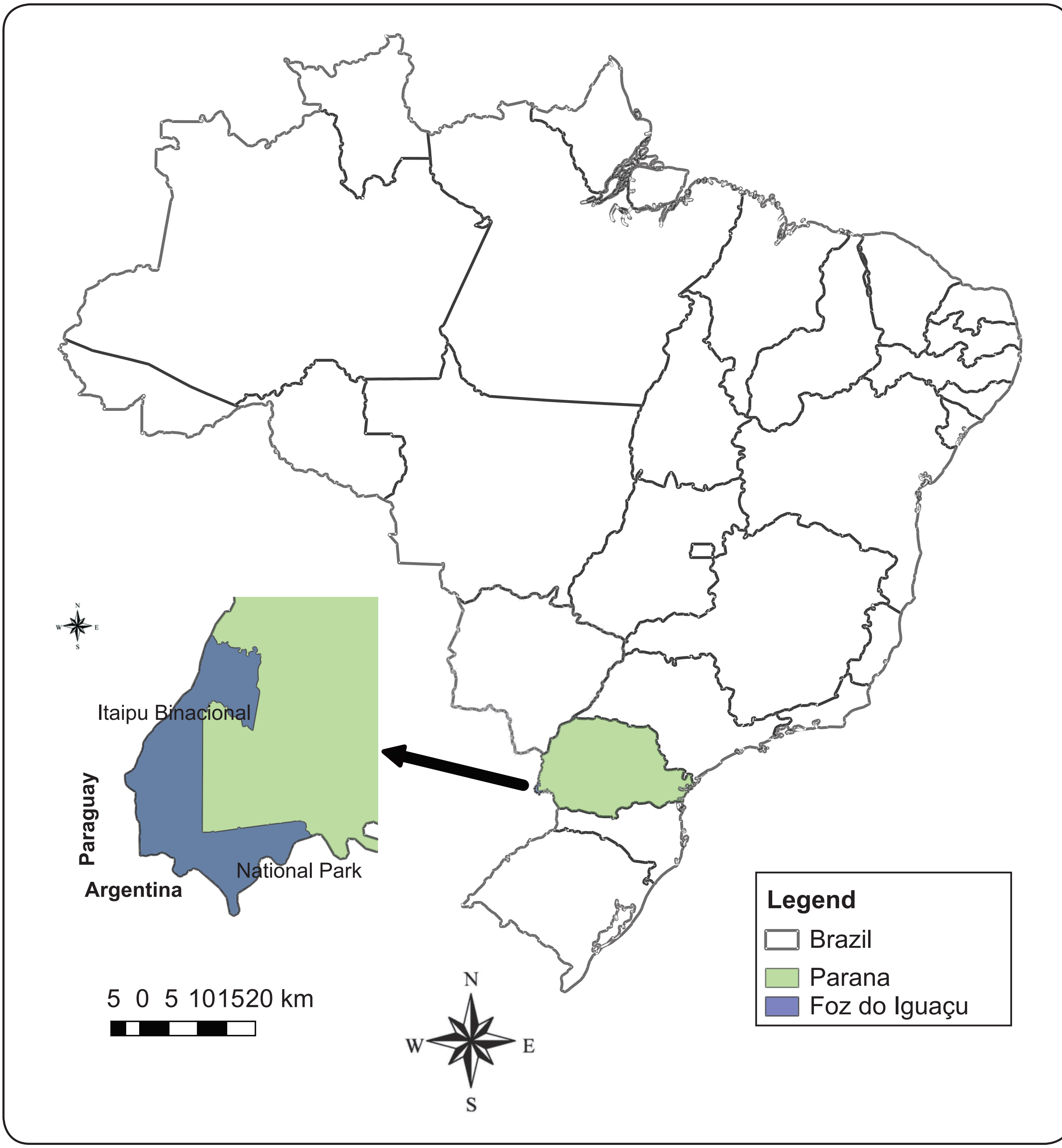


**FIGURE 1:** Location of Foz do Iguaçu municipality in the state of Paraná, Brazil.

houses over a short period of time. If sampling takes several weeks, it is likely that the environment and mosquito populations will change during that time and will not reflect the specific conditions that existed during sampling[10].

The years 2001 to 2016 were evaluated and 58 LIRAas were undertaken, which were performed in different months over the years due to a lack of human resources and the necessary conditions to carry out the survey. Therefore, data were collected when possible and did not follow a collection pattern. The data were tabulated and classified according to the Dengue Transmission Risk Thresholds proposed by the National Dengue Control Program (<1 – Satisfactory; from 1 to 3.9 – Alert; >3.9 – Risk). The BII is calculated using the following formula:

Building Infestation Index (BII): nº positive properties x 100/nº properties searched

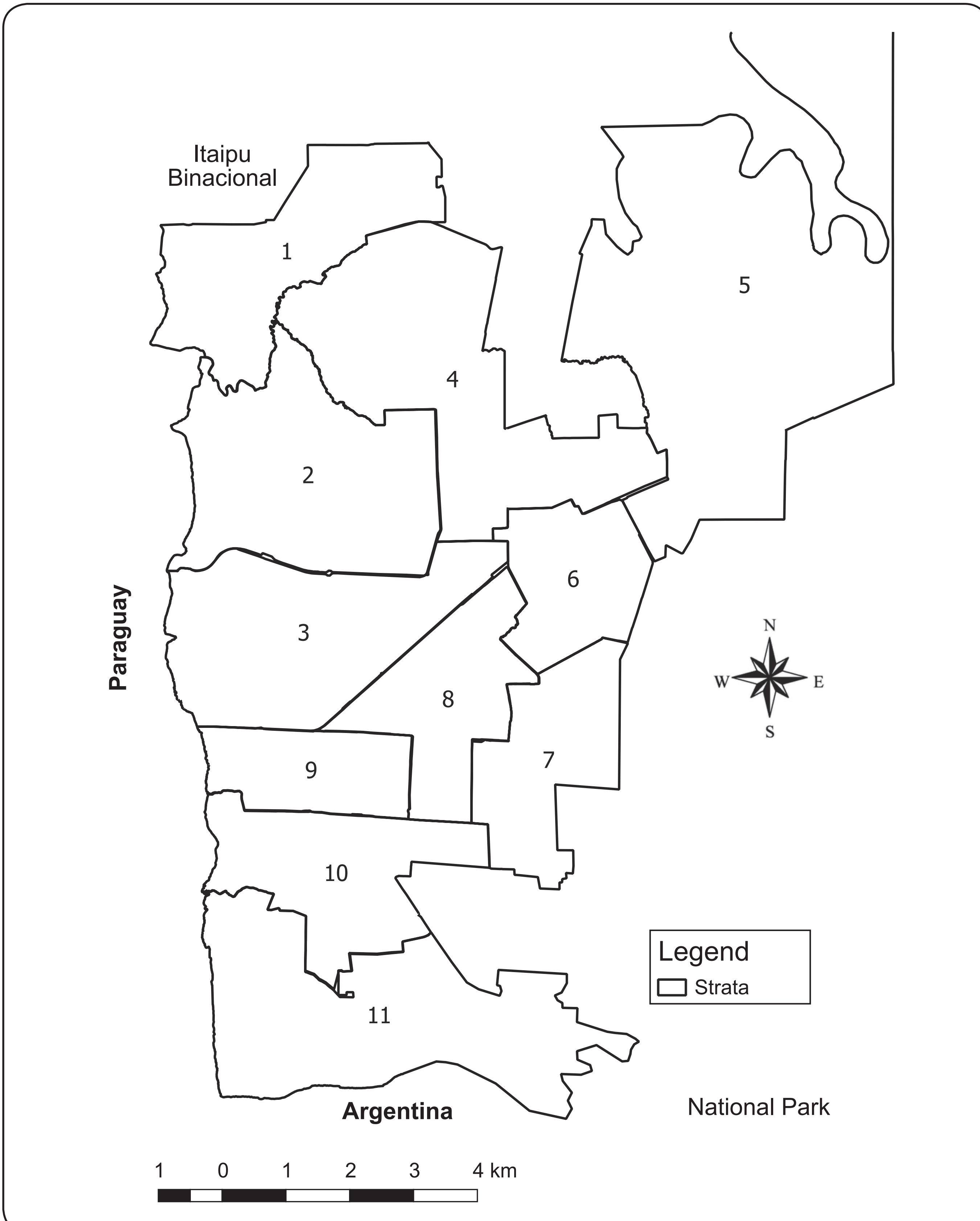


**FIGURE 2:** Strata divisions for Foz do Iguaçu municipality, Paraná, Brazil.

**TABLE 1:** Building Infestation Index, temperature, and rainfall results for each month between 2001 and 2016, and the number of dengue fever cases in the same month and after 1, 2, and 3 months in Foz do Iguaçu, Paraná.

| Year | Month | BII (%) | Temperature (°C) | Rainfall (mm) | Cases (In the same month) | Cases (after one month) | Cases (after two months) | Cases (after three months) |
|---|---|---|---|---|---|---|---|---|
| 2001 | Jan | 16.7 | 26.4 | 7.8 | 12 | 15 | 33 | 32 |
| | Feb | 25.0 | 26.1 | 9.8 | 15 | 33 | 32 | 17 |
| | Mar | 16.5 | 25.6 | 3.8 | 33 | 32 | 17 | 6 |
| | Apr | 17.7 | 24.0 | 4.6 | 32 | 17 | 6 | 2 |
| | May | 10.0 | 17.3 | 2.4 | 17 | 6 | 2 | 6 |
| | June | 6.5 | 16.8 | 3.7 | 6 | 2 | 6 | 2 |
| | July | 3.7 | 18.2 | 2.0 | 2 | 6 | 2 | 1 |
| | Aug | 2.3 | 21.1 | 2.1 | 6 | 2 | 6 | 6 |
| | Oct | 3.5 | 23.1 | 3.3 | 1 | 6 | 5 | 32 |
| | Nov | 3.7 | 24.9 | 7.1 | 6 | 5 | 32 | 87 |
| | Dec | 6.5 | 24.7 | 4.5 | 5 | 32 | 87 | 562 |
| 2002 | Jan | 4.6 | 25.1 | 9.8 | 32 | 87 | 562 | 960 |
| | Feb | 12.2 | 25.0 | 24 | 87 | 562 | 960 | 460 |
| | Mar | 9.3 | 27.6 | 2.5 | 562 | 960 | 460 | 77 |
| | Apr | 6.5 | 25.3 | 1.4 | 960 | 460 | 77 | 10 |
| | May | 7.6 | 21.3 | 13.0 | 460 | 77 | 10 | 2 |
| | June | 4.4 | 18.3 | 1.9 | 77 | 10 | 2 | 2 |
| | Oct | 5.1 | 23.7 | 4.3 | 1 | 2 | 2 | 23 |
| | Nov | 7.4 | 23.9 | 14.0 | 2 | 2 | 23 | 117 |
| | Dec | 9.8 | 26.1 | 5.4 | 2 | 23 | 117 | 311 |
| 2003 | Mar | 5.4 | 25.6 | 1.2 | 311 | 193 | 57 | 0 |
| | July | 2.2 | 18.2 | 1.4 | 0 | 0 | 0 | 0 |
| | Oct | 2.1 | 23.4 | 9.5 | 0 | 0 | 0 | 0 |
| 2004 | Feb | 4.7 | 25.6 | 1.2 | 3 | 3 | 0 | 1 |
| | May | 7.0 | 16.7 | 7.7 | 1 | 0 | 0 | 0 |
| | Oct | 3.4 | 22.4 | 2.7 | 0 | 0 | 1 | 2 |
| 2005 | Sep | 2.2 | 16.5 | 4.0 | 0 | 1 | 1 | 1 |
| | Oct | 3.7 | 22.4 | 9.7 | 1 | 1 | 1 | 4 |
| | Dec | 1.3 | 26.3 | 3.0 | 1 | 4 | 9 | 53 |
| 2006 | Sept | 2.3 | 20.2 | 7.4 | 0 | 1 | 2 | 4 |
| | Nov | 9.9 | 24.5 | 4.8 | 2 | 4 | 36 | 127 |
| | Dec | 5.0 | 27.5 | 6.8 | 4 | 36 | 127 | 144 |
| 2007 | Aug | 0.3 | 17.8 | 0.0 | 1 | 0 | 0 | 4 |
| | Oct | 1.2 | 24.6 | 5.3 | 0 | 4 | 1 | 3 |
| 2008 | Jan | 2.8 | 26.4 | 6.8 | 3 | 6 | 161 | 19 |
| | Apr | 3.2 | 21.1 | 4.5 | 19 | 11 | 2 | 2 |
| | Sept | 1.3 | 18.2 | 3.7 | 3 | 2 | 2 | 2 |
| 2009 | Feb | 4.9 | 25.8 | 6.7 | 7 | 11 | 24 | 16 |
| | May | 3.8 | 19.9 | 11.0 | 16 | 4 | 0 | 1z |
| | Oct | 3.8 | 22.4 | 7.4 | 0 | 0 | 6 | 78 |

**Continue...**

**TABLE 1:** Continuation.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2010 | Mar | 3.8 | 25.3 | 3.8 | 1,983 | 3,442 | 1,613 | 167 |
| | May | 3.1 | 17.7 | 3.1 | 1,613 | 167 | 8 | 1 |
| | Oct | 0.8 | 20.7 | 8.1 | 3 | 5 | 18 | 85 |
| 2011 | Oct | 1.0 | 23.8 | 9.3 | 6 | 5 | 4 | 13 |
| 2012 | Mar | 2.4 | 24.7 | 1.7 | 18 | 31 | 15 | 7 |
| | Sept | 2.2 | 21.9 | 1.6 | 1 | 4 | 2 | 10 |
| | Nov | 4.7 | 25.4 | 4.3 | 2 | 10 | 66 | 172 |
| 2013 | Jan | 4.1 | 26.3 | 4.8 | 66 | 172 | 989 | 1,443 |
| | Mar | 7.0 | 23.9 | 5.7 | 989 | 1,443 | 203 | 40 |
| | Oct | 1.2 | 22.7 | 2.7 | 5 | 6 | 5 | 6 |
| 2014 | Jan | 0.9 | 27.0 | 5.5 | 6 | 3 | 3 | 17 |
| | Mar | 2.6 | 24.2 | 8.3 | 3 | 17 | 15 | 5 |
| | Out | 3.3 | 25.8 | 1.5 | 2 | 6 | 0 | 11 |
| 2015 | Jan | 6.6 | 26.7 | 3.2 | 11 | 61 | 445 | 884 |
| | Mar | 8.2 | 25.1 | 8.4 | 445 | 884 | 648 | 202 |
| | Oct | 3.6 | 24.4 | 3.7 | 22 | 88 | 230 | 799 |
| 2016 | Jan | 6.1 | 27.2 | 8.0 | 1,091 | 2,928 | 1,816 | 538 |
| | Mar | 1.2 | 23.7 | 6.9 | 1,816 | 538 | 72 | 11 |

Secondary data on the number of confirmed dengue cases in Foz do Iguaçu between 2001 and 2016 were provided by the Division of Epidemiological Surveillance of Foz do Iguaçu, and the municipal data for mean temperature and rainfall was obtained from the Paraná Meteorological System (SIMEPAR) (**Table 1**).

The study used the time lag concept of Depradine & Lovell[11], which allows the investigation of events caused by interactions with the environment in a given time interval. Depradine & Lovell[11] suggest that, although statistically significant, the simultaneous correlations used to identify the relationships between dengue cases and climatic variables are weak. The time interval was considered to be due to factors such as the embryonic development period, larval hatching time, larval and pupal development time, extrinsic and intrinsic incubation periods, and the time when cases were registered in the information system.

The relationships between the BII, cases of dengue fever, temperature, and rainfall were analyzed by Spearman correlations using the statistical program "R"[12].

There was a weaker correlation between the BII values, temperature, rainfall, and dengue fever cases when comparing the same month and the following month. Therefore, the BII values and the abiotic factors affecting a given month were relatively highly correlated with the number of cases after two and three months. The data analysis showed that correlations between BII, temperature, and dengue fever cases were higher and statistically more significant when analyzed with a two-month time lag. There was also a low, statistically significant correlation between the occurrence of cases and rainfall when a three-month lag was used (**Table 2**).

This study revealed there was a correlation between dengue fever cases and BII when LIRAas were used to calculate BII. It also shows that there was a relationship between the climate variables, the number of dengue fever cases, and the time it took for these factors to contribute to the generation of new cases. If the biology of *Ae. aegypti* and the dengue virus, and the time taken until positive cases are registered in the information system is used to justify the period association with time lag[11,13,14], then the results suggested that there was a higher positive correlation between BII and dengue fever when there was a two month time lag. This result agrees with Barbosa & Lourenço[14], who concluded that the larval indicator shows the presence of adult mosquitoes in the municipality, although it is not the best indicator for measuring the risk of dengue occurrence.

Climatic conditions, characterized by rainfall and high temperatures, generally show a positive relationship with dengue fever transmission[2,13,15]. Ribeiro et al.[13] observed that the rain and

**TABLE 2:** Correlations (r) between dengue fever cases, Building Infestation Index (BII), mean temperature, and rainfall for Foz do Iguaçu, Paraná, from 2001 to 2016.

| | Simultaneous | | 1 month | | 2 month | | 3 month | |
|---|---|---|---|---|---|---|---|---|
| | r | p | r | p | r | p | r | p |
| BII X Cases | 0,3965 | 0,00103 | 0,43529 | 3,19E-04 | **0,446** | **2,25E-04** | 0,279 | 0,01696 |
| Temperature x Cases | 0,2979 | 0,01156 | 0,5114 | 8,83E-06 | **0,636** | **4,033E-08** | 0,6167 | 1,26E-07 |
| Rainfall x Cases | 0,0081 | 0,4758 | 0,01214 | 0,464 | 0,1882 | 0,07852 | **0,2309** | **0,04053** |

*Correlations significant when p < 0,05; Spearman's correlation test. Were highlighted the statistically significant high correlation value.

temperature in a given month partially explained the number of dengue cases two to four months later. In this study, the results showed that, in addition to BII, temperature also led to an increase in the number of cases two months later. However, the relationship between cases and rainfall was negligible or weak and did not effectively reflect the occurrence of dengue fever cases in the municipality.

The population monitoring method, based on the collection of immature forms, allowed the identification of environmental factors associated with *Ae. aegypti* density. Furthermore, it is important to verify the impact of the basic control strategies on the disease, which focus on the elimination of the vector larvae and pupae[6]. If a minimum two-month time lag when calculating the potential increase in the occurrence of dengue cases, then the control activities based on the LIRAa should be increased so that the mosquito life cycle is interrupted. This prevents them from reaching adulthood and potentially transmitting dengue. If dengue transmission risk in an area is to be immediately assessed, then other entomological indicators associated with LIRAa should be used to indicate more accurately simultaneous relationships that can be used to direct the control of winged forms within the same period.

**Acknowledgments**

The authors thank the institutions that provided technical support for the development and implementation of this study.

**Conflict of interest**

There is no conflict of interest on the part of the authors.

**Financial support**

Centro de Controle de Zoonoses – Prefeitura Municipal de Foz do Iguaçu.

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