



HEALTH SCIENCES

Dynamics of Transmission of Urban Arbovirus Dengue, Zika and Chikungunya in Southwestern Region of Bahia, Brazil

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Abstract: Arboviral diseases are disseminated all over the world. In Brazil, they remain neglected, alerting public authorities to possible outbreaks. Over here, we report the epidemiological indicators of Dengue from 2010 to 2015, Zika between 2015 and 2016, and Chikungunya from 2014 to 2016, within 19 municipalities of Southwestern Region of Bahia, Brazil. The data were collected from Brazilian national public information systems (SISFAD, SINAN, and IBGE) and by Endemic Control Agents. The analysis consisted of a description of vector characteristics, Home Infestation Index and characterization of human reported cases. The years 2011 and 2013 were recorded as having the highest frequencies of positive properties for the presence of the arboviruse vectors. Most municipalities presented high annual values of Home Infestation Index indicating an alert situation (62.28%). In the evaluated period, there were (i) 9,196 cases of Dengue, (ii) 636 cases of Zika and (iii) 224 cases of Chikungunya reported. This is the first report of the epidemiological characteristics of these arboviruses in the 19 municipalities of Bahia. It is believed that the data collected may contribute to public health policies aimed at controlling future epidemics of these arboviruses.

Key words: Arboviruses, epidemiology, infectious diseases, tropical diseases, vector-borne disease.

INTRODUCTION

Dengue (DENV), Zika (ZIKV), and Chikungunya (CHIKV) are arboviruses, widely considered a global threat to public health and well-being, especially in tropical countries. Due to the Americas' climatic conditions, the rapid dispersion and proliferation of the mosquito vectors *Aedes aegypti* and *Aedes albopictus* are favored (Bhatt et al. 2013). The epidemiology of these three arboviruses and the behavior of the vector are affected by factors such as: (i) demographic changes in human populations (ii) urbanization (iii) volume of international traffic (iv) failure of vector control programs (v)

precariousness of basic sanitation. Also, climate and temperature affect the incubation period and the proportion of mosquitoes capable of transmitting arboviruses. These factors can generate changes in biodiversity that facilitate the permanence of the vector and its reproduction (Bhatt et al. 2013, Helmersson et al. 2014, Chediak et al. 2016, Alto et al. 2017, Zanotto & Leite 2018, Vieira et al. 2019).

DENV is the most common arbovirus in the world, affecting about 100-400 million people annually (Figueiredo et al. 2014). In Brazil, according data from the Ministry of Health, from December / 2019 to April / 2020, 603,951 probable DENV cases were recorded (incidence

rate of 287.4 cases/100,000 inhabitants). During this period, the Northeast region recorded 73.9 cases/100,000 inhabitants, the states with the highest number of cases were Bahia (21,483; 50,9%) and Ceará (7,082; 16,7%) (SESAB 2020).

ZIKV and CHIKV are emerging arboviruses, whose distribution and intensity have increased over the last decade. By mid-2015 the first cases of Zika were reported in Brazil, in the northeastern (Zanluca et al. 2015), although the hypothesis is that the virus was introduced in the country either during the 2014 World Cup or in the Va'a canoe event, held in Rio de Janeiro in 2014 (Musso 2015, Zanluca et al. 2015). After ZIKV outbreak mid-2015, there was a growth in the reported cases of congenital microcephaly in new-borns, (Mlakar et al. 2016). Rio Grande do Norte reported ZIKV and CHIKV epidemics accomplished with an increase in microcephaly and Guillain-Barré syndrome cases (Medeiros et al. 2018). This suggested a possible association between ZIKV infections and fetal malformations, like microcephaly, in the Brazilian northeast region, later confirmed (ECDC 2015). In Brazil, according data from the Ministry of Health, from December/2019 to April/2020, 2,058 ZIKV cases were recorded (incidence rate of 1.0 cases/100,000 inhabitants). During this period, the Northeast region recorded 1.4 cases/100,000 inhabitants, the states with the highest number of cases were Bahia (364; 45,7%) and Pernambuco (168; 21,3%) (SESAB 2020).

The CHIKV was isolated for the first time from human serum in Tanzania in 1953. The first recorded report of CHIKV in Brazil occurred in September 2014, in the state of Amapá. Possibly, the introduction of CHIKV in Brazil is related to the epidemic of this arbovirus in the Caribbean, which occurred in 2013 (Honório et al. 2015). In Brazil, according data from the Ministry of Health, from December/2019 to April/2020, 17,636 CHIKV cases were recorded (incidence

rate of 8.4 cases/100,000 inhabitants). During this period, the Northeast region recorded 12.9 cases/100,000 inhabitants), the states with the highest number of cases were Bahia (5,090; 69%) and Rio Grande do Norte (942; 12,7%) (SESAB 2020).

With the steady increase in the last few years of suspected cases caused by the arboviruses DENV, ZIKV and CHIKV in Brazil, the challenge for health authorities is to stop the increase in epidemics. The Community Health Agents and Endemic Disease Combat Agent are in charge of carrying out the mechanical and chemical controls of the vectors. Such controls depend on the destruction and destination of water reservoirs that can potentially serve as a deposit for *A. aegypti* eggs. It is expected that, with the elimination of breeding sites in the properties, the vector transmission chain will be interrupted. The Brazilian Ministry of Health also recommends that, during home visits, Community Agents carry out educational actions (Zara et al. 2016).

Despite the implementation of preventive measures to eliminate breeding grounds for mosquitoes, to date, there is no preventive drug procedure and/or vaccine for DENV, ZIKV and CHIKV. Given this reality, it is essential to carry out epidemiological surveys to identify the most affected areas and to characterize epidemiologically the arboviruses in these areas. Such data can indicate priorities for health management and guide the improvement of control and surveillance actions. These are necessary to improve the health conditions of the population and reduce the rates of epidemics (Martins et al. 2015).

Together, these data demonstrate the need for integration between knowledge about arboviruses and investments in the qualification of epidemiological and vector surveillance actions. In this context, this study aimed to

describe the epidemiological indicators of DENV (2010 to 2015), ZIKV (2015 and 2016) and CHIKV (2014 to 2016), in Southwestern Region of Bahia, Brazil. In this way, the occurrence of vectors (*A. aegypti* and *A. albopictus*) and treatment of breeding-site, as well as the distribution of the reported cases for DENV, ZIKV and CHIKV.

MATERIALS AND METHODS

Study area

The spatial analysis unit consisted of 19 municipalities of Southwestern Region of Bahia, Brazil. The temporal unit consisted of the years of the study period. Epidemiological indicators were studied in the following periods: DENV (2010 to 2015), ZIKV (2015 and 2016) and CHIKV (2014 to 2016).

The Southwestern Region of Bahia (14° to $15^{\circ} 45' S$; $40^{\circ} 15'$ to $42^{\circ} 45' W$) occupying an approximate area of 27,275.6 km², corresponding to approximately 4.8% of the Bahia territory (Figure 1). The altitude is between 600 m and more than 1,000 m, with most of it above 800 m. The Southwestern Region is part of the semiarid biome and the average annual rainfall is 712 mm. The region presents schooling rate of 95% and infant mortality rate of 14.80 deaths per thousand live births. The region's gross domestic product (GDP) is approximately \$ 5.6 billion, representing 3.4% of the state (IBGE 2010, SEI 2015).

The sociodemographic characteristics of the studied municipalities are described in Figure 2. The total population of the 19 municipalities is 632,708 inhabitants, with Vitória da Conquista as the most populous municipality, with 306,866 inhabitants, and Maetinga as the least populous municipality, with 7,038 inhabitants. Most of the residences in the 19 municipalities are located in rural areas and only Poções and Vitória da Conquista have more than 50% of homes



Figure 1. Location of Southwestern Region of Bahia - Brazil.

covered with basic sanitation. The prevalence of sex in most municipalities was female (IBGE 2010).

Data collection

The data were obtained from three sources: (i) the Sistema de Informação da Febre Amarela e Dengue (SISFAD), used for registration and management of epidemiological cycles (ii) the Sistema de Informação de Agravos de Notificação (SINAN), used for notification and investigation cases of diseases and conditions that are on the national list of compulsory notification diseases. Both systems were available by the State Health Secretary and (iii) the Instituto Brasileiro de Geografia e Estatística (IBGE). SISFAD provided the data about vector aspects (number of real estate properties agreed upon, inspected, positive and treated,

and the Home Infestation Index (HI)). The epidemiological data (the number, age, and sex of the cases notified for DENV, and the number of the notified cases for ZIKV and CHIKV in the 19 municipalities of Southwestern Region of Bahia) were gathered from SINAN. The demographic data were taken from IBGE.

Data organization

The vector aspects described were: (i) number of real estate properties agreed upon, inspected, positive and treated, and (ii) the Home Infestation Index (HI). The annual cycles of work were divided into 6 bi-monthly cycles, beginning in January and February (Cycle 1). Concerning

the coverage of properties, each field worker (agents of endemic disease control) supervised about 800 to 1000 properties per cycle.

The number of agreed upon real estate properties refers to the number of properties existing in each municipal multiplied by six. The multiplication was because each agreed property should, ideally, be visited six times a year to be considered completely covered. The number of inspected properties refers to the number of properties visited by the Endemic Control Agents, and it was recommended that it reach at least 1/3 (33.3%) of the properties agreed upon. The positive properties refer to the properties where the *A. aegypti* and/or *A. albopictus* vectors were

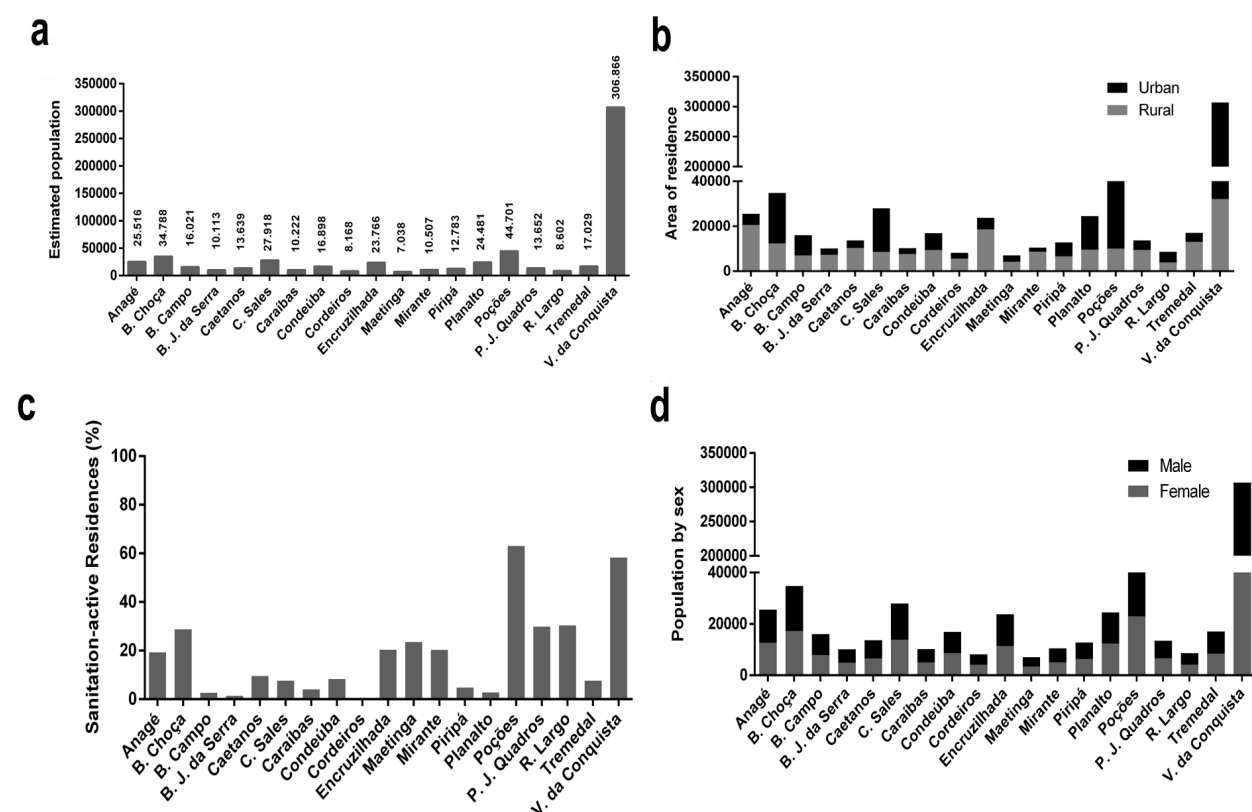


Figure 2. Socio-demographic variables of the Southwestern Region of Bahia - Brazil, 2010. (a) Estimated population. (b) Distribution of residences in urban and rural area. (c) Residences with basic sanitation. (d) Distribution of population by sex. M: Male, F: Female, Municipalities: B. Choça- Barra do Choça; B. Campo- Belo Campo; B. J. da Serra - Bom Jesus da Serra; C. Sales- Cândido Sales; P. J. Quadros - Presidente Jânio Quadros; R. Largo - Ribeirão do Largo. V. da Conquista - Vitória da Conquista. Source: Sistema de Informação de Agravos de Notificação (SINAN). Source: 2010 Population Census. Instituto Brasileiro de Geografia e Estatística (IBGE), <http://www.ibge.gov.br/home/>.

found, in the form of larvae or pupae. These were identified by morphologic and taxonomic characteristics by technicians trained by the Entomology Team the 20ª Diretoria Regional de Saúde Geral (20ª DIRES), a department of the Secretaria da Saúde do Estado da Bahia (SESAB), in Bahia, Brazil. The identification occurred in the entomology laboratories of the municipalities where the vectors had been collected and/or in the entomology laboratory of Endemic Disease Control from the 20ª DIRES.

The treated properties corresponded to 70-100% of the total inspected. The treatment was conducted by applying larvicide in reservoirs that contain or could contain water. From 2010 to 2015, 3 larvicides were applied: (i) ABATE (from 2010 to 2013; Concentration 1 part per million - 1 ppm; Active principle: Temefós), (ii) Novaluron (in 2014, for 6 months; Concentration 1mL/5000L; Active principle: Benzoylphenyl urea), and (iii) Sumilarv (in 2014 and 2015; Concentration 2g/1000L; Active principle: Pyriproxyfen).

According to the Brazilian Health Surveillance Secretary, the potential reservoirs, breeding sites or deposits of mosquito larvae inspected by the Endemic Control Agents are classified into seven categories. These are A1: Water container provided by domestic water supply system; A2: Deposits at ground level; B: Mobile deposit; C: Fixed deposit; D1: Tires and other undercarriages; D2: Garbage; and E: Natural water reservoir (BRASIL 2009).

Home infestation index

The HI corresponds to percentage of houses infested with larvae and/ or pupae of *A. aegypti* and/or *A. albopictus*, with the total of properties inspected, for ZIKV (2015 to 2016) and DENV (2010 to 2015). CHIKV was not included due to the low collected number of cases in this study. In Brazil, the HI conventionally is calculated as a result of the larvae monitoring in 20% of

the properties visited in each block. According to the rules of the Ministry of the Health in Brazil, the HI is classified into (i) Satisfactory (< 1%), (ii) Alert (1% to 3.9%) and (iii) Risk of Outbreak (> 3.9%) (Ministério da Saúde 2009). The annual percentage of HI corresponds to the number of properties classified as positive for the presence of vector x 100 divided by the number of properties inspected (Ministério da Saúde et al. 2005). The Prevalence Index (PI) was calculated by the number of reported DENV cases during the specified period divided by the estimated population (2010) x 100%, to compare the different indices across the cities included in the study.

RESULTS

Distribution of properties monitored and treated for the presence of the vectors

Nineteen municipalities of Southwestern Region of Bahia, Brazil were analyzed. In the period from 2010 to 2015, across the 19 municipalities inspected by Endemic Diseases Control agents, there were 8,504,334 properties agreed upon; 942,934 inspected; 21,215 positive properties (for the presence of *A. aegypti* or *A. albopictus*) and 1,361,837 properties treated (Supplementary Material – Table S1). The years of 2011 and 2013 were the years with the highest number of properties inspected (2011 – 204,471 properties, 2013 – 174,251 properties) and positive properties (2011 – 4,179 properties, 2013 – 4,832 properties). During this period, 2013 presented the highest proportion of positive properties.

The years 2010 and 2013 presented the highest number of treatment visits in the properties (2010 – 274,855 treatments, 2013 – 265,758 treatments). Comparing the two years with the largest number of inspections, positives, and treatments, 2013 was the most contemplated.

Prevalence index of reported cases of DENV, ZIKV and CHIKV

The Prevalence Index (PI) indicated that Piripá was the most affected municipality, with higher prevalence of DENV (4.89%) and ZIKV (0.70%), and the second with higher prevalence of CHIKV (0.16%). Vitória da Conquista and Poções, the two most populous municipalities, presented a PI of 1.16% and 1.34%, respectively (Table SII).

For ZIKV, no data were available on reported cases from Anagé, Maetinga, Mirante, and Planalto, so the PI was calculated for the other municipalities. Piripá and Cândido Sales presented the highest prevalence for ZIKV, 0.70% and 0.67%, respectively (Table SII).

Distribution of reported cases of DENV in relation to year and age

Table I shows the number of reported cases of DENV that occurred in 19 municipalities during period from 2010 to 2015. A total of 9,700 cases of DENV were reported during the study with an increase in the number of cases during 2013. By municipality, most cases were notified during 2012 and 2013. The two largest numbers of notifications per municipality per year occurred in Vitória da Conquista in 2012 (n = 837) and 2013 (n = 953). These notifications correspond to 50.28% of the total reported cases in this municipality.

When the data were analyzed by sociodemographic conditions, it was observed a greater number of reported DENV cases found distributed among the age groups of 10-39 years (58.49%).

Distribution of reported cases of ZIKV in 2015 and 2016

For ZIKV there were 636 registered cases in the 19 municipalities studied in the years 2015 and 2016 (Table SIII). In this period, were recorded 22 cases in 2015 and 614 cases in 2016. In 2016,

the municipalities that recorded the largest notification frequencies were Cândido Sales (29.25%; n = 186) and Vitória da Conquista (41.04%, n = 261).

Distribution of CHIKV reported cases from 2014 to 2016

In the years 2014 to 2016, 239 cases of CHIKV were reported within the 19 analyzed municipalities (Table SIII). Three cases relative to 2014, 12 in 2015 and 224 cases in 2016. In 2014, there were notifications only in the municipalities of Piripá (n = 1), Poções (n = 1) and Vitória da Conquista (n = 1). In 2015, there were cases reported in Cândido Sales (n = 2); Condeúba (n = 2); Cordeiros (n = 2); Piripá (n = 2); Poções (n = 1); Tremedal (n = 1), and Vitória da Conquista (n = 2). In 2016, the municipalities that had submitted more notifications were Cândido dos Sales (n = 68, 30.36% of total cases) and Vitória da Conquista (n = 82, 36.60% of total cases).

HI variation for ZIKV (2015 to 2016) and DENV (2010 to 2015)

It was observed that in the majority of analyzed municipalities that the HI annual values indicated an Alert state (1% to 3.9%), with a percentage of 62.28% (Table II). The municipalities that registered satisfactory annual averages (HI below 1%) for more than a year were Barra do Choça (for 3 years), Caraíbas (for 3 years), Cordeiros (for 2 years), Piripá (for 4 years), Poções (for 2 years) and Ribeirão do Largo (for 6 Years). Ribeirão do Largo was the only municipality to maintain a satisfactory HI for DENV from 2010 to 2015. Throughout the analyzed period, the following municipalities presented indexes that indicate Risk of Outbreak (HI > 3.9%) for over a year: Planalto (for 6 years), Presidente Jânio Quadros (for 2 years), and Tremedal (for 6 years). Planalto and Tremedal were the only municipalities whose HI's indicated a Risk of

Table I. Distribution of reported cases of DENV in Southwestern Region of Bahia -Brazil, from 2010 to 2015.

Municipality	Year						Total
	2010	2011	2012	2013	2014	2015	
Anagé	1	8	94	49	1	1	154
B. Choça	19	19	34	122	13	92	299
B. Campo	1	34	577	25	3	15	655
B. J. da Serra	*	2	33	11	1	*	47
Caetanos	1	5	83	90	1	1	181
C. Sales	17	208	9	313	111	394	1,052
Caraíbas	3	4	2	14	1	9	33
Condeúba	6	1	15	348	26	20	416
Cordeiros	2	40	107	43	*	*	192
Encruzilhada	5	102	33	220	2	8	370
Maetinga	*	8	7	32	*	*	47
Mirante	7	47	56	43	61	10	224
Piripá	1	5	402	195	7	15	625
Planalto	5	16	5	412	1	9	448
Poções	7	19	386	156	12	19	599
P.J. Quadros	3	31	21	326	5	14	400
R. Largo	3	3	3	8	*	*	17
Tremedal	2	115	126	76	4	58	381
V. da Conquista	134	753	837	953	204	679	3,560
TOTAL	217	1,420	2,830	3,436	453	1,344	9,700

* No reported cases. Municipalities: B. Choça- Barra do Choça, B. Campo- Belo Campo. B. J. da Serra - Bom Jesus da Serra. C. Sales- Cândido Sales. P. J. Quadros- Presidente Jânio Quadros. R. Largo - Ribeirão do Largo. V. da Conquista - Vitória da Conquista. Source: Sistema de Informação de Agravos de Notificação (SINAN). Data collected on 07/31/2018.

Outbreak from 2010 to 2015 (for DENV). In 2013, Planalto obtained the highest HI value registered (12.64%), indicating prominently the proportion of properties where larvae and/or pupae of *A. aegypti* or *A. albopictus* were found (Table III).

The variation of HI among the 19 municipalities was analyzed, considering the worst-case scenario in each municipality (Risk of Outbreak, Alert and Satisfactory HI) for ZIKV

(2015 to 2016) and DENV (2010 to 2015), and more than 50% of the six years analyzed are shown in Figure 3. In this, it is possible to see (i) one municipality was classified as Satisfactory HI (Ribeirão do Largo – for 6 years), 16 municipalities were classified as Alert HI, and 2 municipalities classified as Risk of Outbreak HI (Tremedal and Planalto – for 6 years).

Association between HI and distribution of reported cases of DENV and ZIKV

It was observed that the great majority of municipalities in the most analyzed years showed an HI indicating an Alert status (between 1% to 3.9%). Sixteen municipalities demonstrated this status for more than three years out of the six years studied. One municipality demonstrated a Satisfactory HI and two municipalities presented as having a Risk of Outbreak (Figure 3). This seems to be related to the number of cases of DENV and ZIKV. The municipality that maintained a Satisfactory HI in the six years of analysis (Ribeirão do Largo) presented less than 50 reported cases of arboviruses (both DENV and ZIKV).

The municipalities that showed the highest number of reported cases of Dengue (Belo Campo, Cândido Sales, Piripá, Poções, and Vitória da Conquista) presented with an HI Alert status (Figure 3a). Among the two municipalities that presented HI Outbreak (> 3.9%), both Planalto and Tremedal, registered between 91 and 500 reported cases of DENV. The municipality with a satisfactory HI (<1%), Ribeirão do Largo, reported <50 cases of DENV.

Concerning ZIKV, which showed fewer reported cases when compared to DENV, municipalities like Cândido Sales and Vitória da Conquista that presented an HI Alert, reported between 91 and 500 reported cases. However, Tremedal, which presented Risk of Outbreak, reported less than 50 confirmed reported cases (Figure 3b).

DISCUSSION

The data availability of the arboviruses epidemics from the municipalities of southwest of Bahia allowed integration of data which can reveal a new epidemiological perspective

over the reported cases. Furthermore, the HI measurement, a relationship between the number of positive homes and the number of homes inspected, is a useful tool and can be used as an infestation indicator of *A. aegypti*. Our study recovered information about 19 municipalities of Southwestern Region of Bahia and considered the data from 2010 to 2016 period. The Prevalence Index, age, and number of the reported cases, were analyzed together with HI. This research provided information that can be used for epidemiological surveillance and control of the three arboviruses under study.

Dengue transmission presents an alternating behavior, intercalating years with high and low incidence. The highest peaks of the disease coincide with periods of rainfall, as well as in urbanized environments and increases with population density (Teixeira & Cruz 2011), which are most likely associated with the life cycle of the vectors. In our analysis, the peak of DENV reported cases was concentrated between the years 2012 and 2013, with 2013 having the largest number of inspected, positives, and treated properties. This period coincides with an increase in DENV cases in the whole country (Fares et al. 2015, Pilger et al. 2011), and a greater effort from national health surveillance.

Such peaks may likely be associated with the life cycle of the vectors. The prevalence of confirmed cases occurs in months with high rainfall, as well as in urbanized environments and increases with population density; factors that favor the dispersion of the vector (Guerra-Gomes et al. 2017). Also, the virus can alter its epidemic potential and clinical manifestations when it moves between populations; which causes the infection epidemic to appear differently (Teixeira et al. 1999). In line with this study, cities like Salvador (2012) and States like Paraíba (2013) and Goiás (2012-2013) also

Table II. Home Infestation Index (HI) in Southwestern Region of Bahia - Brazil, from 2010 to 2015.

Municipality	2010							2011							2012						
	Work cycles						Year	Work cycles						Year	Work cycles						Year
	1	2	3	4	5	6		1	2	3	4	5	6		1	2	3	4	5	6	
Anagé	0.95	0.61	0.24	3.13	*	*	1.13	3.23	3.9	4.1	*	*	*	2.57	3.04	2.09	0.70	1.57	*	*	2.03
B. Choça	0.35	0.64	0.24	0.20	0.09	0.20	0.29	0	0.09	0.10	0.03	0.05	*	0.05	0.84	0.75	0.77	0.30	0.76	*	0.70
B. Campo	1.14	0.79	0.40	0.21	0.17	*	0.72	2.77	1.46	0.42	0.15	1.46	*	1.23	3.51	1.01	0.60	0.33	1.12	*	1.76
B. J. Serra	0.18	1.40	0.00	1.14	2.93	*	1.28	1.48	0.00	0.00	6.25	*	*	0.73	1.86	2.05	4.66	2.23	1.67	3.15	2.52
Caetanos	0.18	0.00	0.53	0.19	0.00	*	0.18	2.83	2.19	2.12	0.36	3.04	*	2.37	4.31	2.99	2.98	0.75	1.08	*	3.43
Cândido Sales	2.97	3.19	1.19	0.57	0.77	4.63	1.76	6.53	3.61	2.61	0.32	0.65	*	2.81	9.48	5.48	4.40	2.30	1.89	7.65	4.63
Caraíbas	0.00	0.19	0.00	0.00	0.00	0.00	0.04	0.83	2.24	1.81	0.19	0.20	1.73	1.14	1.60	1.05	0.85	0.27	0.41	0.52	0.80
Condeúba	2.64	4.01	2.25	1.82	0.74	2.03	2.26	4.80	2.8	1.42	0.95	0.80	1.33	2.04	2.18	1.63	4.22	0.57	2.14	*	1.56
Cordeiros	*	*	*	*	*	*	*	0.00	0.00	0.00	0.00	0.00	*	0.00	1.44	3.74	3.09	1.85	8.05	*	3.10
Encruzilhada	0.19	0.94	0.13	0.20	*	*	0.34	2.77	2.14	2.63	1.02	3.23	*	2.20	2.21	2.47	0.72	1.40	*	*	1.75
Maetinga	5.87	3.42	1.43	1.41	1.87	2.19	2.11	1.44	1.31	0.91	0.65	0.61	1.02	1.01	2.62	1.92	1.23	1.03	0.20	1.11	1.36
Mirante	2.64	4.55	1.66	3.55	2.77	9.09	3.90	3.69	1.59	1.74	1.36	0.54	5.75	2.38	3.24	3.50	4.84	4.60	1.24	6.03	3.89
Piripá	3.72	2.94	1.04	1.91	3.58	*	2.70	5.45	1.96	0.62	0.38	0.36	*	1.86	1.87	0.84	0.37	0.05	*	*	0.82
Planalto	7.18	2.27	2.71	*	*	*	4.59	23.07	7.93	2.68	3.26	*	*	9.77	14.44	8.72	2.35	*	*	*	9.35
Poções	3.02	2.45	2.39	3.29	*	*	2.78	3.45	2.57	1.02	1.35	*	*	2.14	3.71	3.05	1.70	0.88	1.95	*	2.30
P. J. Quadros	1.02	0.55	0.00	0.05	*	*	0.37	6.25	1.84	1.34	0.76	*	*	2.46	13.58	6.41	4.19	3.45	*	*	7.92
R. Largo	1.02	0.00	0.00	0.00	0.00	*	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tremedal	2.36	1.24	9.75	*	*	*	5.60	5.19	6.82	2.70	1.61	0.68	9.68	4.59	7.53	2.81	2.55	5.55	3.74	7.92	5.07
V. da Conquista	4.51	2.13	0.84	*	*	*	1.83	4.50	2.52	2.32	1.19	0.97	*	2.54	4.33	3.04	1.22	0.48	0.68	*	1.76
Municipality	2013							2014							2015						
	Work cycles						Year	Work cycles						Year	Work cycles						Year
	1	2	3	4	5	6		1	2	3	4	5	6		1	2	3	4	5	6	
Anagé	5.65	7.55	0.42	1.14	*	*	2.62	2.01	10.18	2.22	1.13	*	*	1.96	1.59	6.07	2.47	1.12	0.75	*	1.62
B. Choça	2.50	1.80	1.96	1.77	0.27	*	1.38	1.52	2.22	1.37	0.28	*	*	1.22	1.10	2.51	2.51	2.38	1.24	*	1.69
B. Campo	2.97	0.89	0.12	0.74	2.19	*	1.61	4.15	1.08	1.12	0.30	0.89	*	1.71	2.89	1.97	0.62	1.18	1.89	*	1.81
B. J. Serra	5.70	2.16	2.87	1.00	2.00	1.28	2.53	1.52	2.08	0.39	1.11	0.56	1.61	1.27	2.93	1.78	0.70	1.73	1.57	1.91	1.82
Caetanos	5.78	4.10	1.74	2.07	0.44	*	3.69	4.01	3.13	0.50	1.59	*	*	2.40	1.25	2.40	1.61	0.71	*	*	1.44
Cândido Sales	2.29	4.29	2.35	2.47	4.22	*	3.90	4.23	2.65	0.00	*	*	*	3.48	3.03	2.14	0.63	*	*	*	2.57
Caraíbas	0.15	0.40	0.69	0.38	1.14	1.24	0.64	0.16	1.88	4.20	1.37	1.12	8.91	2.69	7.76	6.40	5.28	4.31	7.19	*	6.04
Condeúba	2.73	1.07	1.51	2.20	1.28	0.77	1.20	1.54	2.25	1.12	0.72	0.91	*	1.31	1.52	1.38	0.49	0.71	2.02	*	1.07
Cordeiros	2.90	0.59	0.00	0.00	0.00	*	1.01	1.16	0.85	1.12	0.57	0.00	*	0.67	1.19	2.14	1.85	1.18	5.10	1.96	1.93
Encruzilhada	6.01	4.02	2.08	1.20	2.13	*	3.15	1.55	1.54	0.73	0.20	0.52	*	1.02	1.30	3.52	2.04	0.62	0.15	*	1.51
Maetinga	1.89	1.87	1.87	3.00	1.65	3.23	2.24	3.62	1.97	1.27	1.30	*	*	2.06	1.08	0.64	0.98	0.77	0.57	0.42	0.74
Mirante	5.56	2.40	2.97	2.61	2.12	5.67	3.49	3.46	0.81	3.35	0.49	0	1.01	1.50	0.34	0.87	1.45	2.49	0.60	0.95	1.18
Piripá	1.84	1.32	0.05	0.36	0.61	*	0.87	1.29	0.82	0.13	0	0.16	*	0.49	0.14	0.17	0.08	1.70	1.70	*	0.61

Table II. (continuation).

Municipality	2013							2014							2015						
	Work cycles						Year	Work cycles						Year	Work cycles						Year
	1	2	3	4	5	6		1	2	3	4	5	6		1	2	3	4	5	6	
Planalto	15.99	5.12	*	*	*	*	12.64	7.00	3.93	*	*	*	*	6.12	5.96	2.83	*	*	*	*	5.44
Poções	2.15	1.90	1.61	1.06	0.53	0.53	1.22	1.21	0.61	0.47	0.29	0.32	0.29	0.55	0.71	0.63	0.70	0.43	*	*	0.63
P. J. Quadros	7.36	4.05	2.50	1.20	0.70	*	3.14	14.24	7.38	0.00	0.00	1.08	0.87	4.24	0.63	1.65	6.22	*	*	*	1.99
R. Largo	0.00	0.00	0.00	0.00	0.12	*	0.02	1.15	0.90	0.30	0.16	0.10	0.00	0.44	1.54	0.78	1.56	0.00	0.56	0.82	0.90
Tremedal	10.24	5.61	4.01	4.55	9.58	10.27	7.30	11.24	5.38	4.25	1.41	0.98	*	4.38	5.10	5.36	4.90	3.70	3.63	2.50	4.31
V. da Conquista	3.14	4.10	2.96	1.23	2.06	*	2.26	3.88	4.45	2.24	1.29	*	*	3.15	4.01	5.41	4.88	2.23	2.38	*	3.75

The work cycles correspond to the bimonthly cycles of data collection, gathered by endemic diseases control agent. The HI corresponds to the proportion of properties marked positive (with larvae and/or pupae of *A. aegypti* and/or *A. albopictus*) in relation to the total of properties inspected. * Data not available. Municipalities: B. Choça - Barra do Choça; B. Campo - Belo Campo; B. J. da Serra - Bom Jesus da Serra; C. Sales-Cândido Sales; P. J. Quadros - Presidente Jânio Quadros; R. Largo - Ribeirão do Largo; V. da Conquista - Vitória da Conquista. Source: Sistema de Informação da Febre Amarela e Dengue (SISFAD).

Table III. Prevalence Index and Home Infestation Index relative to DENV in Southwestern Region of Bahia - Brazil, from 2010 to 2015.

Municipality	Prevalence Index	Home Infestation Index					
		2010	2011	2012	2013	2014	2015
Anagé	0.60	1.13	2.57	2.03	2.62	1.96	1.62
B. Choça	4.09	0.29	0.05	0.70	1.38	1.22	1.69
B. Campo	0.86	0.72	1.23	1.76	1.61	1.71	1.81
B. J. da Serra	0.46	1.28	0.73	2.52	2.53	1.27	1.82
Caetanos	3.77	0.18	2.37	3.43	3.69	2.4	1.44
C. Sales	1.33	1.76	2.81	4.63	3.9	3.48	2.57
Caraíbas	0.32	0.04	1.14	0.80	0.64	2.69	6.04
Condeúba	2.46	2.26	2.04	1.56	1.2	1.31	1.07
Cordeiros	2.35	0.00	0.00	3.10	1.01	0.67	1.93
Encruzilhada	1.56	0.34	2.2	1.75	3.15	1.02	1.51
Maetinga	0.67	2.11	1.01	1.36	2.24	2.06	0.74
Mirante	2.13	3.9	2.38	3.89	3.49	1.50	1.18
Piripá	2.93	2.7	1.86	0.82	0.87	0.49	0.61
Planalto	4.89	4.59	9.77	9.35	12.64	6.12	5.44
Poções	1.83	2.78	2.14	2.3	1.22	0.55	0.63
P. J. Quadros	1.34	0.37	2.46	7.92	3.14	4.24	1.99
R. Largo	0.20	0.20	0.00	0.00	0.02	0.44	0.90
Tremedal	2.24	5.60	4.59	5.07	7.30	4.38	4.31
V. da Conquista	1.16	1.83	2.54	1.76	2.26	3.15	3.75

B. Choça - Barra do Choça; B. Campo - Belo Campo; B. J. da Serra - Bom Jesus da Serra; C. Sales-Cândido Sales; P. J. Quadros - Presidente Jânio Quadros; R. Largo - Ribeirão do Largo; V. da Conquista - Vitória da Conquista. Source: Sistema de Informação da Febre Amarela e Dengue (SISFAD). The Prevalence Index was calculated by the number of reported DENV cases during the specified period divided by the estimated population (2010) x 100%.

recorded in these years cited, the largest number of confirmed cases for Dengue (Fantinati et al. 2013, Martins et al. 2015, Guerra-Gomes et al. 2017).

From 2010 to 2015, the municipalities with the highest numbers of positive properties per year were Vitória da Conquista and Planalto. In Vitória da Conquista, there were 4,267 positive properties in the six years studied for the presence of mosquito pupae, with the highest number of positive properties in 2011 (1,383 properties). Planalto followed with 3,714 positive properties in the six years studied, with the highest number of properties in 2013 (1,144), reflected in the high HI present by this municipality, in the 2013 this number reached 12.64, and also maintained the Risk of Outbreak (HI > 3.9%) throughout all years analyzed. Salvador (2012) and Rio de Janeiro (2011-2013) cities also recorded high numbers of DENV cases in same years of our study, indicating an alignment of our data with other locates (Martins et al. 2015, Xavier et al. 2017). Regarding the Prevalence Index of DENV cases, Vitória da Conquista and Planalto had a PI of 1.16%. and 1.83%, respectively. However, all municipalities with more than 20 thousand inhabitants had a lower PI, except Cândido Sales with an estimated population of 27,918 and a PI of 3.77%. This indicates that despite the Prevalence Index pointed to a low prevalence of DENV in Vitória da Conquista, this may be possibly due to its large territorial extension and dense population. It is important to highlight that Vitória da Conquista is home for Bahia Health microregion, which is composed of the 19 municipalities included in this work. Among them, it is the most populous city, and is also where the 20^o Dires is located (Adriano 2013), indicating that Vitória da Conquista plays a major role for its microregion.

ZIKV occurrence has been associated with several factors such as spread speed of

the virus and those infected, the severity of manifestations, total people affected, and misinformation about such arbovirose (Song et al. 2017). In 2015 and 2016, Brazil was surprised by a huge epidemic of ZIKV. Since then, the Health Surveillance Secretariat (SVS) has monitored such cases. Infection occurrences have been reported to SVS in different states such as Bahia, Maranhão, Sergipe, Paraíba and Rio Grande do Norte (Marcondes & Ximenes 2016). In this study, the most reported cases of infection occurred in 2016, highlighted in Cândido Sales and Vitória da Conquista, with major cases. Cândido Sales presented a PI of 0.67%, the second highest index for ZIKV prevalence in the microregion. According to the SESAB, during 2015 and 2016 there were 64,478 and 56,807 cases of ZIKV reported, respectively, in Bahia (SESAB 2015). The increase of cases of ZIKV in 2016 coincides with the worldwide outbreak of this arbovirus (Ai et al. 2016), although this increase could be related to recent advances in virus detection. High ZIKV infection rate was also reported in Salvador, capital of Bahia (Netto et al. 2017).

Meanwhile, in our study for CHIKV, only 224 cases were registered and reported within the 19 municipalities, with Vitória da Conquista and Cândido Sales having the highest numbers of reported cases, this last one also the highest prevalence of CHIKV (PI: 0.25%). It is worth noting that the same two municipalities presented the highest number of cases for both ZIKV and CHIKV. The confirmed cases of arboviruses are difficult to register since it depends on the patient's return to the health system to the confirmation of the diagnosis, followed by notification of the proper authorities. This causes a lack of automation in the process of entering and crossing the epidemiological data, limiting the surveillance process (Cardoso et al. 2012).

Regarding the demographic aspects, the municipalities with lower population quotas



Figure 3. Home Infestation Index (HI) and distribution of reported cases in Southwestern Region of Bahia - Brazil, for ZIKV (2015 to 2016) and DENV (2010 to 2015). (a) Variation of HI relative to cases of DENV. (b) Variation of HI relative to cases of ZIKV. Municipalities: B. Choça - Barra do Choça; B. Campo - Belo Campo; B. J. da Serra- Bom Jesus da Serra; C. Sales-Cândido Sales; P. J. Quadros - Presidente Jânio Quadros; R. Largo - Ribeirão do Largo; V. da Conquista - Vitória da Conquista. The HI corresponds to the proportion of properties positive (with larvae and/or pupae of *A. aegypti* and/or *A. albopictus*) in relation to the total of properties inspected. The HI colors attributed to the municipalities took into consideration the annual classification of HI of the municipalities in more than 50% of the analyzed years (four to six years). Circles indicate the number of reported cases of arboviruses per municipality considering the six years studied. The size of the circles reflects the number of cases reported. Sources: Sistema de Informação da Febre Amarela e Dengue (SISFAD) and Sistema de Informação de Agravos de Notificação (SINAN).

were Ribeirão do Largo, Cordeiros, and Maetinga, all of them with less than 10,000 inhabitants. Ribeirão do Largo stood out due to the low prevalence of DENV cases (PI: 0.20%) and ZIKV (PI: 0.20%). Values of HI in the area of Alert and/or Outbreak were also reported in, Itabuna (Souza & Dias 2010), Teresina (Monteiro et al. 2009), São Luís (Dias Júnior et al. 2017), cities located in the northeastern of Brazil. This region has reported the major cases of ZIKV-associated microcephalia and outbreaks of the arboviruses. This could be a reflect of the low socioeconomic status of the northeastern states of Brazil. Additionally, Bahia is pointed as one of the most underdeveloped Brazilian states (“Atlas do Desenvolvimento Humano no Brasil” 2013).

These results show that several Brazilian municipalities are in a constant state of Alert which can be possible due to any irregularity in the vector control programs. The HI can be employed as an instrument of control measures, thereby making it possible to intensify interventions or change strategies.

CONCLUSIONS

In this study, we demonstrated for the first time the epidemiological characteristics of DENV, ZIKV, and CHIKV in the 19 municipalities of Southwestern Region of Bahia. Also, the Prevalence Index for the arboviruses was analyzed indicting the maintenance of this virus in the region. In this context, higher the percentage of positivity for larvae of *A. Aegypti* or *A. albopictus* presents a higher probability of transmission, hence DENV or CHIKV or ZIKV disease. The analysis of the data collected has identified that the studied arboviruses continue to be a public health problem in Bahia. Thus, notification and description the arboviruses analyzed are important in determining (i) the

associated risk factors; (ii) how diseases spread among the population; (iii) appropriate way to provide data for planning vector control measures; and (iv) how to raise public awareness of the risks associated with these diseases.

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SUPPLEMENTARY MATERIAL

Table SI. Occurrence and treatment of DENV vectors (2010 - 2015) in Southwestern Region of Bahia - Brazil. Agreed. - properties existing in each municipal multiplied by 6. Insp. - properties visited by the Endemic Control Agents. Posit. - properties where the *A. aegypti* and/or *A. albopictus* vectors were found (in the form of larvae or pupae). Treated - properties treated by applying larvicidal in reservoirs that contain or could contain water. * Data Not Available. Municipalities: B. Choça- Barra do Choça, B. Campo-Belo Campo. B. J. da Serra - Bom Jesus da Serra. C. Sales- Cândido Sales. P. J. Quadros- Presidente Jânio Quadros. R. Largo - Ribeirão do Largo. V. da Conquista - Vitória da Conquista. Source: Sistema de Informação de Agravos de Notificação (SINAN).

Table SII. Prevalence Index for DENV, ZIKV, and CHIKV in Southwestern Region of Bahia - Brazil. (a) DENV (2010 - 2015). (b) ZIKV (2015 - 2016). (c) CHIKV (2014 - 2016). * Data Not Available. Municipalities: B. Choça- Barra do Choça, B. Campo- Belo Campo. B. J. da Serra - Bom Jesus da Serra. C. Sales- Cândido Sales. P. J. Quadros- Presidente Jânio Quadros. R. Largo - Ribeirão do Largo. V. da Conquista - Vitória da Conquista. Source: Sistema de Informação de Agravos de Notificação (SINAN).

Table SIII. Distribution of reported cases of ZIKV (2015 - 2016) and CHIKV (2014 - 2016) in Southwestern Region of Bahia - Brazil. * Data not available. Municipalities: B. Choça- Barra do Choça; B. Campo-Belo Campo; B. J. da Serra - Bom Jesus da Serra; C. Sales- Cândido Sales; P. J. Quadros - Presidente Jânio Quadros; R. Largo - Ribeirão do Largo. V. da Conquista - Vitória da Conquista. Source: Sistema de Informação de Agravos de Notificação (SINAN). Data collected on 07/31/2018.

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LT conceived the idea. JHMS contributed with the availability and interpretation of data about vector aspects from Sistema de Informação da Febre Amarela e Dengue (SISFAD). SCAV helped in the rescue and interpretation of epidemiological data in Sistema de Informação de Agravos de Notificação (SINAN). TBB and PPA carried out the analysis of the data, the preparation of tables and figures, and contributed developing the discussion section and writing the manuscript. All authors are involved in interpreting the results. FFM contributed reviewing the manuscript. RAAS and LT supervised the final version. All authors read and approved the final manuscript.

