Strengthening Entomological Surveillance in Rio de Janeiro: Analysis and Control of Arboviroses Using the LIRAa Toll from 2015 to 2019

Cristina Conceição Rocha Guedes[1,2*], Maria de Lourdes Ferraz Heleodoro[1,2], Carlos Augusto Correia Lima Reis[1,2], Charles da Silva Bezerra[2], Rodrigo Gomes Marques Silvestre[3], Aloisio Santos Nascimento Filho[2], Hugo Sabab[4]
[1]Fundação Oswaldo Cruz, Rio de Janeiro, Rio de Janeiro; [2]SENAI CIMATEC University; Salvador, Bahia; [3]Federal University of Paraná; Curitiba, Paraná; [4]State University of Bahia; Salvador, Bahia, Brazil

The triple arboviruses—Dengue, Zika, and Chikungunya—pose significant challenges for public managers. This study aimed to demonstrate the strengthening of entomological surveillance to control arboviruses using LIRAa as a tool, with an analysis of Rio de Janeiro from 2015 to 2019. The method used was quantitative and exploratory, analyzing data from LIRAa Epidemiological Reports and relevant legislation. Results indicated that LIRAa effectively identifies mosquito infestation hotspots and guides vector control actions. The conclusion underscores that entomological surveillance is critical for preventing arbovirus transmission, emphasizing the importance of continuing such practices to safeguard public health and ensure a safer environment.
Keywords: Rapid Infestation Survey of *Aedes aegypti*. Entomological Surveillance. Triple Arboviruses. Rio de Janeiro.

The arboviruses Dengue, Chikungunya, and Zika are viral diseases caused by Flaviviruses and Alphaviruses. Dengue virus and its serotypes have circulated in Brazil since the 1980s, while Chikungunya and Zika emerged around 2014 and 2015. Classified as neglected diseases, these arboviruses are a significant global public health threat due to their similar clinical symptoms, progression to severe conditions, maternal-fetal contamination syndromes, and increased lethality during epidemic outbreaks [1–4].

Arboviruses are primarily transmitted to humans through the bite of arthropod vectors, specifically mosquitoes of the *Culicidae* family belonging to the genus Aedes (*Aedes aegypti* and *Aedes albopictus* females). Additional modes of viral transmission include transfusion routes and, for Zika, sexual and transplacental transmission, which caused a surge in microcephaly cases among babies born to infected mothers [2,5].

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Address for correspondence: Cristina Conceição Rocha Guedes. Funbdação Oswaldo Cruz. Av. Brasil, 4365 - Manguinhos. Zipcode: 21040-900. Rio de Janeiro, RJ, Brazil. E-mail: cristina.guedes@fiocruz.br.

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Certain factors increase vulnerability to arboviruses, including climatic conditions, environmental challenges, socioeconomic factors, and unplanned urban growth. These factors contribute to structural deficiencies in essential public services such as sanitation, garbage collection, and access to clean water [4–8].

Public Policies to Combat Arboviruses

In 1996, the *Aedes aegypti* Eradication Plan (PEAa) was implemented with a decentralized, multisectoral approach. Actions focused on combating adult mosquitoes using vector control, water treatment of breeding sites, and insecticide applications. However, the plan was discontinued due to health and environmental risks associated with prioritizing insecticides. Measures such as breeding site elimination, environmental education, and sanitation were overlooked [9].

In response to rising dengue cases, the Ministry of Health launched the National Plan to Combat Dengue (PNCD) in 2002, revised in 2006.

Updates included strengthened information campaigns, social mobilization, epidemiological and entomological surveillance, sanitation measures, integration with primary care services, training for endemic agents, and indicators to evaluate action effectiveness [1,10,11].

With the emergence of new arboviruses in 2015, additional guidelines were introduced for early diagnosis, case management, and public health service reinforcement. That year's Zika virus outbreak highlighted the need for mass vaccination or specific antivirals [12]. Collaborative efforts across the Ministry of Health and state and municipal health departments demonstrated the importance of support networks to mitigate public health impacts [13,14].

This study aimed to present an analysis of the entomological indicator LIRAa in the 92 municipalities of Rio de Janeiro from 2015 to 2019 during outbreaks of the triple arboviruses.

Materials and Methods

This research employed a quantitative, descriptive, and exploratory approach, analyzing data from 92 municipalities in Rio de Janeiro between 2015 and 2019. The method involved numerical data extracted from LIRAa Epidemiological Reports for the defined years. These reports facilitated an analysis of the magnitude of arbovirus-related challenges during this period.

The study also involved bibliographic and documentary research, utilizing scientific articles, technical documents, federal legislation, and data from sources such as Gov.br, the Health Surveillance System Panel, and the Brazilian Institute of Geography and Statistics (IBGE).

LIRAa: An Entomological Surveillance Tool

Since 2003, LIRAa (Rapid Infestation Survey of *Aedes aegypti*) has played a critical role in combating arboviruses. Known as the "Dengue Map," this tool enables municipal managers to plan vector control actions such as breeding site elimination, insecticide application, and public awareness campaigns. In 2017, LIRAa became mandatory for municipalities, linking report submission to financial resource allocation [15–17].

The method, revised in 2013, evaluates infestation using Breteau and Predial indices, with standardized procedures for simplified diagnosis. Table 1 outlines key methodological aspects of LIRAa.

Results and Discussion

We analyzed the variables extracted from the LIRAa Reports from 2015 to 2019 from the state of Rio de Janeiro using: number of municipalities that delivered the LIRAa Report and percentage; the results of the Building Infestation Index, demonstrated by the number of municipalities that had satisfactory results, at risk and on alert and their respective percentages; number of municipalities with simultaneous presence of *Aedes aegypt* and *albopictus*; predominant types of deposits; number of strata visited and the percentages of municipalities that presented their Breteau Indexes with satisfactory, alert and risk results.

Teams of endemic disease control agents (ACE) are responsible for all fieldwork and define the visitation strata, which are geographically delimited areas within a municipality or region previously selected for sampling and data collection. Neighborhoods, census sectors, blocks, or other territorial divisions can be listed and segmented into smaller parts, facilitating the assessment and analysis of the infestation and allowing a more practical approach to combating diseases transmitted by mosquitoes [19].

The strata are important in the *Aedes aegypti* Infestation Index Survey (LIRAa), allowing a more detailed and specific assessment of the transmitting mosquito's presence in different parts of a municipality. The classification of strata as satisfactory, at risk, or at risk based on infestation rates collected in these areas helps to identify where vector foci are concentrated and guides control and prevention actions [15,18].

Rio de Janeiro hosted several international sporting events in 2014, 2016 and 2018. In the second half of 2015, the first cases of Chikungunya and Zika were recorded, in addition to dengue [4]. During this period, its municipalities carried out LIRAa systematically and continuously. They recorded for

Table 1. LIRAa methodological aspects.

Methodological Aspects	Goal
Geographic Recognition (RG)	As a preliminary and essential activity for programming the index survey. It involves the identification and delimitation of the areas to be evaluated, considering geographic and population aspects.
Property inspections	Endemic disease control agents conduct inspections of selected properties, checking for the presence of breeding sites, such as containers with stagnant water.
Data collect	During inspections, information is collected about the presence of mosquito larvae, the number of containers with standing water, and other characteristics relevant to assessing the infestation.
Calculation of Infestation Rates	Based on the data collected, infestation rates are calculated, such as the Breteau Index (number of containers with mosquito larvae/100 properties inspected), and the Building Index (percentage of properties with the presence of larvae).
Data Analysis and Consolidation	To identify areas with a higher risk of disease transmission and guide vector control actions. Allowing reliable estimates of *Aedes aegypti* infestation rates to be obtained quickly and economically, contributing to entomological surveillance and the fight against arboviruses

health authorities local epidemiological conditions, detailing the types of deposits and breeding sites found in the strata of the municipalities, defined as satisfactory, alert, and at risk, according to data obtained from inspections of properties, vacant land, and possible sources that could be potential mosquito breeding grounds.

Table 2 presents the results of the Reports and variants analyzed; there was no adherence to delivery of the LIRAa for 100% of the municipalities, which could harm the state's actions, as it does not describe the actual situation of the municipalities that did not present the results. However, from 2018 onwards, the number of participating municipalities increased due to mandatory delivery. Reflecting about the application of the management tool and as agreed by the Rio de Janeiro Bipartite Commission, the method became a mandatory and routine activity in arbovirus prevention and control actions, as well as the understanding that decentralization of management actions combat, allowed greater autonomy and capacity for municipalities to conduct monitoring and report infestation rates, according to data from the Reports, varying in delivery results during the established periods of 2015:68–82 municipality; 2016: 73–75 municipalities; 2017: 64–88 municipalities; 2018: 89–91 municipalities and 2019: 88–90 municipalities An increase in the number of municipalities with satisfactory results can be observed over the years: 2015: Ranged from 29.3% (March) to 57.5% (October); 2016: Ranged from 59.5% (May) to 86.03% (July); 2017: Ranged from 52.4% (March) to 76.1% (October); 2018: Ranged from 35.6% (January) to 61.8% (May) and 2019: Ranged from 45.5% (May) to 68.5% (August).

Variations in the percentage of municipalities at different infestation levels are observed over the months and years due to the increase in the percentage of municipalities at satisfactory levels. There was also an increase in the strata evaluated, indicating higher percentages of alert or risk in the municipalities during the period evaluated. Demonstrating the possibility of each region expressing seasonal variations within the same state implies mosquito infestation within the region.

Table 2. Results of variables by health regions from 2015 to 2019 in Rio de Janeiro, Brazil.

Year	LIRAa	LIRAa Report (%)[1]	Number of Municipality (%)	Number of Municipality Alert (%)	Number of Municipality at Risk (%)	Number of Municipality with *Aedes aegypt* and *albopictus*	Deposits[2]	Strata (N)[3]	S (%)[4]	Alert (%)	Risk (%)
2015	January	76 (82.61)	32 (42.11)	44 (57.89)	0 (0)	49	A2 B	843	52.0	43.80	3.50
	March	82 (89.10)	23 (29.30)	52 (63.40)	6 (7.30)	56	A2 B	874	37.30	51.10	11.60
	May	68 (73.90)	29 (42.60)	37 (54.40)	2 (2.90)	49	A2 B	819	52.63	43.22	4.15
	October	80 (86.96)	46 (57.50)	33 (41.25)	1 (1.25)	45	A2 B	891	57.35	38.95	3.70
2016	May	74 (80.40)	44 (59.50)	29 (39.20)	1 (1.40)	52	A2 B	844	61.50	36.30	2.30
	July	73 (79.03)	63 (86.03)	10 (13.07)	0 (0)	31	A2 B	815	75.58	23.44	0.98
	October	75 (81.50)	54 (72.0)	20 (26.70)	1 (1.30)	44	A2 B	880	66.90	30.80	2.30
2017	January	64 (69.60)	39 (60.90)	24 (37.50)	1 (1.60)	39	C, A2 D2, B	808	58.50	38.0	3.50
	March	84 (91.30)	44 (52.40)	35 (41.60)	5 (6.0)	63	C, A2 D2, B	950	56.40	39.10	4.50
	May	85 (92.40)	47 (55.30)	34 (40.0)	4 (4.70)	62	C, A2 D2, B	884	61.50	30.50	8.0
	October	88 (94.60)	67 (76.10)	21 (23.86)	0 (0)	38	C, A2 D2, B	875	69.50	29.50	1.20
2018	January	90 (97.80)	32 (35.60)	51 (56.70)	7 (7.80)	73	C, A2 D2, B	934	44,80	46.0	9.20
	February	89 (96.70)	35 (39.30)	49 (55.10)	5 (5.60)	68	C, A2 D2, B	922	49.10	43.50	7.40
	May	90 (97.80)	51 (56.70)	34 (37.80)	5 (5.60)	67	C, A2 D2, B	935	61.80	33.70	4.50
	August	89 (96.70)	48 (53.90)	40 (44.90)	1 (1.10)	52	C, A2 D2, B	692	55.50	40.50	4.0
	October	91 (98.90)	45 (49.50)	43 (47.30)	3 (3.30)	59	C, A2 D2, B	929	49.70	44.20	6.0
2019	February	90 (97.80)	53 (58.90)	36 (40.0)	1 (1.10)	58	C, A2 D2, B	938	64.60	32.90	2.50
	May	88 (95.70)	40 (45.50)	46 (52.30)	2 (2.30)	61	C, A2 D2, B	909	50.10	43.20	6.70
	August	89 (96.70)	61 (68.50)	25 (28.10)	3 (3.40)	48	C, A2 D2, B	915	69.20	28.60	2.20
	October	89 (96.70)	55 (61.80)	32 (36.0)	2 (2.20)	53	C, A2 D2, B	916	57.90	37.0	5.10

Source: LIRAa Rio de Janeiro reports from 2015 to 2019.
1: Number of municipality that delivered the LIRAa Report.
2: Types of deposits predominant.
3: Number strata.
4: Satisfactory.

However, it must also be analyzed whether all the combat measures adopted by the municipalities are effective, causing a reduction in the risk and alert strata. Regarding the simultaneous presence of the two vectors *Aedes aegypt* and *albopictus*, a significant increase in samples was observed, according to the results analyzed: 2015: Ranged from 45 to 56 municipalities; 2016: Ranged from 31 to 52 municipalities; 2017: Ranged from 38 to 63 municipalities; 2018: Ranged from 52 to 73 municipalities; 2019: Ranged from 48 to 61 municipalities. *Aedes albopictus* is highlighted as a vector for transmission of the Chikungunya virus.

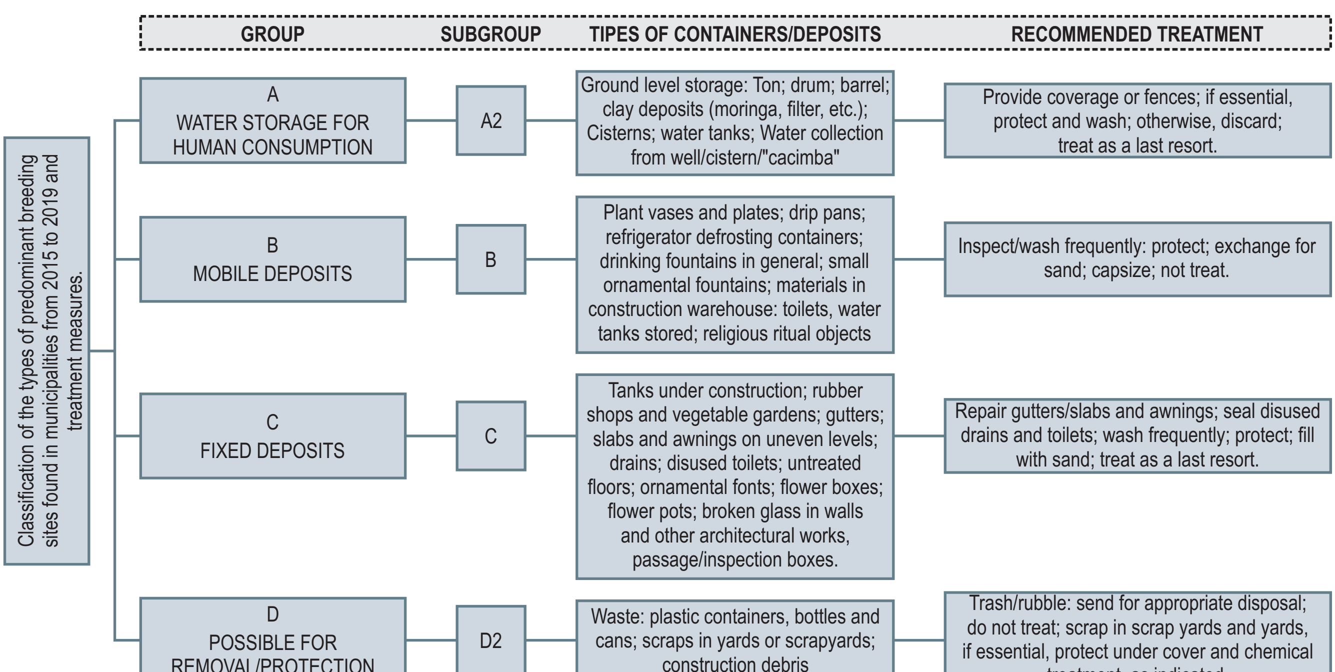
This increase is related to urban infrastructure, environmental changes, and deforestation, as wild mosquitoes have adapted to artificial breeding sites, making it necessary to intensify vector management.

In the diagnosis of the LIRAa tool, the breeding sites found were also highlighted, with a predominance of types of deposits A2, B, C, D2 throughout the analyzed period, determining the need for multidisciplinary actions involving sanitation actions, water supply, disposal of waste, with the participation of government bodies and the Master Plans of each municipality. It also demonstrates the need for ACEs to guide the population in creating continuous and regular monitoring of possible water storage locations and potential breeding sites for the two mosquito species (Figure 1). Classification and actions indicated regarding *Aedes aegypt* breeding sites.

These observations suggest progress in the management of infestation rates but also highlight the need for continuous and adaptive strategies to face persistent challenges in the fight against *Aedes aegypti* and *Aedes albopictus*, mainly focusing on areas that presented alert and risk situations and municipalities that share borders, which can increase the spread of vectors and diseases, through the movement of people and interconnected transport networks.

The strategy public managers adopt involves establishing an intersectoral integration network among the health, environment, education, and sanitation sectors. Key actions include intensifying

Figure 1. Classification of the types of predominant breeding sites found in municipalities from 2015 to 2019 and treatment measures.



Source: Adapted from the LIRAa Manual, (2013) [15].

education and public awareness campaigns, particularly during peak disease seasons, and enhancing monitoring efforts through the adoption of advanced technologies for vector control. This strategy also focuses on preventing outbreaks in urban and rural areas by regularly inspecting high-risk locations such as abandoned buildings, garbage dumps, and containers used for plants and animals.

Additionally, the plan emphasizes significant investments in basic sanitation infrastructure and waste management systems, including efficient garbage collection processes. Training and capacity-building programs for ACE teams are prioritized, alongside support for research and development of innovative technologies and tools. Climate monitoring is also integrated into this approach to predict and mitigate risks effectively.

Conclusion

Entomological surveillance in Rio de Janeiro from 2015 to 2019 demonstrated the effectiveness of LIRAa in identifying mosquito infestation hotspots and guiding strategic public health actions. The tool proved essential for continuous monitoring, vector elimination, and timely intervention.

The results underscore the importance of ACE professionals, whose roles include inspecting properties, eliminating outbreaks, and educating the public on water storage and waste management. The regular use of LIRAa has significantly contributed to reducing the burden of arboviruses on public health systems in Rio de Janeiro, emphasizing its value as a practical and impactful tool.

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