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Dengue Infection in Rondônia-Brazil: Epidemiological and Environmental Aspects during 2001-2010 Occurrence

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Authors' contributions

This work was carried out in collaboration between all authors. Authors AFCSO, ASO and EGS carried out the bioinformatic analysis and drafted the manuscript. Authors CASF, EH and APG participated in the design of the study and analysis. Authors RSB and CCS were essential on the concept of the study, and participated in its design and coordination. Author SODP is the responsible for the design and coordination of the project. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The state of Rondônia is located in the western area of the Brazilian Amazon, and presents a strategic location for the spread of dengue virus. This study aims to characterize the epidemiology of dengue in Rondônia from 2001-2010.

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Study Design: This is a descriptive work that aims to study time series of dengue epidemics from the resident population in the municipalities of the state of Rondonia (Brazil) in the period 2001-2010.
Place and Duration of Study: This study used secondary data. Data was obtained from the Notifiable Diseases Information System (SINAN) using only confirmed cases of dengue during the period from 2001-2010 in the Rondônia state (Brazil). Population statistics were obtained from the Brazilian Institute of Geography and Statistics (IBGE - www.ibge.gov.br).
Methodology: The epidemiological profile of the disease was traced from the following variables: year of reporting; age; gender, education; final classification; and confirmation criterion. Rainfall and migratory pathways were compared with the disease incidence rate of the cities.
Results: 71,541 cases of dengue were reported in this period. Although Rondônia is not one of the states with the highest incidence rates of dengue in Brazil, it presents some cities with over 4,000 cases/100,000 inhabitants. We found that waterways, roads, ports, airports and borders tend to be associated with regions with the highest number of cases.
Conclusion: Cities where many people from various localities circulate require special epidemiological attention. This analysis points to the need to improve the monitoring/control of vectors, patients and possibly sick people.

Keywords: Dengue; epidemiology; migration; rainfall.

1. INTRODUCTION

Dengue viruses (DENV) are members of the family Flaviviridae, genus Flavivirus, and are responsible for 50 to 100 million cases in tropical and subtropical areas, where approximately 500,000 hospitalizations occur each year [1-2]. Dengue is the most important disease caused by an arbovirus in the world and generates a strong impact on the population, health systems, and the economy of most tropical countries [3]. Global incidence of dengue has grown dramatically in recent decades. The disease is now endemic in more than 100 countries in Africa, the Americas, the Eastern Mediterranean, Southeast of Asia, and West Pacífic. In these regions, 90% of dengue hemorrhagic fever (DHF) cases involve children under 15 [3-5].

Most infections occur in urban and semi-urban areas of tropical and subtropical regions where the virus is transmitted by the vectors *Aedes aegypti* and *Aedes albopictus* [6]. The disease can be caused by one of four serotypes (DENV-1, DENV-2, DENV-3 and DENV-4), and its spectrum ranges from asymptomatic infection to dengue fever, dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS), which may lead to the patient's death [7]. Recently, in the Third International Conference on Dengue and Dengue Hemorrhagic Fever, a group from the University of Texas Medical Branch in Galveston announced the discovery of a new serotype of the virus called DENV-5.

Factors responsible for the expansion of dengue as a global public health problem in recent decades are associated with social demographics and environmental changes of the past 50 years [8]. The major factors are unprecedented population growth and uncontrolled urbanization, especially in tropical developing countries. However, epidemiological changes in the Americas were more drastic. In the 50s, 60s, and most of the 70s, epidemics of dengue in the Americas were rare due to the eradication of the mosquito vector [9]. However, the mosquito eradication program was discontinued in the early 70s and this species reappeared, coming to reoccupy in the 90s the geographical distribution it had occupied before the eradication process.

Increased circulation of multiple serotypes with different viral genomes and the (re) introduction of new serotypes in Brazil resulted in the endemicity and hyperendemicity, which changed the epidemiological profile. This change has been associated with increased incidence in children under 14, as well as an increase in the proportion of severe cases [10].

In the 21st century, Brazil has become the country with the highest number of reported cases of dengue fever, with over three million cases reported from 2000 to 2005. This represents 78% of all cases reported in the Americas and 61% of all cases reported to the World Health Organization [11]. The incidence in Brazil is between 446.3 to 63.2 cases per

100,000 inhabitants in 2002 and 2004, respectively [10,12].

In the Brazilian context, the state of Rondônia, located in the western region of the Brazilian Amazon, with an estimated 1,728,214 inhabitants (IBGE 2010), presents a strategic location for the spread of dengue virus by a variety of reasons. The state is located in a tropical area and shares an extensive border with Bolivia. Moreover, it is an important intersection of waterways and transport routes that connect the state with the central and southern areas of Brazil and Bolivia. These routes make possible the importation of several infectious agents, including different dengue serotypes. In recent decades, Rondônia has received hundreds of thousands of migrants from various regions of Brazil, and many of the inhabitants of the state habitually travel to areas where dengue outbreaks occur. The cities of this state have poor sanitation systems, favoring mosquito breeding in peripheral areas [13]. Given these favorable conditions for disease development, this study aims to trace the epidemiologic profile of dengue in the state of Rondônia, Brazil, during 2001-2010.

2. METHODOLOGY

2.1 Study Area

This study was conducted in the state of Rondônia, Brazil, located in the northern region of the country, limiting with the states of Mato Grosso (east), Amazonas (north), Acre (west) and the Republic of Bolivia (to the west and south). Geographic coordinates are 11º30'20" South - 63º34'20" West. The state was created in 1982 and has 52 cities covering an area of 237,576.167 km^2. The estimated population for the year 2013 is about 1,728,214 inhabitants and the Human Development Index (HDI) is 0.690, according to the census of the Brazilian Institute of Geography and Statistics (IBGE) in 2010.

2.2 Study Design

This is a descriptive work that aims to study time series of dengue epidemics from the resident population in the municipalities of the state of Rondonia (Brazil) in the period 2001-2010.

2.3 Sources of Data

This study used secondary data obtained from DATASUS (www.datasus.gov.br). The database includes only confirmed cases of dengue reported in the Notifiable Diseases Information System (SINAN) in the period from 2001-2010. Population statistics were extracted from the Brazilian Institute of Geography and Statistics (IBGE - www.ibge.gov.br).

2.4 Epidemiological Measures and Maps

For the epidemiological characterization of the disease in the state, we performed the following studies:

- Quantification of the disease incidence in the state and cities per 100,000 inhabitants during the years 2001-2010.
- Epidemiologic profile of disease from the variables: year of reporting; age (<1 year, 1 to 4, 5 to 9, 10 to 14, 15 to 19, 20 to 39, 40 to 59, 60 to 64, 65 to 69, 70 to 79, and ≥ 80); sex; education; final classification; mortality and criterion for confirmation.
- The map of the state of Rondônia was used to verify the spatial distribution of disease incidence in the years 2001, 2005 and 2010. The maps were created on the Tabwin 3.6B program. The spatial mesh used is available on the site DATASUS specifically for the Tabwin program. These maps are based on geoscience data from IBGE.
- The incidence of the map of 2010 was analyzed from the superposition of highways, waterways, ports, airports and rainfall. We chose the year 2010 because it showed the highest disease incidence in the studied period. We used the map of transports available from the Ministry of Transport (www.transportes.gov.br), and also the map of rainfall from the Rainfall Atlas of Brazil available from the Company of Mineral Resources Research site (www.cprm.gov.br). To accomplish this overlap, the Inkscape program was used.
- Microsoft Excel 2010 was used to draw the graphs.

3. RESULTS AND DISCUSSION

A total of 68,601 cases of dengue were reported in the state of Rondônia from 2001 to 2010. The highest incidence was in 2010 (131.46/100,000 inhabitants) and the lowest in 2002 (10.91/100,000 inhabitants), with an average of 6,860 cases per year. In 2009 and 2010, a major change was observed in the incidence rate (Fig. 1).

The strength of the transmission of dengue virus is extremely high, comparable to other contagious diseases [14]. The 2008 outbreak in Rio de Janeiro [11] may be related to the explosive increase observed in Rondônia in 2009. The route of Rio to Rondônia was pointed out previously in the dengue epidemic in Porto Velho in 2001-2003, which was derived from the southern areas of the country and brought to Porto Velho by visitors [13].

From 2001 to 2010, people aged 15 to 59 years were the most affected, totaling 52,181 cases, with an incidence of 1003.46 cases per 100,000 inhabitants (Table 1). Of these, 54.6% were female. This range of age includes the population with higher mobility to work and study. Our findings show that this is also the age with the highest number of cases, suggesting that this effect may be related to virus imports from other localities.

The predominant criterion for confirmation were clinical-epidemiological links during the study period (47.9% of all cases). Only in 2004 and 2008 laboratory confirmation was predominant with 62% and 37.1% of all cases, respectively. The total number of dengue cases reported in the state of Rondônia from 2001-2010 may be even greater, as it is estimated that, on average, only 15% of all cases are reported [15]. Difficulties with the notification of the disease are related to the fact that most infections are asymptomatic and that few patients look for medical care [16]. Because most confirmations were made by clinical epidemiological links, false-positive diagnosis are highly probable. This can occur because of the similarity of symptoms between dengue and other acute febrile illnesses. Furthermore, laboratory diagnosis is often expensive and time-consuming, making it difficult to use.

The number of clinical cases of DHF grew considerably in 2009 and 2010, associated with an increase in the number of deaths (Table 2).

The increase in cases of dengue hemorrhagic fever in Rondônia (Table 1) is consistent with the national scenario. From 2000 to 2007, there was a large increase in the number of DHF cases in the country, which represented 0.21% of all cases of dengue registered. This proportion, 3.5 times higher than in the 1990s, most likely occurred as a reflection of improvements in the diagnostic/reporting system during that decade rather than to an increase in the number of DHF cases [17]. We know that contact with serotype 3 virus in 2005 is associated with the increased number of cases of DHF on that year. Previously, this serotype was circulating in the rest of the country, but in 2005 it moved from the north to the southeast of Brazil [12,17]. Deaths were distributed for age groups (Table 1). The age group of 40 to 59 had the largest number of cases.

The evolution of disease incidence was analyzed by cities. In 2001, two cities were highlighted: Presidente Medici, with an incidence of 367 cases per 100,000 inhabitants; and Vilhena, with 1030.39 per 100,000 inhabitants. In 2006, Vilhena considerably reduced the incidence of the illness, decreasing to 384.46 cases per 100,000 inhabitants, while Presidente Medici presented an alarming 4539.53 per 100,000 inhabitants. Other cities are shown as highlighted: AlvoradaD'Oeste; Castanheiras; Alta Floresta D'Oeste; Ji-Paraná; Pimenta Bueno and Rolim de Moura, with 1136.19, 1124.69, 651.57, 659.3, 429.73, and 538.99 cases per 100,000 inhabitants, respectively (Fig. 2). In 2010, all municipalities showed cases of the disease except for Castanheiras (Fig. 2C, arrowhead). Forty-eight zero seven percent (n = 25) of the cities showed high incidence, with more than 1,000 cases per 100,000 inhabitants. Of these, 60.0% (n = 15) have fewer than 20,000 inhabitants, 20.0% (n = 5) have 21,000 to 50,000 inhabitants, and 20% (n = 5) have more than 50,000 inhabitants. The city with the highest incidence was Novo Horizonte do Oeste, with 4384.77 per 100,000 inhabitants.

It is important to highlight the correlation between the geographical position of the municipalities and the incidence of the disease. Localities close to cities and borders showed a higher incidence than other areas in 2006 (Fig. 2B). In fact, despite presenting a less-than-average disease incidence than other states in Brazil [12], there are cities in Rondônia that show very high incidences. If there is no efficient intervention, focusing not only on local measures but also on migration routes, the number of cases in the state can increase considerably in the future.

Another important situation is the absence of cases in Castanheiras in 2010, acting as an "island" between areas with high incidence. Additional studies might indicate whether this phenomenon is related to the efficient performance of epidemiological surveillance at this location, or problems in the notification process.

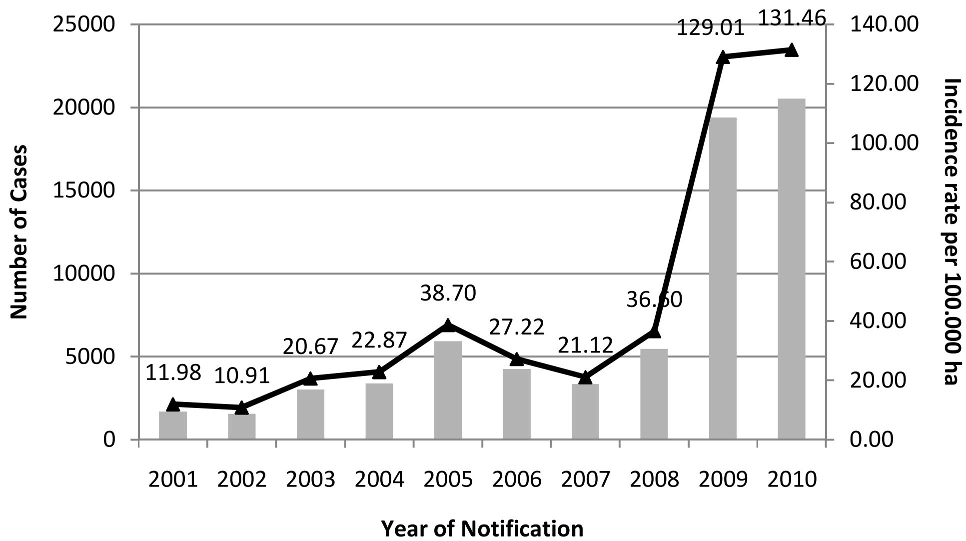

Fig. 1. Number of Confirmed Cases and Incidence of Dengue in Rondônia, Brazil, during the years 2001-2010

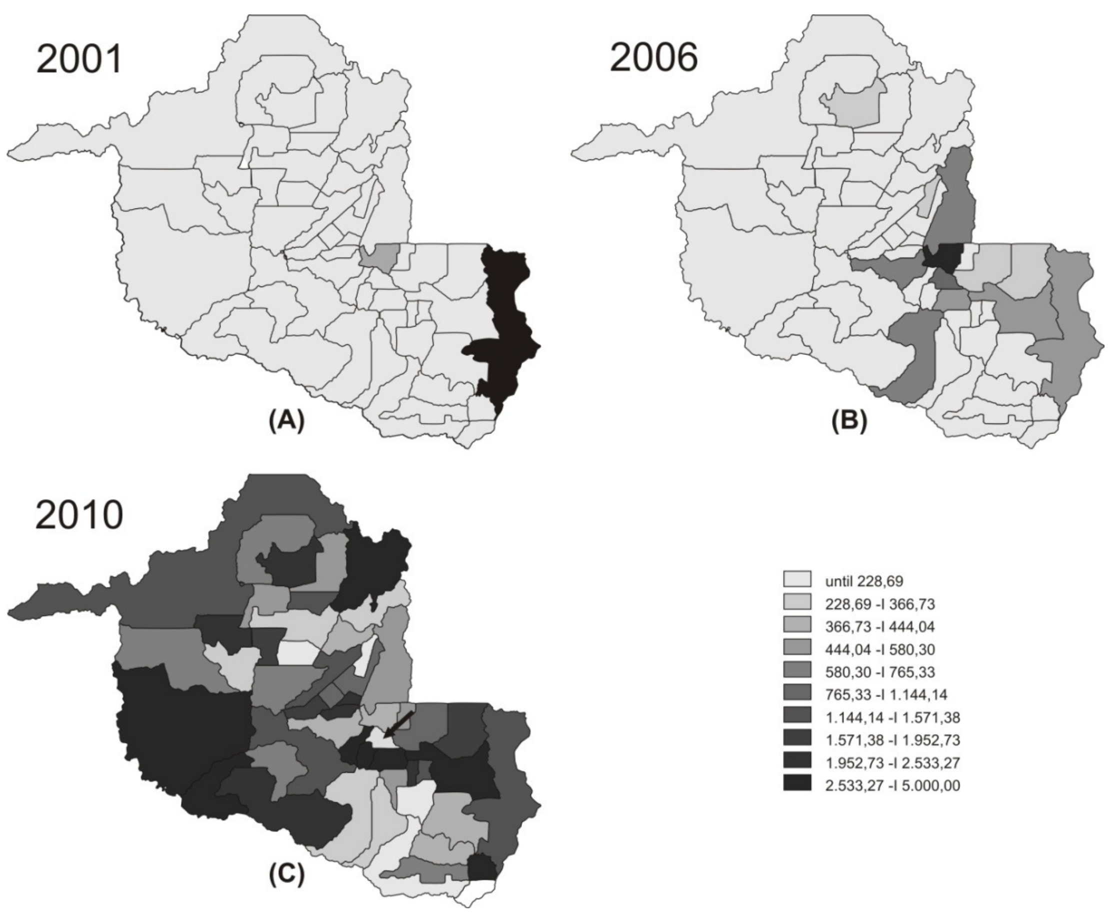

Fig. 2. Geographic Representation incidence of Dengue by cities in 2001 (A) 2006 (B) and 2010 (C) in Rondônia, Brazil

Table 1. Numbers of dengue cases and dengue deaths for age-group in the Rondônia State, Brazil, during the period 2001-2010

Age-Group	Number of dengue cases			Number of dengue deaths	
	n	%	Incidence per 100,00	n	%
0 to 4 years	2,901	4.23	447.31	5	10.00
5 to 9 years	3,560	5.19	499.89	3	6.00
10 to 14 years	5,454	7.95	682.26	1	2.00
15 to 19 years	7,337	10.70	931.61	4	8.00
20 to 39 years	29,131	42.46	1061.62	6	12.00
40 to 59 years	15,713	22.90	941.73	13	25.00
60 to 64 years	1,639	2.39	794.59	4	8.00
65 to 69 years	1,216	1.77	825.47	2	4.00
70 to 79 years	1,258	1,83	718.08	3	6.00
80 and more years	355	0.52	567.00	7	14.00
Ignored	37	0.05	-	3	6.00
Total	**68,601**	**100.00**	**131,46**	**51**	**100.00**

Table 2. Final Classification of confirmed cases of Dengue in the State of Rondônia, Brazil, during the period 2001-2010

Year	Final classification						Death
	Skipped or blanked	Dengue classic	Dengue with complications	Dengue hemorrhagic fever	Dengue shock syndrome	Inconclusive	
2001	664	1.021	2	0	0	0	4
2002	272	1.274	10	6	0	0	0
2003	71	2.907	20	9	0	2	0
2004	180	3.178	25	1	0	1	1
2005	1.435	4.442	56	6	0	0	0
2006	1.308	2.886	42	3	1	13	2
2007	114	1.974	13	0	4	1.253	1
2008	98	3.713	25	9	7	1.614	2
2009	1.262	14.358	182	133	8	3.459	20
2010	0	17.246	14	125	5	3.150	21
Total	**5.404**	**52.999**	**389**	**292**	**25**	**9492**	**51**

Incidences recorded in 2010, compared with the rates of rainfall and the migration paths of individuals (major highways, waterways, ports, and airports), are shown in Fig. 3. The rainfall isohyets are shown in curves that delimit an area with equal precipitation. Values between 1,500 and 2,400 mm of annual rainfall were identified (Fig. 3A). These averages are relatively high, taking as reference the average of the other states of the country (www.cprm.gov.br). We can also observe that waterways, roads, ports, airports, and borders tend to correlate with regions that show higher numbers of dengue cases (Fig. 3B).

Interestingly, regions with high rainfall did not necessarily show the highest incidence of the disease (Fig. 3A). However, border regions and cities where there is a concentration of waterways and highways showed high incidence levels (Fig. 3B). A study in 2007 found similar results on the dynamics of dengue virus serotype 3 introduction and dispersion in the state of Bahia, Brazil, which showed the dispersal of cases through the highways [17]. Our proposal based on this profile is that, although this state presents climatic conditions that favor the spread of the vector, migratory pathways are the main factor explaining the differences in incidence rates. In this sense, the federal government's 2008 Growth Acceleration Program (PAC) caused a considerable increase in immigration rates, especially in Porto Velho. This abrupt growth, with people from different regions, changes the local epidemiological situation, because it increases the quantity and variety of circulating viruses. In addition, there has been an irregular growth of the city in the last years, favoring the spread of the disease and burdening the public health service [18].

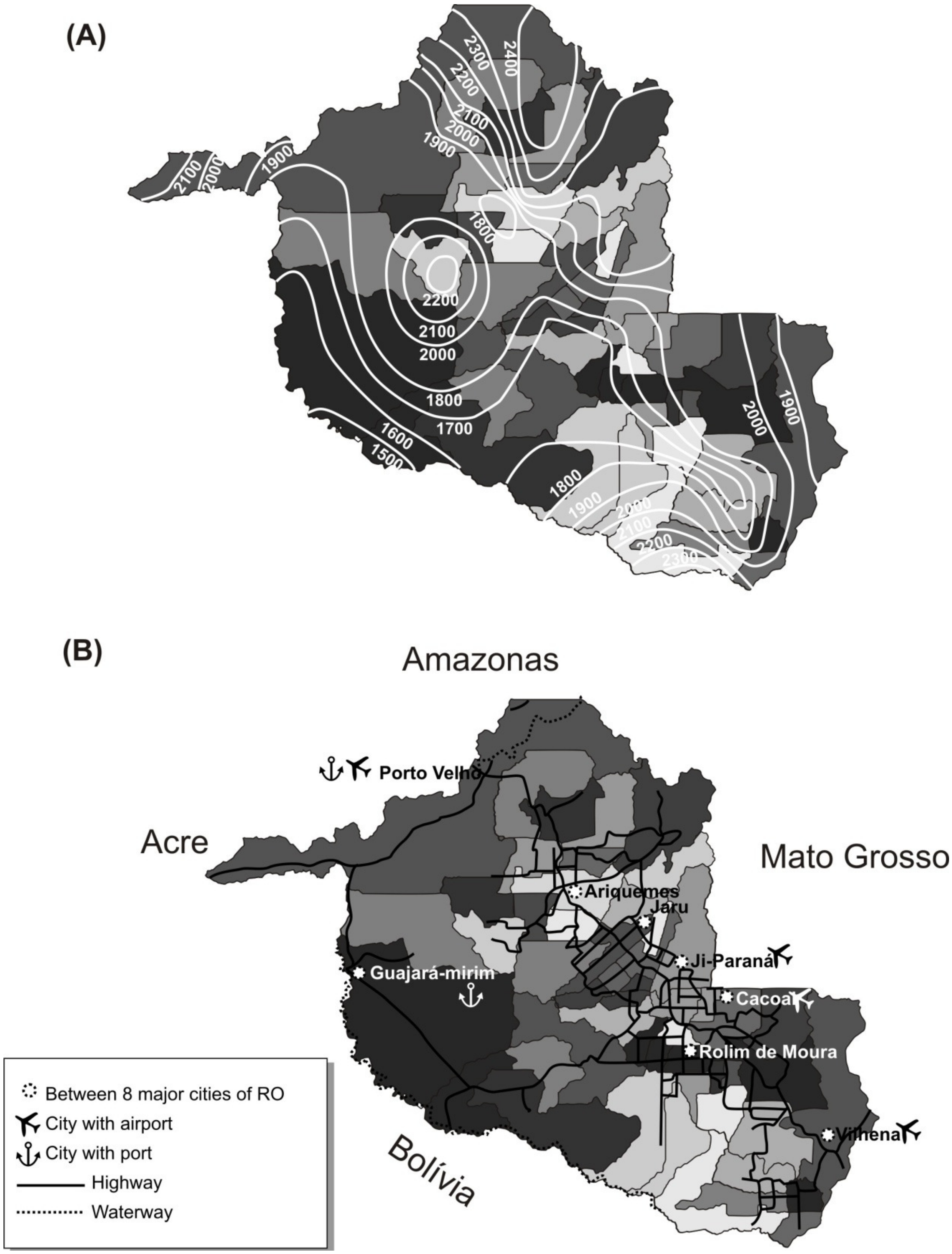

Fig. 3. (A) Representation of the geographical incidence of dengue in 2010 in Rondônia, Brazil, correlated with rainfall; and (B) Geographic representation of the incidence of dengue in 2010 in Rondônia, Brazil, correlated with migration paths (highways, waterways, ports, and airports). The colors represent the incidence that was showed in Fig. 2

4. CONCLUSION

This analysis points to the need to monitor and control the vector, the patients, and possibly sick people. Cities where many people from various localities circulate require special epidemiological attention. People with suspected dengue should be encouraged to look for healthcare, and the investment in training and methods regarding diagnosis/reporting of the disease should be expanded.

CONSENT

Not applicable.

ETHICAL APPROVAL

The study was conducted according to ethical principles contained in the CNS Resolution No. 196, of October 10, 1996, of the National Health Council, maintaining the privacy of individuals and causing no damage to them.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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