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Original Article

# Seroepidemiology of arbovirus in communities living under the influence of the lake of a hydroelectric dam in Brazil

## Soroepidemiologia das arboviroses em comunidades que vivem sob a influência do lago de uma usina hidrelétrica no Brasil

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**Abstract**

**Introduction:** The arbovirus proposes an important problem of public health in Brazil, especially in the Amazon, due to its capacity to cause outbreaks with high levels of morbidity-mortality in humans as well as in animals. **Objective:** This paper had the objective to estimate the prevalence of antibodies to arbovirus in communities that live under the influence of the artificial lake of UHE Tucuruí in the State of Pará, Brazil. **Method:** The analytical transversal study has selected 657 blood serum samples of individuals over 18, both genders, residents at the Sustainable Development Reserves (SDR) in the region of the lake of UHE Tucuruí. The epidemiological information has been registered in an instrument especially designed for such a study and the blood samples were collected in two periods of high and low tide of the lake. The blood serum tests were performed by the method of hemagglutination inhibition (HI). **Results:** The results revealed a prevalence of positive antibodies to arbovirus of 85.0%, being 84.1% related to Flavivirus (vaccine strain of YFV), 25.5% related to Alphavirus and 34.6% to Bunyavirus. The results of serum prevalence to arbovirus between the periods of high tide and low tide have revealed significance amongst the Alphavirus, not observed in the other families. **Conclusion:** In general, the data from this paper have suggested that the anthropoid actions on the environment of the lake have become determinant factors for the prevalence of arboviral antibodies.

**Keywords:** arboviroses; hydroeletric dam; Alphavirus; Flavivirus; Orthobunyavirus.

**Resumo**

**Introdução:** Os arbovírus representam um importante problema de saúde pública no Brasil, especialmente na Amazônia, devido à sua capacidade de causar surtos em seres humanos e em animais. **Objetivo:** Este trabalho teve o objetivo de estimar a prevalência de anticorpos para arbovírus em comunidades que vivem sob a influência do lago artificial de barragem hidrelétrica no Brasil. **Método:** O estudo transversal analítico selecionou 657 amostras de sangue de indivíduos de ambos os sexos, residentes na região do lago. As informações epidemiológicas foram registradas em um instrumento concebido para este estudo e as amostras de sangue foram coletadas em períodos de maré alta e maré baixa do lago. Os testes sorológicos foram realizados pelo método de inibição da hemaglutinação (IH). **Resultados:** Os resultados revelaram uma prevalência de anticorpos positivos para arbovírus de 85%, com 84,1% referentes ao Flavivirus (cepa vacinal de FA), 25,5% em relação ao Alphavirus e 34,6% para Orthobunyavirus. Os resultados de prevalência de anticorpos para arbovírus entre os períodos de maré alta e maré baixa revelaram significância entre os Alphavirus. **Conclusão:** Em geral, os dados sugerem que as ações antrópicas no ambiente do lago tornaram-se fatores determinantes para a prevalência de anticorpos arbovirais.

**Palavras-chave:** arboviroses; usina hidrelétrica; Alphavirus; Flavivirus; Orthobunyavirus.

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## INTRODUCTION

In the State of Pará, as well as in the Amazon Region, the incidence of infectious diseases (as arbovirus), has contributed to the expressive cause of human morbidity-mortality[1-3].

The Amazon Forest presents extended areas of jungle, generally crisscrossed by an exuberant water support, mainly represented by rivers and igarapés, on a hot and humid Day, offering proper conditions for keeping such diseases. The forest is still one of the largest arbovirus reservoirs of the world, not only for its climate conditions but also for its abundance of vegetal and animal species, even hematophagous arthropods and vertebrates that do contribute to the maintenance of the endemicity cycles of the disease[4,5].

In this context, the arbovirus, mandatory intracellular parasites of these forest animals due to their high power of mutation and multiplication, have adjusted themselves to several ecological sites available in the forest until they were able to occupy its totality, being able to easily adapt to ecological changes provoked (or not) by the anthropoid action. It happens due to the fact of the adaptations to the hosts, their preferences, and habits.

As for the regions stricken by dam constructions, there are lots to be studied about the relationship amongst the factors that condition the maintenance and dispersion of the arbovirus as well as it is necessary the performance of additional studies about the man x environment relationship and their patterns of distribution and maintenance in regions that have been modified by degrading actions due to disordered population growth, migration and development and the reflex of such actions on the natural cycles of the electric dam areas[2,6,7].

Studies aiming to demonstrate the incidence and prevalence of arbovirus in some regions of the Brazilian Amazon have been performed, proving the existence of their epidemiological cycles[1,6,7].

Inside those modified environmental characteristics, it was possible to determine the presence of antibodies to *Oropouche virus (OROV)* and *Mayaro virus (MAYV)*, either from the IgG class or from IgM class, suggesting recent infection besides the presence of individuals with *Dengue Virus (DENV3)* presenting fever at the time of blood collection.This enabled to conclude that that is a proper area for the circulation and maintenance of arbovirus, revealing little-immunized population.

The purpose of such a paper is to evaluate the prevalence of antibodies to human arbovirus in rivery communities under the influence of the lake of Tucuruí Hydroelectric Dam through expeditions in the high and low tide periods of the lake, performed in March 2008 and September 2010.

## METHOD

This transversal analytical study has selected 657 individuals over 18 years old, residents at the Sustainable Development Reserves (SDR) Alcobaça and Pucuruí-Ararão, in the Region of the Lake of Tucuruí Hydroelectric Dam. State of Pará, Brazil. These SDR are part of the National System of Nature Conservation Units (NSNC).

The sample was intentionally taken and the individuals were inserted in this study and throughout the text campaigns of health education performed with the partnership of Municipal Health of Tucuruí.Subjects with greater or equal to 18 years old were included in the study, after signing term of consent.

The population of the study was divided into two phases: high tide (March) and low tide (September) of the lake between 2008 and 2010. During the periods of high tide, there were 397 individuals selected and in the low tide period, there were 260.

The selected individuals were clinically evaluated by professional physicians, through data collection into epidemiologic forms, specifically designed to this study which has included demographic data, clinical history, morbid personal and family background as well as the living habits or forest staying habits. For the performance of laboratory tests, it was collected a sample of 8 ml of venous blood in a test tube without anticoagulant. The essays were centrifuged and the serum was separated, loaded and frozen for transportation.

The laboratory analysis for the direct search for antibodies against 19 types of arbovirus (*Alphavirus*: *Eastern equine encephalitis virus - EEEV, Western equine encephalitis virus – WEEV, MAYV and Mucambo virus - MUCV. Bunyavirus: Guaroa virus - GROV, Maguari virus - MAGV, Tacaiuma virus - TCMV, Caraparu virus - CARV, OROV and Catu virus – CATUV, and Flavivirus: Yellow Fever virus (YFV)* – vaccine and wild strains, *Ilhéus virus - ILHV, Rocio virus - ROCV, Saint Louis encephalitis virus - SLEV, DENV* 1,2,3 and 4) was performed through the test of inhibition of hemagglutination (IH)[8], adapted to microplaques[9] and the antibody detection of the IgM class, to *DENV, YFV, OROV* and *MAYV* was performed using the test of *Immunoglobulin M antibody capture enzyme-linked imunossorbent assay* (MAC-ELISA)[10].

In the descriptive analysis of the data, it was obtained the general and specific seroprevalence, by a period of collection, in percent values, considering the confidence interval of 95%, through the EPI INFO program, 3.5.2 version. The statistical association between the characteristics studied and the presence of antibodies to arbovirus was researched using the CHI-SQUARE test or Exact of Fischer test. The measurement of the risk was calculated using the Odds Ratio (OR).

This paper has been approved by the Research Ethics Committee in Human Beings of Tropical Medicine Center of Universidade Federal do Pará (project 056/2008), on November 26, 2008, and the free and clear consent was obtained from each participant.

## RESULTS

The results of this paper have pointed out to a possible association between environmental alterations and the prevalence of antibodies circulating for infectious diseases caused by an

arbovirus. This relationship is a mighty motion force for the maintenance of endemic infectious diseases or even for the determination of epidemical spread.

The serum-prevalence to arbovirus between the periods of high and low tides has been compared amongst the virus genus (Figure 1). The *Flavivirus* have shown a reactivity of 84.2% during the periods of low tide and 84.4% during the periods of high tide. The *Alphavirus* genus has revealed a positivity of 30.8% of the samples in the periods of low tide and 22.2% in the periods of high tide and, amongst the *Orthobunyavirus,* the reactivity was 35% in the low tide and 29.5% in the high tide.

When the prevalence was calculated to the specific virus of each genre, separately, it was verified that the results varied according to each period of collection.

The analysis of the *Flavivirus* genus has shown that the high reactivity is due to the vaccination against *YFV, either in the periods of low tide as in the periods of high tide* (Figure 2). During low tide periods, only 2.7% of the samples remained without identification and, during high tide periods, 14.65% were not identified. There were 1.3% reactive to *DENV*. The others, *ILHV, ROCV* and *SLEV* were not detected in the sample. The highest number of people vaccinated for *YFV has occurred during the low tide period* (OR= 2.88, p= 0.0076). The gathering of both results has shown that, in the relationship between the periods of low and high tide, the results did not present differences (OR=0.98, p= 0.9543), as shown in Table 1.

The *Alphavirus* genus has shown a completely different behavior (Figure 3). It was verified that the *EEEV* presented 3% positive samples during high tide and 1% in the low tide. *WEEV* presented 7% of the positive samples in the low tide and 2% in the high tide. *MAYV* presented 21% positive in the low tide and 18% in the high tide and *MUCV* presented 4% of positive samples in both low and high tides. The calculation of the OR for the genus has shown a result of 1.56, with p= 0.0173 (Table 1). However, when it was analyzed each of the viruses belonging to this genre, it was verified that there are differences amongst them (Table 2). During the low tide, there was a larger circulation of the *WEEV* virus (OR= 2.40 and p=0.003), *MAYV* (OR=1.20 and p= 0.3568) and some viruses that were not able to be identified, whilst the *EEEV* occurred more during the high tide of the reservoir (OR= 0.37 and p=0.1931). As for *MUCV*, it was found in an equal frequency in both periods (OR= 1.09 and p= 0.8308).

Similar results were found to the *Orthabunyavirus* (Figure 4). In general, the greatest positivity was during the low tide of the reservoir. The results of the OR have shown that there is no significant difference between both periods (Table 1). Analyzing each virus (Table 3), it was verified that *OROV* presented reason of chance to happen during low tide, but it was not statistically positive (OR=1.14 and p=0.5567). *TCMV* was not able to be

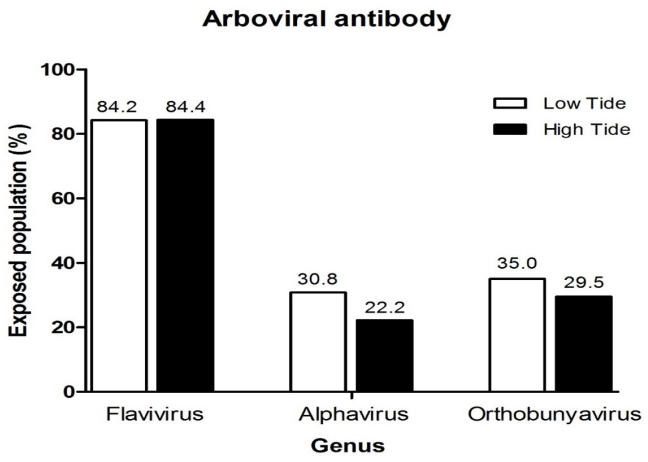


**Figure 1.** Prevalence of arboviral antibodies, by genus, between low tide and high tide periods of the lake

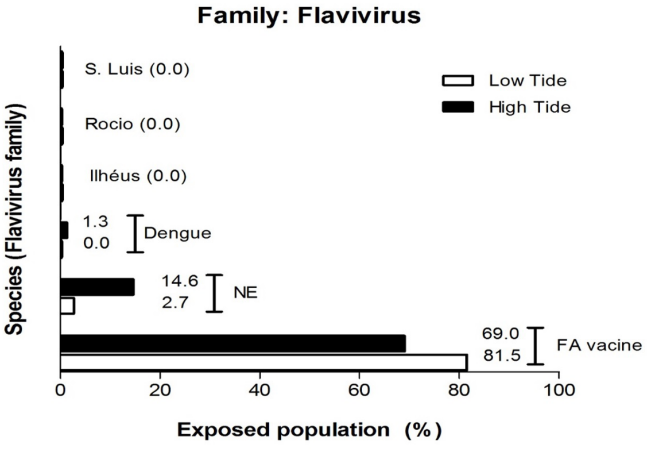


**Figure 2.** Prevalence of antibodies to Flaviviruses, during low tide and high tide periods of the lake. NE: Unexposed; FA: Yellow Fever

**Table 1.** Association between seasonality (flood and ebb) and antibodies to arboviruses by genus

| Genus | Total | Positive | Seroprevalence | OR | p-value |
|---|---|---|---|---|---|
| ***Flavivirus*** | | | | | |
| Flood | 260 | 219 | 84.2% | 0.98 | 0.9543 |
| Ebb | 397 | 335 | 84.4% | | |
| ***Alphavirus*** | | | | | |
| Flood | 260 | 80 | 30.8% | 1.56 | 0.0173* |
| Ebb | 397 | 88 | 22.2% | | |
| ***Orthobunyavirus*** | | | | | |
| Flood | 260 | 91 | 53.8% | 1.28 | 0.1603 |
| Ebb | 397 | 117 | 41.8% | | |

*Statistically significant association (p-value <0.05). OR: *Odds Ratio*; Ebb: vazante

statistically evaluated, it has just happened during the low tide. *CARV* obtained one OR of 1.04 and p=0.8562, posing equal chance for positivity during low or high tide, a similar situation to *GROV* (OR=0.46 and p=0.0092) that was statistically

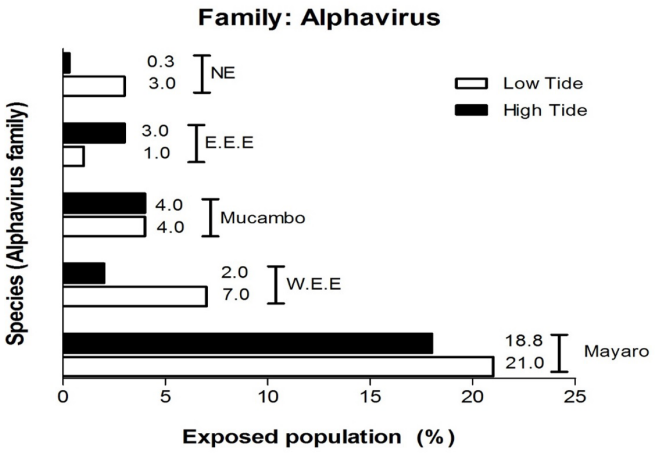


**Figure 3.** Prevalence of antibodies to Alphaviruses, during low tide and high tide periods of the lake. NE: Unexposed; EEE: Est Equine Encephalitis; WEE: West Equine Encephalitis

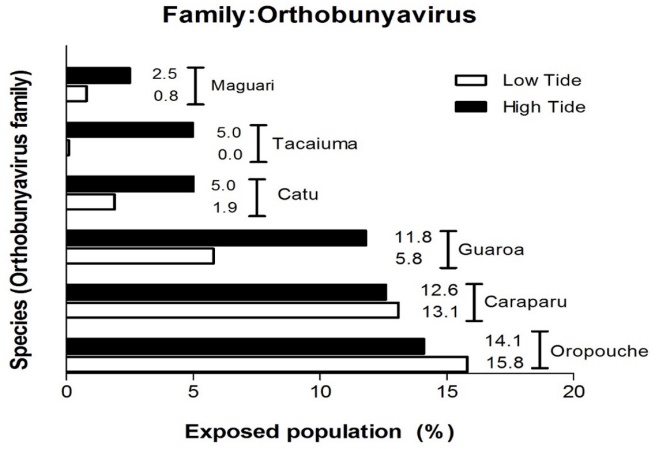


**Figure 4.** Prevalence of antibodies to Orthobunyaviruses, during low tide and high tide periods of the lake

**Table 2.** Association between seasonality and specific viral species of the alphavirus genus

| *Alphavírus* Genus | Total | Positive | Seroprevalence | OR | p-value |
|---|---|---|---|---|---|
| ***EEEV*** | | | | | |
| Flood | 260 | 3 | 1.2% | 0.37 | 0.1931 |
| Ebb | 397 | 12 | 3.0% | | |
| ***WEEV*** | | | | | |
| Flood | 260 | 17 | 6.5% | 2.40 | 0.0030* |
| Ebb | 397 | 8 | 2.0% | | |
| ***MAYV*** | | | | | |
| Flood | 260 | 54 | 20.8% | 1.20 | 0.3568 |
| Ebb | 397 | 71 | 17.9% | | |
| ***MUCV*** | | | | | |
| Flood | 260 | 10 | 3.8% | 1.09 | 0.8308 |
| Ebb | 397 | 14 | 3.5% | | |

*Statistically significant association (p-value <0.05). OR: *Odds Ratio*; Ebb: vazante; EEEV: Eastern equine encephalitis virus; WEEV: Weastern equine encephalitis virus; MAYV – Mayaro virus; MUCV: Mucambo virus

**Table 3.** Association between seasonality and specific viral species of the genus *Orthobunyavirus*

| *Orthobunyavírus* Genus | Total | Positive | Seroprevalence | OR | p-value |
|---|---|---|---|---|---|
| ***OROV*** | | | | | |
| Ebb | 260 | 41 | 15.8% | 1.14 | 0.5567 |
| Flood | 397 | 56 | 14.1% | | |
| ***CARV*** | | | | | |
| Ebb | 260 | 34 | 13.1% | 1.04 | 0.8562 |
| Flood | 397 | 50 | 12.6% | | |
| ***GROV*** | | | | | |
| Ebb | 260 | 15 | 5.8% | 0.46 | 0.0092* |
| Flood | 397 | 47 | 11.8% | | |
| ***MAGV*** | | | | | |
| Ebb | 260 | 2 | 0.8% | 0.30 | 0.1382 |
| Flood | 397 | 10 | 2.5% | | |
| ***CATUV*** | | | | | |
| Ebb | 260 | 5 | 1.9% | 0.37 | 0.0412* |
| Flood | 397 | 20 | 5.0% | | |

*Statistically significant association (p-value <0.05). OR: *Odds Ratio*; Ebb: vazante; OROV: Oropouche virus; CARV: Caraparu virus; GROV: Guaroa virus; MAGV: Maguari virus; CATUV – Catu virus.

significant. *MAGV* presented OR=0.30 and p=0.1382, without any statistical significance and *CATUV* (OR= 0.37 and p=0.0412) was considered statistically significant.

## DISCUSSION

The indiscriminate anthropic action and the disordered population growth generated by the implantation of a hydroelectric dam may lead to an imbalance of the ecosystem; many times in an irreversible way[7]. This imbalance may enable the emergence of different arboviruses when the contact of the man with the agents is intensified by their proximity to the modified environment. Degallier et al.[11], described a comparative epidemiological analysis on the occurrence distribution of yellow fever in South America, concluding that factors such as population migration, climate change and the existence of vectors likely would be relevant characteristics for future studies.

Cruz et al.[1] have developed a study of serological surveillance in the Juruti municipality in the State of Pará, between 2006 and 2008, in order to evaluate the diversity of arbovirus circulating in that area, where there is a company of bauxite mining, what implicates in environmental alterations and ecosystem modification, and have concluded that the city population presented a high level of antibodies to arbovirus, alerting to the disordered population growth due to the new occupational activity to be started.

Nunes et al.[7] have described the eco-epidemiology of the arbovirus in the municipalities of Novo Progresso and Trairão, in the State of Pará. These municipalities are under the direct influence of Cuiabá-Santarém road (BR163) where even though there is no asphalt coverage yet, the environmental impact

of deforestation has transformed the forest landscapes into cattle breeding and agriculture cultivation areas, resulting in a process of disordered migration and changing the indexes of temperature and rainfall.

Despite being considered a relatively clean, safe, cheap and renewable power source, the environmental impacts caused by the implantation of dams are critical factors to be studied and considered[12]. The viabilization of the installation construction leads to a modification of the relationship between society and nature, interfering directly in several aspects of citizenship, as the access to housing, education, job/salary and, overall, health[12-14].

The policy of hydroelectricity generation to the Amazon has been criticized by comprehensive sectors of society, considered excluding, authoritarian, submissive to the urban – industrial and the great national and international capital interests, besides producing several negative social-environmental effects[6].

In this sense, it must be highlighted that the relationships between hydroelectric dams and health processes are multiple and complex as it is believed that not only the demand for health services or the appearance of some diseases that a hydroelectric project may cause are the main interferers in the local population's health. The processes are multiple, producing multiple risks, on different degrees, which are going to determine the conditions of the *health x disease* process of the local population, starting up a new ecologic profile[6].

The presence of circulating arbovirus antibodies, either in the period of high tide as in the low tide period of the lake, points out to two main hypotheses: the elevation of the lake levels during the high tide would increase the circulation of vectors and; the formation of isolated pounds, during the drought, would favor the breeding of larvae of these vectors.

These differences show that the characteristics of the vectors may be influenced the circulation of the virus and the adaptation of the artificial breeding facilities may represent a great step in the direction of the synanthropic behavior[15]. Each one of those viruses owns not only one vector, but several of them, and each one of them presents characteristic behavior of their species[16].

Eco-epidemiological studies previously performed in this region[17-19], revealed that the formation of the lake has potentialized either the maintenance of the cycles of the arbovirus that exist in that area, as the establishment of new cycles demonstrated by the number of isolated samples, as well as by the diversity of virus types.

Hence, it is highlighted the necessity of studies of the detailed environmental impact to enable to evaluate the real risk of environmental manipulation as well as the activity of the hydroelectricity on the circulation of emergent viruses, besides a systematic follow up of the exposed population for a better understanding of the dynamics of maintenance of arbovirus and arboviruses in that region.

The serum-prevalence of antibodies to arbovirus in individuals from this paper may possibly be related to the impacts due to the activities of UHE Tucuruí, as well as it may be associated to environmental unbalance due to territorial reorganization, deforestation, river damming and consequent rise of the fauna of potential vectors for the transmission of arboviruses, facts that do contribute to the epidemic dispersion of such diseases as it was previously reported in the Amazon.

The epidemiological surveillance and studies of population follow up as well as studies that evaluate the environmental impact caused by such unbalance may constitute an important tool for the understanding of the mechanisms of transmission, cycles of maintenance in the nature and the dynamic of the circulation of arbovirus in the region, especially in the areas under the influence of dams.

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