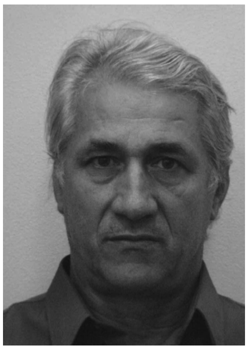
RECIIS
Electronic Journal of Communication Information & Innovation in Health
[www.reciis.cict.fiocruz.br]
ISSN 1981-6286

Original Articles

Climatic zoning of conditions for the development of the larva of the mosquito that transmits the dengue fever virus in the State of Rio Grande do Sul

DOI: 10.3395/reciis.v3i2.146en



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Abstract
Climatic zoning was carried out in the State of Rio Grande do Sul for the development of the larva of the mosquito that transmits the dengue fever virus, *Aedes aegypti.* The study used the average and the variability of the total monthly precipitation, the average number of days per ten day-periods with precipitation, the monthly average temperature charts of medium, maximum, and minimum temperatures, and the probability of occurrence of absolute minimum temperatures below 5°C. The study considered as preferable those regions with average temperature between 24 and 32°C; as tolerable those between 18 and 24°C; as marginal those between 5 and 18°C; and as unsuitable those below 5°C and above 40°C. It verified that hydric conditions in Rio Grande do Sul throughout the year are suitable for the development of the larva of the mosquito transmitter of the dengue virus fever, and that the most suitable thermal availabilities occur during the months of January, February, and December. The most suitable average temperatures occur mainly in the Climatic Regions of the Central Depression, High and Low Uruguayan Valley and Missions; whereas the marginal ones occur in the Northeastern Mountains, West of the Uplands, Southeastern Mountains, and Southern Shore.

Keywords
Aedes aegypti; air temperature; precipitation; indigenous cases

Introduction

Dengue fever is a disease caused by a virus inoculated into the human body through the bite of the *Aedes aegypti* mosquito. The mosquito, which originally came from Africa, arrived in Brazil in the 18^{th} century, carried on the vessels that were used to transport slaves. It was eradicated from the country for the first time in 1958, reappeared in 1967 in São Luís (MA) and Belém (PA), and was subsequently eliminated. It started reappearing in Brazil in 1976, in Salvador (BA). in 1977 it was found in Rio de Janeiro; in 1979, in Natal (RN) and in 1981 in the State of Paraná (MARQUES, 1985; NEVES et al., 1995).

In the South of Brazil, Paraná was the state with the largest number of recorded cases of dengue fever. Notification about the first indigenous cases of dengue fever in that state date back from 1993. Since then important epidemics were recorded: 1995, 1996, 2000, 2001, 2002, and 2003 (MENDONÇA et al., 2007). In Rio Grande do Sul, dengue fever cases were imported until 2007. There were no data proving the occurrence of indigenous dengue fever cases. However, during the summer and fall months of 2007 indigenous dengue fever cases were verified and notified for the first time in the state (PUSTAI, 2007).

The larva of the *A. aegypti* develops in the presence of clean, stagnant water, and heat, and is mainly found in humid tropical regions. Three conditions are favorable for the action of the dengue fever mosquito: temperatures between 25 and 29°C, intermittent rains, and calm winds. This is very well characterized in the results obtained for Paraná and the city of Curitiba (OLIVEIRA, 2004; PAULA, 2005), for the municipality of São Sebastião (MARQUES et al., 2004; RIBEIRO, 2006) and the region of the Paraíba Valley, State of São Paulo (GUIMARÃES et al., 2001), for the city of João Pessoa, State of Paraíba (DANTAS et al., 2007) and for the State of Maranhão (REBÊLO et al., 1999). Basic temperatures for the larva are: lethal if lower than 5°C and higher than 40°C; activity is inhibited below 18 and above 32°C; development is optimal between 24 and 28°C; and, according to the Campaign Against Dengue Fever (2007), transmission rarely occurs in temperatures under 16°C. Optimal temperatures for its proliferation are around 30 to 30°C, and its transmission occurs preferably at temperatures above 20°C. As we can see, climatic elements, especially temperature and humidity, set the conditions for the development of the larva of the mosquito that transmits the dengue fever virus in indigenous cases of the disease (FIOCRUZ, 2002).

According to Sirlei Famer, epidemiologist of the National Health Foundation, the mosquito cannot stand, during the winged phase, the cold winter of the State of Rio Grande do Sul. Nevertheless, it hibernates at places where it finds favorable conditions for its survival until the next heat cycle, and can resist up to 500 days. There is, therefore, a possibility for dengue fever to be transmitted even in the coldest regions of the state (LOCAL GOVERNMENT OF SÃO FRANCISCO DE PAULA, 2007).

Considering the thermal requirements of *A. aegypti* and also that in 2007 there occurred the first indigenous cases of dengue fever in Rio Grande do Sul (PUSTAI, 2007), it can be inferred that this insect finds environmental conditions favorable to its development during the hottest months of the year in that state. It is therefore very important to demarcate the geographical regions of the state with different climatic availabilities in accordance with the bioclimatic requirements of the larva of this mosquito. In this sense, the purpose of this study was to zone regions according to hydric and thermal availabilities for the development of this larva in the geographic space of Rio Grande do Sul.

Materials and methods

The temporal quantification of hydric availabilities for the development of *A. aegypti* in the State of Rio Grande do Sul was carried out using the averages and variability of the total monthly precipitation of 47 meteorological stations (Buriol et al., 2008) and the average number of days with precipitation per ten-day periods in 41 stations (INSTITUTE OF AGRONOMIC SURVEYS, 1989), and its special distribution by means of the charts of the average of the total monthly precipitation published in Buriol et al. (1977). Demarcation of the geographical areas with different thermal aptitudes for the development of the larva was based on its basic growth temperatures (FIOCRUZ, 2002). Geographic areas were considered to be preferable where temperatures were between 24 and 32°C; tolerable if between 18 and 24°C; marginal if between 5 and 18°C and if between 32 and 40°C; and unsuitable if below 5°C and above 40°C. As a cartographic base for the demarcation of the different areas with thermal aptitudes, the monthly charts of the average of average temperatures of the State of Rio Grande do Sul were used (BURIOL et al., 1979). The daily thermal range was also used, considering that at certain periods of the year, such as spring and summer, there are periods during the day when temperatures are optimal for the development of the larva of the *A. aegypti*, and the minimum temperatures are not lethal. Therefore the study used the monthly charts of the average maximum and minimum temperatures (BURIOL et al., 1979), considering the average maximum temperatures as the expression of the thermal variation of the daytime period, and the average minimum temperatures as the thermal variation of the nighttime period.

Lethal temperatures below 5°C were characterized through calculation of the probability of occurrence of temperatures below or equal to 5°C. For that, the averages and standard deviations of absolute minimum air temperatures of the six coldest months of the year of 42 meteorological stations of the State during the observation period 1912-1973 were used (ESTEFANEL et al., 1978).Lethal temperatures above 40°C were not considered, as they rarely occur in the State. Maps were adapted from Buriol et al. (1979), using CorelDRAW.

Results and discussion

Precipitation is well-distributed in the State of Rio Grande do Sul (Figure 1) throughout the twelve months of the year, and varies approximately from 50 mm to 250 mm. Only a slight decrease in precipitation is verified at the end of spring and during summer. Taking the latitude 30°C as a reference, precipitation is heavier throughout the year in the northern region of the state than in the southern region. This happens mainly due to higher altitudes in that part of the state. However, both in the north and in the south of latitude 30°C, the regions at higher altitudes concentrate the highest averages of total monthly precipitation. Therefore, to the north of latitude 30°S, it is in the Climatic Region of the Northeastern Mountains and in regions at the highest altitudes of the Uplands and Missions that the highest averages occur, and to the south of 30°C, it is in the Southeastern Mountains. During winter months, the lowest averages are found in the Low Uruguayan Valley and increase towards the north, northeast, and east of the state. During spring, summer, and fall months, the lowest averages are found in the Southern Shore, and increase towards the north and northwest of the state.

Monthly averages of days with rainfall vary between 5 and 13, and for ten-day periods, between 1 and 5 (Table 1). This shows that the average number of days with precipitation is well-distributed, both during the twelve months of the year, and during each month.

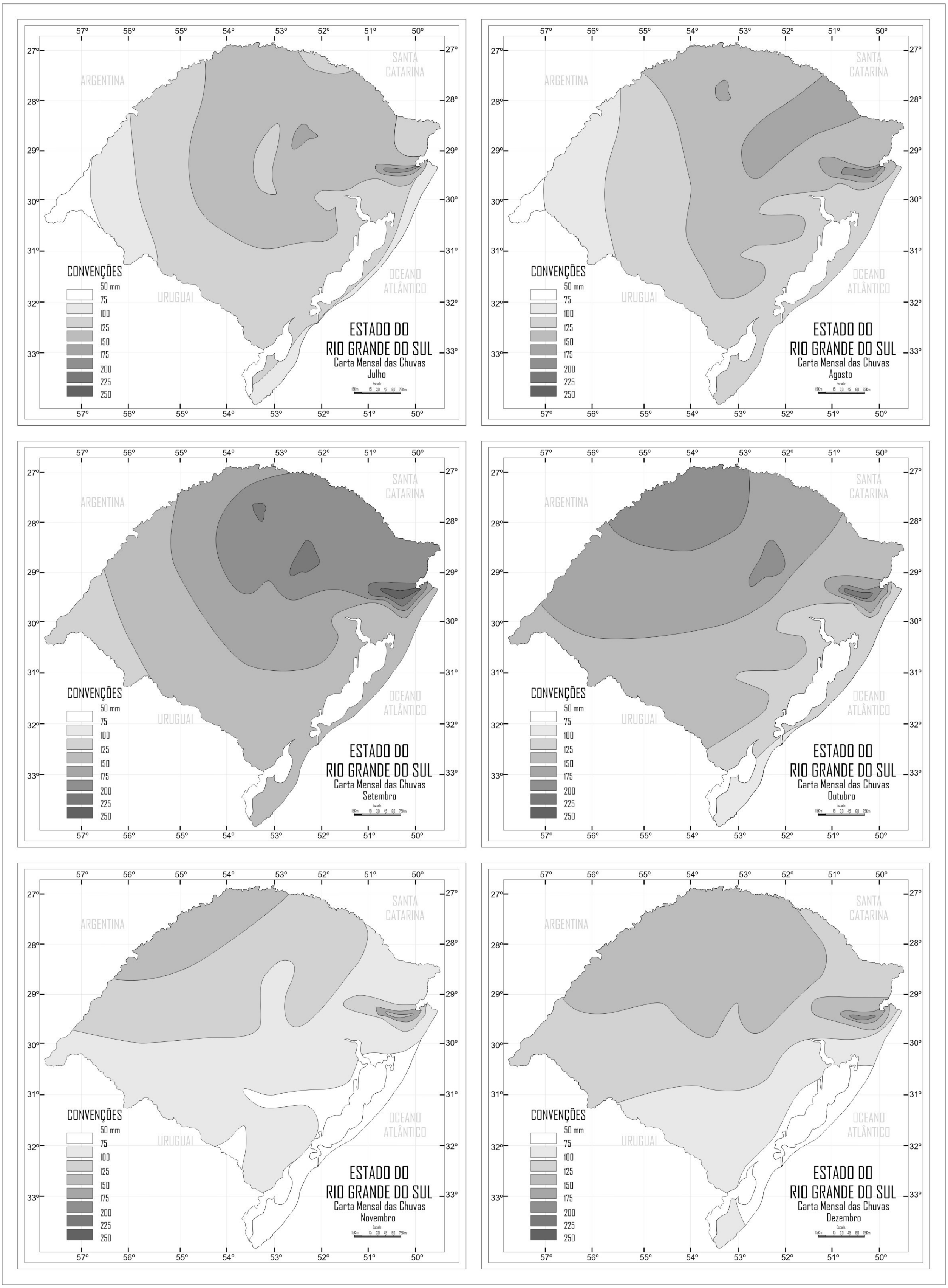
According to the monthly average precipitation (Figure 1) and according to the distribution of the average number of days with rainfall per month (Table 1), it can be inferred that conditions favorable to the accumulation of water in open places where the larva can develop occur throughout the year. However, especially with the monthly totals of precipitation, one or more months of the year can have significant variations, and the values can be close to 0 mm, or else quite above the average of the monthly totals. This can be verified by means of the monthly geographical distribution data of the variation rates, which vary from 52.9% in September to 70.5% in January (BURIOL et al., 2008). Therefore, hydric deficiencies can occur due to the precipitation variability, especially during the hottest months of the year (ÁVILA, 1994; ÁVILA et al., 1996). Climatic conditions under natural conditions are only unsuitable for the development of the *A. aegypti* during these periods, due to the lack of locations with hydric availability.

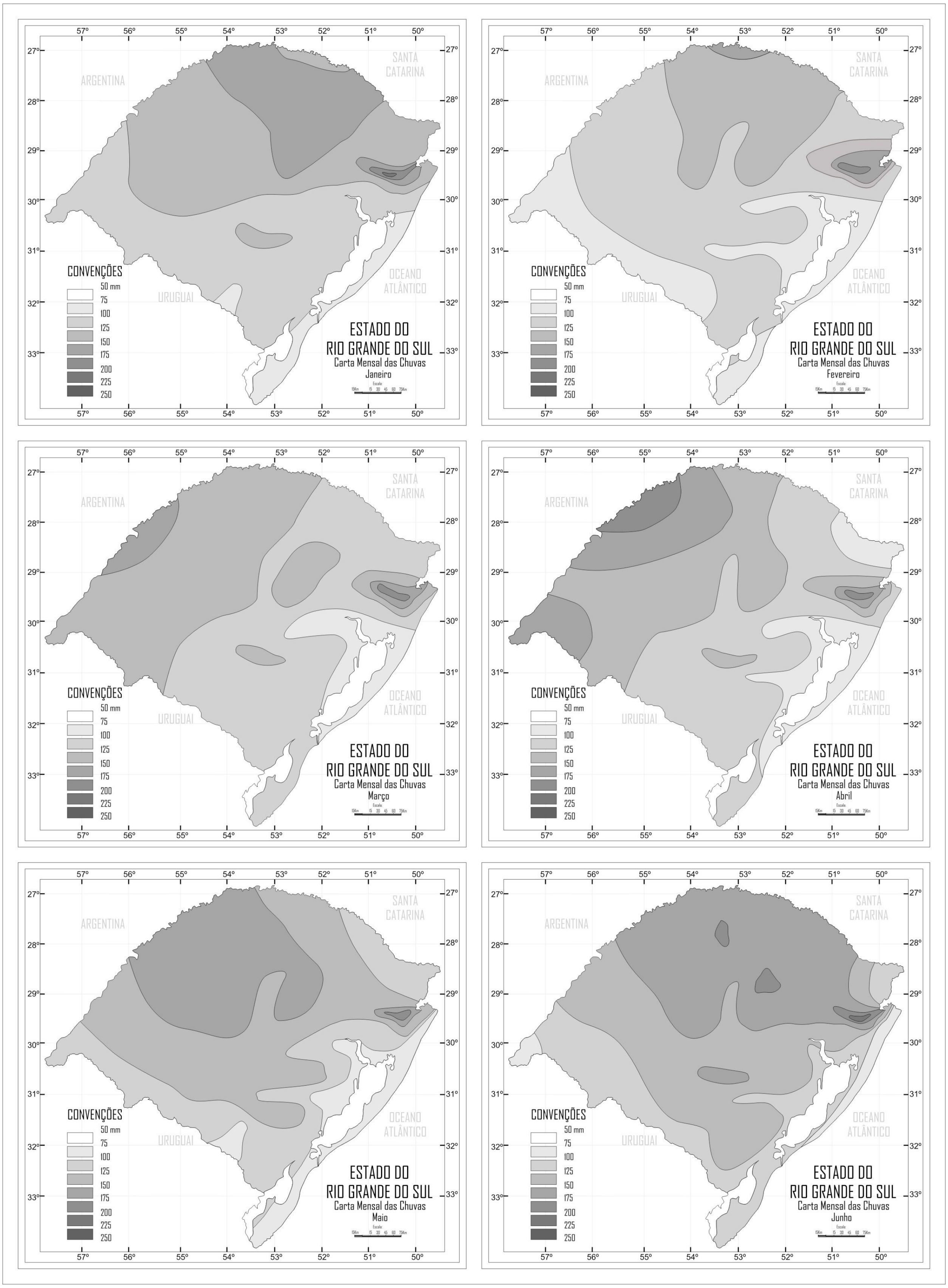
Optimal thermal availabilities for the development of the larva of the dengue fever mosquito in the state, considering the monthly average medium temperatures, only occur during the three hottest months of the year: January, February, and December. Thermal availabilities in January and February occur within the preferable limits, whereas in December they are preferable, tolerable, and marginal. The best thermal availabilities occur in the Climatic Regions of the Central Depression, High and Low Uruguayan Valley, and in the western region of the Missions; especially due to low altitude and to continentality. The highest thermal limitations are observed in the Northeastern Mountains, in the Eastern extremity of the Uplands, and in the Southeastern Mountains, due to higher altitudes, and also in the southern region of the Shore, due to latitude. During the months of March, April, September, October, and November, conditions are tolerable in the hottest regions, and marginal in the coldest regions, and marginal in the entire state during the months of May, June, July, and August. Figure 2 shows the representation of the geographical distribution of the average temperature in the state for the months of January and February, when thermal availabilities are preferable and tolerable, for the months of March, April, September, October, and November, when they are tolerable and marginal, and for the month of December, when they are preferable tolerable, and marginal.

According to the geographic distribution of the monthly average of maximum temperatures, it can be verified that during the months of January, February, March, November, and December, in most of the state, thermal conditions for the development of the mosquito that transmits the dengue fever virus are preferable (Figure 3). It can be observed that, during the months of January, February, and December, in parts of the regions where, according to the monthly average medium temperatures (Figure 2) thermal availabilities are within the limits of the preferable zone, average maximum temperatures are higher than 32°C, which indicates marginal conditions. During the month of March, in almost the entire state, conditions are preferable; in April the preferable zone comprises a little more than half of the state, and in May it comprises only a small region of the Uruguayan Valley; during winter months (June, July, and August) there is no occurrence of preferable conditions; in September, preferable conditions occur in a restricted area of the Uruguayan Valley region, and in October they occur in almost the entire Western half of the state and in the Central Depression.

The results of Figure 4 show that during the months of January, February, March, and December, the monthly average medium temperature conditions are tolerable for the development of the larva, and marginal in the rest of the state. During the remaining months, the average minimum temperature remains between 5 and 18°C in the entire state, resulting in marginal conditions.

As for the absolute minimum temperatures, results are opposite to those obtained with the average medium, average maximum, and average minimum temperatures. Considering the probability of occurrence of monthly minimum absolute temperatures (Table 2), we can verify that, in all meteorological stations used, the probability of occurrence of temperatures below or equal to 5°C - lethal to the *A. aegypti larva* - during the three coldest months of the year is high (equal to or higher than 90%) In a year the probability is 100%, with the exception of São Borja, Itaqui, and some stations at the seashore. Therefore, we can verify that under natural and exposed conditions such as those of the meteorological stations where temperatures are recorded, in every year and in all regions of the state, the larva of this insect finds no


ARGENTINA
SANTA CATARINA
URUGUAI
OCEANO ATLÂNTICO
CONVENÇÕES
50 mm
75
100
125
150
175
200
225
250
ESTADO DO RIO GRANDE DO SUL
Carta Mensal das Chuvas
Julho
Agosto
Setembro
Outubro
Novembro
Dezembro



Source: Buriol et al. (1977)

Figure 1 – Geographic distribution charts of the average of monthly total precipitation in the State of Rio Grande do Sul, for the twelve months of the year, averages of the 1912-1978 period. Source: Buriol et al. (1977).

Table 1 – Average number of days with rainfall per ten-day period in the State of Rio Grande do Sul, based on the 1945-1974[1] period

Month	Jan			Feb			Mar			Apr			May			Jun			Jul			Aug			Sep			Oct			Nov			Dec		
Decêndio	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Alegrete	3	3	3	3	2	2	3	3	3	3	2	2	2	2	3	4	3	3	4	4	3	3	3	4	3	3	3	3	3	3	3	2	2	3	3	2
Bagé	2	2	2	3	3	2	2	2	3	2	2	2	2	2	2	3	2	3	3	3	3	2	2	3	3	3	3	3	2	3	2	2	2	2	2	2
Bento Gonçalves	4	3	4	3	4	3	3	3	3	3	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	4	4	4	4	3	2	3	3	3	3
Bom Jesus	4	5	4	4	4	3	3	4	3	4	3	4	2	3	3	3	3	3	4	3	3	4	3	4	3	4	5	4	4	4	3	3	3	4	3	4
Caçapava do Sul	3	2	2	3	3	2	2	2	3	2	2	2	2	2	2	3	2	3	3	2	3	2	2	3	3	4	3	3	2	3	2	2	2	2	2	2
Cachoeira do Sul	3	3	3	3	3	2	2	2	3	2	2	2	2	2	2	3	2	3	3	2	3	2	2	4	3	3	3	3	2	3	2	2	2	3	2	2
Caxias do Sul	4	3	4	4	5	3	3	3	3	4	3	2	2	3	3	3	3	2	3	3	3	3	3	4	4	4	4	3	4	4	3	3	3	3	3	4
Cruz Alta	3	3	3	3	3	2	2	3	3	2	2	2	2	2	2	3	3	2	3	2	3	2	2	3	3	4	3	3	3	3	3	2	2	3	2	3
Dom Pedrito	3	2	2	2	2	2	2	2	2	3	2	2	2	2	3	3	3	3	2	2	3	2	2	3	3	3	3	3	3	2	2	2	2	2	2	2
Guaporé	4	4	4	3	4	3	3	3	3	3	2	2	2	3	2	3	3	2	3	3	3	3	3	4	3	4	4	3	3	3	3	2	3	3	3	3
Iraí	4	3	4	3	4	3	3	3	3	2	2	2	2	2	2	3	3	2	3	2	3	2	2	3	3	4	3	3	3	4	2	2	2	3	3	3
Itaqui	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	3	2	3	2	2	2	2	2	2	2	2
Jaguarão	3	2	2	3	3	2	3	3	3	3	2	2	2	2	2	3	3	3	3	2	3	2	2	3	3	3	3	3	2	3	2	2	2	2	2	2
Lagoa Vermelha	4	3	6	4	4	3	3	3	3	3	2	3	2	2	2	3	3	3	3	2	3	3	3	4	4	4	4	3	3	4	3	2	3	3	3	3
Marcelino Ramos	4	3	4	4	4	3	3	3	3	3	2	2	2	2	2	3	3	2	3	2	2	2	2	3	3	4	4	3	3	4	3	2	2	3	3	3
Mostardas	3	2	3	2	3	2	2	2	3	3	2	2	2	2	2	3	2	3	3	3	3	2	2	4	3	4	3	2	2	3	2	2	1	2	2	2
Palmeira das Missões	3	3	3	3	3	4	3	2	3	2	2	2	2	2	2	3	3	3	3	2	3	3	2	3	3	4	4	3	3	3	3	2	2	3	3	2
Passo Fundo	4	3	4	3	4	3	3	3	3	3	2	2	2	2	2	3	3	2	3	2	3	3	3	4	3	4	4	3	3	3	3	2	2	3	3	3
Pelotas	3	2	3	3	3	2	2	3	3	3	2	2	2	2	2	3	2	3	3	3	3	2	3	4	3	4	3	3	2	3	2	2	2	2	3	2
Piratini	3	2	3	3	3	2	2	3	3	3	2	2	2	2	3	3	3	3	3	2	3	2	2	3	3	4	3	3	3	3	2	2	2	2	2	2
Porto Alegre	3	3	3	3	3	2	2	2	3	2	2	2	2	2	3	3	3	3	3	2	3	3	2	4	4	3	3	3	3	3	3	2	2	2	2	2
Rio Grande	3	2	2	3	3	2	2	2	3	2	2	2	2	2	2	3	2	3	3	3	3	2	2	3	3	3	3	3	2	3	2	2	2	2	2	2
Santa Cruz do Sul	3	3	3	3	3	2	2	3	3	3	3	2	2	2	2	3	3	2	3	2	3	2	2	4	3	4	3	3	3	3	2	2	2	3	2	2
Sta do Livramento	2	2	2	3	3	2	2	2	2	2	2	2	1	2	2	2	2	3	2	2	2	2	2	3	3	4	4	3	2	2	2	2	2	2	2	2
Santa Maria	3	2	3	3	3	2	2	2	3	3	2	2	2	2	2	3	2	3	3	2	3	2	3	4	3	3	3	3	3	3	2	2	2	3	2	3
Santa Rosa	4	3	3	3	3	2	2	2	3	3	2	2	2	3	2	2	3	2	3	2	3	2	2	3	3	3	3	3	3	3	2	2	2	3	3	2
Santa Vitória Palmar	3	2	2	3	2	2	2	2	3	2	2	2	2	2	2	3	2	3	2	2	2	2	2	3	2	3	2	3	2	2	2	2	2	2	2	2
Santiago	3	3	2	3	2	1	2	2	3	2	2	2	2	2	2	2	3	2	3	2	3	2	2	3	3	4	3	3	2	2	2	2	2	2	2	2
Santo Ângelo	3	3	3	3	3	3	2	2	3	2	2	2	2	2	2	3	3	2	3	2	3	2	2	3	3	4	3	3	3	3	2	2	2	3	2	2
São Borja	3	2	2	3	2	2	2	2	3	3	3	2	2	2	2	3	3	2	3	2	2	1	2	3	3	3	3	3	3	3	2	2	2	2	2	2
São Fco de Paula	3	4	5	5	5	3	4	3	4	4	4	3	3	4	3	3	4	4	3	2	4	3	3	4	4	5	4	4	4	4	3	3	4	3	3	3
São Gabriel	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	2	3	2	2	3	3	4	3	3	3	3	2	1	2	3	2	2
São Luiz Gonzaga	3	3	3	4	3	2	2	2	3	2	2	2	2	2	3	3	3	2	3	2	3	2	2	3	3	4	3	3	3	3	2	2	2	3	2	2
Soledade	4	4	3	3	4	3	3	3	3	3	3	2	2	2	3	2	3	3	2	3	3	3	3	3	4	3	4	4	3	3	3	2	2	3	3	3
Tapes	3	2	3	3	3	2	3	3	3	2	2	2	2	2	2	3	2	3	3	3	3	2	2	4	3	3	3	2	2	3	2	2	2	2	2	2
Taquara	3	3	3	3	4	3	3	3	3	3	3	3	2	3	2	3	3	3	3	2	3	3	3	4	4	4	4	3	3	3	2	3	3	3	2	2
Taquari	3	3	3	3	4	3	2	2	3	3	3	2	2	3	2	3	3	3	3	2	3	2	2	3	3	3	4	3	3	2	2	2	2	2	2	2
Torres	3	3	4	4	5	4	4	5	4	3	3	3	3	2	3	3	4	3	2	2	3	3	2	4	3	3	4	3	4	3	3	3	2	3	3	3
Uruguaiana	3	2	2	3	2	1	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	2	2	2	2	2	2	2	2
Vacaria	3	3	4	3	4	2	3	3	3	3	2	2	2	2	2	3	3	2	3	2	3	3	3	4	3	3	4	3	3	3	2	2	2	3	3	3
Viamão	2	2	3	3	3	3	3	3	3	2	3	2	2	2	3	3	3	3	2	3	3	2	1	3	3	3	4	3	4	2	1	2	3	2	2	2

Source: Institute of Agronomic Survey (1989).

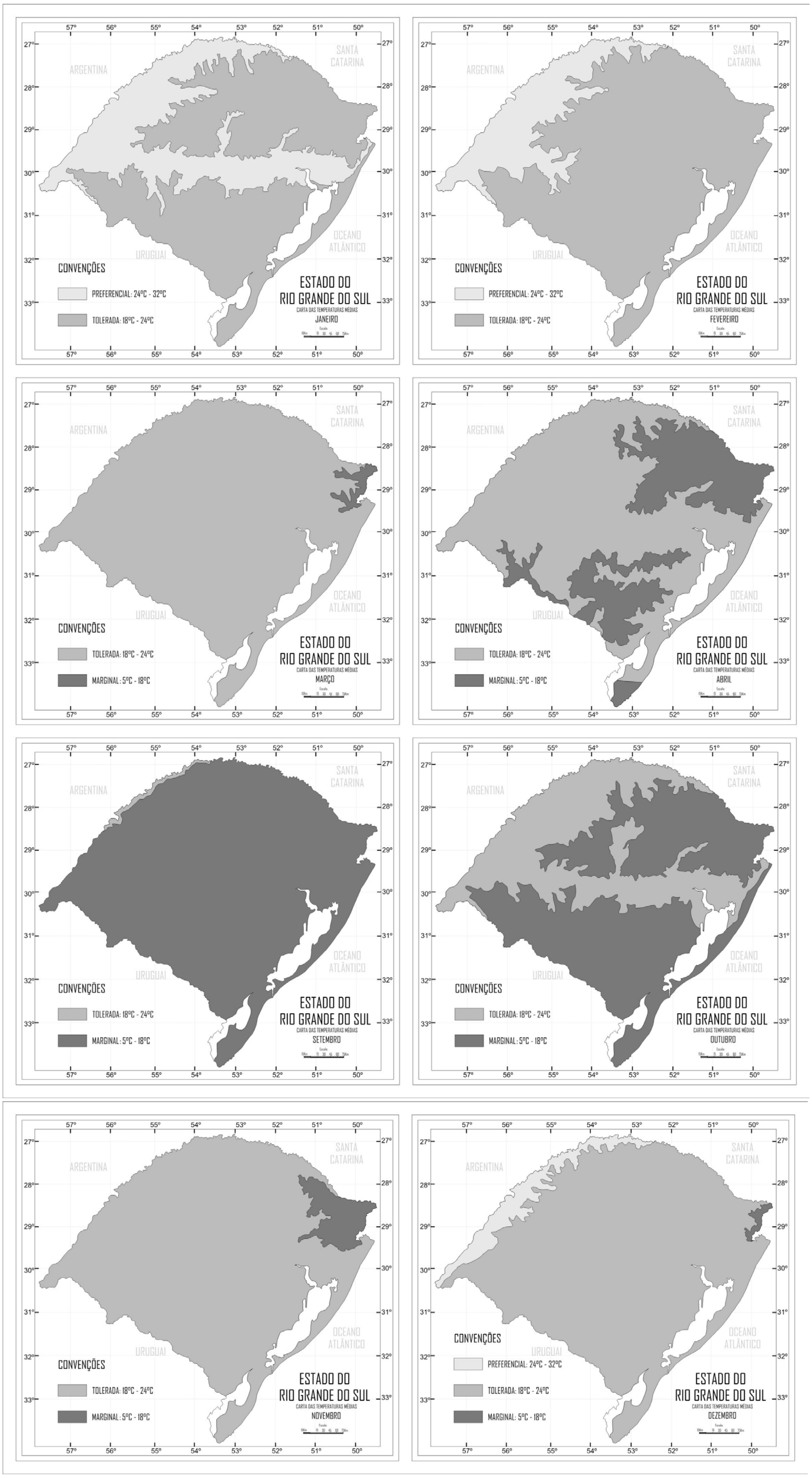
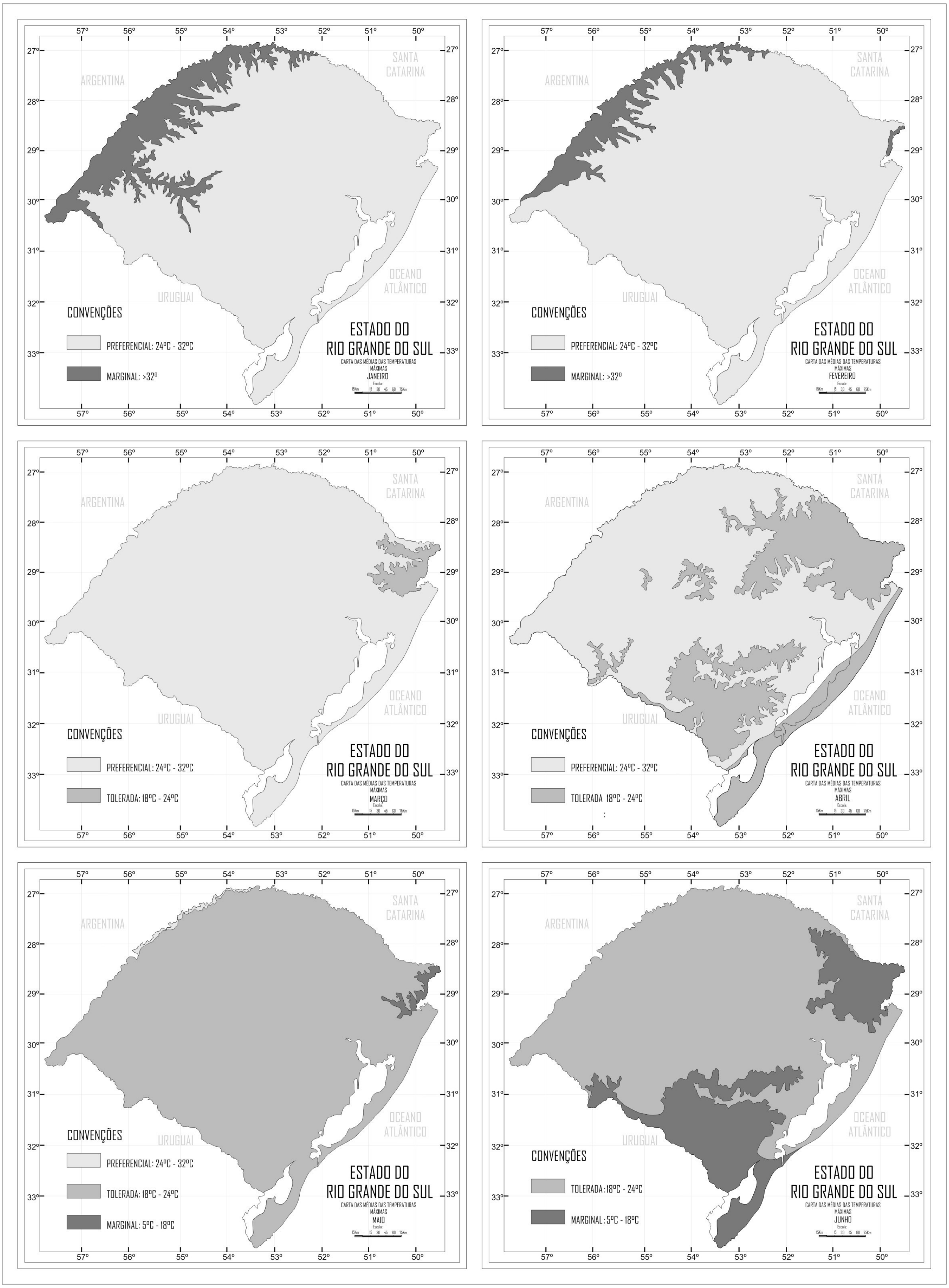


Figure 2 - Zoning for the development of the larva of the denge fever mosquito in the State of Rio Grande do Sul for the months of January, February, March, April, September, October, November, and December, based on the average medium temperatures.



ARGENTINA
SANTA CATARINA
URUGUAI
OCEANO ATLÂNTICO
CONVENÇÕES
PREFERENCIAL: 24ºC - 32ºC
MARGINAL: >32º
ESTADO DO RIO GRANDE DO SUL
CARTA DAS MÉDIAS DAS TEMPERATURAS MÁXIMAS
JANEIRO
Escala:
15Km 15 30 45 60 75Km
ARGENTINA
SANTA CATARINA
URUGUAI
OCEANO ATLÂNTICO
CONVENÇÕES
PREFERENCIAL: 24ºC - 32ºC
MARGINAL: >32º
ESTADO DO RIO GRANDE DO SUL
CARTA DAS MÉDIAS DAS TEMPERATURAS MÁXIMAS
FEVEREIRO
ARGENTINA
SANTA CATARINA
URUGUAI
OCEANO ATLÂNTICO
CONVENÇÕES
PREFERENCIAL: 24ºC - 32ºC
TOLERADA: 18ºC - 24ºC
ESTADO DO RIO GRANDE DO SUL
CARTA DAS MÉDIAS DAS TEMPERATURAS MÁXIMAS
MARÇO
ARGENTINA
SANTA CATARINA
URUGUAI
OCEANO ATLÂNTICO
CONVENÇÕES
PREFERENCIAL: 24ºC - 32ºC
TOLERADA 18ºC - 24ºC
ESTADO DO RIO GRANDE DO SUL
CARTA DAS MÉDIAS DAS TEMPERATURAS MÁXIMAS
ABRIL
ARGENTINA
SANTA CATARINA
URUGUAI
OCEANO ATLÂNTICO
CONVENÇÕES
PREFERENCIAL: 24ºC - 32ºC
TOLERADA: 18ºC - 24ºC
MARGINAL: 5ºC - 18ºC
ESTADO DO RIO GRANDE DO SUL
CARTA DAS MÉDIAS DAS TEMPERATURAS MÁXIMAS
MAIO
ARGENTINA
SANTA CATARINA
URUGUAI
OCEANO ATLÂNTICO
CONVENÇÕES
TOLERADA: 18ºC - 24ºC
MARGINAL: 5ºC - 18ºC
ESTADO DO RIO GRANDE DO SUL
CARTA DAS MÉDIAS DAS TEMPERATURAS MÁXIMAS
JUNHO

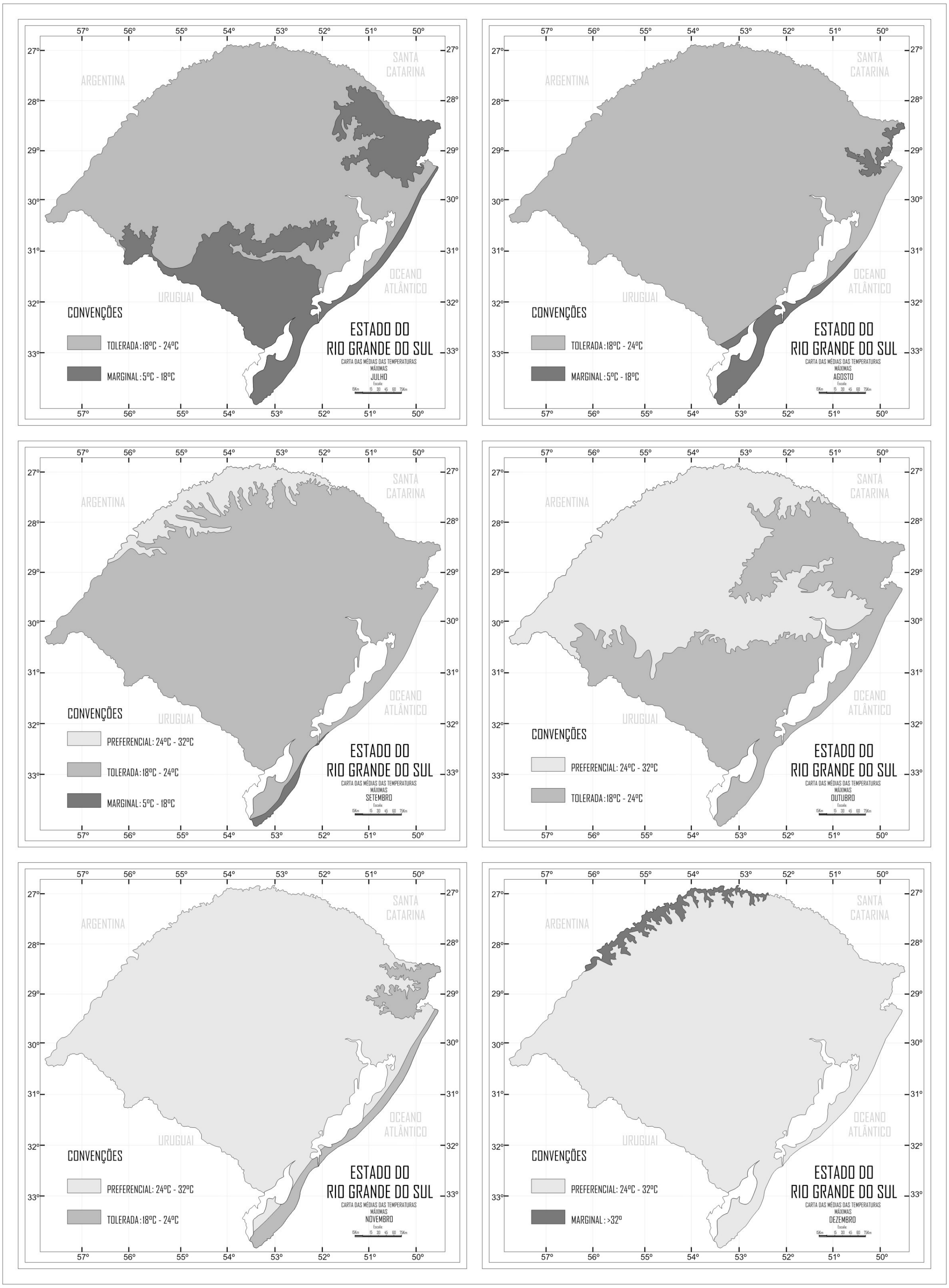


Figure 3- Zoning for the development of the larva of the denge fever mosquito in the State of Rio Grande do Sul for all months of the year, based on the average maximum temperatures.

Table 2 - Probability that the absolute minimum temperature measured at the meteorological station is lower or equal to 5°C [p(x ≤ 5.0)]

Stations	April	May	June	July	August	September	October	Year
Região Continental								
Irai	0,441	0,815	0,935	0,981	0,965	0,814	0,641	1,000
Marcelino Ramos	0,205	0,682	0,878	0,969	0,911	0,606	0,259	1,000
Santa Rosa	0,338	0,826	0,945	0,983	0,980	0,686	0,432	1,000
Palmeira das Missões	0,273	0,793	0,957	0,959	0,974	0,777	0,479	1,000
Passo Fundo	0,319	0,814	0,952	0,955	0,951	0,778	0,478	1,000
Santo Ângelo	0,316	0,830	0,960	0,991	0,978	0,737	0,444	1,000
Lagoa Vermelha	0,612	0,926	0,981	0,993	0,989	0,893	0,789	1,000
São Luiz Gonzaga	0,124	0,627	0,908	0,927	0,941	0,619	0,274	1,000
Vacaria	0,821	0,957	0,993	0,996	0,999	0,952	0,949	1,000
Cruz Alta	0,246	0,767	0,960	0,975	0,983	0,760	0,479	1,000
São Borja	0,111	0,579	0,903	0,912	0,908	0,500	0,140	0,998
Guaporé	0,589	0,949	0,985	0,995	0,992	0,915	0,789	1,000
Soledade	0,452	0,897	0,980	0,970	0,986	0,904	0,746	1,000
Itaqui	0,124	0,708	0,860	0,935	0,914	0,539	0,189	0,999
Bento Gonçalves	0,545	0,920	0,974	0,993	0,993	0,880	0,715	1,000
Caxias do Sul	0,482	0,895	0,973	0,985	0,996	0,912	0,792	1,000
Santiago	0,249	0,802	0,987	0,994	0,988	0,829	0,479	1,000
Júlio de Castilhos	0,316	0,846	0,979	0,992	0,996	0,923	0,665	1,000
São Francisco de Paula	0,771	0,966	0,995	0,996	0,997	0,988	0,958	1,000
Santa Maria	0,137	0,684	0,939	0,956	0,956	0,604	0,240	1,000
Santa Cruz do Sul	0,246	0,786	0,935	0,975	0,976	0,743	0,333	1,000
Taquara	0,184	0,716	0,913	0,987	0,891	0,557	0,221	1,000
Uruguaiana	0,096	0,561	0,922	0,951	0,950	0,637	0,200	1,000
Alegrete	0,333	0,769	0,952	0,979	0,961	0,793	0,384	1,000
Taquari	0,113	0,641	0,900	0,940	0,894	0,480	0,112	1,000
Porto Alegre	0,021	0,386	0,738	0,853	0,741	0,316	0,048	1,000
Cachoeira do Sul	0,124	0,653	0,897	0,946	0,920	0,598	0,229	1,000
Viamão	0,113	0,653	0,799	0,984	0,921	0,548	0,260	1,000
São Gabriel	0,345	0,829	0,963	0,986	0,987	0,837	0,457	1,000
Caçapava do Sul	0,266	0,779	0,976	0,989	0,986	0,915	0,685	1,000
Encruzilhada do Sul	0,210	0,726	0,961	0,971	0,987	0,870	0,605	1,000
Santana do Livramento	0,374	0,886	0,992	0,990	0,990	0,842	0,639	1,000
Dom Pedrito	0,595	0,931	0,985	0,985	0,996	0,953	0,717	1,000
Bagé	0,301	0,815	0,964	0,988	0,997	0,900	0,638	1,000
Piratini	0,392	0,812	0,981	0,998	0,991	0,952	0,799	1,000
Região Litorânea								
Torres	0,003	0,238	0,500	0,681	0,521	0,230	0,027	0,967
Tapes	0,092	0,485	0,854	0,932	0,822	0,460	0,193	0,999
Pelotas	0,198	0,840	0,969	0,961	0,971	0,806	0,439	1,000
Rio Grande (cidade)	0,003	0,258	0,683	0,724	0,543	0,200	0,046	0,965
Rio Grande (barra)	0,004	0,195	0,572	0,702	0,564	0,138	0,011	0,929
Jaguarão	0,224	0,882	0,984	0,988	0,990	0,883	0,523	1,000
Santa Vitória do Palmar	0,169	0,765	0,954	0,954	0,970	0,877	0,500	0,999

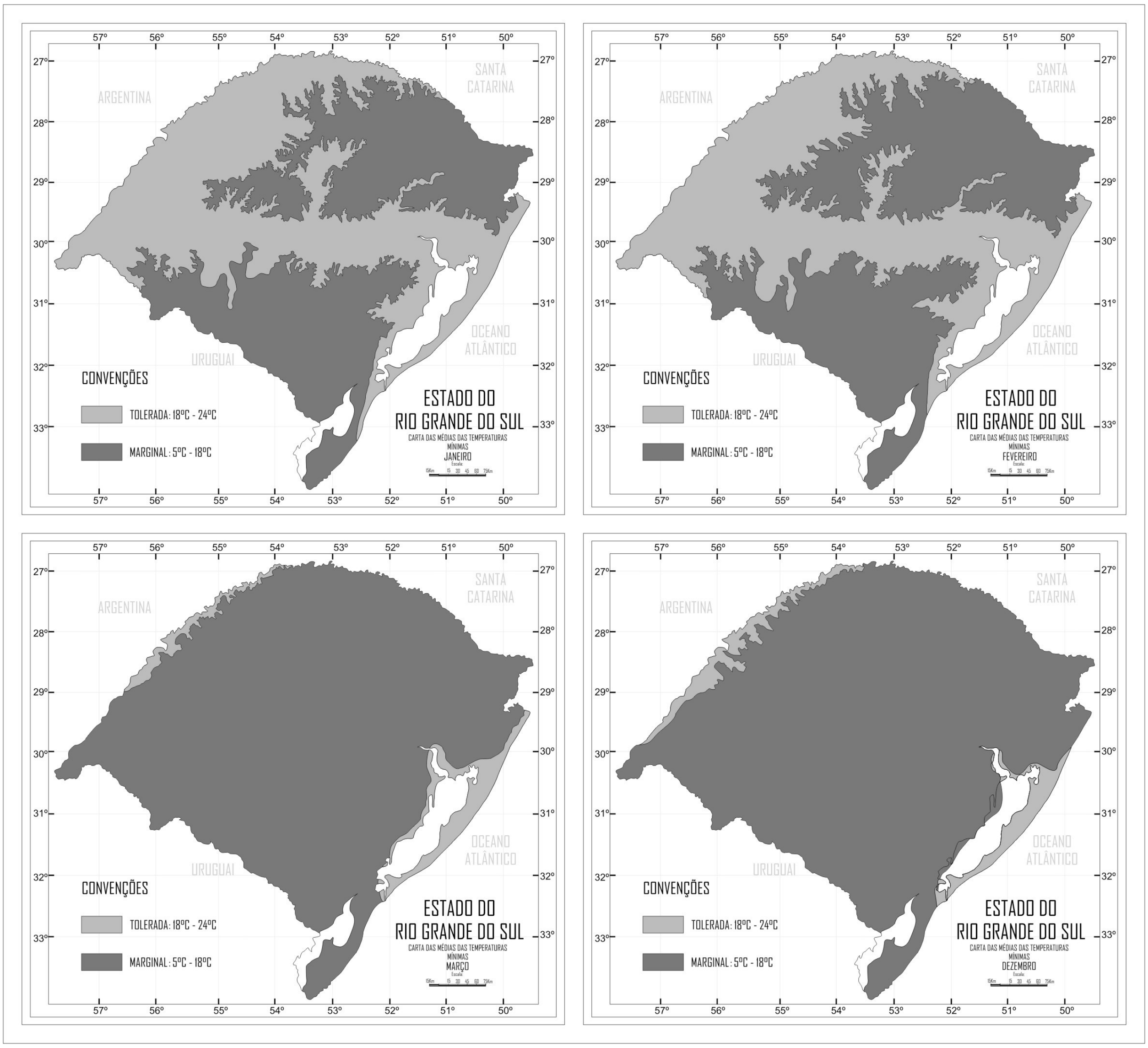


Figure 4 - Zoning for the development of the larva of the denge fever mosquito in the State of Rio Grande do Sul for the months of January, February, March and December, based on the average minimum temperatures.

survival conditions. Its survival can only occur in protected environments.

According to the results obtained with thermal availabilities, the average medium temperature conditions (Figure 2) are favorable to the development of the larva during the months of December, January, and February in the regions of the Central Depression, High and Low Uruguayan Valley, and west of the Missions, and tolerable and marginal during the other months of the year and in the rest of the state; according to the average temperature of the maximum temperatures (Figure 3), and taking it as the expression of the variation of daytime temperatures, conditions are favorable in the hottest period of the year, remaining for a larger number of months than in the case of the average medium temperatures, and encompassing a larger area within the state, whereas during the remaining months, they are tolerable and marginal; and according to the average minimum temperature (Figure 4), considering it as the expression of the variation of nighttime temperature, conditions are tolerable and marginal during the months of January, February, March, and December, and marginal during the remaining months. Accordingly, both the average maximum and minimum temperatures are not lethal to the *A. aegypti* larva. However, when we consider the absolute minimum temperatures of the three coldest months of the year, in every year and in every region of the state, there is a probability of occurrence of absolute minimum temperatures below or equal to 5°C, lethal to the larva of this insect.

Conclusions

Hydric availabilities in the State of Rio Grande do Sul are suitable for the development of the larva of the mosquito transmitter of the dengue virus fever throughout the year and in the entire territory. Favorable thermal conditions appear during the hottest months of the year and in regions where geographic conditions are more suitable for the occurrence of high temperatures, such as the Climatic Regions of the High and Low Uruguayan Valley, Central Depression, and Missions. Considering the monthly average medium, maximum, and minimum temperatures, lethal temperatures do not occur in any month, and in any geographic region of the state. However, in every year and in every region of the state, the probability of occurrence of minimum absolute temperatures equal to or below 5° C is high. These temperatures are considered lethal to the larva of *A. aegypti,* and it is therefore only able to survive in protected locations.

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