Some Health Impacts of Global Warming in South America:Vector-Borne Diseases

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The study and comparison of warming, mosquitos of genus Anopheles and transmission of malaria in the North of Argentina allow to conclude that a possible change could happen. Warming may have three principal impacts in the epidemiology of this and other vector-borne diseases:
a) to shorten vector life cycles;
b) to increase the necesity of blood intake by haematophagous insects;
c) to increase the risk of bites and transmission of pathogens.
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warming, vectors, malaria, Anopheles

A recent publication[1] pointed out that the increase of temperature as a global phenomenom may affect the human health with two kinds of effects: direct and indirect. In the second group, problems that deserve special atention are malaria and other vector-borne diseases. Several pathologies of this group have been studied in relation to the global climate change: yellow fever, dengue, arboviral encephalitides, onchocerciasis, non-viral tick-borne diseases, African and American trypanosomiasis[1]. Special significance may have malaria, dengue and Chagas' disease in South America because these pathologies are public health problems of very difficult solution.

The total population at risk, related to malaria, is estimated in 2,000 million inhabitants, even though the accuracy of that information is uncertain. The incidence is about 250 million of new cases per year. In the Americas, 21 countries are included in the endemic area and 210 million inhabitants are at risk of infection [2].

The case of dengue and yellow fever transmission is also very complicate because there are sylvan species of mosquitoes transmitting in rural environments, as well as urban species vectors or potential vectors in cities. After 30 years of the formal eradication, Argentina has become reinfested with *Aedes aegypti* while *Aedes albopictus* has infested Brazil, making worse the epidemiological forecast of dengue, yellow fever and some viral encephalitides [2,3].

Chagas' disease, even though not strictly related to climatic factors, is known to have higher and faster dynamics of vectors and transmission when the temperature is 28-30C or more [4,5]

Malaria vectors, mosquitoes of the genus *Anopheles* Meigen, 1818, are tropical and subtropical species as a general rule; however, several species may reach temperate areas with adequate conditions of summer temperature, humidity and rainfalls. Some species have a large geographical distribution, including two of the most importantant malaria vectors in the Americas: *A. (A.) pseudopunctipennis* Theobald, 1901 and *A. (N.) darlingi* Root, 1926. The last one is found from Mexico [6] to Argentina [7] in different ecosystems, altitudes and climates. Epidemiological conditions to malaria transmission are related to the distribution and life cycles of vector species as well as to the characteristics of human populations, the presence of previously infected cases (human reservoirs) and environmental conditions permitting the life of parasites (*Plasmodium malariae, P. vivax, P. falciparum, P. ovale*) in the insect. According to several studies summarized in 1995 [8], higher temperatures than 22C accelerate insect metabolic processes. Its consequence is the necesity of a larger amount of food which has effects on the developmental time and population density. At the same time, parasites accelerate their developmental stages

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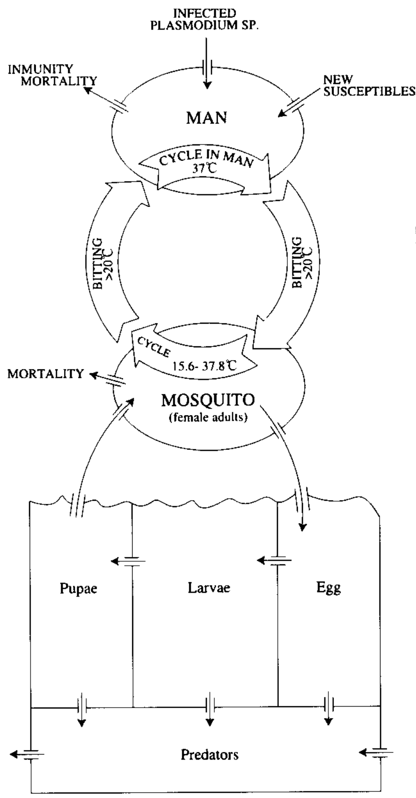


	> TEMPERATURE	> RAINFALL
	> skin exposition * outodoor resting > hours of human activity	* indoor resting < hours of human activity
AIR TEMPERATURE AND HUMIDITY	> metabolism > feeding activity > sexual activity > hours of flying < time of vector cycle < time of parasite cycle ⇓ increased population dynamics	* higher humidity
WATER TEMPERATURE AND RAINFALL	> metabolism > feeding activity of larvae ⇓ shorter aquatic cycle	> breeding places
	> predation ⇓ mosquito population control	

Figure 1. Ecological and epidemiological cycles of malaria and possible changes by warming and increased rainfall.

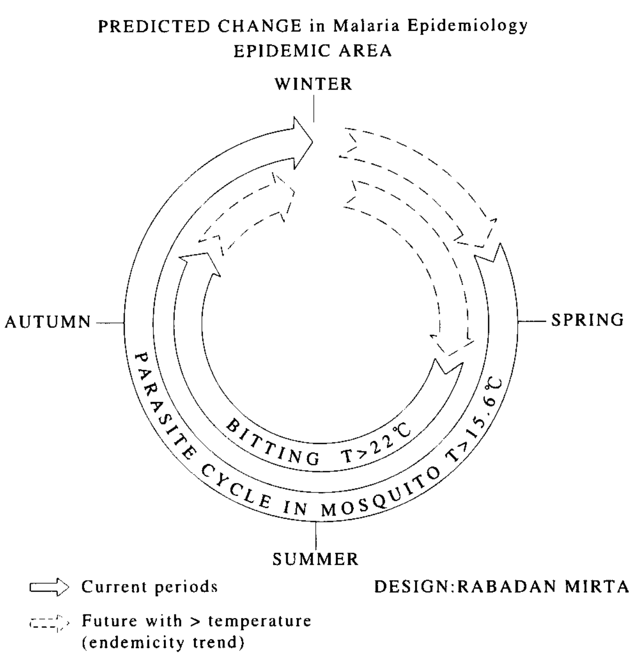


Figure 2. Possible change in malaria epidemiology in the NE of Argentina : vectors activity and <u>Plasmodium</u> cycle may extend through the whole year.

and human infections are more frequent than at lower temperatures. Ideal temperatures needed for the sexual development of Plasmodium species in mosquitoes are: *P. malariae*, 22C, *P. falciparum*, 30C, *P. vivax*, 25C. These parasites are disturbed when temperatures are lower than 15.6C or higher than 37.8C. Anopheles activities related to flying and feeding disappear or are drastically reduced at temperatures lower than 20C. The relationship between warming and increases incidence or changes of the epidemiological patterns have been published recently [8-10]

Rainfall is an important factor for the existence of breeding places for mosquitoes. During the rainy season many places are flooded and residual water remains.Some ecological and epidemiological aspects are shown in Figures 1 and 2.

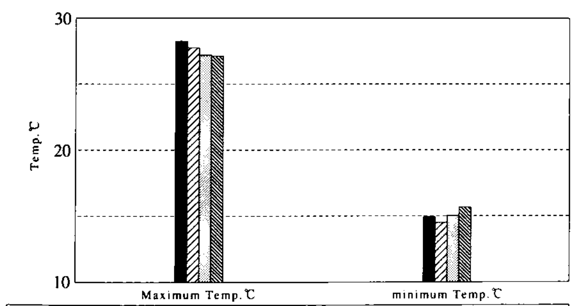
The Northern border of Argentina is a special place to study some changes on climate conditions because it is the southern limit of the geographical distribution of malaria transmission in South America.. The influence of ENSO (El Nino Southern Oscilation) has shown that variations on the general patterns of temperature and rainfall could be related to ecological conditions and epidemiological impacts.

MATERIAL AND METHODS

Temperatures of several meteorological stations in the North of Argentina (NE and NW) were studied from oficial records of the National Meteorological Service. With this information some diagrams were drawn to show tendencies, taking the annual average by decade of maximum and minimun mean temperature, during 30 or 40 years, and in 1990.

At the same time, records of the presence of some vector species were obteined from field research, published data and records of oficial control services. Vectors specially studied are *Anopheles darlingi*, *A. albitarsis*, *A. pseudopunctipennis*, *Aedes aegypti* and some Triatominae species. With this records, maps of geographical distribution were drawn trying to correlate them with isotherms and, in some cases (Triatominae species) making diagrams of alti-latitudinal profiles. In the case of *Anopheles* species, climate and entomological informations were compared with the notification of new human cases of malaria.

Some experimental studies were performed related to life cycles under laboratory conditions for better understanding of the temperature influence on the developmental time and population dynamics of some vectors (*Aedes aegypti* and Triatominae bugs). However, species of *Anopheles* have not been experimentally studied.

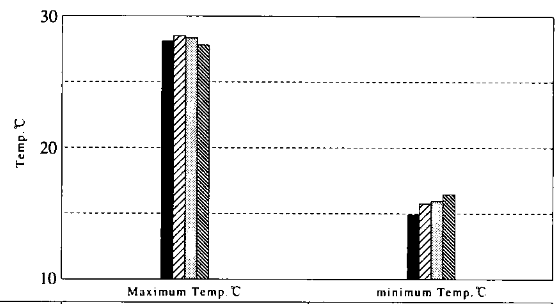


	Maximum Temp.℃	minimum Temp.℃
1951-60	28.3	14.8
1961-70	27.9	14.3
1971-80	27.3	15
1981-90	27.2	15.7

Figure 3. Maxima and minima temperatures (annual average by decades). Misiones: Iguazú. Source: National Meteor ological Service, Argentina, 1991.

RESULTS

In this paper, some results related to Anopheles species and



	Maximum Temp ℃	minimum Temp.℃
1951-60	28	14.9
1961-70	28.5	15.7
1971-80	28.3	15.9
1981-90	27.8	16.3

Figure 4. Maxima and minima temperatures (annual average by decades). Chaco: P.R.Saenz Peña. Source: National Meteorological Service, Argentina, 1991.

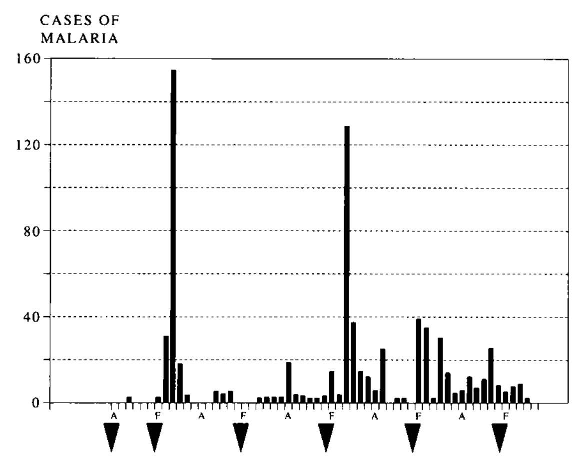


Figure 5. Cases of malaria in the NE of Argentina (Misiones), August 1988 - May 1993. The curve seems to be changing to an endemic-like type. Source: National Service for Malaria Control, 1994.

malaria are given. The historical analysis of the annual average mean temperature, maximum and minimum, grouped by decades, show that in most of the meteorological stations the maxima values were not affected in a definite way; however, when studied the minima annual average temperatures show a general increase with variation between 0.3C and 1.4C (examples of Figures 3 and 4).

Almost every year and during several months over the last years, in several localities of the NE of Argentina, *Anopheles (N.) darlingi* was found by the National Service for Malaria Control and by these authors. Malaria new cases in the part of that area (Province of Misiones) are shown in the diagram of Fig. 5, from 1988 to 1993. It is interesting to see the change of the epidemiological pattern since April 1990 , with new cases every month, except October 1991 and January 1992.

Figure 6 shows a typical dwelling of the NE subtropical dry forest ("Chaco"); Figure 7 is a picture of epiphyte bromeliads of the NE wet subtropical forest one of the important breeding places for some malaria vector species (subgenus *Kerteszia*).

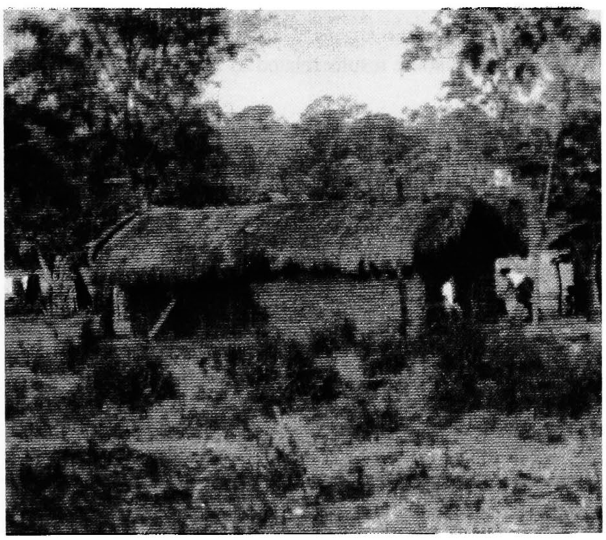


Figure 6. Typical dwelling in the NE dry forest ("Chaco"), environment of malaria and Chagas' disease.

Figure 7. Epiphyte bromeliads in the NE wet subtropical forest, breeding places of several mosquitoes, including malaria vectors of subgenus *Kerteszia*.

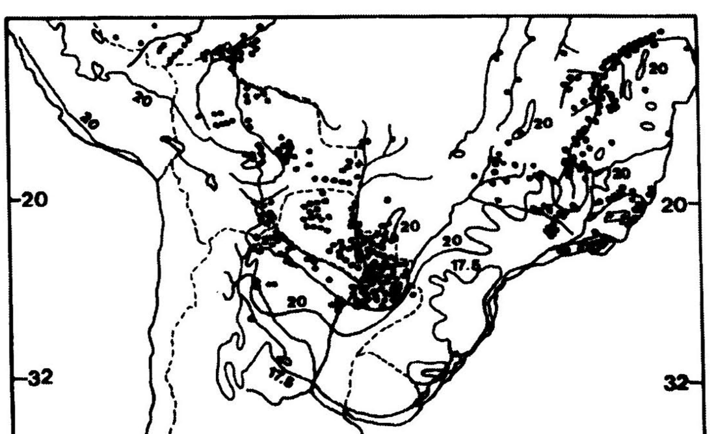


Figure 8. Southern distribution of *Anopheles darlingi* (dots). It corresponds almost exactly to the April mean isotherm of 20℃. Isotherm of 17.5C shows the possible future dispers, ion if warming increases the average temperature 2℃.

DISCUSSION

The increase of the minima annual mean temperature is confirmed by the National Meteorological Service of Argentina in one of its publications [11], for the whole country and not only for the Northern area. ENSO was active between 1991 and 1995, with an anomalous extension of its influyence, usually limited to several months.

At the same time, *Anopheles (N.) darlingi* was found more frequently than in former reports. In some localities, captures of this species almost every year and during several months each year is a different pattern when compared with that of the period 1951-1965 [7], when *A. darlingi* was reported in Misiones in 1951, 1960 and 1965 only. Historically, this species was present mainly at the end of summer (75 % in March), although some exceptional captures were done in winter. Specimens sent to the Entomological Research Institute of Salta (Argentina) and to present authors, or collected by Curto de Casas, Horacio Martinez and Eduardo Corton, correspond to collections performed in January, February, March, April, June, September, November and December, while the years of collections were 1991, 1992, 1993 and 1994. Previously, there was information from Brazil (border with Argentina and Paraguay: Itaipu Dam) of captures in 1987 and 1989.

At the same time, the geographical distribution of this species follows the April mean temperature isotherm of 20C. The month of April was selected because it coincides with the maximum activity of *A. darlingi* in this area ; the 20C is the temperature at which *Anopheles* activities of flying and feeding start [7, 8, 12]. In Figure 8 the isotherm of 20C and point (localities) where *A. darlingi* was found in its southern limit area are shown, as well as the possible future distribution if an increase of about 2C happens (isotherm of 17.5C).

According to field collected information and experimental studies [1, 4, 5, 8, 10, 12] warming could have three principal impacts in the epidemiology of vector-borne diseases:

a) shorter vector life cycles

b) incresed necesity of blood intake by haematophagous insects

c) higher risk of infecting bites and transmission of pathogens

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