ENVIRONMENTAL FACTORS AND THE DISTRIBUTION OF MANSONELLIASES IN SOUTHERN VENEZUELA

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Summary:

The distribution of mansonelliases and their relation to various quantitative criteria were determined through the study of 1,057 subjects in 17 localities in ten regions of Amazonas State and Bolívar State. The total prevalence among the blood samples, determined through the Knott technique, was 18.54 %. 11.26 % were parasited by *Mansonella perstans*, 9.93 % by *Mansonella ozzardi*, and 2.63 % by both species. The average of microfilaremia was 48.19 mf/mL of blood in *M. perstans* and 13.79 mf/mL in *M. ozzardi*. In the regions studied, *M. ozzardi* has a wider area of distribution than *M. perstans*. Prevalence, average number of parasites per host, and the infection index have a positive and statistically significant correlation with the total annual precipitation mean for each region for *M. perstans*; in the case of *M. ozzardi* the quantitative parameters are positively correlated with the altitude of each region, this correlation being statistically significant. With respect to type of vegetation, *M. perstans* had a higher infection index in Amazonian caatinga transition in pluvial lowland forest, and *M. ozzardi* in semideciduous forest of the alisio type. Therefore two types of transmission, *M. ozzardi-Simulium* and *M. perstans-Culicoides* are suggested.

KEY WORDS : mansonelliasis, Venezuela, distribution, vegetation types.

Résumé : FACTEURS ENVIRONNEMENTAUX ET DISTRIBUTION DES MANSONELLOSES DANS LE SUD DU VENEZUELA

La distribution des mansonelloses et leurs relations à divers critères quantitatifs ont été déterminés à partir de l'étude de 1 057 sujets dans 17 localités de dix régions des États d'Amazonas et de Bolivar. La prévalence dans les prélèvements sanguins, déterminée selon la technique de Knott, était de 18,54 %. 11,26 % étaient parasités par Mansonella perstans, *9,93 % par* Mansonella ozzardi, *et 2,63 % par les deux espèces. Le taux moyen de microfilarémie était de 48,19 mf/mL pour* M. perstans *et de 13,79 mf/mL pour* M. ozzardi. *Dans les régions étudiées,* M. ozzardi *a une aire de répartition plus vaste que* M. perstans. *Pour* M. perstans, *la prévalence, le nombre moyen de parasites et l'index d'infection ont une corrélation positive et statistiquement significative avec la moyenne des précipitations annuelles de chaque région. Dans le cas de* M. ozzardi, *les paramètres quantitatifs sont corrélés de façon positive et statistiquement significative avec l'altitude de chaque région. Au regard du type de végétation, l'index d'infection de* M. perstans *est plus élevé dans lest forêts basses et humides, et celui de* M. ozzardi *dans les forêts semi caduques. En conséquence, deux types de transmission sont suggérés :* M. ozzardi-Simulium *et* M. persistans-Culicoides.

MOTS CLÉS : *mansonelloses, Venezuela, distribution, végétation.*

INTRODUCTION

Mansonelliases are endemic in several regions of Africa, the Caribbean and Latin America. In South America it has been reported in Venezuela, Colombia, Brazil, Guyana, Suriname, Argentina and Peru (Sasa, 1976; Hawking, 1979), although in most of these countries its prevalence and geographical distribution, as well as the environmental factors determining distribution, have yet to be defined. However, many of the areas in South America where mansonelliases are endemic lie within the Amazon basin (Kozek *et al.*, 1982b).

In Amazonas State in Venezuela, it has been reported that *Mansonella (Mansonella) ozzardi* (Manson, 1897) and *Mansonella (Esslingeria) perstans* (Manson, 1891) mainly affect the ethnic groups that inhabit the region (Baumgartner, 1955; Beaver *et al.*, 1976; Botto *et al.*, 1983; Formica & Botto, 1990).

These studies show that mansonelliases are widely distributed throughout Amazonas State. However, with the exceptions of Botto *et al.* (1983) and Formica & Botto (1990), they underestimate the infected population because the diagnostic techniques used were not very sensitive. Thus there is a need to evaluate the real situation of these filarial parasites by means of a technique of proven sensitivity, such as the Knott technique (Botto *et al.*, 1983; Raccurt *et al.*, 1982).

Likewise, there have not been any studies which correlate the distribution of these parasites, along with epidemiological indexes such as prevalence and parasitical load, to environmental factors like vegetation and rainfall among others.

For this reason we have carried out studies in different parts of Amazonas State in Venezuela and in one

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locality in Bolívar State in order to determine the prevalence, parasitical load and precise taxonomic identity of the *Mansonella* species involved, and the characteristics of the different regions in terms of their vegetation, precipitation and altitude, with the aim of contributing to the framework of current knowledge about these parasites in the areas in question.

MATERIALS AND METHODS

AREA OF STUDY

This mainly comprises Amazonas State, with one adjacent locality in Bolívar State.

The Amazonas State is located in the south of Venezuela and has an area of 175,750 square kilometres. It lies in the basin of the Orinoco and Negro rivers, upstream from the convergence of the Orinoco and Meta rivers, on the frontier with Brazil and Colombia.

This region is characterised by high average temperatures, abundant and persistent rain, high relative humidity and an extraordinary variety of vegetation, especially of the forestal type. Maximum precipitation occurs in the south-west of the state, while the driest parts are in the south-east and north-west.

It has been estimated that 93 % of the region is covered by forest with two to four layers of vegetation, the lower levels consisting of shrubbery and the upper levels of big trees. The rest of the surface (7 %) comprises savannahs, rivers and rocky outcrops (Boada, 1983).

The samples were collected from 17 localities distributed in 11 areas characterised according to their vegetation, following Huber (1982). The annual mean rainfall and annual mean temperatures given are calculated from figures provided by the Direction of Hidrology and Meteorology at the Venezuelan Environment Ministry.

The areas are as follows (Fig. 1):

A - Rivers Temi and Atacavi, at the source of the Atabapo river (26.74°C, 100 metres above sea level).

B - Upper Orinoco, above the village of Ocamo (26.75°C, 150 m).

C - Cejal, between La Esmeralda and Tama-Tama (27.02°C, 100 m).

D - River Cunucunuma, between Tama-Tama and Culebra (27.02°C, 220 m).

E - Isla Ratón, an island in the Orinoco river south of Puerto Ayacucho (27.03°C, 100 m).

F - River Cataniapo, downstream (27.03°C, 100 m).

G - Rivers Cuao, Sipapo and Autana, downstream and river mouths (27.24°C, 100 m).

H - Upper Ventuari, the head of the river above Cacuri (27.68°C, 500 m).

I - Upper Cuao, midstream (no climatological station, so the figures for G are used).

J - River Parguaza, downstream in Bolívar State (27.03°C, 100 m).

K - The Topocho stream, close to Parhueña village (27.03°C, 100 m).

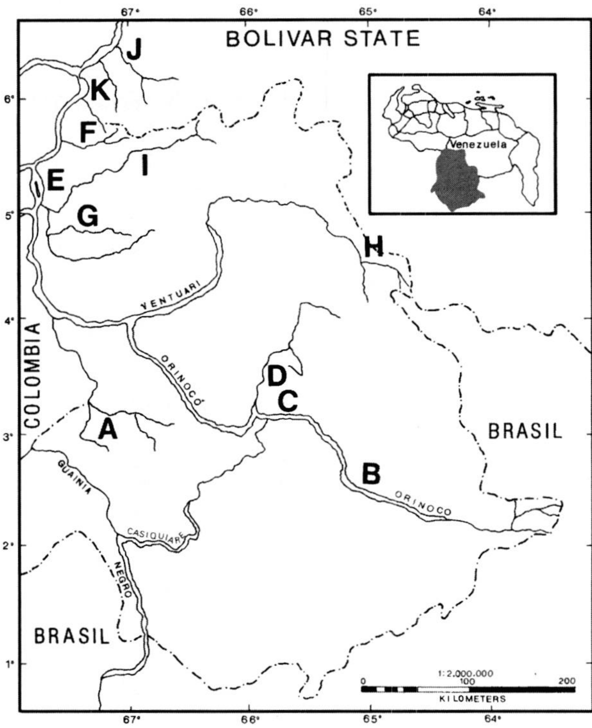

Fig. 1. – Regions where the study was carried out.
A) Temi-Atacavi rivers. B) Upper Orinoco. C) Cejal. D) Cunucunuma river. E) Isla Raton. F) Cataniapo river. G) Cuao, Sipapo, and Autana rivers. H) Upper Ventuari. I) Upper Cuao. J) Parguaza river. K) Topocho stream.

The localities and their environmental characteristics are presented in Table I. The human population studied comprised ethnic groups inhabiting the regions, principally Yanomamis (on the Upper Orinoco), Yekuanas (on the Upper Ventuari and River Cunucunuma), Curripacos, Banivas and Piapocos (on the Temi and Atacavi rivers), and Piaroas and Guajibos (on the Cuao, Sipapo, Autana, Cataniapo and Parguaza rivers and Isla Ratón).

PARASITOLOGICAL METHODS

A blood sample of 1.0 ml was taken from each person and processed by the Knott technique. The complete tube was then examined, using a ZEISS Standard microscope with 10× and 40× magnification. The cases that tested positively for microfilariae were then stained with Mayer's haematoxylin, following the technique described by Denham (1975), and their morphological

Localities	Region	Precipitation[1]	Vegetation
Río Temi-Río Atacavi	A	3,574	Transition amazonian Caatinga/Low lands Pluvial Forest
Alto Río Ocamo	B	2,607	Low lands Pluvial Forest
Mavaca-Río Orinoco	B	2,479	Low lands Pluvial Forest
Ocamo-Río Orinoco	B	2,607	Low lands Pluvial Forest
Platanal-Río Orinoco	B	2,479	Low lands Pluvial Forest
Río Mavaca	B	2,479	Low lands Pluvial Forest
Cejal-Río Orinoco	C	2,632	Low lands Pluvial Forest
Río Cunucunuma	D	3,128	Montainous and basimontainous Pluvial Forest
Isla Ratón	E	2,183	Savannah with Riverside Forest
Río Cataniapo	F	2,571	Rocky Semideciduous Forest alisio type
Río Autana	G	2,533	Low lands Pluvial Forest with bush
Río Cuao	G	2,533	Low lands Pluvial Forest with bush
Río Sipapo	G	2,533	Low lands Pluvial Forest with bush
Alto Río Ventuari	H	2,495	Semideciduous Forest alisio type
Alto Río Cuao	I	2,533	Montainous and basimontainous Pluvial Forest
Río Parguaza	J	2,737	Montainous and basimontainous Pluvial Forest
Caño Topocho	K	2,448	Rocky Semideciduous Forest alisio type

[1] Annual mean (in mm.).

Table I. – Environmental characteristic in the studied localities.

characters were examined for the purposes of taxonomic identification, using 40× and 100× objectives.

QUANTITATIVE METHODS

The quantitative terminology and criteria used are those defined by Kisielewska (1970) and modified by Guerrero (1979, 1996), as follows:

. Prevalence: percentage of infected hosts.

. Relative density: average number of parasites per infected host.

. Absolute density: average number of parasites per host (infected and uninfected).

. Multiple infection: percentage of hosts infected by more than one species of parasite.

. Infection index: a combination of prevalence and absolute density, permitting the determination of the degree of infection of the human groups and regions studied.

It is important to point out here that some authors favour the use of the geometric mean in order to determine parasitic load (density) instead of the arithmetic mean (Brandling-Bennett *et al.*, 1981; Marshall *et al.*, 1974; Sasa, 1976). However, the arithmetic mean, which is employed in the present work, remains a useful measure that provides valid information in the study of filariasis (Sasa, 1976), strictly following the criteria laid down by Kisielewska (*op. cit.*) and Guerrero (*op. cit.*).

STATISTICAL ANALYSIS

For the statistical analysis between the quantitative parameters (Prevalence, both densities and infection index) and rainfall and altitude, the product-moment correlation coefficient (Coefficient for Pearson's correlation) was calculated following the procedure described by Sokal & Rohlf (1969), with data processing carried out by the statistical programme Statgraphics Version 4.0 Co.

RESULTS

In the samples collected from 1,057 inhabitants of 17 localities, total prevalence was 18.54 %. 11.26 % were parasited by *Mansonella perstans*, 9.93 % by *Mansonella ozzardi* and 2.63 % by both species. The average of microfilaremia was 48.19 mf/mL of blood in *M. perstans* and 13.79 mf,mL in *M. ozzardi.*

M. ozzardi was found in 12 (70.6 %) of the 17 analysed localities, and *M. perstans* in eight (47.1 %). In five localities (29.41 %) both species were found, while two localities (the Cunucunuma and Mavaca rivers) were free of mansonelliasis. The prevalence was very high in some localities, especially Alto Ventuari (71.21) for *M. ozzardi* and the Temi and Atacavi rivers (88.16 %) for *M. perstans* (Table II).

The number of circulating microfilariae was low. Generally speaking, in localities where microfilarial density was high the prevalence rate was also high, resulting in an elevated infection index. However, no relation was found between the infection index and multiple infection.

The coefficient for Pearson's correlation shows statistically significant correlations between the quantitative parameters and total average rainfall in the localities studied in the case of *M. perstans*, and altitude in the case of *M. ozzardi.*

Major differences were found in the distribution of both species of *Mansonella* in relation to type of vegetation.

Localities	Number of cases	Prevalence %		Density (mf/mL) Absolute		Density (mf/mL) Relative		Infection index		Multiple infection
		M. o.[1]	*M. p.*[2]	*M. o.*	*M. p.*	*M. o.*	*M. p.*	*M. o.*	*M. p.*	
Río Temi-Río Atacavi	76	13.2	88.2	1.91	467.3	14.5	530.1	0.3	411.9	13.2
Alto Río Ocamo	38	7.9	0.0	7.0	0.0	88.0	0.0	0.6	0.0	0.0
Mavaca-Río Orinoco	82	18.3	0.0	2.4	0.0	12.9	0.0	0.4	0.0	0.0
Ocamo-Río Orinoco	35	5.7	0.0	4.2	0.0	73.5	0.0	0.2	0.0	0.0
Platanal-Río orinoco	47	14.9	0.0	2.3	0.0	15.1	0.0	0.3	0.0	0.0
Río Mavaca	66	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cejal-Río Orinoco	30	3.3	0.0	0.4	0.0	13.0	0.0	0.1	0.0	0.0
Río Cunucunuma	82	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Isla Raton	60	3.3	0.0	5.4	0.0	162.5	0.0	0.2	0.0	0.0
Río Cataniapo	119	2.52	17.7	0.7	39.6	29.3	224.4	0.1	7.0	2.5
Río Autana	8	12.5	12.5	4.3	1.0	34.0	8.0	0.5	0.1	12.5
Río Cuao	50	2.0	4.0	0.1	1.5	3.0	37.0	0.002	0.1	2.0
Río Sipapo	27	0.0	3.7	0.0	0.6	0.0	15.0	0.0	0.1	0.0
Alto Río Venturi	66	71.2	0.0	193.9	0.0	272.3	0.0	138.1	0.0	0.0
Alto Río Cuao	67	19.4	31.3	6.9	150.4	35.4	479.8	1.3	47.1	19.4
Río Parguaza	170	0.0	2.4	0.0	2.7	0.0	116.5	0.0	0.1	0.0
Caño Topocho	34	0.0	5.9	0.0	2.1	0.0	36.0	0.0	0.1	0.0

[1] *Mansonella ozzardi.*
[2] *Mansonella perstans.*

Table II. – Quantitative results in the studied localities.

Criteria	Precipitation	Altitude
Prevalence *M. ozzardi*	– 0.6930 (0.792)	0.897 (0.000)*
Prevalence *M. perstans*	0.7233 (0.001)*	– 0.140 (0.591)
Absolute density *M. ozzardi*	– 0.1169 (0.655)	0.923 (0.000)*
Absolute density *M. perstans*	0.7518 (0.001)*	– 0.093 (0.723)
Relative density *M. ozzardi*	– 0.2953 (0.250)	0.717 (0.001)*
Relative density *M. perstans*	0.5479 (0.023)	– 0.082 (0.754)
Infection index *M. ozzardi*	– 0.1064 (0.685)	0.921 (0.000)*
Infection index *M. perstans*	0.7916 (0.000)*	– 0.113 (0.666)

* Correlation (P = 0.001).

Table III. – Pearson's correlation coefficients between quantitative criteria and environmental variables.

M. ozzardi evidences a higher infection index in those regions which have Alisio-type semi-deciduous forest, while *M. perstans* is higher in Amazonian caatinga transition in pluvial lowland forest.

DISCUSSION

The results of this study confirm that mansonelliases is widespread in Amazonas State and the neighbouring areas of Bolívar State, in the south of Venezuela.

The main focuses are in the regions of the Temi and Atacavi rivers with an infection index (i.i.) of 413.52, and in Upper Venturi (i.i. = 138.09).

The former undoubtedly represents an extension of the focus described by Formica & Botto (1990) in Venezuela and Kozek *et al.* (1982a) in Colombia, a focus in which *M. perstans* must be endemic. Apart from the dominance of *M. perstans*, this focus is characterised by high prevalence and an elevated percentage of inhabitants parasited by both species of Mansonella.

The Upper Venturi focus is probably an extension of the one described by Godoy *et al.* (1980) in the south-west of Bolívar State, and is due to *M. ozzardi*.

Lesser infestations occur in the regions of the Upper Cuao (i.i. = 49.33) and River Cataniapo (i.i. = 7.12). Both of these regions were reported as focuses of mansonelliasis by Baumgartner (1955). The remaining localities studied had infection indexes of less than one (1.0).

M. ozzardi was spread over a wider area than *M. perstans*, the latter being distributed in the north-west of Amazonas State, from the Temi and Atacavi rivers to north of Puerto Ayacucho, on the Cuao, Sipapo and Autana rivers, and in neighbouring localities in Bolívar State.

M. ozzardi is found to the east and south-east of the Temi and Atacavi rivers as far as the Upper Orinoco, and in the regions near to the mouth of the Casiquiare river, where mansonelliasis has previously been reported (Beaver *et al.*, 1976).

Overlapping of both species, and consequently multiple infection, occurs in the regions of the Temi, Atacavi, Autana, Cuao and Cataniapo rivers.

Vegetation types	*M. ozzardi* Prevalence	A. den.[1]	Inf. Ind.[2]	*M. perstans* Prevalence	A. den.	Inf. ind.
Transition amazonian Caatinga/Low lands Pluvial Forest	13.16	1.91	0.25	88.16	467.29	411.29
Low lands Pluvial Forest	9.40	2.43	0.23	0.00	0.00	0.00
Low lands Pluvial Forest with bush	2.35	0.44	0.01	4.71	1.14	0.05
Mountainous and basimountainous Pluvial Forest	4.08	1.44	0.06	7.84	33.04	2.59
Rocky semideciduous Forest alisio type	1.96	0.58	0.01	15.03	31.27	4.70
Savannah with Riverside Forest	3.33	5.42	0.18	0.00	0.00	0.00
Semideciduous Forest alisio type	71.21	193.91	138.08	0.00	0.00	0.00

[1] Absolute density.
[2] Infection Index.

Table IV. – Values of qualitative criteria of *Mansonella* spp. according with the types of vegetation.

The quantitative criteria of prevalence, absolute density and infection index calculated for *M. perstans* evidenced a high correlation to precipitation in each locality, rainfall being the most influential environmental variable for the transmission of this species. This is probably due to the conditions required by the vector: in relative humidity or continuous rain, seasonal effects are eliminated, which produces a more efficient, ongoing transmission of the filaria.

In the case of *M. ozzardi* the correlation is with altitude: in other words, the most effective vectors for transmitting this species are found in localities in higher regions.

With respect to types of vegetation, transmission of *M. perstans* is most favoured by Amazonian caatinga transition in lowland pluvial forest, while *M. ozzardi* is favoured by alisio-type semi-deciduous forest.

These results confirm that the two species of *Mansonella* require different environmental conditions for their transmission, and probably have different vectors in natural conditions.

Laboratory studies reveal that *Culicoides* spp. and *Simulium* spp. can act as vectors for *M. ozzardi* (Tidwell & Tidwell, 1982). In natural conditions it is likely that *Simulium* is the vector for *M. ozzardi* and *Culicoides* for *M. perstans*. It is supported by field observations, in localities with dominance of *M. ozzardi*, species of *Simulium* were abundant and in localities with dominance of *M. perstans*, *Culicoides* ever were present. Larvae and pupae of Simulidae need fast runing waters (Wygodzinsky & Coscarón, 1989) as usually are in localities in higher regions were *M. ozzardi* is dominant.

In conclusion, mansonelliases is widespread in Amazonas State, the main focuses in the localities studied being situated on the Temi and Atacavi rivers and the Upper Ventuari, with *M. ozzardi* having a wider distribution than *M. perstans*. The latter species evidences a greater transmission rate in areas of higher rainfall, while the transmission of *M. ozzardi* is favoured by higher altitude. The two species also evidence different transmission rates with respect to the types of vegetation studied, probably because the respective types of vegetation favour the development of the corresponding vectors for these filariae.

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