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Study of Mansonellosis and Oropouche Fever: Vectors, Life Cycle, Transmission, Pathogenesis, and Diagnosis

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Abstract: Culicoides bites cause discomfort to humans due to an allergic reaction resulting from the proteins in their salivary glands, but they also cause great pain, especially when present in large numbers. They can cause reactions such as allergic dermatitis, papules, and pustules, and even more serious reactions such as eczema, scaling, and scarring with abnormal pigmentation of the human skin, in addition to being vectors of diseases. The objective of this manuscript is to describe mansonellosis and Oropouche fever, as well as their vector, life cycle, transmission, pathogenesis, and diagnosis. Data were collected using a quantitative and descriptive approach, through books and the following databases: SciVerse Scopus, Scientific Electronic Library Online (SciELO), and the Academic Search Tool (Scholar Google). The search was developed using the subject descriptor mosquito, diseases, hosts, transmission, diagnosis, and treatment mentioned in journals, through a review of the literature on the subject. In the initial search, the titles and abstracts of the articles were considered for the broad selection of works of probable interest, with the abstracts being highlighted. The time frame used was between 1972 and 2024, with a preference for searches of recent publications, and those that did not meet the established criteria were excluded.

Keywords: Ceratopogonidae, *Mansonella*, Maruins, Nematoda, Virus.

Research Paper

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1.0. INTRODUCTION

The family Ceratopogonidae is composed popularly known as maruins, mangrove mosquitoes, and gunpowder mosquitoes. By practicing hematophagy, maruins can function as vectors for several species of parasites. Adult individuals of both sexes may visit flowers for sugary substances, but females usually seek a diet rich in animal protein to mature their eggs (Figure 1) (Wirth and Blanton, 1973: Trindade and Gorayeb, 2018).

The life cycle of maruins includes an egg, four larval stages, a pupa, and an adult. This life cycle can last from three weeks in tropical climates to one year in temperate climates. Adult females require a blood meal to mature their ovarian follicles (Figure 2) (Mellor *et al.*, 2000; Borkent and Spinelli, 2007; Carvalho, 2016).

They are also incriminated in the transmission of several arboviruses, including the Akabane virus, an arthropod-borne viral disease affecting cattle, sheep, and goats. African horse sickness virus, Bluetongue virus (a viral disease of ruminants transmitted by mosquitoes of the genus *Culicoides* Latreille, 1809), and Schmallenberg virus affect susceptible wild and domestic ruminants (Hardy *et al.*, 1983; Mellor *et al.*, 2000; Antoniassi, 2010; Ramos *et al.*, 2010; Mota *et al.*, 2011; Kampen and Werner, 2023).

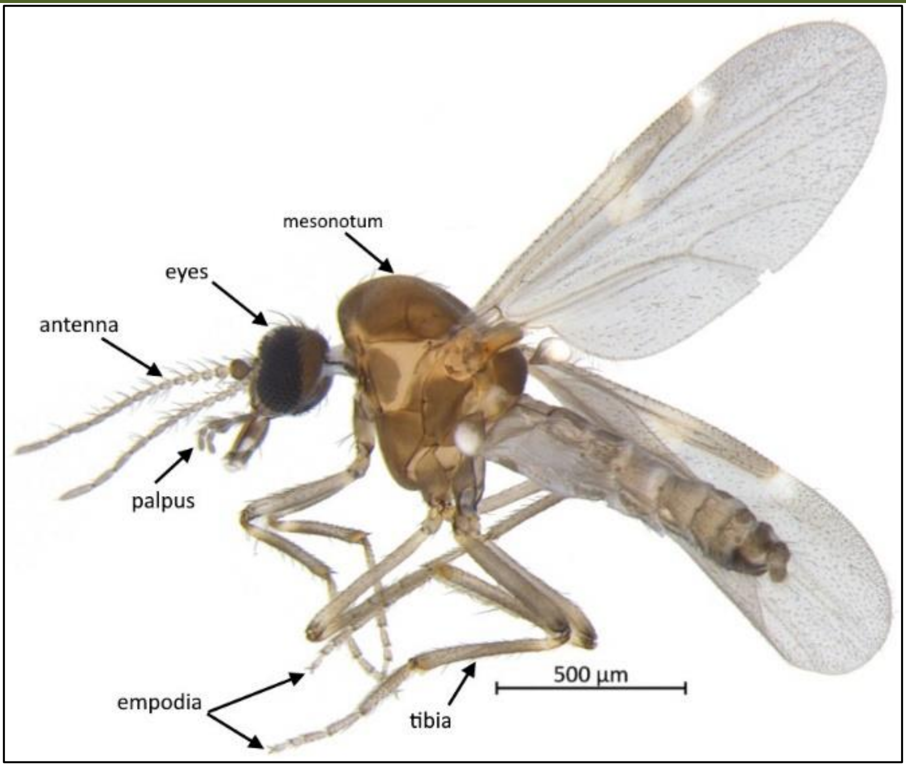

Figure 1: Lateral view of *Culicoides biguttatus* (Coquillett, 1901): Vector female showing important external diagnostic characteristics
Source: Doi:10.3752/cjai.2023.50

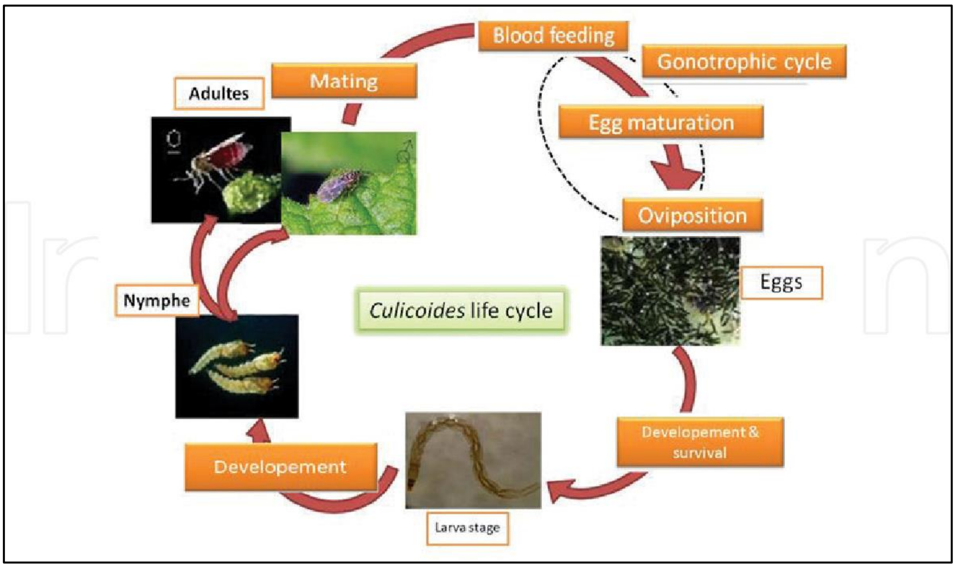

Figure 2: Life cycle of *Culicoides* Latreille, 1809, vectors
Source: https://api.semanticscholar.org/CorpusID:59406897

1.2. Objective

The objective of this manuscript is to describe mansonellosis and Oropouche fever, as well as their vector, life cycle, transmission, pathogenesis, and diagnosis.

2. METHOD

Data were collected using a quantitative and descriptive approach, through books and the following databases: SciVerse Scopus, Scientific Electronic Library Online (SciELO), and the Academic Search Tool (Scholar Google). The search was developed using the subject descriptor mosquito, diseases, filariae, hosts, transmission, diagnosis, and treatment mentioned in journals, through a review of the literature on the subject. In the initial search, the titles and abstracts of the articles were considered for the broad selection of works of probable interest, with the abstracts being highlighted.

The time frame used was between 1972 and 2024, with a preference for searches of recent publications, and those that did not meet the established criteria were excluded.

3. SELECTED STUDY

In humans, their bite can cause hives, and red welts that can persist for more than a week. To bite, the mosquito penetrates the hair and clothing. The discomfort arises from a localized allergic reaction to the proteins in their saliva, which topical antihistamines can relieve. *Culicoides* bites cause great pain, especially when present in large numbers. They can cause reactions such as allergic dermatitis, papules, and pustules and even more serious reactions such as eczema, scaling, and scars with abnormal pigmentation of the skin of humans (Figure 3) (Hendry, 2003; Ronderos *et al.*, 2003; Borkent, 2005; Borkent and Spinelli, 2007; Carvalho, 2016; Trindade and Gorayeb, 2018).

Figure 3: The bite of sand flies of the genus *Culicoides* Latreille, 1809 causes an allergic response in humans known as itchy dermatitis, papules, and pustules and even more serious reactions such as eczema, scaling, and scars with abnormal pigmentation

Source: https://www.youtube.com/watch?v=hElBDODzOr0

3.1. Virus Oropouche (OROV)

Among viruses, Oropouche (OROV) is the most important etiological agent transmitted by *Culicoides paraensis* (Goeldi, 1905) to humans. Although not fatal, this is a debilitating disease. In the Amazon, numerous epidemics of this febrile disease have been recorded in urban outbreaks in the states of Amapá, Amazonas, Maranhão, Pará, Rondônia and Tocantins. In these outbreaks, many people were infected, reaching 96,000 people infected during 1980-1981 in the municipality of Manaus alone. There are also records in northern Argentina and other regions in South America and the Caribbean. In animals, there is the transmission of the equine encephalitis virus isolated from martens in South America (Figure 4) (Pinheiro *et al.*, 1981; Linley *et al.*, 1983; Gorch *et al.*, 2002; Ferreira-Keppler *et al.*, 2016; Biernath, 2024).

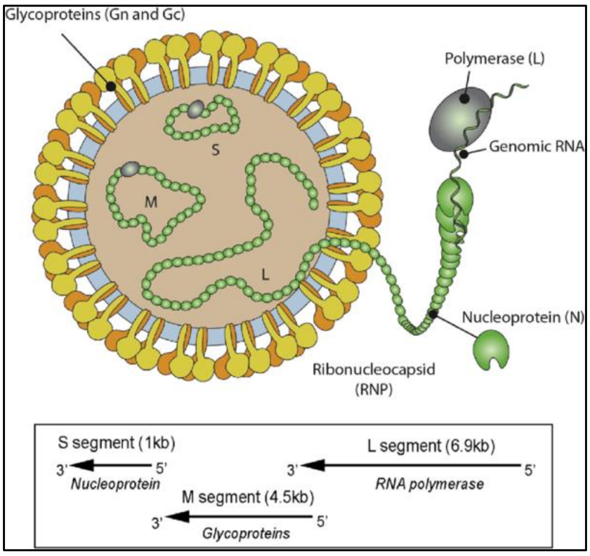

Figure 4: Evidence suggests that all the members of Orthobunyavirus share similar structural characteristics: average virion size (80e120 nm) and average genome size for the three fragmented RNA segments. Arrows in the inset box represent the reading frame 3 0 e5 0 for each RNA segment; the corresponding encoded proteins are in italics

Source: Image credit: Philip Le Mercier. Modified from Viral Zone (www.expasy.ch/viralzone), Swiss Institute of Bioinformatics

The Ministry of Health reports that oropouche fever "is a disease caused by an arbovirus virus transmitted by arthropods of the, of the Bunyavirales order, Peribunyaviridae family", *Orthobunyavirus* genus, The virus in question is known among scientists as especie *Orthobunyavirus oropoucheense* (OROV). An article published by scientists at the University of Kansas, in the USA, explains that the Peribunyaviridae family is among the largest in virology at least 30 infectious agents belonging to this group have already been described. The study also points out that at least five viruses from this family have already been detected in Brazil. OROV is one of them (Pinheiro *et al.,* 1981; Linley *et al.,* 1983; Gorch *et al.,* 2002; Bowden *et al.,* 2013; Ferreira-Keppler *et al.,* 2016; Biernath, 2024).

The virus is transmitted by the bite of mosquitoes, of the *C. paraensis*, species, which is popularly known as the maruim or gunpowder mosquito. Another transmitter of the infectious agent in urban environments is *Culex quinquefasciatus* Say, 1823 (Diptera: Culicidae) commonly called the midge or muriçoca. A study by the Department of Medicine at the University of Texas in the United States highlights that *C. paraensis* is widespread throughout the Americas. It has been identified from the northern United States, on the border with Canada, to the south of Argentina and Chile. *Culicoides paraensis* is found in humid forest areas and near water reservoirs (Figure 5) (Pinheiro *et al.*, 1981; Linley *et al.*, 1983; Gorch *et al.*, 2002; Elliott, 2014; Ferreira-Keppler *et al.,* 2016; Travassos *et al*., 2017; Biernath, 2024).

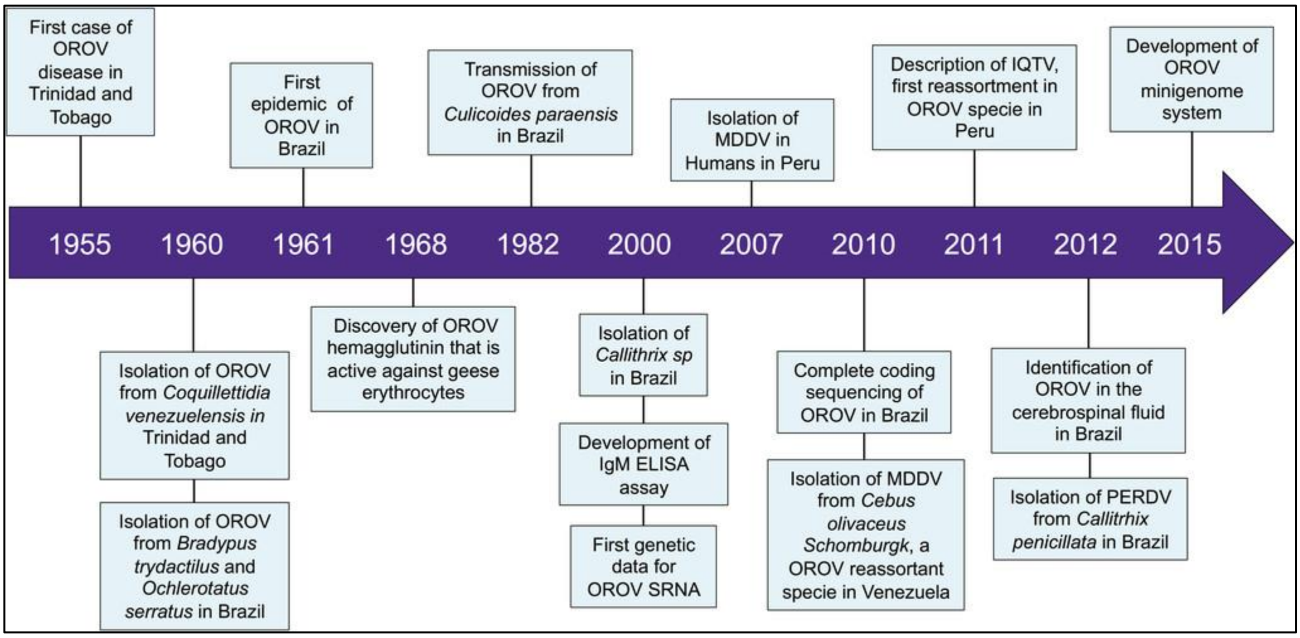

Figure 5: Timeline of advances in Oropouche virus research
Source: The American Society of Tropical Medicine and Hygiene 96, 5; 10.4269/ajtmh.16-0672

The World Health Organization (WHO) points out that, in transmission cycles observed in nature, the virus that causes oropouche fever has also been detected in non-human primates such as capuchin monkeys and sloths. Scientists also suspect that it may affect some birds. In urban epidemic cycles involving humans, no cases of direct transmission from one person to another have yet been observed. However, a report published by the Ministry of Health assesses the possibility and risks of vertical transmission, from a pregnant woman to the baby developing in the womb (Borkent, 2005; Borkent, 2014; Ferreira-Keppler *et al.*, 2014; Eynde *et al.,* 2021).

Published evidence indicates that the incubation period the time between the virus entering the body and the appearance of the first symptoms varies between four and eight days. From then on, the signs of the disease are remarkably similar to those of other arboviruses, such as dengue (Pinheiro *et al.,* 1981; Linley *et al.,* 1983; Gorch *et al.*, 2002; Ferreira-Keppler *et al.*, 2016; Biernath, 2024).

The WHO points out that the main symptoms of oropouche fever are: Sudden onset of high fever; headache; pain behind the eyes; stiffness or pain in the joints; chills; nausea; and vomiting. these discomforts last for a period of five to seven days (Gorch *et al.*, 2002; Ferreira-Keppler *et al.*, 2016; Biernath, 2024).

The scientific studies published so far on oropouche fever have mentioned the possibility of some more serious complications. The main ones would be encephalitis and meningitis, inflammation of the brain or the membranes that cover the nervous system, respectively. However, the two deaths announced by the Ministry of Health are unprecedented. "Until now, there had been no report in the world's scientific literature on the occurrence of death from the disease," the ministry confirmed in a statement (Pinheiro *et al.*, 1981; Linley *et al.*, 1983; Gorch *et al.*, 2002; Ferreira-Keppler *et al.*, 2016; Biernath, 2024).

To date, there is no specific medicine to treat oropouche fever. An article published by experts from India, Nepal, Brazil, and Peru in the academic journal The Lancet Microbe classifies oropouche fever outbreaks as "a growing concern" and warns of the lack of research into new treatments for the disease. The Ministry of Health says that "patients should remain at rest, with symptomatic treatment and medical monitoring". This means that a health professional can prescribe some specific medications to alleviate symptoms, such as fever, pain, and nausea. It is also important for infected people to use repellents to prevent being bitten again by the transmitting mosquitoes, which can pass the virus on to other individuals (Figure 5) (Linley *et al.*, 1983; Ferreira-Keppler *et al.*, 2016).

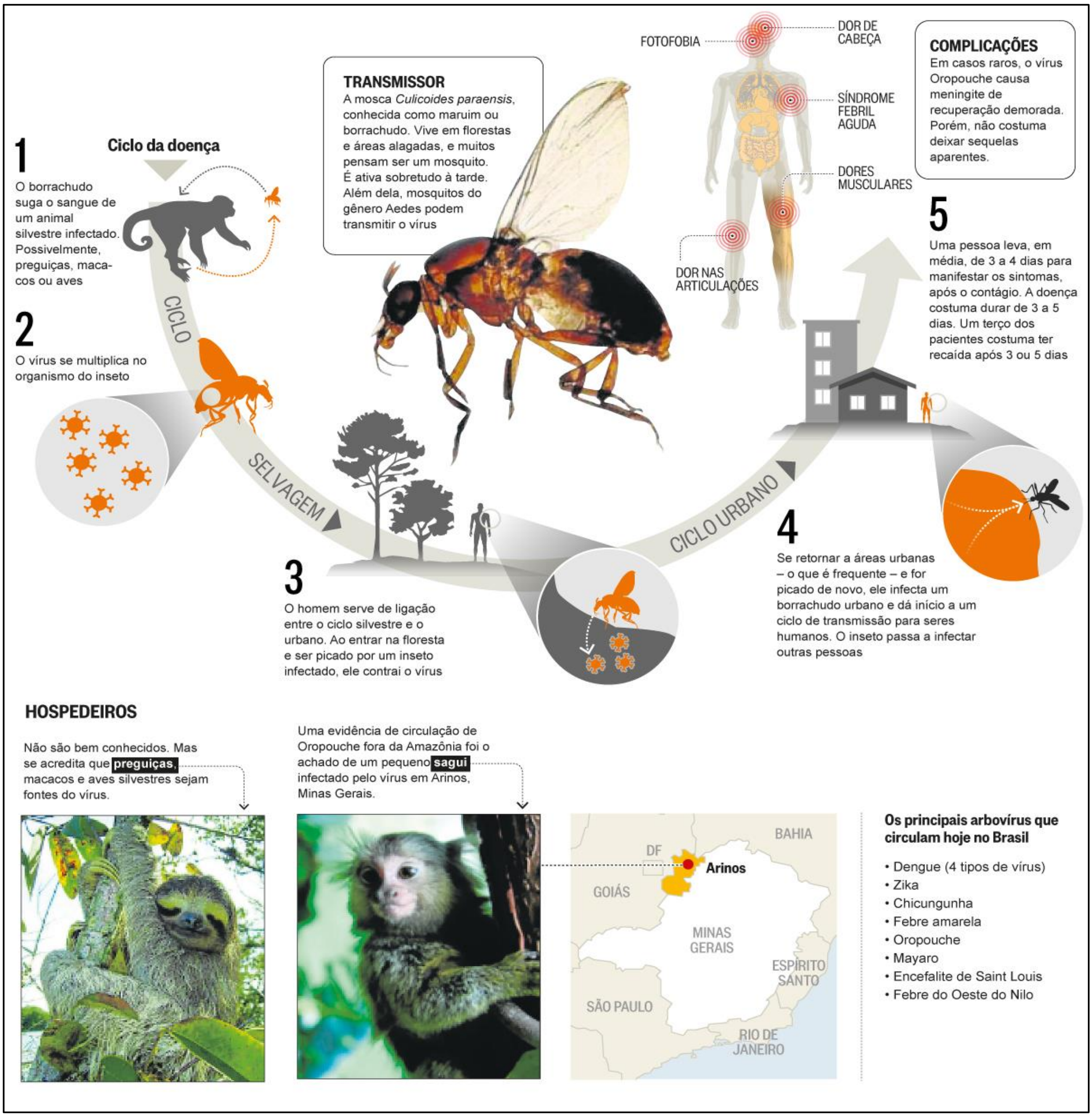

Figure 5: The virus that causes Oropouche fever is transmitted to humans by the bite of *Culicoides* Latreille, 1809, mosquitoes, the species *Culicoides paraensis* (Goeldi, 1905). Direct transmission from one person to another has not been documented. Symptoms are similar to those of dengue fever (sudden onset of high fever, headache, myalgia, arthralgia, and vomiting), and the incubation period is 4 to 8 days (3–12)

Source: https://www.saudedoviajante.pr.gov.br/Noticia/Casos-de-Virus-Oropouche

There are no vaccines available to prevent OROV infection. The same study published in. The Lancet Microbe points out that, to date, there has only been one study on immunizations against oropouche fever. However, this work is at a very preliminary stage, with initial tests on laboratory animals. Health authorities suggest some basic measures to reduce the risk of contracting the infection: Avoid areas where there are many mosquitoes, especially mosquitoes; Install fine-mesh screens on doors and windows; Wear clothes that cover most of the body to prevent mosquito bites; Apply repellent to areas of skin that remain exposed; Keep the house clean, especially outdoor areas with plants or animals organic material, such as leaves and fruits that fall to the ground, can attract mosquitoes (Pinheiro *et al.*, 1981; Linley *et al.,* 1983; Gorch *et al.,* 2002; Ferreira-Keppler *et al.,* 2016; Biernath, 2024).

Some cases may present with signs and symptoms of aseptic meningitis. Given its clinical presentation, Oropouche fever should be included in the differential diagnosis of other common and recently emerging and reemerging diseases such as dengue, Chikungunya fever, yellow fever, and Zika virus disease. Most of these infections, at least during the initial phase, produce fevers that are indistinguishable from one another (Secretary of Health of Paraná, 2017).

Oropouche virus (OROV), an arbovirus first described in 1955 in Vega of Oropouche, Trinidad Tobago, has been responsible for half a million cases in Brazil since its discovery and has recently been epidemiologically active in Peru. However, its similarity to other arboviruses makes its true incidence unknown. Given the wide geographic distribution of the vector, there is a considerable risk of OROV being introduced into countries with ecological characteristics suitable for transmission, such as Venezuela. In these countries, it is recommended that the situation and epidemiological risk be assessed to avoid, in the short or medium term, the emergence of a major public health problem, as occurred with the emergence of Chikungunya in 2014 and Zika in 2016 (Secretary of Health of Paraná, 2017).

3.2. *Mansonella ozzardi* (Manson, 1897)

Mansonella ozzardi is found only in the Americas, with a focus from Mexico to Argentina. In South America, it occurs in Colombia, Venezuela, Guyana, Suriname, Peru, Bolivia, Brazil, and northern Argentina. In Central America, it is found in Panama, Guatemala and some Caribbean islands. In Brazil, the foci are on Amazonas, Roraima, and Mato Grosso (Costa, 2011; Velasques, 2013; Neves *et al.,* 2022; Charro, 2024a).

Phylum Nematoda, Class Secernentea, Order Spirurida, Superfamily Filarioidea, and Famíly Onchocercidae is an autochthonous human filariasis that causes mansonellosis. Microfilariae are characterized by the absence of a sheath, the first somatic nuclei typically arranged in a single row (at least in thick blood smears, the first two form a typical pair, one behind the other), and in stained preparations, the somatic nuclei stain densely; a thin, not very long tail, ending in a hook or sickle shape; caudal nuclei reduced to a row of 7 to 9 elements; the tip of the tail devoid of nuclei (Figure 6) (Costa, 2011; Velasques, 2013; Neves *et al.,* 2022; Charro, 2024b).

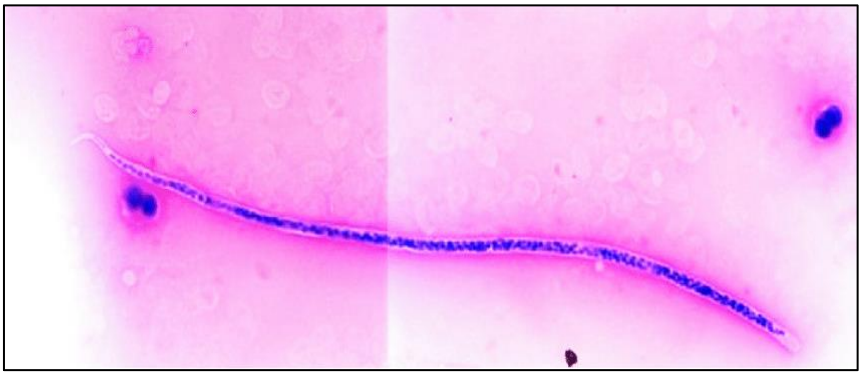

Figure 6: Microfilaria of Nematode *Mansonella ozzardi* (Manson, 1897), microfilarial stage (L3) microfilaria seen in a Giemsa stained blood smear of patient case 1 prepared with the Knott's technique

Source: https://www.researchgate.net/figure/Mansonella-ozzardi-microfilaria-seen-in-a-Giemsa-stained-blood-smear-of-patient-case-1_fig7_51049435

Males are seventeen (17) times the size of females (24 to 28 by 0.07 mm), with a reproductive system in a simple tube and testicles located in the esophageal region. They have two spicules, the left one being larger than the right one, eleven pericloacal papillae, and two other pairs that are more prominent near the posterior end, which is curved anteriorly. Adult worms are found in the mesentery and serous membranes of the human abdominal cavity. Microfilariae are found in peripheral blood and are not found periodically. They can also be found in capillaries in the subcutaneous tissue

(Figure 7) (Costa, 2011; Velasques, 2013; Neves *et al.*, 2022; Charro, 2024a).

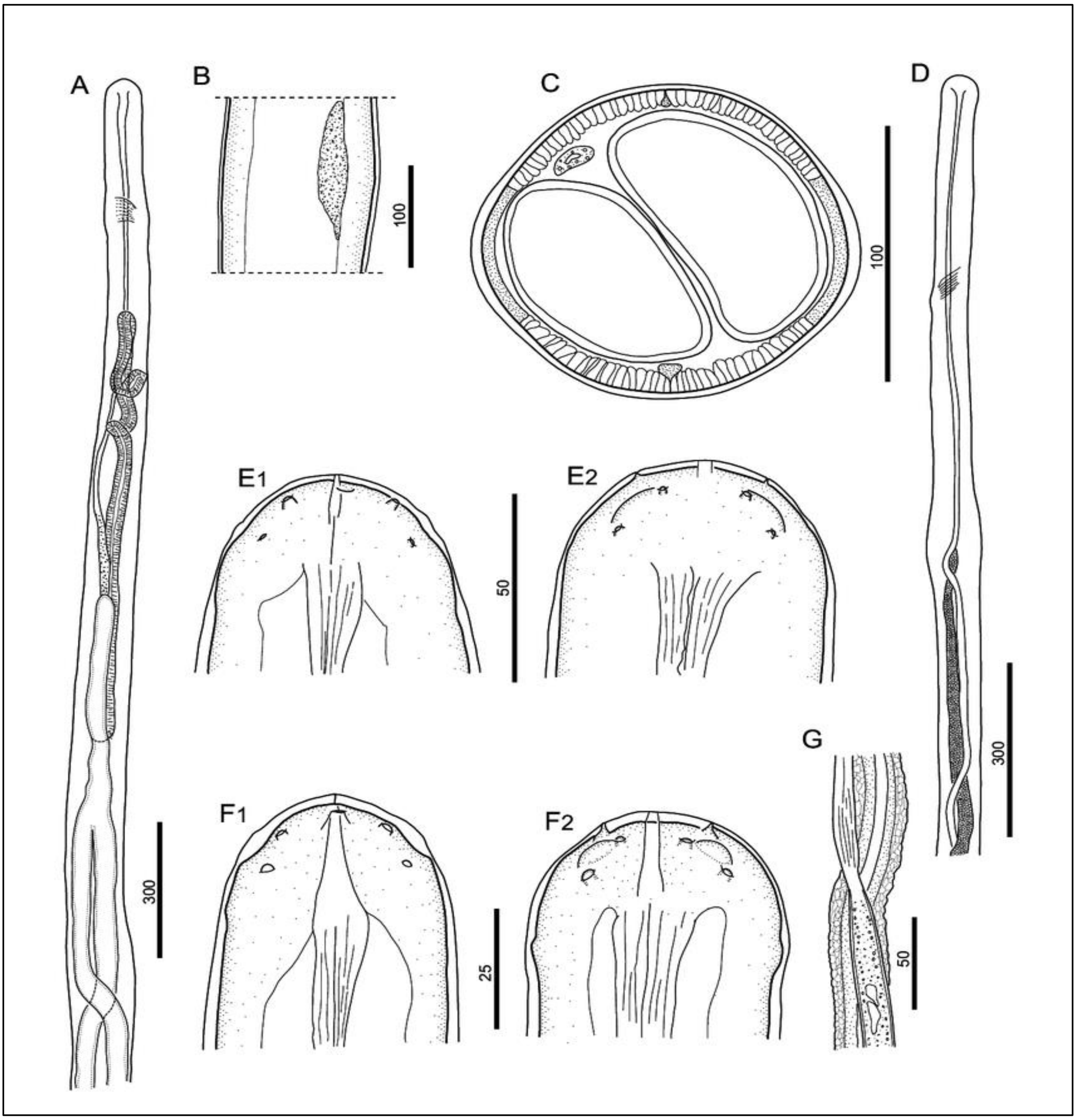

Figure 7: *Mansonella ozzardi* (Manson, 1897). A. Female anterior end, lateral view; B. Body swelling containing giant coelomocyte, lateral view; C. Transverse section of body, female; D. Male anterior end with esophagus and apex of testis; E. Female cephalic region, lateral (E1) and dorsoventral (E2) view; F. Male cephalic region, lateral (F1) and dorsoventral (F2) view; G. Ovejector and oesphago-intestinal junction

Source: https://www.researchgate.net/figure/Mansonella-Mansonella-ozzardi-A-Female-anterior-end-lateral-view-B-Body-swelling_fig1_273444924

During a blood meal (hematophagy), an infected mosquito introduces infective larvae (L3) into the human skin through the bite opening. They become adult worms that remain in the subcutaneous tissue. These adult worms produce microfilariae that reach the bloodstream and, when they feed on a new mosquito, are ingested by the mosquito along with the blood, reaching the stomach from where they migrate through the hemocoel to the mosquito's thoracic muscles. In the mosquito's thoracic muscles, they transform into first-stage larvae (L1), second-stage larvae (L2), and infective larvae (L3), which can infect a new individual during a new blood meal (Figure 8) (Costa, 2011; Velasques, 2013; Lima *et al.*, 2016; Neves *et al.*, 2022; Charro, 2024b).

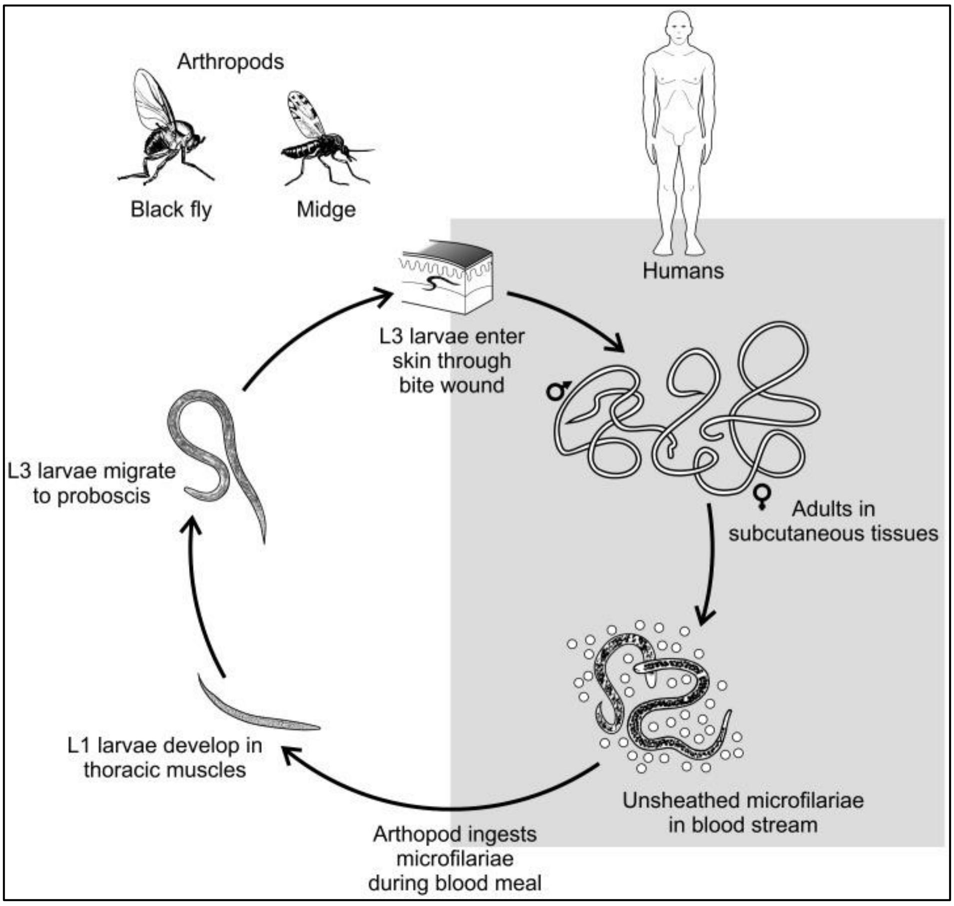

Figure 8: Schematic representation of the life cycle of *Mansonella ozzardi* ((Manson, 1897)
Source: Modified from Centers for Disease Control and Prevention. DPDx – Laboratory Identification of Parasitic Diseases of Public Health Concern. Mansonellosis. 2013. Available at: http://www.cdc.gov/dpdx/mansonellosis/index.html.

The pathogenicity of *M. ozzardi* is asymptomatic in most infected people, but even so, these symptoms are not well defined. However, this parasite can cause symptoms such as fever, dizziness, headache, coldness in the legs, joint pain, inguinocrural adenitis, paresthesia, tingling, erythematous pruritic plaques, and edema of the lower limbs. The patient may present blood eosinophilia and the signs and symptoms are more evident in adults with high parasitemia (Costa, 2011; Velasques, 2013; Neves *et al.*, 2022; Charro, 2024b).

The clinical manifestations of the disease are caused by the accumulation of microfilariae in the peripheral blood vessels of humans and, in individuals with high microfilaremia, there are a variety of symptoms such as headache, moderate fever, joint pain, adenitis accompanied by dizziness and a feeling of cold in the legs; these symptoms can be confused with symptoms of malaria. The symptoms come from local irritation caused by the filariae and/or from toxic and allergic reactions resulting from vascular sensitization, as occurs in other filariasis. Eye lesions have also been found to be associated with this parasitic infection (Costa, 2011; Velasques, 2013; Neves *et al.*, 2022; Charro, 2024a).

Corneal lesions causing opacity suggest a relationship with the presence of *M. ozzardi* microfilariae in the blood. found microfilariae in the cornea of infected individuals and lesions associated with their presence. Studies have also shown microfilariae found in the dermis and collected in skin biopsies in microfilaremic patients. There are also records of papules on the hands and forearms of patients, the most exposed regions and most affected by bites from piuns, incriminated as vectors of this filaria in Brazil (Costa, 2011; Velasques, 2013; Sundu *et al.*, 2015; Neves *et al.*, 2022; Charro, 2024a; Charro, 2024b). The diagnosis of *M. ozzardi* is confirmed by the identification of microfilariae in blood or skin samples. Blood can be collected at any time. Eosinophilia is common. Serologic tests may also be useful in identifying infection but are not specific (Marie and Petri, 2022).

Treatment is with ivermectin (200 mcg/kg orally, in a single dose). Before treatment with ivermectin, patients should be assessed for co-infection with Loa loa, another filarial parasite, if they have been in regions of Central Africa where both parasites are transmitted because ivermectin can cause severe reactions in patients co-infected with severe Loa loa infections. Endosymbiotic *Wolbachia* is present in *M. ozzardi*, but the efficacy of doxycycline in treatment has not been evaluated (Marie and Petri, 2022).

3.3. Life cycle of *Mansonella perstans* (Manson, 1891) and *Mansonella streptocerca* (Macfie & Corson, 1922).

Life cycle during a blood meal, an infected midge introduces third-stage filarial larvae onto the skin of the human host, where they penetrate the bite wound (1). They develop into adults that reside in the dermis, (2). Which reside in the skin but can also reach the peripheral blood (3). The midge vector ingests the microfilariae during a blood meal (4). After ingestion, the microfilariae migrate from the midge's midgut through the hemocoel to the thoracic muscles (5). There the microfilariae develop into first-stage larvae (6) and subsequently into third-stage larvae (7). The third-stage larvae migrate to the midge's proboscis (8) (Figures 9 and 10) (Marie and Petri, 2022; Charro, 2024a; Charro, 2024b).

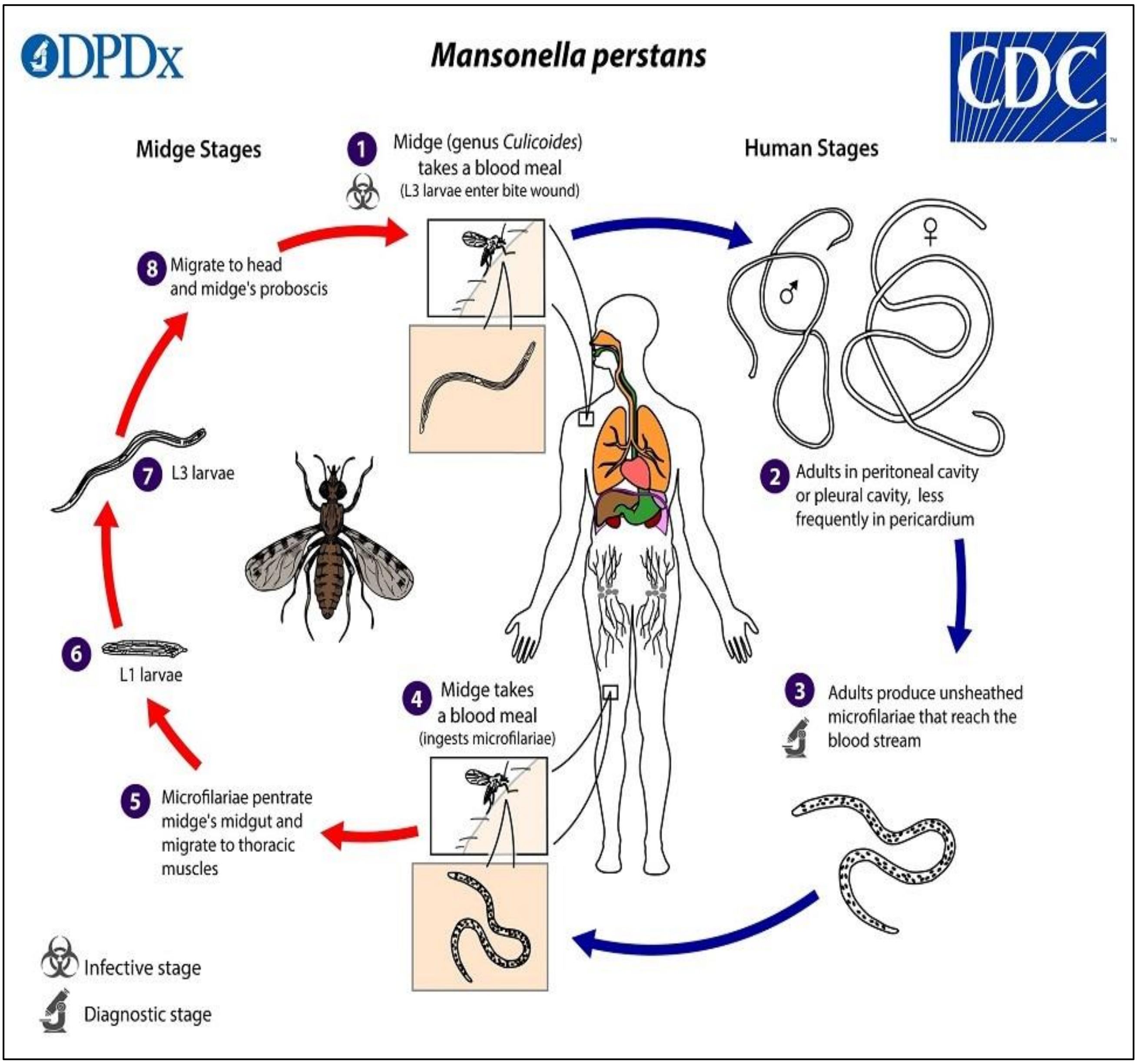

Figure 9: *Mansonella perstans* (Manson, 1891)
Source: https://www.cdc.gov/dpdx/mansonellosis/index.html

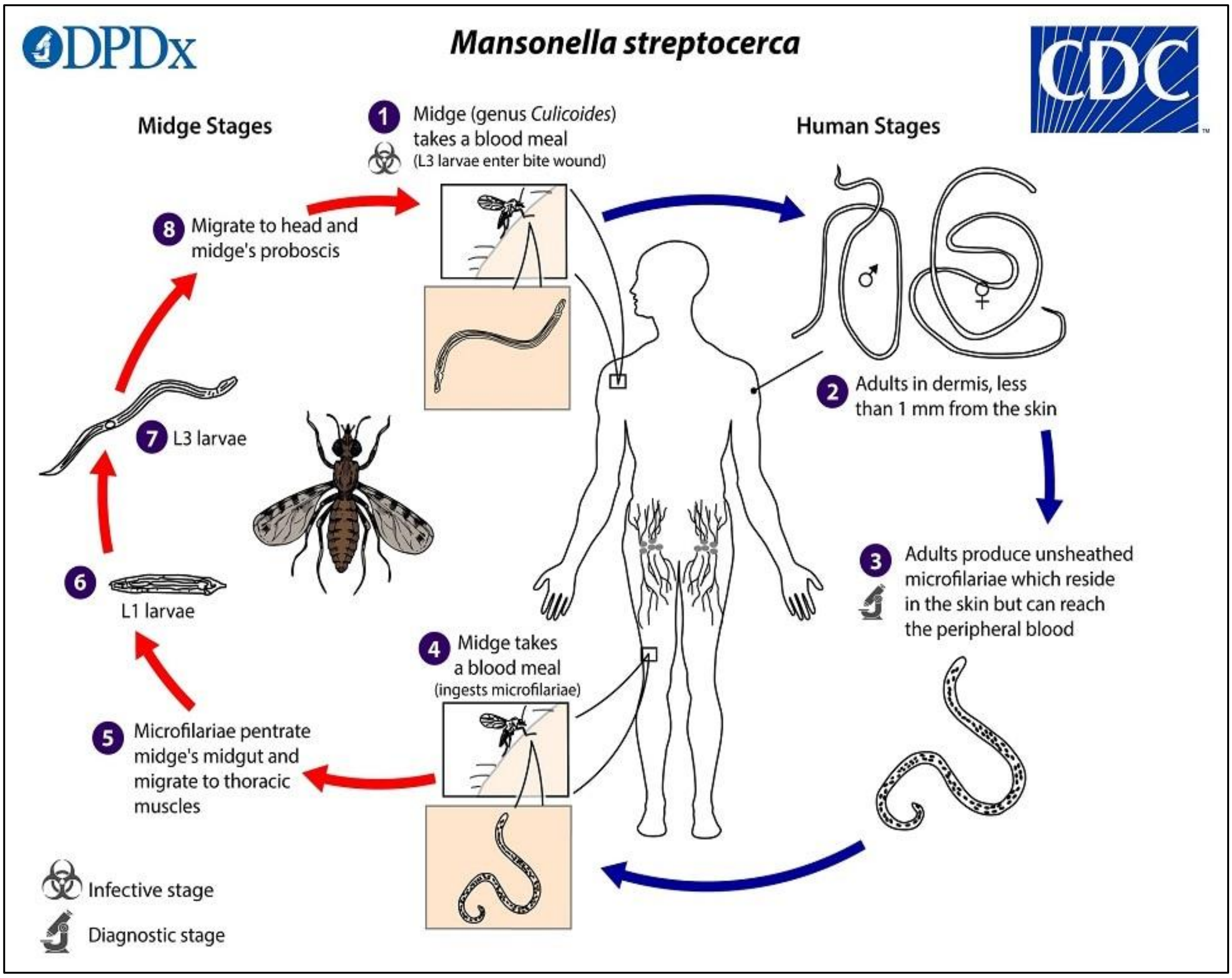

Figure 10: *Mansonella streptocerca* (Macfie & Corson, 1922)
Source: https://www.cdc.gov/dpdx/mansonellosis/index.html

3.4. *Mansonella perstans* (Manson, 1891)

Mansonella perstans is transmitted by mosquito bites *Culicoides* in sub-Saharan Africa and the Americas, from Panama to Argentina. It is estimated that more than 100 million people are infected worldwide. Adult worms reside in the pleural, pericardial, and peritoneal cavities, as well as in the retroperitoneum and mesentery. Unsheathed microfilariae are found in the bloodstream. Mosquitoes acquire them when they suck the blood of an infected human (Marie and Petri, 2022; Charro, 2024a; Charro, 2024b).

Mansonellosis is caused by the filaria *M. perstans*. Adults live in the mesentery and peritoneal cavity of humans and some species of monkeys. Females are 8 cm long and males are approximately 4 cm long. Microfilariae are found in peripheral blood and measure approximately 200 µm, without a covering sheath. Mansonellosis is caused by the filaria *M. perstans*, formerly known as filariasis. Adults live in the mesentery and peritoneal cavity of humans and some species of monkeys. Females are 8 cm long and males are approximately 4 cm long. Microfilariae are found in peripheral blood and measure approximately 200 µm, without a covering sheath (Marie and Petri, 2022; Charro, 2024a; Charro, 2024b).

Most infections are asymptomatic or mild. Migrating adult worms may cause transient subcutaneous edemas similar to Loa loa (Calabar edema), inflammation of the pericardium or pleura, conjunctival nodules, retinal damage, and periocular inflammation. Nonspecific symptoms include pruritus, urticaria, arthralgias, and malaise. Neuropsychiatric manifestations, meningoencephalitis, and hepatitis have been attributed to *M. perstans* on rare occasions (Figure 11) (Marie and Petri, 2022; Charro, 2024a).

Figure 11: Microfilaria of *Mansonella perstans* (Manson, 1891) nematode in peripheral blood mononuclear cells from Buruli ulcer patient in Ghana. Cells were stained with Giemsa (original magnification × 1,000)
Source: https://www.researchgate.net/figure/Mansonella-perstans-nematode-in-peripheral-blood-mononuclear-cells-from-Buruli-ulcer_fig1_262610617

Diagnosis of *M. perstans* is made by identifying unsheathed microfilariae on a blood smear. Microfilariae can be identified in the blood both daytime and nighttime. Eosinophilia is often present. *Mansonella perstans* is resistant to drugs, such as diethylcarbamazine ((DEC), used to treat other filarial diseases. Targeting endosymbiotic *Wolbachia* bacteria in adult *M. perstans* with doxycycline (200 mg daily for 4 to 6 weeks), which is thought to stop adult worms from reproducing, may be curative. *Wolbachia* has been demonstrated in *M. perstans* from Mali, Cameroon, Ghana, and Gabon (Marie and Petri, 2022; Charro, 2024a; Charro, 2024b).

There are conflicting reports of the presence of *Wolbachia* in Uganda, due to methodological constraints or the presence of multiple strains of *M. perstans*. Doxycycline is effective in Mali and Ghana, but the usefulness of this agent in treating infections in regions where *Wolbachia* are absent has not been systematically studied. In cases where doxycycline is ineffective, combination therapy with diethylcarbamazine and mebendazole for 3 weeks has improved activity over monotherapy (Marie and Petri, 2022; Charro, 2024a; Charro, 2024b).

3.5. *Mansonella streptocerca* (Macfie & Corson, 1922)

Mansonella streptocerca is transmitted in the tropical forests of West and Central Africa and Uganda. The prevalence of *M. streptocerca* is unknown. Nonhuman primates are occasionally infected but are not the primary reservoir of infection. The life cycle of *M. streptocerca* is similar to that of *M. perstans*, except that adult worms reside in the upper trunk and shoulder dermis. Microfilariae are found in the skin. Most individuals with *M. streptocerca* are asymptomatic. Thickening of the dermis, hypopigmented macules, and bilateral axillary or inguinal lymphadenopathy may be seen. Unlike *Onchocerca volvulus* Leuckart, 1893 (Rhabditida: Onchocercidae), adult *M. streptocerca* does not form subcutaneous nodules (Bamuhiiga, 1998; Schoch *et al.*, 2020; Marie and Petri, 2022). *Mansonella streptocerca* is diagnosed by identifying microfilariae in skin fragments or biopsies. Eosinophilia is common. Serology may also be useful in identifying filarial infection but is not specific (Bamuhiiga, 1998; Schoch *et al.,* 2020; Marie and Petri, 2022).

Diethylcarbamazine (DEC) 2 mg/kg 3 times daily for 12 days is administered to treat *M. streptocerca*. DEC kills both microfilariae and adult worms. However, it may exacerbate cutaneous and systemic symptoms because of the release of antigens from dying microfilariae. DEC should not be administered to patients with *O. volvulus* or massive Loa loa infections because of the potential for serious adverse effects (Figure 12) (Bamuhiiga, 1998; Schoch *et al.,* 2020; Marie and Petri, 2022).

Figure 12: Microfilaria *Mansonella streptocerca* (Macfie & Corson, 1922)
Source: http://xyala2.bio.ed.ac.uk/research/nematodes/fgn/pnb/manstrep.html

Ivermectin (150 mcg/kg in one dose) may reduce *M. streptocerca* microfilarial loads, but its impact on the course of infection is uncertain. Before treatment with ivermectin, patients should be assessed for co-infection with Loa loa, another filarial parasite, if they have been in regions of Central Africa where both parasites are transmitted because ivermectin can cause severe reactions in patients with intense Loa loa co-infection. It is not known whether *M. streptocerca* hosts *Wolbachia* or whether doxycycline influences treatment (Bamuhiiga, 1998; Ta-Tang *et al.*, 2018; Schoch *et al.*, 2020; Marie and Petri, 2022).

4.0. CONCLUSION

In humans, their bite Culicoides can cause hives, and red welts that can persist for more than a week. To bite, the mosquito penetrates the hair and clothing. The discomfort arises from a localized allergic reaction to the proteins in their saliva, which topical antihistamines can relieve. They are also incriminated in the transmission of several arboviruses, including the Akabane virus, an arthropod-borne viral disease affecting cattle, sheep, and goats. African horse sickness virus, Bluetongue virus (a viral disease of ruminants transmitted by mosquitoes of the genus *Culicoides*), and Schmallenberg virus affect susceptible wild and domestic ruminants.

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