Review article

Methods and procedures used in *Aedes aegypti* control in the successful campaign for yellow fever prophylaxis in Rio de Janeiro, Brazil, in 1928 and 1929

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Abstract

Objective: to review the challenges and procedures used in Aedes aegypti control and the characteristics of the epidemics in the successful campaign, led by Clementino Fraga, for yellow fever control in Rio de Janeiro, Brazil, in 1928 and 1929, before the vaccine (1937) and DDT (1947). **Methods**: a literature review was conducted by searching official reports, scientific journals and historic textbooks on this subject. **Results**: the A. aegypti control was achieved through the hard and organized work of breeding site police teams, priority in eliminating breeding sites through environmental management measures and a qualified training program for the teams. **Conclusion**: the reports demonstrate a set of simple but laborious procedures that could effectively control mosquitoes in urban environment through the work of the teams, who were committed to environmental management measures, aiming at eliminating breeding sites and were capable of handling social and environmental obstacles.

Key words: History; Aedes; Methods; Mosquito Control; Yellow Fever; Review Literature as Topic.

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Introduction

Brazilian Public Health is currently facing new threats from Chikungunya and Zika virus circulation. The circulation of multiple viruses transmitted by *Aedes aegypti* (DENV1-4, CHIKV, ZIKV) and the lack of vaccine to prevent all of them demonstrate an alarming scenario, being extremely important to search for successful strategies on mosquito control. Some authors point to the need for searching new technologies, considering the present obstacles to control the vectors with traditional methods.[1] Nevertheless, the alternative techniques to release infected or genetically modified mosquitoes can take years or, in practice, could not be effective or feasible.[2] In this scenario, the successful national prevention campaigns of yellow fever, before the introduction of the vaccine, in 1937, should be revised.[3,4] The challenge of these campaigns – before the vaccine – had largely depended on the *A. aegypti* control when there were no organosynthetic insecticides, which first appeared in Brazil with the use of DDT, in 1947.[3,5]

> *The success of the campaign led by Clementino Fraga deserves to be analyzed because, after about a year and a half, from May 1928 to September 1929, the epidemic had been completely overcome.*

In the first decades of the twentieth century, among the prophylaxis campaigns of yellow fever in Brazil, two of them, led by Oswaldo Cruz (1903 to 1908) and Clementino Fraga (1928 to 1929), should be highlighted, since they took place in Rio de Janeiro, Brazil's capital city and the largest national urban center at that time. However, in historic literature, Clementino Fraga's campaign has not received the deserved attention and analysis. After two decades of a successful yellow fever prophylaxis campaign, led by Oswaldo Cruz, in 1928 the country's capital faced a new epidemic when it was not expected, so the city was unprepared and Oswaldo Cruz's sanitary brigades had been extinguished.[3]

Clementino Fraga, the former Director General of the National Department of Public Health, had to rearrange the breeding site police services, just like Oswaldo Cruz would do, but he had to deal, in 1928, with a larger and more complex city, where the cases were not concentrated downtown.[6] In 1903, the country was predominantly rural and Rio de Janeiro had 749,000 inhabitants, and part of them lived in the suburbs, that is, outside the epidemiological perimeter: the actions were performed mainly downtown.[3,7,8]

The success of the campaign led by Clementino Fraga deserves to be analyzed because, after about a year and a half, from May 1928 to September 1929, the epidemic had been completely overcome with the same methods and procedures used in 1903, with only a few changes, and 738 cases and 478 deaths recorded.[7,3] According to Sebastião Barroso, Oswaldo Cruz's campaign lasted five years (1903-1908) with a total of 994 cases and 505 deaths.[7]

This study seeks to revise the challenges and procedures used to control the *A. aegypti*, some important socio-environmental conditions and epidemic characteristics of the successful yellow fever control campaign led by Clementino Fraga in Rio de Janeiro, Brazil, in 1928 and 1929.

Methods

This is a literature review, which was conducted by consulting scientific literature from that period (scientific journals), especially those from 1925 to 1932, books, historic textbooks and official reports from Clementino Fraga's campaigns. All references which addressed or reported the methods and procedures used in vector control during the campaign were analyzed, as well as the epidemic characteristics and some socio-environmental conditions of the 1928 Rio de Janeiro that could had influenced the control measures.

Results

The results will be presented in three subsections: (i) socio-environmental conditions of Rio de Janeiro, in 1928; (ii) epidemic characteristics; and, finally, (iii) techniques and procedures used to combat *A. aegypti* during the campaign.

Socio-environmental conditions of Rio de Janeiro, in 1928

In 1928, the country's capital, Rio de Janeiro, had some important socio-environmental conditions that, today, would influence the proliferation and control of mosquito vectors: social exclusion, disorderly and unplanned occupation of urban space, priority or

even exclusivity of basic public services for the elite, and lack or absence of sanitation for a large portion of the population.

There was a significant urban expansion from 1906 to 1930, and the city of Rio de Janeiro extended over the North and South Zones and suburbs, however the government actions focused only on middle and upper classes.[9] Free of yellow fever and other insalubrious problems, the city had to fill free areas due to population growth, promoting an uncontrolled increase of the opening of new streets and housing developments.[10] Favelas became part of the urban landscape, as shown by the Law No. 2,087, dated January 19, 1925.[11]

In 1928, the population of Rio de Janeiro was estimated at over 1.7 million inhabitants[7,3] and the city had already some industrialization areas, after the World War I.[12] The reinforced concrete as a new element construction arose and were regulated by Decree No. 2,021, dated September 11, 1924, and Decree No. 2,087, dated January 19, 1925, which allowed a fast development of buildings with more than six floors.[10] Comparing to the 82,396 buildings and 83,686 households catalogued in the 1906 census, Rio de Janeiro had 198,738 units (131,032 in the urban area, 66,700 in the rural area and 1,006 in the sea area) at the beginning of the epidemic, spreading over a large area, where the conditions were excellent for the mosquito which "invaded the households in considerable amount".[7]

According to Carvalho,[13] Brazilian people were not politically organized and had not developed a national feeling yet. On the other hand, the popular movements – such as the Vaccine Rebellion (1904), the Revolt of the switch (1910), the Contestado War (1914-1916), the labor movement that culminated in a general strike for better conditions of life and work (1917) and the Tenentism (1922-1927) – revealed a population walking toward citizenship and less tolerant with government impositions and abuses of power, due to an oligarchic republic, whose representation was totally fake. In the cultural and artistic life, the Modern Art Week (1922) revealed a society who was seeking an identity and freedom of expression.

Epidemic characteristics

Although the mosquito control services had been kept, even with reduced resources and staffs, the capital of the Republic faced a new yellow fever epidemic in 1928-1929.[7] In 1925, the Director General of the Department of Public Health at that time, Professor Carlos Chagas, reported the drastic reduction of workers responsible for the control of mosquitoes for financial reasons, from 2,500 at the intense campaign against yellow fever to 400 at that year.[7] This negligence occurred in the whole country.[14,15] Besides the difficulties to maintain the resources to breeding site polices, there were also difficulties to maintain the strictness and quality control through monotonous and exhausting routines.[4] Of course, the main result of these difficulties was the proliferation of *A. aegypti*. A report of yellow fever service at the north sector, in 1929, under the responsibility of the Rockefeller Foundation, presented tables with thousands of breeding sites found in the states of Alagoas, Bahia, Ceará, Maranhão, Pará, Paraíba, Pernambuco, Rio Grande do Norte and Sergipe.[16] Two other evidence with a high level of *A. aegypti* infestation in the country were the dengue epidemics in Rio Grande do Sul, 1916,[17] and in Niterói-RJ, in 1922.[18] In both cases, it was not realized that dengue is transmitted by the same mosquito of yellow fever, although it had already been proofed of *Aedes aegypti* involvement on dengue transmission in 1906.[19]

In this scenario, in 1925, there were infection outbreaks in several states, such as Rio Grande do Norte, Paraíba, Bahia and Minas Gerais; later, in 1927, new cases of yellow fever were reported in Pernambuco and Sergipe; and, in 1928, the epidemic occurred in Rio de Janeiro.[3]

The description of the origin and beginning of the first cases in the Brazilian capital, in 1928, shows that there were infestation rates of mosquitoes high enough to propitiate new local outbreak[7]. According to the report of Clementino Fraga, at the beginning of the work, it was not difficult to find buildings with at least one breeding site of *Culex* or *Aedes*. Infestation was no longer concentrated, it occurred in a larger city with an irregular topography, including hills, wastelands and several watercourses, in which, at that time, all kinds of recipients were already thrown away. There were many different types of buildings, some were settled in places of difficult access.[20] Epidemiological analyses reported that yellow fever cases had spread throughout the city, beginning from regions close to the docks in a district called *Saúde*.[6] The amount of non-immune individuals was estimated at 1,153,000, and the affected area no longer concentrated in the central part of the city, –it

spread to the built-up area downtown, surroundings, suburban and rural areas.[7]

Techniques and procedures used to combat *A. aegypti* during the campaign

In 1928, from the former staff of the Oswaldo Cruz campaign, only few qualified staff had remained. The staff had not been renewed, on the contrary, year after year, they had been reduced due to budget cuts.[7,20]

In the first decades of twentieth century, the strategies to tackle the vector were defined as health actions imposed by hard, strict, detailed, ruled and continuous work to search, eliminate or treat breeding sites of mosquitoes with insecticides in vertical structures. The workers were divided in teams to scrutinize the urban space, which had been previously divided and defined. The main objective of tackling the mosquitoes was to eliminate the breeding sites and, if it was not possible, to treat them using the insecticides available then, especially the Paris Green, pyrethrum, sulfur and kerosene. According to Franco,[3] "the combat against mosquitoes in their aquatic phase was the cornerstone of the campaign, being the most important part and the one that needed a larger number of workers".

Clementino Fraga used the same methods used by Oswaldo Cruz, which were common to all yellow fever campaigns in the first decades of the century,[21] but with some changes, such as home sprinkler services (purges), composition of insecticides (kerosene with 3.5% carbon tetrachloride) and, above all, the use of compressed air electric engines allowing the reduction of tarpaulins and weatherstrips.[22]

At that time, an important advance in entomological surveillance had been developed, with the improvement of infestation indices covering all urban breeding sites, including those outside of homes.[23] Clementino Fraga mobilized ten thousand men, using the same rules from the 1928-1929 campaign adopted by Oswaldo Cruz (Decree No. 5,157, dated March 8, 1904) and the classical known methods. Despite the difficulties, the campaign was successful. In Fraga's report, however, the success came because of hard work:

> *[...] For months, the Director General and his immediate staff would not leave the office until after midnight. The destruction of larva breeding sites, where there was fire, began in the early hours of the morning and continued as late as daylight allowed; the purges were performed also at night to cover more areas; the surveillance was extended and multiplied; the isolations and removals were promptly carried out. [...] from August 1928 to March 1929, 183,243 floors had been purged.*

The tasks of the breeding site police groups were strict and systematic in the search for households, commercial houses, factories, churches, garage, barns, cemeteries, and in all parts: flowerpots, plants, refrigerator deposits, spittoons, pitchers, filters, backyards, gardens, laundries, garages, basements, animals watering and stables, baths, old cans, holy water fonts in churches, etc., checking water tanks, eliminating the bromeliads, cleaning floor drains – even those without larvae, observing the slopes of gutters, among many other additional measures.[24] There were teams for specific services – such as inspection of roofs and gutters, drains and culverts, wastelands –, health police and office.[25]

Fraga[7] reported that everything was "meticulously analyzed, treated and given conditions that would preclude culicidae or their larvae to proliferate", and presented the results:

> *[...] At the beginning of the work, the home larval index of mosquitoes often found in this city – Culex and estegomya – was almost one hundred percent [...] Today the general index of the city walks the neighborhood unit almost always below, reaching zero in many areas.*

The rainwater galleries represented the largest sources for mosquito breeding sites in the city. This control was costly and ineffective, although the infestations were not from *Aedes* but from *Culex*, in those galleries. During the campaign, a device coupled to the drains was developed, with so many positive results that 15,000 devices were installed in the city. Such device, called Aculex (Figure 1), had a false bottom; when it was closed, it prevented the access of mosquitoes to galleries; it was opened with the weight of the water on the advice (600g) and the rainwater would go down to the gallery.[24,26,20]

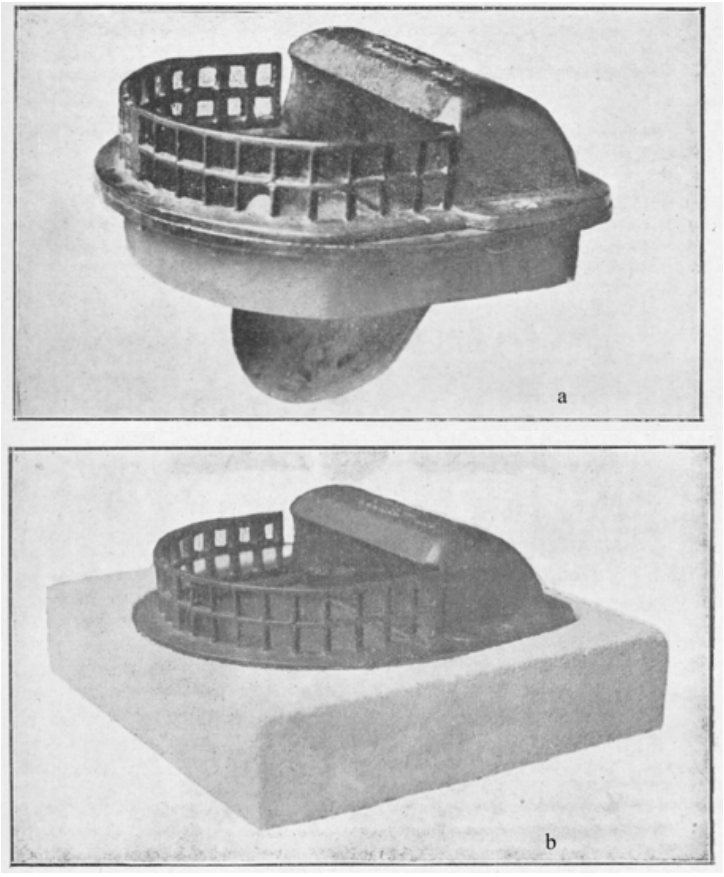
In many occasions, the activities of anti-vector services, which worked since Oswaldo Cruz, were embarrassing or invasive of citizens' privacy. Some examples are the Articles 23, 24 and 25 of the Regulation of the Yellow Fever Prophylaxis Service, which are presented in the Decree No. 5,157, dated March 8, 1904:

[...] Article 23 – All parts of households will be caulked in order to eliminate mosquitoes. Consequently, it will be used paper, cloth and gum, and then burned pyrethrum or sulfur for one hour, at least, in the proportion to what was predetermined; Article 24 – If the sulfur is the agent used, the staff shall take all precautions to prevent deterioration of gilded, silver and lacquered objects and furniture, and paints and decor that could not be removed; and, Article 25 – All furniture will be open, the clothes from drawers and closets will be swung, so that mosquitoes cannot stick to them to protect from the insecticide.[3]

These activities generated huge inconvenience caused by sulfur purges. This method can damage metals, machinery, clothes, food and beverage, and can cause fire, either in the removal and protection of objects or in the preparatory practice to caulk and cover.[22]

Upon a review of reports of this period, we can notice a military and police inspiration in the way of organization and working of the campaigns, with a freedom to transgress the citizens' rights, if necessary. This inspiration is evident in the names 'brigade', 'breeding site police', 'health police', in addition to the possibility of fines and prison.

In the epidemic of 1928-1929, for the first time, large companies, trade associations and other civil society organizations actively collaborated in an effort to mobilize the population against the targets of the Public Health.[8] However, the former Assistant Director General of the National Department of Public Health,



Fonte: Roças, 1930[26]
a) Device with partly opening lid
b) Device set on a concrete slab [26]

Figure 1 – Aculex device installed in manholes to control the infestation of *Culex* mosquitoes in underground galleries in Rio de Janeiro, 1928-1929

João de Barros Barreto, reported the resistance of the population to methods of searching, eliminating and controlling the mosquitoes, including refusals, absences, threats and bribes. Some obstacles were the closed and holiday homes. The Director General also reported difficulties to search and analyze the breeding sites, as it was already discovered that the mosquito "does not stay only in households as stated," being found in wastelands and hillsides. Special resistance had occurred to the purges due to the nature of the service:

> *[...] Individuals, who knew about the purge, purposely left their houses, closing them. It's the old cries of the inviolability of the home, the requirement for a specific hour or the postpone for the next day or week.*[28]

Outside the capital, reports of resistance to vector control by the population were made particularly against the strict model used by the US Rockefeller Foundation, in the 1930s or even before.[2] This resistance to methods of combating the mosquito at that time is justified due to the particularly coercive methods mentioned before.

The combat against the vector in the 1928-1929 epidemics had to be carried out with coercive methods in a less tolerant society to the abuse of power. Therefore, it should be mentioned the program of Technical School to prepare professionals for the breeding site police teams, which was ordered to Dr. Abelardo Marinho de Andrade in the course of the epidemic. The description of that training course shows that the professionals selected to integrate the breeding site police teams received extensive amount of technical information, procedures and basic concepts of the different services and several other aspects involved in vector control in an urban environment. It is important to highlight that this program taught ethics and citizenship notions, the concern on respecting the citizen, as can be seen below, in the content of Parts I and IV:[29]

> *[...] General Part – I: a) Because there is an office for public health – For those working to Public Health – Who pays for public health services – The source is the government's money; b) Civil servants duties to the public, the government, the departments, their bosses and their conscience – work, honesty, economy, discipline, fairness, justice and fraternity. Friendship between co-workers – a concept of limit. c) The main objective of civil servants: the fulfillment of service – the duty of spontaneous collaboration." ... "Special Part – IV: Urbanity and service – How to treat the public – Attitudes and behavior in the department, in the street and inside the houses, during office hours and outside them. Individual tidiness and garb.*

In the service reports, we can highlight, above all, the dedication and efforts in the search and elimination of breeding sites with environmental management measures: inclining or eliminating gutters; cleaning the ditches of the dirt road and the streams to ensure the flow of water; caulking or eliminating tanks; removing containers; cleaning wastelands; cementing the hollows of tree trunks; and, closing the galleries with Aculex device, etc.

Fraga[20] reported that, in only one week of service,

> *[...] it was found 16,540 gutters with wrong inclination and 14,540, holding back waters, this was only in the urban area, even if all the effort to get their rectification or removal [...] ditches were opened in extension of 20,370 meters, analyzed others with 177,619 meters, and preserved others with 224,096 meters [...] lands were cleaned in an area of 1,096,343 square meters.*

Barreto[28] reported that the actions of cleaning lands, earthmoving and drainage of water to clean the watercourses that crossed the city counted with thousands of men from City Hall.

Discussion

The successful control of yellow fever before the introduction of the vaccine was determined by the *A. aegypti* vector control. The great reduction of mosquitoes' infestation in the city of Rio de Janeiro, reported by Clementino Fraga, can mostly explain the success of the 1928-1929 campaign. This control depended on the hard and organized work teams and the government support. The objective to always eliminate breeding sites in all their diversity (gutters, ditches, streams, containers, galleries, etc.) confirms the relevance of environmental management measures for successfully tackle mosquitoes in urban areas.

It is noteworthy the success of the Aculex device in controlling the mosquito infestation in the galleries. Nowadays, these devices are not found, probably due to subsequent urban reforms that intended to optimize

the drainage system of rainwater already in the epoch of organosynthetic insecticides. The use of Aculex and other measures aforementioned are examples of unusual or low priority control methods in the current vector control activities: environmental management.

The environmental management is the adjustment of the environment, as much as possíble, inappropriate to vector proliferation, and this is undoubtedly the most effective method for vector control.

It is also noteworthy the quality of professionals training at the Training Staff School from Breeding site Police. It might not be possible to know, historically, if the teams acted according to the guidelines or to the reports of the brigades' activities from Clementino Fraga. However, considering that the teams worked for a society in construction to their citizenship, it is feasible to assume that the control activities were performed searching to convincing the population. On the other hand, reports show that they had legal support by the government, such as the health regulations from December 9, 1929, establishing obligations, prohibitions and fines for the citizens.[24]

The reports demonstrate a set of procedures and simple practices primarily dedicated to environmental management and, although laborious, they were successful in controlling mosquitoes in the urban area of Rio de Janeiro, during the 1928-1929 campaign. This study suggests that these practices, carried out by dedicated and qualified staff, were capable of handling social and environmental obstacles in the Federal Capital at that time. The introduction of yellow fever vaccine and, especially, of organosynthetic insecticides seems to have relegated these practices to oblivion. In the current epidemiological situation, those campaigns deserve to be remembered.

Authors' Contributions

ED Wermelinger contributed to the conception of the study, to the literature review and to the writing of the manuscript.

Carvalho RW contributed to the conception of the study, to the discussion and to the critical revision of the manuscript's content.

Both authors approved the manuscript's final version and declared to be responsible for all aspects of the study, ensuring its accuracy and integrity.

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