

# Costa Lima and the campaign against yellow fever in the States of Rio de Janeiro and Pará, Brazil

Costa Lima e a campanha de combate à febre amarela no Rio de Janeiro e no Pará, Brasil

Costa Lima y la campaña de lucha contra la fiebre amarilla en Rio de Janeiro y Pará, Brasil

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## ABSTRACT

After the confirmation of the role of insects in disease transmission, a "school of entomologists" was soon developed in Manguinhos. The foundations of this school were undoubtedly outlined by Oswaldo Cruz, who acquired, at the Institut Pasteur, in Paris, the fundamental knowledge which enabled him to study the Culicidae even though he had not been an expert in entomology. Costa Lima's strong relationship with Manguinhos and Oswaldo Cruz is closely linked to the beginning of his career, since his first contact with entomological research occurs in this Institute, and through its director. Graduated in Medical Sciences in 1910, he soon left the position of academic auxiliary of federal services in public health he held as a student, to be part, as a health inspector, of the commission organized by Oswaldo Cruz to fight yellow fever in Pará State. In Belém, and especially in the municipalities of Santarém and Óbidos, Costa Lima had his first opportunity to approach the entomological research by studying the bionomics of Culicidae. In a relatively short time, he became an important scientist, standing out as one of the most notable entomologists in Brazil.

**Keywords:** History of Science; Costa Lima; Yellow Fever; Entomology; Biography.

## INTRODUCTION

Ângelo Moreira da Costa Lima was born in Rio de Janeiro on the 29<sup>th</sup> of June, 1887. In 1904, he started medical school at the Faculdade de Medicina in Rio de Janeiro, which, at the time, was the nation's capital. With the intent of obtaining some monetary assistance to support himself through college, he started to write and publish notes on the classes that were of most interest to the students. The first was that of Physiology, taught by Professor Oscar de Souza, whose notes were reviewed and extended by the professor himself. Also in 1904, he worked as an editor for the *Correio da Manhã* newspaper. In 1907, he continued publishing his notes, editing those on the Surgical-Medical Anatomy class of Professor Paes Leme, and, in 1909, those on Hygiene of Professors Rocha Faria and Afrânio Peixoto<sup>6</sup>.

In his third year of medical school, the sales of his notes were no longer sufficient to support and provide for him and his family. It therefore became urgent to find a more secure and profitable job. Upon learning that, through the Departamento Nacional de Saúde Pública, Oswaldo Cruz would open a competition for academic assistants for the Serviço Nacional de Saúde Pública, Costa Lima, still a medical student, saw in the competition an opportunity to obtain a fixed and regular income. Worried about the selective process, he began to devote himself to the study of the morphology of mosquitoes<sup>2</sup>.

The attention he dedicated to these studies was finally rewarded. On March 27, 1907, Costa Lima was admitted as an Academic Assistant of the Serviço de Prophylaxia da Febre Amarela of the Justice and Interior Affairs Ministry, placing first in a competition of more than 100 applicants for 17 positions<sup>10</sup>. This job eventually became his primary means of sustenance.

## COMBATING YELLOW FEVER IN RIO DE JANEIRO

The SPFA was organized by Notification no. 571, dated April 15, 1903, to solve one of the biggest public health problems of the capital<sup>1</sup>: yellow fever, which, since the middle of the 19<sup>th</sup> century, had been a health scourge in Rio de Janeiro and the main source of the city's infamy as an infested city. Along with the increasing number of foreign immigrants and national migrants from rural areas,

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epidemic outbreaks, in particular of yellow fever, regularly occurred, each time at shorter intervals and with frightening violence<sup>3</sup>. In the beginning of the 19<sup>th</sup> century, the capital's population was a little less than a million inhabitants, and the majority was extremely poor, crowding into old houses from the 19<sup>th</sup> century located downtown, in the areas around the harbor. These old houses, degraded due to the concentration of people in that area, had transformed into slums, divided into small, overcrowded rooms rented to whole families who lived in extremely precarious conditions, particularly in terms of hygiene, without any type of resources or infrastructure<sup>24</sup>.

The epidemics that raged in the Federal capital, in addition to jeopardizing the survival of the ruling classes, caused serious embarrassment for commercial relations with other countries and for the stimulus policies for foreign immigration. The service organized by Oswaldo Cruz was then inserted in the political-administrative project of Rodrigues Alves, who sought to modernize and transform the city of Rio de Janeiro. The project was simultaneously aimed at harbor modernization, city sanitation, and urban reform. For the project's administration, in addition to Oswaldo Cruz, the engineers Lauro Müller and Francisco Pereira Passos were invited, the latter having participated in the urban reform of Paris headed by Mayor Eugène Haussmann. Unlimited powers were given to the three individuals to execute their tasks, making them exempt from any judicial proceedings, which created a situation of triple dictatorship in the city<sup>24</sup>.

Housing, an excellent venue for the physical and moral regeneration of individuals, became the main target of medical attention<sup>5</sup>. Oswaldo Cruz created a plan to combat yellow fever in Rio de Janeiro based on the theory of the Cuban doctor Juan Carlos Finlay. In June of 1900, the health service of the American army sent a committee to Cuba to study the etiology and prophylaxis of the disease that, from the end of the Spanish-American war, had decimated the occupation troops of the island. Through several experiments performed with human volunteers, the committee headed by Walter Reed confirmed the theory that Finlay had insistently defended since 1881: that the mosquito *Culex fasciatus* (now known as *Aedes aegypti*) was the intermediary host of the yellow fever parasite, which was transmitted to the non-immune individual through a bite from a mosquito that had previously fed on the blood of an infected individual. In accordance with the Havana theory, the fight against yellow fever depended on mosquito control and on the protection of infected individuals from their bites<sup>4</sup>. The campaign was structured in typical military bases: the city was divided into ten sanitary districts under the jurisdiction of health offices, whose medical personnel were in charge of receiving the notifications, levying fines, and calling on owners of unsanitary property to reform or demolish it.

Decree no. 5157, which regulated the "Serviço de Prophylaxia da Febre Amarela", was finally approved on March 8, 1904. This decree granted the sanitary authorities, among other powers, the power to demolish unsanitary buildings; a novelty was that it nominated a special judge, independent of the common justice system, to judge the pending cases<sup>5</sup>.

With the support of the central offices, which kept continuously updated maps and epidemiologic statistics, the sanitary brigades of the "Serviço de Prophylaxia", known as "mata-mosquitos (mosquito killers)," covered the capital streets, washing water reservoirs, pouring mineral oil in drains and manholes, cleaning roofs and gutters, and removing any type of mosquito larvae. The isolation and purge division, using Clayton equipment, disinfected the houses in the outbreak zones by burning pyrethrum (an herb cultivated in Rio Grande do Sul, which has insecticidal properties, with pyrethrin as the active substance)<sup>26</sup>, and sulfur. They also provided in-home isolation for sick individuals or asked the Central Disinfecting Office to remove them to the São Sebastião Isolation Hospital<sup>20</sup>.

In order to overcome resistance to the campaign, Oswaldo Cruz also counted on the support of the French mission, which, since 1901, had been present in Rio de Janeiro to observe, from a privileged position, the validity of Finlay's theory. The conclusions of the Reed commission in Cuba were being verified by other committees in places where yellow fever was as prevalent as in Cuba. The French committee was formed by researchers from the Pasteur Institute of Paris, Drs. Paul-Louis Simond, Émile Marchoux, and Alexandre Salimbeni, who were under the coordination of Émile Roux at the time. The mission was sponsored by the French government, which had great interest in using the new prophylaxis strategy in its colonies. The French mission remained in Brazil for almost four years, and at the end of the mission, they presented a report confirming the veracity of the Havana theory<sup>3</sup>. During the four years they stayed in Rio de Janeiro, in a laboratory inside São Sebastião Hospital, the committee carried out several experiments to better understand the habits and the biology of *Stegomyia fasciata*, to clarify controversial aspects of the transmission and the still obscure etiology of yellow fever<sup>3</sup>.

Another foreign mission to arrive in Brazil was the German one, which arrived in 1904, formed by doctor Hans Erich Moritz Otto, from the Maritime and Tropical Diseases Institute of Hamburg, and Rudolph Otto Neumann, a pharmacist associated with the same Institute. With the same objective as the French mission, during the three months (March to May) they stayed in Rio de Janeiro working at the São Sebastião Hospital, the German researchers worked together with the French and concluded that *Stegomyia fasciata* was the responsible for the transmission of yellow fever<sup>6</sup>.

The SPFA, in addition to using methods of coercion, such as the compulsory notification of cases of the disease, also used all possible means of persuasion. Educational pamphlets titled "Conselhos ao povo: meios de evitar a febre amarela (Advice for the People: how to avoid yellow fever)" were published and distributed to the general population and to doctors, most of whom were hostile to the proposed prophylaxis and resistant to report patients to the Public Health offices<sup>9</sup>.

Even though Costa Lima apparently did not plan to work as an entomologist, his job as an Academic Assistant for the "Serviço de Prophylaxia da Febre Amarela", and

consequently his contract with the Oswaldo Cruz Institute, was decisive in changing his career path. This was solidified in 1910 when Costa Lima was invited by Oswaldo Cruz to join the yellow fever combat committee in Pará.

### THE YELLOW FEVER COMBAT COMMITTEE IN BELÉM, PARÁ (1910–1913)

After receiving his medical doctorate degree, Costa Lima resigned his job as an Academic Assistant of the SPFA of Rio de Janeiro to be part of the committee organized by Oswaldo Cruz to combat yellow fever in Belém, Pará State, as a Sanitary Inspector.

Invited by the Governor of Pará, Mr. João Antonio Luiz Coelho, Oswaldo Cruz accepted the duty of organizing a general plan to attack malaria and yellow fever in the capital of that state. On the visit of Oswaldo Cruz to Belém, a message from Governor Coelho, presented on September 7, 1910 to the *Assembleia Legislativa do Estado do Pará* (House of Representatives of Pará), included the following record on the topic of "Visitas Illustres (Important Visitors)".

Your arrival coincided with my decision to combat yellow fever, which, as you know, has been my idea since my first days of governance. The recognition of Dr. Oswaldo Cruz is fair and glorious, especially regarding sanitation; the brilliant success of the campaign he directed to exterminate the terrible disease in Rio de Janeiro, liberating the capital of Brazil from its disgraceful fame as an unhealthy city, which had impeded progress and compromised national civilization, led me to the decision to submit the city to examination by the professor for the prophylaxis program that I have designated as a great sanitary undertaking, of which I make special mention and ask for your attention<sup>11</sup>.

In one of his meetings with João Coelho, Oswaldo Cruz affirmed that he could extinguish the disease within a year: in the first six months, all measures that he designated would be adopted, destroying the epidemic form of yellow fever, and, in the next six months, the sporadic cases that always emerge after prophylaxis would be combatted<sup>11</sup>.

To carry out the sanitation and eradication campaign, besides the previously mentioned timeframe, Oswaldo Cruz established some norms that he considered of major importance for the success of the undertaking:

a) Spend approximated 3,000 "contos de réis" (Brazilian currency at that time) during the campaign; b) adoption by the State of the sanitation rules in force in the Federal Capital and those of the sanitary services of the country; c) creation of a completely autonomous Yellow Fever Prophylaxis Committee, whose legal representative will deal with the state governor or with the municipal representative if needed; d) execution of the coercive measures that are part of the mentioned rules, through the administration and the Sanitary Committee,

providing resources to the Committee head, or its representative, or in the last instance to the State Governor; e) concession to the Committee head ample technical or administrative autonomy and the needed moral and material support to execute the required sanitary measures; f) in addition to the chairman—whose remuneration will be previously agreed upon—the Committee will consist of a staff who will be paid according to a settled table and who will be hired by the Committee chairman inside or outside the State: 1 general inspector; 6 health inspectors; 10 assistant doctors; 4 team leaders; foremen, guards, cleaners, administrative employees, etc.<sup>9</sup>.

The organization and execution of this campaign followed the same rules implemented in Rio de Janeiro. After establishing all the conditions needed to start the activities, Oswaldo Cruz went back to Rio de Janeiro to gather the team that would join him on that Committee. He returned to Pará in November 1910 with 10 health workers: João Pedroso Barreto de Albuquerque, Francisco Ottoni Mauricio de Abreu, Belisario Augusto de Oliveira Penna, Augusto Serafim de Souza, João Pedro de Albuquerque, Leocádio Rodrigues Chaves, Caetano da Rocha Cerqueira, Abel Tavares de Lacerda, Ângelo Moreira da Costa Lima, and Emygdio José de Mattos<sup>16</sup>.

A huge agency was organized to conduct the campaign. As previously mentioned, the "Serviço de Prophylaxia da Febre Amarela" in Belém was organized as in Rio de Janeiro. An outbreak brigade to prevent the reproduction of mosquitoes, a purging service aimed at exterminating the existent infected mosquitoes, an isolation service to prevent sick individuals from being bitten by the mosquitoes within the first four days of the disease, and, finally, a medical surveillance service that would identify the first cases of yellow fever in the infested areas<sup>13</sup>.

In addition to the implementation of those services, the following items were also purchased: two thousand boxes of kerosene, six tons of kreolin, thirty-three tons of sulfur, two tons of pyrethrum, three pieces of Clayton equipment, eighteen wagons, a truck and two cars<sup>17</sup>. The volume of material and equipment showed the size and importance of the campaign implemented in Belém, Pará.

After the founding of the Service and the start of its activities, on November 12, 1910, Oswaldo Cruz returned to Rio de Janeiro and left João Pedroso Barreto de Albuquerque in his place as general inspector. As promised to the Pará State Government, yellow fever epidemics were suppressed within the first six months of activities of the "Serviço de Prophylaxia"<sup>9</sup>. After this point, as previously outlined, another six months of uninterrupted work would be necessary to completely eradicate yellow fever in Belém. Therefore, the Committee's attention turned to sanitary surveillance, which was very strict and relentless, and aimed at preventing the import of infection outbreaks and maintaining the defensive measures in force: outbreak brigades, visits to homes, and isolation of sick individuals.

The sanitary campaign in Belém was very different from that which occurred in Rio de Janeiro in regard to the receptiveness of the population, the press, the doctors, and the political authorities. It is clear that the success of his work in the Federal Capital positively and decisively influenced Belém society, which accepted, with no resistance, all the rules established by the "Serviço de Prophylaxia". From a letter sent to the Governor of the Pará State, we have selected a portion where Oswaldo Cruz makes the following comment on the behavior of Belém citizens in relation to the campaign:

At last, I have to acknowledge that the fast, favorable results already obtained are especially due to the good and neat character of the Pará population, to the inestimable support of the doctors of Belém, the sensible press that has been very competent in instructing the population, not to mention the continuous support from all the authorities and the Herculean effort of those fellows who left family, home, and all sort of personal interest to bring to Pará an intelligent and abnegated effort of long practice and perfect technique, making them useful to the cause everyone embraced as an ideal, with total dedication, and with no other objective than to accomplish this work of national interest and therefore showing their clear understanding of true patriotism<sup>9</sup>.

Yellow fever was declared eradicated in Belém on October 16, 1911, and the Pará government, based on Oswaldo Cruz's recommendations, decided to create a "Comissão de Prophylaxia Defensiva da Febre Amarela" (Yellow Fever Defensive Prophylaxis Committee) to replace the "Comissão de Prophylaxia da Febre Amarela" (Yellow Fever Prophylaxis Committee)<sup>20</sup>, which was dissolved on the same date. For the Defensive Prophylaxis Committee, in the same Decree, the following technicians were appointed: General Inspector: Francisco Ottoni Mauricio de Abreu; Health Inspectors: Abel Tavares de Lacerda, Ângelo Moreira da Costa Lima, Emygdio José de Mattos, Jayme Aben Athar, and Ageleu Domingues; Administrator: Theophilo Ottoni Maurício de Abreu<sup>9</sup>. On October 17, 1911, Oswaldo Cruz returned to Rio de Janeiro with the rest of the committee that had participated in the Belém campaign.

### THE YELLOW FEVER DEFENSIVE PROPHYLAXIS COMMITTEE IN SANTARÉM AND ÓBIDOS, PARÁ

After the conclusion of activities in Belém, the "Serviço de Prophylaxia Defensiva" (Defensive Prophylaxis Service) started to monitor the whole city, with the aim of preventing any conditions that would facilitate the development of yellow fever. As in Rio de Janeiro, the harbor was one of the places that presented the most risk, as people arrived in vessels from different regions where yellow fever was still endemic<sup>8</sup>.

Following reports of the emergence of yellow fever cases, first in Santarém and then in Óbidos, the Service sent

a committee, of which Costa Lima was a member, to characterize the situation in that region and to take the necessary measures. In this region, it was possible to observe which *Culicidae* species existed in the cities of Santarém and Óbidos. Then, some experiments were carried out in relation to the biology of these insects<sup>6</sup>. This campaign of sanitation and eradication of yellow fever, in which Costa Lima participated as a health inspector, was the first effort he directed in the field of entomological research, which decisively marked his career path thereafter.

First, he identified all *Culicidae* mosquitoes that existed in both cities by using the same methodology employed by Oswaldo Cruz, explaining where they were found, in what quantity, and their habits. He made a detailed description of some species. As a result of these observations and experiments, Costa Lima performed a complete characterization of the biology of the *Culicidae* in the region.

The mapping he performed started in Santarém. In this city, Costa Lima listed the species and commented on their habits, type of flight, periodicity, occurrence, and habitat, identifying 16 species of mosquitoes: *Stegomyia calopus*, *Megarhinus hemorrhoidalis* Fabricius, *Cellia argyrotarsis* Robin Desvoid, *Myzorhynchella lutzi* Cruz; *lanthinosoma sayi* Theobald, *lanthinosoma lutzi* Theobald, *Mansonia titillans* Walker, *Mansonia pseudo-titillans* Theobald, *Mansonia amazonensis* Theobald, *Taeniorhynchus fasciolatus* Theobald, *Culex fatigans* Wiedemann, *Culex cingulatus* Fabricius, *Culex bilineatus* Theobald, *Melanoconion chrysothorax* Theobald, *Aedomyia squamipennis* Lynch Arribalzaga, and *Limatus durham*.

Among these species, of greatest concern was *Stegomyia calopus*, as it was a vector of yellow fever virus. At the beginning of the "Comissão' work", samples of this *Culicidae* mosquito could be captured anywhere in the city, especially downtown. After the job had begun and the outbreak brigade's services had been set up for improving sanitary conditions, isolation, and health surveillance, it took two or three months until the mosquito vectors were controlled and the epidemic suppressed and declared eradicated in Santarém<sup>9</sup>. Once more, the methodology established by Oswaldo Cruz proved its efficacy in suppressing yellow fever.

Other mosquitoes that drew Costa Lima's attention were species of the genus *Mansonia*. Even though they were not yellow fever vectors, they were found in the city, mainly in the coastal region, from sunset until late at night. They were characterized by the voracity with which they attacked individuals and by their painful bites. In his report, Costa Lima reported that:

They bit at any hour, day or night. At night, they bit inside and outside of houses, frequently from 6 pm to midnight. In the morning, it was hard to find a Mansonian in the home. During the day, they were abundantly found and bit at any time in the surroundings of the focus of origin, that is, the

bushes around the swamps. The proboscidae are very hard and can bite even through not-so-thick clothes. To protect the feet from being bitten, 2 cotton socks are needed. For the legs, the use of underpants is essential<sup>15</sup>.

The voracity of these mosquitoes led Costa Lima to study their habits, behavior and breeding. The outbreak brigade, which had the objective of avoiding the propagation of mosquitoes, could never find a *Mansonia* outbreak in the surroundings while inspecting the city. On the other hand, Costa Lima observed that when he went to the swamps in the eastern side of the city, to the small lake (a swamp located 2 km to the west of Santarém) or on the opposite side of the Tapajós River, at the border of the city, he was always followed by several mansonians. In spite of the fact that these places were far from the city, Costa Lima was sure that the mansonians originated there<sup>15</sup>. According to his observations, the species that infected the city every night were *Mansonia titillans* Walker, *Mansonia pseudo-titillans* Theobald, and *Mansonia amazonensis* Theobald. Samples of the second and third species were always more abundant<sup>15</sup>.

Believing that these species flew into the city, aided by weak or mild wind, he began to observe the frequency and speed of the wind in the region. On the nights when the east wind was strong, a reduced number of mansonians appeared, and only later, when the wind increased in speed, did they start showing up in the city. As they do not fly very fast, they could easily be captured during their flight. Regarding their method of landing, here is a quote from Emílio Goeldi's book:

When penetrating the houses and while they were there for the first hours, they remained grounded, in a *dasculicinar* position, alternately moving their 2 back legs up and down. When they definitely wanted to rest on the surface upon which they had landed, they assumed a characteristic position very well illustrated in drawing no. 12 of Goeldi's book<sup>19</sup>.

In his studies, Costa Lima highlights the difficulty in finding males, as he had only once captured a male *Mansonia pseudo-titillans* Theobald in Santarém. This relevant capture was first described in detail by him and then sent to Manguinhos for support with the taxonomic study of the species. Costa Lima's observations contributed to demonstrating the specificity of this group in relation to its breeding – on the opposite side of the Tapajós River and not in the city water reservoirs – and its ability to roam to search for food.

Upon its arrival in the city of Óbidos, the Committee found a considerable number of mosquitoes of the genus *Stegomyia*, responsible for yellow fever transmission. According to Costa Lima, "it was almost impossible to work between noon and four o'clock in the afternoon due to the large quantity of *Stegomyia* during the hotter hours of the day"<sup>15</sup>. With the beginning of the Outbreak Brigade Service

work, which was implemented by the Committee, the quantity of mosquitoes was drastically reduced so that during the whole month of December 1912, only one female was captured by the Brigade<sup>26</sup>.

In the search for *Stegomyia*, Costa Lima monitored the regions of Jaretepáua and Mamahurú, on the shores of Lake Jacarepurú, the Cocal, and the Cocasal Imperial, where he could not find any samples. However, he found many of the mosquitoes in the city of Oriximiná, located on the left shore of the Trombetas River. In one house of that city, 21 clay pots with water were found, which were used to protect plants from ants. All of the pots contained large numbers of *Stegomyia* larvae and nymphs<sup>15</sup>.

According to statistical data, yellow fever had not yet arrived in Oriximiná. Even though there was no recorded case of the disease, the city was at great risk of infection, as it was in contact with Óbidos and Manaus through motor boats with their respective batelões (large flat boats, made of iron or wood, with or without a propelling system, used for cargo transportation—the ones used in the region were towed by motor boats). The danger was that infected mosquitoes could be transported to Oriximiná inside of the batelões<sup>7</sup>.

Similar to what had been done in Santarém, Costa Lima carried out a complete mapping of culicidae existing in the city of Óbidos and could list 13 species: *Stegomyia calopus* Meigen, *Cellia albimana* Wiedemann, *Megarhinus hemorroidalis*, *Ianthinosoma musica* Say, *Culex fatigans* Wiedemann, *Protoculex serratus* Theobald, *Mansonia titillans* Walker, *Mansonia pseudo-titillans* Theobald, *Mansonia amazonensis*, *Ianthinosoma lutzi*, and *Limatus durham*<sup>15</sup>.

In this report, Costa Lima described in detail the places where the culicidae and their respective larvae were captured, specifying their diurnal and nocturnal habits. In addition, he outlined the geographical aspects that facilitated the swamp formation along the riverside that could harbor foci of mosquitoes.

As a result of the Comissão's services in the drainage of a large wet area between the city of Óbidos and the Serra da Escama, as an attempt to combat malaria and yellow fever, Costa Lima was honored by the local prefecture, and the Igarapé Pauxis was renamed Igarapé Dr. Costa Lima.

The campaigns carried out in Santarém and Óbidos led Costa Lima to search for alternative ways to combat mosquitoes. He attempted to establish a methodology to "naturally" combat the proliferation of these insects, especially the yellow fever vector *Stegomyia*. For these efforts, Costa Lima started to study other regional insects and larvae-eating fishes that could be used to combat the *Stegomyia* larvae.

## NATURAL ENEMIES OF LARVAE

Several studies on mosquito larvae were developed by the researchers of the United States Department of

Agriculture. In 1900, Leland Osborn Howard published a short manual: *Prevention and remedial work against mosquitoes*. In that publication, he detailed methods of prevention and combat, declaring that the larvae of the *Megarhinus* species, diptera whose larvae exhibit carnivorous behavior, were used in some American rivers to destroy the *Stegomyia* larvae<sup>21</sup>. Upon learning of this publication, Costa Lima asked his American colleague to send him a copy. In his reply to that request, Howard informed that:

Upon receipt of your note dated April 18, with \$4.00 attached, I will try to buy a copy of the book and mail it to you together with the change. In addition, I'll send you the Bulletin 88 and the Farmer's Bulletins 444 and 450 of the Department<sup>20</sup>.

Costa Lima applied the American experience in his studies during his work to combat the mosquitoes in Santarém and Óbidos. For him, it would be useful for prophylaxis to cultivate *Megarhinus* to obtain larvae that would be distributed in water reservoirs whose water could not be filtered or discarded. In addition, the *Megarhinus* larvae were as carnivorous or more so than another genus of mosquito, *Lutzia*, as confirmed in his experiments. These larvae were used to avoid wasting drinking water, as that was neither a reasonable nor a practical measure in a city where those larvae existed. His observations on the voraciousness of the *Megarhinus*, in other words, the quantity of larvae eaten in a specific interval, allowed him to estimate the quantity of larvae needed to populate regional domestic wells and rivers.

In the combat of *Stegomyia*, the use of fish was another natural and also practical process used in the destruction of larvae, especially in a region that had a great variety of fish that could be used in the research.

Still in Belém, before leaving for Santarém and Óbidos, Costa Lima, together with Jacques Huber, a Swiss biologist who was at that time director of the Goeldi Museum, directed a series of investigations in the *Paraense* Museum to identify which regional fishes presented more voracity for the destruction of *Stegomyia* larvae and that could be used in domestic wells to combat these insects. These investigations, which were continued in Santarém and in Óbidos, led him to carry out observations on mosquito larva respiration. The data collected in that investigation were very helpful in the work he later published in the *Memoirs of the Oswaldo Cruz Institute* in 1914<sup>14</sup>.

Both in Santarém and Óbidos, the Committee populated the water reservoirs with the fish to avoid the proliferation of *Stegomyia*. In Santarém, they used small *piabas* from the Tapajós River, whereas in Óbidos, the largest source of fish was Lake Pauxis. To study which species of fish consumed larvae with the most voracity, Costa Lima had a cedar swimming pool built, which was divided into three compartments internally covered with zinc: the first compartment housed the fish used in the experiment where water with larvae was poured; the second compartment the small fish; and in the third compartment the bigger fish were saved for subsequent use<sup>14</sup>.

The experiments were performed by taking one or two fish of the same or different species from the second or third compartments, and placing them in the first compartment. In that compartment, the water with *Stegomyia* or *Culex* larvae was added. After that, he observed how long the fish took to eat the larvae<sup>14</sup>.

Costa Lima performed the experiment with some of the most common species in the city of Óbidos: Oscar fish ("acará assu", *Astronotus ocellatus*); angelfish ("acará bandeira", *Pterophyllum scalare*); "acará branco", *Chaetobranchius flavescens*; "acará tinga", *Geophagus camopiensis*; "corimatá", *Prochilodus nigricans*; "jaraquí", *Prochilodus insignis*; "matupiry", *Tetragonopterus argenteus*; "mossú", *Synbranchus aff. marmoratus*; "poraquê", *Electrophorus electricus*; "sarapó", *Sternopygus macrurus*; "tamboatá", *Hoplosternum littorale*; jejuí; "traíra", *Hoplias sp.*; "tralhoto", *Anableps anableps*; "jacundí", *Crenicichla lepidota*; "tucunaré-tinga", *Cichla ocellaris*; and uéna, *Xiphostoma taedo*. He concluded that, in general, the "acarás", "corimatas", "jejuís", "tamoatás", "tucunarés", "uénas", and the "jacundís" proved to be good larvae eaters; the "traíras", which almost always lived buried in the dirt at the bottom of the swimming pool, did not eat the larvae. The same was shown for the "mossú", "poraquê", and "sarapó". The spellings used here for the names of the fishes are the same described by Costa Lima in his report of 1912<sup>15</sup>.

## CONCLUSION

The research with carnivorous larvae and with larva-eating fishes had the objective of creating natural mechanisms to combat mosquito proliferation. These two methods showed Costa Lima's concern for the preservation of the environment and for the costs needed to execute this task. The experiments made it possible to combat yellow fever in these cities by using local elements, making the process very accessible to everyone willing to adopt it.

From all the freshwater fishes described in his work, the ones most used by the outbreak brigade to populate the reservoirs were "acarás", "jacundís", and "corimatás". In particular, "acará", or "acará tinga", could eat a huge quantity of larvae in a few minutes, along with "acará bandeira" and "acará assu", which could also eat many larvae in a few minutes<sup>14</sup>.

The results of the research carried out by Costa Lima on larva respiration with this Committee, in the cities of Santarém and Óbidos, were later published in the *Memoirs of the Oswaldo Cruz Institute* in 1914. These works became classics, and the combating of larvae came to be based mostly on that methodology.

The experiences of Costa Lima during the time he spent in the Amazon Region were of fundamental importance for his establishment in the field of systematic entomology. When he returned to Rio de Janeiro, his scientific reputation had already been established. He became a systematic entomologist, and the studies he performed during that period guided his entire academic life.

## Costa Lima e a campanha de combate à febre amarela no Rio de Janeiro e no Pará, Brasil

### RESUMO

Com a confirmação do papel dos insetos na transmissão de doenças, rapidamente se desenvolveu, em Manguinhos, uma "escola de entomologistas". As bases desta escola foram, sem dúvida, lançadas por Oswaldo Cruz, que, mesmo sem ser um especialista em entomologia, adquiriu no Instituto Pasteur de Paris os conhecimentos fundamentais que lhe permitiram ocupar-se posteriormente do estudo dos culicídeos. A aproximação de Costa Lima com Manguinhos e Oswaldo Cruz está intimamente ligada ao início de sua trajetória, pois é neste Instituto, e com seu diretor, o contato inicial do cientista com a pesquisa entomológica. Diplomado em medicina em 1910, logo deixou o cargo que exercia, ainda como estudante, de auxiliar acadêmico dos serviços federais de saúde pública, passando a fazer parte, como inspetor sanitário, da comissão organizada por Oswaldo Cruz para combater a febre amarela no Estado do Pará. Em Belém, e sobretudo em Santarém e Óbidos, Costa Lima teve a primeira oportunidade de abordar a pesquisa entomológica, estudando a bionomia dos culicídeos. Em um espaço de tempo relativamente curto, tornou-se um importante cientista, destacando-se como um dos mais proeminentes entomologistas do país.

**Palavras-chave:** História da Ciência; Costa Lima; Febre Amarela; Entomologia; Biografia.

## Costa Lima y la campaña de lucha contra la fiebre amarilla en Río de Janeiro y en Pará, Brasil

### RESUMEN

Con la confirmación del papel de los insectos en la transmisión de enfermedades, se desarrolló rápidamente en Manguinhos (Rio de Janeiro) una "escuela de entomólogos". Los fundamentos de esta escuela fueron, sin duda, establecidos por Oswaldo Cruz, que, aunque no era un experto en entomología, adquirió en el Instituto Pasteur de París los conocimientos fundamentales que le permitieron abordar más adelante el estudio de los culícidos. La aproximación de Ângelo Moreira da Costa Lima a Manguinhos y Oswaldo Cruz está estrechamente relacionada con el inicio de su carrera, ya que fue en este Instituto, y con su director, donde se dio el contacto inicial de ese científico con la investigación pesquisa entomológica. Graduado en medicina en 1910, dejó el cargo que ocupaba como estudiante como auxiliar académico de los servicios federales de salud pública, y pasó a formar parte, como inspector de salud, del comité organizado por Oswaldo Cruz para luchar contra la fiebre amarilla en Pará. En Belém, en especial en Santarém y en Óbidos, Costa Lima tuvo la primera oportunidad de abordar la investigación entomológica estudiando la bionomía de los culícidos. En un espacio de tiempo relativamente corto, se convirtió en un científico importante, destacando como uno de los entomólogos más prominente de todo Brasil.

**Palabras clave:** Historia de la Ciencia; Costa Lima; Fiebre Amarilla; Entomología; Biografía



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