

# Myiasis by *Cochliomyia hominivorax* (Coquerel, 1858): A Neglected Zoonosis in Brazil

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**How to cite this paper:** de Barros, G.P. and Bricarello, P.A. (2020) Myiasis by *Cochliomyia hominivorax* (Coquerel, 1858): A Neglected Zoonosis in Brazil. *Open Journal of Veterinary Medicine*, 10, 80-91.  
<https://doi.org/10.4236/ojvm.2020.106007>

**Received:** May 27, 2019

**Accepted:** June 25, 2020

**Published:** June 28, 2020

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## Abstract

Myiasis is the lesion resulting from the parasitism of diptera larval form in the living tissues of vertebrate animals. These are bloody conditions, causing severe damage to the welfare and the health of humans and animals. In Brazil, *Cochliomyia hominivorax* is the main responsible species for causing myiasis in humans and animals. The conventional treatment of these lesions in animals massively uses chemosynthetic products. The irrational use of these molecules has led to environmental degradation and has affected human health. The standard treatment of human myiasis is based only on larvae removal, surgically or not, supported by the use of antiparasitic drugs. Human myiasis is an important zoonosis, given its close relation with animal myiasis. However, this zoonosis has currently been neglected in Brazil and other developing countries in America. The One Health approach makes it possible to realize that the occurrence of myiasis in humans is directly related to the maintenance of stocks of this diptera in nature. Recognizing the direct relation that domestic and wild animals have as reservoirs in the human myiasis cycle is essential, in order to formulate strategies to control this ancient and important disease that still affects the population in Brazil.

## Keywords

Parasites, Screwworm Fly, One Health

## 1. Introduction

Myiasis is the lesion resulting from infestation by larvae of dipterans that parasitize and destroy the tissues of vertebrate hosts. This term was created by Hope, (1840) [1] and its use is adapted according to the focus of the study and to the area of interest on the topic. The two main approaches are clinical and parasitological. In the clinical approach, myiasis is classified based on parasitized sites of

the host: myiasis of the cutaneous, cavitary (nasopharyngeal, ocular and urogenital) or intestinal types. As for the parasitic aspect, the infestation can be classified as being obligatory, optional or accidental, as well as primary and secondary [2] [3].

In Brazil, myiasis with the highest occurrence and relevance is caused by the fly *Cochliomyia hominivorax* (Coquerel, 1858), classified as obligatory myiasis. This fly is the main cause of primary myiasis in both animals and humans in the country [4] [5] [6]. These conditions are commonly named “screwworm” and cause extremely bloody and aggressive injuries, mainly because they have very fast clinical evolution. Myiasis caused by *C. hominivorax* in animals predisposes to the occurrence of new diptera ovipositions at the edges of the active lesion, further increasing the severity of the disease [7]. Myiasis naturally tends to suffer bacterial contamination and this fact can promote bacterial migration via bloodstream and culminate in septicemia and death of the host when without immediate treatment [8]. Myiasis is a serious problem for both human and domestic animals' health [9].

For thousands of years, humans have tried to treat the omnipresent infections in our communities. With the advent of improvement in basic sanitation and advances in medicine, parasitic infections rarely affect human life in the developed world. However, this reality contrasts with the developing world, where being infected is still commonplace in many communities. Programs aiming at eradication of parasites through mass chemotherapy have the inherent risks of resistance to antiparasitic drugs. The evolution of widespread parasitic drug resistance in the parasite population makes a medication ineffective and inefficient, reducing its ability to treat diseases in a short time. This is especially problematic in case of only one or a few medications being effective against a specific parasite [10].

The One Health concept provides an integrated framework for observing and improving health problems involving human, animal and environmental factors [11], and it can be applied, in particular, to issues related to zoonotic diseases such as myiasis.

## **2. *Cochliomyia hominivorax* Biology**

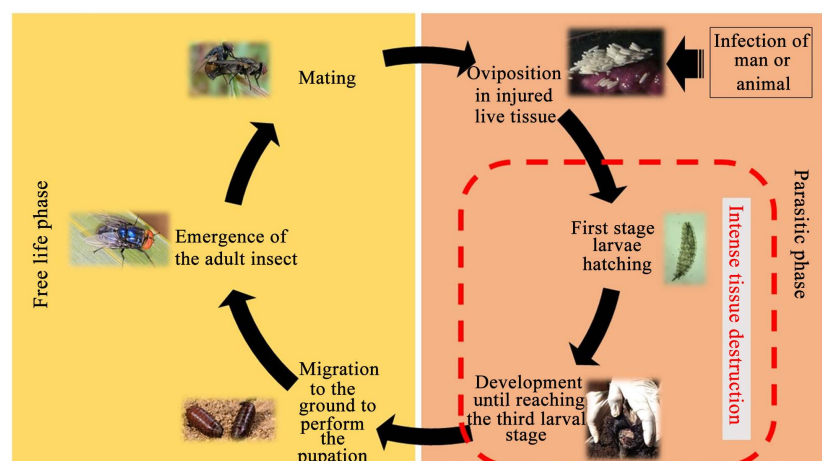
*C. hominivorax* is a dipteran of the Calliphoridae order and it had its biology first described by Coquerel, (1858) [12]. Currently, this species is known as the “New World Screwworm” due to its endemic occurrence in tropical, subtropical and temperate zones in the western hemisphere [13]. The northern and southern borders of its geographical reach are mainly due to low temperatures [14]. *C. hominivorax* is present in all countries in South America, with exception for Chile. This fly is also present in Cuba, Dominican Republic, Haiti, Jamaica and Trinidad and Tobago. *C. hominivorax* has been eradicated from the United States of America, Mexico, Guatemala, Belize, Honduras, El Salvador, Nicaragua, Costa Rica and Panama. Currently, there is a barrier zone maintained in Panama, by using the sterile male technique and field operations to prevent its immi-

gration to areas already eradicated. Eradication has also been achieved in Curaçao, Netherlands Antilles, British Virgin Islands, American Virgin Islands and Puerto Rico [3] [4] [15].

Individuals of the species *C. hominivorax* have holometabolous development (Figure 1). Adults feed on nectar, but their larval stage must necessarily feed on the living tissues of warm-blooded animals. Flies are attracted by blood odor and secretions from the inflammatory process of animals and humans. They lay their eggs near wounds, skin lacerations or damaged natural orifices. Each fly of this species can lay more than 400 eggs at a time, which hatch after 12 to 24 hours. The larvae immediately migrate into the traumatized tissues and form the characteristic lesions named myiasis. They feed on the living tissues of the hosts as they increase in size and develop, until they reach the third and final larval stage. Larval parasitism remains for 5 to 7 days and during this period, the host suffers several damages to its health and welfare. After this period, the larvae actively leave the host's body and migrate to the soil, where they undergo a period of complete metamorphosis until they emerge as an adult fly after 9 days [3] [13] [16].

### 3. Impact on Animal and on Environmental Health

The occurrence of myiasis by *C. hominivorax* in livestock results in major negative economic impact on productive chains linked to production of protein from animal origin, mainly beef cattle [17]. The economic losses are mainly due to the drop in the zootechnical performance of affected animals. The main effects reported in animals parasitized by *C. hominivorax* are decrease in live weight, drop in milk production, loss of skin and leather and even mortality. In addition, there is also an increase in health inspection costs, treatment and labor costs, increased use of insecticides, services and veterinary medicines [18]. The eradication of this species had an annual saving of approximately US\$ 796 million for US producers. In Mexico, this impact was US\$ 292 million and US\$ 77.9 million



**Figure 1.** Life cycle of *Cochliomyia hominivorax* (Coquerel, 1858). Source: Own authorship.

in Central America [19]. In Brazil, Grisi *et al.*, (2014) [18] estimated that the annual economic losses resulting from the occurrence of myiasis by *C. hominivorax* in cattle are approximately US\$ 0.61 billion. In a prospection on possible effects of eradication of this diptera in South America, Wyss (2000) [15] estimated that the annual economic benefits for producers in this region could reach US\$ 2.8 billion (corrected for 2015: US\$ 3.91 billion).

The main form of treatment and control of myiasis by *C. hominivorax* in zootechnical animals consists of massive use of chemosynthetic insecticides, either topically or systemically [17]. Currently, there are several scientific reports on the loss of therapeutic and prophylactic efficacy of chemosynthetic insecticides to control myiasis in domestic animals [17] [20]. The indiscriminate use of these products causes high economic expenses for producers, besides offering risks to managers' and consumers' health [21]. In addition, these products pose very harmful effect on the environment, as being basically composed of synthetic molecules, they tend to persist in environments and bioaccumulate in living organisms [22]. Many of these drugs, routinely used as antiparasitic in livestock, should be considered by the current Brazilian legislation of the Ministry of Agriculture, Livestock and Supply, as pesticides for veterinary use. The invisibility of risks, associated with the handling of veterinary insecticides, increases human exposure to chemical agents, and this may cause serious public health problems [23]. This very invisibility leads to neglect of respect for the grace period of animal by-products, resulting in insecticides residues in foods such as meat, milk and honey. The action mechanisms of these drugs are not mostly species-specific. Thus, they have lethal or toxic action not only on the target parasites, but also on a range of organisms, which are beneficial to the maintenance of life and the ecological balance of the agroecosystems, in which the animal production is inserted [22] [24] [25]. The harmful impact of these molecules on bees is already well known [26] [27] [28].

#### 4. Impact on Human Health

The World Health Organization (WHO) classifies human myiasis as a serious medical condition, requiring urgent treatment after its diagnosis [29]. Myiasis represents a major health risk for people with inadequate hygienic habits and the ones who are more predisposed to skin lesions, this way, increasing their susceptibility to these infestations [30]. However, parasitism is not uncommon in travelers from countries where infestation is atypical, rare and, in some cases, reported as exotic [31] [32]. Accurate and timely diagnosis is important, not only to relieve the patient's symptoms, but also in order to prevent the establishment of myiasis-causing flies in regions where it is not endemic; a phenomenon that is already happening with the circulation of farm animals [2] [5]. There is great concern about the possible introduction of this species in countries where this fly does not currently occur. In Australia, for example, the Department of Agriculture, Water and Environment has a robust surveillance program to prevent this disease. The Australian program includes fly bait traps around airports,

seaports, areas considered high-risk and animal inspection [31].

The prevalence and incidence of myiasis in humans are directly correlated with the increase in fly populations, poor hygiene conditions and the presence of animals in domestic environments [8]. Poor hygiene and low socioeconomic status are the most important risk factors for the occurrence of human myiasis in Brazil. The abundance of suppurative exposed lesions ends up attracting and stimulating the deposit of eggs by the female of *C. hominivorax*. In some cases, specific habits of certain populations, such as sitting or lying on the floor, and some religious rites, as well as regional climatic conditions, can also contribute to the occurrence of myiasis [5]. In addition, factors such as neglected open wounds, and the presence of natural fetid discharge in openings of the body are also linked to the occurrence of myiasis in humans [33]. This incidence in humans is generally underreported [32], particularly in tropical regions [34]. There is significant amount of scientific communications reporting on human beings affected by myiasis in Brazil [30] [33]-[39]. The incidence of oral myiasis in humans is 28% in India and 26% in Brazil, with *Chrysomya bezziana* and *Cochliomyia hominivorax* as the most prevalent species, respectively [40]. Clinical manifestations of human myiasis depend on the affected organ or tissue, and the prognosis is directly related to the duration and the location of the lesion, as well as the patient's general health conditions. Patients with chronic diseases, immunosuppressed and with impaired mobility are the most affected [39].

One of the biggest problems for myiasis treatment in humans is the lack of suitable and tested drugs for safe use in humans [41]. Empirical and domestic treatments of affected patients are common. Even when care is available, access to entomologists with experience in classifying diptera is often difficult. Thus, medical reports presenting the number of cases observed do not represent the reality. Epidemiological studies of this disease tend to show high percentage of underreporting. In some developing countries [2] [5], human myiasis can be a real public health problem, being neglected [34]. Commonly described treatment in scientific literature for cases of myiasis in humans begins with the removal of the larvae from the affected site. This procedure occurs instrumentally, with the use of local analgesia or even anesthesia, when necessary [30]. The location of myiasis can be a limiting factor in the removal procedure and in some cases surgical intervention is required [40], making this a bloody and painful procedure for the patient. In order to remove the larvae from the host's body, it is essential that they are dead or paralyzed [41]. The *C. hominivorax* larvae have very effective spines in promoting their adhesion to the host's tissues [9].

Currently, the most commonly used medication in this situation is oral ivermectin [30] [42] [43] [44] [45] [46]. Ivermectin is a broad-spectrum antiparasitic drug, traditionally used in veterinary medicine to treat ectoparasites and nematodes [47]. In humans, it is used only orally, combating some worms and infestations by mites and lice [48]. In case of myiasis, ivermectin causes paralysis of the larvae and facilitates their removal [49]. However, there are no consistent pharmacological or toxicological studies to date, attesting to a safe therapeutic

dose for use in humans, in order to subsidize the regulation of this drug for the treatment of human myiasis at the National Health Surveillance Agency of Brazil.

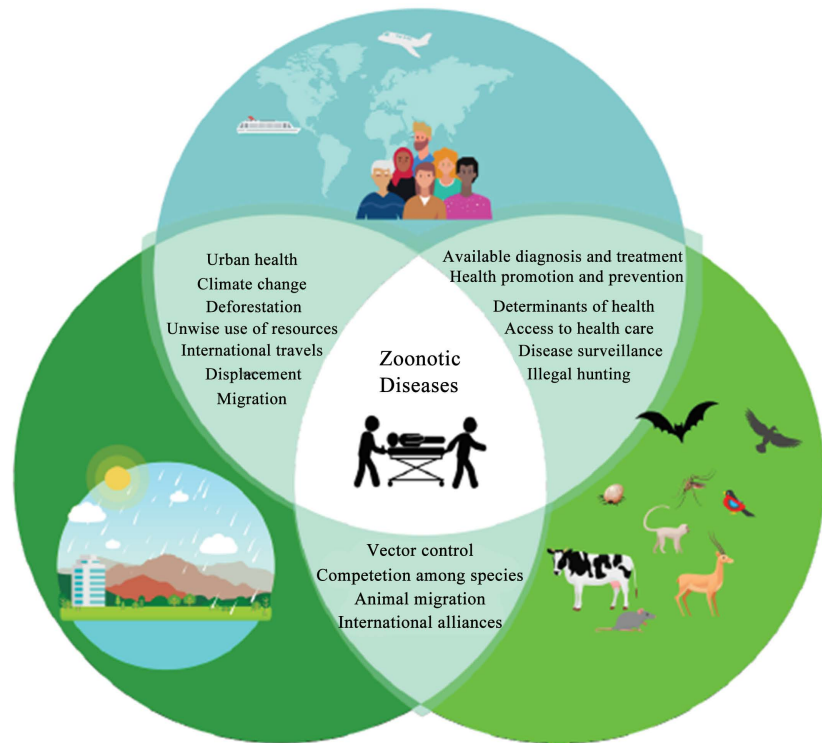
## 5. One Health-Relation among Human and Animal Myiasis and the Environment

The One Health (OH) concept helps us understand interactions among animals, humans and the environment, and how these interactions affect the occurrence of infectious and parasitic diseases. OH provides an integrated framework for observing and improving health problems involving these three factors and it can be applied, in particular, to problems related to zoonotic diseases [50]. This approach aims to promote interdisciplinary collaborations among wildlife biologists, behavioral scientists, ecologists, agronomists, veterinarians, doctors, engineers, bioscientists, epidemiologists, among others, to achieve optimal health for humans, animals and the environment [51]. Many emerging diseases arise from complex, diverse and constantly evolving factors related to the environment (e.g. deforestation, climate change), people (e.g. urbanization, food purchases) and animals (e.g. intensification of animal production, translocation of wildlife) [52] [53].

Zoonoses are diseases or infections naturally transmitted between animals and humans in different situations and environments. They can be transmitted directly by animals or, indirectly, through the consumption of contaminated animal products, through insect vector stings or through production residues that can contaminate the environment [54]. According to the World Organization for Animal Health (OIE), about 70% of human diseases emerging in the last century are zoonoses. According to the same source, more than 60% of all human infectious diseases in the world today come from animal transmission and 80% of agents with potential for bioterrorist use are zoonotic pathogens. Zoonoses contribute significantly to losses in animal production systems, due to decreased productivity and welfare, as well as imposing economic losses on countries, due to the health status of herds [55]. Human myiasis is an important zoonosis, given its close relation with animal myiasis [2] [5]. However, this zoonosis may currently be neglected in Brazil and other developing countries [51] [56].

The study on dynamics of contemporary diseases occurrence from the perspective of One Health has enabled better understanding of the overview, thus, allowing for more appropriate and assertive control measures (Figure 2) [50] [53] [57].

Growing urbanization, industrialization and the advancement of agriculture and livestock provide deeper contact between human populations and their domestic animals, with populations of wild animals in their habitats, facilitating the spread of infectious and parasitic agents among these hosts [55]. Animals can be reservoirs and zoonoses carriers of potential significance in public health, in the conservation of wildlife and in economic aspects [57].



**Figure 2.** “One Health” approach to address zoonotic diseases (Source: Marbán-Castro, E., Mattar, S. and Tous, M. G. (2019). Las zoonosis reemergentes bajo el enfoque de “Una salud”. *Revista MVZ Córdoba*, 7280-7284. <https://doi.org/10.21897/rmvz.1777>).

Applying the epidemiology concepts on the understanding of the occurrence dynamics of human myiasis by *C. hominivorax*, the role of natural reservoirs for human myiasis can be attributed to domestic and to wild animals. The occurrence of myiasis in humans is directly related to the maintenance of stocks of this diptera in nature. As the larvae of *C. hominivorax* necessarily feed on the living tissues of warm-blooded animals, they find their most frequent hosts as domestic and wild animals, only occasionally affecting humans. Human beings are generally parasitized when in situations of poor health or reduced mobility, since being in perfect health conditions easily repels the fly and stops it from ovipositing on exposed wounds or tissues [2] [5] [16] [58].

This type of approach has gained researchers’ adherence in the study of other parasitic zoonoses, especially in human scabies [54] [59] [60].

## 6. Final Considerations

The concept of One Health helps us understand the interactions among animals, humans and the environment, and how these interactions affect the occurrence of diseases. This approach can offer tools, which are compatible with contemporary paradigms related to the development, implementation and maintenance of health policies, implementing coordinated actions for humans, animals and the environment, in order to reduce parasitism by *C. homonivorax* and other parasitic zoonoses.

Constant and impacting human action in the environment, such as deforestation of ecosystems and the intensive livestock production model, has placed humanity increasingly in contact with pathogens that cause zoonoses, especially those not species-specific, as is the case with *C. hominivorax*.

Prevention and control of disease-causing agents in humans and animals are priorities for research in veterinary medicine. Several actions aimed at zoonoses control, such as myiasis, can be carried out or improved by public agencies linked to health defense, along with private entities, universities, among other civil institutions. Among these actions, the encouragement for epidemiological studies about the population dynamics of *C. hominivorax* can be mentioned, as well as planning and periodic evaluation of techniques for parasitological diagnosis, entomological surveillance, publication of results and notification of outbreaks, including compulsory notification. In addition, information and training for health professionals are important for timely diagnosis and treatment of myiasis.

## Acknowledgements

The authors thank the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for the research scholarship awarded to G. P. Barros and financial support for this study (Grant number 402867/2017-3).

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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