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Chapter

Bronchopulmonary Lophomoniasis, Infection by Endocommensal Protozoa of Intradomiciliary Cockroaches: Presentation of a Case in an Immunocompromised Patient from Querétaro, Mexico

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Abstract

Infection in humans by the intestinal protozoan of cockroaches and termites called *Lophomonas blattarum* has been diagnosed in respiratory infections of children aged 2–5 years contaminated orally or by air, with cysts or trophozoites contained in the feces of the cockroach *Periplaneta americana*. In respiratory infections of adults, it is difficult to diagnose since the cyst or trophozoite is not recognized as a human pathogen and is only related to immunosuppressed patients, transplant patients with severe lung disease and those living in poor and unhealthy sanitary conditions. Normally, its presence is manifested with fevers of 38–39°C, cough with thick expectoration, respiratory insufficiency and pulmonary abscesses. The laboratory diagnosis is mainly based on bronchoscopic cytologies and bronchoalveolar lavage biopsies. The case in question is about a 60-year-old male. Single, he lives alone, with a diagnosis of 9 baths behind non-Hodgkin lymphoma, undergoing treatment with radiotherapy and chemotherapy. For edema after treatment, thoracentesis and pericardiocentesis were performed, as well as gastrostomy, which he maintained for 1 year. He started with throat discomfort, followed by production of productive cough without blood, general weakness, and difficulty breathing, with apparent diagnosis of possible respiratory failure due to mycobacteria. It was possible to visualize the protozoan, in fresh preparations of bronchial aspirate and expectoration in wet assembly with saline solution and stained with Pap smears, Harris Hematoxylin and Eosin (H/E), and Giemsa.

Keywords: American periplaneta, multiflagellated protozoan, bronchopulmonary lophomoniasis, endocommensal, immunosuppression

1. Introduction

1.1 *Lophomonas blattarum*

It is an anaerobic multiflagellated intestinal protozoan, endocommensal in the intestine of some arthropods, such as termites and cockroaches (Dictyoptera: Blattoidea), which contaminate in its path food, dust and clothes with its secretions and feces [1–11].

The genus *Lophomonas*, since 1990, has been considered among the protozoa that cause damage to the respiratory tract, especially in immunocompromised individuals (HIV/AIDS, with neoplasms, and use of corticosteroids and transplants) and in adult and pediatric asthmatic individuals [2–6].

The signs and symptoms of *Lophomonas* infection are similar to pneumonia and bronchitis or bronchopulmonary pathologies of various etiologies; therefore, a correct diagnosis is difficult. The above requires us to duly attend the microbiological study of expectoration, brushing, biopsy or bronchoalveolar lavage samples, whether fresh or stained preparations, especially when observing multiflagellated forms, since if you do not have enough experience trophozoites of *Lophomonas blattarum* can be confused with ciliated epithelial cell fragments (ciliocytoforia) of the bronchi [5–7].

It is important to note that conventional techniques, such as staining of Gram, Giemsa and Papanicolaou smear, do not allow adequate visualization of multiflagellating. Therefore, it is necessary that upon suspicion, a fresh preparation with saline solution is first performed on all samples of the respiratory tract that arrive at the laboratory for parasitological diagnosis, and subsequently, perfectly extended smears are stained with special dyes such as Masson's trichrome [5].

The most clinically important species are *Lophomonas blattarum* and *Lophomonas striata*. The latter was the species first identified in the intestine of the cockroach *Blatta orientalis* by S. Stein in 1860 [6]. The structure of *L. blattarum* was identified in the optical microscope in 1911 and in 1990 with a scanning and electron microscope. The shape of the *Lophomonas* trophozoite is usually round, oval or pyriform, ranging in size from 15 to 50 μm in diameter, with a plume of flagella that form a bunch located at the anterior end, the largest being those found far away from the apical fissure. It contains phagocytic vacuoles in its cytoplasm, with outward rhythmic movements directed to the apical end in order to eliminate excretions or trap foreign materials [1] (**Figure 1**).

The cockroaches (**Figure 2**) originate as perfectly recognized pests of closed, dark places, which abound at the beginning of the hot climate and which become visible at night when leaving their natural habitat (sewers) to look for their food in the periphery and/or inside the houses [12]. As vectors were not considered capable of transmitting pathogenic organisms to humans, however, studies were conducted by Roth and Willis in 1957, and citing evidence occurred in a pediatric hospital in Brussels, Belgium, where an epidemic of *Salmonella typhimurium* persisted in newborns, despite the rapid isolation of patients, the absence of healthy carriers and the suppression of direct or indirect contact, except for the isolation of cockroaches. However, it was discovered that at night the cockroaches walked on the clothes, blankets and bodies of the babies, and the bacteria were isolated from the body of a considerable number of insects [13]. The epidemic ceased immediately after a severe control of the cockroaches. Rueger and Olson in 1969 showed that the feces

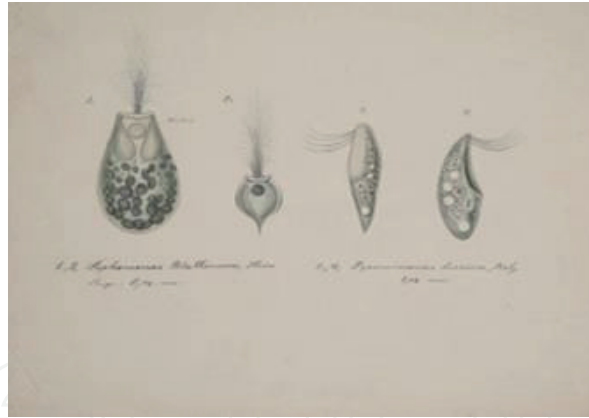


Figure 1.
In the 1860s, S. Stein discovered some multiflagellates in the cockroach's intestine. Drawings of the structures identified as *Lophomonas blattarum* and *Lophomonas striata* are shown [7].



Figure 2.
Home cockroach. Photo Villagrán-Herrera.

of *Periplaneta americana* infected with *Salmonella oranienburg*, being spread over food and vessels, still contained live bacteria after 3.25–4.25 years [14]. These same authors provided a list of 18 species of domestic cockroaches; from which, it was possible to isolate the pathogenic organisms for man, due to its allergenic exposure or toxicity due to its bite [14] (**Figure 2**).

Let us consider Cornwell's paraphrase in 1968, which stated the following:

(1) Cockroaches prefer environments where both human pathogens and human food are found, freely passing from one to the other; (2) cockroaches can carry pathogens both inside and outside their bodies, which remain viable on the cuticle in the digestive tract and feces to the extent that insects can be chronic carriers and (3) the evidence is sufficient to justify the various programs of control for this insects where human health is endangered [15].

They are usually confined to buildings in cold climates, but domestic cockroaches can escape freely, and in temperate, tropical or hot weather, they can migrate to other buildings through drains, garbage dumps, septic tanks and latrines where they feed, both on human feces and on food. Isolates of intestinal diners from trapped cockroaches indicate that they are carriers of microorganisms (viruses, fungi and intestinal parasites). Among the viruses, there are 4 strains of polio-virus; and approximately 40 species of pathogenic bacteria (enterobacteria), the mycobacterium of leprosy, two pathogenic fungi (*Aspergillus*), and the protozoan *Entamoeba histolytica* are also mentioned. On the other hand, other pathogens that are harbored by these arthropods are mentioned under experimental conditions,

such as Coxsackie virus, mouse encephalitis and yellow fever; the bacterial agents of cholera, cerebrospinal fever, pneumonia, diphtheria, undulant fever, anthrax, tetanus, tuberculosis and others; and the protozoa *Pentatrichomonas hominis*, *Giardia intestinalis* and *Balantidium coli*, agents that produce diarrhea or dysentery [13].

A protozoan that is considered important is the sporozoan *Toxoplasma gondii*, which causes human toxoplasmosis and spreads in many mammals besides birds. This disease is common in humans, although asymptomatic, but it can cause congenital defects in the fetus. It has recently been shown that the biological cycle of this coccidium is limited to domestic cats and other felines [16]. Cats can become infected by feeding on parasitized birds and rodents and subsequently transmit the parasite in their feces and a cockroach that feeds on these debris can transmit the parasite to man. Chinchilla and Ruiz in 1976 demonstrated in Costa Rica the potential transmission of *Toxoplasma gondii* by domiciliary cockroaches to humans [17] (Figure 3).

These species of cockroaches in urban areas have been seen mainly in nurseries, schools or hospitals, where a certain number of their population had presented lung problems of various types, and these problems were not related to the presence of these insects. It was not until the year 2015 that Dalmiro Cazorla-Perfetti found in dissected intestines of some captured insects, in addition to eggs of geohelminths, trypanosomatids, cysts and trophozoites of a multflagellated protozoan called *Lophomonas blattarum* [18] (Figure 4).

On the other hand, in the city of Wuhan, in an intestinal study of 110 specimens of *Periplaneta americana* (pipe cockroach), they showed in preparations stained with Giemsa and seen at 1000 magnifications, oval, pearly shapes, from 20 to 40 μm , with a tuft of flagella extended down the central axis of the parasite and one of its trumpet-shaped ends enveloped the only nucleus shown. It also showed a thin terminal axostyle posterior to the multflagellated part. Based on the above morphological characteristics, the parasite was identified as *L. blattarum*. Of the 110 cockroaches, 44 tested positive for *Lophomonas blattarum* (44%) [18] (Figure 5).

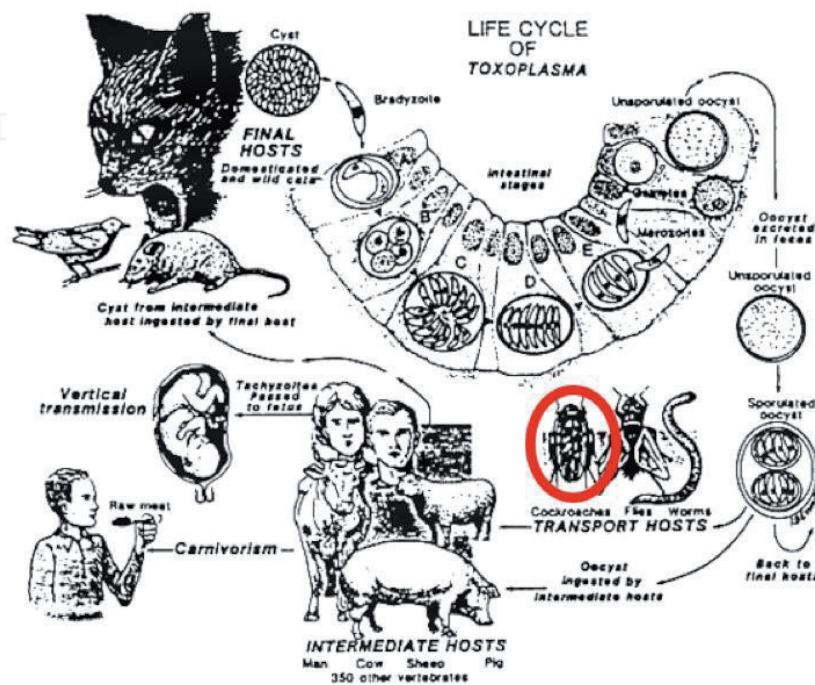


Figure 3. Biological cycle of *Toxoplasma gondii*. You can see the cockroach enclosed in a red circle, like a transporter or possible reservoir of coccidium [16].

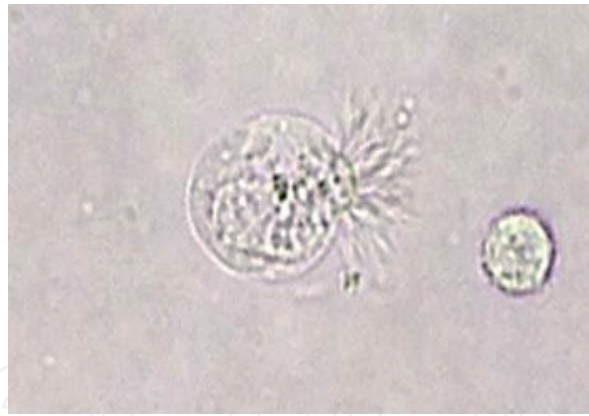


Figure 4.
Cytoplasmic and multifloous trophozoite forms of Lophomonas blattarum are observed 400× [19].

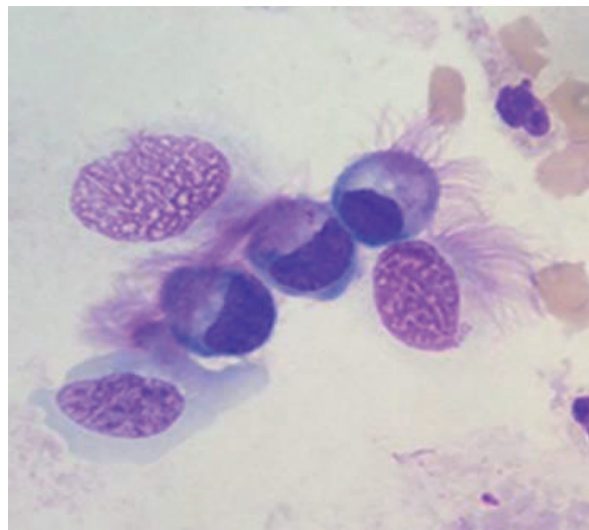


Figure 5.
Structures found in the intestinal dissections of pipe cockroaches in the city of Wuhan. Staining [18].

2. Medical importance of arthropods

The different ways in which arthropods are related to the health and well-being of man are classified into three groups:

- Arthropods as direct agents of diseases or discomfort
 - Entomophobia. Including illusory parasitosis
 - a. Disturbances and blood loss
 - Accidental damage to sense organs
 - a. Poisoning
 - Dermatitis
 - a. Myiasis and associated infestations
 - b. Allergies and associated conditions
- Arthropods as vectors or as intermediate hosts

- Mechanical vectors (more or less casual transmission)
- Mandatory vectors (including some degree of development within the arthropod)
- Intermediary guests (as passive carriers)
- Foretic carriers of harmful arthropods
- Arthropods as natural enemies of medically harmful insects
 - Competitors
 - Predatory parasites

The taxonomic scope of arthropods should be considered together with pentastomids, since the latter have always been considered as a phylum or class apart from the arthropods, however pentastomids such as the *Linguatula serrata* whose adult forms live in the nose of dogs (and exceptionally in the human). Embryonated eggs are released via nasal mucosa or feces. If the intermediate hosts ingest the eggs, the primary four-legged larva emerges and migrates via blood vessels to the internal organs. When the final host ingests raw or undercooked meat from the infected intermediate host, the adult form develops in the nasal tract. These can be parasites of the respiratory tract and cavities of reptiles, birds and mammals. Humans can also be accidental hosts and can be infected by ingesting eggs that later develop nymphs in their tissues (visceral pentastomiasis), or ingest meat infected with nymphs in their tissues, developing in the nose and pharynx adult forms (nasopharyngeal pentastomiasis) or Halzoun disease [20].

In 1973, Lavoipierre and Rajamanickam cited cockroaches as intermediate hosts of long-necked pentastomids [21].

2.1 Nomenclature

The modern system of naming and classifying animals dates from the 10th edition of Linnaeus *Systema Naturae* (1758), in which not only the first complete and ordered group of animals but also a new system of nomenclature appeared. It was Linnaeus who first devised the method of substituting specific unique names for the descriptive phrases that until then had been used in combination with the words that are now known as generic names. Linnaeus recognized six classes of animals; the fifth is the insect, whose definition allowed the inclusion of a large number of creatures that are no longer called insects, rather with their popular name, such as spiders, mites, crabs and centipedes. Its Insecta class was divided into seven orders; each of which contained several genera and each of which included numerous species [22].

2.2 Order dictyoptera

2.2.1 Cockroaches and praying mantises

The only members of this order that have any medical importance are the cockroaches (suborder Blattoidea) associated with man. These rather flattened insects, sometimes similar to beetles that move quickly, are familiar to most people; they can be easily distinguished from beetles by their very flexible, wire-like antennae [23].

Class Insecta	
Subclass Pterygota	
Division Exopterygota	
Order Dictyoptera	Cockroaches and mantids

Table 1.
Taxonomic classification of cockroaches [24].

The cockroaches form an ancient group, which goes back to the Silurian and which has few changes in its general structure since the Devonian, around 320 million years ago. They were very abundant in the Carboniferous marshes, as indicated by their fossil remains in the coal deposits of that period. They are taxonomically admitted in a separate order together with the mantids, in the Dictyoptera or as a suborder of the Orthoptera, in addition to the evidences that show a strong ancestral relationship with the termites [24] (**Table 1**).

The species associated with man attack stored food and infest premises used for storing, preparing and cooking food, such as bakehouses and kitchens, as well as sewers and rubbish dumps. They are known to carry pathogenic viruses, bacteria and helminths and to act as intermediate host for such pathogens as the nematode *Gongylonema pulchrum* Molin (gullet worm) and the Acanthocephalus *Moniliformis moniliformis* Bremser; they are also capable of causing allergic dermatitis. More than a dozen species have some degree of medical importance, but the following six species, all with worldwide distributions, are the principal vectors: the common cockroach (Blackbeetle) (*Blatta orientalis*), the American cockroach (*Periplaneta americana*), the Australian cockroach (*P. australasiae*), the German cockroach (*Blattella germanica*), the brown-banded cockroach (*Supella supellectilium** (Serville) and the Madeira cockroach (*Leucophaea maderae*).

The following descriptions are key to identify the adults of six medically important species of cockroaches:

1. Well-developed forewings, reaching at least the tip of the abdomen.
Front wings absent or underdeveloped, not reaching the tip of the abdomen.
2. Total length (up to the tips of the front wing) more than 18 mm.
3. Total length (up to the tips of the front wing) less than 17 mm.
4. General grayish brown color, pronotum and front wings stamped (**Figure 6F**) *Leucophaea maderae* (Fab).
5. Front wings with a pale yellow stripe along the basal part of the anterior margin (**Figure 6C**) *Periplaneta australasiae* (Fab).
6. Front wings without a pale yellow stripe along the basal part of the anterior margin (**Figure 6B**) American *Periplaneta* (L.).
7. Pronotum with two conspicuous longitudinal dark bands. Front wings uniform color (**Figure 6D**) *Blattella germanica*.
8. Pronotum without dark bands (brown with translucent lateral margins).
Forewings dark basally and pale distally in the male, and dark with pale bands in the female (**Figure 6E**) *Supella supellectilium* (Serville).
9. Legs from reddish brown to dark brown. Uniformly opaque pronotum. Total length greater than 15 mm (**Figure 6A**) *Blatta orientalis* L.

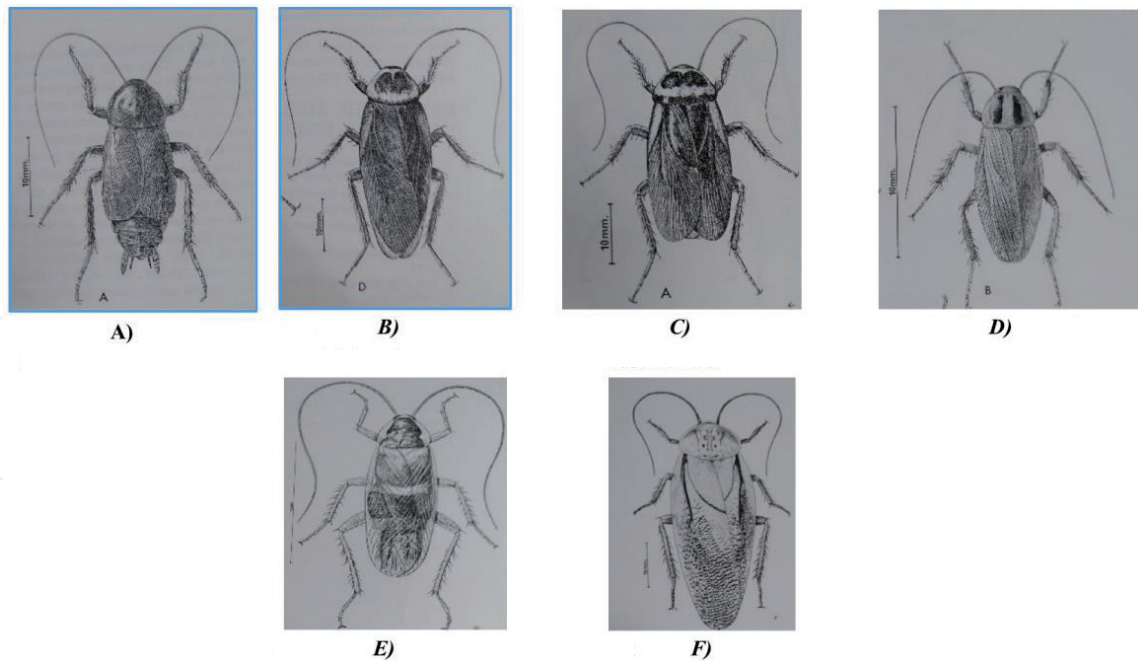


Figure 6. Species of cockroaches of medical importance. A, C, D, E and F are vector agents of viruses, helminths and bacteria for both humans and animals. B is a host of the endocomponent *Lophomonas blattarum*, a multifiliated protozoan [23].

Young cockroaches are similar to those of adults but lack wings [25] (**Figure 6E and F**).

The legs of insects are mainly for walking or running. The prominent antennae are filiform and multiarticulate. The mouthparts are of the generalized biting-chewing type (Orthoptera type). In most species, there are two pairs of wings; in some, the wings are vestigial, and in others, for example in *Blatta orientalis*, they are well developed in the male and short in the female. The outer pair of wings (tegmina) is narrow, thick and coriaceous; the inner pair is membranous and folds like a fan. It is assumed that the common name in English, cockroach, is derived from the pronunciation of Cockroach name in Spanish (koo-kah-rah-chah) [24].

3. Presentation of a clinical case

This is a 60-year-old male doctor by profession, originally from Pachuca Hidalgo, who has lived in the municipality of Cadereyta for 18 years. Denies trips abroad, without physical activity, and indicates adequate personal hygiene. He refers to the diagnosis 9 years ago of non-Hodgkin lymphoma and is in treatment with radiotherapy and chemotherapy. Due to edema after treatment, thoracentesis and pericardiocentesis were performed, as well as gastrostomy, which he maintained for 1 year. Six months ago, he presented with respiratory symptoms, characterized by fever, malaise, cough with expectoration, and data of mild respiratory insufficiency. It is treated with antibiotics, and salbutamol is administered; however, the symptoms reappear after 15 days.

One month ago, he presented with respiratory symptoms with the same characteristics, and he reported that a chest X-ray was performed with unspecified pneumonia data. Presents 6 days ago asthenia, adynamia, hyporexia, malaise, fever of 38.5°C, self-medicated Levofloxacin 750 mg every 12 h, Ceftriaxone 1 g every 24 h, Paracetamol and Metamizol 500 mg orally. Three days

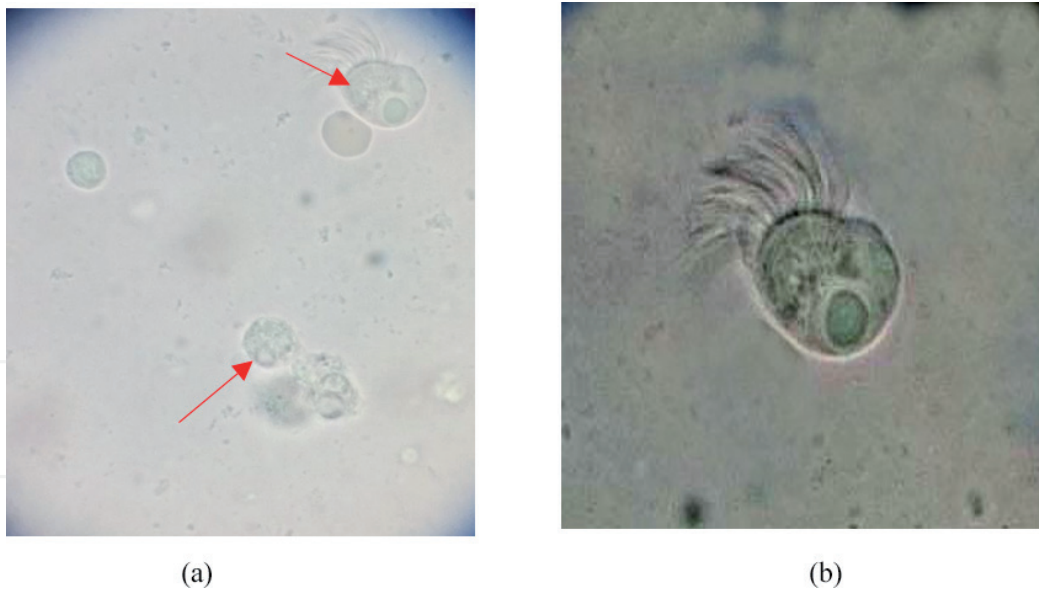


Figure 7.
(a and b) Wet assembly with saline solution, where trophozoites and cysts of *Lophomonas blattarum* are observed. 400 \times . Photo Villagrán-Herrera.

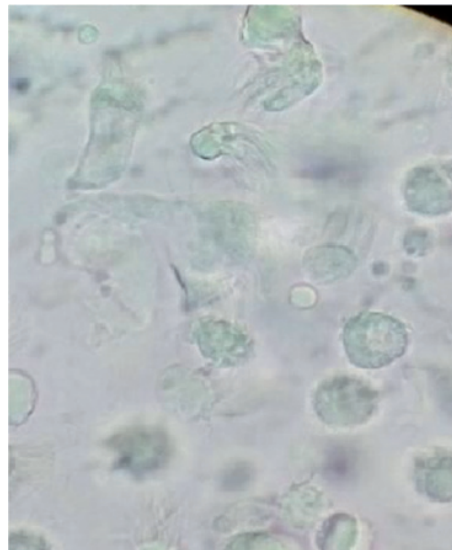


Figure 8.
Wet assembly with saline solution. Multiflagellated trophozoites and cysts were observed in a sample of unstained morning sputum. The vacuole and the many flagella in its narrow part are seen in some forms. These characteristics are compatible with *Lophomonas blattarum*. Erythrocytes are seen that reveal a throat bleeding process. 400 \times . Photo. Villagrán-Herrera.

later, productive cough is added, expectoration with blood streaks, and later, it becomes a uniform reddish color; likewise, the cough persists and the amount of phlegm increases. There is mild dyspnea and no predominance of hours, and salbutamol is self-medicated, showing improvement with the application of the medication. Currently fever, general malaise and mild headache persist. Freshly emitted specimens of sputum are requested and fresh observations are made with saline and several smears, which are stained with Hematoxylin and Eosin (H/E), Papanicolaou and Giemsa. The study on fresh smears reveals trophozoites and cysts of a protozoan multiflagellate identified as *Lophomonas blattarum* (Figure 7a and b).

A large amount of polymorphonuclear leukocytes was observed in the smears before staining, coinciding with an acute inflammatory process (Figure 8).

After the identification of the multiflagellated protozoan, treatment with metronidazole of 500 mg every 8 h was started orally for 7 days, improving symptoms, decreasing dyspnea and continuing with unproductive cough. Control studies are carried out 15 days after the last antiparasitic intake, and the samples were negative for the presence of this protozoan.

4. Discussion

To the cases reported in Peru, China and Spain (**Table 2**), where they found this protozoan in sputum samples, we must add 1 case recorded of a sinusitis in Iran [9], and this one that we are presenting from Mexico, since they have in common denominator deficiencies in the immune system, which makes them extremely sensitive to any infection no matter how mild. It also indicates a possible airborne transmission, with the influence of a humid environment through waste and environmental dust, and that by aspiration, the trophozoites or protozoan cysts can lodge in the bronchopulmonary epithelium, developing the infection with manifestations similar to any bacterial or fungal pulmonary pathology, which makes diagnosis even more difficult.

Our patient presented with respiratory symptoms that indicated possible miliary tuberculosis or some acute respiratory pathology, since in the expectorant product blood threads were observed in some of the emissions, so that without the saline solution wet study, the differential diagnosis would not have been possible to reach.

The immunological commitment of the patient was a crucial and decisive factor for the development of the infection, as self-medication and the lack of an accurate diagnosis were important factors to delay his full recovery.

Autor(s) y años	Caso(s) registrados	País
Chen and Meng [26]	1	China
Dong et al. [27]	1	China
He et al. [28]	2	China
Kang et al. [29]	1	China
Liu et al. [30]	1	China
Liu et al. [31]	1	China
Martínez Girón et al. [32]	1	España
Martínez Girón & Doganci [33]	1	España
Miao et al. [34]	1	China
Shi et al. [35]	1	China
Wang [36]	26	China
Wang et al. [37]	1	China
Yang et al. [38]	1	China
Yao [39]	1	China
Yao et al. [40]	1	China
Yao et al. [41]	1	China
Yao et al. [42]	1	China
Yao et al. [43]	1	China
Yao et al. [44]	1	China

Autor(s) y años	Caso(s) registrados	País
Zerpa et al. (2010)	6	Perú
Zhang, F. et al. [45]	6	China
Zhang, R. S. et al. [46]	1	China
Zhang et al. [47]	1	China
Zhou et al. [48]	1	China
Fariba Berenji et al., 2015	1	Irán
Villagrán et al. 2016	1	México
Total	63	

Two more cases have been added. From Peru and Mexico. It is presumed that in the world, there may be many more cases that have not been reported.

Table 2.
 Reported cases of bronchopulmonary diseases with *Lophomonas blattarum* [5–10].

5. Conclusions

This particular case has been the first diagnosed in the city of Querétaro and reported in the Mexican Republic and illustrates casual infection of *L. blattarum*, a rare opportunistic pathogen, probably acquired by air, developing the patient's lung infection, due to his immunocompromised state. It is essential that doctors consider *Lophomonas blattarum* in their differential clinical diagnosis. Since some dust mites are vectors of similar flagellates, whose respiratory manifestations are due to allergy, are similarly presented and are due to lack of an accurate diagnosis, they are transformed

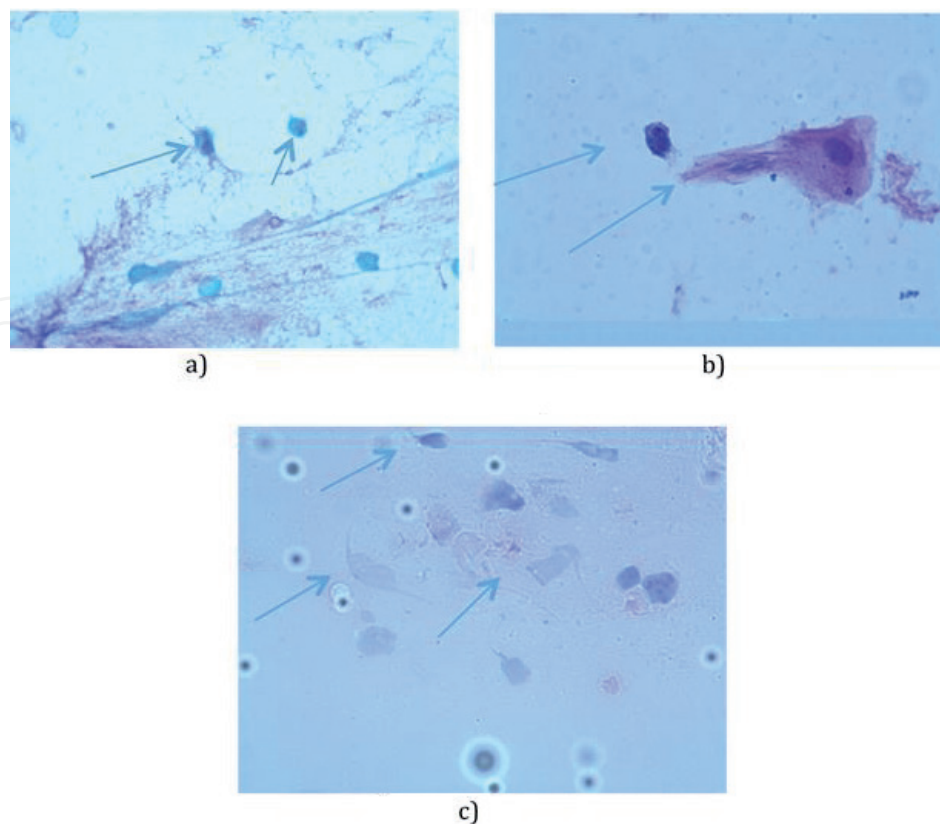


Figure 9.
 Expectoration samples stained with Papanicolaou, Hematoxylin and Eosin (H/E) and with Giemsa, respectively. Observed at 400 X. with immersion oil. Note the difference in the observation of the parasites with each of the staining procedures. Photo Villagrán-Herrera.

into chronic allergies without response to the administered treatment. Regarding the staining procedures applied to the biological sample of our patient, a great difference was observed between the multifilated structures worked in fresh and with saline solution, finding more clearly in the fresh and staining of Hematoxylin and Eosin, than with preparations with Pap smears and Giemsa (**Figure 9**).

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Conflict of interests

The authors declare that there is no conflict of interest in relation to the publication of this clinical case.

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