A Historical Overview of the Classification, Evolution, and Dispersion of Leishmania Parasites and Sandflies in Morocco

Ahmed Tabbabi1,2, Sajida Sboui2 and Khadija Bekhti1

1Laboratory of Microbial Biotechnology, Faculty of Science and Technology, Fez, Morocco
2Faculty of Medicine of Monastir, Monastir University, Monastir, Tunisia

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Abstract

In Morocco, as in most countries around the Mediterranean, leishmaniasis is an important public health problem. The situation has become worrying since the 1970’s and continues to be more complicated. The objective of this work was to realize a historical overview of the classification, evolution, and dispersion of Leishmania parasites and Sandflies in Morocco. The status of the different leishmaniasis could be illustrated in three epidemiological entities: zoonotic cutaneous leishmaniasis (ZCL) due to L. major transmitted by P. (Phlebotomus) papatasi, Anthropornotic cutaneous leishmaniasis (ACL) due to L. tropica transmitted by P. sergenti and cutaneous and visceral leishmaniasis (VL) due to L. infantum transmitted by P. ariasi, P. perniciosus, and potentially by P. longicuspis. Actually, VL occurred mainly in Northern Morocco. The ACL is widely distributed in the central and western Morocco. The ZCL occurred mainly in the south and south-east of the Atlas Mountains.

Introduction

In Morocco, as in most countries around the Mediterranean, leishmaniasis is an important public health problem [1]. The situation has become worrying since the 1970’s and continues to be more complicated. With the agro-sylvo-pastoral practices, hydraulic development, overpopulation, and migration, the disease becomes more extensive in recent years, and the emergence of new Leishmanian foci has been noted. In 2011, Moroccan Ministry of Health reported 4319 cases [2] of cutaneous leishmaniasis (CL) and 107 cases of visceral leishmaniasis (VL).

Cutaneous leishmaniasis has been known in Morocco for almost a century. It was considered a sporadic affection. Foley et al. [3] reported the existence of the endemic buds in the southeast Morocco. Cases of Oriental buds were reported in Fiqug [4] and the Moroccan Atlas [5]. In 1977, with the halting of DDT spraying operations against malaria in the south of the country, it began the development of epidemic fashion. Several epidemic outbreaks erupted in the sub-Saharan zones, due to L. (Leishmania) major [6].

The first mention of human visceral leishmaniasis in Morocco was mentioned by Klippel and Monier [7] in Meknes in 1921. Observations recorded thereafter showed a wide dispersion of the disease in the various provinces of the country. If the region of the North: Tangiers [4], Fez [8], Casablanca [9] and Azrou are frequently cited, other publications located further south: Inherm, Tata and Goulimime [10].

Since 1970s, the situation of leishmanioses become worrisome in Morocco, which has led to the development of a Franco-Moroccan study program, under the direction of Professor Rioux, to analyze the different Leishmanian foci. The trapping of sandflies and the isolation of Leishmania were carried out. According to Rioux [11], L. major, L. tropica and L. infantum were identified as the parasite species responsible for the diseases.

Before 1993, the lack of epidemiological information system based on collected data on leishmaniasis means that the available data hardly reflect the actual epidemiological situation. Between 1994 and 1999, taking into account the case reports during this period, the situation of the different leishmaniasis could be illustrated in three epidemiological entities [12]: zoonotic cutaneous leishmaniasis (ZCL) due to L. major transmitted by P. (Phlebotomus) papatasi, Anthropornotic cutaneous leishmaniasis (ACL) due to L. tropica transmitted by P. sergenti and cutaneous and visceral leishmaniasis (VL) due to L. infantum transmitted by P. ariasi, P. perniciosus, and potentially by P. longicuspis. Actually, VL occurred mainly in Northern Morocco. The ACL is widely distributed in the central and western Morocco. The ZCL occurred mainly in the south and south-east of the Atlas Mountains.

Zoonotic cutaneous leishmaniasis due to L. major

In southern and eastern Morocco, ZCL due to L. major was characterized by its endemo-epidemic character. The first outbreak was identified in the south of the Anti-Atlas, in the palm groves of Wadi Tata, where a major outbreak of cutaneous leishmaniasis occurred in the late 1970s. After the Tata epidemic two new outbreaks have been identified: one in Ouarzazate and the other in Oujda [6,13].

The enzymatic analysis of the isolates obtained at the beginning of the epidemic allowed identifying L. major MON-25 [14], the only zymoderm involved throughout the Maghreb. The intra-vector infestation was demonstrated in the Akka-Ighan douar (East of Tata) by the identification of a female P. (Phlebotomus) papatasi carrying L. major's promastigotes [13].

Leishmania major occurs exclusively in the arid and semi-arid bioclimatic stages. The vector species is P. papatasi and its density

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increases with increasing aridity. The main actors in the cycle were identified by the isolation of the parasite (L. major MON-25) in humans, the vector and the Meriones shawi reservoir [15,16].

Currently, foci of ZCL are linked to rural areas with degraded environmental and socio-economic conditions [17]. It is widespread from the Atlantic coast, south of the anti-atlas mountains to the northeast, crossing south saharan area of the Anti-Atlas and High Atlas mountains, and east of the middle Atlas mountains [18].

**Anthroponotic cutaneous leishmaniasis due to L. Tropica**

The ALC is an anthroponose whose proven vector is *P. sergenti* and the reservoir is the man [19]. In 1989, Marty et al. [20] located the first outbreak of ALC in Tanant in the region of Azilal after the diagnosis of this parasitosis in a Moroccan girl on the move in Nice. Other outbreaks, similar to Tanant, were identified in Smimou [21], in Taza [22], Zouagha My Yacoub [23], and Chichoua [24-26].

*Phlebotomus sergenti*, a proven vector of *L. tropica* [27], was abundant in Moroccan foci. The proof of its role as vector in Morocco was done in the Tanant home. *Leishmania tropica* is still regarded in Morocco as an anthroponose. The dog found repeatedly infected with the MON-102 and MON-112 zymodemes sporadically, however, is not considered a "real reservoir" [28]. This form of leishmaniasis rages in the semi-arid zones of the country ranging from the plateau of Tadla to Essaouira. In these areas, the disease is found in rural douars between 400 and 1000 m above sea level in the vicinity of vast cedar forests. In Taounate province [31].

**zymodem was isolated from a case of infantile visceral leishmaniasis in zymodem, is an excellent nosogeographic indicator: better than any other method, screening for canine visceral leishmaniasis makes it easy to recognize the disease.** Thus, *L. major* and *L. tropica*, the chorology of *L. infantum* is modeled on that of the vector, but there is at least three species, belonging to the subgenus *Larroussius*, share responsibility for transmission: *P. ariasi*, *P. perniciosus* and *P. longicuspis* [37,38]. The role of *P. perniciosus* and *P. ariasi* has been demonstrated in Spain [6], northern Morocco (Taounate) where a female of *P. ariasi* was found infected [39]. According to Rioux et al. [32], the three species: *P. ariasi*, *P. perniciosus* and *P. longicuspis* are responsible for transmission in humid and subhumid regions in northern Morocco, whereas in the south of the country, only *P. longicuspis* is known as a potential vector of *L. infantum* [33]. The association of morphometric, isoenzymatic and molecular tools in northern Morocco [40-43] has shown the existence of atypical morphs of *P. Perniciosus*, combined with *P. longicuspis*, and an introgression between *P. perniciosus* and *P. longicuspis*. The morphological analysis of the sub-genus *Larroussius* in central and south-west Morocco [44] showed that the atypical form of *P. perniciosus* appeared to be widespread in these regions.

**Salt flies in Morocco**

Sandflies were subject of several studies in Morocco before leishmaniasis was considered a major public health problem. After the observations and notes of Ristorcelli [45-49] on sandflies harvested in the south and in eastern Morocco, Gaud [48] made a first study on sandflies in Morocco. He gave a general overview of the regional distribution and seasonal frequency of sandflies across the country [49-51] and in the Rabat region [52]. More detailed studies on the biology of sandflies in Figuig region were done by Parrot and Durand-Delacre [53]. The work of Bailly-Choumara et al. [54] presented a geographical and bioclimatic synthesis of the existed data on sandflies from Morocco and on their own research between 1965 and 1970.

Beginning 1970s, the work of Rioux, in collaboration with the Moroccan authorities, was aimed to analyze different households [11]. The Rioux team's missions in northern and southern Morocco allowed studying the inventory of sandflies fauna [55-57], to study the correlations between vector/bioclimat [58] and to consider predictions of the distribution of leishmaniasis with climate change [32]. Rioux et al. [59] reported *P. Larroussius* mariae in Meknes region at Ouraza. This species was found by Lambert et al. [60] in the High Atlas of the semi-arid and cold sub-humid stages. Leger et al. [61] conducted an ecological and systematic study of *Complex S. (Sergentomyia) antennata* of southern Morocco. *P. (Paraphlebotomus) riouxi* was reported in Morocco by Depaquit et al. [62]. The work of Guerroui et al. [63-65] in southwestern Morocco updated Rioux data in this region and revised the distribution of *Larroussius* according to the observations of Benabdembri et al. [42] in northern Morocco. Preliminary studies [66,67] in Marrakech revealed a high-risk of leishmaniasis status by demonstrating three leishmania vector species: *P. papatasi*, *P. sergenti* and *P. longicuspis*. In addition to ecological and epidemiological studies, biochemical analyzes have also been used to characterize populations of sandflies in Morocco. Thus, in the Moroccan Rif, isoenzymatic analysis revealed a diagnostic allele at the hexokinase locus between *P. perniciosus* and *P. longicuspis* and showed that the identification of males could also be done on the Number of midline bristles of coxites, lower in *P. perniciosus* than in *P. longicuspis* [40].

Conclusion


Leishmaniasis is a reportable disease in Morocco, and is still a real public health problem. The two clinical entities observed visceral and cutaneous are widely distributed throughout the territory.

Leishmaniasis in Morocco constitutes three well differentiated nosogeographic entities requiring codified control measures adapted to each one. The implementations of the control program and its generalization made it possible to implement various control measures. An information system allows, in particular, monitoring of the epidemiological situation and the degree of implementation of the different control measures. While screening and treatment of human cases is operational in the various endemic provinces, vector and animal reservoir control (rodent and dog) remains limited and insufficient.

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