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Asian Pacific Journal of Tropical Disease

journal homepage: www.elsevier.com/locate/apjtd

Review doi: 10.1016/S2222-1808(15)60893-3

Epidemiological role of a rodent in Morocco: Case of cutaneous leishmaniasis

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ARTICLE INFO

Article history:
Received 28 Apr 2015
Accepted 14 May 2015
Available online 10 Jul 2015

Keywords:
Rodents
Geographical distribution
Epidemiological risk
Reservoir
Morocco

ABSTRACT

Commensal rodents as well as wild ones may present a potential risk to public health. They are reservoirs or vectors of many pathogens. This review provides an update on their epidemiological role in the spread of leishmaniasis in Morocco. In Morocco, the order Rodentia is represented by 7 families and 32 species of which *Rattus norvegicus*, *Psammomys obesus*, *Mastomys erythrolecus*, *Meriones shawi*, *Meriones crassus* and *Meriones libycus* are considered reservoirs of leishmaniasis in Asia, Midle East and Africa. With the aim to define the extent of zoonotic leishmaniasis risk in Morocco, we represent and discuss the geographical distribution of these potential reservoirs in relation to that of *Phlebotomus papatasi*, proven vector of cutaneous leishmaniasis by *Leishmania major* in Morocco.

1. Introduction

The rodents (order: Rodentia) have a natural geographical distribution that covers the whole world[1]. This order is also the most diverse, if we consider the morphological characteristcs, physical skills and different environments occupied by these animals[2]. They represent 2 277 species, compared with 5 416 species of mammals and constitute 40% to 42% of mammal species known in the world[3].

With the exception of a number of rodents which are beneficial to humans, several hundreds of rodents are considered as pests[4]. Indeed, they threaten human and animal health. Rodents have an important role as reservoirs of many infectious organisms causing diseases of varying degrees. Various microorganisms (bacteria, viruses and parasites) are in their natural reservoirs of rodents. They also damage the cultivated fields and food stocks.

Many species of wild rodents have relatively little contact with humans and animals; however, they can be used to maintain circulating infectious agents in endemic foci, for long periods (Table 1). When commensal rodents in rural areas come into contact with wildlife, infectious organisms can be transmitted directly, through contact with urine, feces, excretions from infected rodents or contaminated food, or indirectly, by bites or stings of vectors such as insects, ticks, mites, fleas, lice, mosquitoes, *etc*. The commensal rodents that live in close contact with humans and animals, cause outbreaks of zoonotic diseases[3,5], often with significant morbidity and some mortality. Rodents are also responsible for health problems associated with asthma and allergies[6].

Morocco has 92 species of wild terrestral and non-introduced mammals, divided into 8 orders, and of very variable specific wealth: rodents, chiropter, carnivores, insectivores, artiodactyles, lagomorphes, maroscelides, and primates. The order of rodents is numerically the most important, with 32 species. The ecology of rodents is widely

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Table 1

The most important anthropozoonotic diseases and their rodent reservoirs.

Disease	Etiologic agent	Rodent reservoir	References
Salmonellosis	*Salmonella* sp.	*R. norvegicus*	[17]
Hymenolepiasis	*Hymenolopis diminuta*		[18]
Toxoplasmosis	*Toxoplasma gondii*	*Ctenodactylus gundii*	[19]
Bubonic plague	*Yersinia pestis*		[20]
Hantavirosis	*Bunya virus*		[21,22]
Leptospirosis	*Leptospira icterohaemorrhagiae*	*R. rattus*	[23,24]
	Leptospira grippotyphosa		
	Leptospira canicola		
	Leptospira hardjo		
	Leptospira autumnalis		
	Leptospira pomona		
Spotted fever Murine typhus	*Rickettsia typhi*	*R. norvegicus*	[25]
Angiostrongyliasis	*Angiostrongylus cantonensis*		[26,27]
Hemorrhagic fever associated with renal syndrome	*Dobrava seoul*	*R. norvegicus*	
		Apodemus flavicollis	
Korean hemorrhagic fever	*Hantaan* sp.	*Apodemus agrariae*	
			[22,28]
Lymphocytic choriomeningitis	*Arena virus*	*Mus musculus*	[29]
		Apodemus sylvaticus	[30]
Lassa fever		*Mastomys natalensis*	[31]
Scrub typhus	*Rickettsia tsutsugamushi*	*Rodents*	[32]
Schistosomiasis	*Schistosoma japonicum*	*R. rattus*	[33]
		Rattus exulans	
Leishmaniasis	See Table 3		

R. norvegicus: Rattus norvegicus; R. rattus: Rattus rattus.

studied in Morocco[7,8] but few studies have addressed the epidemiological role of these 32 species.

In this review, after check list of Moroccan rodents, we discuss its epidemiological role in Morocco through the example of leishmaniasis.

2. Moroccan rodents

In Morocco, rodents are represented by seven families (Table 2) more or less diversified according to Thévenot and Aulagnier[1]. The most represented family is that of Gerbillidae with 16 species, including five endemic species that colonize the country, leaving only the most anthropized habitats for the favor of commensal species (rats and mice). The Muridae includes nine species. The other two families are represented by only one species. The family of Ctenodactylidae is endemic to North Africa and the Dipodidae has primarily adapted to arid environments.

3. Rodents and cutaneous leishmaniasis in Morocco

The importance of rodents as reservoir hosts for different *Leishmania* species has already been described worldwide (Table 3). In Morocco, except for *Meriones shawi* (*M. shawi*), little is known about the role of rodents in leishmaniasis epidemiology.

Table 2

Rodents of Morocco.

Family	Species	Reported in Morocco
Muridae	*R. rattus*	[1,2,8,34]
	R. norvegicus	
	Apodemus sylvaticus	
	Mus spretus	
	Mus musculus	
	Pachyuromys duprasi	
	Lemniscomys barbarus	
	Mastomys erythroleucus	[1,2]
	Acomys cahirinus	
Gerbillidae	*M. shawi*	[1,2]
	M. libycus	
	M. crassus	
	Merione grandis	
	Gerbillus campestris	[1,2,34]
	Gerbillus nanus	[1,2]
	Gerbillus henleyi	
	Gerbillus gerbillus	
	Gerbillus hesperinus	
	Gerbillus hoogstraali	
	Gerbillus occiduus	
	Gerbillus riggenbachi	
	Gerbillus simoni	
	Gerbillus maghrebi	
	Gerbillus tarabuli	
	Meriones spp.	[34]
Sciuridae	*Atlantoxerus getulus*	[1,2]
	Xerus erythropus	
Dipodidae	*Jaculus orientalis*	
	Jaculus jaculus	
Ctenodactylidae	*Ctenodactylus gundi*	
	Ctenodactylus vali	
Hystricidae	*Hystrix cristata*	
Gliridae	*Eliomys quercinus*	[1,2,34]

Table 3

Rodent reservoir of *Leishmania* sp.

Rodent species	*Leishmania* species	Country	References
Rattus norvegicus		Iran	[35]
Meriones libycus		Tunisia	[36]
		Saudi Arabia	[37]
		Iran	[38-40]
		Jordan	[38]
		Libya	[36,41,42]
P. obesus		Algeria	[36,42,43]
		Tunisia	[42,44]
		Lybie	[36,43]
		Saudi Arabia	[38,43]
	L. major	Jordan	[43]
		Syria	[43]
		Israel	[45]
M. shawi		Tunisia	[44,46,47]
		Algeria	[36]
		Morocco	[10,13,14,36,43]
		Lybie	[41]
Meriones crassus		Egypt	[44,45]
		Israël	
Gerbillus pyramidum		Egypt	[41,48]
M. erythroleucus		Senegal	[49]
Tatera gambiana		Senegal	[49]
Rattus norvegicus		Nigeria	[50]
	L. infantum	Brazil	[16]
		Greece	[15]
Mus musculus		Portugal	[51]
R. rattus		Italy	[52]
Ctenodactylus gundi	*L. killicki*	Tunisia	[53]
	L. tropica		[36,48]
Gerbillus pyramidum	*L. tropica*	Egypt	[54]
Rattus rattus	*L. infantum*	Turkey	[55]
		Spain	[56]
Mastomys natalensis	*Leishmania* sp.	Nigeria	[50]

Leishmaniasis are diseases caused by *Leishmania* parasitic protozoans (Kinetoplastida: Trypanosomatidae) and transmitted by phlebotomine sand flies (Diptera: Psychodidae). In Morocco, leishmaniasis is a growing public health problem. According to the Moroccan Ministry of Health[9], 2 877 cases of cutaneous leishmaniasis were reported in 2012.

Three species of *Leishmania* are the causative agents of cutaneous leishmaniasis in Morocco. There is anthroponotic cutaneous leishmaniasis caused by *Leishmania tropica* (*L. tropica*) which is transmitted by *Phlebotomus* (*Paraphlebotomus*) *sergenti* and there is zoonotic cutaneous leishmaniasis (ZCL) caused by *Leishmania major* (*L. major*) and *Leishmania infantum (L. infantum)* which is transmitted by *Phlebotomus papatasi* (*P. papatasi*) and *Phlebotomus* (*Larroussius*) *ariasi*, respectively[10]. Domestic dogs are the main reservoir host of *L. infantum*[10], while, rodents of species *M. shawi* is the main reservoir host of *L. major*[10-14].

Here, we investigated the potential role of other rodent species in epidemiological cycle of *L. major*, in Morocco. We noted the presence of one proven (*M. shawi*) and five [*R. norvegicus*, *Psammomys obesus* (*P. obesus*), *Mastomys erythrolecus* (*M. erythrolecus*), *Meriones crassus* (*M. crassus*) and *Meriones libycus* (*M. libycus*)] potential reservoirs of *L. major* in Morocco (Tables 2 and 3).

Figure 1 shows the geographical distribution of these rodent

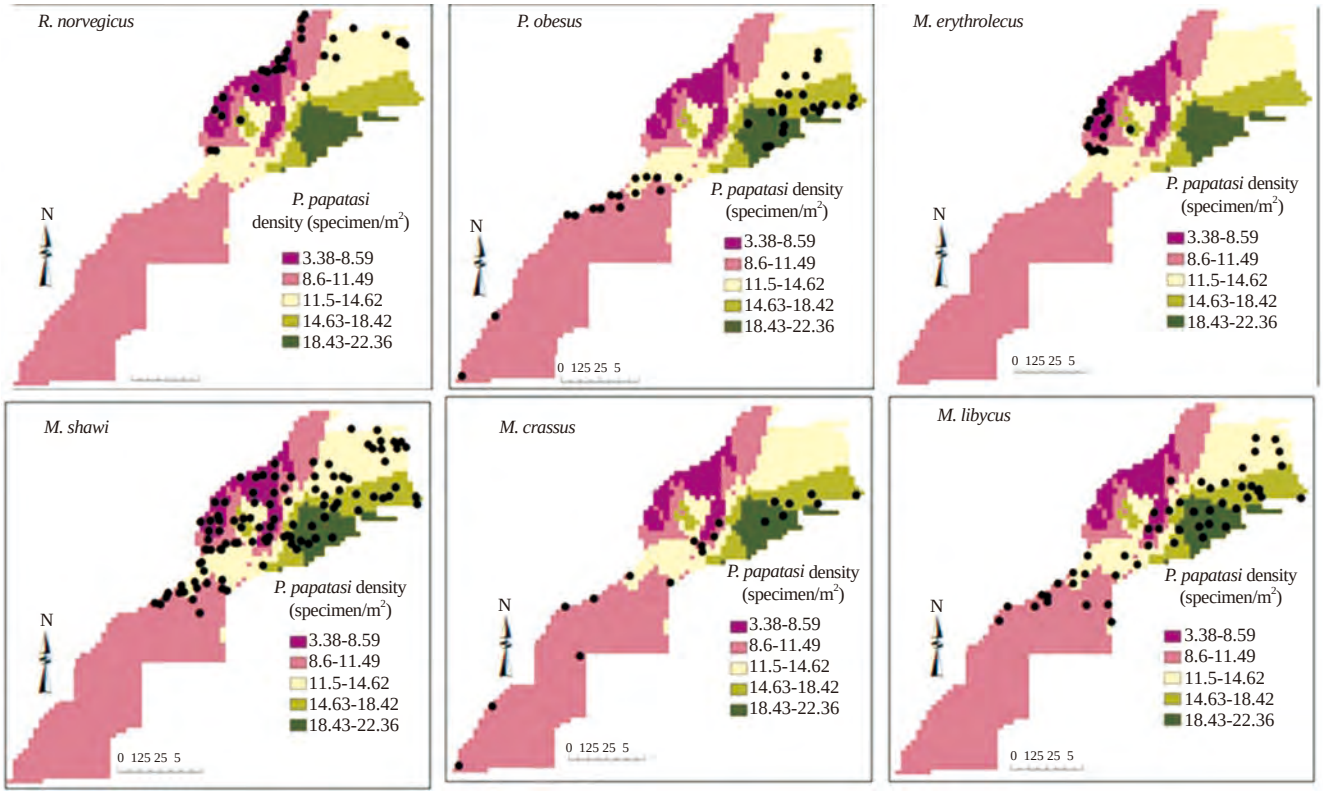

Figure 1. *P. papatasi* and rodent species distribution in Morocco.

species according to *P. papatasi* densities in Morocco. For map generation, the input rodents used in the geographic information system analysis (ArcGis v.10 software) are selected based on their presence (Table 2). *P. papatasi* metadata were extracted from literature[10,12,13] and after interpolation, we chose Kriging because it is the most adequate method by using ArcGis v.10.

As shown in Figure 2, ZCL by *L. major* in Morocco is located in the east of the country. It is corresponding to Saharan and sub-Saharan regions[10]. Our results in Figure 1 show corresponding also to the higher vector density (between 14.63 and 22.36 specimen/m^2). In term of reservoir, we note that two (*R. norvegicus* and *M. erythrolecus*) of our potential reservoirs (Figure 1) are absent in *L. major* area. *M. erythrolecus* distribution is very limited, so we cannot discuss its epidemiological role. In contrast, *R. norvegicus* can be implicated in *L. infantum* transmission in Morocco according to their distributions (Figures 1 and 2). In addition, its reservoir role for *L. infantum* is identified in Greece and Brazil[15,16].

For *P. obesus*, *M. crassus* and *M. libycus*, they were well presented in *L. major* area and they are more extended to Southern Morocco (Figure 1). We hypothesize their co-implication, with *M. shawi*, in *L. major* transmission.

Among these six rodent species, *M. shawi* is the most ubiquitous species in Morocco (Figure 1 and Table 2) and its distribution largely exceeds *L. major* repartition (Figures 1 and 2). This remark highlights the role of vector density in parasite transmission. It is the same for reservoir implication. Presence of both transmission cycle link is not enough to determine area with leishmaniasis risk. Zone of CL risk will be characterized by vector and reservoir presence as well as their abundance.

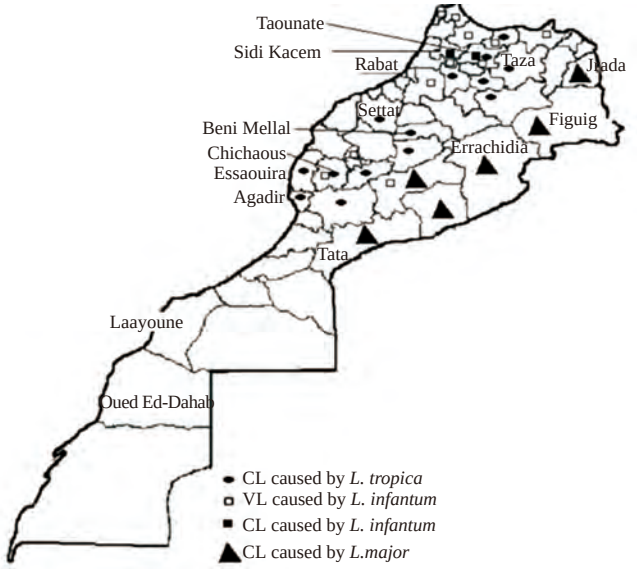

Figure 2. Cutaneous (CL) and visceral (VL) leishmaniasis distributions in Morocco[57].

4. Conclusion

In conclusion, the omnipresence in Morocco of *P. papatasi*, the proven vector of zoonotic cutaneous leishmaniasis, and many rodent species, including *M. shawi*, the main *L. major* reservoir host, suggest the need for a continuous surveillance to prevent risk of ZCL.

There is clearly a need for a strong collaboration between the Health Ministry and other sectors of the Moroccan government, besides optimization of their efforts, we suggest to give a particular attention to area with higher vector and reservoir densities.

Acknowledgments

The authors would like to appreciate the kind collaboration of Directorate of Epidemiology and Disease Control, Ministry of Health, Rabat 10010, Morocco. This article is supported by Laboratory of Ecology and Environment, (CNRST, URAC 32) and the National Centre for Studies and Research on the Sahara, CNERS Project (Contract N 06/ ERACNERS).

Conflict of interest statement

We declare that we have no conflict of interest.

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