Asian Pacific Journal of Tropical Disease

journal homepage: http://www.apjtcm.com

Review article https://doi.org/10.12980/apjtd.7.2017D7-188

The current status of phlebotomine sandflies (Diptera: Psychodidae) in Tunisia and their role on *Leishmania* transmission: A review

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ARTICLE INFO

Article history:
Received 15 Aug 2017
Received in revised form 28 Aug, 2nd revised form 12 Sep 2017
Accepted 30 Sep 2017
Available online 29 Nov 2017

Keywords:
Leishmaniasis
Sandflies
Parasites
Vectors
Tunisia

ABSTRACT

In Tunisia, the epidemiological situation of leishmaniasis is characterized by the coexistence in a rather circumscribed territory (165 000 km^2, including the Sahara) of 4 forms of leishmaniasis caused by 3 species: *Leishmania infantum, Leishmania major* and *Leishmania tropica* (*L. tropica*) (synonymous *Leishmania killicki*). One of the factors determining the clinical, epidemiological and immunological diversity of leishmanioses is certainly the existence of a vector-parasite specificity of often sub-generic, sometimes even specific and even sub-specific level. The aim of this paper was to review the current status of phlebotomine sand flies in Tunisia and their role on *Leishmania* transmission. The geographical distribution of *Leishmania infantum* in Tunisia is modeled on that of the vectors. Indeed, the species *Phlebotomus perfiliewi, Phlebotomus perniciosus, Phlebotomus longicuspis* and *Phlebotomus langeroni* were found exclusively in the northern and central Tunisia. The confirmed vector of *Leishmania major* is *Phlebotomus papatasi*. The vector of *L. tropica* was identified as *Phlebotomus sergenti*. *L. tropica* is classically an anthroponotic form; however, a zoonotic reservoir was identified in Tunisia.

1. Introduction

Sandflies (Diptera: Psychodidae) are insects of the order Diptera. Their morphology is directly related to their way of life. The pre-imaginary young stages are terricole while adults are aerial. These insects play an important role in human pathology. Their involvement in the transmission of human and veterinary diseases has now been proved[1]. The first rank of these diseases is the leishmaniasis. These multi-faceted parasitoses affect about 350 million people worldwide and have been causing a disturbing upsurge in recent years. They are among the five priority diseases of World Health Organization[2]. One of the factors determining the clinical, epidemiological and immunological diversity of leishmanioses is certainly the existence of a vector-parasite specificity of often sub-generic, sometimes even specific and sub-specific level. The aim of this paper was to review the current status of phlebotomine sandflies in Tunisia and their role on *Leishmania* transmission.

2. Species composition of phlebotomine sanflies in Tunisia

Sandflies described in Tunisia (Table 1, Figure 1) included 17 species belonging to 2 genus: *Phlebotomus* Rodani, 1843 and *Sergentomyia* Franca & Parrot, 1920[3-10]. The genus *Phlebotomus* is divided into 3 subgenus: the subgenus *Phlebotomus* Rodani, 1843 with just one species: *Phlebotomus papatasi* Scopoli, 1786 (*P. papatasi*); the subgenus *Paraphlebotomus* Theodor, 1948 with four species: *Phlebotomus*

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The journal implements double-blind peer review practiced by specially invited international editorial board members.

sergenti Parrot, 1917 (*P. sergenti*), *Phlebotomus alexandri* Sinton, 1928, *Phlebotomus chabaudi* Croset, Abonnenc and Rioux, 1970, *Phlebotomus riouxi* Depaquit, 1998 and the subgenus *Larroussius* Nitzulescu, 1931 with 6 species: *Phlebotomus ariasi* Tonnoir, 1921, *Phlebotomus chadlii* Rioux, Juminer et Gibily, 1966, *Phlebotomus perfiliewi* Parrot, 1930 (*P. perfiliewi*), *Phlebotomus perniciosus* Newstead, 1911 (*P. perniciosus*), *Phlebotomus longicuspis* Nitzulescu, 1930 (*P. longicuspis*), *Phlebotomus langeroni* Nitzulescu, 1930 (*P. langeroni*). The genera *Sergentomyia* Franca & Parrot, 1920 is divided into 3 subgenus: the subgenus *Sergentomyia* Franca & Parrot, 1920 with 3 species: *Sergentomyia antennata* Newstead, 1912, *Sergentomyia fallax* Parrot, 1920, *Sergentomyia minuta* Adler & Theodor, 1927 (*S. minuta*); the subgenus *Sintonius* Nitzulescu, 1931 with just one species: *Sergentomyia christophersi* Sinton, 1927 and the subgenus *Grassomyia* Theodor, 1958 with just one species: *Sergentomyia dreyfussi* Parrot, 1933. *Sergentomyia* (*Sintonius*) *clydei* (Sinton, 1928) (*S. clydei*) has just been recently described by Chelbi and Zhioua[6] and Ayari *et al.*[7].

Figure 1. Map of Tunisia with its administrative regions (by Rafik Garni). Administrative district codes are provided in parentheses.

3. Current status of leishmaniasis and their proven vectors in Tunisia

In Tunisia, the epidemiological situation of leishmaniasis is characterized by the coexistence in a rather circumscribed territory (165 000 km^2, including the Sahara) of 4 forms of leishmaniasis caused by 3 species: *Leishmania infantum* (*L. infantum*), *Leishmania major* (*L. major*) and *Leishmania tropica* (*L. tropica*) (synonymous *Leishmania killicki*).

L. infantum is responsible for visceral and cutaneous leishmaniasis. Visceral leishmaniasis prevails in north and center of the country in its Mediterranean infantile form[11]. This is a serious health problem characterized by parasite dissemination in the deep organs. The reservoir of this form is the dog[12,13] and the vectors belong to the subgenus *Larroussius*[14]. Cutaneous leishmaniasis due to *L. infantum* is found in the north of the country. The geographical distribution of *L. infantum* in Tunisia is modeled on that of the vectors. Indeed, the species *P. perfiliewi, P. perniciosus, P. longicuspis* and *P. langeroni* were found exclusively in northern and central of Tunisia (Table 1). *P. perfiliewi* is the proven vector of *L. infantum* in surrounding countries[15-17], that's why it was considered as potential vector of *L. infantum* in Tunisia[18]. *P. perniciosus* is the principal vector of *L. infantum* in Tunisia (Figure 2), Algeria, and Italy[17,19,20]. *P. longicuspis* was found naturally infected with *L. infantum* in Algeria[21], in Morocco[22] and Tunisia[23]. Natural infection of *P. langeroni* with *L. infantum* was found in Tunisia[24]. This result was proved by artificial infection in 1991[25]. Many authors showed that the presence of *L. infantum* DNA in *S. minuta* and *P. papatasi* could be explained by recent feedings on infected animals resulting in parasite DNA remnants after blood digestion[23].

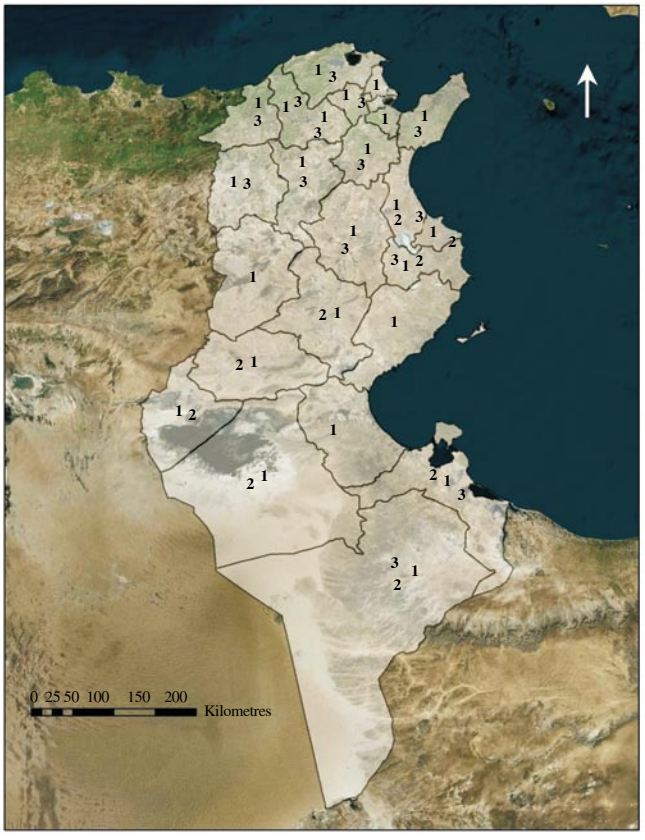

Figure 2. Map of main vectors of *Leishmania*.
1: *P. papatasi*; 2: *P. sergenti*; 3: *P. perniciosus*.

Table 1
List of the Psychodidae species, their distribution in Tunisia and *Leishmania* species detected.

Genus	Species	Distribution[a]	*Leishmania* transmission
Phlebotomus	*P. papatasi*	Biz, Grt, Nab, Zag, Elk, Bej, Jan, Sel, Kai, Sou, Mon, Mah, Kas, Sib, Sfa, Gaf, Toz, Gab, Keb, Med, Tat,	*L. major*
	P. sergenti	Sou, Mon, Mah, Sib, Gaf, Toz, Keb, Med, Tat	*L. tropica*
	Phlebotomus alexandri	Sou, Mon, Mah, Sib, Gaf, Toz, Keb, Med, Tat	-
	Phlebotomus chabaudi	Sou, Mon, Mah, Sib, Gaf, Toz, Keb, Med, Tat	-
	Phlebotomus riouxi	Sou, Mon, Mah, Sib, Gaf, Toz, Keb, Med, Tat	-
	Phlebotomus ariasi	Biz, Grt, Nab, Zag, Elk, Bej, Jan, Sel, Kai, Sou, Mon, Mah	-
	Phlebotomus chadlii	Biz, Grt, Nab, Zag, Elk, Bej, Jan, Sel, Kai, Sou, Mon, Mah	-
	P. perfiliewi	Biz, Grt, Nab, Zag, Elk, Bej, Jan, Sel, Kai, Sou, Mon, Mah	*L. infantum*
	P. perniciosus	Biz, Grt, Nab, Zag, Elk, Bej, Jan, Sel, Kai, Sou, Mon, Mah, Med, Tat	*L. infantum*
	P. longicuspis	Biz, Grt, Nab, Zag, Elk, Bej, Jan, Sel, Kai, Sou, Mon, Mah, Med, Tat	*L. infantum*
	P. langeroni	Biz, Grt, Nab, Zag, Elk, Bej, Jan, Sel, Kai, Sou, Mon, Mah	*L. infantum*
Sergentomyia	*Sergentomyia antennata*	Biz, Grt, Nab, Zag, Elk, Bej, Jan, Sel, Kai, Sou, Mon, Mah, Kas, Sib, Sfa, Gaf, Toz, Gab, Keb, Med, Tat	-
	Sergentomyia fallax	Biz, Grt, Nab, Zag, Elk, Bej, Jan, Sel, Kai, Sou, Mon, Mah, Kas, Sib, Sfa, Gaf, Toz, Gab, Keb, Med, Tat	-
	S. minuta	Biz, Grt, Nab, Zag, Elk, Bej, Jan, Sel, Kai, Sou, Mon, Mah, Kas, Sib, Sfa, Gaf, Toz, Gab, Keb, Med, Tat	-
	Sergentomyia christophersi	Tat	-
	Sergentomyia dreyfussi	Kai, Sib, Gaf, Tat	-
	S. clydei	Kai, Sib	-

Biz: Bizerte; Grt: Grand Tunis; Nab: Nabeul; Zag: Zaghouan; Elk: El Kef; Bej: Beja; Jan: Jandouba; Sel: Seliana; Kai: Kairouan; Sou: Sousse; Mon: Monastir; Mah: Mahdia; Kas: Kasserine; Sib: Sidi Bouzid; Sfa: Sfax; Gaf: Gafsa; Toz: Tozeur; Gab: Gabes; Keb: Kebili; Med: Medenine; Tat: Tataouine. [a]: District codes are shown as in Figure 1.

Zoonotic cutaneous leishmaniasis, caused by *L. major*[26,27], is endemo-epidemic in central and southern arid regions[28,29]. It is the most frequent form of leishmaniasis and generates on average 3 to 5 thousand cases/year[28-30]. Clinically, it is characterized by multiple, moist, inflammatory, superinfected and rapidly developing skin lesions. The confirmed vector of *L. major* is *P. papatasi* (Table 1, Figure 2)[31,32] and the main reservoir is the wild rodent of the genus *Meriones*[26]. The presence of *L. major* DNA in *S. clydei*[7] and *S. minuta*[33] could be explained by recent feedings on infected animals resulting in parasite DNA remnants after blood digestion. Sandflies of the genus *Sergentomyia* are vectors of reptile *Leishmania*[34].

Leishmaniasis due to *L. tropica* zymodeme MON-08 (*Leishmania killicki*) has traditionally developed in micro-foci in the pre-desert mountainous regions of southeast of the country[35]. However, the distribution of this form is currently marked by an extension outside the classical foci. In fact, *L. tropica* has been reported in the central and southwestern regions[36]. Clinically, lesions are usually unique at the face. Their clinical appearance is polymorphic, dominated by ulcerative-crusty forms. These lesions are distinguished by their chronicity and long duration of development[37,38]. Its causal agent, *L. tropica*[27,39], was identified. *L. tropica* is classically an anthroponotic form[14,40-44]. However, sporadic and remote cases have led some authors to suspect a zoonotic reservoir in Tunisia[26]. Jaouadi *et al.*[45] and Bousslimi *et al.*[46] have recently confirmed this hypothesis by isolating *L. tropica* from *Ctenodactylus gundi*. The isolation of the same zymodeme in a specimen of *P. sergenti* (Table 1, Figure 2)[47,48] and in human cases[47] of the same region confirms the vectorial role of this species in the transmission of *L. tropica* in Tunisia. Indeed, *P. sergenti* is the proven vector of *L. tropica* in the Middle East and Morocco[14,42]. It has a high susceptibility to *L. tropica* in the laboratory[44] and in nature[49,50].

4. Conclusion

Sandflies cause human and animal health problem. Their vector role in *Leishmania* and arboviruses transmission has been demonstrated. An effective vector control should be based on a prior knowledge of the vectors in their natural environment. The precise identification of vectors is very important to understand the vector-parasite specificity and interaction.

Conflict of interest statement

We declare that we have no conflict of interest.

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