



Diversity of sand flies (Diptera, Psychodidae) in southwest Iran with emphasis on synanthropy of *Phlebotomus papatasi* and *Phlebotomus alexandri*



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ARTICLE INFO

Article history:

Received 22 February 2014
Received in revised form 12 August 2014
Accepted 18 August 2014
Available online 24 August 2014

Keywords:

Diversity
Synanthropic index
Richness
Shannon–Weiner index
Ecology of sand flies
Iran

ABSTRACT

Zoonotic Cutaneous Leishmaniasis (ZCL) is still a serious health problem in Iran. The objective of the study was to determine the differences in sand fly biodiversity in Shush (plain) and Khorramshahr (littoral) Counties, Khuzestan Province, southwest Iran. Sand flies were collected using sticky paper traps from urban, semi urban, agricultural and natural ecotypes. Alpha and beta diversity were calculated using Shannon–Weiner index and Jaccard's and Sorensen's coefficients, respectively. Synanthropic index was determined for the first time for *Phlebotomus papatasi* and *Phlebotomus alexandri* in different land use categories in Iran. Totally 11213 specimens, 68.47% in Shush and 31.53% in Khorramshahr, were collected. Eleven species of sand flies including, 2 of genus *Phlebotomus* and 9 of genus *Sergentomyia* were identified. *Sergentomyia christophersi* was found as a new record. Dominant species were *P. papatasi* and *Sergentomyia sintoni*. Shannon–Weiner index, richness and evenness in semi urban area of Shush County were more than other habitats. The analysis of α biodiversity showed that agricultural ecosystem of Khorramshahr County had the highest diversity due to maximal richness and diversity and also relatively high evenness. Comparison of similarity of the sand flies population composition between Shush and Khorramshahr indicated the maximum similarity between the urban area of Shush and the semi urban area of Khorramshahr ($S_j = 75\%$ and $S_s = 86\%$). Synanthropic index of *P. papatasi* and *P. alexandri* were calculated to be -83.34 and -91.18 , respectively in Shush County. Estimated synanthropic indices for *P. papatasi* and *P. alexandri* in three habitats (natural, semi urban and urban) of Khorramshahr County were -69.84 and -85.89 , in the same order. The factors for having high diversity of sand flies in the plain area studied may be due to higher annual precipitation, the related land use and land cover. The changes on the composition of sand flies are perhaps due to human intervention in their natural habitats.

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1. Introduction

Cutaneous Leishmaniasis (CL), due to *Leishmania major* is a neglected disease that occurs throughout the old world. In Iran, disease is endemic in many rural areas of 17 out of 31 provinces

(Yaghoobi-Ershadi, 2012). Khuzestan Province in Southwest Iran is considered to be an important endemic focus of Zoonotic Cutaneous Leishmaniasis (ZCL) due to environmental impact of the warfare (Nadim et al., 2008). In the past, the incidence of ZCL was relatively low; however, as a result of high CL incidence among soldiers during Iran–Iraq war, leishmanization program was carried out from 1982 to 1989 on more than 200,000 Iranian soldiers. During the war (1980–1988), there were over 10,000 reported cases among soldiers and immigrants every year. In 1983, more than 3000 patients were treated at health centers and clinics in Khuzestan (Nadim et al., 2008).

The first entomological studies on CL in Khuzestan were conducted during 1962 in Shush, Dezful, Abadan, Izeh and Ahvaz Counties and 20 sand fly species were collected: *Phlebotomus*

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alexandri Sinton, *Phlebotomus halepensis* Theodor, *Phlebotomus jacusieli* Theodor, *Phlebotomus keshishiani* Shchurenkova, *Phlebotomus neglectus* Tonnoir, *Phlebotomus mongolensis* Sinton, *Phlebotomus papatasi* (Scopoli), *Phlebotomus tobbi* Adler, Theodor & Lourie, *Phlebotomus salehi* Mesghali, *Phlebotomus sergenti* Parrot, *Sergentomyia antennata* Newstead, *Sergentomyia baghdadis* (Adler & Theodor), *Sergentomyia dentata* arpaklensis (Perfiliev), *Sergentomyia iranica* Lewis & Mesghali, *Sergentomyia mervynae* Pringle, *Sergentomyia palestinensis* Adler & Theodor, *Sergentomyia sintoni* Pringle, *Sergentomyia squamipleuris* (Newstead), *Sergentomyia theodori* Parrot and *Sergentomyia tiberiadis* Adler, Theodor & Lourie (Nadim et al., 1974). Another study conducted in Ahvaz and Dezful also added two other species of *Sergentomyia clydei* Sinton and *Sergentomyia pawlowski* Perfiliev to the sand flies fauna of this province (Javadian and Nadim, 1975). Jahanifard et al. (2009) also reported *P. papatasi*, *P. alexandri* and *P. mongolensis* in Hoveizeh and Shadegan marshlands of Khuzestan. Natural promastigote infection was observed in several occasions in *P. papatasi*, *P. alexandri* and *S. sintoni* from rodent burrows in Ahvaz, Shush and Shushtar Counties (Javadian and Mesghali, 1974) of the province. Kavarizadeh et al. (2013) collected 10 species of sand flies (*P. papatasi*, *P. alexandri*, *P. mongolensis*, *S. sintoni*, *S. antennata*, *S. mervynae*, *S. theodori*, *S. clydei*, *S. tiberiadis* and *S. palestinensis*) in Musian District, situated in north-west Khuzestan Province. Also, they reported species composition in Musian to be the same as those in other parts of Iran.

Akhoundi et al. (2012) collected 16 species of sand flies (*P. papatasi*, *P. sergenti*, *P. mongolensis*, *Phlebotomus caucasicus*, *Phlebotomus jacusieli*, *Phlebotomus major* s.l., *P. tobbi*, *Phlebotomus perfiliewi*, *Phlebotomus kandelakii*, *P. halepensis*, *Phlebotomus brevis*, *Phlebotomus longiductus*, *Phlebotomus balcanicus*, *S. sintoni*, *S. dentata* and *S. theodori* in northwestern Iran in 2010. *P. papatasi* had been the predominant species in many areas, followed by *P. perfiliewi* and *P. kandelakii*. They found that two districts (Meshkin-Shahr and Sarab) had the highest similarity with a high diversity and richness.

P. papatasi is the main vector of *L. major* in Iran as it is being collected from different provinces of the country with an altitude range of 8 to 1756 m (Yaghoobi-Ershadi, 2012). *P. alexandri* has also been reported as a probable vector of Zoonotic Visceral Leishmaniasis (ZVL) in Iran (Azizi et al., 2006). Furthermore, these species together with *Phlebotomus andrejevi*, *P. caucasicus*, *P. mongolensis* and *Phlebotomus ansarii* are suggested to be the vectors of ZCL among rodents in rural areas (Yaghoobi-Ershadi et al., 2005). Altitudinal distribution of *P. alexandri* was reported from the sea level to 1500 m (Maroli et al., 2001; Kamal et al., 2003). This species is generally distributed in mountainous regions although reported from almost all parts of Iran (Yaghoobi-Ershadi, 2012). Cutaneous leishmaniasis became epidemic twice in Khorramshahr County during 1990–1991 and 2009. It is a serious endemic health problem in Shush area (Institute of Public Health, unpublished data).

Little data are available on the diversity, species composition, and distribution of sand flies in different land use categories of Khorramshahr and Shush. Furthermore, data on leishmaniasis vectors should be updated regularly in order to prepare the control programs. Monitoring the insects in natural ecosystem is one of the simplest ways to observe and provide early warning of changes to biodiversity and habitat structure (Uribe-M et al., 2010). Synanthropic species, associated with humans, are able to transmit pathogen either mechanically or biologically. On the other hand, synanthropy indicates the degree of avoidance of human association (Das et al., 1981).

Sand flies are very sensitive to environmental changes. In this regard, soil type, land use and modification of natural habitats are critical factors affecting changes in the vector, reservoir population densities, and leishmaniasis risks (Yuval, 1991; Fryauff et al., 1993; Kassem et al., 1999; Hassan et al., 1999). Furthermore, Kassem et al.

(1999) found that soil types and underlying geology can model the distribution of sand flies in central and southern Sinai.

Alpha (or within habitats) diversity is the most common form of inventory diversity, which records the number of taxa per area of homogenous habitat therefore reflecting species packing within a community. Beta (or between habitat) diversity is the category of differentiation diversity that measures the variation in taxonomic composition between areas of alpha diversity (Magurran, 1988).

To obtain useful information about vector control and their biological indicators of environmental changes caused by man, the present study aimed to identify the current situation of species composition, diversity, richness and community similarity of sand flies and analyzing the level of synanthropy of species captured in different ecotypes in two important foci of ZCL located in Khuzestan Province, plain (Shush) and littoral (Khorramshahr) areas, which experienced extensive environmental changes over the last three decades.

2. Materials & methods

2.1. Study area

The study was conducted from March 2012 to January 2013 in two counties of Khuzestan Province, Shush and Khorramshahr, southwest Iran. Shush County (32° 11'21"N, 48° 15'28"E) is situated in northwest of Khuzestan at an altitude of 71 m above the sea level (Fig. 1), with a hot and arid climate. In 2012, the average maximum and minimum monthly temperatures were reported to be 15.9–30.23 °C. The total annual rainfall was 236.8 mm (<https://edata.sci.org.ir/AllUser/DirectoryTreeComplete.aspx>). Wheat, rice, corn and summer crops are the major produces. The county has 3 districts, 5 towns and 195 villages.

Khorramshahr County (48°10'45"N, 30°26'21"E) at an altitude of 3 m is located in the southwest of Khuzestan Province, and bounded on the west by Iraq and on the south by the Persian Gulf (Fig. 1). It has hot, long summers with mild, short winters. The average minimum and maximum monthly temperatures were 18.5 and 33.62 °C, respectively. The total annual rainfall was 112.4 mm (<https://edata.sci.org.ir/AllUser/DirectoryTreeComplete.aspx>). Khorramshahr experiences many sandstorms. Date and rice are the major crops in this county. The county has 2 districts, 2 towns and 67 villages. It should also be mentioned that the province of Khuzestan is a major natural oil and gas reservoir in Iran. Oil and gas development on public lands has contaminated soil, air, water, damaged ecosystems, animal habitats, species biodiversity and their behavior. Furthermore, the presence of the main vector of ZCL, *P. papatasi*, and non-endemic workers facilitate preserving the leishmaniasis in this Province.

For the purpose of this study, sampling was performed in four ecotypes (natural, agricultural, semi urban and urban) in each county, where the cases of ZCL have been recorded. Six fixed places were selected from each county. In order to maximize the opportunity to catch sand flies from other locations, four random places have been selected in each county. Six fixed collection areas in Shush were natural (Shavoor and Malhe), agricultural (Aboozar and Danesh), semi urban (Shahrak Salman) and urban (Zaminshahri) while the fixed areas in Khorramshahr included: natural (Arayez and Kofaysheh), agricultural (Menikh and Haneishyeh), semi urban (Sarhanyeh) and urban (Taleghani). JaryehSaydRazi, Hanoosh, Shahrak Bahram and Ebrahimabad in Shush County and Shaneh, Mino Island, Abareh, Sotongar in Khorramshahr County were selected at random for natural, agricultural, semi urban and urban habitats, respectively. By natural habitat, we mean an ecological or environmental area inhabited by a particular species of animal, plant or other type of organism. The agricultural habitat was

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