Journal of Medical Entomology, 55(2), 2018, 317–322
doi: 10.1093/jme/tjx210
Advance Access Publication Date: 30 November 2017
Research Article

Phlebotomus halepensis (Diptera: Psychodidae) Vectorial Capacity in Afyon and Nigde Province, Turkey

Hakan Kavur,[1,4] Hüseyin Arikan,[2] and Yusuf Ozbel[3]

[1]Cukurova University, Karaisali Vocational School, Karaisali, Adana, Turkey, [2]Department of Zoology, Ege University Science Faculty, Bornova, Izmir, Turkey, [3]Department of Parasitology, Ege University Medical School, Bornova, Izmir, Turkey, and [4]Corresponding author, e-mail: hkavur@cu.edu.tr

Subject Editor: Richard Johnson

Received 26 July 2017; Editorial decision 21 September 2017

Abstract

Leishmaniasis is a one of the vector-borne diseases and has two clinical forms in Turkey: cutaneous and visceral. The aim of this study was to determine the sand fly fauna in Afyon and Nigde provinces where endemic foci of cutaneous leishmaniasis (CL) in Turkey. In Afyon, 2,259 sand flies were collected in 73 locations in August 2009 and August 2010, using CDC light traps. In total, eight *Phlebotomus* species were identified; *Phlebotomus halepensis* (47.41%), *Phlebotomus papatasi* (31.42%), *Phlebotomus neglectus/syriacus* (9.38%), *Phlebotomus balcanicus* (7.48%), *Phlebotomus simici* (2.12%), *Phlebotomus perfiliewi* (1.90%), *Phlebotomus sergenti* (0.08%), *Phlebotomus similis* (0.13%), and *Sergentomyia dentata* (0.04%). A total of 418 sand fly specimens were caught by CDC light traps in 40 stations in Nigde in September 2009 and September 2010. In total, seven *Phlebotomus* species were identified; *P. halepensis* (74.16%), *P. simici* (13.87%), *P. papatasi* (3.82%), *P. neglectus/syriacus* (2.87%), *P. balcanicus* (2.63%), *P. sergenti* (2.39%), and *Phlebotomus tobbi* (0.23%). Collected sand flies were examined by microscope, and no promastigotes were found in their midguts. We categorized and pooled female specimens (1,031 females, 73 pools of 2–33 individuals). *Leishmania* species-specific ITS1 real-time PCR assay was performed for detection and identification of parasites. We detected 6 of the 73 pools with *Leishmania tropica* (Ross, 1903), (Trypanosomatidae). In conclusion, *P. halepensis* was found to be dominant species in both areas. We are in opinion that our findings support *P. halepensis* vectorial role for *L. tropica* in nature and it could be responsible for the transmission of *L. tropica* in these endemic areas.

Key words: sand fly, *Leishmania*, vector, fauna, cutaneous leishmaniasis

Phlebotomine sand flies are the arthropod vectors of the *Leishmania* species and played an important role for the transmission of leishmaniasis in The Old World. Both types of leishmaniasis, visceral and cutaneous known as major public health problem in Turkey, and cause 30–40 and 2,000 cases every year, respectively. *Leishmania infantum* is responsible for both clinical forms occurring in the Aegean and Mediterranean regions and sporadically in other regions of Turkey while *Leishmania tropica* (Ross, 1903), (Trypanosomatidae) causes cutaneous leishmaniasis (CL) which is especially highly endemic in the southeastern, western, and eastern Mediterranean parts of Turkey (Ok et al. 2002, Yaman and Ozbel 2004). Svobodova et al. proved vectorial role of *Phlebotomus tobbi* microscopically in Osmaniye, Turkey and observed promastigotes of *L. infantum* in its midguts. Also, *Phlebotomus sergenti* and *Phlebotomus similis* are probable vectors of *L. tropica* in southeastern and western Turkey, respectively (Depaquit et al. 1998, Depaquit et al. 2002, WHO 2010).

L. tropica can also be transmitted by *Phlebotomus halepensis*, which show high susceptibility to both leishmaniasis forms, supporting typical suprapylarian parasite development similar to the other vectors (Sadlova et al. 2003).

Twenty-eight sand fly species (or subspecies recently raised to species level) belonging to the *Phlebotomus* and *Sergentomyia* genera have been described in Turkey, 18 of them known as proven or probable vectors of human leishmaniasis in The Old World (Houin 1971, Yaman and Ozbel 2004, WHO 2010).

In this study, the aim was to determine sand fly fauna of two endemic areas for CL in Afyon and Nigde provinces located in the Aegean and Southeastern Anatolia Regions, respectively. In our study areas, a total of 51 (28 cases are in Afyon, 23 cases are in Nigde) CL cases were reported between 2006 and 2010 (Ministry of Health [MoH] 2015).

Materials and Methods

Study Area

Our study was conducted in five villages in (Aydin, Yiprak, Kulak, Gocerli, and Doganli) Afyon and three villages (Eynelli, Feslegen, and

© The Author(s) 2017. Published by Oxford University Press on behalf of Entomological Society of America.
All rights reserved. For permissions, please e-mail: journals.permissions@oup.com.

Downloaded from https://academic.oup.com/jme/article-abstract/55/2/317/4675308
by guest
on 28 February 2018

Balci) in Nigde. Afyon province has a basin of 14570 km^2 in area, and is located in the eastern part of Turkey (altitude 1034 m, latitude 38° 45′ 20.88″ N, longitude 30° 32′ 30.48″ E). Niğde province has a basin of 7795 km^2 in area, and is located in Central Anatolia, Turkey (altitude 1218 m, latitude 37° 53′ 34.09″ N, longitude 34° 41′ 14.95″ E) (Fig. 1).

Collection of the Data and Statistical Analyses

The data for instant temperature and humidity was recorded using thermo-hygrometer in each location. A Global Positioning System (handheld) (Magellan Explorist 310) was used to record the coordinates (Table 1).

Sand Fly Collection and Identification

Sand fly specimens were collected from 113 locations (73 in Afyon and 40 in Nigde) using CDC light traps, in two different periods, August 2009 and September 2010. In each area, we set up the traps according to the number of CL patients recorded by MoH. During the collection period, traps were setup in animal (goat, cattle, sheep, or poultry) sheds near or under rooms in which an active or treated case of CL was living, and left for one night (Alten et al. 2015). The animal sheds and nearby houses are usually made of brick, mud, wood and/or stone. Specimens were kept in 96% alcohol for morphological identifications, which were based on the morphology of male genitalia and female spermatheca and pharynges using several written keys (Theodor 1958, Lewis 1982, Killick-Kendrick et al. 1990).

The midguts of 116 females were examined by direct microscopy technique for the presence of promastigotes in both study areas.

DNA Extraction From Sand Flies and ITS-1 PCR

Zymo insect kit (Zymo Research Corp., Irvine, CA) was used for obtaining DNA from sand flies. In our study, for detection of *Leishmania* promastigote, we prepared 73 pools, which consisted of 2–33 individuals from 1,031 out of 1,089 female sand fly specimens to detect *Leishmania* promastigote. The real-time PCR method targeting ITS1 region specific for *Leishmania* species was performed using primers LITSR/L5.8S. Real-time PCR assay amplification was carried out in a reaction mixture containing 5 µl of extracted DNA, LITSR (5′CTGGATCATTTTCCGATG 3′), L5.8S (5′TGATACCACTTATCGCACTT 3′).

Results

Afyon Fauna

Overall, 73 CDC light traps were placed in five villages. A total of 2,259 (1,356 male, 903 female) sand flies were collected and eight *Phlebotomus* species (47.41% *P. halepensis*, 31.42% *Phlebotomus papatasi*, 9.38% *Phlebotomus neglectus/syriacus*, 7.48% *Phlebotomus balcanicus*, 2.12% *Phlebotomus simici*, 1.90% *Phlebotomus perfiliewi*, 0.08% *P. sergenti*, 0.13% *P. similis*) and one *Sergentomyia* species (0.04% *Sergentomyia dentata*) were identified (Fig. 2). Among all study areas, in Afyon, *P. halepensis* appeared to be the most abundant species. *P. papatasi* and *P. neglectus/syriacus* were second and third dominant species in Afyon. In addition, the male/female rate was found to be 1.50 (Table 2).

Nigde Fauna

A total of 40 CDC light traps were setup in three villages. Overall, 418 (232 male, 186 female) specimens belonging to seven *Phlebotomus* species were caught by using CDC light traps and seven *Phlebotomus* species (74.16% *P. halepensis*, 13.90% *P. simici*, 3.83% *P. papatasi*, 2.87% *P. neglectus/syriacus*, 2.63% *P. balcanicus*, 2.39% *P. sergenti*, and 0.23% *P. tobbi*) were identified (Fig. 2). Among all study areas, in Nigde, *P. halepensis* appeared to be the most abundant species. Also, the male/female rate was found to be 0.80 (Table 2).

Leishmania-Infected Sand Flies and PCR

During the field work, no promastigotes were found in the midgut specimens obtained from 116 (76 in Afyon, 40 in Nigde) females. Overall, 1,031 female sand flies were placed into four categories as blood-fed, normal, gravid and blood-fed + gravid. Also, specimens

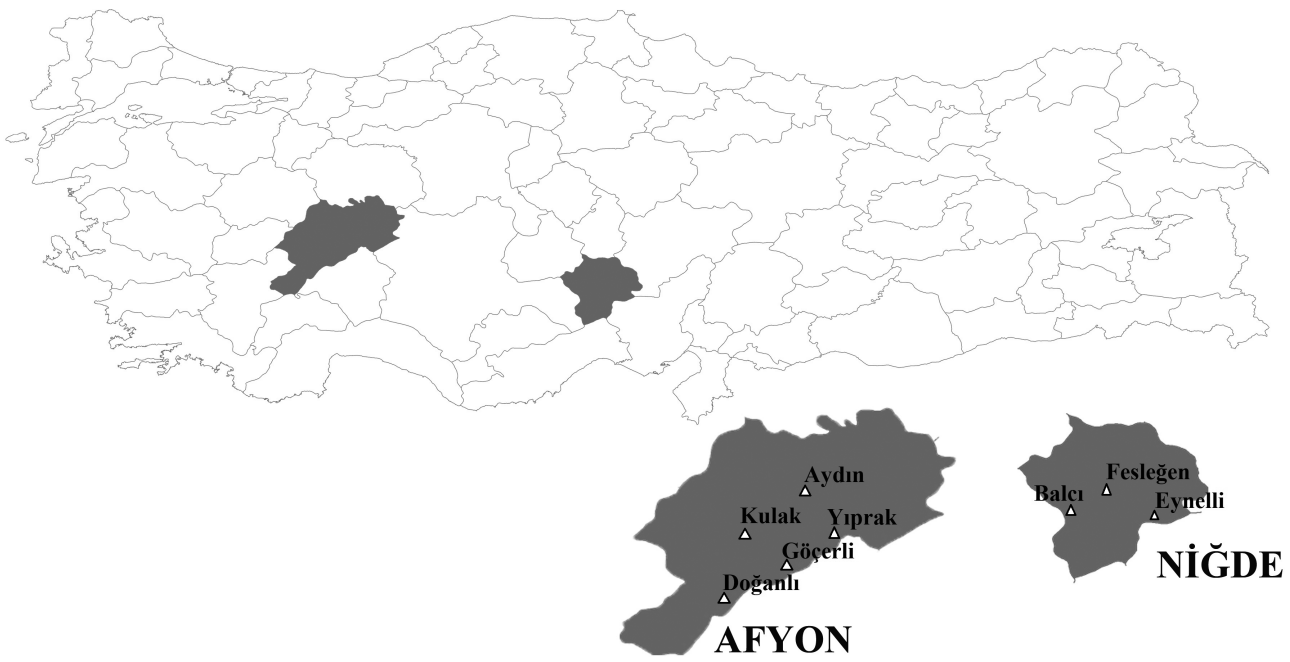


Fig. 1. The locations of both provinces that the present study conducted.

Downloaded from https://academic.oup.com/jme/article-abstract/55/2/317/4675308
by guest
on 28 February 2018

Table 1. Geographical data of study area

Villages	City	CL cases	Altitude (m)	Temperature max–min (°C)	Humidity max–min (%)	Coordinates
Aydin	Afyon	5	1242	30.43–22.73	55.6–27.05	38° 30′ 36.19″ N 30° 28′ 39.09″ E
Yiprak	Afyon	1	1329	27.1–17.6	51–24	38° 19′ 56.61″ N 30° 27′ 47.25″ E
Gocerli	Afyon	7	1237	31.33–22.34	62.11–25.66	38° 17′ 53.44″ N 30° 26′ 55.41″ E
Kulak	Afyon	2	1349	28.6–22.1	74.5–34.5	38° 23′ 04.55″ N 30° 35′ 23.22″ E
Doganli	Afyon	13	1136	28.87–22.32	56–26	38° 32′ 00.00″ N 30° 33′ 00.00″ E
Eynelli	Nigde	77	1674	33.68–24.43	47.4–24	37° 55′ 50.70″ N 35° 00′ 55.48″ E
Feslegen	Nigde	1	1692	30.63–24.35	47–26	37° 59′ 21.98″ N 34° 33′ 25.17″ E
Balci	Nigde	15	1545	30.36–24.26	46–30	37° 58′ 18.19″ N 34° 27′ 46.08″ E

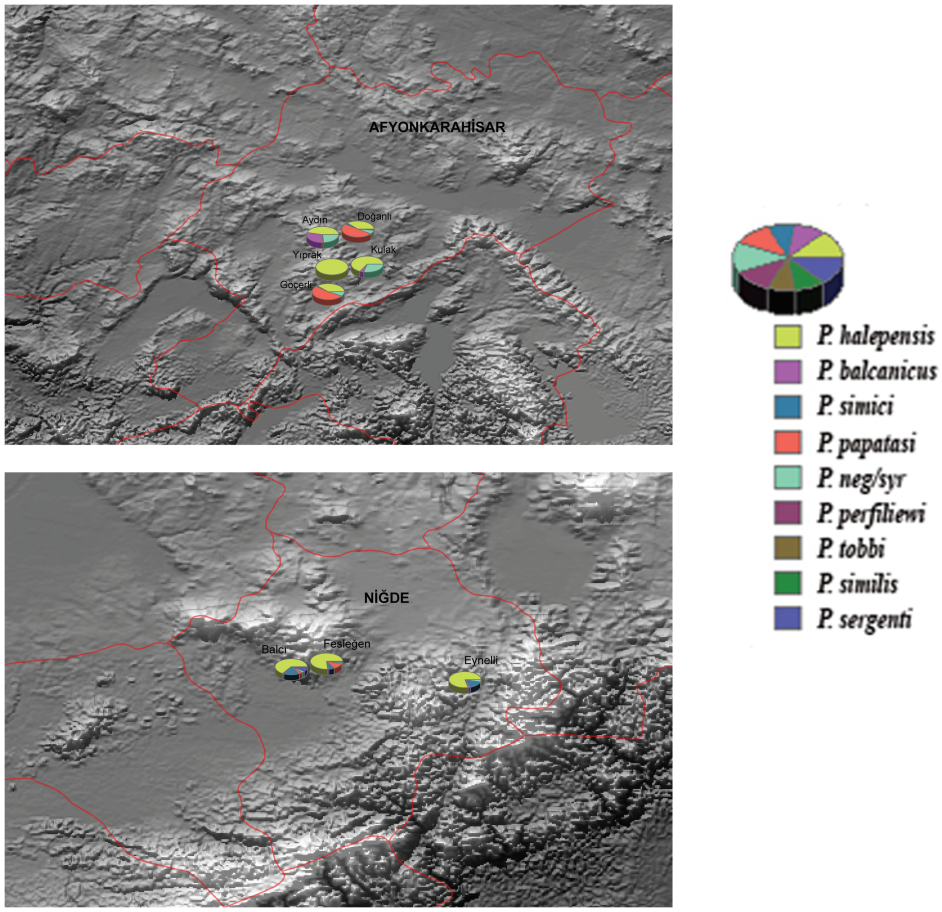


Fig. 2. Densities of the sand fly species in the study villages of Afyon and Nigde provinces.

were pooled for examination of *Leishmania* presence. *Leishmania* DNA was detected in 6 of 73 pools, containing DNA of infected female sand flies captured in Afyon and Nigde. Melting curves of control pools, which included *L. tropica*, *L. infantum* and *Leishmania major* were detected as 61.35°C Tm, 65.88°C Tm, and 53.10°C, respectively in real-time PCR. Melting curves of three (pool 1, 2, and 5), two (pool 20 and 33), and one (pool 35) positive pools containing *P. halepensis*, *P. papatasi*, and *P. neglectus/syriacus* female specimens, showed similarity to *L. tropica* positive control, respectively (Fig. 3a–g).

Discussion

According to literature, 28 sand fly species resident in Turkey. To date, various sand fly fauna studies were carried out in

Downloaded from https://academic.oup.com/jme/article-abstract/55/2/317/4675308
by guest
on 28 February 2018

Table 2. The results of the sand fly collection in Afyon and Nigde province, 2009–2010

Taxon	Subgenus	Species	AFYON								NIGDE					
			Aydin	Kulak	Yiprak	Gocerli	Doganli	♂	♀	♂/♀	Total (%)	Eynelli	Feslegen	Balci	♂	♀	♂/♀	Total (%)
Phlebotomus	*Adlerius*	*P. halepensis*	352	13	5	231	470	749	322	2.32	1071 (41.41)	165	78	67	189	121	0.64	310 (74.16)
		P. balcanicus	140	1	—	14	14	97	72	1.34	169 (7.48)	7	2	2	0	11	0	11 (2.63)
		P. simici	5	—	—	5	38	12	15	1.25	27 (1.78)	29	7	22	21	37	1.76	58 (13.90)
	Phlebotomus	*P. papatasi*	69	—	—	178	463	377	333	1.13	710 (31.42)	1	11	4	9	7	0.78	16 (3.83)
	Larroussius	*P. neglectus/syriacus*	118	6	—	29	59	110	102	1.07	212 (9.38)	7	2	3	2	10	2	12 (2.87)
		P. perfiliewi	7	—	—	4	32	7	36	0.19	43 (1.90)	—	—	—	1	—	—	—
		P. tobbi	—	—	—	—	2	2	0	—	2 (0.08)	1	2	8	10	—	0	1 (0.23)
	Paraphlebotomus	*P. sergenti*	—	—	—	—	2	1	2	0.5	3 (0.13)	—	—	—	—	—	—	10 (2.39)
		P. similis	1	—	—	—	2	0	1	0	1 (0.04)	—	—	—	—	—	—	—
Sergentomyia	*Sergentomyia*	*Sergentomyia dentata*	—	—	—	—	1											
All			692	20	5	461	1,081	1,356	903	1.50	2,259 (100)	210	102	106	232	186	1.24	418 (100)

approximately 40 endemic areas in Turkey. Results of studies emphasize that there is a relationship between sand fly fauna and either one or both of the two forms of the disease epidemiology. Twenty-eight sand fly species have been described belonging to the *Phlebotomus* (24 species) and *Sergentomyia* (four species) genera. In Anatolia, 18 of 28 species can transmit leishmaniasis as proven or probable vector, in other words they are medically important (WHO 2010, Ozbel et al. 2011, Alten et al. 2015, Kasap et al. 2015). In addition, only *P. tobbi* known proven vector (Svobodova et al. 2009).

P. sergenti and *P. similis* are the probable vectors of *L. tropica* in southeastern and western parts of Turkey, respectively (Depaquit et al. 1998, Alptekin et al. 1999, Depaquit et al. 2002, Svobodova et al. 2009, WHO 2010). *P. halepensis* infection rates were ~90% for *L. major* and ~80% for *L. tropica* with high parasite densities (Sadlova et al. 2003). Tagi-zade et al. (1989) detected *P. halepensis* as potential and predominant vector of CL and VL in endemic areas. In Afyon and Nigde *P. halepensis* is the predominant sand fly species, so there it is a suspected vector of *L. tropica*.

The study was conducted for determining the sand fly fauna in two CL endemic areas located in Central Anatolia of Turkey. In our study, we also found that *P. halepensis* was the dominant species among all study areas. Also *P. sergenti* was recorded for the first time in Afyon (0.66%) and Nigde provinces (2.39%). In accordance with previous studies performed in Afyon and Nigde, the authors reported *P. halepensis* among most dominant species (Cicek et al. 2005, Simsek et al. 2007).

A total of 2,677 (2,259 in Afyon, 418 in Nigde) sand flies were collected from two study areas. Although Svobodova et al. (2009) and Ozbel et al. (2016) found promastigotes in *P. tobbi* and *P. tobbi* and *S. dentata* respectively, no promastigotes were found in the midgut specimens obtained from 116 females and studied by microscopically after the dissection in mobile laboratory. We prepared 73 pools containing 687 female sand fly specimens, for searching the presence of Leishmania DNA by using ITS1 real-time PCR assay. PCR were used to amplify ribosomal internal transcribed spacer 1 (ITS1) separating the gene coding for ssu rRNA and 5.8S rRNA for confirmation of *Leishmania* species identification in clinical samples and sand flies specimens (Svobodova et al. 2009, Ozensoy Toz 2013, Ayari et al. 2016).

We detected six pools (4 pools from Afyon, 2 pools from Nigde) as *L. tropica* positive by ITS1 real-time PCR method in species level. Pool 1, pool 2 and pool 5 contained *P. halepensis* females, pool 20 and pool 35 contained *P. papatasi* females, pool 33 contained *P. neglectus/syriacus* females. It is known that *P. halepensis* can transmit *L. tropica* promastigotes (Sadlova et al. 2003, Svobodova et al. 2009) while *P. papatasi* and *P. neglectus/syriacus* cannot. According the results of real-time PCR method targeting ITS1 region, only *L. tropica* was detected while *L. major* and *L. infantum* were not found among the specimens (Table 3). For that reason, we can speculate that, *P. papatasi* and *P. neglectus/syriacus* females that found positive had the blood meal containing *L. tropica* amastigotes.

L. infantum DNA was detected in *P. tobbi* females using real-time PCR assay and it was shown microscopically (Svobodova et al. 2009, Ozbel et al. 2016). Aghaei Afshar et al. (2014) determined 2.6% infection rate of *L. tropica* in *P. sergenti* female samples by using ITS1-HRM PCR assay. Eleven isolates from sand flies, which were collected from Adana and Osmaniye, showed *Leishmania* infection by using PCR-restriction fragment length polymorphism of ITS1 fragments of DNA digested with HaeIII (Svobodova et al. 2009).

Downloaded from https://academic.oup.com/jme/article-abstract/55/2/317/4675308
by guest
on 28 February 2018

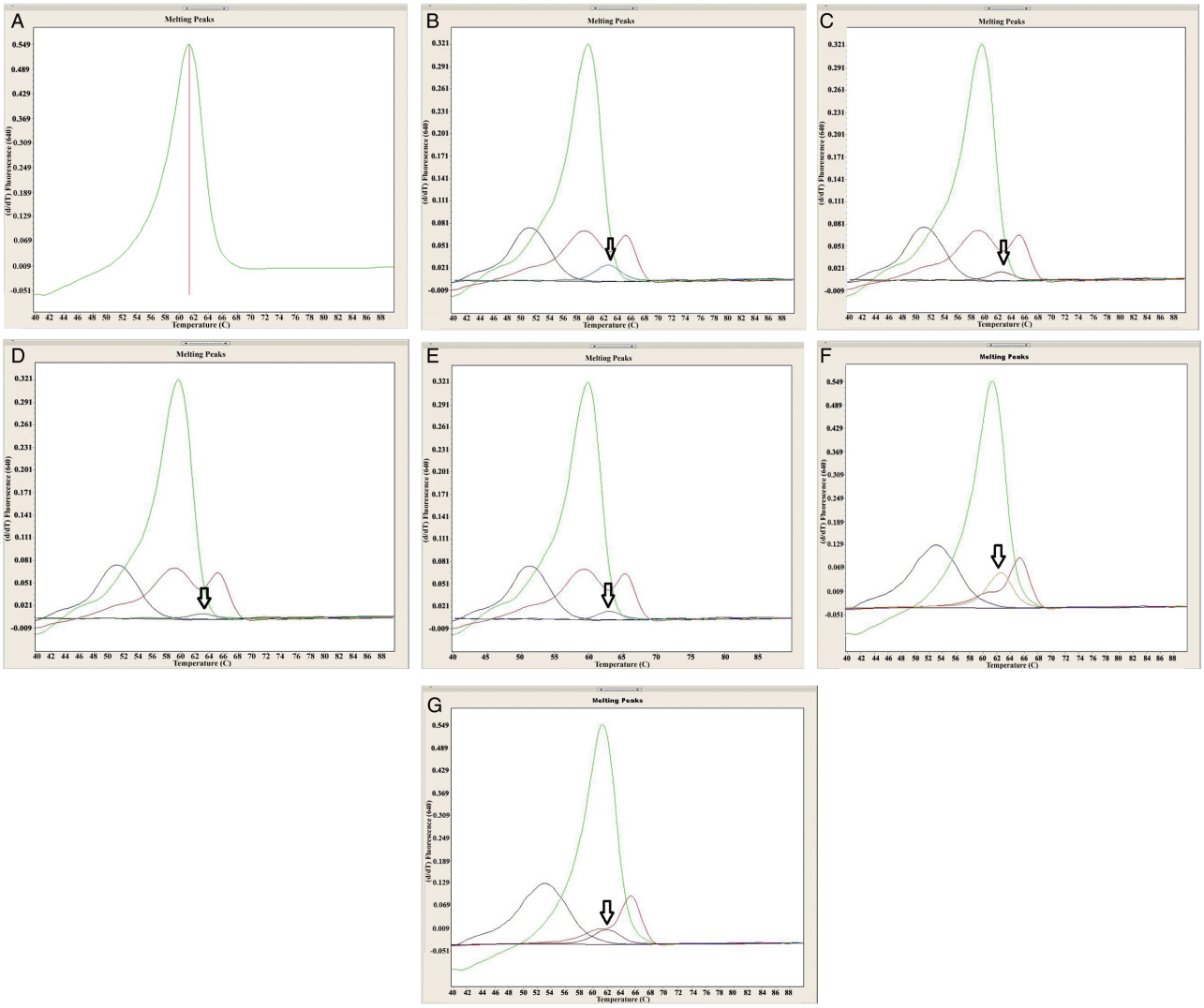


Fig. 3. (A) Melting curves of *L. tropica* positive pools, (B) melting curves of pool 1, (C) melting curves of pool 2, (D) melting curves of pool 5, (E) melting curves of pool 20, (F) melting curves of pool 33, (G) melting curves of pool 35.

Table 3. ITS-1 PCR results

	Total number of specimens						
Species	N	G	BF	BFG	Total	*Leishmania*-positive pool no.	The villages of positive pools
P. halepensis	284	0	0	149	433	3 (Pool 1, 2 and 5)	Yıprak/Kulak; Göçerli; Doganli
P. balcanicus	58	0	0	24	82	0	—
P. simici	46	0	0	20	66	0	—
P. papatasi	222	0	0	98	320	2 (Pool 20, 35)	Doganli; Feslegen; Balci
P. neglectus/syriacus	54	0	0	41	95	1 (Pool 33)	Eynelli
P. perfiliewi	22	0	0	2	13	0	—
Total	686	0	0	334	1,020	6	—

N: Number; G: Gravid; BF: Blood-fed; BFG: Blood-fed gravid.

In conclusion, in our present study, performed in Afyon and Niğde provinces where KL disease is endemic in Turkey, sand fly fauna was determined; and *P. halepensis* was detected as dominant species in both areas; and 3 of 38 pools, in which collected sand fly females were contained, included *P. halepensis* females, and they were identified as *L. tropica* positive. Our findings which are believed to be the first evidence to be shown in nature, suggest that the *P. halepensis* may be the probable vector of *L. tropica* in two provinces.

Downloaded from https://academic.oup.com/jme/article-abstract/55/2/317/4675308
by guest
on 28 February 2018

Acknowledgments

We thank Scientific Research Projects Coordination Unit of Ege University, which supported our study with a project ID of '2009 TIP 32'.

References Cited

Aghaei Afshar, A., Y. Rassi, I. Sharifi, H. Vatandoost, H. R. Mollaie, M. A. Oshaghi, and M. R. Abai. 2014. First report on natural *Leishmania* infection of *Phlebotomus sergenti* due *L. tropica* by high resolution melting curve method in South-eastern Iran. Asian Pac J Trop Med 7: 93–96.

Alptekin, D., M. Kasap, U. Luleyap, H. Kasap, S. Aksoy, and M. L. Wilson. 1999. Sand flies (Diptera: Psychodidae) associated with epidemic Cutaneous Leishmaniasis in Sanlıurfa. Turkey. J. Med. Entomol. 36: 277–281.

Alten, B., Y. Ozbel, K. Ergunay, O. E. Kasap, B. Cull, M. Antoniou, E. Velo, J. Prudhomme, R. Molina, A. L. Bañuls, et al. 2015. Sampling strategies for phlebotomine sand flies (Diptera: Psychodidae) in Europe. Bull. Entomol. Res. 105: 664–678.

Ayari, C., S. B. Othman, J. Chemkhi, A. Tabbabi, R. Fisa, A. B. Salah, and S. Abderrazak. 2016. First detection of *Leishmania major* DNA in *Sergentomyia* (*Sintonius*) *clydei* (Sinton, 1928, Psychodidae: Phlebotominae), from an outbreak area of cutaneous leishmaniasis in Tunisia. Infect. Genet. Evol. 39: 241–248.

Cicek H., M. Yaman, S. Yagcı, and Z. Karaer. 2005. Afyon yöresi Phlebotomus (Diptera: Psychodidae) türleri. Ankara Üniv Vet Fak Derg. 52: 49–51.

Depaquit J., N. Leger, and H. Ferte. 1998. Le statut taxinomique de *Phlebotomus sergenti* PARROT, 1917, vecteur de *Leishmania tropica* (WRIGHT, 1903) et *Phlebotomus similis* PERFILIEV, 1963 (Diptera-Psychodidae). Approches morphologique et morphometrique. Corollaires biogeographiques et epidemiologiques. Bulletin de la Societd de Pathologie Exotique. 9I: 346–352.

Depaquit J., H. Ferte, N. Leger, F. Lefranc, C. Alves-Pires, H. Hanafi, M. Maroli, F. Morillas-Marquez, J. A. Rioux, M. Svobodova, et al. 2002. ITS 2 sequences heterogeneity in *Phlebotomus sergenti* and *Phlebotomus similis* (Diptera, Psychodidae): possible consequences in their ability to transmit *Leishmania tropica*. Int. J. Parasitol. 32: 1123–1131.

Houin, R., E. Abonnence, and M. Deniau. 1971. Phlébotomes du Sud de la Turquie. Ann. Parasitol. Hum. Comp. 46: 633–652.

Killick-Kendrick, R. 1990. Phlebotomine vectors of the leishmaniases: a review. Med. Vet. Entomol. 4: 1–24.

Lewis, D. J. 1982. A Taxonomic Review of the Genus *Phlebotomus* (Diptera: Psycodidae). Bull. Br. Mus. Nat. Hist. Ent. 45: 121–209.

(MoH) Ministry of Health. 2015. Leishmaniasis data of Adana province, Turkey. MoH, Ankara, Turkey.

Ok Z., I. C. Balcioglu, A. T. Ozkan, S. Ozensoy, and Y. Ozbel. 2002. Leishmaniasis in Turkey. Acta Tropica 84: 43–48.

Ozbel, Y., I. C. Balcioğlu, M. K. Olgen, M. F. Simsek, S. Ozensoy Töz, H. Ertabaklar, S. Demir, M. Z. Alkan. 2011. Spatial Distribution of Phlebotomine Sand Flies in Aydin Mountains and Surroundings; the Main Focus of Cutaneous Leishmaniasis in Western Turkey. J Vector Ecol. 36(Suppl 1): S99–S105.

Ozbel, Y., M. Karakus, S. K. Arserim, S. O. Kalkan, and S. Toz. 2016. Molecular detection and identification of *Leishmania* spp. in naturally infected *Phlebotomus tobbi* and *Sergentomyia dentata* in a focus of human and canine leishmaniasis in western Turkey. Acta Tropica 155: 89–94.

Ozensoy Toz, S., G. Culha, F. Yildiz Zeyrek, H. Ertabaklar, M. Z. Alkan, A. Tetik Vardarlı, C. Gunduz, and Y. Ozbel. 2013. A Real-Time ITS1-PCR based method in the diagnosis and species identification of *Leishmania* parasite from human and dog clinical samples in Turkey. PLoS Negl. Trop. Dis. 7: 1–8.

Sadlova, J., M. Hajmova, and P. Volf. 2003. *Phlebotomus* (*Adlerius*) *halepensis* vector competence for *Leishmania major* and *Le. tropica*. Med. Vet. Entomol. 17: 244–250.

Simsek, F. M., B. Alten, S. S. Caglar, Y. Ozbel, A. M. Aytekin, S. Kaynas, A. Belen, O. E. Kasap, M. Yaman, and S. Rastgeldi. 2007. Distribution and altitudinal structuring of phlebotomine sand flies (Diptera:Psychodidae) in southern Anatolia, Turkey: their relation to human cutaneous leishmaniasis. J. Vector Ecol. 32: 269–279.

Svobodová, M., B. Alten, L. Zídková, V. Dvorák, J. Hlavacková, J. Myšková, V. Šeblová, O. E. Kasap, A. Belen, J. Votypka, et al. 2009. Cutaneous leishmaniasis caused by *Leishmania infantum* transmitted by *Phlebotomus tobbi*. Int. J. Parasitol. 39: 251–256.

Tagi-zade, T. A., G. B. Gasanzade, and V. M. Safyanova. 1989. Visceral leishmaniasis in the Ordubad district of the Nakhichevan ASSR. Med Parazitol (Mosk) 3: 22–27.

Theodor, O. 1958. Psychodidae-Phlebotominae, pp. 1–55. *In* Die Fliegen Der Palaerktischen Region Lindner E. (ed.), Lieferung 201. E. Schweizerbart'sche Verlagsbuchhandlung (Nagele u. Obermiller), Stuttgart, Germany.

WHO-World Health Organization. 2010. WHO Technical Report Series Report No: 949. WHO, Geneva, Switzerland.

Yaman M., and Y. Ozbel. 2004. The sandflies (Diptera: Psychodidae) in the Turkish province of Hatay: some possible vectors ofthe parasites causing human cutaneous leishmaniasis. Ann. Trop. Med. Parasitol. 98: 741–750.

Downloaded from https://academic.oup.com/jme/article-abstract/55/2/317/4675308
by guest
on 28 February 2018