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Faunistic Study of Sand Flies in Northern Cyprus

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Abstract. A faunistic study of Phlebotominae (Diptera: Psychodidae) sand flies was carried out in northern Cyprus. A total of 12,517 sand flies (3,285 males and 9,232 females) was collected from 20 different localities in July and September 2004. Nine species belonging to genus *Phlebotomus* and 3 species of genus *Sergentomyia* were identified. Of these, the presence of the species *Phlebotomus neglectus* Tonnoir was reported for the first time in Cyprus, while *P. jacusieli* Theodor, *P. kyreniae* Theodor and *P. economidesi* Léger, Depaquit & Ferté were reported from the island for only the second time. However, *P. mascittii* Grassi which was previously reported from southern Cyprus was not found in this study. The most abundant species for the overall northern Cyprus were *P. galilaeus* Theodor (60.88%), *P. papatasi* Scopoli (15.67%) and *P. tobbi* Adler & Theodor (12.47%). These three species account for 89.02% of all sand flies collected in this survey. Because of the previously reported parasitic diseases such as human and canine visceral leishmaniasis, cutaneous leishmaniasis and viral diseases such as sand fly fever, the distribution of the sand fly species belonging to genus *Phlebotomus* found in northern Cyprus and their vectorial status were discussed and the results were compared with previous reports.

Key words: *Phlebotomus*, *Sergentomyia*, Cyprus, sand fly.

Introduction

Cyprus is the third largest island (9,251 km²) situated in the north eastern corner of the Mediterranean Sea. It is located in 34°33′ - 35°42′ northern latitudes and 32°16′ - 34°36′ eastern longitudes. The landscape of Cyprus is characterized by mountains and plains. The two highest mountain ranges of Cyprus are Troodos, that covers most of the southern and western portions of the island, and Pentadactylos, which runs along most of the north coastline. The neighbors of Cyprus are Turkey, 70 km to the north, Syria and Lebanon, 102 km and 65 km to the east respectively, Egypt, 232 km to the south-east and Greece, 835 km to the north-west (Göçmen et al. 2008). The mountains are separated by the Central Mesaoria Plain that extends the length of the island from east to west and is generally marked as a breadbasket of Cyprus, owing to the production of cereal crops such as wheat, barley and oats. Cyprus has three different vegetation zones due to its topography, which are; Pentadactylos Mountains vegetation zone, inner vegetation zone and Troodos Mountains vegetation zone (Göçmen et al. 2008).

Cyprus has the Mediterranean climate, warm and rainy in winter and hot and dry in summer. Rainfall is rare and only occurs in winter in plain areas. The mean daily temperature in July and August ranges between 29°C on the central plain to 22°C in the Troodos mountains, while the average maximum temperature for these months ranges between 36°C and 27°C, respectively. Relative humidity of

the air is on average between 40% and 60% in summer with even lower values over inland areas around midday (İlseven et al. 2006).

The first sand fly survey of Cyprus mainly concentrated on the northern coast and Kyrenia range inland and central Troodos Mountains, was carried out by Adler in the period of 10th August and 9th September 1944 (Adler 1946). In this first study, about 2 000 specimens were collected from all parts of the island. The survey revealed a characteristic east Mediterranean fauna of 7 *Phlebotomus* and 3 *Sergentomyia* with some endemic forms. A partial re-survey in the southeast of the island was done 41 years later in 1985 by Minter and Eitrem (Minter & Eitrem 1989). In a study conducted by Depaquit et al. (2001), the presence of 8 *Phlebotomus* and 3 *Sergentomyia* species were reported from the south part of the island.

The island of Cyprus which lies at the crossroads of three continents is part of the eastern Mediterranean Region where several clinical forms of leishmaniasis are endemic. A few reports have described the occurrence of human visceral leishmaniasis (VL) in Cyprus since 1935 (Deplazes et al. 1998, Minter & Eitrem 1989). Sporadic cases of human cutaneous leishmaniasis (CL) were also observed in Kyrenia (Desjeux 1991). According to Deplazes et al. (1998), Howard et al. (1992) reported that the parasite isolated from a 61 year-old CL patient was identified as *Leishmania infantum* by isoenzyme electrophoresis. Deplazes et al. (1998) also identified parasite isolates from dogs as *L. infantum* zymodeme MON-1 which is the most common and the most widespread in the Mediterranean Basin. Léger et al. (2000b) isolated one and four *Leishmania* strains from sand fly (*P. tobbi*) and dogs, respectively. All these 5 strains were identified as *L. infantum* MON-1.

However, in 2006, three CL and two VL human cases were diagnosed in Cyprus and all five isolates were found to be *L. donovani* MON-37. In addition, one of the canine isolates studied, originating from a dog living in the same district as the three human CL cases, gave two amplicons, one corresponding to *L. infantum* MON-1 and the other to *L. donovani* MON-37, suggesting that the dog was co-infected with both parasite species (Antoniou et al. 2008). Canine leishmaniasis (CanL) has also been known for long time in the island, but first time it is mentioned with 4 CanL cases from different locations in Kyrenia region by Adler (1946). Especially, after the last findings obtained by Antoniou et al. (2008), faunistic studies of Phlebotominae sand flies in Cyprus had more significance for the control of leishmaniasis in endemic foci as they provide valuable data on the biology of vectors that transmit the causative agents of the disease, such as leishmaniasis and sand fly fever.

In the present study, we aimed to determine the Phlebotominae fauna of the northern part of Cyprus, where few studies were done previously, and to provide additional data/ records on sand fly distribution in the island.

Materials and Methods

Study Area: Field studies were conducted in the northern part of Cyprus. The altitudinal range of the localities is between 10 and 255 m (Table 1). The inhabitants work mainly in agriculture, and keep domestic animals such as sheep, goats, and poultry. Houses are built of concrete and stone in urban and suburban areas. In the study area, we noted that the animal barns are located 2-3 km away from the villages or settlements.

Collection and identification: In this survey, sand flies were collected at 20 localities from widely diverse areas of northern Cyprus using CDC miniature light traps and sticky paper traps in two periods, between July 25-29, 2004 and September 13-18, 2004 (Fig.1). Most of the captures were done in human/animal-inhabited biotopes. CDC light traps were operated overnight in the animal barns, backyards of the houses and within the caves. A total of 3 traps were set at each location in both trips for one night. The insect catch was checked each morning and sand flies were sorted and kept in 96% ethanol. The sticky paper traps were set within walls of animal (goat, cattle, sheep or poultry) sheds, desolated houses and within the caves. Between 5 and 10 sticky

Table 1. The geographic and climatic information of the localities.

		Altitude (m)	Lat (DMS)	Long (DMS)	Temp* min-max	Hum* max
1.	Aghirda (Agirdag)	227	35° 17' 15N	33° 16' 00E	19.8-32.9	65
2.	Klepini (Arapkoy)	255	35° 18' 30N	33° 25' 60E	24.8-34.6	73
3.	Zodhia (Bostanci)	98	35° 10' 00N	33° 00' 00E	21.8-34.7	82
4.	Komi Kebir (Buyukkonuk)	103	35° 24' 30N	34° 00' 00E	28.8-35.9	68
5.	Kalopsidha (Cayonu)	10	35° 60' 00N	33° 47' 60E	26.1-38.9	88
6.	Kythrea (Degirmenlik)	252	35° 15' 15N	33° 28' 60E	28.4-36.8	77
7.	Rizokarpasso (Dipkarpas)	128	35° 36' 00N	34° 22' 30E	28.5-39.4	79
8.	Prastio (Dortyol)	34	35° 10' 30N	33° 45' 30E	24.3-36.7	70
9.	Trimithi (Edremit)	89	35° 19' 45N	33° 15' 45E	21.7-34.6	69
10.	Ayios Khariton (Ergenekon)	227	35° 18' 15N	33° 36' 15E	27.9-34.9	53
11.	Lefkoniko (Gecitkale)	58	35° 15' 30N	33° 43' 60E	26.9-36.8	62
12.	Panagra (Gecitkoy)	22	35° 20' 15N	33° 40' 15E	20.9-32.9	84
13.	Mia Milia (Haspolat)	91	35° 12' 30N	33° 25' 15E	21.5-30.3	77
14.	Kanli Keuy (Kanlikoy)	180	35° 13' 15N	33° 15' 30E	23.8-33.5	79
15.	Orga (Kayalar)	255	35° 21' 45N	33° 1' 60E	20.3-31.2	58
16.	Kouklia (Koprulu)	24	35° 6' 30N	33° 45' 0E	23.6-40.9	84
17.	Lapithos (Lapta)	190	35° 20' 15N	33° 10' 45E	26.3-35.7	72
18.	Philia (Serhatkoy)	161	35° 11' 15N	33° 5' 30E	20.5-40.6	70
19.	Yialousa (Yenierenkoy)	192	35° 31' 60N	34° 11' 30E	26.2-39.8	72
20.	Leonarisso (Ziyamet)	75	35° 28' 15N	34° 8' 30E	29.0-34.8	75

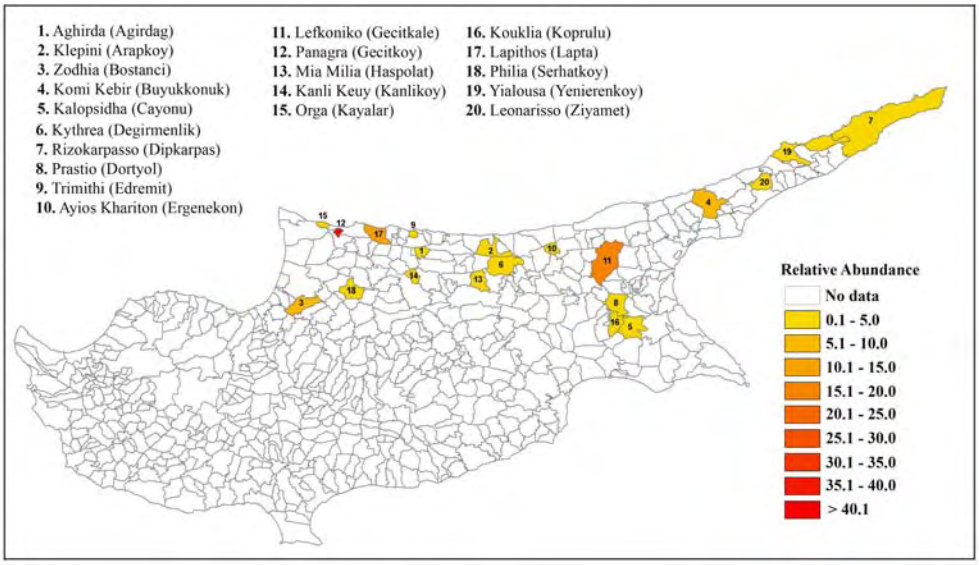

Figure 1. The relative abundance of all sand fly species.

traps (20x20 cm) coated with castor oil were placed in each sampling location and left for one night. The trapped sand flies were removed using water color brushes and kept in the tubes containing 96% ethanol. The collected sand flies were mounted on permanent microscope slides for species identification, which was carried out according to the keys by Adler 1946, Lewis 1982, Perfil'ev 1968, Lane 1986b, 1993, Artemiev & Neronov 1984, Depaquit et al. 2001.

To understand the dominancy of phlebotomine sand fly species in total or in different locations, the following indices were calculated for captures with CDC and sticky traps (Boudabous et al. 2009).

Relative abundance (RA) was calculated as follows: No of specimens of species Px / Total number of phlebotomine X 100.

The degree of presence (D) was calculated as follows: No of locality containing species Px / Total number of localities X 100.

The environmental temperature and relative humidity of the air were measured during each collection, using a maximum-minimum digital thermo-hygrometer.

Results

In total, 12,517 sand flies (3,285 males and 9,232 females) were collected during two surveys from all localities by both types of traps. By sticky paper traps, only 72 specimens (0.57% of the total) were collected in three locations (nos. 1, 17 and 19) and 69 of them were belonging to the genus *Sergentomyia,* while 2 and 1 of them were identified as *P. tobbi* and *P. papatasi*, respectively. The average male: female ratio was 1:2.81. During the collection period, the average minimum and maximum temperatures were 23.55°C and 34.33°C while the mean maximum humidity was 74.75% (Table 1).

The following 12 species belonging to genera *Phlebotomus* and *Sergentomyia* were identified (Table 2): *Phlebotomus* (*Phlebotomus*) *papatasi* Scopoli, *P.* (*Paraphlebotomus*) *alexandri* Sinton, *P.* (*Paraphlebotomus*) *sergenti* Parrot, *P.* (*Paraphlebotomus*) *jacusieli* Theodor, *P.* (*Larroussius*) *neglectus* Tonnoir, *P.* (*Larroussius*) *galilaeus* Theodor, *P.* (*Larroussius*) *tobbi* Adler and Theodor, *P.* (*Adlerius*) *kyreniae* Theodor, *P.* (*Transphlebotomus*) *economidesi* Léger, Depaquit and Ferté, *Sergentomyia azizi* Adler, *S. minuta* Rondani, and *S. fallax* Parrot. The presence of the species *P. neglectus* in Cyprus was reported for the first time. In addition, *P. jacusieli*, *P. kyreniae* and *P. economidesi* were secondly reported from the island. However, *P. mascittii* which was previously reported from southern Cyprus (Depaquit et al. 2001) was not found in this study (Table 3).

The relative abundance and the degree of presence were calculated for each species and the results were given in Figure 1 and Table 2. The most abundant species for overall northern Cyprus were *P. galilaeus* (60.88%), *P. papatasi* (15.67%) and *P. tobbi* (12.47%). These three species account for 89.02% of all sand flies collected in this survey.

P. galilaeus was found in 16 out of 20 localities (D: 80%) and it was the most abundant species in 6 out of 20 localities. Most of the specimens of *P. galilaeus* (63.82%) were obtained from locality no. 12, Panagra. *P. tobbi* was found in 17 out of 20 localities (D: 85%) and it was the most abundant species in locality no. 17, Lapithos. The relative abundance of *P. neglectus* was 0.18% and it was found only in localities no. 17 and 20 (D: 10%), Lapithos and Leonarisso. Regarding species identification for *P. neglectus*, coxite and style of each specimen were measured and the number of setae on coxite were counted. The length of the coxite and style were between 323 and 426 μm (mean 378 μm), and 139-202 μm (mean 181 μm), respectively. The number of the setae was found to be between 26 and 32 (mean 30) (Figure 2).

P. papatasi was the second most abundant species (15.67%) in the island and it was found in all 20 localities (D: 100%), predominant in 11 of them.

P. sergenti was detected in 5 localities (D: 25%) in small numbers while *P. alexandri* was found in 7 of 20 localities (D: 35%) with low relative abundance (0.60%). *P. jacusieli* was

Table 2. Species and numbers of sand flies collected in diverse areas of northern Cyprus (F: female; M: male)

Species name	F	M	Total	F/M ratio	Relative Abundance	Degree of Presence (D) %
Phlebotomus galilaeus	6418	1203	7621	5,33	60.88	80
Phlebotomus papatasi	1035	927	1962	1,12	15.67	100
Phlebotomus tobbi	1010	551	1561	1,83	12.47	85
Phlebotomus alexandri	44	31	75	1,42	0.60	35
Phlebotomus sergenti	21	17	38	1,24	0.30	25
Phlebotomus economidesi	6	16	22	0,38	0.18	10
Phlebotomus neglectus	11	11	22	1,00	0.18	10
Phlebotomus kyreniae	1	18	19	0,06	0.15	5
Phlebotomus jacusieli	12	4	16	3,00	0.13	10
Sergentomyia azizi	344	200	544	1,72	4.35	75
Sergentomyia minuta	286	222	508	1,29	4.06	85
Sergentomyia fallax	44	85	129	0,52	1.03	50
Total	9232	3285	12517	2,81	100	-

Table 3. The list of the species reported from Cyprus up to present. Then known as (1): *P. perniciosus var. tobbi*, (2): *P. perfiliewi*, (3): *P. larroussei*, (4): *P. chinensis*, (5): *P. parroti*, (6): *P. azizi*, (7): *P. fallax* var. *cypriotica*

The date and author of the report	Adler, 1946	Minter and Eitrem, 1989		Depaquit et al. 2001		Present study
The year of the sampling	1944	1971-1984	1985	1993	1998-1999	2004
Genus *Phlebotomus*						
Subgenus *Phlebotomus*						
Phlebotomus papatasi	+	+	+	+	+	+
Subgenus *Paraphlebotomus*						
Phlebotomus sergenti	+	+	0	+	+	+
Phlebotomus jacusieli	0	0	0	+	+	+
Phlebotomus alexandri	+	0	0	+	+	+
Subgenus *Larroussius*						
Phlebotomus tobbi	+ (1)	0	+	+	+	+
Phlebotomus galilaeus	+ (2)	+	+	+	+	+
Phlebotomus neglectus	0	0	0	0	0	+
Phlebotomus mascittii	+ (3)	0	0	+	+	0
Subgenus *Transphlebotomus*						
Phlebotomus economidesi	0	0	0	0	+	+
Subgenus *Adlerius*						
Phlebotomus kyreniae	+ (4)	0	0	0	0	+
Genus *Sergentomyia*						
Sergentomyia minuta	+ (5)	+	+	+	+	+
Sergentomyia azizi	+ (6)	0	+	+	+	+
Sergentomyia fallax	+ (7)	0	+	+	+	+

found in northern Cyprus for the first time in the localities no. 3 and 17 (D: 10%), Zodhia and Lapithos.

P. kyreniae was detected only in Lapithos (D: 5%) located in Kyrenia region where the species was described for the first time Regarding species identification for *P. kyreniae*, additionally the number of setae on coxite were counted. The number of the setae was found to be between 29 and 42 (mean 33) (Figure 3). *P. economidesi* was present in the localities no. 12 and 17 (D: 10%), Panagra and Lapithos, with the relative abundance of 0.18% (Table 2 and 4).

A total of 1,181 specimens belonging to genus *Sergentomyia* was found. *S. azizi* was found in 15 of 20 localities (D: 75%) and it was the most abundant *Sergentomyia* species in northern Cyprus (the relative abundance 4.35% among all sand flies) while *S. minuta* was the most widespread one (in 17 of 20 localities-D: 85%, relative abundance is 4.06%). *S. fallax* was found in 10 localities (D: 50%) with low relative abundance (1.03%) (Table 2 and 4).

Discussion

Sand fly collection was carried out in 20 localities and 9 *Phlebotomus*, 3 *Sergentomyia* species were found in northern Cyprus. The maximum species diversity was determined in Lapithos and Leonarisso with 12 and 9 different species, respectively. More importantly all proven or suspected vectors of leishmaniasis in northern Cyprus were also present in these areas.

Among 12 sand fly species recorded in this study, those most important in terms of public health include *P. neglectus, P. tobbi, P. galilaeus* and *P. papatasi*.

P. neglectus, the proven vector of zoonotic VL in Greece (Léger et al. 1988, Chaniotis et al. 2000) was also reported from western and southern parts of Turkey (Tok et al. 2009, Yaman and Özbel 2004). Moreover this species is also a probable vector in Adriatic countries such as Croatia (Bosnić et al. 2006), Albania (Velo et al. 2005) and Italy (Maroli et al. 2008). In this study, we are reporting the presence of this usual vector of *L. infantum* in the Eastern Mediterranean area, for the first time from Cyprus. However, it was captured from only two locations, Lapithos and Leonarisso, and in low relative abundance (Table 4).

P. tobbi, P. galilaeus and *P. alexandri* are putative vectors according to the recent papers reporting the presence of *L. donovani* in Cyprus. Particularly *P. tobbi*, a broadly permissive vector, could be a suspected vector for the transmission of both *L. infantum* and *L. donovani* (Antoniou et al. 2008, 2009). *P. tobbi* was also previously reported as vector of canine leishmaniasis caused by *L. infantum* in Cyprus (Deplazes 1998, Léger et al. 2000b). The recent study conducted in south Anatolia, Turkey by Svobodová et al. (2009) reported that the causative agent of human CL is *L. infantum* and the strains isolated from humans and 13 *P. tobbi* specimens are identical. Bloodmeal analysis showed that females of *P. tobbi* had fed on human; furthermore human blood was detected in four females infected by *L. infantum*, suggesting that the population of *P. tobbi* is highly anthrophophilic in southern Turkey (Svobodová et al. 2009). The only previous isolation of *L. infantum* from this species has been reported from Cyprus. The infected sand fly from Cyprus was caught near an infected dog and identified as *L. infantum* MON-1 (Léger et al. 2000b). However, local populations of *P. tobbi* did not seem to be man-biting in Azerbaijan and Cyprus (Gasanzade et al. 1990, Léger & Depaquit 2008). Antoniou et al. (2009) suggested that this lack of anthropophily may be illusive. These controversies prompt us to conduct a more detailed study of the biology of this sand fly species in the island. *P. tobbi* was also found to be infected by *L. donovani* in the vicinity of Kassab, northern Syria 10 years ago. The isolate was typed as

Table 4. The number of collected sand flies from each locality in northern Cyprus

	Locality	Total	Species											
			P. galilaeus	*P. papatasi*	*P. tobbi*	*P. alexandri*	*P. sergenti*	*P. economidesi*	*P. neglectus*	*P. kyreniae*	*P. jacusieli*	*S.azizi*	*S. minuta*	*S. fallax*
1.	Aghirda (Agirdag)	210	4	96	31	-	2	-	-	-	-	31	22	24
2.	Klepini (Arapkoy)	178	155	3	17	2	-	-	-	-	-	-	1	-
3.	Zodhia (Bostanci)	861	777	35	4	-	-	-	-	-	1	37	7	-
4.	Komi Kebir (Buyukkonuk)	626	264	134	80	2	-	-	-	-	-	124	18	4
5.	Kalopsidha (Cayonu)	3	-	2	-	-	-	-	-	-	-	-	1	-
6.	Kythrea (Degirmenlik)	13	1	6	2	3	1	-	-	-	-	-	-	-
7.	Rizokarpasso (Dipkarpas)	486	7	178	73	-	-	-	-	-	-	64	134	30
8.	Prastio (Dortyol)	194	69	117	1	-	-	-	-	-	-	1	3	3
9.	Trimithi (Edremit)	148	31	67	47	-	-	-	-	-	-	-	3	-
10.	Ayios Khariton (Ergenekon)	15	1	3	1	2	-	-	-	-	-	4	3	1
11.	Lefkoniko (Gecitkale)	1 901	1 352	336	23	-	1	-	-	-	-	50	130	9
12.	Panagra (Gecitkoy)	5 427	4 864	273	207	10	-	2	-	-	-	53	13	5
13.	Mia Milia (Haspolat)	18	-	17	1	-	-	-	-	-	-	-	-	-
14.	Kanli Keuy (Kanlikoy)	21	2	18	-	-	-	-	-	-	-	1	-	-
15.	Orga (Kayalar)	321	-	262	47	-	-	-	-	-	-	4	8	-
16.	Kouklia (Koprulu)	28	4	15	7	-	-	-	-	-	-	1	1	-
17.	Lapithos (Lapta)	1 830	10	328	1 000	55	31	20	19	19	15	147	135	51
18.	Philia (Serhatkoy)	50	5	25	3	-	-	-	-	-	-	6	11	-
19.	Yialousa (Yenierenkoy)	11	-	3	-	-	-	-	-	-	-	3	4	1
20.	Leonarisso (Ziyamet)	176	75	44	17	1	3	-	3	-	-	18	14	1
	TOTAL	12 517	7 621	1 962	1 561	75	38	22	22	19	16	544	508	129

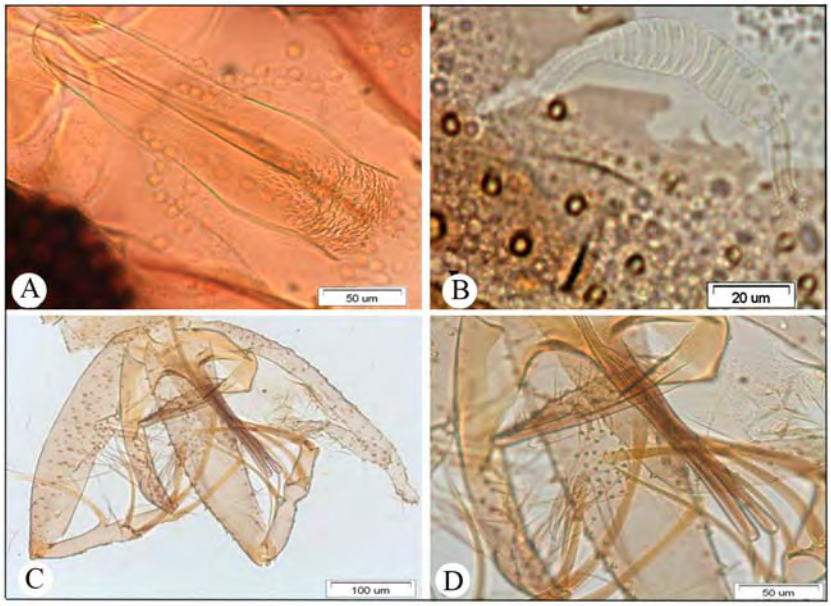

Figure 2. *P. neglectus* **A**. female pharynx, **B**. spermatheca, **C**. male genitalia, **D**. aedeagus

belonging to a zymodeme close to *L. donovani* MON-3 (Rioux et al. 1998). In our study, *P. tobbi* was the third abundant species among all as well as most abundant species in the locality no 17, Lapithos.

L. donovani has been limited to Africa, India, and China; however, it seems that its geographical distribution is gradually expanding since there are some reports on the presence of this species in the Mediterranean region and Middle East countries such as Iraq, Yemen, Saudi-Arabia and Pakistan (WHO 1990, Oshaghi et al. 2009). Cutaneous leishmaniasis caused by *L. donovani* was diagnosed in Sri Lanka (Karunaweera et al. 2003) and in the south part of Cyprus (Antoniou et al. 2008). The latter was an important report notifying the presence of *L. donovani* species in Europe/ Mediterranean for the first time.

The sand fly vector of *L. donovani* causing VL in the Indian subcontinent is *P.* (*Euphlebotomus*) *argentipes*. In addition, *P. martini* and *P. orientalis* transmit *L. donovani* in East Africa (Killick-Kendrick 1999). *P. alexandri* is the proven vector of *L. donovani* and *L. infantum* in China (Li-Ren et al. 1986) and Iran (Javadian & Nadim 1975, Azizi et al. 2006), respectively. *P. alexandri* was also suspected of transmitting CL in Tunisia (Croset et al. 1978). Interestingly, none of the above vectors are found in the Mediterranean region, excluding *P. alexandri* which is scarcely encountered and thus less likely to be a vector of *L. donovani*. *P. alexandri* was found in Kyrenia region by Adler (1946), and Depaquit et al. (2001) also recorded this species in southern and southeastern part of the island. This species was found in 7 localities (D: 35%) but in low relative abundance (0.60%) in our study.

In Iran, one and six *P. perfiliewi transcaucasicus* specimens were found to be infected with *L. infantum* and *L. donovani,* respectively (Oshaghi et al. 2009). Like previous studies carried out in the island, we did not find this

Phlebotomus species in Cyprus. However, it is known that *P. galilaeus* is phylogenetically close to both *P. perfiliewi* (vector of *L. infantum*, a species that belongs to the same complex as *L. donovani*) and *P. perfiliewi transcaucasicus*. *P. galilaeus* was firstly reported by Adler (1946) and was found in all localities as the most abundant species in northern Cyprus in this study as well as in southern Cyprus (Depaquit et al. 2001) where *L. donovani* MON-37 cases were identified (Antoniou et al. 2008).

P. galilaeus and *P. tobbi* could be responsible for the transmission of *L. infantum* as well as *L. donovani* in this geographical area. Other species are less likely to be vectors, because of their unsuitability in visceral leishmaniasis transmission (e.g. *P. papatasi*) or their scarcity (e.g. *P. alexandri*, *P. economidesi* and *P. neglectus*). Such investigations are also required to understand the sand fly species playing vectorial roles for *Leishmania* species causing anthroponotic VL and to prevent an extension of this illness in Europe.

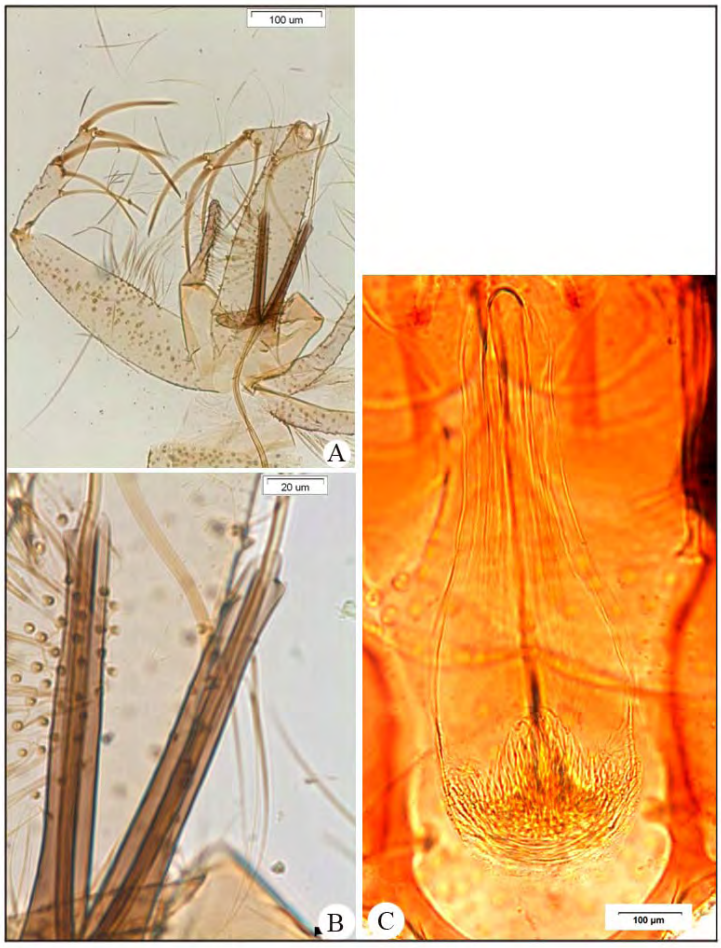

Figure 3. *P. kyreniae* **A**. male genitalia, **B**. aedeagus, **C**. female pharynx.

P. papatasi is also known to transmit *Leishmania major* in many countries in the Mediterranean Basin (Killick-Kendrick et al. 1985). The widest distribution of *P. papatasi* in northern Cyprus has been indicating the potential risk for zoonotic cutaneous leishmaniasis. As an example of *L. donovani* presence in the island, the transportation of *L. major* infection by different ways can cause the establishment of zoonotic CL in the island. This highly anthropophilic species was found in all studies done in Cyprus so far.

Another species found to have limited distribution in our survey was *P. sergenti* which is the proven vector of *L. tropica* in several countries around the Mediterranean Basin (Jacobson et al. 2003). This species was detected in 5 localities in low relative abundance (0.30%). We also would like to note that, there is no reported case due to *L. tropica* from Cyprus so far.

Adler (1946) first reported *P. kyreniae* (formerly known as *P. chinensis*) from northern Cyprus. This species could not be found by other researchers in the island until this study. *P. kyreniae*, a highly uncommon species in the island, was detected only in Lapithos.

P. jacusieli was first reported from southern Cyprus by Depaquit et al. (2001). In our study it was also found in two localities, Zodhia and Lapithos, in northern Cyprus.

Phlebotomus economidesi, captured in the central part of the island (Troodos region), was described as a new species from Cyprus by Léger et al. (2000a). In our study, this species was also found in two localities, Lapithos and Panagra. *P. economidesi* appears to be widely distributed in the island if we evaluate the results together with previous studies (Léger et al. 2000a, Depaquit et al. 2001). However, the relative abundance of this species was very low, (0.18%) among all sand flies collected.

Viruses from the genus *Phlebovirus* (Bunyaviridae) constitute a significant problem of public health, especially for foreign or non-native and non-immune visitors, as they cause diseases with a variety of clinical signs and symptoms (Dionisio et al. 2003). They are responsible for a disease known as sand fly fever, *Phlebotomus* fever or *Pappataci* fever. Genus *Phlebovirus* consists at least 68 distinct virus serotypes, but eight serotypes, including sand fly fever Naples (SFN), sand fly fever Sicilian (SFS) and sand fly fever Toscana virus (TOS) have been linked to disease in humans (Liu et al. 2003). Cyprus was reported for the first time as an endemic area for phleboviruses by Sabin and then SFS virus is serologically confirmed among Swedish UN troops situated in Cyprus in 1984 and 1985 (Niklasson & Eitrem 1985). Sporadic similar cases have also been reported among tourists who visited Cyprus during the years between 1986 and 1989 (Eitrem et al. 1991). A major outbreak caused by SFS-like phlebovirus (now named as Cyprus serotype) was observed during 2002 among Greek army forces in Cyprus. In total, 256 (44%) of 581 soldiers developed a self-limited illness (Konstantinou et al. 2007).

SFN and SFS viruses are transmitted by *Phlebotomus papatasi* while TOS virus is transmitted by *P. perniciosus* and *P. perfiliewi*. Epidemiological studies have shown that SFS virus and SFN virus have the same geographic distribution as their vector, *P. papatasi* (Mediterranean region countries, Middle East, West Asia and South Africa) (Tesh et al. 1976). In the present study, *P. papatasi* was found to be the second abundant species (15.67%) and has widest distribution being present in all 20 locations representing all northern part of Cyprus. This situation is creating a serious risk, especially for non-immune visitors, by provoking sporadic as well as epidemic cases of sand fly fever in the island. The physicians in the island should consider sand fly fever in the differential diagnosis of the patients with symptoms similar to viral infections.

In our study, 3 *Sergentomyia* species were found as indicated in previous studies (Adler

1946, Depaquit et al. 2001). *S. azizi* and *S. fallax* which were firstly recorded by Adler (1946), were found to be the most and the least abundant *Sergentomyia* species in northern Cyprus, respectively. *S. minuta* was the most widespread one (D: 85%).

The general fauna of northern Cyprus represents a typical Mediterranean distribution and includes the species that may transmit different *Leishmania* species causing cutaneous, visceral and canine leishmaniasis. Moreover, some of these species can transmit both *L. infantum* and *L. donovani* (Volf & Myskova 2007, Antoniou et al. 2008). The island presents a mosaic of risk factors for leishmaniasis such as urbanisation, extended agricultural projects, environmental/climatic changes and the daily movement of populations along the Green Line (Antoniou et al. 2008).

In conclusion, a serious leishmaniasis risk related with vector sand fly distribution was confirmed in northern part of Cyprus and establishment of a surveillance system including improvement official recording, standardized diagnosis and treatment methodologies for human and canine leishmaniasis as well as sand fly fever cases are of prime urgency in the northern part of the island.

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