Acta Tropica 141 (2014) 32–36

Contents lists available at ScienceDirect

Acta Tropica

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

Response of the sand fly *Phlebotomus papatasi* to visual, physical and chemical attraction features in the field

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ARTICLE INFO

Article history:
Received 22 March 2013
Received in revised form 10 April 2014
Accepted 18 June 2014
Available online 27 June 2014

Keywords:
Sand flies
CDC traps
UV light
CO_2
Visual preference

ABSTRACT

In this study, 27 CDC traps were modified with various attractive features and compared with a CDC trap with no light source or baits to evaluate the effects on attraction to *Phlebotomus papatasi* (Scopoli) north of the Dead Sea near Jericho. Attractive features included CO_2, lights, colored trap bodies, heat, moisture, chemical lures and different combinations of the same. Traps were placed 20 m apart and rotated from one trap location to the next after 24 h trapping periods. The most significant attractive feature was CO_2, which attracted more sand flies than any other feature evaluated. Ultraviolet light was the next most attractive feature, followed by incandescent light. When evaluated alone, black or white trap bodies, heat and moisture, all influenced trap catch but effects were greater when these attractive features were used together. The results of this study suggest that traps with CO_2 and UV light could be used in batteries as control interventions if suitable CO_2 sources become available.

1. Introduction

Phlebotomine sand flies are distributed mainly in the tropics and subtropics of the Old World (Adler and Theodor, 1957). They are the major nuisance and known vectors of leishmaniases, bartonellosis (Birtles, 2001) and numerous viruses including phleboviruses, flaviviruses, orbiviruses and vesiculoviruses (Ashford, 2000, 2001; Comer and Tesh, 1991). Leishmaniasis remains a severe global public health problem with an estimated 12 million patent cases and a yearly incidence of 1.5–2 million cases. Of these, most are of the cutaneous form (Desjeux, 2001). Today, leishmaniases undoubtedly have a wider geographical distribution than before and are now being reported in areas that were previously non-endemic (Ashford, 2000; Oumeish, 1999). Increasing risk factors related to natural and man-made environmental changes are making leishmaniasis a growing public health concern for many countries (Daulaire, 1999; WHO, 1990). A major risk factor is the worldwide phenomenon of urbanization (Desjeux, 2001). Leishmaniasis is a major military concern for troops in endemic areas (Burkett et al., 2007).

Phlebotomus papatasi (Scopoli) is one of the most important vectors of cutaneous leishmaniasis, and the only vector of *Leishmania major* Yakimimoff and Schokhornin. *P. papatasi* is widespread in Israel and the Middle East, commonly biting humans indoors and outdoors from sunset to sunrise. It is an important vector of the parasite in the Jordan Valley and southern Israel where large sand fly populations are found in the burrows of the rodent reservoir, the fat sand rat (*Psammomys obesus* Cretzschmar) (Jainini et al., 1995; Schlein et al., 1982, 1984). *P. papatasi* is also common in Mediterranean habitats and a nuisance species in many of the settlements and larger cities. However, in the absence of sand rats,*P. papatasi* does not transmit *Leishmania*. The constant need for blood by female sand flies for egg development is the reason for frequent contacts between vectors and hosts (Killick-Kendrick, 1999).

Sticky papers and CDC type traps are the standard sampling methods for sand flies (Alexander, 2000; Killick-Kendrick, 1987) but catches without additional attractants like CO_2 are often small (Kline, 2006).

There is a large body of literature discussing all kinds of attractive features for biting flies but comparatively, little in this

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http://dx.doi.org/10.1016/j.actatropica.2014.06.007
0001-706X/

aspect is known about sand flies (Allan et al., 1987; Gibson and Torr, 1999).

The purpose of this study was to explore optical, physical and chemical features that might lead to more effective trapping methods for monitoring and possibly controlling sand flies in the future.

2. Materials and methods

2.1. Study site

The study was conducted in mid-autumn near Jericho, about 10 km north of the Dead Sea at an altitude of about 300 m below sea level. This region is an extreme desert and belongs to the Saharo-Arabian phyto-geographical zone (Danin, 1988). The annual precipitation of 50–100 mm is restricted to short winter rains. The average temperature ranges from around 20 °C at the end of September through early April to more than 30 °C from May through August (Ashbel, 1951).

Attraction features were evaluated in a neglected date plantation where a large population of *P. papatasi* was associated with colonies of fat sand rats and Wagner's gerbils (*Gerbillus dasyurus*) (Wagner, 1842). Zoonotic cutaneous Leishmaniasis is endemic in this area (Schlein et al., 1982, 1986) and *P. papatasi* is the dominant sand fly species comprising almost 100% of the catch, while other species are rare or absent (Faiman et al., 2009; Müller and Schlein, 2004; Schlein et al., 2001).

During autumn when the experiment was conducted, the annual winter and spring vegetation was already dry and some scattered shrubs and semi-shrubs dominated the little remaining natural vegetation found inside the plantation. About 20% of these were *Suaeda asphaltica* (Boiss.), *Salvia fruticosa* (Forsk.), *Atriplex halimus* (L), *Aglaia leucoclada* (Boiss.): Chenopodiaceae and *Prosopis farcta* (Macbride): Mimosaceae. On the periphery of the oasis, some groups of *Tamarix nilotica* (Ehrenb.): Tamaricaceae trees and shrubs, like *Alhagi graecorum* (Boiss.): Papilionaceae and *Salsola tetranda* (Forssk.): Chenopodiaceae, were restricted to small water catchments. Flowering plants, honeydew or honeydew producing insects of any kind were not found in the area at the time of the experiment.

2.2. Experimental design

The study was conducted for 10 consecutive days from late September to mid-October 2007 in the date plantation. During this time, the weather conditions were stable with clear sky during daytime and few to no clouds at night without any precipitation. Night temperatures ranged from 25–27 °C in the early evening to 20 –22 °C in the early morning and RH from 64 to 75%, respectively. To evaluate attraction features, CDC traps (Model 512, John Hock, Gainesville FL, USA) were operated without a lid and with their original white net bags, but were modified by adding attraction features like lights, black or white colored cardboard, heat, moisture, several chemical lures and CO_2 in different combinations described in detail below.

The baited traps, placed 20 m apart, were operated simultaneously and continuously (from late afternoon to early morning), along an unpaved road crossing the plantation. Traps were suspended from bamboo tripods with the top of the trap body 50 cm above the ground. Traps were rotated clockwise daily at 17:00 through the trap sites (in intervals of three positions) to eliminate areal bias. Insects drawn to the traps were collected promptly at 07:00 h to prevent degradation; the catch was stored in a freezer and processed at a later point of time. The CDC traps were powered by 6 V motorcycle batteries, which were recharged daily.

2.3. Evaluating attraction features

Altogether, we evaluated 28 features or combinations of features for their attractiveness to *P. papatasi* (Table 1). For a non-attractive control, we used CDC traps with no light. To test the effect of light, the original CDC light trap configuration with incandescent light (bulb model: model CM-47) was maintained. To test the effect of UV light, the incandescent bulb was removed and a small portable money checker (Tragbarer Geldschein-Prüfer mit Leuchte, model 751778–62, Conrad Munich, Germany) equipped with a 4 W, 6 V UV tube (model: F4T5 BLB) was attached horizontally 3 cm above the cylindrical body of the trap (very much like the CDC Model 1212, John Hock, Gainesville FL, USA). The UV unit was connected to a separate 6 V motorcycle battery.

For color modification, if needed, the original transparent cylinders of the CDC traps were wrapped either in white or non-glossy black cardboard.

Heat was generated by heat film (MDS Heating Industries Ltd., Nazareth, Israel) beneath the metal jacket of a 4 mm iron sheet that fit tightly around the trap cylinders. The modified cylinders were then wrapped with cardboard (either white or black) as mentioned above. The temperature was adjusted to 41 °C on the outside surface of the cylinders, which was measured with a laser-sited infrared thermometer (model OS546, Omega Engineering Inc., Canada). Though the surface temperature of potential hosts is usually lower mosquito traps are usually utilizing heaters ranging from 40 to 45 °C because of a significantly higher attraction rate of biting flies.

Table 1
Mean numbers (±SE) of *Phlebotomus papatasi* adults (both males and females) captured in CDC traps with 28 different combinations of attractant features ($n = 10$).

NO.	Light[a]	CO_2 (ml/min)	Lures[b]	Other[c]	Mean ± SE
28	UV	750	–	B, H, M	1554.79 ± 0.10a
26	UV	250	–	B, H, M	1300.22 ± 0.09a
23	UV	250	–	–	696.11 ± 0.08b
25	Incand.	250	–	B, H, M	570.61 ± 0.13b
27	–	750	–	B, H, M	491.32 ± 0.16b
24	–	250	–	B, H, M	466.63 ± 0.14b
22	Incand.	250	–	–	278.45 ± 0.11c
21	–	250	–	–	194.93 ± 0.15c
20	UV	250	–	B, H, M	30.62 ± 0.13d
3	UV	250	–	–	21.96 ± 0.12d
19	Incand.	250	–	B, H, M	12.76 ± 0.124e
16	–	250	Kaz	B, H, M	9.05 ± 0.19ef
18	–	–	Oct.	B, H, M	8.67 ± 0.13ef
14	–	–	–	B, H, M	8.14 ± 0.18ef
17	–	–	BG	B, H, M	6.67 ± 0.20fg
10	–	–	–	B, M	6.30 ± 0.10fg
2	Incand.	–	–	–	5.99 ± 0.09fg
15	–	–	–	W, H, M	5.69 ± 0.18fg
7	–	–	–	M	4.96 ± 0.10fgh
11	–	–	–	W, M	4.16 ± 0.13gh
8	–	–	–	B	3.57 ± 0.10ghi
12	–	–	–	B, H	3.01 ± 0.19hij
5	–	–	Kaz	–	2.84 ± 0.16hijk
6	–	–	BG	–	1.98 ± 0.13ijk
9	–	–	–	W	1.58 ± 0.13jk
1	–	–	–	–	1.41 ± 0.13jk
13	–	–	–	W, H	1.36 ± 0.18k
4	–	–	Oct.	–	1.34 ± 0.14k

Means followed by the same letter are not significantly different [$P < 0.05$; Ryan–Einot–Gabriel–Welsch Multiple Range Test (SAS Institute, 2003)].

[a] Incand.: incandescent bulb supplied with trap; UV: BLB-T5/4 W fluorescent tube (peak wave length = 365 nm), Conrad Electronic SE, Hirschau, Germany.

[b] Kaz: 2-in-1 Power Bait (1-Octen-3-ol, 6.531% AI and Lactic acid, 5.331% AI), Kaz-Inc., Southborough, MA; Oct: Octenol lure (1-Octen-3-ol, 6.531% AI), AgriSense BCS Ltd., Pontypridd, UK; BG: BG-Lure (lactic acid, 13% AI, caproic acid, 1% AI, and ammonium bicarbonate, 4% AI), Biogents, Regensburg, Germany.

[c] B: black cardboard over cylindrical trap body; W: white cardboard over cylindrical trap body, H: heat film over cylindrical trap body; M: moisture.