International Journal of Mosquito Research

ISSN: **2348-5906**
CODEN: **IJMRK2**
IJMR 2018; 5(1): 138-142

Received: 19-11-2017
Accepted: 20-12-2017

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Efficiency of three light traps for sampling Mosquitoes in the western regions of Saudi Arabia

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Abstract
Entomological surveys were carried out in six localities representing three regions in the western coast of the Kingdom of Saudi Arabia for two years to evaluate the efficiency of CDC (Centers for Disease Control and Prevention) miniature light traps, Black Hole (BH) traps and Fay-Prince Blacklight (FP) traps in collecting mosquitoes. The CDC showed higher efficiency in collecting more numbers of mosquito species (19/19:100%) and of adults (19.33 adult / trap, $P<0.01$)) than either BH (78.95% spp, 4.89 adult / trap) or FP (68.42% ssp, 13.44 adult / trap). Sorensen coefficient showed moderate similarity (45-48%) in mosquito species composition attracted by the different traps. Adult collections fluctuated monthly with peaks of collection were during spring and autumn months. So that, light traps mainly CDC could be useful as a tool for the study of species composition and seasonal distribution of mosquito vectors of diseases. This is important for planning and implementing vector control programs.

Keywords: Mosquitoes, light traps, CDC traps, black hole traps, black light traps, Saudi Arabia

1. Introduction
Several techniques are used to capture mosquito adults including hand collection (aspiration method), indoor collection after pyrethrum/pyrethrin spraying (spray sheet collection), and direct catches of mosquitoes off animal and human baits (biting collection). Historically, human landing catches (HLCs) in which humans act as baits were used to survey for the existence of potential vectors of disease and to evaluate the efficacy of vector control operations. However, the ethical issue of placing humans at greater risk for contracting disease justifies the need for alternative tools that are relatively safer. To avoid human contact with mosquitoes, various devices have been developed over the years to survey mosquitoes [1]. So that, effective trapping methods are necessary to enable accurate surveillance, improve control methods, enhance understanding of dispersal, and use for early detection of vectors and pathogens [2]. In this respect, light traps are the best tool for faunistic studies as they provide a tool for overall sampling of the mosquito fauna in an area [3]. Moreover, light traps will remain a relevant tool for host-seeking mosquitoes especially in the absence of HLCs and can substitute the more labor-intensive and intrusive pyrethrum spray catches (PSCs) for routine monitoring of indoor resting mosquitoes [4].
Several researchers [1, 3, 5-12] evaluated the effectiveness of different light traps for examples the CDC (Centers for Disease Control and Prevention) miniature light traps, Ultraviolet (UV) light traps, New Jersey (NJ) light traps, Mosquito magnets. The BG-Sentinel (BGS) mosquito traps, Blacklight traps, and Yellow fluorescent light traps in comparison to some other techniques mainly HLCs and PSCs for mosquito collection.
Thirty six species of seven genera are indigenous in the western part of the Kingdom [13] of which *Culex pipiens, Cx. quinquefasciatus, Cx. tritaeniorhynchus, Cx. perexiguus*, *Stegomyia (=Aedes) aegypti, Aedimorphus arabiensis*, *Anopheles sergenti*, An. *fluviatili*s and *An.* multicolor are known as important vectors of diseases in the Kingdom of Saudi Arabia mainly *filariasis*, RVF, dengue fever, West Nile Virus (WNV) and malaria [14-20].
Due to the abundance and diversity of mosquito species mainly the disease vectors in Saudi Arabia, the case that necessitates finding an appropriate trapping tool for determining their

relative abundance and monitoring and assessing the impact of control measures. As we are aware, no available studies comparing the effectiveness of different light traps in collecting mosquitoes in Saudi Arabia? This study was planned with a goal to compare the efficiency of three types of light traps: the standard-use CDC trap and two UV traps "Black Hole and Fay-Prince Blacklight" in collecting mosquitoes of the western coast.

2. Materials and Methods

2.1 Study area

The study was carried out in six localities (Taif: 21°26′N, 40°21′E, Mecca: 21°30′N, 41°0′E, Jeddah: 21°32′36″N, 39°10′22″E, Yanbu: 24°05′N, 38°00′E, Duba: 27°20′57.3″N, 35°41′46.2″E and Haql: 29°17′N, 34°56′E) representing three regions (Mecca, Al Madinah and Tabouk) of the western part/coast of the Kingdom (Figure 1). The detailed description of the three regions is given in a concurrent study by Hassan *et al* [13]. In each locality, certain sites were selected and sampled for mosquito adults biweekly from January 2013 to December 2014.

2.2 Light traps

Three different types of traps (Figure 2) were evaluated: (1) the CDC miniature light trap (Model 512, John W. Hock Co, Gainesville, FL, USA), (2) the V-Mart Super photo-catalyst "Black Hole (BH)" trap (Venus Technology Co, Ltd. Wangthonglang, Bangkok, Thailand) and (3) the CDC Fay-Prince (FP) Blacklight (UV) Trap (Model 812, John W. Hock Company, Gainesville, Florida, U. S. A).

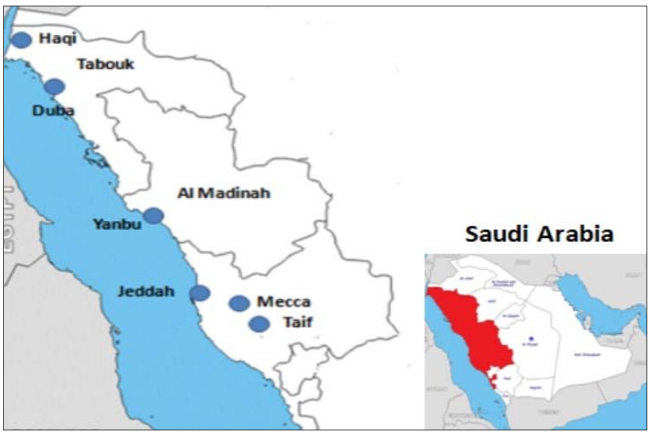

Fig 1: The study area and localities in the western part of Saudi Arabia

Fig 2: CDC miniature light (A), Black Hole (B) and Black light (C) traps.

2.3 Mosquito collection and processing

Adult mosquitoes were collected from indoors and outdoors (in yards, gardens and farms) close to human settlements. Traps were usually suspended at about 2 meters above ground, set before sunset and collected after sunrise next morning. The collected mosquitoes were aspirated and placed in labeled paper cups that kept in a picnic ice box while being transported to the laboratory. In the laboratory, mosquitoes were preserved in 70% alcohol till identified using morphological keys [21-23].

2.4 Statistical analysis

Monthly means (number collected per trap) and Standard Deviations were calculated and compared by the one-way ANOVA. If ANOVA shows significant inequality of the means, they were further exposed to pairwise comparisons by the Tukey's honestly significant difference (HSD) test. The PAST (Paleontological Statistics Version 2.08) computerized software [24] was used for such analysis. To measure the degree to which the 3 types of traps differ in their species composition, the Sorensen coefficient (Sorensen similarity index) was calculated using the equation: $S_s=2a / (2a+b+c)$ (https://ag.arizona.edu/classes/rnr555/lecnotes/10.html)
where: a = number of species collected by both traps, b = number of species in the1st trap type and c = number of species in the 2nd trap type.

3. Results

3.1 Collected mosquito species

A total of nineteen mosquito species belonging to six genera (*Culex, Anopheles, Stegomyia, Ochlerotatus, Aedimorphus* and *Culesita)* were collected by the different traps in all localities (Table 1).

Table 1: List of mosquito species collected by different traps in all localities of the western part of Saudi Arabia.

Species	Light traps		
	CDC[1]	BH[2]	FP[3]
Culex (*Culex*) *pipiens* L	◙	◙	◙
Cx. (*Cux.*) *perexiguus* Theobald	◙	◙	◙
Cx. (*Cux.*) *sinaiticus* Kirkpatrik	◙	◙	◙
Cx. (*Cux.*) *quinquefasciatus* Say	◙	◙	◙
Cx. (*Cux.*) *tritaeniorhynchus* Giles	◙	◙	◙
Cx. (*Cux.*) *theileri* Theobald	◙	◙	◙
Cx. (*Cux.*) *sitiens* Wiedemann	◙	◙	◙
Cx. (*Cux.*) *torrentium* Martini	◙	◙	
Cx. (*Cux.*) *simpsoni* Theobald	◙		
Cx. (*Cux.*) *laticinctus* Edwards	◙		
Cx. (*Barraudius*) *pusillus* Macquart	◙		
Anopheles (*Cellia*) *dthali* Patton	◙	◙	◙
An. (*Cel.*) *multicolor* Cambouliu	◙	◙	◙
An. (*Cel.*) *sergentii* Theobald	◙	◙	◙
An. (*Cel.*) *fluviatilis* James	◙		
Stegomyia (*St.*) *aegypti* (L.)	◙	◙	◙
Ochlerotatus (*Oc.*) *caspius* (Pallas),	◙	◙	
Aedimorphus vexans arabiensis (Patton)	◙	◙	◙
Culiseta (*Allotheobaldia*) *longiareolata* Macquart	◙	◙	◙

[1]CDC miniature trap, [2]Black Whole trap, [3]Fay-Prince Blacklight trap

3.2 Sørensen similarity index

The similarity degree of species composition among the three types of traps was measured and revealed that the calculated values of Sorensen coefficient indicated moderate similarity between CDC and BH (0.47), CDC and FP (0.45) and between BH and FP (0.48).

3.3 Trap efficiency in collecting mosquito species

The efficiency of the three types of light traps in collecting the different species of mosquito adults (ranges of species from all localities altogether) were compared and generally revealed that the CDC collected all the reported 19 species (100%) as compared to 15 spp. (78.95%) by BH and 13 spp. (68.42%) by FP tarps.

From the different localities (Figure 3), CDC traps collected higher number of species (11/13-14/14 species: 84.62-100%) than the other two types (BH, 6/13-7/9 species: 46.15-77.78%) and FP (3/13-10/14 species: 23.08-71.42%).

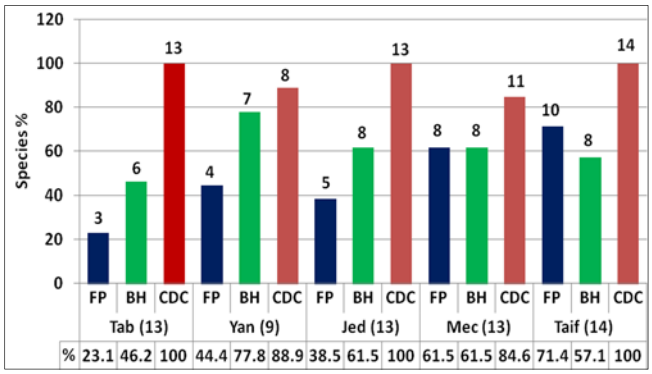

Fig 3: Numbers and percentages of mosquito species collected by different traps in the different localities (Tab: Tabouk represented by Duba and Haql, Yan: Yanbu, Jed: Jeddah, Mec: Mecca)

3.4 Monthly trap collections

Adult collections by the three types of traps fluctuated monthly (Figure 4) with peaks of collection during March (FP), May (CDC) and September (BH). The overall monthly means of adults (all species, all localities) collected by a single trap was calculated (Table 2) and revealed that significantly ($F=7.32$, def. $=2, 33$, $P<0.01$) higher mean collection by CDC traps (19.33 adult / trap) than those by either BH (4.89 adult / trap) or FP (13.44 adult / trap) traps. Multiple comparison (Tukey's HSD) revealed that all means of the three types of traps were significantly different ($P<0.01$).

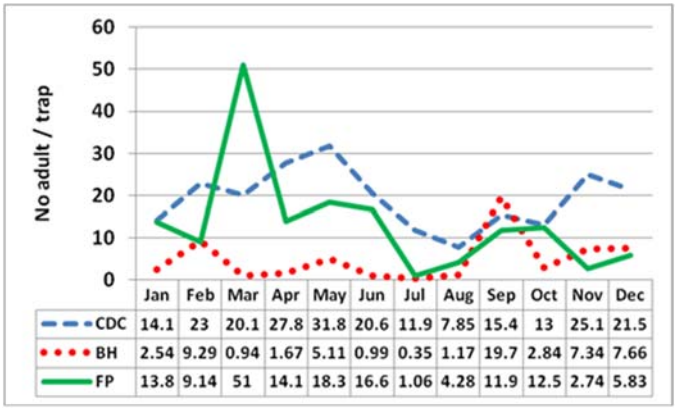

Fig 4: Monthly collections of mosquito adults by different traps

Table 2: Comparison of overall monthly mean collections by different traps in all localities (2013+2014)

Attribute	CDC	BH	FP
Total traps	986	1350	484
Total mosquitoes	19317	5992	6606
Mean± SD*	19.33±7.06 A	4.89±2.01 B	13.44±3.06 C

Means with different letters are significantly different ($P<0.01$, Tukey's HSD test).

4. Discussion

Mosquito traps play a vital role in monitoring mosquito populations and mosquito-borne diseases [25]. Since the

invention of the New Jersey light trap, many mosquito traps have been developed and tested for mosquito surveillance [26, 27]. There has been a vast amount of research on the ability of different types of light traps to capture mosquitoes [9, 26-28]. Currently, the most popular of the developed traps, the CDC light trap, incorporates light and a secondary mosquito attractant, such as CO2, to increase the number of mosquitoes captured [12, 29]. The CDC light trap is the most widely and commonly used mosquito monitoring tool by mosquito control agencies in the world [25, 30]. The use of CDC light traps for sampling mosquito populations has been investigated by many workers and various modifications have been suggested to improve their efficiency as sampling tools [31, 32]. There are reports [3] indicating that CDC light traps catch more anopheline and culicine mosquitoes than do human bait collections and that they are useful for sampling outdoor mosquito populations in many areas. However, biting collections were found more effective than the CDC traps in capturing *Anopheles* species [5, 10]. Reisen *et al* [6] reported that CDC traps collected significantly more females of most species than did NJ light traps, regardless of background illumination. Moreover, population assessments of diurnally active mosquitoes as most of *Aedes* (*Stegomyia*) mosquitoes is difficult with commonly used adult traps such as the New Jersey or CDC light traps [9, 33, 34].

Our results indicated that the three types of light traps (CDC, BH and FP) had moderate similarity (45-48%) in their mosquito composition indicating differences in the numbers of collected mosquito species however, no available reports on this aspect. On the other hand, the CDC collected more species than the other traps and proved significantly (P<0.01) more efficiency in collecting mosquitoes (number of collected adults) than either BH or FP traps. Also, results indicated that FP traps were more efficient than BH traps based on the number of captured mosquito adults. This in agreement with most of previous reports [3, 6] especially with the observations of Li *et al* [12]. that in the evaluation of light traps without a chemical lure, the blacklight (FP) (27.4 mosquito/trap) and CDC (11.8 mosquito/trap) traps were the best performing traps and the most effective at collecting mosquitoes of medical and veterinary importance. The author added that experience has shown that CDC light traps are an efficient and productive means of collecting mosquitoes, both in consideration of the numbers of individuals captured and the diversity of species represented.

In the present study, adult collections by the three types of traps fluctuated monthly with peaks of collection were during March (FP), May (CDC), i. e. spring and September (BH), i. e. autumn. In a concurrent study [35] using the same types of traps, *Cx. pipiens and Cx. quinquefasciatus*, the common mosquitoes adults in the western part of Saudi Arabia showed peaks of abundance during spring with high activity was during autumn and winter. This indicates that light traps mainly CDC traps can be used to investigate the seasonal prevalence of the mosquito vectors. Similarly, it was indicated [3] that CDC light traps are useful for the study of seasonal distribution of *An. stephensi* and *An. fluviatilis* in Iran.

5. Conclusion

The CDC miniature light trap showed more efficiency in collecting mosquitoes based on the numbers of individuals captured and the number and diversity of species. So that, light traps mainly CDC traps could be useful as a tool for the study of species composition and seasonal distribution of mosquito vectors of diseases. This is important for planning and implementing vector control programs.

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