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Eco-friendly and Energy Efficient Traps for Mass Capturing of Mosquitoes

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ABSTRACT

Background: More than half of the world's population lives in mosquito inhabited areas. So, continuous mosquito control efforts are important to prevent the epidemics of mosquito borne diseases. **Methods:** Mass trapping strategy for mosquitoes and other insects was developed in this study. Three simple traps (Type A, Type B and Type C3) and three modified miniature traps (Type A1, Type B1 and Type C1) were designed. The different baits (sugar and yeast) were used in each type of trap. The traps with different colour lights were installed and analysed in the fields to record their efficiency to attract and trap the mosquitoes. **Results:** Results showed that modified miniature traps were better than simple traps. Furthermore, the efficiency of baited traps was higher. The efficiency of modified miniature traps was significantly improved by attaching coloured light, especially red light. **Conclusion:** It was concluded from the study that modified miniature traps with sugar and yeast as bait and red light attached are highly efficient in capturing mosquitoes. These traps can be further improved and used for mass trapping of mosquitoes and other insects.

Keywords: Insects; traps; modified miniature traps; baits; mosquitoes

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INTRODUCTION

Being vectors of several diseases, mosquitoes are amongst the lethal creatures of the world and are responsible for millions of deaths every year. According to the World Health Organization (WHO) malaria alone caused 0.44 million deaths in 2015. Moreover, upto 30-folds increase has been reported by WHO during the last five decades. Mosquitoes serve as vectors of many pathogens that cause diseases such as malaria, zika, dengue, chikungunya, and yellow fever, filariasis. More than half of the world's population lives in mosquito inhabited areas. Continuous mosquito control efforts are important to prevent the epidemics of mosquito borne diseases (Wilson et al., 2020).

Mosquito control is important to the community because of the vector potential of mosquitoes to transmit diseases and the disturbance they cause by inhibiting daily outdoor activities. The vector potential of mosquitoes arises from the female's bloodsucking habits for the completion of their reproductive cycle. A mosquito can only transmit the disease after it becomes infected after gaining the pathogen from an infected animal or person (Ruiz-López, 2020).

In most cases, a single bite from an infected mosquito does not cause sickness but in some cases mild or long-term illness can be caused even with a single bite. Some mosquito- borne diseases can even result in death (Silva et al., 2018). In 2013, around 390 million people experienced dengue virus infections, of which 96 million cases had some kind of apparent manifestation. In 2015, 212 million malaria cases were reported worldwide with approximately 429, 000 deaths, 92% of them occurred in Africa (Alout et al., 2017).

Vector control techniques by means of insecticides started in 1947. The mosquito eradication was possible with the discovery of. DDT globally. This attitude led to the Pan American Health Organization (PAHO) and the World Health. Organization (WHO) to form a new strategy to fight mosquitoes: the Eradication Program of *Ae. aegypti* in the Western Hemisphere. It was considered that *Ae. aegypti* be eradicated from. Brazil by the end of the 1950s. In the 1950's and 1970's two major outbreaks of dengue were observed due to environmental changes and rapid urbanization (Gubler, 2011).

The use of chemical insecticides for vector control is in decline due to high costs, the development of insecticidal resistance in many target populations, and environmental and human health (Gould et al., 2018). Although insecticides were successful in many cases but due to increase in zoonotic disease incidences it was concluded that insecticides are not sufficient to control these epidemics (Azarm, et al., 2024). Due to increasing health and environmental risks, the scientific community is now diverting towards alternative control agents (Achee et al., 2019).

To reduce the contact of humans with these vector different strategies have been adopted like, mosquito proofing of houses with screens on windows and doors. To keep mosquitoes out of our houses we should keep doors and windows tightly shut or should add insect-proof nets. By keeping these nets in good condition, we can provide an effective barrier against these disease vectors (Deepak et al., 2017). With the advancement in technology different devices have been made to control mosquitoes (Ponlawat, 2017). Development of eco-friendly traps is the future of successful mosquito control and it would be helpful to avoid outbreaks of vector borne diseases.

Outdoor mosquito trapping techniques have been successfully devised for ovipositing mosquitoes. However, this technology is not available yet for mass trapping of host seeking mosquitoes (Lima et al., 2017). Cost effective mosquito traps which are easy to handle and eco-friendly can be prepared using limited resources. Setting a number of traps in an area helps reduce the mosquito population and inhibits disease transmission. This method has no harmful effects on humans and other animal populations. At large scale, this technique can eliminate the primary vectors of many medically important arthropod-borne diseases.

The current study was designed to develop eco-friendly traps that are easy to handle, and economically cheap, with increased mosquito trapping efficiency as an alternative to chemical control.

MATERIALS AND METHODS

Study area

The study was conducted from June to September, 2018 at Government College University, Lahore (31.5732° N, 74.3079° E) and Botanical Garden of Government College University, Lahore (31.5582766°N 74.3290015°E), located at Mall Road Lahore. Mosquito traps were set from dawn to dusk for 3 days in a week and continued for two months. The location of traps was changed from time to time for random data collection.

Mosquito traps

Two types of mosquito traps were designed i.e. simple mosquito traps (Type A, Type B and Type C) and modified miniature CDC traps (Type A1, Type B1 & Type C1).

1. Simple mosquito traps

Simple traps were designed using plastic bottles, tape and black paper. A plastic bottle was cut in two pieces. The upper part of the bottle was inverted so that it looks like a funnel. This part was placed over the bottom of the bottle (fig. 1). The ends of the inverted bottle were sealed with tape and black paper was wrapped around it as it attracts more mosquitoes. Different solutions were used as bait in the bottom of the trap. In simple mosquito traps CO_2 was used as a bait to attract mosquitoes (Meyer *et al.,* 2018). Simple traps were further divided into three types.

Type A

In these traps CO_2 was generated by fermentation of brown sugar in the presence of yeast in a ratio of 5 g yeast in 280 g sugar. Brown sugar and water solution was heated until the sugar was completely dissolved in it (fig. 2). After making a homogeneous mixture it was cooled down for 10 minutes. The solution was poured in the bottle and yeast was added to it. The solution was not mixed for long term production of

CO_2 gas.

Type B

In these traps a solution of baking soda in vinegar was used as bait (fig. 3). The rest of the trap assembly was kept the same as in Type A. Vinegar (100 ml) was added in baking soda (200 ml) for the production of CO_2 to attract the mosquitoes, so that they come into the funnel and get trapped in the bottom section of the bottle. This solution can generate CO_2 for 16-18 hours (Girard *et al.*, 2021).

Type C

In Type C traps liquid detergent and water solution was used as bait. Liquid detergent increases the surface tension of the water which makes it difficult for mosquitoes to escape out and they are trapped to be drawn in water. A Control trap was set with these traps in which water was used instead of chemical baits (fig.3).

2. Modified miniature CDC traps

CDC (Centre for Disease Control) light traps were designed in such a way that each trap had a 12 V fan attached with a battery powered by solar panel. The traps were hanged with a tree branch for 24 hours (fig. 3). The traps were set for 3 nights in a week and continued for two months. Trapped mosquitoes and insects were collected and brought to the laboratory for further processing. To enhance the efficiency of miniature traps different coloured lights (green, blue and red) were attached to these traps to attract the mosquitoes. Each trap was equipped with light of only one colour.

To reduce the expenditure in designing traps, traps were powered with solar panels and a battery was also attached to each trap. Batteries were charged during the day and the fan of trap was in operation mode from dawn to dusk. This solar powered system has been successful in temperate regions where solar energy is used which is eco-friendly and cheap (Oria et al., 2014). It reduces the cost of traps and is easy to deal with.

Light sensitive sensor was also added to the solar powered traps to maximise the charging. The solar panel traps ran out of power supply after 3-4 h and their fan stopped as a result captured mosquito escaped out. These traps were set in the field in the morning around 11am till next morning. In daytime the batteries were charged and at night the fan started working and mosquitoes were collected (fig. 4).

Modified miniature traps were further divided into three types.

Type A1

In these traps sugar and yeast solution was used as bait and red coloured light was used.

Type B1

Solution of baking soda in vinegar was used in these traps and the rest of the assembly was the same as in *Type A1 trap*. However, green light was used in these traps.

Type C1

In these traps liquid detergent in water was used as bait and blue coloured light was used.

Collection and identification

In the morning, traps were removed after disconnecting the electric supply to the fans. The lower part of the trap was separated. Collected mosquitoes were placed on ice and kept in the refrigerator for 10 minutes (Jawara et al., 2009). Mosquitoes were morphologically identified and counted.

Experimental design and data analysis

The data of different traps was collected from different traps and the number of trapped mosquitoes and other insects was counted. The number of mosquitoes caught in different traps was compared using One-way ANOVA (SPSS 16). Tukey's test was used for multiple comparisons.

RESULTS

Type A trap which contained brown sugar and yeast as bait was found to be the most efficient simple trap. The mosquitoes capturing efficiencies of three traps with different baits differed significantly ($F_{3, 18}$= 19.88; P <0.001). Results of Tukey's test showed that there was non-significant difference in mosquitoes capturing efficiency of control and Trap C in which liquid detergent in water was used as bait (fig. 5). However, the efficiency of Trap A and Trap B was significantly better than control traps. In the modified CDC trap the trend was the same as in simple trap.

The efficiency of Type A1 and type B1 was significantly higher than control ($F_{3, 18}$= 56.35; P <0.001; fig. 6). The comparison of efficiency of CDC traps with different coloured lights as mosquito attractants revealed that the traps with red light are efficient as compared to green and blue light ($F_{2,6}$= 40.92; P<0.001; fig. 7). The comparison of mosquito capturing efficiency of best simple (Type A), best modified (Type A1) and best trap with light (Type A1 + Red light) is depicted in (fig.8). Statistically significant difference was observed in number of mosquitoes captured in three types of traps ($F_{2, 6}$= 57.62; P <0.001).

DISCUSSION

Mosquito capturing efficiencies of simple and modified miniature CDC traps with different baits were compared in the study. In simple traps, black paper was used to wrap the trap based on the fact that black colour attracts more mosquitoes than other colours (Huang et al., 2017). These traps were developed on the bases of odour baited trapping technique. The most effective simple traps were Type A in which sugar and yeast solution was used as bait. Similar approaches have been successfully used for arthropods trapping especially mosquitoes by other researchers (Roiz et al., 2012; Matowo et al., 2013).

The second type of trap used in this study was a modified miniature trap. They were designed on the principle to spread the CO_2 produced by the bait with the help of a solar powered fan. Mosquito capturing efficiency of these traps was significantly higher than simple traps as the fans attached in these traps were successful in spreading the attractant over a large range and by keeping the insects trapped in the container (Krockel et al., 2006) conducted a field study and reported that CDC-LT traps efficiently captured a higher number of *Aedes aegypti* than the BG Traps (Biogents' mosquito trap for researchers). In our traps, most of the mosquitoes were Culex followed by *Aedes*. No Anopheles mosquito was recorded in the collection. This result was not surprising as the area where the traps were set was not the habitat of anopheles mosquitoes. Anopheles mosquitoes prefer fresh stagnant water such as fishponds, pools, paddy fields etc. (Kline, 2006) used professional (PRO) and counter flow geometry (CFG) traps for capturing mosquitoes with propane power as bait. He also reported capturing of flies and bees in the traps other than Culex and Anopheles.

Another achievement of our modified traps was the enhanced run time of solar powered fans by attaching light sensitive sensors with solar panels. This increased the operational time of the fan from dawn to dusk. At day time the batteries were charged using light energy and at night the electricity was used by the traps. The use of different coloured light to attract the mosquitoes was also unique in our study. In our study it was found that red coloured lights are more efficient in attracting mosquitoes (reason unknown). Only three lights of different colours were used in our study but it is suggested that use of more colours for their possible role in mosquito capturing should also be tested.

The traps developed by us use less number of chemicals which limits the environmental pollution. The developed traps can be used as indoor traps (simple traps) and outdoor traps (Modified miniature traps). They are easy to carry so they can be used in remote and rural areas by using fewer resources. By setting a significant number of modified miniature traps, potential disease vectors can be eradicated from a specific area. By improving these traps in future they can be used for mass trapping and will be helpful in preventing epidemics of vector borne diseases.

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Statement of conflict of interest

None to declare.

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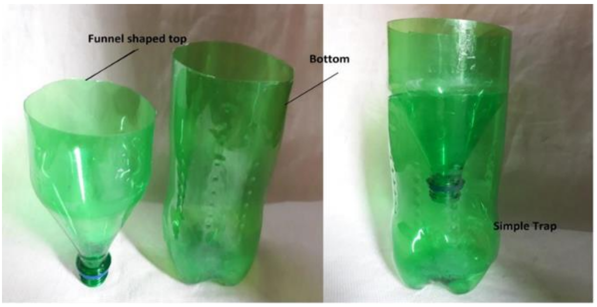

Figure 1: Simple trap assembled for mosquitoes capturing.

Figure 2: Type A Trap containing brown sugar and yeast solution as bait (A), Type B containing water and liquid detergent as bait (B) and Type C Trap containing baking soda and vinegar solution as bait (C).

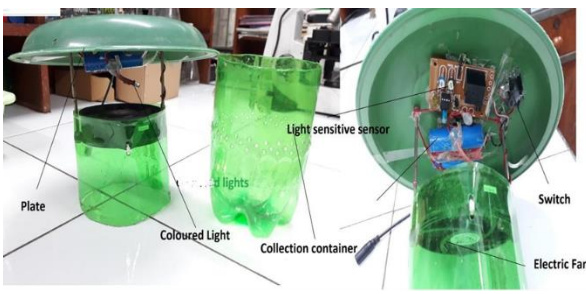

Figure 3: Assembly of modified CDC light trap.

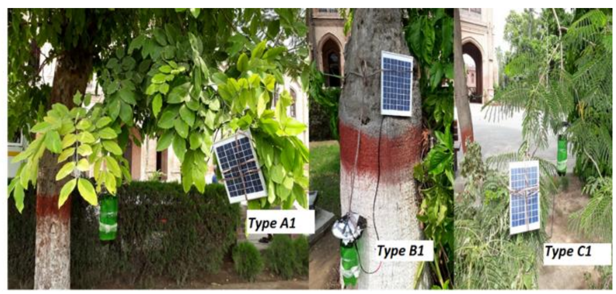

Figure 4: Modified CDC traps installed at GC University Lahore.

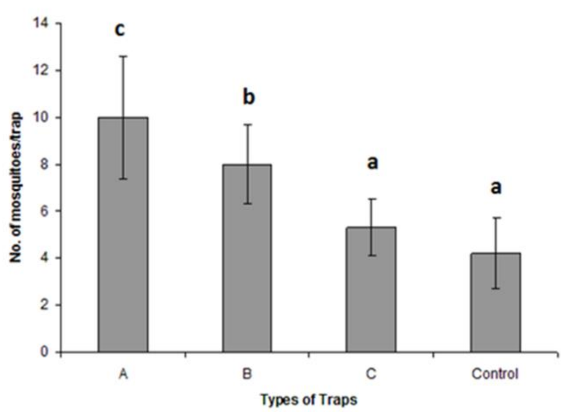

Figure 5: Comparison of mosquito capturing efficiency of simples traps with different baits. Different letters on bars are indicating significant difference.

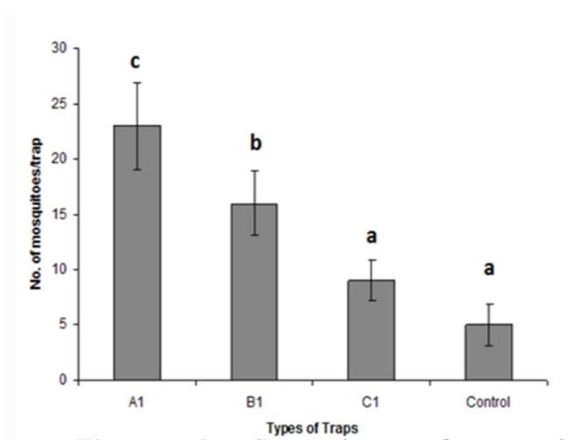

Figure 6: Comparison of mosquito capturing efficiency of CDC modified traps with different baits. Different letters on bars are indicating significant difference.

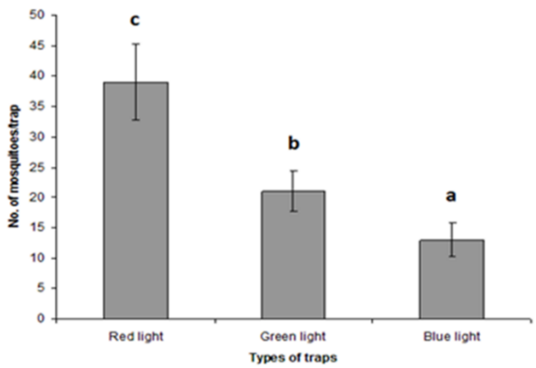

Figure 7: Comparison of mosquito capturing efficiency of modified traps with different lights. Different letters on bars are indicating significant difference.

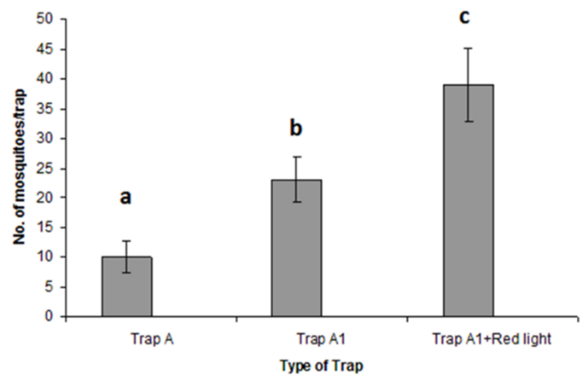

Figure 8: Comparison of mosquito capturing efficiency of best simple (Type A), best modified (Type A1) and best trap with light (Type A1 + Red light). Different letters on bars are indicating significant difference.