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A COMPARATIVE RISK ASSESSMENT OF THE USE AND EFFICACY OF HIGH VOLTAGE AND ADHESIVE ULTRA VIOLET LIGHT TRAPS FOR THE MONITORING AND CONTROL *MUSCA DOMESTICA* L.

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ABSTRACT

Ultraviolet light traps are a commonplace solution to the monitoring and control of flying insects in commercial premises. There are many different trap designs and there are no agreed methods of quantifying their efficacy at catching flying insects. A quantifiable measure of performance has been developed by calculating the shortest period to catch 50% of house flies released into sealed test rooms containing a single ultra violet light trap. Traps using electrified grids were found to be less effective when compared with traps using an adhesive surface. This information is put into the context of the use of such traps to control flying insects in kitchens and food preparation areas where an increased risk of food and surface contamination from insect body fragments and bacteria carried on electrocuted flies. It is asserted that electrified grid traps are best used as control mechanisms where exclusion and restriction of flies is not practical and where there is little or no risk of particulate contamination of food.

INTRODUCTION

Ultra violet flying insect traps are common in food preparation areas: their presence is often mandated by best practice guidelines the business is following. The reason they are mandated is to reduce risk of food contamination from flying insects. House flies (*Musca domestica*, L.) are capable of transmitting a number of pathogens to our food that can cause diseases including salmonellosis and other forms of food poisoning (Nazni *et al*, 2005; Yap, *et al* 2008). There is risk of food contamination with this type of trap due to fragmentation of insects and a release of micro-particles from surface of the insect when it is electrocuted (Ananth *et al*, 1992; Broce, 1993; Urban & Broce, 2000). However, this risk is reduced far more effectively by glue traps than by high voltage traps as trapped flies remain intact when captured rather than stunned, maimed or shattered when they come into contact with a high voltage grid (Pickens, 1989).

Tolerance to house flies varies. In food preparation areas there is generally a very low tolerance, whilst in storage areas many more will be accepted before they become a nuisance. Risk of disease transmission from particulate contamination increases arise when an electrocution trap best suited to control is used in a monitoring situation. Traps with removable glue boards are most suited for monitoring purposes. The glue boards are changed at known intervals throughout a year and the number of types of flying insects captured on the boards will provide a valuable insight into when and where insect proofing should be improved and enforced. Boards may become clogged with flies and covered in dust and not the best solution these situations.

A third type of trap, encapsulates insects in a rolling film. The advantages of this type of trap are that the catch surface is routinely refreshed, reducing problems in dusty environments. These traps are better suited for control of flies rather than monitoring as, once encapsulated in the roll, the flies are more difficult to count and identify. The use of encapsulation traps would reduce the risk of particulate contamination in food preparation areas. The servicing cost of these traps is higher than for electrocution traps as the adhesive rolls needs to be changed more regularly than a catch tray would need to be emptied, especially in situations where flies are routinely trapped in high numbers.

The aim of this work was to quantify the efficacy of all three types of trap to assess whether the use of encapsulation traps over electrocution traps is preferable when considering particulate contamination in food preparation areas.

MATERIALS AND METHODS

Ultraviolet traps of the same design fitted with different catch surface were used to compare different methods of removing insects from the environment in near isolation. Removing flies from the environment as fast as possible is seen as the most important factor for the end user (Sargent, 2010), therefore the catch rate of a number of different commercially available traps was quantified by calculating the average time to catch 50% of flies within a sealed room at the traps fastest recorded catch rate.

There are a diverse range of ultra violet light traps marketed for the monitoring and control of flying urban insect pests. There are an equally diverse number of methods employed to qualify their efficacy. Whilst the design of commercial light traps differs, all incorporate a UV-A light source and a lethal surface, be it an electrified metal grid or an adhesive board or roll. Quantifiable measurements from these traps that purport to effect catch rate are often quoted as de facto figures for their efficacy, including total bulb power, UV-A output and lethal surface area. Whilst there is certainly some evidence to support the maximisation of these measurements (Pickens & Thimijan, 1986), previous studies and preliminary laboratory testing suggest that various design factors that may negate any advantages gained through such efforts (Hanley *et al*, 2009).

Two different ultra-violet light traps were used in these tests: Unit 1 could be fitted with an electrified grid or a double-sided adhesive surface, Unit 2 could be fitted with an adhesive surface or an adhesive roll that catches and encapsulates captured insects. Both units were tested in two identical controlled environment rooms (2.0m x 2.1m x 2.4m), maintained at 25℃ ± 2℃ and 50% ±10% RH, illuminated daily on a 12 hr cycle. The rooms were subject to 10 air changes per hour and sealed to prevent flies escaping.

All UV lamps used in the traps were burned in for a minimum of 100 hours prior to testing and all traps used were electrically tested for safe use. Identical plastic-sleeved shatter-proof lamps were used in all tests. All traps tested were mounted securely to the wall at height of 1.8m from the floor.

Unsexed adult *M. domestica* from laboratory cultures, selected for the ability to fly, were captured, anesthetised with carbon dioxide and counted into cups. One hundred flies were used in each replicate test; any remaining flies were discarded. Flies were released at floor level from the centre of the room, marked with a plumb line suspended from the ceiling.

Atmospheric pressure was recorded using a manometer (Digitron Instrumentation P200) and ultra-violet light was monitored using a MACAM 101 UV radiometer to ensure consistent output throughout the test. All readings were taken from the centre of the room; UV output was measured from the vertical mid-point 0.8m directly in front of the trap.

Variables that were considered likely to influence catch rate were recorded from each of the traps tested, these included: Total lamp output (W), UV-A output, distance between lamps and catch surfaces.

The number of flies captured in the unit was counted eight times in seven hours at intervals of: 15, 30, 60, 90, 120, 240 minutes, 5 hours, 7 hours and again at 24hrs. After 24 hours all live flies still in the room, dead flies on the floor or within the unit (not on the glue) and observed escapees were accounted for.

Six replicates of each test (three in each room) were conducted with fresh glue surfaces for each test and tubes emitting the same level of UV-A light.

RESULTS

An average time for half the flies to be caught (C_{50}) was calculated from six days of testing. The C_{50} score is the minimum possible time that it would take each unit to catch 50% of the available flies (given maximal performance of the unit based on the catch rate), using the following equation:

$$C_{50} = \frac{t}{\log_2 (N_0/N_t)}$$

where C_{50} is the optimal half life value, *t* is the time elapsed, N_0 is the initial percentage of flies (100) and N_t is the percentage remaining after *t*.

Table 1: UV Trap specifications

Unit No.	Catch surface	Catch surface area (cm^2)	Distance: catch surface to light source (mm)	Output power (W)	UV-A at 0.8m ($\mu W/cm^{-2}$)
1	Electrified grid	1330	40	60	0.073
1	Adhesive board	1600	40	60*	0.048
2	Adhesive board	1347	72	45	0.046
2	Adhesive roll	959	74	45	0.045

*Unit 1 has four UV tubes in two staggered columns of two tubes. The adhesive boards are fitted between the columns blocking some of the light from the rear column of tubes. Light from the rear column transmits through the electrified grid, hence the difference in UV-A readings.

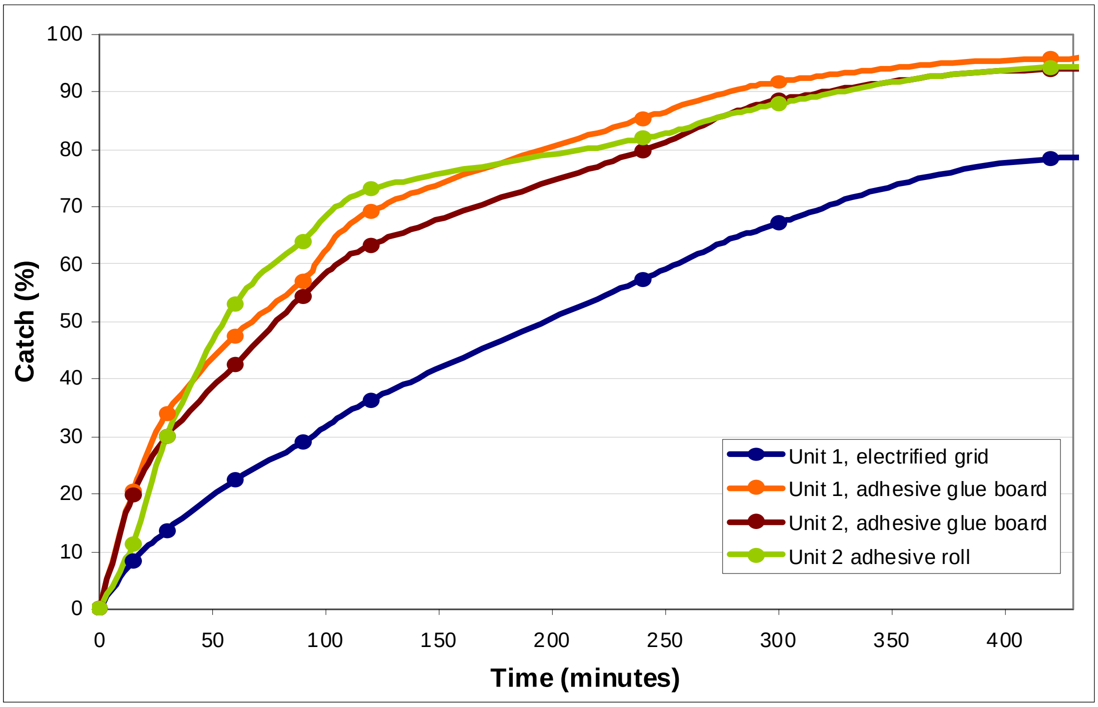

Figure 1: Percentage catch over a 7 hour period

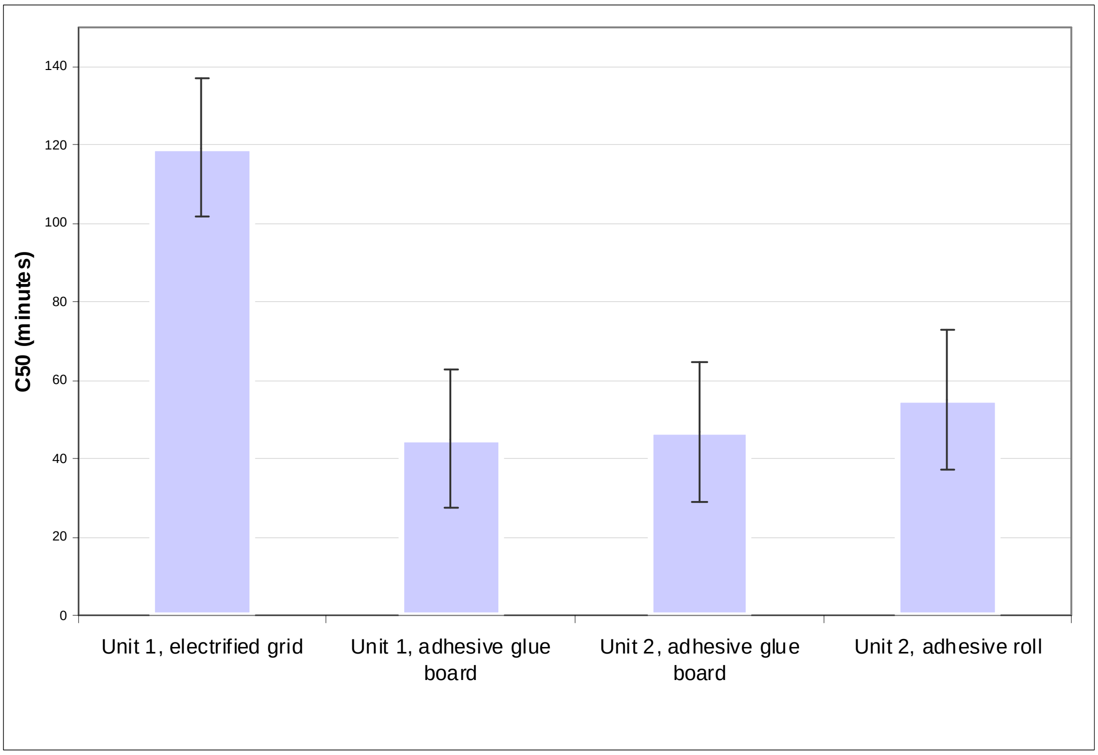

Figure 2: Average time taken to catch 50% of available flies at fastest recorded catch rates

Unit 1 fitted with an electrified grid takes a significantly greater length of time to catch 50% of available flies when catching them at the fastest recorded rate than it does with an adhesive board. Unit 2 is not significantly worse at catching flies than Unit 1with an adhesive board, despite a 15W lower power output.

DISCUSSION

The electrified grid trap used in this study was not as efficient at removing flies from the environment as either the same trap with an adhesive catch surfaces, or a lower powered trap with a glue board surface or an encapsulation roll. The electrocution traps was capable of removing flies over extended periods of time suggesting that this sort of trap is best suited to low risk, low service interval control uses, rather than higher risk control situations.

Encapsulation traps seal insects in a rolling film. The advantages of this type of trap are that the catch surface is routinely refreshed and, like other adhesive traps, there is no fragmentation or spread of surface contaminants from killed flies. Not only did the encapsulation trap catch flies faster, on average, than the electrocution trap it did so without releasing potentially harmful particles from dead flies into the air.

The reason for the differences in time taken to catch 50% of available flies with this electrified grid unit are thought to be related to the difference in certainly of catch when an insect approaches the catch surface. An adhesive trap will hold all insects that land on it with near certainty. In contrast an electrocution trap relies on an insect receiving a lethal shock from the grid, which is not a certainty and can lead to maimed flies walking of food surfaces unable to fly (Pickens, 1989).

Calculating best potential 50% catch values provides a definitive measure of how quickly each unit can catch house flies. Expressing the effectiveness of a trap as a single value has a clear benefit to end users in that it provides an indication of risk.

This work suggests the use of electrocution traps in food preparation areas increases the risk of food contamination in two ways: firstly by lengthening the amount of time a living fly is present in the environment and secondly by generating airborne particulate waste that could contaminate food.

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