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# EFFICACY OF A POLYDIMETHYLSILOXANE FORMULATION AGAINST URBAN MOSQUITO PESTS IN THE UK

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**Abstract** The silicon-based, monomolecular film, mosquito control product Aquatain was introduced into an on-going programme to control *Culex pipiens molestus*, in a partially flooded undercroft, in September 2015. The impact on the control programme is reviewed in this study. Application of Aquatain was far simpler than was the case for the larvicidal insecticide used previously, and it is considered that the introduction of this product had a significant positive impact on the effectiveness of the control programme. It is believed that this is the first occasion when such a benefit has been observed in the subterranean habitat typically inhabited by *C. p. molestus*.

**Key words** Aquatain AMF, mono-molecular film, *Culex pipiens molestus*, subterranean, Bti

## INTRODUCTION

In August 2013, the pest management consultancy Acheta Consulting Ltd was approached by a food manufacturing site in East London. The site had a long-standing problem with mosquitoes, with large numbers of staff reporting significant mosquito nuisance, with large numbers of people being bitten, often very severely. The problem was causing significant industrial relations concerns. The building is built on stilts, above reclaimed land, and the mosquito population was said to be emanating from a large undercroft, which extends, largely at surface level, throughout the footprint of the building. Drainage leaks from the production areas above, and a varying water table, were creating numerous pools of water, of widely varying size and depth. The undercroft is classed as a confined space, and specialist training is required before access is permitted. Access is extremely challenging, and involves a team of at least three people, equipped with gas detection and escape breathing apparatus.

A pest control contractor had been engaged for several years, to carry out mosquito control works. Access for this work was provided in conjunction with a drainage maintenance company who enter the undercroft on a frequent basis. Our initial investigation highlighted that there were large numbers of mosquitoes present in areas above the undercroft, and our initial survey (done without entering the undercroft) suggested that these were emanating from the undercroft, as mosquitoes could be seen clustering in large numbers where there was a direct access point between the undercroft and areas above (Figure 1). The control programme had involved the use of the larvicide Vectobac (*Bacillus thuringiensis israelensis)* and, for surface treatment, a synthetic pyrethroid insecticide. The contractor's control programme did not extend throughout the undercroft, focusing only on one area where access was relatively easy. Additionally, there was no monitoring programme, of any description, in place.

*Culex pipiens molestus (C. p. molestus)* has been found in subterranean locations around the world. It has been suggested that it has only relatively recently adapted to man-made underground systems from local above-ground populations of *C. pipiens*, but more recent evidence suggests it is a southern mosquito variety related to *C. pipiens* that has adapted to the warm underground spaces of northern cities (Fonseca et al., 2004). *C. p. molestus* breeds all-year round, is cold intolerant, and bites rats, mice, and humans, in contrast to the above-ground species, which is cold tolerant, hibernates in the winter, and is considered to feed primarily on bird hosts. The two species are commonly referred to as *Culex pipiens pipiens*, and *Culex pipiens molestus*.

**Figure 1.** A drain connection between the undercroft and a production area. Drain was dry and contained large numbers of adult mosquitoes.

Although no formal identification was done of the species encountered in this study, beyond *C. pipiens* status, the behavioural and environmental preference characteristics would strongly suggest that it was the *molestus* form that was the dominant species present in the undercroft.

**Mono-Molecular Films For Mosquito Control**

Most mosquito control products target either the waterborne or aerial stages of the lifecycle; larvicides and adulticides respectively. Monomolecular layers differ from such agents as they target multiple stages in the mosquito life cycle, with all stages that contact the water surface (eggs, larvae, pupae, emerging adults, and ovipositing females) being affected by the lowered surface tension caused by such layers.

The product Aquatain™ is a polydimethylsiloxane (PDMS, 80%) based liquid that was developed as an anti-evaporation product, to prevent water loss from large water storage basins. It can cover large areas containing vegetation, and is resilient to wind and rain. It is also reported to have no adverse effect on water quality and has been certified for use on drinking water in the USA. It's positive impact in mosquito control programmes has been the subject of several studies in a variety of situations; in a laboratory setting (Bukhari and Knols, 2009) in rice paddies (Bukhari et al., 2011), in laboratory and field-test situations (Mbare et al., 2014), and in backyard container-type habitats (Webb and Russell, 2012). It is not known whether any trials concerning the efficacy of any monomolecular film product have taken place in the flooded subterranean habitats that are favoured by *C. p. molestus*.

## MATERIALS AND METHODS

**Monitoring Programme**

A formal monitoring programme commenced in April 2014. The undercroft was divided into monitoring zones, bordered by the supporting walls for the building above (Figure 2). Double-sided yellow drystick glueboards (20 x 40 cm) were installed at permanent locations. With some exceptions (due to staff availability) these were serviced on a weekly basis between April and October/ November (inclusive), and fortnightly for the remainder of the year. Service involved removal and replacement of the board by the drainage company employees, with insect count and analysis provided by Acheta personnel. Monitoring Zones 6 and 7 were a later addition (April 2015) to the monitoring programme. Although these zones were known to the drainage company, they had not been highlighted to Acheta personnel. They are the most challenging locations to access.

In addition to analysing catches of mosquitoes on the glue-boards, qualitative (high, medium or low) data was collected concerning the presence of larvae, pupae and egg-rafts in and around water bodies near each of the monitoring locations. Air temperature at each monitoring location, and approximate water depth, was also measured.


**Figure 2.** Site plan of the undercroft showing the 7 monitoring zones and locations of the glue-boards.

**Control Programme**

Prior to the availability of the PDMS film the control programme consisted of: 1) Aquapy; natural pyrethrins, used for surface treatment of fly alighting surfaces using a 5 litre compression sprayer, or space treatment using an electrically operated fogger. The latter technique could only be done from outside due to the potentially explosive atmosphere within the undercroft.; 2) Ficam W; bendiocarb containing wettable-powder insecticide, applied using a 5-litre compression sprayer. Used for treatment of the building structure within the undercroft.; 3) Dobol Fumigators; water-activated smoke generators, containing cyphenothrin, for treatment of the undercroft airspace, and exposed surfaces; 4) Vectobac; a mosquito larvicide containing *Bacillus thuringiensis var israelensis* (Bti), for treatment of standing water within the undercroft, applied using either a 5-litre compression sprayer, or 10-litre knapsack sprayer.

The PDMS product was gradually phased into the control programme between 7 September and 26 October 2015. There was no use of Vectobac after October 2015, and adulticide treatment since that time has been limited to sporadic use of Dobol Fumigators. The PDMS film is applied by simply adding the required amount to the water body, as determined by an estimate of the size of the area to be treated.

## RESULTS AND DISCUSSION

The percentage breakdown of adult mosquitoes caught on glue-boards in zones 1 to 7, during 2015 and 2016, is shown in Figure 3. Zones 3 and 6 returned a large proportion of the catch in both years, with zone 2 decreasing in importance, and zone 4 increasing in importance during the monitoring period. The importance of Zone 6 should be noted, due to its late introduction to the monitoring programme.

The mean air temperature within the undercroft during 2015 and 2016 is shown in Figure 4. The temperature followed the expected seasonal trend, though temperatures during 2016 were, for much of the year, slightly cooler than those recorded during 2015. Importantly, temperatures remained within the zone where *C. p. molestus* will continue to breed, for the duration of both years.

Figures 5a and 5b display the relationship between the total mosquito catches in 2015 and 2016, and the mean water depth in the undercroft during those years. There is no clear relationship, suggesting that water depth was not the primary factor regulating the mosquito population. However, it must be pointed out that pumping works were instigated during 2016, for the express purpose of aiding the mosquito control programme. As a direct result of this, water levels during 2016 were consistently lower than during 2015. This certainly had the potential to reduce the availability of breeding areas for mosquitoes throughout the undercroft.

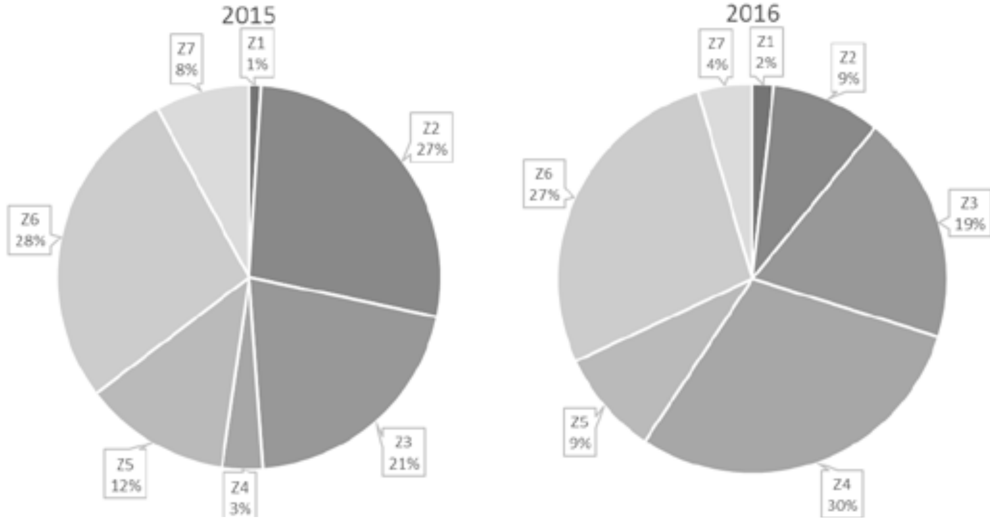



**Figure 3.** Percentage breakdown of mosquito catch by zone during 2015 (April to December) and 2016 (full year)

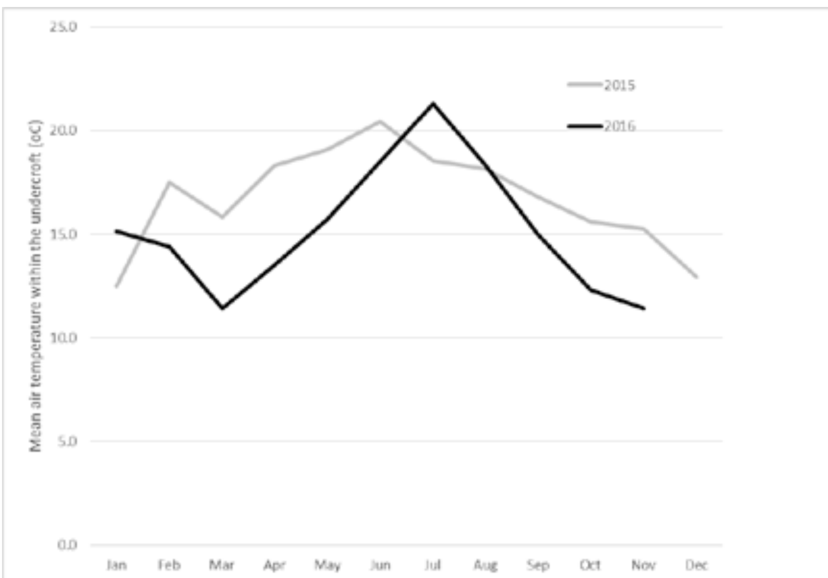
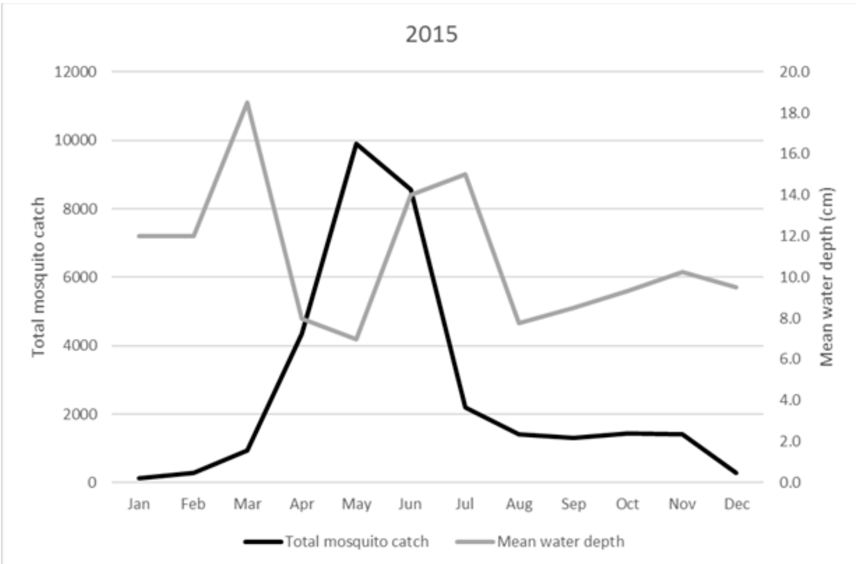
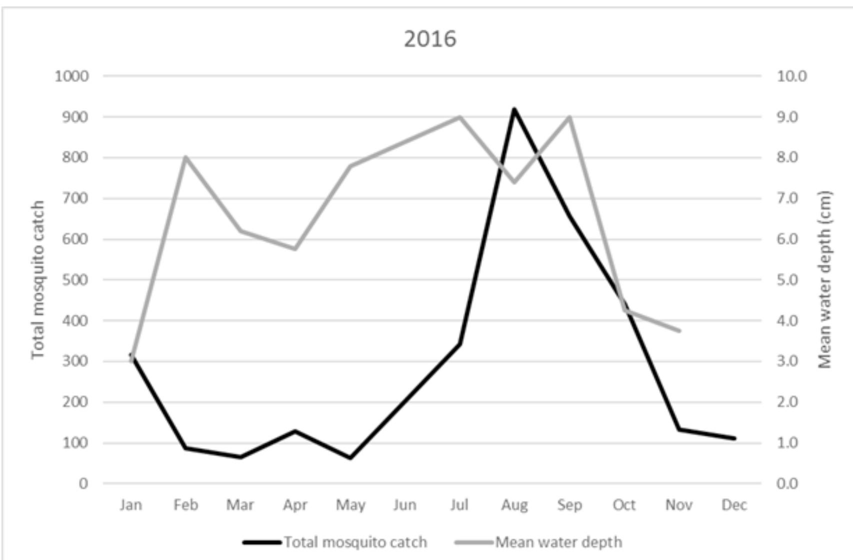



**Figure 4.** Mean air temperature ($^{o}C$) within the undercroft 2015 - 2016.

The total adult mosquito counts, aggregated for all monitoring zones, for the three years of the trial, are shown in Figure 6. It should be remembered that Zones 6 and 7 (Zone 6 being an important breeding ground for mosquitoes) were added to the monitoring programme during April 2015. This in part accounts for the height of the peak noted in May of that year. The switch from *Bti* to the PDMS film for treatment of standing water occurred during September and October 2015. This introduction was followed by a rapid decline in mosquito numbers, albeit at a time of year when the population would be expected to decline naturally anyway. However, the increase in the mosquito population that might have been expected to appear in the spring of 2016 did not appear, with adult mosquito numbers remaining low throughout the whole of that year.




**Figures 5a and 5b.** Relationship between total mosquito catch and mean water depth (cm) within the undercroft during 2015 and 2016.



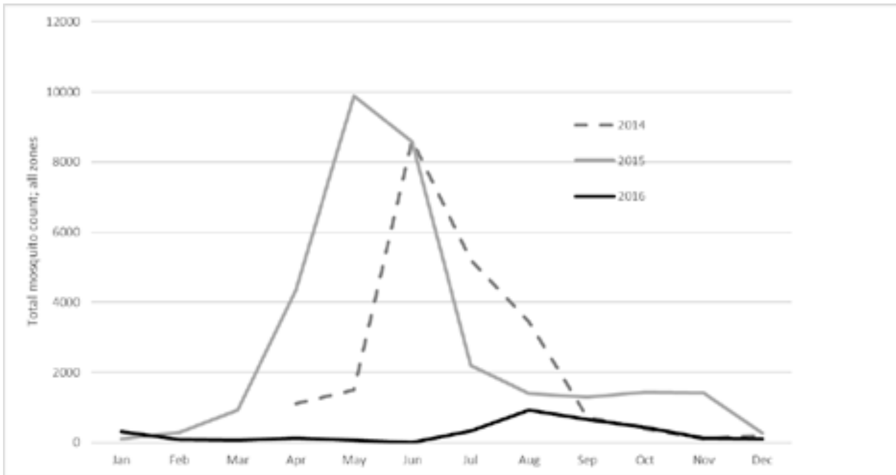



**Figure 6.** Total mosquito counts recorded in all monitoring zones.

## CONCLUSION

Introduction of a PDMS monomolecular film product resulted in a significant, and sustained, fall in the mosquito population. It is believed that this is the first time this product has been demonstrated to have such an effect in the control of *C. p. molestus* in a flooded subterranean environment. The environment involved in this study is extremely challenging from both an access and health and safety viewpoint, and the simplicity of application of the PDMS film is considered to have considerably enhanced the safety and efficacy of the treatment programme.

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