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UNITED KINGDOM URBAN MOSQUITO SAMPLING

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Abstract There has been relatively little research work done in collecting mosquitoes in urban areas of the UK. During the summer of 2010, the research team collected mosquitoes from nine urban sites and mosquito samples were collected over a 14 week period. All specimens were taken to the laboratory and adults were killed by freezing and immature aquatic stages were bred through to adulthood. Most adults were captured using CO_2 baited adult traps, but suitable sites were restricted due to security and safety factors. The other stages were captured by surveying aquatic sites and sampling by dipping. Mosquitoes from *Anopheles, Aedes, Culex* and *Culiseta* were captured. Results confirmed the need to undertake sampling for all stages of the life cycle in urban sites to determine the mosquito diversity present.
Key Words British mosquitoes, mosquito distribution, urban

INTRODUCTION

With the discovery that mosquitoes could act as vectors of disease to both man and animals in the early part of the nineteenth century, there was great interest in understanding the life cycle and control of vector species (Silver, 2008). Marshall's (1938) very detailed work on British mosquitoes remains an important text for UK entomologist and ecologists. Both Snow (1990) and Cranston et al. (1987) provided useful handbooks to assist with identification. Globally, entomologists and health experts have focused significant attention in understanding the ecology of tropical mosquitoes because of the risk they pose as vectors of pathogenic organisms. The paucity of information on the distribution and habitat preferences of British mosquitoes in part relates to the difficulty of identifying them and to the low risks they pose being restricted mostly to a biting nuisance. UK mosquitoes were known to have vectored arboviruses and Hutchinson and Lindsay (2006) in examining historical records, were convinced that malaria was present in the coastal marshes of England between the 16th – 19th centuries.

There are over 30 native UK mosquito species recorded, although five are considered to be either rare, or possibly not native as they have not been recorded for many years (Medlock and Snow, 2008). Six are members of the sub family Anophelinae and the other 28 belong to the sub-family Culicinae and are spread across five genera: *Aedes*, *Coquillettidia, Culex, Culiseta* and *Orthopodomyia.*

Renewed interest in the distribution of UK mosquitoes has been sparked by a number of factors. Reports that several exotic mosquito species have managed to invade, disperse and establish breeding colonies has raised the question of whether exotic species could survive in Britain and more worryingly, pose a significant threat to public health. *Aedes albopictus*, following its first introduction into Albania in 1979, has continued to expand its range in Europe. Until 2010 it was reported to survive only in greenhouses in the Netherlands, but in 2010 a colony was found living outdoors during routine surveillance at a tyre importing company (Schaffner and van Bortel, 2010). Although its natural habitats are tropical rain forests, it has shown a remarkable adaptive capacity, exploiting artificial environments such as plastic containers and used tyres. Many of its European introductions have been traced back to the importation of *Dracaena sanderiana* (Lucky Bamboo) plants and the global trade in used tyres. Straetemans (2008) also postulates that public or private transport from infested areas by highway, ferry or air travel could also contribute to its passive dispersal (Straetemans, 2008).

This study aimed to survey a number of typical urban sites for mosquitoes to establish the methods that could be used to monitor mosquito distribution.

METHODS

Reisen and Lothrop (1999) noted that sampling for mosquitoes is influenced by practical constraints that include landscape, access to sites, availability of human and other resources, time required for sample processing etc. As a result, sample sites are almost never randomly distributed and are frequently stratified, based on prior knowledge of distribution of the target species or other parameters.

A list of typical urban sites was considered and the potential constraints for sampling at each discussed. Some sites were selected because of previous work which suggested that they could support species of particular interest (e.g. *Culex pipiens molestus*) (Ismay and Schulten, 2004). Three main constraints were identified: access to the sites, safety of those collecting samples and potential interference/vandalism of adult traps. Nine site types were defined: allotments, parks/urban woods, used tyres, urban drains, domestic gardens, cemeteries, around ports/airports, salt marshes and farms.

There was no real attempt to quantify the abundance of mosquitoes at each site, but rather, to record the presence/absence of mosquitoes in these locations and to consider the suitability of two main methods of collection: dipping of aquatic sites (egg rafts, larvae and pupae), and adult trapping using CO_2 baited adult traps (Mosquito magnets ®). In addition a number of resting adults were collected at sites where dipping was undertaken.

Aquatic stages were collected and placed in specimen tubes with around 30 mls of the water they were found in and taken back to the laboratory. Adult traps were deployed to collect adults and the nets within these adult traps were collected and placed in a plastic container and taken back to the laboratory. Resting adults were placed in a 30 ml tube and taken back to the lab. Adults were placed in a freezer overnight to kill them and then put in smaller tubes for later identification. Aquatic stages were decanted into a larger glass jar, and grown through to adults and then processed as above.

Aquatic stages were kept at room temperature and daily checks were made to collect any adults. A plastic cup pierced with a cocktail stick was placed over the glass container, to provide a resting place for newly emerged adults. A number of different methods were trialled to provide an initial sugar source for newly emerged adults. Cotton wool soaked in a sugar solution, a grape and orange marmalade were each tried in turn. The soaked cotton wool was found to dry out too quickly and the grape encouraged mould growth. Marmalade worked well and was adopted for the aquatic sample. Adults were not always able to fly clear of the water and a proportion drowned; this was a particular problem over the weekends. Adults that did manage to survive were captured using a WHO aspirator. Males were discarded as they did not take blood meals and identification was complex. Females were identified down to Family/subfamily.

RESULTS

There were 259 sampling events over a 14 week period. Mosquitoes were collected from eight of the nine types of typical locations identified. No mosquitoes were found in the drains sampled and although a few mosquitoes were found at the cemetery, the team did not manage to rear the larval stages through to adulthood. The team took the decision not to sample any further cemetery sites because of the sensitivities around sampling at these sites. No adults were caught in the adult traps placed at the two sites at Manchester airport (at the Border Inspection Point and the Cargo handling Unit).

The sites where adult traps could be safely sited were limited, either because of difficulties in transporting the trap to the site or because of concerns around interference/damage/vandalism. They were placed in back gardens, secure allotments, next to a tyre dump and two sites at Manchester Airport. A fairly high mortality rate occurred in the aquatic samples collected. This was probably related to one or more of the following: Too great a density of larvae; Damage to larvae during transport from collection site to the labs; Low oxygen; Lack of food; Changes in temperature.

Although larval sampling was very resource intensive, both in the time taken to reach the site to collect samples and in the time needed to rear the larvae through to adults. However, for many of the urban sites dipping and collection of resting adults were the only suitable sampling methods. The adult catchers were easier to operate as they only required checking once a week, but the sites where they could be used without interference were limited. Table 1summarises the range of species caught.

The adult traps use a mammal lure and therefore caught a number of mosquitoes know to bite man. The most numerous species found during aquatic sampling was *Culex pipiens* (the most ubiquitous of the mosquitoes in the UK). In the UK it is ornithophilic and does not bite man. Table 2 presents the results of the two methods of sampling showing that both aquatic and adult sampling (using traps and/or aspirators) are useful in determining mosquito diversity at the sites visited.

Table 1. Presence/absence data for the six British family/sub family at the nine urban site types (numbers in brackets refer to number of different site types visited, n = 99).

Family/Sub-family	**Anophelinae**	***Culicinae***				
	Anopheles	*Culex*	*Culiseta*	*Aedes*	*Coquillettidia*	*Orthopodomia*
Allotments [15]	_	_	_	_	-	-
Urban parks/Woods [26]	-	_	-	_	-	-
Cemeteries* [1]	-	-	-	-	-	-
Used tyres [6]	-	_	_	_	-	-
Drains [28+]	-	-	-	-	-	-
Domestic Gardens [3]	-	_	_	_	-	-
In/near port [15]	_	_	-	_	-	-
Salt marsh [1]	-	_	-	_	-	-
Farm [4]	-	_	-	_	-	-

* No were reared to adult and no further samples were taken.
+ Drains from 28 Streets in Manchester, UK were sampled.

Table 2. Range of mosquitoes found using aquatic and adult sampling.

Genus	**Aquatic sampling**	**Adults (trap and/or aspirator)**
Anopheles	1	4
Culex	82	5
Culiseta	4	7
Aedes	19	1

Both methods captured a similar range of mosquitoes and are therefore useful in establishing the mosquito fauna present, however they had strengths and weaknesses. Aquatic sampling was resource intensive, but had a straightforward methodology. The CO_2 baited adult traps were expensive to purchase and finding sites where they could be left safely for a week proved difficult. The propane cylinders needed to operate the traps had to be replaced every 3 weeks. However, it only required a visit once a week to collect the samples caught.

CONCLUSIONS

The experiences of Scholte et al. (2010) underscore the importance of routine sampling. They suggest a regime of both passive and active surveillance activities in areas at high risk of invasion. Having witnessed the introduction of exotic invasive mosquitoes, Scholte et al. (2010) concluded that international collaboration and action was needed to address the potential public health risks posed.

It is clear that further information is needed on UK tyre imports, the sites where such tyres are stored and the surveillance techniques that could be deployed to monitor at these sites. This confirms previous work in the West Midlands of the UK where all tyre dumps sampled were found to have mosquito populations (Hatherly et al. 2009). Our work on examining the most appropriate techniques will continue, with the trialling of passive techniques such as the use of ovitraps and the efficacy of other adult traps such as the Eisenhans and BG Sentinel adult traps will also be trialled. The intensity of the lab work will be reduced by rearing aquatic stages through to 4th instar stages before preserving in alcohol and identifying the species collected using the keys of Snow (1990) and Cranston et al. (1987). The use of GIS and remote sensing may also provide a useful mechanism by which sampling efforts can be focused on areas of high risk.

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