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# MOSQUITOES AT UNITED KINGDOM PORTS: SURVEILLANCE AND OPERATIONAL CHALLENGES

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**Abstract** Port health authorities have played an important role in the control of infectious diseases. The International Health Regulations (2005) further clarifies this role and provides a legal statutory instrument which aims to assist the international community to prevent and respond to global public health risks. Eleven Ports around the UK were recruited to join a pilot, investigating the challenges ports could face in attempting to monitor for mosquitoes. The study also examined the types of habitat that could support mosquitoes. Although the UK's current native mosquito species pose, at worst, a biting nuisance, there is concern that exotic vector species, such as *Aedes albopictus*, could invade and become established in the UK. Following two summers of surveying, the port health officers met to discuss the resource requirements and the methods that they found to be suitable at their sites. It was clear that the environments in and around ports differed and this was reflected in the species of mosquitoes caught. Ports used different methods to collect mosquitoes and developed a range of techniques for surveying, which suited the conditions at their Port. It is hoped that more ports will agree to monitor and that methods of sharing this information between ports can be developed.
**Key Words** *Aedes albopictus*, International Health regulations, surveying

## INTRODUCTION

In the UK there are 34 recorded species of mosquito (Medlock and Vaux, 2010) and whilst some may cause severe biting nuisance locally, none are presently know to transmit pathogens in Britain. Ten different mosquito-borne arboviruses are known to be transmitted by, or associated with, mosquitoes in Europe (Medlock et al., 2007; Angelini et al., 2007).

The continued growth in global trade and human travel has enabled some of the worlds most diverse and isolated ecosystems to become connected (Tatem and Hay, 2006). International transport networks and hubs have been important in providing movement routes and gateways for people and commodities between these areas. Numbers of passengers transported by air in the EU rose by 4.9, 8.5, 4.7 and 7.3% each year from 2003-07. Of these passengers, about 34% were carried on external-EU flights (Paupy, 2009). More extensive travel, shorter flight times to tropical regions, where vector-borne diseases are endemic, and increased trade has led to the introduction and establishment of several potential vector species not previously found in Europe (Gratz, 2000, 2004, ECDC, 2009). Aircraft and ships are both believed to have played a key role in the rapid expansion in the range of a number of exotic mosquito species (e.g. *Aedes albopictus, Ochlerotatus atropalpus, Ochlerotatus japonicus* and *Aedes aegypti*) into mainland Europe (Reiter 1998; Schaffner et al., 2003; ECDC, 2009, Scholte et al., 2009). The trade in used tyres has been implicated in the spread and development of self sustaining mosquito populations in Europe (ECDC, 2009).

An exotic species which is of particular concern to the UK is Aedes albopictus which was originally native to areas of South East Asia but has rapidly expanded its range into more temperate regions of the world. It has been identified as one of the World's top 100 worst invasive alien species (ISSG, 2011). Aedes albopictus was first detected in Europe in 1979 and this introduction to Albania was traced back to the importation of used tyres from China. It was later recorded in Italy in 1990 as a result of an importation of used tyres from US into Genoa. Concerns were heightened when in August 2007 it vectored an outbreak of chikungunya virus in North Eastern

Italy (Angelini et al., 2007). It has now been recorded in 17 of the 59 countries of Continental Europe (Schaffner, 2010) and risk mapping has shown that there are potential sites where it could become established in the UK (Medlock et al., 2006)

Germany, Belgium, the UK and Italy are the largest importers of used and retreaded tyres in Europe, accounting for 65% of all EU imports in 2006 (WRAP, 2008). The most important source of imports to the EU is Sri Lanka, accounting for around 40% of the total EU used import market by tonnage. The potential risks posed by the importation of used tyres have been recognized and a number of countries which have introduced either partial or complete bans on used tyre imports (WRAP, 2008). In Italy, restrictions were implemented at a regional rather than national level, with local laws on quarantining used tyres. The European Union Landfill Directive banned the disposal of tyres to landfill (whole tyres from July 2003 and shredded tyres from July 2006). The EU has millions of used tyres that have been illegally dumped or stockpiled. The inadequate disposal of tyres may, in some cases, pose a potential threat to human health (by harbouring mosquitoes) and potentially increase environmental risks. The current estimate for these historic stockpiles throughout the EU stands at 5.5 million tonnes (European Tyre and Rubber manufacturers' association, 2010).

The risks of importing diseases through international trade and travel have been recognised for centuries and port areas have played a key role in ameliorating these risks by limiting the movements of people, animals and goods arriving from known areas affected by disease outbreaks (Hardiman, 2003). Leibold et al., (2004) reported that international air travel is a significant route for the movement of economically damaging pest species, with 73% of pest interceptions in the US Port Information Network database occurring at international airports.

In the UK, Port Health Authorities were established to prevent the introduction of dangerous epidemic diseases through shipping activity whilst minimising the disruptions to world trade. In partnership with UK Local Authorities at each port, they enforce the statutory powers embodied in the Public Health (Control of Disease) Act 1984. In parallel with this UK infectious disease control legislation, the revised International Health Regulations (2005) provide an international legal instrument to facilitate the international community's efforts to prevent and respond to acute public health risks with the potential to cross borders and threaten people worldwide (WHO, 2010). Annex 5, which outlines specific measures for vector-borne diseases, stipulates that States parties must establish programmes to control vectors that may transport an infectious agent that constitutes a public health risk to a minimum distance of 400 metres from those areas of points of entry facilities that are used for operations involving travelers (conveyances, containers, cargo and postal parcels). The minimum distance must be extended if vectors with a greater dispersal range are present.

The aims of this research work were: 1) To investigate suitable methods for mosquito surveillance at UK sea- and airports and the potential risks and barriers associated with sampling for different stages of mosquitoes; 2) To identify the extent and nature of suitable mosquito aquatic habitats in and around sea- and airports; 3) Identify the species present.

## METHODS

Following discussions with several UK Chief Port Health Officers, UK port sites were visited and discussions took place regarding the sampling methods that would be feasible at each site. Port Health Officers (PHOs) received initial training in mosquito sampling and identification and during summer 2009, six UK ports participated in the pilot study; sampling aquatic habitats in and around their port areas. PHOs sampled for mosquito larvae from aquatic habitats, and reared them through to adults using sealed containers. Adults were then sent to the Health Protection Agency for identification.

The following summer (2010), nine ports participated in sampling for mosquitoes. In addition to sampling larval sites, $CO_2$ baited adult traps (Mosquito magnets ®) were trialled. Each trap was run for four consecutive nights every two weeks between April and September. A number of sites also tested the use of ovitraps.

## RESULTS

A key observation from this study was the variability in the nature and habitat types present at the air and sea ports that participated in this trial (Figure 1). This underscores the importance of local knowledge when considering the habitats that could support mosquito populations. It also impacted on the methods of surveying for mosquitoes that could be used at each site. In the first year (2009) four mosquito species were recorded at the 6 sites that participated in the trial (Table 1). In the following year 6 mosquito species were reported at the 9 sites that participated.

The two most common species recorded were *Culex pipiens* s.l. and *Culiseta annulata*. *Culiseta annulata* is a widespread and abundant mosquito in the UK, and has a host preference for both birds and humans (Service

1969). Most of the *Culex pipiens* were recorded as larvae from containers (eg: tyres) and ponds, and are assumed to be *Culex pipiens* typical biotype on account of their habitat, which are almost exclusively ornithophagic in the UK (Medlock et al., 2005). *Anopheles maculipennis* s.l. and *Anopheles claviger* were associated with vegetated ditches, and both are known to bite animals including humans (Medlock et al., 2005). *Coquillettidia richiardii*, which feeds on birds and animals including humans (Service, 1969), was recorded in a vegetated reedbed lagoon. *Ochlerotatus detritus* was recorded in a saltmarsh nature reserve, and is known to bite mammals and humans, indeed can cause a biting nuisance in local areas.

The sampling methods were often driven by particular characteristics of the sites and/or the human resources available. In the first year, the use of adult traps was considered to be risky because of security concerns about the presence of propane cylinders, either because of the potential risk of explosion, or because of concerns about the trap being tampered with at the site. However, in the second year, the mosquito magnet® was used successfully at two airports and three sea ports. Larval sampling was heavily used in the first summer, and at sites where security remained an issue, continued in the second year. Rearing the larvae through to either 4$^{th}$ instar or imagos was labour intensive. The sampling method used did appear to impact on the mosquitoes captured. Many of the aquatic sites surveyed around the ports were likely to support *Culex pipiens* s.l. so it is not surprising that this was the most common species caught using this method. Very few *Culex pipiens* s.l. were caught in the mosquito magnets® as the lure was attractive to mosquitoes that feed on mammals. The mosquito magnet® was the only adult trap used as early trials with other

**Table 1.** Mosquito sampling for 2009 and 2010. 1 London Heathrow airport; 2 London Gatwick airport; 3 Southampton seaport; 4 Felixstowe seaport; 5 Liverpool seaport; 6 Manchester seaport;7 Hull seaport; 8 Bristol seaport; 9 Belfast City airport; 10 Belfast seaport; 11Belfast International airport.

| **Mosquito sampling Summer 2009 (6 sea/airports)** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mosquito species/Port** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** |
| *Culex pipiens* | ■ | ■ | ■ | ■ | ■ | ■ | - | - | - | - | - |
| *Culiseta annulata* | ■ | ■ | | ■ | | ■ | - | - | - | - | - |
| *Anopheles maculipennis* | ■ | | | | | | - | - | - | - | - |
| *Anopheles claviger* | | | | | | ■ | - | - | - | - | - |
| **Mosquito sampling Summer 2010 (9 Sea/airports)** | | | | | | | | | | | |
| **Mosquito species/Port** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** |
| *Culex pipiens* | - | - | ■ | ■ | | ■ | | ■ | | ■ | |
| *Culiseta annulata* | - | - | | | ■ | ■ | ■ | | ■ | | ■ |
| *Anopheles maculipennis* | - | - | | | | | | | | | |
| *Anopheles claviger* | - | - | | | ■ | | ■ | | ■ | | ■ |
| *Ochlerotatus detritus* | | | | | ■ | | ■ | | | | |
| *Coquillettidia richiardii* | - | - | | | | | | | ■ | | ■ |

adult traps had proved unsuccessful. Further work is needed on developing a system that would facilitate the sharing of this monitoring information between ports to build up a detailed understanding of the diversity of mosquitoes in and around ports and the habitats that seem to encourage their presence.

## DISCUSSION

Annex 5 of the International Health Regulations requires member states to undertake routine monitoring and surveillance at ports to reduce the risks posed by vector species. Whilst there is no evidence that exotic mosquitoes have been imported and become established in the UK, reports from other European countries suggest that this could happen in the future. Indeed, Cristo et al., (2006) suggest that the intense traffic of cargo and vehicles is highly likely to facilitate the arrival of a species such as *Aedes albopictus* via a port area.

Puth and Post (2005) highlight the three phases of invasion – initial dispersal (where an organism moves from its native habitat, often over long distances, to a new habitat outside of its home range), establishment of self-sustaining populations within the new habitat, and finally spread to nearby habitats. They also confirm that in a management context, the initial dispersal stage is where management efforts can prevent the establishment and subsequent, often detrimental impacts of invasive species. Eradicating invasive species has proved to be very costly and will often involve the use of potentially harmful chemicals (Myers et al., 2000) and is rarely accomplished in isolated areas, or before a species has spread widely.

Historically, there are examples of successful eradication of invading mosquitoes, achieved primarily through targeting larval habitats (Ramsdale and Snow, 1995; ECDC, 2009). *Anopheles albimanus* was eradicated from Barbados, (Seagar, 1928); *Anopheles gambiae* s.l. from Brazil (Sopher and Wilson, 1943) and from Egypt (Shousha, 1948). More recently there are reports from Europe detailing the successful eradication of *Aedes albopictus* from relatively small, local isolated populations in France, Switzerland and Italy (ECDC, 2009; Scholte et al., 2010).

Whilst Annex 5 of the IHR requires surveillance, there is currently no European standard for vector surveillance methods, which influences the comparability of data between countries (Straetemans et al., 2008). Vector surveillance in European Member States is mostly conducted in regions at high risk for establishment of *Aedes albopictus* and is focused on likely geographic areas which could support *Aedes albopictus*. The need for more robust local information on the characteristics and micro-climates of sites is needed.

The concepts of Integrated Pest Management (IPM) are part of the Global Strategic framework for integrated vector management. At port areas there is a need to consider: 1) Environmental modification: long lasting physical transformation of vector habitats (ensuring that used tyres are removed from port areas); 2) Environmental manipulation: temporary changes to vector habitat as a result of planned activity to produce conditions unfavourable to vector breeding (using pesticides in high risk areas); 3) Changes to human habitation or behaviour: efforts to reduce human-vector-pathogen contact.

Whilst it is important that effective and consistent surveillance and monitoring is established at all UK ports, the recent experiences in the Netherlands (Scholte et al., 2010) highlights the importance of local monitoring and surveillance, not only at ports, but at the destination sites for used tyre imports. There is little information available relating to the final destination and no systematic monitoring at sites where used tyres are stored in the UK.

Member states of the European Union continue to harmonise their regulatory frameworks, however the approaches adopted to the control of *Aedes albopictus* show significant variations (Scholte and Schaffner, 2007). The collective experiences of the PHOs that participated in the trials at UK ports have been invaluable in testing and trialing sampling techniques that could be used at UK Ports. The next step is to embed routine monitoring into the core capacities of Port Health Authorities to ensure that ports are meeting the requirements of Annex 5.

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