**Contingency plan for an incursion of**

**non-native mosquitoes in the UK Overseas Territories**

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## **Introduction**

This contingency plan covers an outbreak of a new invasive mosquito species to a UK Overseas Territory (OT). It is concerned with the first detection of mosquitoes and not with the containment, management or eradication of a more widely established population.

A new species of mosquito will be:

* Non-native to the territory;
* Likely to survive in the territory;
* Able to spread by human mediated or natural means;
* Likely to become a pest and nuisance with social, environmental and economic implications. Mosquitoes are important as vectors for a range of serious parasites and viruses that cause diseases of public health or animal health concern. There are thousands of species, and different ones bite people, mammals, birds, reptiles or invertebrates.

## **Species covered**

This plan is targeted at the 8 species of mosquito of concern to 11 territories identified from the horizon scanning exercise carried out in 2018/2019[[1]](#footnote-1) as shown in the table below. It can be adapted and applied to any mosquito species.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Scientific name | Common name | St Helena | Ascension | Tristan | Anguilla | Bermuda | BVI | Montserrat | TCI | CSBA | Gibraltar | Pitcairn |
| *Aedes aegypti* | Yellow fever mosquito | x | x |  |  | x |  |  |  | x | x | x |
| *Aedes albopictus* | Tiger mosquito | x | x | x | x |  | x | x | x | x |  | x |
| *Aedes japonicus* | Asian bush mosquito |  |  |  |  | x |  |  |  | x |  |  |
| *Aedes triseriatus* | Eastern tree mosquito |  |  |  |  | x |  |  |  |  |  |  |
| *Culex quinquefasciatus* | House mosquito |  |  |  |  |  |  |  |  | x | x |  |
| *Anopheles gambiae* | African mosquito | x | x |  | x | x | x |  |  |  |  |  |
| *Anopheles plumbeus* | Mosquito |  |  |  |  |  |  |  |  |  | x |  |
| *Anopheles quadrimaculatus* | Malaria mosquito | x | x |  |  |  |  |  |  |  |  |  |

BVI = British Virgin Islands; TCI = Turks & Caicos Islands; CBSA = Cyprus Sovereign Base Areas.

**Aim**: To prevent a new mosquito species from establishing in the territory.

**Objectives:**

* Detect the arrival of a new mosquito species as soon as possible
* Contain and eradicate a newly detected population of mosquitoes
* Prevent further spread, by human mediated or other means
* Surveillance of ports of entry (high risk sites) to identify other possible incursions
* Raise public awareness to encourage reporting of other infestations
* Prevent new introductions arriving

It is important to note that early detection of a new mosquito species depends on a routine programme of mosquito monitoring being already in place. To set-up or strengthen an existing monitoring programme, details of monitoring and detection methods for mosquitoes are given in Annex 3.

If detected early, still with a limited range and low numbers, mosquitoes are relatively easy to control using insecticides. The species could spread quickly so early action following detection would be important. Pathways of re-invasion need to be regulated to ensure the eradication was sustainable. It may not be possible to completely prevent re-invasion in the short term and contingency planning should be prepared to deliver responses to multiple separate invasions. Meanwhile, awareness raising on the need to report sightings can increase the chances of new arrivals being picked up.

The document has three main sections, together with a number of annexes giving additional information and best practice:

**Section I** covers preparation for readiness in anticipation of an incursion

**Section II** covers the organisational framework required to respond

**Section III** is the operational plan to be delivered in the event of an incursion

## **Summary of the stages in a response**

Agencies / departments highlighted in yellow need to be identified.

Biosecurity strengthened to prevent reintroduction

Return to pre-invasion footing

Management responsibility moves to Agency TBA

Escalate

Stand down

Eradication unsuccessful

Eradication successful

Lead to establish **Operational Group** which delivers operational response with oversight of **Response Group**

Action to eradicate

Confirmed population

Lead to establish **Response Group**, who provide recommendations for action

Agency TBA to investigate

**Response Group** provides recommendations on when to stand down and / or escalate

Establish extent of population

Monitoring to confirm eradication

Suspected sighting

STAGE

RESPONSIBILITIES

# **Section I Anticipation and Preparation**

This section covers actions which need to be in place for new potentially invasive species which have a high likelihood of arrival, and subsequent impact.

## **Risk assessment**

Ideally risk assessments (rapid or detailed) and risk management appraisals should be completed before species invade. However, where this is not the case it should not prevent a response. Instead a rapid assessment should be completed as soon as possible following invasion.

A risk assessment for mosquito introduction to an OT has not yet been completed. A summary of information on the main mosquito species of concern is given in Annex 1.

## **Training**

Key operational staff need to be able to confidently identify and treat mosquito larvae and adults in the event of an incursion. The table below captures what skills are required, who already has these skills and where further training is needed. Training for key staff should be updated regularly, especially for new staff.

|  |  |  |
| --- | --- | --- |
| **Skills required** | **Who has these skills** | **Who needs training** |
| Identification of species |  |  |
| Larval monitoring |  |  |
| Adult monitoring |  |  |
| Controlling larvae |  |  |
| Pesticide application - insecticides |  |  |

## **Equipment**

Essential equipment required to implement the operation should be held in a centralised location. Items should be regularly replaced / tested / updated as appropriate by the person or agency responsible in each case.

|  |  |  |
| --- | --- | --- |
| **What** | **How many/much** | **Where stored/ responsible** |
| Nets |  |  |
| Dippers, for larvae |  |  |
| Pipettes for taking water samples |  |  |
| Aspirators |  |  |
| Battery operated aspirators |  |  |
| Torches |  |  |
| Ovitraps |  |  |
| Larvitraps |  |  |
| Adult mosquito traps |  |  |
| Coveralls |  |  |
| Nitrile gloves |  |  |
| Face shields |  |  |
| Respirators |  |  |
| Non-chemical pesticide, eg biological larvicides such as Bacillus thuringiensis israelensis (Bti) or Bacillus sphaericus. |  |  |
| Aerial pyrethroid pesticide |  |  |
| Aerosol pryrethroid sprays |  |  |
| Knapsack sprayer |  |  |
| Fogger / mist blower |  |  |
| Measuring jug |  |  |
| Pesticide transport box |  |  |

## **Detection**

It is important to be aware of the different ways in which an incursion of a new species of mosquito might get detected, so that the report of a sighting reaches the lead person at the designated agency (usually Public or Environmental Health) as quickly as possible. This section covers who might spot it, and who they could tell. This information can be used to design Alert posters and awareness materials for the different groups. Best practice guidelines for monitoring mosquitoes is given in Annex 3.

|  |  |  |
| --- | --- | --- |
| **Where** | **What is in place** | **Adequate? / What else is needed?** |
| Points of entry - sea | ??? | ??? |
| Points of entry - air | ??? | ??? |
| Marinas | ??? | ??? |
| Urban areas (eg near plant nurseries) | ??? | ??? |

# **Section II Organisational framework**

This section provides the framework for action. The contingency plan requires the formation of a Response Group which oversees the plan, and an Operational Group which delivers the actions. There may be overlap between the members and functions of the two, and it is important that the lead person / agency of the Operational Group attends all Response Group meetings.

If the delivery lead is different from the policy lead there should also be a quality assurance plan to ensure that treatment is carried out to the appropriate standard. Details of the roles of the Response and Operational Groups are given in Annex 2.

## **Roles and responsibilities**

|  |  |
| --- | --- |
| Who / what agency is the policy lead? | TBC. This will depend on the territory |
| Who / what agency is the delivery lead? | TBC. This will depend on the territory |
| Roles and responsibilities – Response Group (oversight) | (List the agencies/bodies/people who will be involved in overseeing the eradication. Add lines as necessary) |
| **Agency/body/person** | **Role**  |
| Public / Environmental Health? Name of person |  |
| ??? |  |
| ??? |  |
|  |  |
| Roles and responsibilities – Operational Group (delivery) | (List the agencies/bodies/people who will be directly involved in the eradication actions. Add lines as necessary) |
| **Agency/body/person** | **Role**  |
| Public / Environmental Health? Name of person |  |
| ??? |  |
| ??? |  |
|  |  |

## **General considerations**

|  |  |
| --- | --- |
| Legal provisions | (Identify the legislation which covers the eradication of mosquitoes, noting any critical gaps. Access to private property will be required). * TBC. This will depend on the territory
 |
| Financial provisions | (Give an estimate of the cost of action, and who is responsible)TBC. This will depend on the territory |
| Has a risk assessment been done? | (Summarise the results of the risk assessment, if available)Not yet done |

## **Stakeholders**

|  |  |
| --- | --- |
| Key stakeholders affected by this species | (List the key stakeholders and note briefly their interest in this species – impacts or benefits. Add lines as necessary) |
| **Stakeholder** | **Interests** |
| Public Health | Costs of monitoring and control; indirect costs to health service of bites and disease |
| Community | Disease transmission, bites and nuisance  |
| Hoteliers | Negative impact on tourism through perceptions of disease risk, bites and nuisance |
| Tourism | Deterrent through perceptions of disease risk, bites and nuisance |
| Wildlife | Negative impact through bites, and disease transmission |
| Domestic animals | Negative impact through bites, and disease transmission |

## **Communications**

|  |  |
| --- | --- |
| Messages | (Define the main messages to be used in the different scenarios) |
| * on suspected sighting
 | “Have you seen this pest? A new mosquito has invaded our shores; mosquitoes bite and carry diseases. Check your water tanks, ponds and any other water containers on your property for the distinctive larvae. Adults can be spotted resting on walls inside houses. Please report any sightings to xxx” Plus images for identification. In English and any other local languages |
| * on confirmed sighting
 | “Help us to eradicate this new pest. Mosquitoes bite and carry diseases. * Check and treat your water tanks for the distinctive larvae.
* Treatment can be by xxxx
* Cover treated tanks to stop mosquitoes entering to lay eggs
* Remove any standing water in bowls, tyres and old tanks
* Spray residual insecticide on internal house walls
* ???

Plus images as guidance. In English and any other local languages |
| * during eradication
 | As above.Plus press releases justifying action to promote compliance and cooperation |
| * following removal
 | “Have you seen this pest? Check your water tanks, ponds and any other water containers on your property for the distinctive larvae. Adults can be spotted resting on walls inside houses. Please report any sightings to xxx” Plus images for identification. In English and any other local languages |
| * in the case of standing down
 | Messages to reduce impact: cover tanks, don’t let water stand, use mosquito nets, window screens, etc. |
| Responsibility for communications | (Identify who will be responsible for the various communications, and how they will do it. Add lines as necessary) |
| **Agency** | **Medium** |
| * Press lines for internal communications
 | ??? | Briefing memos |
| ??? | Guidance documents |
| ??? |  |
| * With external stakeholders
 | ??? | Press releases, articles |
| ??? | Radio |
| ??? | Posters |
| ??? | Leaflets |
| ??? |  |

# **Section III Operational Plan**

This section covers action to be taken in the event of an incursion.

## **Immediate action on suspicion**

Actions to be taken by the lead agency, plus any appropriate members of the Operational Group team, once a new species of mosquito has been reported (see Section ID Detection) but identification and presence has not been confirmed.

|  |  |
| --- | --- |
| Confirm identification | (Who confirms the identification as a new mosquito species?)TBC. This will depend on the territory |
| Check extent of infestation / occurrence | Survey of area including at least 100m around the outer border of the known infestation area, see best practice for monitoring mosquitoes in Annex 3.  |
| Assess area of potential spread | Assessment of potential breeding sites in surrounding area, and likely pathways of spread associated with the species concerned (see Pathways, below, and Annex 1 for some general information on common species.). For most mosquito species, this may be the entire urban area; other urban areas; off-shore islands. |
| Notification | Response Group notified, to decide on further action if required. |

## **Action on confirmation**

A rapid response takes place when a new mosquito species incursion has been confirmed by a competent authority.

Public Health as lead agency is usually responsible for initiating action.

|  |  |
| --- | --- |
| Assessment of the situation | Detailed assessment of the incursion site using best practice guidelines outlined in Annex 3. |
| Pathways of spread to control movement out of the confirmed outbreak area (add lines as necessary) |
| **Pathway** | **Mitigation actions** | **Who is responsible** |
| Vehicles carrying adults | Aerosol spray with knock-down pyrethroid insecticides |  |
| Tyres | Check for water; dry and clean with household bleach |  |
| Other items which may contain water with mosquito eggs and larvae | Check for water; dry and treat: with household bleach or a non-chemical larvicide eg Bti |  |
| Boats, including canoes and kayaks | Check for water in the bilges; dry and treat: with household bleach or a non-chemical larvicide eg Bti |  |
| Other locally important pathways? | TBC. This will depend on the territory |  |
| Eradication | Within the infested area: (i) treatment (with bleach or non-chemical larvicide eg Bti) or elimination of all potential breeding sites, and (ii) spraying of all premises with a residual insecticide; see best practice in Annex 4. |
| Escalation and standing down | If for any reason initial eradication efforts are not successful, the Response Group will advise senior officials / Ministers on the need for escalation of eradication efforts or to stand down and move to long term management.In the case that eradication effort is stood down, management responsibility would usually revert to Public Health and those that are affected by mosquitoes (e.g. local community, hoteliers, etc.). The Response Group would usually be responsible for providing management advice to affected parties. |
| Post-eradication monitoring at incursion location | Following successful eradication, monitoring needs to be continued by Public Health for at least two full years, targeted at the incursion site but also covering other likely areas identified by survey.  |

## **Lessons learnt**

It’s very important to have a lessons learned exercise after every incursion (anything that triggers a response) and to revise the contingency plan accordingly. This may include considerations such as:

Certain pathways of introduction are a higher risk than expected;

Biosecurity measures on certain pathways aren’t working;

There are gaps in detection and reporting;

The best practice guidelines require revision, etc.

|  |  |  |
| --- | --- | --- |
|  **Lesson learnt**(add lines as necessary) | **Action needed** | **Responsible** |
|  |  |  |
|  |  |  |
|  |  |  |

# **Annex 1. Species information**

Mosquitoes are flies (Diptera) and there are two main subfamilies, the Anopheline (*Anopheles* species) and Culicine (including *Culex* and *Aedes* species) mosquitoes. Common to all is the life cycle: the egg, larvae and pupae are aquatic stages, and the adult fly feeds on nectar and other sugar sources. The female fly needs a full blood meal to mature her eggs. Different species have different preferences for the type of water bodies in which to lay eggs, and which species they prefer to bite for the blood meal.

Mosquitoes of the three main genera of concern (*Anopheles*, *Aedes* and *Culex*) are distinctive and easily distinguished in both the larval and adult stages by their posture, as shown in the table below. Adult *Aedes* mosquitoes also have noticeable black and white markings on the bodies and legs.

|  |  |  |  |
| --- | --- | --- | --- |
|  | *Anopheles* | *Aedes* | *Culex* |
| Larva – in water |  |  |  |
| Adult – resting on surface such as a wall |  |  |  |

The genera can also be distinguished by their general behaviour.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Genus | Biting activity | Egg laying site | Water condition | Eggs laid |
| *Aedes* | Day | Cavities | Stagnant, high organic content | By the side of the water |
| *Culex* | Night  | Every type | Stagnant, clean or polluted | In rafts on top |
| *Anopheles* | Night | Sunlit, shallow water bodies | Clean unpolluted | Singly on top of the water, with floats |

Key features distinguishing adults for the 8 species identified as priority are given below.

|  |  |  |  |
| --- | --- | --- | --- |
| Scientific name | Common name | Distribution | Features |
| *Aedes aegypti* | Yellow fever mosquito | Worldwide: tropical, subtropical, and in some temperate climates | White scales on the dorsal surface of the thorax (scutum) that form the shape of a violin or lyre. |
| *Aedes albopictus* | Tiger mosquito | Worldwide: tropical, subtropical, and temperate climates | White stripe down the middle of the top of the thorax. |
| *Aedes japonicus* | Asian bush mosquito | Japan and Korea, Europe, China, Taiwan and the US | Several lines of yellowish scales on a black background on the dorsal surface of the thorax. |
| *Aedes triseriatus* | Eastern tree mosquito | North American species | Absence of pale rings on the legs and the presence of two pale-scaled stripes on the sides of the dorsal surface of the thorax. Dorsal surface dark with no lines or patterns. |
| *Culex quinquefasciatus* | Southern house mosquito | Worldwide: tropical, subtropical, and warm temperate regions | Culicine mosquito wings tend to be clear; females have short palps. |
| *Anopheles gambiae* | African malaria mosquito | Sub-Saharan Africa | Large, dark brown mosquitoes, difficult to distinguish species. Anopheline mosquito adults tend to have dappled or spotted wings; palps are as long as the proboscis, especially in the females. |
| *Anopheles plumbeus* | Mosquito | Europe and North Africa |
| *Anopheles quadrimaculatus* | Common malaria mosquito | North America |

Species with a European distribution can be identified using MosKeyTool, an interactive identification key for 128 mosquito species (4th stage larvae and female specimens) in 70 countries (Euro-Mediterranean, Black Sea and Western Palaearctic Regions. The user-friendly tool is freely downloadable: <https://www.medilabsecure.com/moskeytool.html>

**For general information on mosquitoes and their control see: Becker**, N., **Petric**, D., **Zgomba**, M., **Boase**, C., **Madon**, M.B., **Dahl**, C., **Kaiser**, A. (2010) Mosquitoes and Their Control. Springer. ISBN 978-3-540-92874-4.

## ***Aedes* mosquitoes**

Larva has a short breathing tube and lies at an angle to the water; adults have noticeable black and white markings on the bodies and legs.

There are more than 950 species of *Aedes* (in the culicine mosquito subfamily). Four species are of concern for the UK Overseas Territories:Yellow fever mosquito *Aedes aegypti*,Asian tiger mosquito *Aedes albopictus*, Asian bush mosquito *Aedes japonicas* and Eastern tree mosquito *Aedes triseriatus*.

Adult *Aedes* species can be distinguished by the pattern on the scutum (dorsal part of the thorax): Aedes japonicus (left), Aedes aegypti (centre), and Aedes albopictus (right). The scutum of *Aedes triseriatus* is unmarked (extreme right).



Photo © Florida Medical Entomology Laboratory

Photo © Lyle J. Buss, University of Florida.

**Yellow fever mosquito *Aedes aegypti***

|  |
| --- |
| Description |
| Egg | Eggs are long, smooth, ovoid shaped, and approximately 1mm long. When first laid, eggs appear white but within minutes turn a shiny black. |
| Juvenile | The larvae have a short air tube and rest at an angle below the water surface. Pupae are mobile and respond to stimuli. They do not feed and take approximately 2 days to develop. The larvae and pupae stages both live entirely in water, but have to come up to the surface to breathe. |
| Adult | Adult yellow fever mosquito is a small to medium-sized mosquito, approximately 4 to 7mm. The tip of the abdomen comes to a point, which is characteristic of all Aedes species. The adult mosquito can be recognized by white markings on its legs and a marking in the form of a lyre on the upper surface of the thorax. Females are larger than males, and can be distinguished by small palps tipped with silver or white scales. Males have plumose antennae, whereas females have sparse short hairs. When viewed under a microscope, male mouthparts are modified for nectar feeding, and female mouthparts are modified for blood feeding.  |
| Life cycle | After taking a complete blood meal, females produce on average 100 to 200 eggs per batch; however, the number of eggs produced is dependent on the size of the bloodmeal. Females can produce up to five batches of eggs during a lifetime. A smaller bloodmeal produces fewer eggs. *Aedes* mosquitoes breed in pools of stagnant water, such as flower vases, plant pots, tyres, uncovered barrels, buckets, untreated swimming pools, blocked gutters, drainage ditches, discarded tyres, wet shower floors and toilet tanks. Eggs are laid on damp surfaces in areas likely to temporarily flood, such as tree holes and man-made containers, and are laid singly, rather than in a mass. Not all the eggs are laid at once, but can be spread out over hours or days, depending on the availability of suitable substrates. Most often, eggs will be placed at varying distances above the water line, and a female will not lay the entire clutch at a single site, but rather spread out the eggs over two or more sites.The female sticks her eggs by the side of the water which hatch into larvae. Eggs hatch within days, but can remain viable for up to 8 months if the water dries. It takes 7 – 10 days from egg to adult. If temperatures are cool, Ae. aegypti can remain in the larval stage for months so long as the water supply is sufficient. |
| Ecology and behaviour | To find a host, these mosquitoes are attracted to chemical compounds emitted by mammals and will preferentially feed on humans, even in the presence of alternative hosts. Most female *Ae. aegypti* may spend their lifetime in or around the houses where they emerge as adults and they usually fly an average of 400 metres.*Aedes* mosquitoes most commonly feed at dusk and dawn, indoors, in shady areas, or when the weather is cloudy. |
| Entry and colonisation |
| Pathway(s) of entry | Adult mosquitoes as hitchhikers in:* Ships, yachts and other vessels
* Aircraft, both passenger and cargo planes
* Shipping containers
* Vehicles

Eggs and larvae:* In any container which has or has had water (including in ships and aircraft) eg tyres, tanks, barrels, etc. The used tyre is heavily implicated in spread of mosquitoes.
 |
| Detection | See Annex 3. |
| Similar species | Adult Ae. aegypti resemble the Asian tiger mosquito Ae. albopictus with a slight difference in size and thorax patterns. Ae. aegypti adults have white scales on the dorsal (top) surface of the thorax that form the shape of a violin or lyre, while adult Ae. albopictus have a white stripe down the middle of the top of the thorax.Ae. albopictus larvae out-compete Ae. aegypti larvae for food, and develop at a faster rate. Some research also suggests there is a hybridization of the two species in zones where they overlap, producing sterile offspring.Ae. aegypti mosquitoes live in tropical, subtropical, and in some temperate climates. This species lives near and prefer to feed on people, and are more likely to spread these viruses than other types of mosquitoes.*Ae. albopictus* live in tropical, subtropical, and temperate climates, but can live in a broader temperature range and at cooler temperatures than *Ae. aegypti.* Because these mosquitoes feed on animals as well as people, they are less likely to spread viruses like Zika, dengue, chikungunya and other viruses. |
| Where likely to colonise | This species prefers artificial water sources and feeding and resting indoors, it is often not found further than 100m from human habitations.The female will feed on multiple hosts, which makes it dangerous for transmitting disease from one person to another. |
| Longevity | Adults can live for 2 – 4 weeks. |
| Dispersal methods | * Adults transported by sheltering in vehicles.
* Eggs and larvae in any container which has or has had water (including in ships and aircraft) eg tyres, tanks, barrels, etc.
 |
| Distribution | The yellow fever mosquito *Ae. aegypti* originated in Africa, but is now found in tropical and subtropical regions throughout the world.  |
| Further information | * <http://ecdc.europa.eu/en/healthtopics/vectors/mosquitoes/Pages/aedes-aegypti.aspx>
* <http://www.who.int/denguecontrol/mosquito/en/>
* <http://www.cdc.gov/chikungunya/resources/vector-control.html>
* <http://entnemdept.ufl.edu/creatures/aquatic/aedes_aegypti.htm>
 |

**Asian Tiger mosquito *Aedes albopictus***

|  |
| --- |
| Description |
| Egg | No information |
| Juvenile | The larvae have a short air tube and rest at an angle below the water surface. Pupae are mobile and respond to stimuli. They do not feed and take approximately 2 days to develop.The larvae and pupae stages both live entirely in water, but have to come up to the surface to breathe. |
| Adult | Aedes albopictus adults are relatively small and show a black and white pattern due to the presence of white/silver scale patches against a black background on the legs and other parts of the body.[Ae. albopictus](http://entnemdept.ufl.edu/creatures/aquatic/asian_tiger.htm) has a silver line down the middle of the scutum. |
| Life cycle | After taking a complete blood meal, females produce eggs, laying 150 to 250 eggs per oviposition, and 1 to 4 ovipositions per female. *Ae. albopictus* is a treehole mosquito, and so its breeding places in nature are small, restricted, shaded bodies of water surrounded by vegetation. It inhabits densely vegetated rural areas where it will breed in pools of stagnant water such as flower vases, plant pots, tyres, vases in cemeteries, blocked gutters, discarded tyres and toilet tanks. The female lays her eggs above the water line. Larval/pupal development takes three to eight weeks. The pupae move about but don’t feed.*Ae. albopictus* can overwinter as eggs, and European populations can survive temperatures of -10°C, while tropical populations can survive -2°C.  |
| Ecology and behaviour | Ae. albopictus feeds on a wide range of hosts, including humans, domestic and wild animals, reptiles, birds and amphibians; humans are preferred. Only the female bites for blood, which she needs to mature her eggs. Adult females bite aggressively, usually during the day and preferably outdoors, with feeding peaks early morning and late afternoon. Females may then rest on walls indoors. |
| Entry and colonisation |
| Pathway(s) of entry | Adult mosquitoes as hitchhikers in:* Ships, yachts and other vessels
* Aircraft, both passenger and cargo planes
* Shipping containers
* Vehicles

Eggs and larvae:* In any container which has or has had water (including in ships and aircraft) eg tyres, tanks, barrels, etc. The used tyre is heavily implicated in spread of mosquitoes.
 |
| Detection | See Annex 3. |
| Similar species | Adult Ae. aegypti resemble the Asian tiger mosquito Ae. albopictus with a slight difference in size and thorax patterns. Ae. aegypti adults have white scales on the dorsal (top) surface of the thorax that form the shape of a violin or lyre, while adult Ae. albopictus have a white stripe down the middle of the top of the thorax.Ae. albopictus larvae out-compete Ae. aegypti larvae for food, and develop at a faster rate. Some research also suggests there is a hybridization of the two species in zones where they overlap, producing sterile offspring.*Ae. albopictus* live in tropical, subtropical, and temperate climates, but can live in a broader temperature range and at cooler temperatures than *Ae. aegypti.* Because these mosquitoes feed on animals as well as people, they are less likely to spread viruses like Zika, dengue, chikungunya and other viruses. |
| Where likely to colonise | Urban and suburban areas.  |
| Longevity | Adult females can survive over 3 weeks. |
| Dispersal methods | * Adults transported by sheltering in vehicles.
* Eggs and larvae in any container which has or has had water (including in ships and aircraft) eg tyres, tanks, barrels, etc.
 |
| Distribution | Worldwide, tropical, subtropical, and temperate climates. |
| Further information | * <https://www.ecdc.europa.eu/en/disease-vectors/facts/mosquito-factsheets/aedes-albopictus>
* <http://www.iucngisd.org/gisd/species.php?sc=109>
* http://entnemdept.ufl.edu/creatures/aquatic/asian\_tiger.htm
 |

**Asian bush mosquito *Aedes japonicus***

|  |
| --- |
| Description |
| Egg | Eggs are small, approximately 0.5 mm in length, matte black in colour, and cigar shaped. |
| Juvenile | The larvae have a short air tube and rest at an angle below the water surface. Pupae are mobile and respond to stimuli. They do not feed and take approximately 2 days to develop. The larvae and pupae stages both live entirely in water, but have to come up to the surface to breathe. |
| Adult |  Adults of Ae. japonicus are relatively large and show a black and white pattern due to the presence of white scale patches on a black background on the legs and other parts of the body. The main diagnostic character is the presence of several lines of yellowish scales on a black background on the scutum (dorsal part of the thorax). |
| Life cycle | *Aedes* mosquitoes breed in pools of stagnant water, such as vases in cemeteries, plant pots, tyres, uncovered barrels, buckets, blocked gutters, drainage ditches, rock pools, tree holes, discarded tyres, wet shower floors, fountains and bird baths. The female sticks her eggs by the side of the water which hatch into larvae. Eggs hatch within days. Ae. japonicus can produce freeze and desiccation-resistant eggs that can remain dormant over winter and hatch once environmental conditions become favourable. This allows for the species to be transported in infested containers. Larvae also overwinter in its native range. Compared to other Aedes larvae, Ae. japonicus can typically be found earlier in the year when temperatures are cooler. |
| Ecology and behaviour | This species preferentially feeds on mammalian hosts.Adults are often found in forested areas being active during the daytime and crepuscular hours. This species is an aggressive biter and will readily bite humans outside and occasionally inside housesAe. japonicus has less specialised requirements for aquatic habitats, compared to Ae. albopictus. It can withstand long distance dispersal and winter temperatures in temperate regions, and its high tolerance to organic concentrations in a number of natural and artificial containers. |
| Entry and colonisation |
| Pathway(s) of entry | Adult mosquitoes as hitchhikers in:* Ships, yachts and other vessels
* Aircraft, both passenger and cargo planes
* Shipping containers
* Vehicles

Eggs and larvae:* In any container which has or has had water (including in ships and aircraft) eg tyres, tanks, barrels, etc. The used tyre is heavily implicated in spread of mosquitoes.
 |
| Detection | See Annex 3. |
| Similar species | Adults can be distinguished from *Ae. aegypti* and *A. albopictus* by markings on the scutum.  |
| Where likely to colonise | Urban and suburban areas. |
| Longevity | No information. |
| Dispersal methods | * Adults transported by sheltering in vehicles.
* Eggs and larvae in any container which has or has had water (including in ships and aircraft) eg tyres, tanks, barrels, etc.
 |
| Distribution | Native to Korea, Japan, Taiwan, Southern China, and Russia, and established in parts of Europe, Canada, and throughout most of the eastern United States. |
| Further information | * <https://www.ecdc.europa.eu/en/disease-vectors/facts/mosquito-factsheets/aedes-japonicus>
* http://entnemdept.ufl.edu/creatures/AQUATIC/aedes\_japonicus.html
 |

**Eastern tree mosquito *Aedes triseriatus***

|  |
| --- |
| Description |
| Egg | No information. |
| Juvenile | The larvae have a short air tube and rest at an angle below the water surface.Pupae are mobile and respond to stimuli. They do not feed and take approximately 2 days to develop. The larvae and pupae stages both live entirely in water, but have to come up to the surface to breathe. |
| Adult | Distinguished by the presence of two pale-scaled stripes on the sides of the scutum (dorsal part of the thorax). |
| Life cycle | Aedes triseriatus breeds in tree-holes, tyres and other artificial containers. The life cycle usually takes 2 weeks to complete.Ae. triseriatus can produce freeze and desiccation-resistant eggs that can remain dormant over winter and hatch once environmental conditions become favourable. |
| Ecology and behaviour | To find a host, these mosquitoes are attracted to chemical compounds emitted by mammals and will preferentially feed on humans, even in the presence of alternative hosts. Females tend to prefer mammalian hosts, including humans, but also bite birds, reptiles and amphibians.Active during the day, with peaks of activity in the early morning and late afternoon. Adults tend to rest in shaded areas during the day, often near larval habitats, and often in vegetation. Flight range is reportedly limited to 200 m but may be greater in wooded areas. |
| Entry and colonisation |
| Pathway(s) of entry | Adult mosquitoes as hitchhikers in:* Ships, yachts and other vessels
* Aircraft, both passenger and cargo planes
* Shipping containers
* Vehicles

Eggs and larvae:* In any container which has or has had water (including in ships and aircraft) eg tyres, tanks, barrels, etc. The used tyre is heavily implicated in spread of mosquitoes.
 |
| Detection | See Annex 3. |
| Similar species | It is easily distinguished from the other invasive and indigenous European species breeding in natural or man-made containers by the absence of pale rings on the legs and the presence of two pale-scaled stripes on the sides of the scutum (dorsal part of the thorax). |
| Where likely to colonise | Urban and suburban areas. |
| Longevity | No information. |
| Dispersal methods | * Transported by sheltering in vehicles.
* Eggs and larvae in any container which has or has had water (including in ships and aircraft) eg tyres, tanks, barrels, etc.
 |
| Distribution | North America |
| Further information | * <https://www.ecdc.europa.eu/en/disease-vectors/facts/mosquito-factsheets/aedes-triseriatus>
* https://www.neha.org/vector/eastern-tree-hole-mosquito
 |

## ***Culex* mosquitoes**

Larva has a relatively long breathing tube and lies at an angle to the water; adults rest with the head higher than the hind end.

*Culex* is a diverse genus in the culicine subfamily, comprising over 20 subgenera that include a total of well over 1,000 species. C. *quinquefasciatus* is sometimes considered to be subspecies of Culex pipiens.One species is of concern for the UK Overseas Territories, theSouthern house mosquito *Culex quinquefasciatus*.

**Southern house mosquito *Culex quinquefasciatus***

|  |
| --- |
| Description |
| Egg | Laid in oval rafts loosely cemented together with 100 or more eggs in a raft. |
| Juvenile | The larval head is short and stout becoming darker toward the base. The mouth brushes have long yellow filaments that are used for filtering organic materials. The abdomen consists of eight segments, the siphon, and the saddle. |
| Adult | A medium-size mosquito (4-10 mm), brown with the proboscis, thorax, wings, and tarsi darker than the rest of the body. The head is light brown with the lightest portion in the centre. The antennae and the proboscis are about the same length, but in some cases the antennae are slightly shorter than the proboscis.Stand with the head higher than the rest of the body. |
| Life cycle | Females lay their eggs on water surfaces in batches as egg rafts containing around 200 eggs. These eggs are non-dormant and the larvae hatch rapidly as soon as the embryonic development is complete. The duration of the development depends on temperature. Thus the eggs hatch after only one day at 30°C, after three days at 20°C, ten days at 10°C, and below 7°C, embryonic development cannot be completed. The larvae develop into adults within a few weeks, depending on the temperature (6-7 days at 30 °C, 21-24 days at 15 °C).  |
| Ecology and behaviour | Both males and females take sugar meals from plants. Following mating, the female seeks a blood meal. Males survive only on sugar meals, while the female will take multiple blood meals. After a female mosquito digests the blood meal and the eggs develop, she finds a suitable place to lay her eggs, and the cycle begins again. A single female can lay up to five rafts of eggs in a lifetime. *C. quinquefasciatus* are active at night.They can inhabit nearly every type of water source. Larvae can be found in temporary or (semi-)permanent water sources, ponds with vegetation, rice fields, along river edges in still zones, in areas prone to inundation, in puddles and ruts, occasionally even in water-filled tree-holes. The larvae also frequently occur in man-made water bodies, such as flooded cellars, construction sites, road drains and pits, water barrels, metal tanks, ornamental ponds and any type of container (e.g. in gardens or cemeteries). They can breed in clear water but also in water polluted by organic matter, and can even tolerate a small amount of salinity (e.g. coastal marshes or rock pools).Mated females overwinter in shelters free of deep frost, such as cellars, caves, bunkers, or ground burrows. Females bite any warm-blooded vertebrates, feeding on a variety of vertebrate hosts, at night, indoors or outdoors, and rest indoors for blood digestion.Adults do not disperse far from their breeding site - usually less than 500 metres. In nature, females are more abundant at canopy level than at ground level, where other mosquito species occur more frequently. |
| Entry and colonisation |
| Pathway(s) of entry | Adult mosquitoes as hitchhikers in:* Ships, yachts and other vessels
* Aircraft, both passenger and cargo planes
* Shipping containers
* Vehicles

Eggs and larvae:* In any container which has or has had water (including in ships and aircraft) eg tyres, tanks, barrels, etc.
 |
| Detection | See Annex 3. |
| Similar species | Culex quinquefasciatus freely mates with Culex pipiens, which is usually not found south of 39° N. Mating between these two members of the Culex pipiens complex produce viable offspring within the hybrid zone. The extent of the hybridization is extensive and, as a result, the members are sometimes considered to be subspecies of Culex pipiens. |
| Where likely to colonise | Houses, urban areas in general. |
| Longevity | No information |
| Dispersal methods | * Adults can fly up to 500m
* Transported by sheltering in vehicles.
* Eggs and larvae in any container which has or has had water (including in ships and aircraft) eg tyres, tanks, barrels, etc.
 |
| Distribution | Found throughout the tropical, subtropical, and warm temperate regions, usually found within the latitudes 36° N and 36° S. |
| Further information | * <https://www.ecdc.europa.eu/en/all-topics-z/disease-vectors/facts/mosquito-factsheets/culex-pipiens-factsheet-experts>
* <http://entnemdept.ufl.edu/creatures/aquatic/southern_house_mosquito.htm>
* <https://www.cabi.org/isc/datasheet/94031>
 |

## ***Anopheles* mosquitoes**

Larva has no breathing tube and lies parallel to the water; adults rest with the head lower than the hind end.

There are around 430 species of *Anopheles* (anopheline mosquito subfamily). Three are species of concern for the UK Overseas Territories:African malaria mosquito *Anopheles gambiae*, *Anopheles plumbeus* andthe Common malaria mosquito *Anopheles quadrimaculatus*.

**African malaria mosquito *Anopheles gambiae***

|  |
| --- |
| Description |
| Egg | Eggs are between 0.47 and 0.48 mm long, convex below and concave above, and the surface is covered with a polygonal pattern. |
| Juvenile | Larvae have no breathing tube and position themselves so that their body is parallel to the surface of the water.Larvae reach 5 to 6 mm by the completion of the fourth (final) instar. |
| Adult | Adult Anopheles can be identified by their typical resting position: males and females rest with their abdomens sticking up in the air rather than parallel to the surface on which they are resting.Stand with the head lower than the rest of the body. |
| Life cycle | The female *Anopheles* breed in clean unpolluted water, such as ponds and tanks, or accumulated in discarded tyres, bottles, buckets, tins, etc. A female lays 30-150 eggs every 2-3 days, eggs singly and directly on the water, with each egg having floats on either side. Anopheles eggs are not drought resistant. The larvae and pupae live entirely in water but have to come up to the surface to breath. An. gambiae larvae typically inhabit sunlit, shallow, temporary bodies of fresh water such as ground depressions, puddles, pools and hoof prints. Larvae are able to develop very quickly (~six days from egg to adult under optimal conditions). |
| Ecology and behaviour | Only the female bites for blood, which she needs to mature her eggs. An. gambiae feeds preferentially on humans and is one of the most efficient malaria vectors known. Females of An. gambiae typically feed late at night, and both indoor and outdoor biting are common and both indoor and outdoor resting behaviour appear to be regularly reported. Different species of *Anopheles* have different preferences for when they bite (day or night), where they bites (indoors or outdoors), and their preferred host (people or other mammals such as cattle). Adult *An. gambiae* mosquitoes hide behind cupboards, clothes, curtains and other dark and cool corners during the day. They enter houses in the early evening and start biting by late evening, with a peak of biting activity at midnight and early hours of morning. |
| Entry and colonisation |
| Pathway(s) of entry | Adult mosquitoes as hitchhikers in:* Ships, yachts and other vessels
* Aircraft, both passenger and cargo planes
* Shipping containers
* Vehicles

Eggs and larvae:* In any container which has water (including in ships and aircraft) eg tyres, tanks, barrels, etc. The used tyre is heavily implicated in spread of mosquitoes.
 |
| Detection | See Annex 3. |
| Similar species | *Anopheles* mosquito species are difficult to distinguish apart visually. Species swarms occur, with hybridisation. The Anopheles gambiae complex of sibling species comprises eight reproductively isolated species that are almost indistinguishable morphologically. |
| Where likely to colonise | Houses, urban areas in general. |
| Longevity | Adults can live for up to a month. |
| Dispersal methods | * Adults can fly several kilometres
* Transported by sheltering in vehicles.
* Eggs and larvae in any container which has water (including in ships and aircraft) eg tyres, tanks, barrels, etc.
 |
| Distribution | Sub-Saharan Africa |
| Further information | * <https://www.ecdc.europa.eu/en/all-topics-z/disease-vectors/facts/mosquito-factsheets/>
* <https://www.vectorbase.org/organisms/anopheles-gambiae>
* <http://entnemdept.ufl.edu/creatures/aquatic/Anopheles_gambiae.htm>
 |

**Mosquito *Anopheles plumbeus***

|  |
| --- |
| Description |
| Egg | The eggs have floats on either side. |
| Juvenile | Larvae have no breathing tube and position themselves so that their body is parallel to the surface of the water. |
| Adult | Adult Anopheles can be identified by their typical resting position: males and females rest with their abdomens sticking up in the air rather than parallel to the surface on which they are resting. |
| Life cycle | *An. plumbeus* breeds in tree holes, and artificial containers such as tyres, rainwater casks, tanks, and cemetery vases. Larvae of Anopheles plumbeus can be found in water-filled tree-holes with a high salt concentration and deficiency of oxygen. Eggs are not laid on the water surface but on the sides of potential breeding habitats, just above the waterline. Overwintering takes place in the egg or larval stages, which can survive long periods of water-freezing.The larvae and pupae live entirely in water but have to come up to the surface to breathe. The larvae lie horizontally at the surface of the water where they filter feed on organic material. |
| Ecology and behaviour | This species is known to be a particularly aggressive biter, feeding at any time of the day on different mammalian hosts, including humans and on birds and reptiles. |
| Entry and colonisation |
| Pathway(s) of entry | Adult mosquitoes as hitchhikers in:* Ships, yachts and other vessels
* Aircraft, both passenger and cargo planes
* Shipping containers
* Vehicles

Eggs and larvae:* In any container which has water (including in ships and aircraft) eg tyres, tanks, barrels, etc. The used tyre is heavily implicated in spread of mosquitoes.
 |
| Detection | See Annex 3. |
| Similar species | *Anopheles* mosquito species are difficult to distinguish apart visually. Species swarms occur, with hybridisation.  |
| Where likely to colonise | Rural and urban areas. |
| Longevity | Up to 2 months. |
| Dispersal methods | * Adults can fly several kilometres
* Adults transported by sheltering in vehicles.
* Eggs and larvae in any container which has water (including in ships and aircraft) eg tyres, tanks, barrels, etc.
 |
| Distribution | Europe, the Caucasus, the Middle East, Iran and Iraq and in North Africa. |
| Further information | * <https://www.ecdc.europa.eu/en/disease-vectors/facts/mosquito-factsheets/anopheles-plumbeus>
 |

**Common malaria mosquito *Anopheles quadrimaculatus***

|  |
| --- |
| Description |
| Egg | The eggs have floats on either side. |
| Juvenile | Larvae have no breathing tube and position themselves so that their body is parallel to the surface of the water. |
| Adult | Adult Anopheles can be identified by their typical resting position: males and females rest with their abdomens sticking up in the air rather than parallel to the surface on which they are resting.They are large, very dark mosquitoes covered in dark brown to black hairs. An. quadrimaculatus has dark scales on the wings with patches of scales forming four darker spots on the wing.  |
| Life cycle | Females deposit eggs individually on the surface of the water. Preferred oviposition sites include fresh water streams, ponds, and lakes with abundant aquatic vegetation. They will also breed in ponds, ditches, shallow margins of reservoirs and lakes.The eggs of An. quadrimaculatus cannot survive drying/desiccation; they will hatch within two to three days after oviposition. A female lays eggs singly and directly on the water, with each egg having floats on either side. One hundred or more eggs are laid at a time. A single female may lay as many as 12 batches of eggs and a total of more than 3,000 eggs. The eggs of An. quadrimaculatus cannot survive drying/desiccation; they will hatch within two to three days after oviposition. The larvae and pupae live entirely in water but have to come up to the surface to breathe. The larvae lie horizontally at the surface of the water where they filter feed on organic material. Egg to adult takes 5 to 14 days.  |
| Ecology and behaviour | The most common hosts are large mammals including humans. The feeding preference is principally for ruminants, equines, lagomorphs and canines.Feeding occurs at night. During the day, the adults rest inside dark buildings and shelters in dark corners. Flight activity peaks a short period after dark, with limited flight for blood for the remainder of the night and at dusk they search for resting sites. Flight range is usually regarded as less than one mile under normal conditions, but can be longer. |
| Entry and colonisation |
| Pathway(s) of entry | Adult mosquitoes as hitchhikers in:* Ships, yachts and other vessels
* Aircraft, both passenger and cargo planes
* Shipping containers
* Vehicles

Eggs and larvae:* In any container which has water (including in ships and aircraft) eg tyres, tanks, barrels, etc. The used tyre is heavily implicated in spread of mosquitoes.
 |
| Detection | See Annex 3. |
| Similar species | *Anopheles* mosquito species are difficult to distinguish apart visually. This species has been recognized as a complex of five sibling species and is commonly referred to as An. quadrimaculatus (sensu lato) when in a collection or identified in the field. |
| Where likely to colonise | Urban and suburban areas. |
| Longevity | 2 to 4 weeks. |
| Dispersal methods | * Adults can fly up to a mile
* Adults transported by sheltering in vehicles.
* Eggs and larvae in any container which has water (including in ships and aircraft) eg tyres, tanks, barrels, etc.
 |
| Distribution | North America. |
| Further information | * <http://entnemdept.ufl.edu/creatures/aquatic/Anopheles_quadrimaculatus.htm>
* https://www.cabi.org/isc/datasheet/94031
 |

# **Annex 2. Roles of the Response Group and Operational Group**

**Response Group**

The Response Group is responsible for oversight of the work, and represents the policy lead.

The Response Group will determine when to move from the eradication phase to the monitoring phase and determine when monitoring can stop as a result of successful eradication.

**Operational Group**

The Operational group represents the delivery lead. On instruction from the Response Group, the Operational Group, will:

* Undertake additional monitoring / surveillance as necessary to establish the likely extent of the population.
* Provide advice on the best eradication strategy to use and any site specific issues to be overcome.
* Liaise with landowners and interested parties as necessary to obtain access and other permissions, if necessary utilising species control orders.
* Implement the eradication strategy.
* Monitor the site following eradication to ascertain success.
* Investigate the source of the outbreak.

These steps are not detailed or exhaustive, additional steps may be required as determined by the Response Group on advice from the Operational Group.

**Quality assurance**

The agency tasked with delivery should have a quality assurance plan to assess the effectiveness of treatments. For example, adult or larval mosquito numbers can be assessed post-treatment.

Experience in Europe has found that private companies that engage with mosquito control often do not do what they promise, so the Operational Group should be responsible for checking their work.

# **Annex 3. Best practice – monitoring and detection methods for mosquitoes**

The effectiveness of this contingency plan requires two pre-existing conditions:

1. An existing mosquito monitoring programme is in place;
2. An inventory of existing mosquito species has been established.

If these conditions aren’t met, the territory is urged to put them in place as soon as possible. Appropriate monitoring and detection methods (see details below) can be used in a permanent monitoring programme. Samples of captured larvae and adult mosquitoes should be sent to an entomologist to confirm identification. Larvae can be reared into adults so that both stages can be sent.

## **General**

* Following the detection of a new mosquito species extend the search to at least 100m around any site where mosquitoes are detected:
	+ Active searching for breeding sites and larvae
	+ Monitoring with traps for flying adults
* Continue to search for at least 30 days after the last sighting (3 potential breeding cycles).

## **Visual searches**

Adult mosquitoes:

* Monitoring adult mosquitoes is labour-intensive and depends heavily on the operatives proficiency and skill.
* Equipment:
	+ Torch
	+ Aspirator
	+ Small net
	+ Collecting tubes
* Search for adult mosquitoes at resting places such as on walls, in dark corners, behind cupboards, and curtains etc;
* Densities are recorded as the number of adult mosquitoes per house (females, males, or both) or the number of adults collected per hour of effort. Where infestation levels are low, the percentage of houses positive for adults is sometimes used.

Larval mosquitoes:

* This is the simplest method for monitoring mosquitoes.
* The basic sampling unit is the house or premise, which is systematically searched for water-holding containers.
* The sampling procedure is as follows:
	+ For large water bodies (eg. tanks, barrels, ditches etc) sample taking at least 3 dips of 330ml, and examine a total of 1l of water for each sample;
	+ For small water bodies of around or less than 1l, examine all of the water (or as much as possible);
	+ Tree holes and similar containers can be sampled in a similar way using pipettes to extract the water sample;
* Record findings in the form of the Breteau index (BI) is the percentage of positive containers in inspected houses:

number of positive containers X 100

number of houses inspected

* The BI can be compared between areas and also between time.
* This also gives a profile of the characteristics of the larval habitat by recording the various container types either as potential or actual sites of mosquito production.

## **Mosquito traps**

Adult mosquitoes

1. Light traps.

Baited light traps are an effective means of trapping particular mosquito species, including *Aedes aegypti* and *Aedes albopictus*; however they are better targeted by using BG traps, ovitraps, sentinel tyres or dipping of receptacles.

Light traps are baited with CO2 and various designs are commercially available which use either yeast, dry ice or a CO2 gas cylinder as source. Production of CO2 using a yeast-sugar solution in plastic bottles is a relatively easy and cheap method.

Traps are placed late afternoon, in a sheltered spot upwind from the target area, and at least 50m apart. Traps should not be placed in strong winds or rain as this affects catch rate.

Traps are checked each morning, and the catch container placed in a freezer for at least 1 hour to kill them; up to 5 hours may be required to kill all of them. Samples should be stored in the freezer until required for identification. If freezing is not possible, identification should be done within 48 hours of collection.

1. BG sentinel traps

BG Sentinel traps are manufactured by Biogents and attract many mosquito species, including *Aedes aegypti* and *Aedes albopictus.* BG Traps mimic convection currents created by a human body and employ attractive visual cues, they can be used as they are, with CO2 or with a specially designed attractant lure such as octanol, which is known to attract a broad range of mosquito species.

Traps are positioned in sheltered areas away from wind, heavy rainfall and direct sunlight. Ideal locations should be close to resting areas of mosquitoes and should be visible to patrolling mosquitoes. Placing the trap in a confined location should be avoided as it may impair the effectiveness of the trap. For emergency response, traps should be run continuously for the required response time with the catch bags collected daily. The catch bag is placed in a freezer for at least 1 hour to kill them; up to 5 hours may be required to kill all of them. Identification should be done within 48 hours of collection.

1. Human Landing Catch

The human landing catch (HLC) is a very efficient method which involves the surveyor exposing their bare arm for a set amount of time; they should not allow the mosquitoes to bite them. Mosquitoes are captured as they land and attempt to feed on collectors. However, the HLC exposes collectors to potentially infectious mosquito bites, is labour-intensive and requires highly trained collectors: professional entomologists of the public health team. Results obtained by HLC can also be biased due to natural human variations in attractiveness to mosquitoes.

Egg and larval mosquitoes

These traps relay on creating an attractive place for mosquitoes to lay eggs, which are then readily detected either in the egg stage (ovitraps) or larval stage (larvitraps).

1. Ovitraps

Ovitraps are a sensitive and economical method to detect the presence of mosquitoes in situations where infestations are low and larval surveys are generally unproductive (e.g. when the Breteau index is < 5). They have proved especially useful for the early detection of new infestations in areas where the mosquito has been previously eliminated. However, their effectiveness as a monitoring tool relies on good training and attentive operators, otherwise the operators can miss the eggs.

The standard ovitrap is a wide-mouth 0.5 litre glass jar painted black on the outside and equipped with a hardboard or wooden paddle that is clipped vertically to the inside with a roughened side facing inwards. The jar is partially filled with clean water and placed in a rain-sheltered site outdoors and close to habitation. In hot weather the jar will need to be refilled regularly.

Density of ovitraps:

* For domestic buildings, place at least 1 trap for every average size property.
* For ports of entry, place at least 10 traps at the airport, or wharf.

Ovitraps should be checked weekly and the paddles are examined for the presence of mosquito eggs. The percentage of positive ovitraps provides the simplest index of infestation levels.

1. Larvitraps

Tyre section larvitraps (sentinel tyre traps of various designs have also been used to monitor oviposition (egg laying) activity, being a water-filled radial section of a tyre). Traps should be placed in shady areas, away from wind, close to vegetation and, if possible, close to people.

Water level fluctuations caused by rainfall induce the hatching of eggs, and it is the larvae in the water that are counted. The usefulness of tyre section larvitraps has been well demonstrated as an alternative to ovitraps for early detection of new infestations and surveillance of low-density vector populations.

## **Summary**

Pros and cons of the methods outlined above are given below. What is used in any given situation will depend on the budget and circumstances. Ideally, a range of methods should be used, to increase the likelihood of detection.

|  |  |  |  |
| --- | --- | --- | --- |
| Method | Target | Pros | Cons |
| Visual search  | Adults | SimpleRelatively cheap - little equipment requiredRelatively little training required | Labour intensive |
| Visual search – dipping | Larvae | SimpleRelatively cheap - little equipment requiredRelatively little training required | Labour intensive |
| Baited light traps | Adults | Efficient – can be operated every 2 -3 weeksEffective | ExpensiveTraining required |
| BG Sentinel traps | Adults | Efficient – can be operated every 2 -3 weeksVery effective | ExpensiveTraining required |
| Human Landing Catch | Adults | SimpleCheapVery effective | Labour intensiveDepends on skill levelRisk of being bitten and infectedBias due to different levels of vulnerability |
| Ovitraps | Eggs | Relatively cheap - little equipment requiredEfficient – can be operated every 2 -3 weeks | Depends on high levels of skill or is not effectiveWater can evaporate quickly in the heat |
| Larvitraps | Larvae | SimpleRelatively cheap - little equipment requiredEfficient – can be operated every 2 -3 weeks | Training requiredWater can evaporate quickly in the heat |

## **Further information**

Anon (2010) Mosquito Vector Monitoring. Work Instruction. Australian Government Biosecurity Services Group. 2 November 2010.

Bullivant, G. and Martinou, A.F. (2017) Ascension Island: a survey to assess the presence of Zika virus vectors. Journal of the Royal Army Medical Corps, March 2017. DOI: 10.1136/jramc-2016-000730. <https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2664.13631>

Kenea, O., Balkew, M., Tekie, H. *et al.* (2017) Comparison of two adult mosquito sampling methods with human landing catches in south-central Ethiopia. *Malar J* **16,** 30 (2017). <https://doi.org/10.1186/s12936-016-1668-9>

Martinou A.F. *et al* (2020). A call to arms: Setting the framework for a code of practice for mosquito management in European wetlands. J. Appl. Ecol. 2020;57:1012-1019. DOI: 10.1111/1365-2664.13631

World Health Organisation (2016). Entomological surveillance for *Aedes spp.*in the context of Zika virus. Interim guidance for entomologists. <http://apps.who.int/iris/bitstream/10665/204624/1/WHO_ZIKV_VC_16.2_eng.pdf?ua=1>

# **Annex 4. Best practice – control methods for mosquitoes**

The infestation (quarantine) area

* The *infestation area* is the area of known infestation plus a buffer zone of at least 100m around the outer border.
* If legally possible, declaration of quarantine in the *infestation area*.
* Area-wide monitoring within the entire *infestation area* to assess the expansion or reduction in range of the insect population, using methods outlined in Annex 2.
* Note that the *infestation area* / declared quarantine area may be increased in the light of findings, if the mosquito population is found to be expanding.

Treatment

* Operatives working within the *infestation area* should wear light-coloured, loose fitting clothing treated with a mosquito repellent.
* The eradication programme should include:
	+ Treatment or elimination of all potential breeding sites. For mosquitoes it is where standing water can be collected or held such as:
		- Tyres
		- Buckets, bottles, cans
		- House plant containers
		- Troughs, animal drinking water bowls
		- Tanks, toilet tanks, wet showers
	+ Treatment is, as appropriate, by:
		- Addition of disinfectant or detergent to the water
		- Addition of vegetable oil on the surface of the water
		- Application of a larvicide to kill larvae, active ingredient as recommended by WHO for this purpose; see <http://www.who.int/whopes/en/> . Non-lethal larvicides are available in the form of products with Bacillus thuringiensis israelensis (Bti) or Bacillus sphaericus as the active ingredient.
	+ Good practice in the event of finding any material looking like eggs in traps is to clean the trap and freeze what is collected for a few days before disposal.
	+ Spraying of all premises within the *infestation area* with a residual insecticide, active ingredient as recommended by WHO for this purpose; see <http://www.who.int/whopes/en/>
	+ If appropriate, indoor or outdoor space spraying with an insecticide, active ingredient as recommended by WHO for this purpose; see <http://www.who.int/whopes/en/>
	+ Restriction of movement of goods or materials such as tyres out of the *infestation area*:
		- Items to be routinely treated before leaving the area. Treatment will depend on the nature of the goods, and may include scrubbing with disinfectant to remove eggs, or spraying with an insecticide (active ingredient a synthetic pyrethroid) to kill adults.
	+ Restriction of movement of vehicles out of the *infestation area*:
		- Vehicles to be routinely sprayed with a residual insecticide (active ingredient a synthetic pyrethroid) before leaving the area.
* Visits to promote management techniques which reduce infestation and spread, and raise awareness of the issue and preventing spread, including:
	+ Elimination or treatment of potential breeding areas;
	+ Citizen science for reporting infestations, and management of breeding sites are encouraged.
* Where suspicion is raised of a possible other outbreak, visits made to monitor for adults and larvae using methods outlined in Annex 2, adapted to other species as required.

Applying pesticides

* Pesticides must be applied according to an appropriate Code of Best Practice.
* The appropriate Personal Protective Equipment must be worn before preparing or using pesticides, according to the product label instructions.

Post eradication monitoring

* Extend the search to at least 100m around any site where the new species or outbreak is detected:
	+ Active searching for breeding sites and larvae
	+ Monitoring with traps for flying adults
* Continue to search for at least 30 days after the last sighting (3 potential breeding cycles for mosquito species, continue longer if required for other species).

Further information

* <http://ecdc.europa.eu/en/healthtopics/vectors/Pages/vectors.aspx>: mosquitoes in Europe
* <http://www.who.int/whopes/en/>: WHO recommended pesticides for vector control
* <http://www.who.int/entity/mediacentre/factsheets/en/index.html>: WHO fact sheets
* <http://www.cdc.gov/>: US centers for disease control and prevention
* Bullivant, G. and Martinou, A.F. (2017) Ascension Island: a survey to assess the presence of Zika virus vectors. Journal of the Royal Army Medical Corps, March 2017. DOI: 10.1136/jramc-2016-000730. <https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2664.13631>
* Martinou A.F. *et al* (2020). A call to arms: Setting the framework for a code of practice for mosquito management in European wetlands. J. Appl. Ecol. 2020;57:1012-1019. DOI: 10.1111/1365-2664.13631 <https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2664.13631>

# **Annex 5. Example data sheets**

**Larval recording**

|  |  |
| --- | --- |
| Sampler |  |
| Date |  | Time |  |
| Location |  | Altitude |  |
| Grid Ref |  | Distance from Coast |  |

|  |  |  |
| --- | --- | --- |
| **GENERAL HABITAT** | **WATER TYPE** | **Shade** |
| Domestic environment |  | Fresh |  | Dense |  |
| Arable land |  | Brackish |  | Moderate |  |
| Scrub land |  | Polluted |  | None |  |
| Woodland |  | **WATER SPEED** | **Associated Vegetation** |
| Salt marsh |  | Static |  | None |  |
| Other |  | Moving |  | Submerged |  |
|  | Emergent |  |
| Marginal |  |

|  |
| --- |
| **breeding site** |
| Drain |  | Rain Barrel |  |
| Storm Drain |  | Sand Collecting Pit |  |
| Septic Tank |  | Well |  |
| Marsh/Swamp |  | Street Gutter |  |
| Floodwater |  | Rain Puddle |  |
| Pond/Lake |  | Water Reservoir/Dam |  |
| Transient/Temporary Pool |  | Sewage |  |
| Permanent Pool |  | Lagoon |  |
| Ditch |  | Stream/River |  |
| Artificial Container |  |

No of Larvae collected ………………………………………………………………………..

No of Pupae collected …………………….………………. Eggs ……………………………

Dips ……………………...

**Climate *(To be completed by the entomologist)***

Rainfall ……………………… Humidity ……………………

Temperature ……………………… Wind Velocity …..………………..

Species Identified: …………………………………………………………………………………………

|  |
| --- |
| Adult Recording |
| Date (from-to) |   |   |   | Recorders |  |  |
| Area |   |   |   | Trap code |   |   |
| Sector onmap |   |   |   | Time trap was placed |   |   |
| GRID REF |   |   |   | Time it was collected |   |   |
|   |  |  |  |  |  |  |  |
| Habitat type |   | Shade |   |  | Trap operated |   |  |
| Domestic |   | Dense |   |  | Night |   |  |
| Farmland |   | Moderate |   |   | Day |   |  |
| Scrubland |   | None |   |  | Both night and day |   |  |
| Forest |   | Flyinginsects |   |  | Near water source |  |
| Swamp/Marsh |   | Yes |   |  | Yes |   |  |
| Other |   | None |   |  | No |   |  |
|   |  |  |  |  |  |  |  |
| Number of mosquitoes caught |   | Species caught/no per species |
|   | Male: |   |   | 1 |   | 4 |   |
| Mosquitoes | Female: |   |   | 2 |   | 5 |   |
|   | Total: |   |   | 3 |   | 6 |   |
|   |   |   |   |   |   |   |   |
| Other species |   |   |   |   |   |   |   |
|  |  |  |  |  |  |  |  |
|   |  |  |  |  | Mosquito specimen to be dispatched for identification |
| Climate data |   |   |   |   |
| Rainfall | ………….. | Humidity | ………… | 1 | …….. | 6……… |
| Temperature | ………….. | Wind speed | ………… | 2 | …….. | 7……… |
|   |  |  |  |  | 3 | …….. | 8……… |
|   |  |  |  |  | 4 | …….. | 9…….. |
|   |  |  |  |  | 5 | …….. | 10 |
| Comments: |   |   |   |   |   |   |   |
| …………………………………………………………………………………………………………… |
| …………………………………………………………………………………………………………… |
|  | Trap type: | Circle the trap that you used |  |  |  |  |  |
|   |  |  |  |  |  |  |  |
|  | CO2 | Carbon dioxide |  | CO2 | BG sentinel |  | BG |
|   | CO2 | White light | WLB | BG sentinel with BG lure |  | BGL |
|   | CO2 | Black light | BLB | BG sentinel with Octenol | BGO |

# **Annex 6. Equipment suppliers**

Below is given a list of some suppliers of specialist equipment. This list is not exhaustive and should not be taken as an endorsement of the company or brand.

|  |  |  |
| --- | --- | --- |
| Company | Equipment supplied | Link |
| BioQuip Products Inc. | Sampling equipmentBreeding cagesTrapsLures and baitsMosquito protection clothing | <https://www.bioquip.com/>  |
| Biogents | Mosquito trapsLures and baits | <https://eu.biogents.com/>  |
| BG-Sentinel | BG sentinel traps (Information and links to distributors worldwide) | <https://www.bg-sentinel.com/en/distributors.html>  |
| Natural History Book Society | TrapsLures and baitsEntomological equipment, general | <https://www.nhbs.com/>  |
| Watkins and Doncaster | Entomological equipment, general | <https://www.watdon.co.uk/>  |
| Wildcare | Entomological equipment, general | <https://www.wildcare.co.uk/>  |

1. http://www.nonnativespecies.org/index.cfm?pageid=634 [↑](#footnote-ref-1)