Exotic *Aedes* surveillance and exclusion from the Northern Territory of Australia

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EXOTIC Aedes SURVEILLANCE AND EXCLUSION FROM THE NORTHERN TERRITORY OF AUSTRALIA

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1.0 INTRODUCTION

Dengue, a human arbovirus disease, is carried primarily by the dengue mosquito Aedes (Stegomyia) aegypti and closely related mosquitoes such as Aedes (Stegomyia) albopictus. The disease causes high fevers, severe headaches, and muscle and joint pains, with some cases presenting with internal or external bleeding. A more dangerous manifestation includes haemorrhagic symptoms and shock, which can lead to mortality, particularly among children. Dengue is an emerging potential public health problem, particularly in South East Asia and the Western Pacific, including Queensland (QLD) in Australia, (Kay et al 1990).

The Northern Territory (NT) of Australia is one of the few large areas in the tropics that does not have indigenous transmission of the mosquito borne disease dengue.

The dengue free status of the NT is due to the absence of the mosquito vectors, (Whelan 1991). While Australia is free of Ae. albopictus, Aedes aegypti is present in QLD, (Kay et al 1990). Both species are present in neighbouring Indonesia and the island of New Guinea.

Aedes aegypti is widespread in QLD, with reported occurrences close to the NT border in the inland town of Mount Isa, and Mornington Island in the Gulf of Carpentaria, (Sinclair 1992). Aedes aegypti is closely associated with human settlement and breeds in a variety of water filled containers such as old tyres, tins, drums, jars, rain water tanks and other containers used to store water. The drought resistant eggs can be easily transported in containers that have held water. There have been instances of the interception of importations of Ae. aegypti and Ae. albopictus from containers on overseas vessels arriving in Darwin, and of Ae. aegypti in a container carried by road transport from QLD, (Whelan 1991).

The NT is both vulnerable and receptive to the importation of this species and other exotic Aedes species from QLD and overseas, (Russell et al 1984; Whelan 1981; Whelan & Laskowski 1984). The NT has maintained a dengue free status by both Federal and Territory programs designed to intercept and eradicate any importation of the vectors, and to reduce the receptivity at vulnerable locations. This paper outlines the various elements of the surveillance program, details of the eradication procedures and information on the current vulnerability for the importation and establishment of exotic Aedes mosquitoes.

2.0 HISTORY OF Aedes AEGYPTI AND DENGUE IN THE NT.

Aedes aegypti was recorded as early as 1903 in Port Darwin, (Lee et al 1987). Aedes aegypti was reported from a number of towns from 1911 to 1943, and was common in a widespread survey in 1956, with collections made from Darwin, Point Charles, Howard Creek, Koolpinyah, Adelaide River, Roper River, Pine Creek, Brocks Creek, Katherine, Anthonys Lagoon, Daly Waters and Roper River (O'Gower 1958). The past mosquito distribution in the NT largely followed the course

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of the railway, with its associated rainwater tanks and fire buckets, and the road links to QLD, (Marks 1973, Lee et al 1987).

Dengue cases occurred in various towns in the NT and were often reported from Darwin during World War 2. The last reported outbreak in the NT was in 1955, which coincided with a large epidemic in QLD. *Aedes aegypti* disappeared from the NT sometime between 1956 and 1969. It was absent in Darwin at least in 1969, when it was reported that it had not re-established after adults were detected flying from the hold of a cargo ship from Japan, (Marks 1973).

The Department of Health and Community Services (DHCS) has confirmed the absence of this mosquito in the NT between 1974 and the present, (Whelan 1991). It is thought that the move to reticulated water supplies, the introduction of the diesel locomotive, the domestic lawn mower, fire extinguishers and a general improvement in sanitation with the removal of disused drums, tyres and old rain water tanks has been responsible for its disappearance, (Marks 1973).

### 3.0 EXOTIC **Aedes** SURVEILLANCE PROGRAMS IN THE NT.

There are essentially two surveillance programs in the NT to detect the importation of exotic *Aedes* mosquitoes. The first line of defence is provided by the Federal program carried out by the Australian Quarantine and Inspection Service (AQIS) around points of first entry. This is backed up by a more widespread surveillance organised by the Medical Entomology (MEB) of Department of Health and Community Services. There is considerable cooperation between these two agencies in the NT.

#### 3.1 AQIS Surveillance

The AQIS surveillance for exotic *Aedes* is conducted around the Darwin airport and port area. The program has three main elements, namely overseas aircraft surveillance, overseas vessel surveillance, and *Aedes* ovitrap surveillance.

##### 3.1.1 Aircraft surveillance

All overseas aircraft arriving in Darwin are subject to cabin and hold disinsection procedures. The monitoring of these procedures is performed by AQIS. A number of airlines including QANTAS, have residual applications of insecticide and are not routinely sprayed on arrival. All other international aircraft are subject to pre-flight disinsection in their country of departure and top of descent cabin disinsection. Aircraft arriving without disinsection are sprayed on arrival in both cabins and holds with an aerosol knockdown insecticide. The arriving aircraft are inspected by AQIS officers for any flying insects, and any seen are collected for identification by an entomologist.

There have been instances of recovery of flying and freshly killed insects, including mosquitoes, collected from aircraft arriving in Darwin from Indonesia, (Russell et al 1984).

##### 3.1.2 Overseas vessel surveillance

All legal overseas vessels arriving in the NT are directed to designated first points of call including Darwin, Gove, and Alyangula. The latter two largely receive bulk ore and oil carriers, with Gove receiving some yacht traffic. Darwin receives a range of vessels including yachts, small coastal vessels and general cargo vessels as well as large carriers.
In general the vessels are subject to general quarantine inspections, including inspection for exotic insects, after the vessel has tied up at the wharf.

Illegal fishing vessels or refugee vessels are generally brought to Darwin by the Australian Navy and processed in the Harbour at a special quarantine area approximately 1 km offshore.

The first element of the inspection procedures is to look for any flying insects. If any are seen, there is an application of knockdown insecticide throughout the vessel and knocked down insects are collected for identification.

The principal part of the inspection is a search for any water holding containers, or any container used for transporting or storing water. This can include bulk water tanks, down to 200 litre drums, Jerry cans, and clay jars. Each container is inspected for the presence of mosquito larvae, pupae, or their remains. Any insects or remains are collected and identified within one day of collection. Any possible exotic mosquito specimens are forwarded to the MEB for confirmation.

Any container with mosquito larvae or any container suspected of or capable of breeding mosquitoes is filled with water and super chlorinated at the rate of 1/2 cup (125 ml) of granular pool chlorine per 20 litres of water.

If pupae or pupal skins are found in containers on a vessel, adult mosquitoes are assumed to be on board and the entire vessel is fogged with aerosol knockdown spray.

There has been a number of interceptions of exotic mosquitoes including *Ae. aegypti* and *Ae. albopictus* from vessels arriving in Darwin, (Kay et al 1990; Whelan 1991). The number of interceptions from various types of vessels, the species intercepted, and the types of containers with larvae on the vessels arriving in Darwin over a 20 year period are shown in Table 1-3. Illegal fishing vessels are by far the most frequent vessels with exotic mosquitoes, with *Ae aegypti* most frequently intercepted and most commonly found in containers used to transport drinking water.

The interceptions from illegal fishing vessels showed a sharp increase from 1994. Most of the vessels were from Indonesia, and most are processed in Darwin, followed by Broome. The number of foreign vessels apprehended in Australia by year and the number apprehended at the various ports of processing is shown in Figure 1 and Figure 2 respectively. The vessels originated from a wide area of South East Asia, with a relatively large number from the Indonesian island of Roti near Timor. The origin of these vessels from 1994 to 1998 is shown in Figure 3.

Illegal fishing vessels pose an increasing threat for the importation of exotic mosquitoes into Australia and Darwin in particular. These vessels are primarily from Indonesia and increasing overfishing in Indonesian waters is encouraging more illegal fishing within Australia's economic zone.

### 3.1.3 Ovitrap surveillance at ports and airports

AQIS has a comprehensive ovitrap or egg trap program at Darwin’s seaport and airport. The ovitraps consist of black glass jars filled with water with a "masonite" paddle dipping into the water. These ovitraps are very attractive places for container breeding *Aedes* to lay eggs.

The ovitraps are placed on the main wharves, and around the small boats facilities in the wharf area where coastal and overseas barges and yachts arrive or are moored.
The ovitraps are inspected weekly for larvae and all larvae are collected. The ovitrap paddles are collected on inspection, conditioned by drying, and flooded to initiate the hatching of any mosquito eggs. All hatched larvae are reared to 4th instar and identified. Any possible exotic mosquito specimens are referred to the MEB for confirmation.

There has been only one instance of an ovitrap interception in Darwin, (Whelan 1991). In June 1989, two *Ae. albopictus* larvae were recovered from an ovitrap located at the small ships facility near the wharf area. This recovery triggered a rapid response by both AQIS and DHCS. Additional ovitraps were positioned by both the Quarantine and Health authorities. The MEB undertook an inspection and treated all possible water holding receptacles around the wharf area with a super chlorine solution. No additional larvae were recovered. From the follow up investigations it was concluded that the interception was a result of the recent importation of a single female mosquito from a container on an arriving overseas vessel.

### 3.2 DHCS Surveillance

The DHCS surveillance program carried out by the MEB consists of an ovitrap program, a vulnerable points container survey, a general container survey in Darwin and other towns in the NT, a container survey of all properties near the road connection routes to QLD, adult mosquito monitoring at major towns, a public awareness program to prevent road importations and reduce receptivity, and the development and implementation of onshore eradication measures.

#### 3.2.1 MEB Ovitrap program

The MEB ovitraps are similar to the AQIS ovitraps, utilising a 'masonite' paddle, but differing in detail with a glass jar inside an outer black plastic container. Ovitrap pads are placed in the general Darwin port area at alternative sites to the AQIS sites.

Ovitraps are also placed at residential sites in most of the suburbs of Darwin, and at vulnerable points of importation of exotic mosquitoes from QLD, such as yacht facilities, caravan parks, removalists, and trucking companies. Ovitraps are also set in conjunction with local authorities in Nhulunbuy and Alyangula.

The traps in Darwin are inspected once per fortnight. The exposed paddles are exchanged for clean ones, with any larvae and all the water collected from positive traps. Any eggs present on the paddles are hatched after conditioning and reflooding, with larvae reared to maturity (fourth instar) in a mosquito proof insectary for identification. The ovitraps in Gove and Alyangula are positioned near the airport and port areas, and are inspected monthly in Alyangula and fortnightly in Gove, with any collected larvae placed in labelled vials of alcohol and the collected paddles sent to MEB for hatching and rearing. There have been no interception of exotic mosquitoes from the MEB ovitraps. Most of the ovitraps have been positive for *Ae. notoscriptus*, with a number of other species including *Ae. tremulus* and *Culex quinquefasciatus* also collected. The results are reviewed annually and under-performing traps are repositioned.

#### 3.2.2 Darwin vulnerable points container surveys

Vulnerable points for the importation or establishment of exotic *Aedes* from overseas or QLD, including shipping and yacht facilities, caravan parks, removalists, trucking companies, plant
nurseries, tyre yards and tyre dumps, are inspected on average every three years during the wet season. All containers with water are sampled for larvae and all or most of the larvae present are collected. Early instar larvae are raised to later instars. There have been no detection of exotic mosquitoes from this program.

3.2.3 Queensland road connection survey

Towns, station properties or road houses on the road routes between the NT and QLD are inspected at least every three years. The places inspected include Borroloola, Barkly Homestead, Three Ways, Larrimah, Mataranka and Katherine. For locations such as cattle stations and road houses along the Barkly Highway, all containers are inspected for larvae. In the smaller towns of Larrimah and Mataranka, all of the residential properties and business locations are inspected. In the larger towns of Borroloola and Katherine, all vulnerable sites and a selection of residential properties are inspected.

There has only been one interception of an exotic species from this program. In 1980 *Ae. aegypti* larvae were discovered in Larrimah during a routine survey, (Whelan 1991). They had been introduced from QLD as eggs in an old 20 litre drum which was off-loaded from a truck and subsequently filled by rain. As soon as the larvae were discovered, a thorough survey of the town was carried out to determine if any other exotic larvae were present. After sampling every tin, tyre, rain water tank or other water holding container likely to be breeding mosquitoes, the containers were either treated with insecticide, sealed, holed or taken to a sanitary rubbish disposal site. Follow up surveys have shown that *Ae. aegypti* did not become established in Larrimah.

3.2.4 General town surveys throughout the NT

Inspections for container breeding mosquitoes are also carried out at various towns and communities throughout the NT. Surveys are on an ad hoc basis as time permits, and are generally carried out in the wet season. Particular attention has been placed on coastal communities from the Western Australian border to Groote Eylandt, where possible illegal vessel landings from overseas or coastal vessels from QLD may have introduced exotic species. Darwin, as the principal port and largest town, has received the most scrutiny. The surveys in Darwin have established a profile of potential breeding places for exotic species, and has demonstrated that Darwin and the surrounding rural areas are receptive to container breeding *Aedes* species.

Surveys in the suburbs of Darwin in 1981 showed that of 460 houses searched, there were 760 containers holding water in backyards and over 20% had mosquito larvae in them. The most frequent breeding places were pot plant bases, old tyres, old tins and drums, old ice cream containers, containers of plant cuttings, buckets and building materials, (Whelan & Laskowski 1984).

In a survey of the rural area of Darwin in 1983, over 32% of premises were breeding mosquitoes in containers. Many rainwater tanks in the rural area were not adequately screened but few larvae were found in them. This was because most tanks were actually water holding tanks rather than rainwater tanks. They are filled by bores on a routine basis and regular water surface agitation makes them unsuitable as breeding sites, (Whelan & Laskowski 1984).

An extensive container survey during a clean up campaign in urban Darwin in 1984 revealed there were, on average, 5 containers holding water per premise, and 30% of premises breeding mosquitoes,(Whelan & Laskowski 1984).
3.2.5 Adult mosquito monitoring

Adult mosquito monitoring is carried out on a routine basis at all of the major towns in the NT. This includes Darwin, Nhulunbuy, Alyangula, Katherine and Tennant Creek. These towns are either relatively close to the QLD border, on the road route between QLD and Darwin, or are ports where importations of exotic Aedes could occur. The monitoring is carried out at most towns on a weekly basis using CO\textsubscript{2} baited EVS traps. The location of trapping in Darwin includes sites at creeks and swamps near the airport, as well as in residential areas. The locations in Nhulunbuy and Alyangula include sites near the port areas.

Other adult collections are carried out at least for the first 12 months, on a monthly basis, at all new mining developments in the NT. New mining developments have a relatively high potential to import *Aedes* eggs in machinery and equipment, including large tyres, if equipment is transported into the NT from QLD or overseas.

Additional mosquito trapping is carried out at smaller communities as part of ongoing general mosquito surveys, or in urban or rural residential areas as part of mosquito complaint investigations or arbovirus and malaria case investigations. While CO\textsubscript{2} baited traps are not the ideal method to detect *Ae. aegypti* and *Ae. albopictus*, these species have been frequently recovered from these types of traps in other areas. Adult mosquito monitoring, either near sites of possible importations, in residential areas, or near more vulnerable sites, is an additional method to detect possible importations of exotic mosquitoes.

3.2.6 Public Awareness program

The DHCS conducts various public awareness campaigns to alert people to the need to prevent breeding mosquitoes on their premises. The program includes paid television, radio and print advertisements with messages detailing potential backyard breeding places, news stories and media releases after detection of importations of exotic mosquitoes, the publication and dissemination of conference papers, and public talks and exhibitions.

The message of the risk of importation of exotic mosquitoes is also disseminated by DHCS and MEB annual reports to participating local governments and other organisations, and the Darwin based Mosquito Control Advisory Committee. All of these programs alert people to the possibility of accidental importation of *Aedes* eggs from QLD or overseas, and encourage people to reduce the possibility of the establishment of importations by reducing the availability of local breeding sites. The programs include seasonal alerts at the start of the wet season targeting rain filled container breeding sites.

4.0 ON SHORE ERADICATION PROCEDURES

If onshore ovitraps, CO\textsubscript{2} traps, or water holding containers are positive for exotic mosquito species, the MEB of DHCS is responsible for eliminating the introduction. This responsibility is currently under review. In the past the Quarantine responsibility has ended once onshore detection has been confirmed.

However onshore surveys and eradication procedures are also initiated by MEB if a risk assessment of collections from overseas vessels indicates a possibility that adult mosquitoes could have escaped from an arriving overseas vessel. Generally this will be initiated if pupae, pupal skins or adults are detected on board vessels tied up at the wharf or other vessel facilities.
The MEB has drawn up detailed procedures and recommendations for the inspection and eradication of exotic mosquitoes, (Whelan 1998). These procedures include vessel inspection procedures, eradication procedures on vessels, and onshore eradication procedures. The mainstay of the onshore eradication recommendations has been thorough container surveys, filling of all containers with water and applying a super chlorine treatment, and follow up container surveys after rain.

5.0 CONCLUSIONS

Airports and seaports in the NT which receive overseas traffic are vulnerable to the importation of exotic *Aedes* species. The Australian Quarantine Inspection Service is responsible for surveillance at major ports and international airports. They however do not monitor Australian coastal vessels or internal aircraft flights from QLD. The AQIS ovitrap program at the ports and airports, and the MEB ovitrap program around the port area in Darwin and other ports should however detect vessel importations of *Aedes aegypti* from QLD.

Darwin, closely followed by Broome in WA, has the highest demonstrated risk in Australia for the importation of exotic *Aedes* species from overseas. The greatest risk of importation into the NT is from illegal landings or the interception of illegal fishing vessels. Small fishing vessels from Indonesia with drinking water carried in makeshift containers pose the greatest threat. *Aedes aegypti* was most frequently intercepted, but *Ae. albopictus* is also a considerable threat.

The NT is also vulnerable to the importation of *Ae. aegypti* from QLD by road. The potential mode of importation of desiccant resistant eggs includes the transport of machinery, spare vehicle tyres, rain-filled boats, garden ornaments, pot plant bases, and other containers capable of collecting rain water during mining, defence, or household equipment relocation. Particularly vulnerable points of importation are truck and caravan stopover facilities on the Barkly and Stuart Highway between QLD and Katherine. Importation from QLD is also possible by sea, via prawn and fishing vessels, and on ocean going yachts. Vulnerable points of importation are the yacht facilities on the Gove Peninsula, and at the small boat and yacht facilities near Darwin.

Darwin in particular, and other towns in the NT, are receptive to the importation of exotic *Aedes* species. Continued public awareness campaigns warning of container breeding situations in backyards or other premises has not eliminated these containers. There needs to be more effort at reducing this receptivity in Darwin and other receptive parts of Australia by publicising the danger of providing potential mosquito breeding sites for exotic *Aedes* mosquitoes.

AQIS and DHCS surveillance programs assist in ensuring that the NT remains free of exotic *Aedes* mosquitoes. The expenditure on these programs, and any immediate response when required, is small compared with that required if exotic species became established and eradication measures or routine dengue control measures became necessary. Mining, fishing, road and sea transport personnel, and the general public, should continue to be encouraged to prevent the inadvertent importation of exotic mosquitoes or their eggs into the NT. The present review of AQIS mosquito detection procedures around ports and airports in Australia should strengthen the quarantine surveillance programs and establish surveillance in those areas that have been lacking effective surveillance.

The NT would be less vulnerable to the importation of *Ae. aegypti* from QLD if that State could reduce the distribution of this species away from the NT border. This appears to be feasible but requires a national program as there is no priority for QLD to do this alone. Australia, and QLD in
particular, face a grave threat of severe outbreaks of dengue and dengue haemorrhagic fever, if the
distribution of *Ae. aegypti* is not reduced or the populations controlled. The eradication of *Ae.
aegypti* in QLD is feasible but also requires a national program with support from all States and
Territories. The impetus for this effort must come from the health and scientific community. The
eradication of *Ae. aegypti* in Australia would have enormous public health benefits for present and
future Australians.

6.0 ACKNOWLEDGMENTS

The assistance, and ready cooperation of the Nhulunbuy Corporation, the Groote Eylandt Mining
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Gwenda Hayes, Senior Technical Officer of the MEB has ably supervised the daily operations of
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**Tables**

**Table 1. Quarantine interceptions from vessels NT 1978-98**

**Table 2. Exotic mosquitoes intercepted NT 1978-98**

**Table 3. Vessel Containers Positive 1978-98**

**Figures**

**Figure 1. Foreign vessels apprehended by calendar year in Australia**

**Figure 2. Foreign fishing vessels apprehended by port of processing**

**Figures 3. Location of origin of fishing vessels**

**Table 1. Interception of exotic mosquitoes. Darwin 1978-98**

<table>
<thead>
<tr>
<th>Quarantine interceptions from vessels by type</th>
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<tbody>
<tr>
<td>Illegal fishing vessels</td>
<td>24</td>
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<tr>
<td>Refugee vessels</td>
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<tr>
<td>Yachts</td>
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Coastal Barges 2
Large vessels 1

Table 2. Interception of exotic mosquitoes. Darwin 1978-98

<table>
<thead>
<tr>
<th>Exotic mosquito species intercepted from vessels</th>
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</thead>
<tbody>
<tr>
<td><em>Aedes aegypti</em></td>
</tr>
<tr>
<td><em>Aedes albopictus</em></td>
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<tr>
<td><em>Anopheles farauti</em></td>
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<td><em>Culex fragilis</em></td>
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Table 3. Interception of exotic mosquitoes Darwin 1978-98

<table>
<thead>
<tr>
<th>Intercepted Vessel Containers Positive for Larvae</th>
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<tbody>
<tr>
<td>Water drums 200 litre</td>
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<tr>
<td>Water drums small</td>
</tr>
<tr>
<td>Water jerry cans</td>
</tr>
<tr>
<td>Tyres</td>
</tr>
<tr>
<td>Water clay jars</td>
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<tr>
<td>Machinery</td>
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</tbody>
</table>
Figure 1: Foreign vessels apprehended by calendar year in Australia

*1998 figures to 9/9/98
Figure 2: Foreign fishing vessels apprehended by port of processing

1998 figures to 9/9/98
Figure 3. Location of origin of illegal fishing vessels 1994-98