Mosquito vector control in the Northern Territory

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Background

In 1972 the Northern Territory (NT) Department of Health established a small Medical Entomology Branch (MEB) to investigate and organise control of insects of medical importance in the NT, with an emphasis on the mosquito vectors of malaria. The NT was one of the first States or Territories to set up such a unit devoted solely to the above purpose and to have a full-time medical entomologist with state-wide responsibility.

As a result of the 1974 Australian encephalitis outbreak, the need for research and control of mosquito borne diseases on an Australia-wide basis became apparent. The Commonwealth Department of Health established financial assistance to the State and Territories in late 1974, under the Australian Encephalitis Control Program. This early assistance contributed towards the equipment and operational needs of the MEB and aided the establishment of mosquito control programs in Alice Springs, Darwin, Nhulunbuy and Alyangula. The control programs in the various towns were carried out with assistance from the various local councils, corporations or mining companies, in cooperation with the local departmental health surveyors or with direct assistance from the MEB. The guidance of vector control operations by the various operational bodies was undertaken by the Medical Entomology Section. The process of gathering medical entomology data on a Territory wide basis was started, in order to establish vector control operations on a more scientific basis.

From the beginning, with a single entomologist and a part-time tearoom laboratory, the MEB evolved into a distinct branch of the NT Department of Health, with a well equipped laboratory, professional and technical staff and a comprehensive vector surveillance and control program. The activities of MEB have been reported regularly in the Annual Reports of the NT Department of Health and in the MEB annual reports.

This paper was prepared for a workshop on vector control organised by the National Disease Control Program in Canberra in 1987. It summarises the main elements of the NT Vector Borne Disease Control Program and highlights some of the results and achievements of this program. This paper was revised in 2007 to reflect current methods and altered situations.

Vector control problems peculiar to the Northern Territory

Different geographic areas

The NT has a range of geographic areas, from the tropical monsoonal north to the semi-arid desert areas of Central Australia. In the northern area, the timing of vector surveillance and control operations can be scheduled with some degree of certainty, depending on the arrival and the end of the monsoon season and tidal predictions. Vehicle access to many of the areas during the wet season can be very limited, posing particular problems. In the semi-arid areas, the timing of surveillance and control operations is variable and dependent on seasonal conditions. After widespread rains, vast areas can be covered with water and become inaccessible. Even within one geographic area in the NT, differing land forms and swamp systems produce different peak periods of abundance of mosquitoes due to variable vegetation and water characteristics. The differing habitats within the one region mean that many habitats require individual assessment for vector prevalence and vector control requirements.

Widespread and small population

Major towns in the NT are widely dispersed, and stretch the time and available resources of the MEB to the limit. In addition there are many small communities, frequently with housing styles or at locations that expose people to relatively high numbers of mosquitoes. Mosquito surveys of small communities must necessarily be on a relatively long return cycle in the NT, and even some of the major towns pose problems for regular vector surveillance and control operations. Much of the assistance with vector control and surveillance operations in major towns other than Darwin is carried out by environmental health officers (EHOs) or other people whose main job does not necessarily involve mosquitoes.
Wide range of mosquito species

There are many pest and vector mosquitoes in the NT with over 100 species of mosquitoes. They include all the major potential and actual mosquito borne disease vectors in Australia with the exception of the dengue mosquito *Aedes aegypti*. The habitats of the mosquitoes range from freshwater swamps, brackish water lagoons, salt marshes and temporary flood waters to artificial mosquito breeding sites such as storm drains and household water receptacles. Each mosquito species has particular periods of prevalence and particular control challenges.

Numerous potential mosquito borne diseases

Unlike some of the southern states, the NT has to contend with the threat of malaria reintroduction, arbovirus diseases from infection with Murray Valley encephalitis and Ross River virus, as well as the potential reintroduction of *Aedes aegypti* and other exotic mosquito species.

These diverse problems, together with the relatively small resources available in the NT, have required a somewhat different approach to vector control than in other states. In the NT, the program includes a mosquito borne disease surveillance program, regular mosquito monitoring at major population centres, planning inputs in urban areas, larval vector control operations in major towns, and source reduction and major engineering projects in those towns where cost benefits are maximized. All of these various components of the program are linked with a wide-spread mosquito awareness program, which aims to raise the public awareness of mosquito borne disease and to encourage self protection and avoidance measures.

Mosquito borne disease surveillance

Malaria

The NT is both vulnerable and receptive to malaria with:
- A history of malaria up until 1962
- The presence of all the major Anopheles vectors of malaria
- The receptivity of many population centres, with large numbers of mosquitoes in close proximity to urban areas
- The proximity of malarious countries in South-East Asia and the Pacific, and regular tourist traffic.

Malaria prevention in the NT relies largely on the health services detecting any malaria cases. Once a case is detected and confirmed by blood examination, the NT Department of Health and Community Services (DHCS) Centre for Disease Control (CDC) has the responsibility to coordinate the gathering of information and to organise any necessary medical response. Entomological assessments are carried out for each detected malaria case. If warranted an entomological investigation will then be carried out. This investigation involves examination of vector control maps or other mosquito distribution data, the review of the epidemiological data, the inspection of residences and places visited by the patient, the setting up of carbon dioxide baited mosquito traps, the location of nearby and significant mosquito breeding and harbouring areas, and the assessment of responses necessary, including adult mosquito fogging.

An important component of the malaria control program is the reduction of receptivity in the Darwin urban area. The Darwin urban area is home for nearly 50% of the Territory population and a reduction in receptivity by source reduction measures such as draining and filling mosquito breeding areas has a maximum cost benefit.

Dengue

The MEB has comprehensive programs to ensure that the NT remains free of *Aedes aegypti* and *Aedes albopictus*, the principal vectors of dengue fever. The NT has a history of dengue including a large outbreak reported during World War 2. The vector, *Aedes aegypti* was present in the NT at least until 1956. By 1969 Darwin was regarded as being free of *Aedes aegypti* from 1973 to the present, except in Tennant Creek where an importation was detected in February 2004 and in Groote Eylandt when another importation was detected in November 2006. In response the MEB established *Aedes aegypti* eradication programs which eradicated the dengue mosquito in Tennant Creek in 2006 and is currently active in an eradication program on Groote Eylandt. The Dengue Surveillance
Program consists of a number of elements including those below.

**DHCS Aedes aegypti ovitrap surveillance Darwin**

Special *Aedes* ovitraps are placed in each suburb in Darwin, other major towns of the NT and at vulnerable points of introduction such as the various port areas, airport, caravan parks and in interstate transport terminal vicinities. The ovitraps are inspected fortnightly for any mosquito larvae and all larvae are identified in the MEB laboratory. This program enables the rapid detection of any importation or introduction of *Aedes aegypti* or other exotic *Aedes* species.

**Quarantine ovitrap surveillance at the airport and wharf**

An ovitrap surveillance program is conducted at the various Darwin port facilities and airport under the operation of the Austrian Quarantine Inspection Service (AQIS). The AQIS officers routinely submit mosquito larvae to the MEB for identification. This program is aimed at intercepting any importation or introduction of *Aedes aegypti* at the most vulnerable points.

**Quarantine inspections**

All incoming overseas vessels and cargo are inspected by AQIS for the presence of mosquito larvae, and all overseas planes are routinely sprayed for exotic insects. AQIS, in cooperation with the MEB, conducts routine surveillance around ports and airports for mosquito breeding. AQIS in cooperation with the MEB also conducts or investigates source reduction and precautionary sprays of receptacles in the port areas.

**Northern Territory-wide Aedes aegypti surveys**

Regular surveys are conducted in communities and cattle stations between Tennant Creek and the Queensland border to detect the possible introduction of *Aedes aegypti* from Queensland. As opportunity permits, other towns and communities throughout the NT are surveyed. *Aedes aegypti* has been intercepted on a number of occasions very soon after introduction, in both towns and on board visiting boats. In each case the mosquitoes have been eliminated and their continued absence has been confirmed.

The importation of *Aedes aegypti* as eggs in receptacles such as used pot plant drip trays or old tyres remains a possibility, as evident from the Tennant Creek importation in 2004. A major point of a public awareness program has been to outline that the reduction in available domestic mosquito breeding sites will reduce the probability of a successful reintroduction of exotic *Aedes* species.

**Arbovirus surveillance**

A number of arboviruses are present in the NT including Murray Valley encephalitis virus, Kunjin virus, Ross River virus and Barmah Forest virus. Cases of vector borne disease are assessed by the MEB and entomological investigations are conducted during outbreaks of arbovirus disease.

**Ross River virus and Barmah Forest virus surveillance**

Ross River virus (RRV) is the most common arboviral disease in the NT. Under the *Notifiable Diseases Act* laboratories notify confirmed cases of RRV and Barmah Forest virus (BFV) to CDC where they are recorded on the NT Notifiable Diseases System. Resident location is recorded on the system and this has allowed identification of the most vulnerable areas for the transmission of these diseases.

**Arbovirus research**

The MEB has established the presence of the various arboviruses in the NT by the isolation of virus from wild caught mosquitoes. This program has involved the collection and processing of many thousands mosquitoes. The result of this program has been the isolation of arbovirus from certain species of mosquitoes.

The viruses isolated have included numerous isolations of RRV, BFV, Sindbis virus, with a few isolates of Murray Valley encephalitis virus (MVEV) and Kunjin virus. *Aedes normanensis* from the semi-arid areas and *Aedes vigilax* from the Top End have been indicated as an important potential vectors of RRV with numerous viral isolates of these species. *Culex annulirostris*
yielded isolates of Sindbis virus, RRV, MVEV and Kunjin virus. This work confirms the potential disease risks posed by the various mosquito species in the NT. When this is correlated with the prevalence and distribution of the various species of mosquitoes, it allows some degree of assessment of the potential diseases in the various areas. Those areas with high numbers of vectors, or where transmission has been demonstrated are given a higher priority for vector control or public awareness needs.

Mosquito monitoring

Mosquito monitoring operations are carried out over as much of the NT as possible, with emphasis on the major towns. This program has built up an information base of the species and prevalence of mosquitoes over a wide area of the NT. A comprehensive reference collection of the mosquitoes from the NT has been assembled and new species and new Australian and NT records have been established.

Mosquito Monitoring Darwin

Mosquito monitoring using carbon dioxide (CO₂) baited light traps has been conducted continuously in Darwin since 1979. Over 20 trap sites are currently utilized and these traps are set weekly at the various sites, adjacent to major swamps near urban areas. This program allows a rapid assessment of any mosquito problems in the Darwin area and is used to determine the need and assess the success of larvicide operations and the mosquito engineering works. The monitoring also allows assessment of risks for malaria transmission as part of the Malaria Surveillance Program. Additional traps are set for actual or potential mosquito problems associated with developmental projects and mosquito complaints. The graphs of mosquito monitoring at Leanyer Swamp (Darwin) are shown in Appendix 1 to demonstrate the dramatic reduction in mosquito numbers from 1983, before the enhanced engineering program and the helicopter applied insecticide program, to 1986 when both programs were in operation.

Mosquito Monitoring Northern Territory-Wide

A comprehensive picture of the prevalence and distribution of mosquito species in the NT has been built up by a program of ad hoc mosquito surveys throughout the Territory at communities, towns, cattle stations and in non-populated areas. These surveys include collections along the Victoria Highway to the Western Australian border and collections throughout the Barkly Region, to establish, among other things, the distribution of Anopheles farauti, the Australian malaria mosquito. For new tourist, mining, and urban development projects, detailed monitoring surveys for 12 months or over are undertaken to provide detailed information on the potential mosquito problems.

Mosquito Monitoring Major Towns

Regular adult and larval mosquito monitoring is carried out at the major centres of Darwin, Katherine, Nhulunbuy, Jabiru, Alyangula, Tennant Creek and Alice Springs, with these towns except Nhulunbuy receiving assistance for monitoring from the MEB under the NT Centre for Disease Control (CDC) Program. In most of these towns, CO₂ traps are set either once per week or once per month by either health surveyors, mining personnel, town council or town corporation employees. Catches of mosquitoes are forwarded to the MEB for identification and comment. The monitoring data for mosquitoes from these communities is used to determine the need and timing of vector control operations or public awareness notices.

Planning and mosquitoes

DHCS places a large emphasis on planning as a means to reduce people-mosquito contact. There has been a large input of information to the Department of Infrastructure Planning and Environment, on a diverse range of proposed mining, aquaculture, semi-rural residential, urban residential and recreation developments.

Project Development

MEB comments on preliminary environmental reports or environmental impact statements on many development projects including new airports, proposed mines, proposed dams, industrial developments, new urban developments and many others. The aims of these comments are to prevent the creation of new mosquito breeding areas and to ameliorate or rectify any existing mosquito breeding areas.
Rural Development

In Darwin, MEB has had inputs into the Land Use Objectives formulated by the DIPE. The input includes comments on certain activities (sand mining in low lying areas), locations (residential developments near major mosquito breeding areas), population densities (blocks below 2 hectares in size for rural residential development adjacent to large mosquito breeding areas are discouraged), and access (for maintenance reasons). The result of these inputs is to encourage planning which minimises people-mosquito contact, thus avoiding expensive rectifications at a later date when mosquito problems become obvious.

Residential Urban Development

Creation of new towns (such as Palmerston), and the expansion of residential development in existing towns (such as Darwin and Alice Springs) may place people near existing mosquito breeding areas or create additional mosquito breeding sites. The mosquito breeding area can be inadvertently created by activities such as the construction of road embankments, storm water drain construction and disposal, sewerage pond construction and disposal of excess effluents, and soil borrowing and sand mining operations. MEB has an input into the planning stages and assists the planners to consider biting insects when making detailed plans for urban and other developments.

Palmerston is a model of a well planned tropical urban area with minimal mosquito problems. The storm water drainage system has been designed as wide grassed open floodways with subsoil low flow drains. This has minimised mosquito breeding in the actual drains. The drain end points are directed to the daily flushed tidal areas, thus avoiding ecological changes and subsequent mosquito breeding that has been a feature of the older residential areas in Darwin. Mosquito breeding areas have been drained, filled, recontoured or reconstructed and in one instance a large shallow reed lagoon was excavated and formalised to create an aesthetic water feature that does not produce mosquitoes.

An important feature of MEBs inputs has been the acceptance that urban residential developments should be excluded from within 1 kilometre of large expanses of mangroves and within 1.6 kilometres of large and uncontrollable mosquito breeding areas.

Recreational Development

Mosquito surveys are undertaken in recreation areas to determine the species and relative numbers of mosquitoes, to assist park management in the siting of camping and other developments, and assess the need for public awareness information on mosquitoes. Surveys have been undertaken in Kakadu National Park, Litchfield National Park and Charles Darwin Park and the results have highlighted the need for public education on personal protection against mosquitoes in particular areas.

Vector Control

Vector Control in the NT is conducted under 3 linked programs, with each program aimed at specific mosquito stages, species or breeding areas. The underlying philosophy of vector control operations in the NT is to aim for the long-term source reduction of mosquito breeding areas around population centres. Insecticide treatment near urban areas is regarded as a stopgap measure until source reduction measures can be achieved. For most urban centres, larval control measures are carried out within urban areas, while adult control measures are limited to mosquito breeding and harbouring areas during a vector borne disease outbreak or a period of enhanced potential disease transmission.

The NT Vector Borne Disease Control Program Operations

The NT Vector Borne Disease Control Program is the major ongoing vector control program covering the principal population centres. The approach to vector control is different in each town, due to the particular type and location of the mosquito breeding areas and the local resources available. In Darwin, the Darwin City Council carries out larval control operations at specific sites, on advice from the MEB. The bacteria product Bacillus thuringiensis var israelensis (B.t.i.), and the insect growth regulator methoprene are the principal insecticides used and are applied by hand held pressure sprayers, motorized backpack units, or quad bike mounted spray units. No regular adult
mosquito control operations are carried out in Darwin except directly by the MEB around potentially transmissible malaria cases.

In Alice Springs the Alice Springs Town Council carries out a regular larval monitoring and control program within the municipality. An adult mosquito control program is carried out around Ilparpa swamp outside the urban area. All larvae and adult mosquito monitoring samples are identified by MEB in Darwin and advice is given on the frequency and timing of mosquito control operations.

Jabiru, with its enormous pest and vector mosquito numbers (sometimes in excess of 30,000 mosquitoes per trap night), has little opportunity for any significant source reduction. Mosquito monitoring is used to alert residents of periods of increased vector numbers.

Many other smaller communities are visited by MEB under this program and particular mosquito breeding areas are located and advice is given on the control of specific mosquito problems.

**Major Engineering Program**

Engineering developments conducted by other departments and authorities may be modified on advice from the MEB, to reduce potential mosquito breeding. The MEB also supervises a large mosquito control engineering program in Darwin. This program is funded jointly by the NT Government and the Darwin City Council on a 2 to 1 basis with annual expenditure in the region of $190,000. This program aims to physically remove mosquito breeding areas affecting the urban areas of Darwin by draining or filling and upgrading stormwater drains. This program has successfully reduced the number of mosquitoes in those swamps adjacent to many suburban areas of Darwin. The graphs in Figures 1 and 2 illustrate this reduction in numbers in Leanyer swamp that has been partly a result of reducing the source of mosquitoes by draining the swamp.

**Helicopter Applied Larvicide Program**

Darwin is the most populous city in the NT and the proximity to very large coastal swamps that cannot be drained has meant that many people in residential areas bordering these swamps are exposed to high mosquito numbers. Apart from the severe pest problems, these mosquito species pose a potential health risk from mosquito borne disease. The principal problem from these coastal swamps has been plagues of *Aedes vigilax* (the salt marsh mosquito).

The NT Government has recognised this problem and the MEB conducts a specific salt marsh mosquito control program aimed at preventing plagues of the salt marsh mosquitoes. Predictions of potential plagues are made from an examination of tide charts and rainfall data.

In Darwin tides of over 7.4 m or rainfall of over 25mm in October to January can initiate large hatches of salt marsh mosquitoes. Specific breeding places have been detected and mapped on a vector control map. A comprehensive larval control program using helicopters has been organised to apply liquid *Bti* onto the breeding areas, after breeding has been detected. This program enables large areas to be covered rapidly before the larvae reach the late 4th instar growth stage (last growth stage) and has been extremely successful in reducing the number of salt marsh mosquitoes in the residential areas. The program is outlined in the following article.

**Mosquito awareness program**

The Mosquito Awareness Program conducted by the MEB is carried out with assistance from DHCS Corporate Communications. The program utilises Television and radio advertisements, public mosquito displays, newspaper stories and occasional visits to schools, to enhance public awareness of mosquitoes and mosquito borne disease. Pamphlets and information sheets have been prepared to explain the principle mosquito breeding areas, the methods available to reduce mosquito breeding around the home, and recommended self protection measures. This awareness program is necessary in the NT, where many people visit areas of high mosquito activity in more remote areas for recreation, and when self protection measures are the only practical method of reducing person-mosquito contact.
Figure 1. Leanyer Dump - 1983

Number of females per trap night

- *Ae. (Och) vigilax*
- *An. (Ano) bancroftii*
- *An. (Cel) farauti s.l.*
- *An. (Cel) hilli*
- *Cx. annulirsotris grp.*

Figure 2. Leanyer Dump - 1986

Number of females per trap night

- *Ae. (Och) vigilax*
- *An. (Ano) bancroftii*
- *An. (Cel) farauti s.l.*
- *An. (Cel) hilli*
- *Cx. annulirsotris grp.*