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Draft Assessment Report for *Aedes (Stegomyia) polynesiensis*

Contents:

1. Taxonomy of the species

a) Family name: Culicidae

b) Genus name: *Aedes*

c) Species: *polynesiensis*

A recent suggested change in taxonomy (Reinert, Harbach, and Kitching 2004, 2009) has elevated the subgenus *Stegomyia* to generic level, but this change has not been fully accepted. The most frequently used species name is: *Aedes (Stegomyia) polynesiensis*

http://mosquito-taxonomic-inventory.info/sites/mosquito-taxonomic-inventory.info/files/Valid%20Species%20List_60.pdf (Last updated 7 September 2017).

d) There are no known subspecies of *Ae. polynesiensis.*

e) Marks, EN.1951:138 (M, L). The vector of filariasis in Polynesia: A change in nomenclature. Annals of Tropical Medicine and Parasitology 45: 137-140. [1]

f) Common Name: Polynesian tiger mosquito.

g) This is not a genetically-modified organism (GMO).

2. Status of the species under CITES

Aedes polynesiensis is not listed either on Appendix I or II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

3. Ecology of the species

a) Longevity: The longevity of *Aedes polynesiensis* in the wild is unknown. In captivity, at 20°C and 85% relative humidity, the recorded half-life for males is 16.5 days and 23.5 days for females; maximum age for males and females is 42 days and 48 days, respectively. The survival of females nearly doubles with periodic blood meals [2]. Longevity in the wild is not known, but for mosquitoes it is usually shorter than longevity in captivity.

b) Size and weight of mosquitoes will differ depending on temperature, food availability and presence of competitors in their larval habitat. The mean wing length, which is commonly used as a proxy for body size of insects, is around 2.1 mm in wild-caught males, and 2.0-2.2 mm in laboratory-reared males [3]. Females are larger than males, with the wing length of around 3 mm (see Image 1). The dry weight of adult specimens is 0.11-0.37 mg for males, and 0.25-0.59 mg for females [4].

Image 1. *Ae. polynesiensis* female with wing (left) and thoracic lengths (right) measured. Photo credit: MAF Plant Health & Environment Laboratory (2011) Polynesian Tiger Mosquito *(Aedes polynesiensis)* Updated on 5/7/2014 2:07:55 AM Available online: PaDIL - http://www.padil.gov.au. Free for use under the Creative Commons Attribution 3.0 Australia License

c) Identification of the individuals in this species: Male and female mosquitoes are quite easy to differentiate, based on antennae (males have much more feathery antenna, see Image 2).

Image 2. *Aedes* male with distinctive antennae (left) and female (right). Photo credit: Richard C. Russell.

Aedes polynesiensis adults are most similar in morphology and behaviour to the invasive species *Ae. albopictus*, and have some superficial resemblance to a few native Australian mosquitoes (e.g. *Aedes notoscriptus, Ae. palmarum*) and the invasive mosquito *Ae. aegypti*. The combination of the mesonotum without lyre-shaped silvery markings and clypeus without scales, absence of scales at the subspiracular area, presence of supra-alar white line (complete and well developed, with broad flat scales over wing root and toward scutellum), and with basal hind tarsomere 4 of the leg 0.7 white, makes the identification of the species relatively easy within the Australian context.

Pictorial [5] and Online identification keys are available at:
http://www.wrbu.org/keys/PA_AE_A/Aedes_Australasian_PACOM_A.html

Photographs of adult females are available (Image 3) from the Mosquito identification at WRBU, US Department of Defense Unified Command Areas of Responsibility, PACOM. We do not have publically available photos of the larvae or pupae at this time.

Image 3. *Aedes polynesiensis* adult female thorax, lateral view (left), head. dorsal view (center), thorax, dorsal view (right). Photo credit: J. Stoffer, Walter Reed Biosystematics Unit (WRBU).

d) Natural geographic range. The native range of *Ae. polynesiensis* is Fiji and Samoa (State of Samoa, American Samoa, Western Samoa) (http://www.wrbu.org/mqID/mq_medspc/AD/AEpol_hab.html).

Population limiting influences in Australia for *Ae. polynesiensis* would include habitat availability (rock pools, artificial containers, used tires) and predation (Australia has a native predatory mosquito *Toxorhynchites speciosus*, as well as other invertebrate predators such as backswimmers, that prey on mosquito larvae found in containers and tires). Ae polynesiensis is a tropical species. It is not found at high elevation or in subtropical / temperate Pacific islands. Sub-tropical zones like Brisbane, Australia are not suited to establishment.

e) *Aedes polynesiensis* is not known to be migratory.

f) *Aedes polynesiensis* eggs may survive freezing during the winter months, but no data are currently available.

g) Larval, pupal and adult stages of *Ae. polynesiensis* breathe air (the aquatic stages breathe air at the water surface using a siphon).

h) Habitat requirements for all life stages of the species:

Salinity: The aquatic larvae of *Ae. polynesiensis* have been found in brackish waters, but they are most commonly found in natural and artificial containers filled with rain water. Since mosquito larvae breathe air through a siphon, they do not necessarily need well-oxygenated water. That being said, the requirements for water quality and oxygen content have not been evaluated for *Ae. polynesiensis*. The full range of pH that Ae. *polynesiensis* can tolerate has not been investigated.

Climate: *Aedes polynesiensis* is known to live only in tropical climates. It is not found at high elevation or in subtropical / temperate parts of the Pacific. *Ae. polynesiensis* larvae have been found in a wide range of breeding places that includes tree-holes, coconut shells and husks, various types of artificial containers, leaf axils, crab holes, banana stumps, cacao pods and canoes. *Aedes polynesiensis* has not been found to nest in marshes, swamps, estuaries, lakes, ponds, dams, rivers, channels, streams, banks of water bodies, coastal beaches or sand dunes.

i) Social behaviour or groupings: Mosquitoes are largely solitary. Larvae from the same egg batch would co-habit in a water source, but that would not be considered as “social” behaviour. Adult males may form swarms to attract females or may gather around hosts visited by blood-feeding females (thereby increasing mating opportunities)[6].

j) Mosquitoes are not known to be territorial or aggressive to other species, beyond females seeking out warm-blooded hosts to blood feed.

k) Injury and harm to humans: Female *Ae. polynesiensis* bite humans and are the primary vectors of lymphatic filariasis in French Polynesia and other Pacific islands [7]. The species is considered a potential vector of dengue, Ross River virus and Chikungunya [8-10]. Like all blood feeding mosquitoes, their bite can cause an allergic response including reddening, itchiness and slight swelling at the bite site.

4. Reproductive biology of the species

Reproductive characteristics of the species:

a) Most *Ae. polynesiensis* males are sexually mature by the third day of adulthood, and females by the second day of adulthood [11].

b) For most blood-feeding mosquito species, after the female mates, she requires a blood meal to gain the protein needed to produce eggs. Mated *Ae. polynesiensis* females will lay 60-90 eggs three or four days after a successful blood meal [12]. It is unknown if *Ae. polynesiensis* is autogenous (meaning they do not require a blood meal to lay eggs), but it is likely that some level of autogeny can occur, given that related species (e.g. *Ae. albopictus*, *Ae. aegypti*) can be autogenous under some genetic and environmental conditions [13].

Drying of eggs is fatal to the larvae within the eggs during the first three days after the oviposition, while they undergo embryonic development. After the completion of embryonic development, dry eggs can resist desiccation. Under normal conditions (21-32 C, high relative humidity) the larval period lasts 4-10 days, and the pupal period lasts 2-4 days in laboratory conditions [12].

Breeding sites for mosquitoes are almost always still water. For *Ae. polynesiensis*, old tires and artificial containers and road gutters around buildings are all suitable habitats, as well as natural habitats like tree holes, coconut shells and husks, leaf axils, crab holes, banana stumps, cacao pods and canoes. *Aedes polynesiensis* females lay eggs above the waterline, preferably in cracks, rather than on smooth surfaces.

c) It is not known how often *Aedes polynesiensis* breed in the wild, but the breeding populations in the native tropical range are present throughout the year [14].

d) Mosquitoes have not been known to change sex.

e) Hybridization involving *Aedes polynesiensis* has been studied in the laboratory. The direction and success of inter-species hybridization with closely related members of the *Aedes scuttelaris* complex (e.g. *Ae. kesseli, Ae. riversi, Ae. albopictus*) depends on the presence and strain of *Wolbachia* symbionts that cause cytoplasmic incompatibility [11, 15, 16].

f) None of the species found to hybridize with *Ae. polynesiensis* are present in mainland Australia.

g) All mosquitoes are single-sexed, but gynandromorphs have been observed (albeit very rarely) in the laboratory.

5. Feral populations

a) *Aedes polynesiensis* has established breeding populations in the Austral Islands, Cook Islands, French Polynesia, Niue, Polynesian Islands (Howland, Jarvis, Johnston Atol, Pitcairn, Wallis & Futuna), South China Sea Islands (Paracel, Spratly, Tokelau), Tuvalu.

b) *Aedes polynesiensis* is considered a pest and a disease vector in its known and introduced habitat. The species is under active management to reduce numbers of populations across its range.

c) *Aedes polynesiensis* larvae and pupae have been intercepted at the Ports of Auckland, New Zealand on two occasions in 2004.
http://www.smsl.co.nz/site/southernmonitoring/files/NZB/Aedes%20polynesiensis%20-%20profile%20Apr%2007.doc.pdf

6. Environmental risk assessments of the species

No risk assessment has been carried out in Australia or overseas for *Ae. polynesiensis.*

7. Likelihood that the species could establish a breeding population in Australia

a) Ability to find food sources. The diet of adult and larval *Ae. polynesiensis* is very similar to that of native Australian mosquitoes: aquatic detritus, algae and microorganisms for the larvae, and nectar and mammal / bird for the adults. *Ae. polynesiensis* would be able to find food in Australia.

b) Ability to survive and adapt to climatic conditions. Since *Ae. polynesiensis* mosquitoes breed in artificial containers such as plant pots, used tired and bird baths, it would be possible for them to continue breeding even during a drought. Eggs of all *Aedes* mosquitoes can survive in a dry state for up to a few months until triggered to hatch by rain. In temperate areas of Australia, the eggs are unlikely to be sufficiently cold-tolerant to survive the winter.

c) Ability to find shelter. *Aedes polynesiensis* is a peri-domestic mosquito and can live in habitats such as cities or towns; gardens; channels or drains, construction sites/buildings

d) Reproduction. *Aedes polynesiensis* seems to be well-adapted to human modified habitat. They have been found breeding in sewers, artificial containers and used tires. Mosquitoes can lay over a hundred eggs in their lifetime, so that could increase the likelihood of *Ae. polynesiensis* to establish. This is nothing unique to *Ae. polynesiensis*, however.

e) *Aedes polynesiensis* is a tropical species. It is not found at high elevation or in subtropical / temperate Pacific islands. Sub-tropical / temperate zones like Brisbane, Australia are not optimal for establishment. Another limiting influence on *Aedes polynesiensis* in Australia would be competition from native mosquitoes. *Ae. notoscriptus*, for instance, is a container breeding mosquito present all over Australia it would compete with *Ae. polynesiensis* over its entire range.

f) Since *Aedes polynesiensis* is not present in mainland Australia, any imported individuals should be limited to research facilities with appropriate quarantine facilities and experienced staff to prevent their escape into the environment. The establishment of feral populations in Australia would therefore be extremely unlikely.

8. Potential impact of the species should it become established in Australia

a) *Aedes polynesiensis* fills a similar niche as a number of native Australian container-breeding mosquitoes, most notably *Ae. notoscriptus*. They would be expected to compete for larval habitats and food (i.e. aquatic microorganisms and detritus) should *Ae. polynesiensis* be released into the environment.

b) *Aedes polynesiensis* is a major vector of lymphatic filariasis and a secondary vector of dengue in the South Pacific. It likely has a potential to transmit other arboviruses such as Chikungunya and Ross River virus [8-10]. Lymphatic filariasis is not present in Australia. *Aedes aegypti*, already established in Queensland, and *Ae albopictus*, established on the Torres Strait islands are more commonly recognised as the most efficient vectors of many human arboviruses.

c) *Aedes polynesiensis* females are known to bite humans, other mammals such as dogs, cats, rats, and possibly livestock. Their biting peak is usually in the late afternoon and early morning [17].

d) Impacts on habitat and local environments: *Aedes polynesiensis* will not reduce ground vegetation cover. It does not construct burrows or dig near or around waterways. It has not been recorded causing damage to: native animals' habitats; natural communities; native plants; forestry; agriculture. It will not inhibit tree seedling regeneration or spread weeds.

e) Australia has a control program in place for a related species, *Ae. albopictus* in place. Something like this might be used to combat any potential establishment in Australia [19].

f) Behaviours that cause environmental degradation: *Aedes polynesiensis* is not known to exhibit any behaviours that cause physical disturbance to the environment. It does not disturb wetlands or wetland vegetation. It does not cause pollution of water bodies. The known habitats of *Aedes polynesiensis* are artificial containers, used tires, and rock pools. These are not particularly sensitive environments in general, and there is no indication they would be adversely affected by *Ae. polynesiensis.*

g) Impacts on primary industries: *Aedes polynesiensis* is not known to cause damage to livestock, poultry, etc., although it may bite livestock or poultry that are near breeding areas. This mosquito is not known to transmit any livestock or poultry diseases, and bites are unlikely to have a serious impact (e.g. milk production, egg laying, general health, etc.) unless there were large numbers of biting mosquitoes.

This species is not expected to eat or damage any plants or plant parts. It will not compete with livestock. It will not have a negative impact on tree plantations/silvicultural activities.

h) Damage to property: *Aedes polynesiensis* will not damage buildings, either through physical damage or depositing excrement. It will not damage fences. It will not cause damage to domestic or commercial equipment.

i) *Aedes polynesiensis* could potentially be a social nuisance by biting if it is prevalent near humans in large numbers. This is no different than the social nuisance already presented by native Australian mosquitoes.

j) Describe any potentially harmful characteristics of the species.

Aedes polynesiensis is known to bite humans and feed on blood. This can cause itching and swelling at the site of the bite, which can be treated with any one of a number of ointments or natural treatments. Typical mosquito repellents available in Australia would be expected to be effective against *Ae. polynesiensis* as well.

This mosquito is the primary vector of lymphatic filariasis in French Polynesia and other Pacific island countries [7]. The species is considered a potential vector of dengue viruses. Lymphatic filariasis is not present in Australia. In the laboratory, it is shown to be ability to transmit Ross River virus, Chikungunya virus and Murray Valley encephalitis virus [8-10, 18]. A range of endemic and established mosquitoes including *Aedes aegypti*, already established in Queensland, and *Ae albopictus*, established on the Torres Strait islands, and a variety of Culex species with Australia-wide distributions are commonly recognised as efficient vectors of these arboviruses.

Aedes polynesiensis is an important vector of dog heartworm (*Dirofilaria immitis)* in the Pacific. In Australia there are many established, competent Dirofilaria vectors. Dogs can be protected by a variety of veterinary medicines.

9. Reduction of potential negative environmental impacts

Restrictions placed on the import of *Aedes polynesiensis* should include limiting importation to research use only, in addition to the requirements for an import permit and containment in quarantine facilities (QC2). Imported mosquitoes in colony should only be handled by experienced staff that have completed quarantine-accredited training. QIMR Berghofer already holds a number of exotic mosquitoes in colony and has substantial experience in their containment.

10. Summary of proposed activities

The Mosquito Control Laboratory at QIMR Berghofer has a long history of conducting comprehensive assessments of mosquito ecology, genetics, *Wolbachia* interactions and vector competence. We are collaborating with the Institut Louis Malardé (ILM), Tahiti, French Polynesia to generate genomic resources that will facilitate an understanding of *Ae. polynesiensis* dispersal and population structure and their interaction with viruses of global concern such as Zika, Chikungunya and Dengue. Our planned collaboration would benefit greatly from having access to live material.

QIMR Berghofer has extensive experience of working with quarantine mosquito species and we maintain a number of exotic colonies in our state of the art QC2 insectaries. We intend to import this species under quarantine for research purposes only, and all mosquitoes will be destroyed at the end of the research.

Aedes eggs can be laid on paper towels or similar surfaces, dried out, then hatched up to three months later. Our intention is to import about 5000 eggs under an approved permit from ILM to our quarantine facility. These will be not be infected with any human pathogen. Eggs will be hatched out in our insectary and the resulting juvenile stages will be reared through to emergence as adults and initiate a laboratory-reared colony. Males and females will be allowed

to mate, produce eggs and continue the life cycle according to our well-established laboratory protocols. The mosquito will be used for research purposes only. This may include genetic studies, protein studies and laboratory-based behavioural and physiological studies. Will also examine their interaction with viruses of public health concern.

11. Guidelines on how species should be kept

Mosquitoes not native to Australia will be contained within a quarantine approved insectary. *Aedes polynesiensis* will be shipped as eggs in approved IATA packaging by an approved courier. Mosquitoes are typically kept in secure 30 cm^3 cages with a density of several hundred individuals per cage, and secondarily contained in a stainless steel cabinet enclosed with stainless steel mesh within an insectary.

Mosquitoes typically hatch in a 50/50 male: female ratio. Since females live longer than males, a colony with overlapping generations tends to have more females than males. Breeding is easily controlled by withholding of oviposition sites within the cage, so populations within the cage are easily maintained.

Aedes polynesiensis will be kept in a quarantine-approved insectary at QIMR Berghofer in Herston, Brisbane, Queensland (Quarantine Approved Premises Q2344, QIC2 [Quarantine Insectary Containment 2]).

They will be housed in standard 30.5 x 30.5 x 30 cm insect cages from BioQuip (http://www.bioquip.com/search/DispProduct.asp?pid=1450A). These cages will be secondarily contained within a stainless steel 1.5 m x 41 cm shelving unit enclosed in 100 micron stainless steel mesh. These mosquitoes will be used for research only, and destroyed when the research project is complete. All containment procedures are carefully audited and controlled. QIMR Berghofer already maintains a number of exotic colonies of mosquitoes including *Aedes aegypti* from East Timor, *Ae albopictus* from the Torres Strait, *Ae koreicus* from Italy and *Anopheles stephensi* (native to the Indian subcontinent).

12. State/Territory controls

There are no Commonwealth, state or territory legislative controls on *Aedes polynesiensis* other than quarantine legislation. *Aedes polynesiensis* must be added to the Department of the Environment's "List of Specimens Suitable for Live Import (requiring an Import Permit)" before an appropriate import permit can be applied for. Import and containment conditions are stipulated on the import permit.

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