Australian Government
Department of the Environment and Energy

Department Risk Analysis

Application to add *Aedes polynesiensis* (Polynesian Tiger Mosquito) to the Environment Protection and Biodiversity Conservation Act 1999 *List of Specimens taken to be Suitable for Live Import*

March 2019

Introduction

Purpose of the proposed import

The purpose of the application is to allow the importation of wild strains of the Polynesian tiger mosquito (*Aedes polynesiensis)* to the Queensland Institute of Medical Research Berghofer. The Mosquito Control Laboratory at QIMR Berghofer has a long history of conducting research in mosquito ecology, genetics, *Wolbachia* interactions and vector competence.

QIMR Berghofer is collaborating with the Institut Louis Malardé in Tahiti and French Polynesia to generate genomic resources that will facilitate an understanding of *A. polynesiensis* dispersal and population structure and their interaction with viruses of global concern such as Zika, Chikungunya and Dengue.

Aedes polynesiensis is a major vector of lymphatic filariasis and a secondary vector of dengue in French Polynesia and other Pacific island countries and may potentially transmit other mosquito borne viruses such as Chikungunya, Ross River Virus and Murray River Encephalitis.

The mosquito will be used for research purposes and will held in a Quarantine Insectary Containment 2 facility. QIMR Berghofer propose to use the mosquitos for genetic studies, protein studies, laboratory-based behavioral and physiological studies and their interaction with viruses of public health concern. QIMR Berghofer currently maintain 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) (applicant).

Background

Under s.303EC of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the responsible Minister may amend the *List of Specimens taken to be suitable for live import* (Live Import List) by including a specimen on the list. There are two parts to the list - Part 1 comprises specimens that can be imported without a permit under the EPBC Act. Part 2 comprises specimens that require a permit under the EPBC Act to be imported. Import restrictions generally apply to the species listed on Part 2, such as 'for research only' and 'high security facilities only'. Additional conditions may also be applied when the permit for import is issued.

Before amending the Live Import List, the Minister must consult with appropriate agencies and other persons, and consider a report assessing the potential environmental impacts of the proposed amendment. When submitting an application to the Department to amend the Live Import List, all applicants are required to provide an accompanying report that addresses specific terms of reference. The Department undertakes a risk assessment using the information in the applicant's report and any other sources of relevant information. The Department also considers comments and information received through the public consultation process (including states and territories). The application and accompanying report for the proposed import of *A. polynesiensis* was released for public comment in January 2018.

Biology and Ecology of *Aedes polynesiensis*

Mosquito description

Aedes polynesiensis is a member of the *Aedes scutellais* complex (Hapairai *et al*. 2014) and has established breeding populations in the Austral Islands, Cook Islands, Fiji, French Polynesia, Niue, Tuvalu, the Polynesian Islands of Howland, Jarvis, Johnston Atoll, Pitcairn, Wallis and Futuna, and the South China Sea Islands of Paracel, Spratly and Tokelau (Mathieu-Daude, 2018).

A. polynesiensis adults are similar in morphology and behavior to the invasive species *Aedes albopictus*, and have some superficial resemblance to the native Australian mosquitoes *Aedes notoscriptus* and *Aedes palmarum* and the invasive mosquito *Aedes aegypti* (applicant)

The females are an opportunistic, outdoor daytime biting mosquito (Tuten *et al*. 2013) with minor biting peaks at 08:00 hours and at 17:00–18:00 hours (Bockarie *et al.* 2009).

Wing length is used as a proxy for body size of mosquitos with female being slightly larger at 3 mm than males at 2.1 mm wing length (applicant). The lifespan in the wild is unknown but in captivity, the maximum is 48 days for females and 42 days for males (applicant).

Life cycle

Females require a blood feed to produce eggs preferentially seeking humans as a host over other species (Mercer *et al.* 2012a). Oviposting has been recorded as utilising any water containing object including rock pools, plant containers, water supplies, land crab holes, discarded tyres and rat-chewed coconuts (Burkot *et al.* 2007). Densities are strongest near human habitation. *A polynesiensis* also has a high tolerance for salinity (Grziwotz *et al.* 2018), which provides a wider range of possible breeding sites than other species of mosquitos.

Mosquito eggs, which are capable of drying and surviving for weeks have been suggested as the most likely life stage for dispersal (Brelsfoard and Dobson, 2012). Laboratories studies show that females produce an average of 63.9 eggs per cycle with clutch size decreasing with age of the female. The eggs are resistant to desiccation with viability dropping by 20% after 1 month and 40% at 3 months. Max life span of eggs (laying to hatching) is 218 days (Gubler, 1970).

Life span of the adult increases with humidity with female mosquitos held at 27% humidity averaging 22 days, at 85% humidity this increases to 48 days. Access to blood which is required for egg production also increases the female lifespan results from 48 days to 83 days. Under laboratory conditions a female mosquito gives rise to an average 85 females (Gubler, 1970).

Climate

The exact climatic conditions for the species is not known. However given the species is only known to inhabit tropical islands in the Pacific and there is no evidence that the species has established outside of its native range the climate of these islands can be used as the insects climate requirements. These islands generally have a temperature range of between 23 - 30ºC and year round humidity of around 80% (Weather and Climate). In French Polynesia, *A. polynesiensis* were shown to be most active between 26 - 28ºC with abundance dropping dramatically above 29ºC (Grziwotz *et al.* 2018).

Environment:

A. polynesiensis is a semi-domestic salt-tolerant species with an extremely wide range of breeding habitats (ECDC, 2014). Polynesian islands endemic for the species generally have 60–80% canopy cover with females rarely leaving cover to secure blood meals from humans (Mercer *et al.* 2012b). The utilisation of a wide range of natural and artificial sites for larvae development combined with the use of humans, dogs, rats, chickens and other birds as a blood sources suggest the species is highly anthropophilic (Mercer, *et al*. 2012b).

Disease transmission

A. polynesiensis is the primary vector of lymphatic filariasis (*Wuchereria bancrofti*) and dog heartworm (*Dirofilaria immitis*) and an important vector for Dengue in French Polynesia and other Pacific island countries (Russell *et al*, 2005, Hapairai *et al*. 2013).

Lymphatic filariasis affects about 120 million people worldwide (Bockarie*, et al.* 2009), in the Pacific Region about 38% of the population or about 2.9 million people have antibodies to the parasite (Burkot *et al*. 2002). The parasite causes severe damage to the lymphatic and renal systems resulting in permanent and long-term disability in tropical and subtropical areas (Bockarie *et al*. 2009)

Dengue fever is a systemic mosquito borne viral infection of tropical and subtropical regions infecting about 390 million people per year (Bhatt *et al*. 2013) with infection rates increasing 30 fold in the past 30 years and appearing in new regions (WHO). There are no licensed vaccines or specific therapeutics for the disease and despite substantial vector control efforts the disease is still spreading. In urban areas of French Polynesia it is predominately spread by *Aedes aegypti* and by *A. polynesiensis* in rural areas (Lardeux, *et al*. 2002).

A. polynesiensis has been found to be an efficient vector of low-level microfilaraemics, as the number of ingested microfilariae decreases females mosquitos become more efficient at spreading the disease (Brelsfoard, *et al*. 2008).

Ross River Virus was isolated from *A. polynesiensis* in the Cook Islands during an outbreak of the disease in 1980 and has been shown to transmit the virus in laboratory experiments (Harley, *et al*. 2001). The spread of Ross River Virus through the Pacific is attributed to mosquitos such as *A. polynesiensis* acting as a vector in these regions (Flies, *et al*. 2018).

The mosquito has been proposed as a vector for Zika and Chikungunya viruses, both of which are present in the Pacific region. Laboratory testing has shown that the mosquito can transmit Zika virus (ECDC 2014, Calvez, *et al*. 2018) and Chikungunya virus (Nhan and Musso, 2015: Richard *et al*. 2016) although at lower efficiency than other endemic *Aedes* species such as *A. aegypti* or *A. albopictus.*

Heartworm disease due to *Dirofilaria immitis* is a serious and potentially fatal disease in dogs worldwide. Infections can result in severe lung disease, heart failure and damage to other organs in the body (American Heartworm Society). While *D. immitis* infections are most common in canids (dogs and foxes), cats, mustelids, pinnipeds, horses, and humans can also become infected. (CDC).

Dengue, Ross River Fever and Heartworm all occur and are transmitted in Australia by mosquitos. In Australia endemic Lymphatic filariasis transmission has not been reported for over 50 years (Jeremiah, *et al*. 2011). There have been no Australian acquired cases of Zika or Chikungunya to date (Department of Health 2018a, Department of Health 2018b).

If *A. polynesiensis* were to establish in Australia the mosquito may act as a vector for the above mentioned disease some of which are zoonotic and may pose a risk to native animals. Importation of *A. polynesiensis* would be subject to assessment and approval by the Commonwealth Department of Agriculture and Water Resources under the *Biosecurity Act 2015*.

Establishment

The species is a tropical mosquito which is located on Pacific Islands and has not been reported as establishing way from its native range. Given its ability to source food from a range of species and its wide range of larval habitats it is possible the species could establish if introduced into the environment.

The species is poorly matched to the Australian environment based on the climatch output shown below with a Climate match score of 1 or very low (Bomford, 2008). This may be due to the tropical nature of the species and its intolerance to the cold or altitude. The mosquitos are dependent on human habitats with dispersal from larval sites being less than 100 m (Guillamont, 2005). This dependence on humans suggests it is unlikely to disperse or establish away from populated areas.

The Aedes genus is defined as having high ecological plasticity due to their ability to colonise new regions (ECDC, 2019). This may mean the species current range is not fully reflective of its potential range which will in turn under estimates its predicted range in Climatch.

Climatch potential suitable habitat for *A. polynesiensis* based on current range.

In Samoa the introduced mosquito *A. aegypti* has been shown to outcompete *A. polynesiensis* for larval sites resulting in a drop in the *A. polynesiensis* numbers (Samarawickrema, *et al*. 1993). *A. aegypti is* present in Australia and is the main vector of dengue (Russell, *et al*. 2009), this may inhibit the establishment of *A. polynesiensis* in Australia. *Aedes albopictus*, although not present in Australia has been shown to outcompete *A. polynesiensis* (Gubler, 1970*)*. Given its proximity to northern Australia it is probable that eventually *A. albopictus* will invade and colonise Northern Australia (Lamche and Whelan, 2003) A native species of mosquito, A.

Notoscriptus, may also impede colonisation of *A. polynesiensis* through competition for larval breeding sites (applicant).

There are native container breeding mosquitos present in Australia which would apply competition for resources pressure to any A*. polynesiensis* trying to establish (applicant).

Related Live Import List listings

Eight species of mosquito are listed on Part 2 of the Live Import List (*Aedes aegypti, Anopheles farauti, Anopheles koliensis, Anopheles punctulatus, Anopheles stephensi, Culex quinquefasciatus, Halaedes australis* and *Ochlerotatus (Aedes) koreicus).* All with the conditions *'Eligible non-commercial purpose only, excluding household pets. High security facilities only*".

Conservation status

A. polynesiensis is not listed on the International Union for Conservation of Nature's Red List of Threatened Species or the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES) list. The species is not listed on the EPBC Act Live Import List.

Risk assessment

Assessing the risk of the potential of introducing a new organism into the environment involves assessing the risk of it becoming established and spreading and the likely impacts if establishment occurred.

There are no accepted risk assessment models that can be used to calculate the establishment risk of invertebrates in Australia. Bomford (2008) found that for vertebrates, the level of risk can be assumed in accordance with the four key factors of establishment success. These factors are:

- Propagule pressure – the release of large numbers of animals at different times and places enhances the chance of successful establishment
- Climate match – introduction to an area with a climate that closely matches that of the species' original range
- History of establishment elsewhere – previous successful establishment
- Taxonomic group – belonging to a family or genus which has a high establishment success rate.

Although these factors apply to vertebrates, they have been used as a guide for this risk assessment of *A. polynesiensis*. In addition, using the information compiled from research into the above factors for *A. polynesiensis* the potential impacts of establishment of feral populations can also be assumed.

Risk of establishment

Propagule pressure – the release of large numbers of animals at different times and places

The application is for the listing of *A. polynesiensis* for research purposes in secure facilities only. This means all imports would be subject to an import permit which would limit the numbers of the mosquitos imported into Australia into quarantine approved facilities.

The likelihood of escape of specimens from an accredited biosecure facility is negligible. Quarantine facilities are required to have security measures in place to ensure that the movement of specimens in and out of the facility are tightly controlled and these measures should negate any chance of the specimens escaping.

The applicants are experienced in maintaining and the containment of mosquito species within a quarantine facility having maintained a number of exotic mosquito colonies in QC2 insectaries.

As the importation of the species would be restricted to research purposes only and the specimens will be kept in an accredited biosecure facility, all waste would be treated to a standard well beyond that which would kill all eggs or mosquitos. A one-off deliberate or accidental release is unlikely and multiple releases would be highly improbable.

Climate match – introduction to an area with a climate that closely matches that of the species' original range

The native range of *A. polynesiensis* in the Pacific is limited to tropical islands and appears only at low elevations. The climatch map shows most of Australia is climatically unsuited to the mosquito. The climatch score of 1 is based on there being less than 100 grid squares in Australia within the 6 highest climate match classes. The number of actual grid squares was 8 (classes 5+6) meaning it scored at the lower end of this scale, which reinforces the low suitability for the species. Many mosquitos require temperatures above 20°C for successful fertilisation and ovipositing. Although the specific temperatures for *A. polynesiensis* are unknown, *A. aegypti* mosquito eggs are reported as not hatching or having incomplete larval development below 13°C (Missin, 2019). The proposal to keep *A. polynesiensis* in South Eastern Queensland would add a further level of security as the climate is unsuited to the species developmental requirements.

History of establishment elsewhere – previous successful establishment

The original location of *A. polynesiensis* is unknown but it is thought to be Samoa (ECDC, 2014) from here it expanded its range with the arrival of man in the South Pacific, approximately 1500-3000 years ago (Beresford and Dobson, 2012).

Despite the mosquito being established on a range of south Pacific Islands there is no evidence suggesting the species is expanding its range, despite other mosquito species establishing or expanding their ranges in the region.

Taxonomic group – belonging to a family or genus which has a high establishment success rate

The *Aedes* genus has several members regarded as highly invasive. *Aedes albopictus* is regarded as one of the top 100 invasive pests worldwide having established in 42 countries (GISD, 2019) but has not yet established in Australia. *Aedes aegypti* is one of the most widespread mosquitos worldwide (ECDC, 2019) and is present in Australia.

Potential impacts of established feral populations

A. polynesiensis is unlikely to establish a feral population in Australia given the lack of suitable habitat in Australia and the proposed restricting the species to high security facilities. If a population did establish the species could have an impact as a vector for lymphatic filariasis, dengue fever, dog heartworm, Ross River virus, Murray River Encephalitis and possibly Zika or Chikungunya if these viruses entered Australia. Some of these viruses are zoonotic and hence may pose an environmental risk to the Australian Environment.

A full assessment of the disease risks of the mosquito would be undertaken by the Department of Agriculture and Water Resources under the *Biosecurity Act 2015*.

The mosquito is an aggressive day biting species with biting rates of over 600 bites per person per hour being recorded (Guillaumont, 2005). They are defined as a major nuisance impacting local tourism of Pacific Islands (Mathieu- Daude, *et al*. 2018).

Risk summary and mitigation measures

The risk of animals escaping or being deliberately released into the wild is negligible given the strict security measures that would be undertaken. The imported animals would be required to remain in Quarantine Approved Premises for the duration of their lives. These premises are audited by the Commonwealth Department of Agriculture and Water Resources and have to meet strict criteria to ensure that animals are kept in a highly secure environment that prevents escape of animals and any related pathogens. All waste products and contaminated materials are to be appropriately treated or disposed as part of the certification of the facilities.

Table 1: Summary of risks and mitigation measures

Risk	Likelihood	Impact	Mitigation measures	Overall risk
Release or escape of adult specimens	unlikely	minor	The species will only be held in a Quarantine Approved facility.	Low
Release or escape of immature specimens	unlikely	minor	The species will only be held in a Quarantine Approved facility.	Low
Disease transmission to native species populations	possible	unknown	The import of the mosquitos will need to meet the conditions applied by the Department of Agriculture and Water Resources as part of their import permit.	low

			For the duration of the research, the mosquitos will be housed in a quarantine approved facility and all specimens will be destroyed at the conclusion of the research. Therefore there is a very low chance of interacting with native species.	
Theft and deliberate release	unlikely	unknown	Quarantine facilities are required to have security measures in place to ensure that access is controlled. The Security procedures would mean that the risk of theft is extremely low. The species are not of any value. It is unlikely that they would be of interest to any groups apart from Mosquito researchers.	Low

The listing of *A. polynesiensis* should only occur under Part 2 the Live Import List. The proposed mosquitos for research purposes are unlikely to pose an environmental risk, and it is improbable that the species would be of any value to any other groups. Based on evidence of the mosquitos natural habitat and environmental requirements it is also very unlikely the species would establish in Australia. However, the consequences from the mosquito establishing in Australia could be serious from the disease and social nuisance perspective and therefore importation of the mosquito should be limited to research facilities only.

Comments on the proposal to import *A. polynesiensis*

One response was received from a state government when the application and reports were released for public comment in February 2018 supporting the amendment of the Live Import List to include *A. polynesiensis* for research purposes in high security. No comments were received from the public.

A second consultation round was undertaken in April 2019 with state and territory government agencies. No responses were received. The consultation notification stated if no comments are received by the due date the Department will assume support for the draft report and recommendations.

Conclusion

The Department has undertaken a risk analysis and reviewed the available information on *A. polynesiensis* and the proposed amendment to include this species on the Live Import List.

The biology and ecology of *A. polynesiensis* suggests that if released, the species is unlikely to establish populations in Australia due to its very specific environmental requirements. Evidence from around the world indicates that the species has not established a population outside of it native range on southern Pacific Islands. However, as an aggressive day biting mosquito that has a role in transmitting numerous diseases, the establishment and spread of the species in Australia is undesirable.

On the basis of the very low risk of the imported populations of *A. polynesiensis* escaping from the secure facilities and becoming established in the wild, it is recommended that *Aedes polynesiensis* be listed on Part 2 of the Live Import List, with conditions restricting imports to "**Research only. High security facilities only**".

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