

The Asian tiger mosquito (*Aedes albopictus*) in the Netherlands: should we worry?

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In 2005, during routine inspections the presence of *Aedes albopictus* mosquitoes was identified from a greenhouse. Follow-up investigation revealed that these insects were introduced through the import of *Dracaena sanderiana* ('Lucky Bamboo') from Southern China. Following reports of this finding to the National Institute of Public Health and the Environment, a joint risk assessment was done to assess the potential risks to human health as the basis for an advise to the Ministry of Health, Welfare and Sports. The imported *Aedes albopictus* originate from an area in Southern China where arboviral infections do occur. Although surveillance data from China are sparse, it is assumed that dengue viruses are the most prevalent arboviruses in the region. Dengue viruses can be transmitted by *A. albopictus*, and may cause acute febrile illness in humans, sometimes complicated by e.g. severe joint pains. It is unclear whether *A. albopictus* would be able to survive, breed and become established under the climate conditions in the Netherlands, thereby creating a reservoir for a range of arboviral diseases unknown to the population of the Netherlands. Therefore, control measures to reduce the potential for import of these mosquitoes was recommended. In addition, four intertwined studies were started in 2006 to address the following questions: 1) what is the current spread of the mosquitoes in the Netherlands? 2) can *A. albopictus* establish itself in the Dutch climate?, 3) are the 'Dutch' *A. albopictus* mosquitoes infected with dengue virus? 4) Are there indications that dengue has been transmitted to people in the Lucky Bamboo-importing companies?

Keywords: *Aedes albopictus*, lucky bamboo, dengue virus, acute febrile illness, establishment, spread

BACKGROUND

Aedes albopictus (Skuse), also called the 'Asian tiger mosquito', is a vector for a series of human arboviruses among which flaviviruses (dengue virus, yellow fever virus, Japanese encephalitis virus, and West Nile virus) and togaviruses (Ross River virus and Chikungunya virus) (Gratz 2004). The species is known to be an important vector of dengue, second only to *Aedes aegypti*, and is suspected to be the only important vector of the Chikungunya outbreak on the Indian Islands outbreak in 2006 (WHO 2006).

The Asian tiger mosquito is a highly invasive mosquito species and is difficult to control. It is an aggressive day-biting mosquito whose bites can cause dermatological and allergic reactions. It is considered a container breeder, preferring to oviposit in small quantities of water such as drums, tyres, buckets, flower saucers, tarpaulins, and manholes (Carrieri *et al.* 2003).

The Asian tiger mosquito is indigenous to South East Asia, but has spread to parts of Africa, the Middle East, the Americas, and Europe. In Europe the mosquito has been present from the 1970's in Albania, and from the early 1990's in Italy, where it has established. Over the last few years the mosquito has also been found in other areas in Europe, including France, Spain, Belgium, Switzerland, Greece, Serbia and Montenegro, Croatia, Bosnia and Herzegovina, and Slovenia (Adhami & Reiter 1998, Flacio *et al.* 2006, Petric *et al.* 2006, Roiz *et al.* 2006, Sabatini *et al.* 1990, Samanidou-Voyadjoglou *et al.* 2005, Schaffner *et al.* 2004, Schaffner & Karch 2000, Schaffner 2006). The species is spread to new areas mostly through international car tire trade (Knudsen 1995). Car tires are known to be attractive oviposition sites for this mosquito species. Larvae will develop in the tires when it rains and small puddles are left in the tires. Occasionally, however, the introduction pathway is different, *e.g.* through the import of the ornamental plant *Dracaena sanderiana*, also called 'Lucky bamboo', which happened in California in 2001 (Linthicum *et al.*, 2003). In this situation, eggs are deposited at the stems, and will hatch during transport or at the importing company when the plants are placed in boxes with water. The recent findings of *Ae. albopictus* in the Netherlands are also linked to this introduction pathway (Scholte *et al.*, submitted).

SITUATION REPORT

In July 2005, a routine inspection of the Dutch National Plant Protection Service (NPPO) at a horticultural company in the municipality of Haarlemmermeer (Netherlands) was carried out. This company imports Lucky bamboo from southern China (Guangdong and Guangxi Provinces) on a regular basis. The inspector reported the presence of large numbers of an unknown mosquito species on the premises of the company where the plants were kept. Several mosquitoes were caught and tentatively identified as *Ae. albopictus*. Specimen of adults and larvae were sent to the Natural History Museum, London for mor-

phological and molecular verification (courtesy of Y. Linton) (Linton *et al.* 2001). Shortly after these findings, *Ae. albopictus* was found at two other Lucky bamboo-importing companies as well, both in large scale glasshouses. People working at these companies had experienced mosquito nuisance by 'black and white mosquitoes'. A later analysis of import of Lucky bamboo in the Netherlands revealed that these plants are all imported from the same area in the southern Provinces in China (Guangdong and Guangxi).

RISK ASSESSMENT

Dengue virus is endemic in the regions of Lucky bamboo export in China (CDC 2006). *Ae. albopictus* can acquire all four existing dengue virus serotypes by feeding on dengue-viraemic people. It can transmit these viruses by taking subsequent bloodmeals on other, non-dengue-infected people. In addition, dengue virus can spread both by horizontal and vertical transmission (CDC 2006, Rosen *et al.* 1983). Studies by Rosen *et al.* (1983, 1988), indicate that the level of transovarial transmission is enough to maintain dengue circulation without interference of humans as infectious hosts, whereas other studies indicate that passage in an amplification host (humans and primates) is needed (Markoff & Falgout 1995). On the basis of these publications it was concluded that eggs and larvae that are imported with *Dracaena* plants can be carriers of dengue virus, and that there is a small risk that adult mosquitoes can transmit the virus to humans in the Netherlands (Kamminga 2006).

Dengue transmission could only occur if a (dengue infectious) vector is present. For the Dutch situation this means that *Ae. albopictus* would need to survive in the Netherlands. The climatological conditions in glasshouses are favourable for survival of *Ae. albopictus* indoors, and some studies suggest that it could survive outdoors in the Netherlands (Knudsen *et al.* 1996, Mitchell 1995). Kobayashi *et al.* (2002), using Geographical Information System software, showed that *Ae. albopictus* could survive when the annual mean temperature is higher than 11°C and the mean temperature of the coldest month is not lower than -2°C. These conditions are met in The Netherlands. More restrictive is the requirement for temperatures above 11°C for more than 186 days per year. These data suggest that it will be difficult for *Ae. albopictus* to establish in the Dutch climate. However, the species has shown a capacity to adapt to colder climates, such as in Chicago (Rightor *et al.* 1987), which makes it difficult to predict if the species will be able to survive the Dutch climate.

It is not clear whether locally acquired dengue virus would be diagnosed in the Netherlands. Primo-infection with a dengue virus can cause a range of physical ailments, although most infections do not cause any symptoms. Classical dengue fever is apparent in older children and adults. After an incubation period of 2-14 days an infection can lead to high fever with cold shivers, severe headaches, and pain in muscles, bone, and joints. In most cases the disease pass-

es without complications, but recovery can take a long time. There is no specific medication to treat dengue. In rare cases, particularly when persons are infected for the second time with a dengue virus strain belonging to one of the other three serotypes, infection may lead to dengue shock syndrome (DSS) or dengue hemorrhagic fever (DHF). Since the majority of infections with dengue virus do not result in overt illness, persons who acquire a dengue infection in the Netherlands are likely not to be diagnosed correctly.

Based on this initial risk assessment we concluded that with importation of *Ae. albopictus* there is a small but real risk of establishment of a vector for a range of arboviral diseases which are presently unknown in Northern-Europe, and that control measures are needed to limit this risk. In addition, the Ministry of Health, Welfare and Sport commissioned a targeted surveillance coordinated by the National Institute for Public Health and the Environment (RIVM) to address the following questions:

- What is the geographic distribution of *Aedes albopictus* on high risk locations, and what are the population dynamics and densities of mosquito's at these locations?
- Can *Aedes albopictus* survive and establish in The Netherlands?
- Is dengue virus present in *Aedes albopictus* detected in The Netherlands?
- Is there any evidence for infections with flaviviruses in persons that, due to their profession, are exposed to *Ae. albopictus* in The Netherlands?

ADDITIONAL CONSIDERATIONS

Besides the risk of dengue transmission, there are other reasons why this potentially invasive mosquito species is not welcome in the Netherlands, including nuisance, competitiveness with indigenous mosquito species and transmission of other disease agents. Although eradication of most insect pests in glasshouses is feasible, control of insect pests in the outdoor environment is much more complicated and difficult. Moreover, control of *Ae. albopictus* is generally regarded as very difficult. Larval control is difficult because the breeding sites are not easily located in a (semi)urban environment and control of adults by using chemical pesticides in densely populated areas faces many practical obstacles. France, Belgium, and Switzerland are the only countries in Europe known to have effectively controlled or even eradicated small populations of *Ae. albopictus*. In other countries, such as Albania, Greece, Spain and Italy, control has proven to be extremely difficult. In Italy, the species has become a true pest: despite control efforts in several areas, it has spread from Genoa to almost the entire country within a time span of 10 years only (Bellini *et al.* 2005). Locally, the population densities are so high that they do not only cause severe nuisance, but also compete with indigenous mosquito species (Carrieri *et al.* 2003), a phenomenon that was already described in the USA (O'Meara *et al.* 1995).

The findings of the four intertwined studies described in this manuscript, expected to be available by the end of 2007, will give insight to the level of distribution of *Aedes albopictus* in the Netherlands, their population dynamics over time, dengue virus presence in the mosquitoes, and potential endemic dengue transmission in the Netherlands, and will form the basic information on which policy regarding control policy will be based. In the autumn of 2006, an agreement aimed at stopping introduction of *Ae. Albopictus* with Lucky Bamboo was already signed between the Ministry of VWS and several *Lucky Bamboo* importing companies.

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