

Introduction and control of three invasive mosquito species in the Netherlands, July-October 2010

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In July 2010, during routine mosquito surveillance inspections at companies that import used tires, three invasive species were found at five locations in the Netherlands: the yellow fever mosquito (*Aedes aegypti*), the Asian tiger mosquito (*Ae. albopictus*), and the American rock-pool mosquito (*Ae. atropalpus*). This is the first time that *Ae. aegypti* is reported from the Netherlands. Mosquito control was initiated one week after the first invasive mosquito was found, using adulticides and larvicides. The available data suggest that the implemented control measures have been effective for this season.

Introduction

Following the discovery of *Aedes albopictus* in the Netherlands in 2005 related to companies that import Lucky bamboo [1], continuous surveillance at these companies was started in 2006. Gradually, other national surveillance activities for this mosquito species were initiated, including passive surveillance (since 2007), active surveillance at parking lots along main highways entering the country from the south and east (since 2008), and at companies that import used tires (since 2009). In 2009, during routine surveillance activities, the exotic mosquito species *Ae. atropalpus*, a North American species that had been encountered several times in Europe [2], but had never established here, was found for the first time in the Netherlands [3].

These surveillance activities are meant to identify as early as possible the presence of exotic mosquito species with the aim to prevent the establishment of invasive exotic mosquito species, especially those that are known to be vectors of pathogens of public health importance such as dengue- and chikungunya virus. Here we report the finding and the successive con-

trol of three invasive mosquito species, *Ae. aegypti*, *Ae. albopictus* and *Ae. atropalpus* in the Netherlands.

Methods

A total of 34 companies that import used tires into the Netherlands were included in the invasive mosquito survey. Routine inspections were carried out from April to the last week of October [2]. A qualitative risk assessment on the introduction of invasive mosquito species was performed to determine the frequency of inspection of a company. Parameters in the risk assessment were (i) the type of tires that are imported, (ii) the countries from which tires are imported, and (iii) whether the tire storage is in- or outdoors. Collected larvae and adult mosquitoes were diagnosed either morphologically by using the diagnostic keys from Schaffner *et al.* [4], or molecularly by PCR sequencing the mitochondrial cytochrome oxidase subunit 1 (CO1) gene [5]. A week after the first finding, infested locations were treated by spraying *Bacillus thuringiensis israelensis* (*B.t.i.*) serotype H14 or *Bacillus sphaericus* (*B.s.*) against larvae and/or deltamethrin (aqua K-Othrine, Bayer Environmental Sciences) against adult mosquitoes. Larval control of the surrounding area (predefined perimeter of 500 m) consisted of removal of potential larval habitats for container-breeding *Aedes* spp. when possible, or treatment with either *B.t.i.* space spray (VectoBac WG, Valent BioSciences), or with *B.t.i./Bacillus sphaericus* (*B.s.*) granules (Vectomax, Valent BioSciences). It was decided to perform larvicidal treatment once every two to three weeks, until the first week of November.

Following the discovery of an exotic species at a location, surveillance was intensified to assess the potential spread of the invasive species and the effectiveness of the control activities by placing traps for adult mosquitoes (BG-sentinel, Biogents) and oviposi-

tion traps [6] in the 500 m perimeter surrounding the company site.

Results

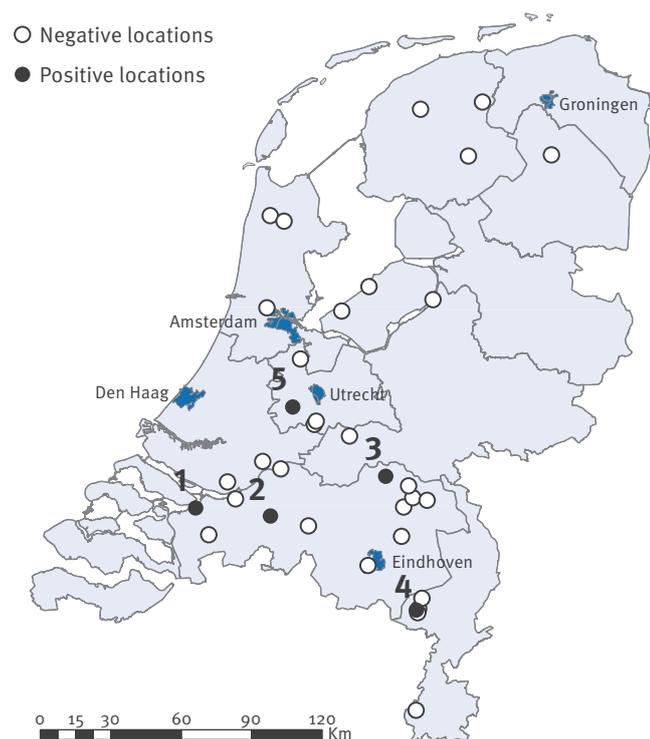
Three exotic mosquito species (*Ae. aegypti*, *Ae. albopictus*, and *Ae. atropalpus*) were found in five locations in the Netherlands. The first two mosquito larvae, *Ae. atropalpus*, were found on 21 July 2010, during a routine inspection at Location 1 (Heijningen) (Figure, Table 1).

On the next day, during an intensified inspection, one adult *Ae. albopictus* and one adult *Ae. aegypti* were collected, in addition to the two initial *Ae. atropalpus* larvae. The infestation level for *Ae. atropalpus* (in terms of percentage of infested tires and total number of larvae) at this company was relatively high, but less so for *Ae. albopictus* and *Ae. aegypti*, of which no larvae and/or pupae were found. Results of intensified inspection suggest that *Ae. atropalpus* and *Ae. albopictus* (but not *Ae. aegypti*) had spread to the surrounding areas of Location 1. On 3 September 2010, the last exotic species was collected from Location 1 and its surroundings (Table 2).

At Location 2 (Oosterhout), several male *Ae. aegypti* specimens were collected starting with 26 July. The last invasive species were found at this location on 6 August, when two adult *Ae. atropalpus* were collected. Despite intensive surveillance, no immature forms of invasive species were found at the company's premises or in the surrounding areas.

FIGURE

Locations of tire companies that were positive (n=5) and negative (n=29) for at least one of the invasive mosquito species, the Netherlands, 2010



On 26 July, three adult specimens (but no larvae) of *Ae. atropalpus* were collected from Location 3 (Oss). In addition, another three adult *Ae. atropalpus* were found on 5 August at this location. In the surrounding area, one *Ae. albopictus* was collected in a BG-sentinel trap placed approximately 50 m from the tire platform on 9 August, but no larvae of exotic species were found in the surrounding area. The last specimen (larva) was found at this location on 23 August.

On 24 August, the first larvae (six specimens) of *Ae. atropalpus* were collected from Location 4 (Weert). On 13 September, high numbers of this species (larvae and adults) were found at this location and several larvae were found in the surrounding area, including at the premises of a neighbouring tire-importing company. The two companies are considered as one location (Location 4). In addition, one *Ae. albopictus* specimen was collected from the tire platform on 13 September and one *Ae. albopictus* specimen was found in a BG sentinel trap at approximately 25 m from the infested companies, one week later. The last specimen was found on 27 September.

On 28 September, two *Ae. albopictus* larvae were collected from Location 5 (Montfoort). The third (and last) specimen was collected in an adult trap on the tire platform on 5 October. No specimens were found in the surrounding area.

All infested companies described here belong to the 'high risk'-category for importing exotic mosquito species, based on the type, origin and storage of the tires that are imported, and are therefore inspected every two weeks. No invasive mosquito species were found at any of the other companies that were included in the survey.

Discussion and conclusion

The discovery of *Ae. aegypti* in the Netherlands was unexpected, mostly because, unlike *Ae. albopictus* [3], *Ae. aegypti* is not directly associated with the international trade in used tires [7]. Even without control measures, the tropical *Ae. aegypti* will probably not survive the winter in temperate areas such as the Netherlands and consequently does not pose a direct health risk for the country. This is in contrast with the public health risks related to re-introduction of *Ae. aegypti* into southern Europe [8,9].

In addition, this report describes the discovery of an *Ae. albopictus* for the first time in the outdoor environment in the Netherlands. Although the species is still regularly found in glasshouses as hitchhikers in importation of Lucky bamboo [10], preventive and curative indoor control measures in these glasshouses appear to be effective to prevent indoor or outdoor establishment, since a location never stays positive for *Ae. albopictus* longer than 1,5 month (Scholte, unpublished data).

Back-tracing data of the company at Location 1 suggests introduction of *Ae. albopictus* and *Ae. aegypti* by a shipment of used airplane tires at the end of May 2010, originating from southern Florida, an area inhabited by both species. On 24 July, part of the same shipment was transported to Location 2 (belonging to the same company), and on 4 August to Location 3. Back-tracing information of the companies at Location 4 showed recent tire import from Italy. *Ae. albopictus* from Italy [11] and the United States [12] are considered to display diapause and potentially to survive temperate climates [13,14]. *Ae. atropalpus* had already been found at two sites in the Netherlands in 2009 [2] which indicates that the first introduction of *Ae. atropalpus* was in or before 2009, although more recent introductions are not excluded either. This species had a relatively large population at Locations 1 and 4, and colonised larval habitats in the surrounding areas, other than tires.

The fact that relatively few adults and no other life-stages of *Ae. aegypti* and *Ae. atropalpus* were found at Location 2, indicates a low level of infestation.

The available data for this season (Table 2) suggest that the implemented control measures have been effective, although it is too early at this moment in time to assess if eradication has been achieved. Per location, it took between one and three treatments and a maximum time span of seven weeks between the first treatment and the day when the last exotic species was found. It will be crucial in the years to come to

monitor the locations (including the surrounding areas) that had been infested with one or more of the exotic species in 2009 and 2010, in order to restart mosquito control as early as possible.

Having witnessed these introductions of exotic invasive mosquito species that pose a potential threat to public health in Europe, international collaboration and action of medical entomologists, public health experts, policy makers, and the tire-business industry is critical to address this.

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TABLE 1

Summary of the results of the invasive mosquito survey at used tire companies by location, the Netherlands, July-October 2010

Location	Adults collected				Larvae collected			
	<i>Ae. aegypti</i>	<i>Ae. albopictus</i>	<i>Ae. atropalpus</i>	Total	<i>Ae. aegypti</i>	<i>Ae. albopictus</i>	<i>Ae. atropalpus</i>	Total
1	5	11	68	84	0	0	80	80
2	8	0	2	10	0	0	0	0
3	0	1	6	7	0	0	1	1
4	0	2	45	47	0	6	122	128
5	0	1	0	1	0	2	0	2
Total	13	15	121	149	0	8	203	211

TABLE 2

Inspections, mosquito control, and findings of at least one of the three exotic mosquito species for each location per week, the Netherlands, July-October 2010

Location	Week (2010)																												
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
1																X	X		X			X			X		X	X	
2																X			X			X			X			X	
3																		X			X			X			X	X	
4																								X	X	X			X
5																										X			X

- No inspection
- No exotic species found (negative)
- Larvae and/or adults found of one of the three exotic mosquito species
- X Control measures

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