

## First record of *Stegomyia albopicta* (Skuse) (Diptera: Culicidae) in Germany

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### Abstract

With the help of the international used tyre trade, the Asian tiger mosquito, *Stegomyia albopicta*, has been able to expand its range world-wide. In 1979, the species was recorded in Europe for the first time in Albania, and has since been reported in 14 European countries. In addition to its rapid spread, *St. albopicta* is of particular interest due to its vector capacity for certain infectious viral diseases. Due to the increasing threat of an introduction of *St. albopicta* from neighbouring countries, a national monitoring programme was initiated in Germany by KABS (German Mosquito Control Organization) in 2005. In addition to used tyre trading companies, sampling was carried out at container terminals at inland ports along the Rhine, terminals receiving trains from Italy, and rest areas and parking lots along the German highway A5 coming from the south. At the end of September 2007, five eggs from the non-indigenous species *St. albopicta* were found on oviposition substrate in an ovitrap in the southern section of this major north-south highway. This is the first report of this non-indigenous species in Germany and demonstrates that live adults can be transported over long distances within motor vehicles.

**Keywords:** mosquito, *Stegomyia albopicta*, *Aedes albopictus*, Germany

### Introduction

The mosquito *Stegomyia albopicta*, previously *Aedes albopictus* (Reinert & Harbach 2005), originating from Southeast Asia, has undergone a noteworthy expansion of its range in the last few decades (Hawley 1988). Mainly with the help of the international used tyre trade, the so-called “Asian tiger mosquito” has been able to travel across very large distances and between continents (Reiter 1998). Due to its ability to colonise a wide range of natural and artificial breeding places, and coupled with the resistance of its eggs to desiccation and the relative lack of host preference (Hawley 1988), this species has been able to rapidly build up populations in new geographic regions large enough to successfully establish stable populations. Once consolidated, national trade and traffic has facilitated subsequent rapid

spread into further regions within these new countries (Moore & Mitchell 1997).

In Europe, *St. albopicta* was first reported in Albania in 1979 (Adhami 1998) and later in Italy in 1990, where it was introduced through the import of used tyres from the USA into the port town of Genoa (Sabatini *et al.* 1990, Dalla Pozza and Majori 1992). Within the next few years, the species rapidly dispersed to other regions of Italy (Romi 1994), and in the meantime it has been reported from France (Schaffner & Karch 2000), Serbia and Montenegro (Petric *et al.* 2001), Belgium (Schaffner *et al.* 2004), Switzerland (Flacio *et al.* 2004), Greece (Samanidou *et al.* 2005), Croatia (Klobucar *et al.* 2006), Spain (Aranda *et al.* 2006) and the Netherlands (Scholten *et al.* 2007).

Apart from its rapid geographical dispersion, *St. albopicta* is of special interest due to its vector capacity for infectious viral diseases (Reiter *et al.* 2006). It is, for example, assumed that this species was involved in the spread of chikungunya virus to humans in Italy in 2007 (Beltrame *et al.* 2007).

An analysis of the literature and preliminary unpublished laboratory data suggests that, given the current climatic conditions, the only region in Germany where *St. albopicta* might be expected to establish persistent populations is the Upper Rhine valley. This region is located in southwestern Germany, is approximately 300 km long and on average 30 km wide, and has an especially mild climate compared to central European standards (Liedtke 2002).

In May 2005, KABS (German Mosquito Control Organization) initiated a project to take action against the increasing threat of *St. albopicta* introduction into and its establishment in Germany. The primary goal of the project is to analyse the pathways of introduction into Germany, thereby identifying sites that have the highest probability of being colonized by *St. albopicta*, and to regularly monitor these “hot spots”.

The primary mode of dispersal of *St. albopicta* by human activity has been through transport of desiccation-resistant eggs with cargo that previously contained water serving as breeding sites. The most important type of cargo is old tyres that have been stored outdoors (Knudsen 1995). Therefore, companies processing or trading used tyres are most likely to introduce *St. albopicta* and were therefore given high monitoring priority.

Another type of cargo in which a large number of eggs or larvae can be transported over great distances is the so-called Lucky Bamboo (*Dracaena* spp.). For instance, the trade in this ornamental plant, which is boxed with standing water, permits an “ideal insectary in transit” and was the reason for the introduction of *St. albopicta* from Asia to California (Madon *et al.* 2004). Similarly, multiple introductions of the Asian tiger mosquito to the Netherlands in greenhouses of horticulture companies could be traced back to intensive trade of this plant (Scholten *et al.* 2007). However, we were not able to locate any intermediate trading

companies for Lucky Bamboo within our monitoring area or in other parts of Germany.

Due to high humidity and cool air temperature, freight containers offer conditions suitable for the transport of living insects (Reiter 1984). Therefore, container terminals at inland ports along the Rhine as well as terminals receiving trains from Italy were regularly monitored.

Rest areas and parking lots along the German highway A5 have a high potential to serve as sites of introduction and were, therefore, major components of the monitoring programme. This highway runs from south to north through the entire Upper Rhine valley and is part of the most important continuous south-north highway in Europe, running from Sicily to Stockholm. It is a main truck and tourist route for those returning from Italy and southern France to Germany, the Benelux and Scandinavia. Transportation of adult *St. albopicta* by cars and trucks was documented during a monitoring programme in 2003, when the species was detected for the first time in Switzerland (Flacio *et al.* 2004). Since then, multiple introductions of Asian Tiger mosquitoes from Italy to southern Switzerland have been observed, and, in autumn 2007, it was first recorded in northern Switzerland (Bundesamt für Gesundheit 2007). There are indications that the number of mosquitoes transported correlates with traffic volume (Flacio *et al.* 2006).

## Materials and Methods

During 2007, the monitoring programme employed 80-100 ovitraps at 47 trapping sites. The number of ovitraps used per location varied between one and six, depending on suitable habitats and the probability of *St. albopicta* being introduced to the site.

From the beginning of May to the end of September of each year, potential sites are monitored using ovitraps, which are examined for eggs and larvae every 14 days. In addition, in the areas surrounding the traps, promising shrubs and trees are checked for mosquitoes using the human bait method. Eggs are preliminarily identified microscopically and are kept in the laboratory at 25°C and 80% humidity for one week to ensure complete embryonic development. Deoxygenated tap water, enriched with a small amount of

brewer's yeast, is used as a hatching stimulus. Following hatching, larvae are reared to the adult stage, if possible. Identification keys of Becker *et al.* (2003) are used to determine the species.

### Results

In total, four species from the family Culicidae have been collected since the monitoring programme was initiated. Most of the mosquitoes collected were of the indigenous dendrolimnobioc species *Ochlerotatus geniculatus* and *Anopheles plumbeus*, as well as *Culex pipiens* in isolated cases. During the last trap inspection, at the end of September 2007, five eggs from the non-indigenous *St. albopicta* were found on the oviposition substrate in one of the traps at a parking lot in the southern part of the German highway A5 (Latitude 47°42'22"N, Longitude 7°31'28"E). Only two of the eggs hatched after being flooded three times for 72 hours at weekly intervals and partial drying between flooding. Both hatched larvae developed into adults and were conclusively identified as *St. albopicta*. No *St. albopicta* eggs were found in the second ovitrap at the same site, nor were adults found up to 200 m around the traps using the human bait method.

### Discussion

The discovery of eggs of *St. albopicta* in an ovitrap located at a parking lot on a highway used by tourists and transport vehicles coming from southern Europe is the first documented case of this non-indigenous species in Germany. Furthermore, it demonstrates that living adults can be transported over extended distances within these vehicles. Through regular monitoring and the initiation of control measures, *St. albopicta* has only been reported sporadically and in small numbers in parts of southern and, since autumn 2007, also in northern Switzerland. The female, which laid the above-mentioned eggs, thus most likely came from more distant populations in northern Italy.

Particularly at the end of vacation periods in Germany, Scandinavia and Benelux, a large number of tourists drive back from Italy on the German highway A5, a major south-north route. In vacation areas *St. albopicta* is most likely attracted to the campers and caravans by

human olfactory cues. Since these mobile living spaces are mostly unused while driving, mosquitoes attempting to feed during transport are less likely to be discovered than in cars and truck cabins.

The fact that only five eggs were found in only one trap and that no adults were collected implies that the eggs were laid by a single transported female that was already inseminated. According to Gubler (1970), *St. albopicta* females lay an average of 62.5 eggs and tend to deposit these in multiple oviposition sites (Hawley 1988). Therefore, it is likely that more eggs from this female could have been found in natural or human-made containers at this site. Nevertheless, the probability of successful colonization of an empty habitat patch depends, besides species-specific and environmental factors, mainly on the number of immigrants and the initial size of the founder population (Hanski 1999). Therefore, the establishment of a stable population on the basis of such a small number of eggs the next spring is rather unlikely. Cornel & Hunt (1991) also assumed that, even though *St. albopicta* has been reported to have been transported into South Africa several times, due to the small numbers transported at each occurrence, a breeding population has not been established there.

However, additional mosquitoes introduced in the next year could supplement the small founder population genetically as well as quantitatively, preventing them from dying out. Such a mechanism, by which so-called "sink populations" with negative population growth ( $r < 0$ ) do not expire due to regular immigration from distant "source populations" ( $r > 0$ ), is known from metapopulation ecology (Hanski 1999) and is also described as the "rescue effect" in island biogeography (Brown & Kodric-Brown 1977). In addition, with increasing population density and an expanding range in Italy, the number of "blind passengers" and consequently successful introductions to hitherto unsettled areas and also immigrations in existing small founder populations along human-made distribution routes increases. For example, Flacio *et al.* (2006) reported that the invasion of the mosquitoes from Italy to southern Switzerland continues to grow; the number of positive cases increased by 35% from 2005 to 2006.

It has been shown that, after an introduction and establishment of a sufficiently large population, *St. albopicta* can rapidly increase its population size and range (Fontenille & Toto 2001). If control measures are initiated too late, there is a great risk of stable establishment of an originally small and locally restricted population and dispersion of *St. albopicta* to other climatically suitable regions.

Therefore, in 2008, the number of surveillance traps will be increased at the positive site, potential breeding sites will be mapped and appropriate control measures will be implemented. Furthermore, monitoring will be intensified in general and international cooperation will be initiated, especially with the countries neighbouring Germany. Public relations measures such as an information homepage and information brochures will be prepared in order to activate community participation.

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