VBORNET Thematic Report 'MOSQUITOES', January 2010

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Editorial

Dear VBD expert,

VBORNET is now nearing cruise speed. This thematic report has been sent to more than 300 European experts on vector-borne diseases and is an open invitation to join the network. This can be achieved easily by contributing data to the network and is a unique opportunity to create a sustainable shared data base of vector information at the administrative unit level in Europe. More details are given in this NL and on the VBORNET websites.

This is our first thematic report. It focuses on mosquitoes, with particular attention paid to invasive species in Europe and its associated territories. Review articles include an overview of the current status of invasive mosquito species in Europe; the public health importance of invasive mosquitoes in Europe; important aspects of mosquito surveillance and control in Europe; an overview of invasive mosquito species in European associate Continental and Overseas Territories; and an overview of international legal instruments related to the management of invasive mosquitoes.

A brief description is also given of VECMAP, a new project funded by ESA which aims to develop standardized software tools and services for mosquito surveillance and control.
We hope you enjoy reading the report and invite all those interested to contribute to future issues. Such contributions for other reports might include information about ongoing research projects, calls for partnership, VBD news items, expert comments etc. Contributions should reach us by the 15th of each month. Reports will be published at the end of each month. Topics for future thematic issues are:

- NL5 end April = Ticks
- NL8 end July = Phlebotomines
- NL11 end Oct = Other VBD

Paolo Calistri from IZS (Teramo, Italy), p.calistri@izs.it, is in charge of editing the report. Editors for thematic issues respectively are:

- Mosquitoes: Francis Schaffner – fschaffner@avia-gis.be
- Ticks: Laurence Vial – laurence.vial@cirad.fr
- Phlebotomines: Bulent Alten – kaynas@hacettepe.edu.tr
- Other VBD: Pierre-Edouard Fournier – pierre-edouard.fournier@univmed.fr

We look forward to your contributions to the network and the Reports!

Guy Hendrickx, Coordinator
Paolo Calistri, Editor
Francis Schaffner, Editor thematic issue on mosquitoes

1. CALL FOR COLLABORATION: VBORNET DATABASE AND MAPS OF VECTOR DISTRIBUTION AND SURVEILLANCE IN EUROPE

W. van Bortel, Institute of Tropical Medicine, Antwerpen, Belgium
F. Schaffner*, Avia-GIS, Zoersel, Belgium & University of Zurich, Switzerland*
G. Hendrickx, Avia-GIS, Zoersel, Belgium

The objective of VBORNET is to establish a European Network of entomological and public health specialists in order to assist ECDC in its preparedness activities on vector borne diseases (VBD) (see for a detailed description of VBORNET http://ecdc.europa.eu/en/activities/diseaseprogrammes/Pages/VBORNET.aspx
An important activity of VBORNET is the establishment and maintenance of databases on vector distribution and surveillance in Europe. Data gathered by the Network will be used to create Pan-European vector distribution maps at three sub-national scales (NUTS 1-2-3). These maps will be made freely available on the VBORNET website on a quarterly basis. http://ecdc.europa.eu/en/activities/diseaseprogrammes/Pages/VBORNET-WP3.aspx

Those willing to collaborate are invited to download the customised vector-distribution questionnaire from the VBORNET mirror-page on the EDEN-DMT website: http://edendatasite.com: click on VBORNET 'TAB' and scroll to 'VBORNET vector questionnaire'. More information on contributing vector data is also provided on that page.

The aim of the **Vector Distribution Questionnaire** (see screen shots Figures 1-3 below) is to gather entomological and surveillance data at three levels of administrative units: NUTS1 (country level), NUTS2 (regional level) and NUTS3 (province/district level) both for continental Europe as well as its overseas territories.

Using the interactive tool, the expert can set the current status of presence/absence of mosquito, tick and phlebotomine species at the different geographic levels. In addition, the expert can enter surveillance activity data for the selected species. Once uploaded, the data will be transferred to a centralized data repository for further processing. This processing stage includes a validation stage by 4 focal experts (Mosquito: Francis Schaffner; Ticks: Laurence Vial; Phlebotomes: Bülent Alten; Other vectors: Pierre-Edouard Fournier). After this validation phase, quarterly outputs will be made available to the contributors.

The tool will be available online at the beginning of February. The expert can download the tool. He/ she will receive a username and password. These will also be requested prior to the upload of the data.

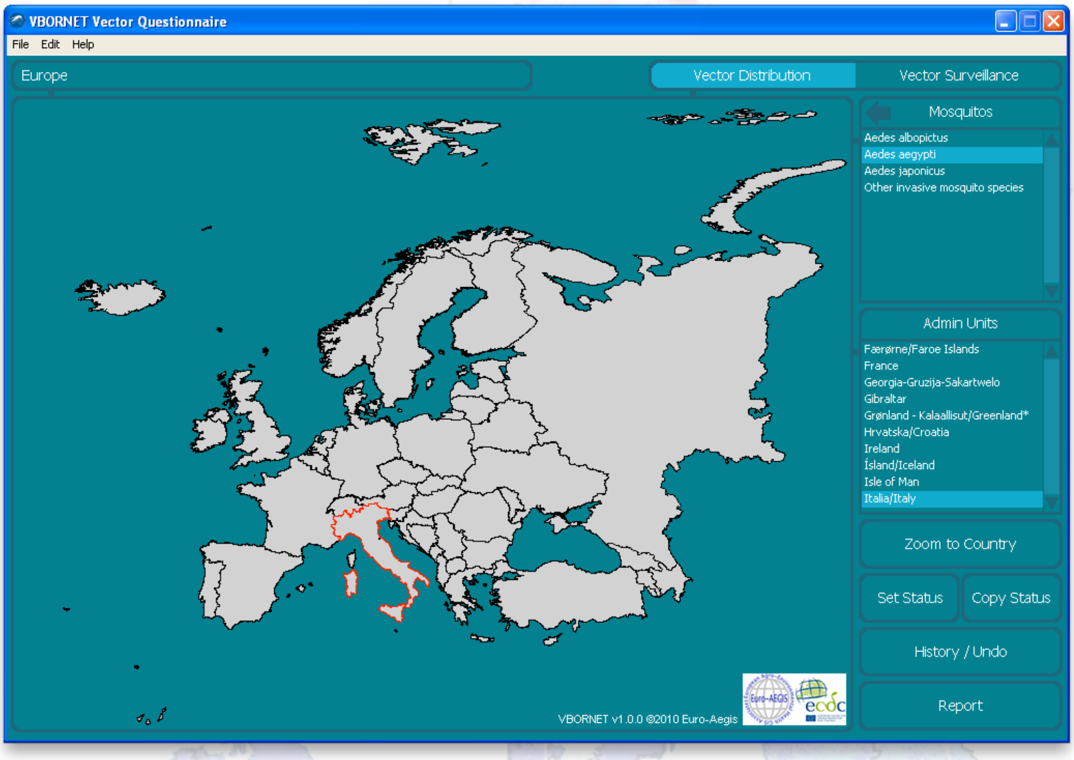

Figure 1. Vector distribution questionnaire: main window where the expert can select the vector and administrative unit of interest. Experts can select the administrative units either by clicking on the map or by selecting in the list. Clicking on the set status button will load the vector distribution and vector surveillance questionnaire respectively.

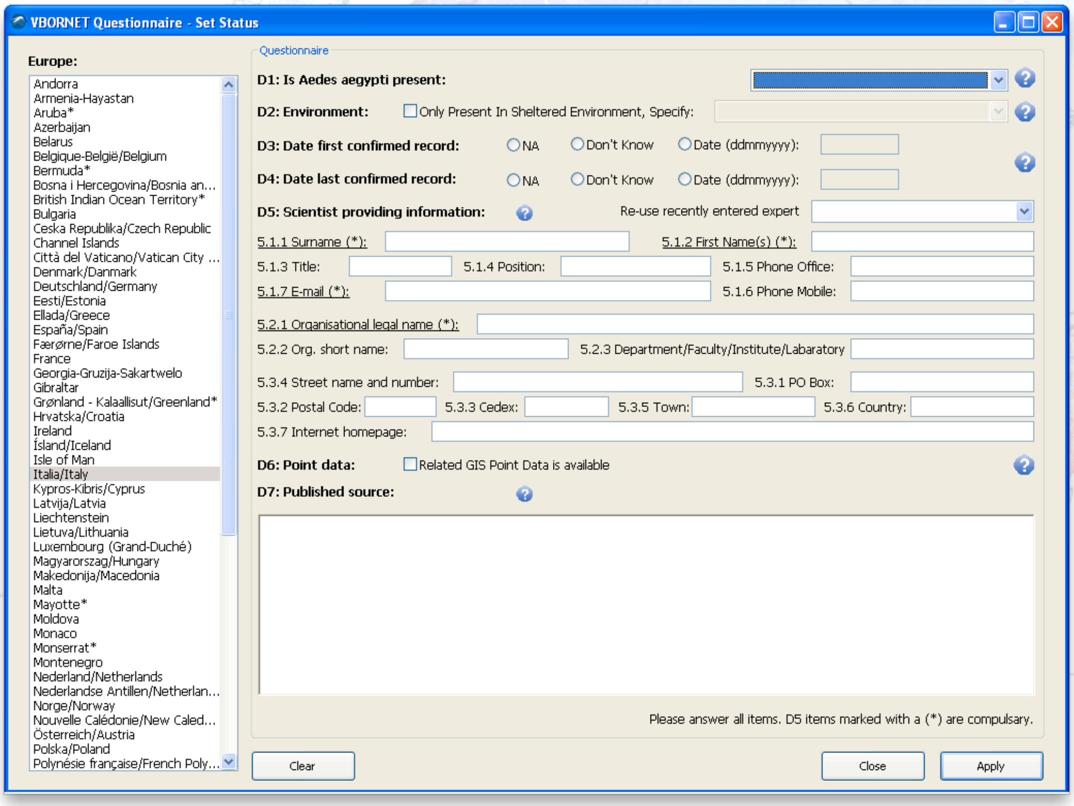

Figure 2. Vector distribution questionnaire: distribution data. The expert can enter data with respect to presence of species at the selected administrative unit.

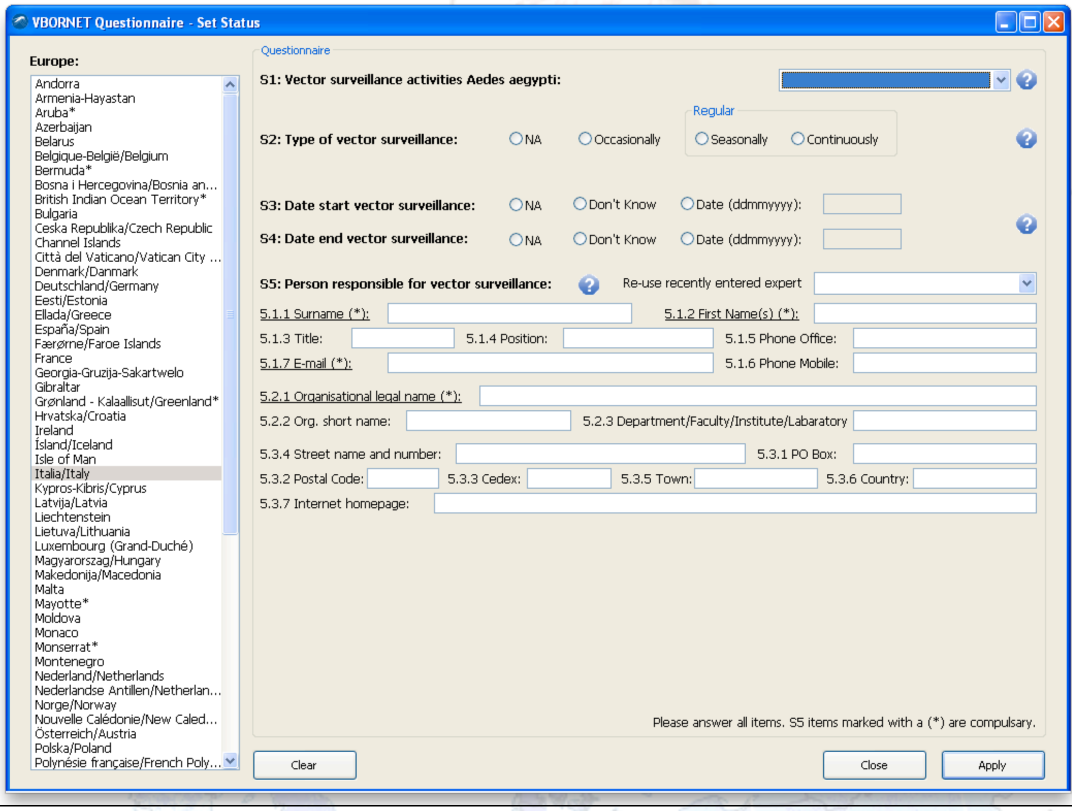

Figure 3. Vector surveillance questionnaire: surveillance data. The expert can enter data with respect to the current surveillance systems for the given selected administrative unit.

The recently developed risk map of *Aedes albopictus* will be the first to be updated and will serve as an example of the way VBORNET will approach the development of vector distribution maps. The *Ae. albopictus* risk map was based on all confirmed observations of the species in Europe. Based on this information three different *Aedes albopictus* distribution maps have been produced: Map 1: Distribution in whole Europe at NUTS 3 level (Figure 4); Map 2: distribution in the Mediterranean basin at municipality level; and Map 3: distribution in Central Europe including historical foci at municipality level. All three maps show records available up to January 2008, and provide an historical view of the progressive spread of the mosquito in Europe over the past 10–20 years.

An important part of the work was the assessment of the quality of existing data and their historic and current relevance. Different colour codes were used to distinguish different levels of establishment of the mosquito species and to show the accuracy of the data (See Figure 4). In particular, a distinction was made between countries where (1) surveys and studies on mosquitoes were conducted during the last five years (2003–2007) and where no specimen of *Ae. albopictus* was reported, (2) no recent (last five years) data on mosquito fauna were available to local scientists, (3) no information was available about the existence or not of studies on mosquito fauna. The maps also clearly show the information gaps. No data has been received from six countries namely Belarus, Iceland, Malta, Moldova, Macedonia and from several sub-national regions, as shown in white on the maps. The distribution maps and risk maps for *Aedes albopictus* in Europe, status January 2008, can be downloaded from ECDC web site, as well as the complete report 'Development of *Aedes albopictus* Risk Maps' (ECDC technical report, 12 May 2009):
http://ecdc.europa.eu/en/publications/Publications/0905_TER_Development_of_Aedes_Albopictus_Risk_Maps.pdf

The data for the *Ae. albopictus* maps were provided by experts in their respective countries. To update this map, and to establish other maps on vector distributions, the VBORNET network is therefore looking for VBD experts who are interested in data sharing and networking. At this early stage of the project, VBORNET will focus on acquiring baseline data for confirmed vector presence at various administrative scales (NUTS 1-2-3) as well as on the quality of the various VBORNET database inputs.

Active network members contributing information to VBORNET will have access to the VBORNET raw VBD data and resources, and will be able to contribute to VBD/PH priority setting in Europe as a member of expert panels (e.g. annual VBORNET meeting) and be listed as an official VBORNET network member.

Other existing networks will also be contacted and asked to contribute to VBORNET. Among them, EMCA (European mosquito control association) has already confirmed its willingness to support to the project.

As well as updating the *Ae. albopictus* maps, VBORNET will also focus on other arthropod vectors during the first year. These will include:

- Mosquitoes: *Ae. japonicus*, *Ae. atropalpus, Ae. aegypti* and other invasive mosquitoes.
- Ticks*: Hyalomma spp.* and *Ixodes ricinus*. For the latter particular attention will be given to species limits and shifts.
- Phlebotomines: distribution limits of species of particular interest in the transmission of leishmaniasis and viruses around the Mediterranean.
- Other vectors: focus will be on the identification of disease hotspots transmitted by fleas and lice.

Key words: VBORNET questionnaire, European Network for arthropod vector surveillance.

Mosquito names: *Aedes? Ochlerotatus? Stegomyia? Hulecoeteomyia?*

Major generic changes within the tribe Aedini were recently published (Reinert, 2000; Reinert *et al*. 2004, 2006, 2008), leading to a scientific debate and some confusion because two or more names are being simultaneously used for a single taxon. Editors of several scientific journals therefore suggest that usage of the traditional names (JME Editors 2005) be continued until there is a consensus on this major nomenclature change. In this NL we use the traditional names as shown below:

Aedes aegypti = *Stegomyia aegypti* sensu Reinert *et al*. 2004

Aedes albopictus = *Stegomyia albopicta* sensu Reinert *et al*. 2004

Aedes japonicus = *Ochlerotatus japonicus* sensu Reinert *et al*. 2004 = *Hulecoeteomyia japonica* sensu Reinert *et al.* 2006

Aedes atropalpus = Ochlerotatus atropalpus sensu Reinert *et al. 2004* = *Georgecraigius atropalpus sensu* Reinert *et al.* 2006

Aedes triseriatus = *Ochlerotatus triseriatus* sensu Reinert *et al*. 2004

What is an invasive species?

The World Conservation Union (IUCN Guidelines 2000) and the Convention on Biological Diversity (COP 6, decision VI/23, 2002) have quite similar definitions (combinations below) based on threats to biological diversity:

"Alien invasive species" (or invasive alien species) means an alien species which becomes established in natural or semi-natural ecosystems or habitat, is an agent of change, and threatens native biological diversity.

"**Alien species**" (*syn*: non-native, non-indigenous, foreign, exotic, introduced) means a species, subspecies, or lower taxon occurring outside of its natural range (past or present) and dispersal potential (i.e. outside the range it occupies naturally or could not occupy without direct or indirect introduction or care by humans) and includes any part, gametes seeds, eggs, or propagule of such species that might survive and subsequently reproduce.

"**Native species**" (indigenous) means a species, subspecies, or lower taxon, occurring within its natural range (past or present) and dispersal potential (i.e. within the range it occupies naturally or could occupy without direct or indirect introduction or care by humans).

Invasive alien species are a major threat to native biodiversity, natural ecosystems and ecosystem services.

The US National Invasive Species Council associates also threats to economy, environment and human health:

An "**invasive species**" is a species

1. that is non-native (or alien) to the ecosystem under consideration and
2. whose introduction causes or is likely to cause economic or environmental harm or harm to human health.

Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions.

2. CURRENT STATUS OF INVASIVE MOSQUITOES IN EUROPE

F. Schaffner, Avia-GIS, Zoersel, Belgium & University of Zurich, Switzerland
W. van Bortel, Institute of Tropical Medicine, Antwerpen, Belgium

Invasive mosquitoes are a topical subject. Following the chikungunya outbreak in the Indian Ocean (2005-2007) and in Italy (2007), in which the invasive *Aedes albopictus* was recognized as vector, ECDC has disseminated recommendations and European countries have developed risk assessment and management plans for invasive mosquitoes and related mosquito-borne diseases. In 2009, *Ae. albopictus* was reported as newly introduced into Malta, *Ae. japonicus* was reported as established in Belgium, Switzerland and Germany and *Ae. atropalpus* was reported for the first time from Netherlands (see VBORNET NL1 for more details). The international used tyre trade is once more confirmed as an essential role-player for mosquito introductions and for the first time an invasive mosquito, *Ae. japonicus*, is widely spreading in central Europe. There are still big gaps in information on mosquito fauna from several regions or countries, and it may be that the known occurrences of invasive mosquitoes are just the 'tip of the iceberg'.

Aedes albopictus

The number of European countries/micro-states in which the Asian tiger mosquito *Ae. albopictus* has been observed at least once has risen to 17 i.e. 29% of the 59 countries of continental Europe. It is well established and spreading in Albania, Croatia, France, Greece, Monaco, Montenegro, Italy, San Marino, Slovenia, Spain, and the Vatican City, and the species could now be considered as established in southern Switzerland. North of the Alps, in Belgium and Germany, no established populations have been recorded so far and in The Netherlands the species is only observed inside greenhouses. The record in northern Switzerland was a misidentification of *Ae. japonicus*.It is also present in isolated foci in Bosnia and Herzegovina, but few details are available (see ECDC technical report 'Development of *Aedes albopictus* Risk Maps' for more details). The recent observation in Malta, where no homogenous population have been previously recorded, raises the possibility of spread of the species from Italy to northern Africa by ferry traffic. In addition, the establishment of homogenous populations in southern France, including the city of Marseille where people have relatives in tropical regions where dengue or chikungunya circulate, raises the risk of import of pathogens and local transmission in Europe. Moreover, mosquitoes may start to spread further north by road traffic along the Rhone valley.

Aedes aegypti and other invasive mosquitoes

Aedes aegypti was once found sporadically in Europe from the Atlantic coast (Britain, France, and Portugal) to the Black Sea. It was assumed to be eradicated for decades, despite some occasional records from Italy in 1971 and Turkey in 1984 and 2001, but new infestations have recently appeared in Madeira and southern Russia. Its establishment in areas with temperate climates is constrained by its intolerance to cold winters (no cold-tolerant diapausing eggs), but changes in climates mean that its re-establishment in Southern Europe is becoming more likely.

Aedes atropalpus is an invasive North American mosquito that has been reported from Italy (1996) and France (2003) from where it has been eradicated. Very recently the species was found to have become established in the Netherlands, in two used tyre yards. In all cases there is evidence of introduction by the international used tyre trade and preliminary modelling shows that climatic conditions in The Netherlands are not a limiting factor for further spread of this species either in the country or further within Europe.

Aedes japonicus was reported from northern France and Belgium in 2000 and 2002 respectively. Once again, these introductions are related to the used tyre trade. The species was eradicated from the French site, thanks to mosquito control measures. and it remains confined to two used tyre yards in Belgium. In contrast, *Aedes japonicus* was also very recently (2008) found to be widespread in Switzerland and southern Germany

Aedes triseriatus is not yet known to be established in Europe but it has been intercepted in a batch of used tyres imported from Louisiana (USA) into France, in 2004, and the risk of its establishment in Europe following repetitive introductions is significant.

The situation in European overseas territories is totally different to that in continental Europe because many are in (sub)-tropical regions. Both *Ae. aegypti* and *Ae. albopictus* are active vectors of diseases (dengue, chikungunya) in these territories, and other mosquitoes are involved in vector-borne diseases outbreaks, like malaria and filariasis.

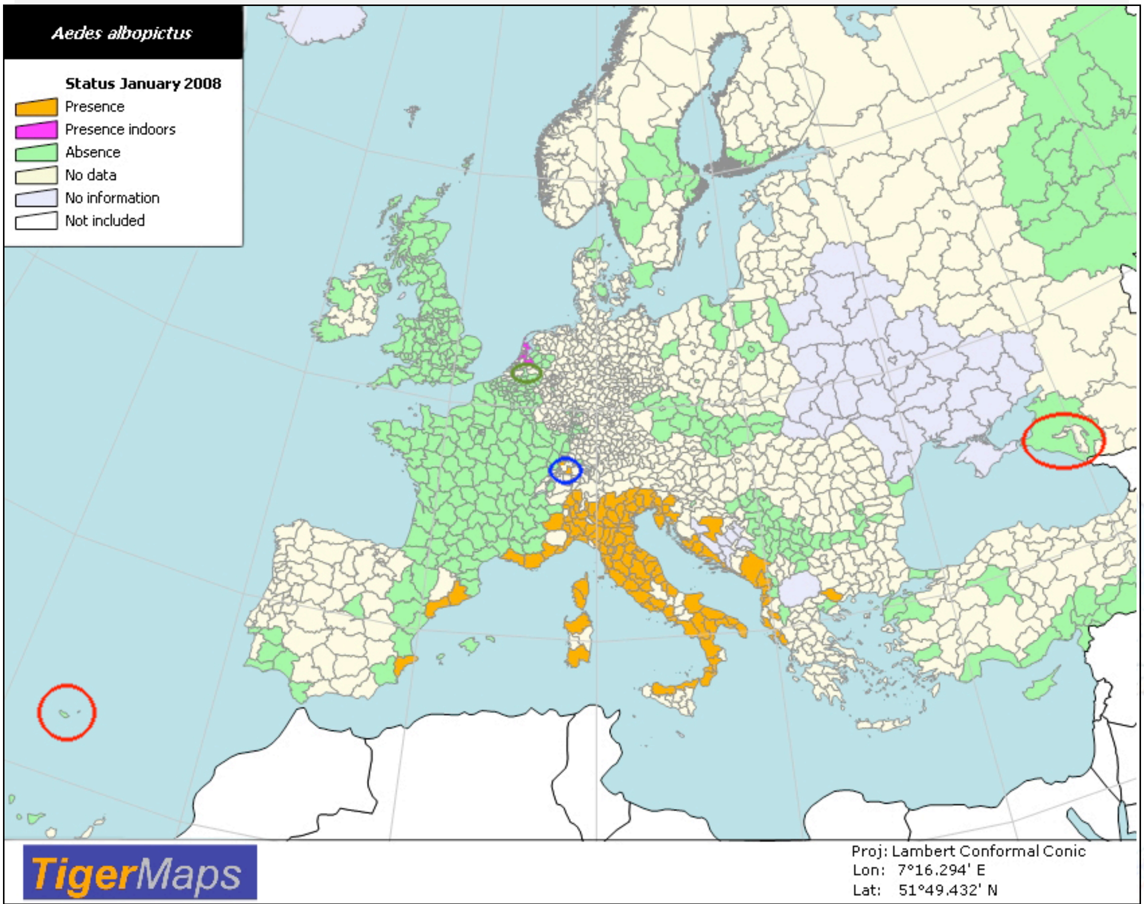

Figure 4. Distribution of invasive mosquitoes in Europe. Orange: *Ae. albopictus* (as for 2008); Red: *Ae. aegypti*, blue: *Ae. japonicus,* dark green: *Ae. atropalpus* (2009). See item 3 for references.
Source for albopictus: Development of *Ae. albopictus* Risk Maps, ECDC tech. report, 2009

Surveillance and control programmes in Europe

A major objective during the coming years will be the control of sanitary and vectorial risk related to invasive mosquitoes. The efficiency of this control will arise from (1) the active risk assessment, based on entomological surveillance (presence or abundance of vectors) and disease surveillance (surveillance of introduced pathogens and early detection of autochthonous transmission), and (2) the application of efficient sanitary control measures including integrated vector control. To date, only a few countries implement such measures. France and the Italian region Emilia-Romagna (Northern Italy) have an action plan for chikungunya and dengue control. Several other countries implement active or passive invasive mosquito surveillance in order to detect invasion as early as possible: Belgium, Croatia, Czech Republic, Germany, Greece, Montenegro, the Netherlands, Serbia, Spain, Switzerland, and the UK. In some countries, mosquito abatement measures are also implemented: Albania, Croatia, France, Italy, Spain, Switzerland; but action plans are often limited in space and/or time. The few successes in eradication or effective control are reported from locations in Croatia, France, Italy and Switzerland, and can be attributed directly to the early detection and abatement before spread starts. (See also ECDC technical report)

First reports of invasive species have been collected in different ways (Table 1): many of them (10 items, 40 % of the cases) were acquired during specific active surveillance, 7 were based on nuisance complaints (among them one from a report in a newspaper), 4 were based on expert observations during occasional visits, 3 were acquired during local mosquito studies (occasional) or surveillance (regular), and 1 was acquired during a routine inspection for plant protection.

This underlines the role and efficiency of specific surveillance for the early detection of invasive species. In very few cases specific surveillance has failed to find a species which was then reported in another way. This was the case in Spain where the tyre trade was investigated but *Ae. albopictus* was only found to be established in a residential area, most probably after its introduction by road transport. Another such case was in Malta where some specimens where observed in villages not considered as possible ports of entry. Unfortunately sometimes the media translate surveillance into discovery of the species, or report the presence of the Asian tiger mosquito without any scientific confirmation. This occurred in Hungary (2001), United Kingdom (2007) and Austria (2008).

Table 1. Ways of report of introduction of invasive mosquitoes in Europe: country and date of report per species

	Specific active surveillance	*Local mosquito study or surveillance*	*Nuisance complaint*	*Expert observation during occasional visit*	*Other inspection or insect monitoring*
Ae. albopictus	France, 1999[I] Belgium, 2000[T] Montenegro, 2001 Switzerland, 2003 Germany, 2007	Croatia, 2004 Bosnia and Herzegovina, 2005 Malta, 2009	Albania, 1979[I] Italy, 1990[T] Greece, 2003 Spain, 2003 Slovenia*, 2005	Monaco, 2006 San Marino, 2007 Vatican City, 2007	Netherlands, 2005[I]
Ae. aegypti			Madeira, 2004		
Ae. atropalpus	Italy, 1996[I] France, 2003[T] Netherlands, 2009[T]				
Ae. japonicus	France, 2000[I]		Switzerland, 2008[I]	Belgium, 2002[I]	
Ae. triseriatus	France, 2004[I]				

* In newspaper; [I] probable introduction by international trade

Among these first introductions, almost half of them (12/25) are most probably due to transport by international (often intercontinental) trade, mainly of used tyres, though in one case of Lucky Bamboo, and sometimes of unknown goods, most probably imported by ground traffic (road or ferry) originating from an infested area.

Evidence therefore suggests that movements of invasive mosquitoes are increasing, probably due to a rise in volumes of international trade and of movements of ground traffic from infested areas (e.g. from Italy to the Balkans during the last decade). Entomological surveillance of invasive mosquitoes has also been shown to be essential for early detection and efficiency of subsequent mosquito abatement measures.

Finally another important factor in the future will be the ability of authorities to adapt to and cope with changes of mosquito borne disease risk caused by proliferation of new vectors and the introduction of pathogens in a changing environment and climate. This adaptation wills of course first need to be directed towards mosquito surveillance and control methods, but attention should also be targeted towards disease surveillance and adjusting regulations for a global risk management.

Key words: invasive mosquitoes, *Aedes*

3. PUBLIC HEALTH IMPORTANCE OF THE INVASIVE MOSQUITOES OF EUROPE

Hansford K., Bennett E. & Medlock J.M., Medical Entomology group, Health Protection Agency, UK

3.1 *Aedes albopictus*

The invasive mosquito *Aedes albopictus* has recently been identified in Malta (Gatt *et al*., 2009; Buhagiar, 2009), adding another European country to the list of those now possibly at risk of the diseases this vector can transmit. Although the mosquito established itself in Europe for the first time in Albania in 1979 it has since been reported in 17 other European countries/micro-states, and has recently been recognised as a vector of disease in Europe.

Following the chikungunya virus (CHIKV) epidemics in the Indian Ocean (2005-2007), which caused millions of cases and significant morbidity and burden on health resources, the virus was imported into the first European country in 2007 and caused an autochthonously transmitted virus outbreak in Italy. This outbreak involved local transmission via *Ae. albopictus* mosquitoes and resulted in 205 cases (one fatal) with a further 129 suspected cases identified (Rezza *et al*., 2007). However, the true extent of this outbreak is said to be underestimated (Angelini *et al*., 2007). Imported cases of chikungunya have also been reported in Belgium, Czech Republic, France, Germany, Norway and United Kingdom, (Depoortere *et al*., 2006).

Aedes albopictus has also been associated with dengue virus (DENV) and has been implicated as the vector involved in the 1977-78 Seychelles (Metselaar D et al, 1980) and Reunion Island epidemics, an outbreak in Hawaii in 2001-2002 (Effer *et al*., 2005) and more recently in an outbreak in Reunion island again in 2004 and Mauritius in June 2009, which caused at least 220 cases (Pierre *et al*., 2005; Ramchurn *et al*., 2009). An estimated 50-100 million dengue cases occur annually worldwide (Paupy *et al*., 2009) and although dengue remains an imported infection in Europe, case numbers according to TropNetEurope are increasing: from 64 cases in 1999 to a maximum of 224 cases in 2002 and remaining at 100-170 cases since then (Jelinek, 2009). Data from INVS in France suggests that this number is higher, and since dengue was made notifiable in France in 2006, 420 imported cases were reported in 2007 alone. (Ledrans & Dejour Salamanca, 2010). Severe forms of dengue result in dengue haemorrhagic fever (DHF) and dengue shock syndrome, with case fatality rates reaching 50% in untreated cases (Seyler *et al*., 2009).

Aedes albopictus is also a known vector of *Dirofilaria* (filarial nematodes *D. immitis* and *D. repens*), a parasite transmitted primarily between dogs and mosquitoes, but which can also affect humans. Recent evidence has shown transmission of the parasite by Italian *Ae. albopictus* populations (Cancrini *et al*., 2003a; Cancrini *et al*., 2003b), coupled with an increase in prevalence of human dirofilariasis in Italy (Pampliglione *et al*., 2001).

A number of other viruses important to human health have been isolated from field collected *Ae. albopictus* in different countries and laboratory transmission of such viruses by *Ae. albopictus* has been demonstrated (Paupy *et al*., 2009). Such viruses include Eastern Equine encephalitis virus (Mitchell *et al*., 1992; Turell *et al*., 1994), La Crosse virus (Gerhardt *et al*., 2001; Grimstad *et al*., 1989), Venezuelan equine encephalitis virus (Beaman & Turell, 1991; Turell & Beaman, 1992), West Nile virus (WNV) (Holick *et al*., 2002: Sardelis *et al*., 2002c) and Japanese encephalitis virus (JEV) (Paupy *et al*., 2009). Field isolation and experimental infection studies alone do not mean this mosquito species is involved in transmission of these viruses, but the mosquito's biting habits, increasing global distribution and recent involvement in a CHIKV outbreak highlights the importance of monitoring *Ae. albopictus*.

3.2 *Aedes aegypti*

Aedes aegypti is an invasive mosquito that has been found sporadically in Europe from Atlantic coast to the Black Sea (Christophers, 1960). It was supposed to be eradicated for decades, despite some occasional records from Italy in 1971 (Callot & Delécolle, 1972), and

Turkey in 1984 and 2001 (B. Alten, pers. comm.), but new infestations have recently appeared in Madeira (Almeida *et al*., 2007) and southern Russia (A. Baranova, pers. comm.). Its establishment in more temperate zones is currently restricted due to its intolerance to temperate winters, but there is concern that this could change in the future should global climate change predictions become reality (Gould & Higgs, 2009).

Major dengue fever epidemics, due to *Ae. aegypti*, occur in the Americas, South East Asia and the western Pacific, and the disease is now endemic in >100 countries worldwide. Incidence of this disease has increased dramatically and the incidence of the more severe DHF has also been increasing (Wichmann & Jelinek, 2003). WHO estimates that there may be 50 million infections worldwide every year. This mosquito was once endemic in Europe and was responsible for large epidemics of dengue and yellow fever until its disappearance after the second world war; with the last dengue outbreak recorded in Greece in 1927-1928 (Rosen, 1986). *Aedes aegypti* is also known to cause outbreaks of CHIKV and has done so recently in Kenya, the Comoros, India, Mayotte (Gould & Higgs, 2009).

Additionally and importantly, *Ae aegypti* is a highly effective vector of yellow fever virus (YFV), a disease found in West, Central and East Africa (where large, severe epidemics have been recorded, with tens of thousands of deaths) and in South America. Imported yellow fever cases have been reported from Germany (Kiehl, 1999), Belgium (Colebunders, 2001), Spain, France, the Netherlands and Switzerland (Monath *et al*., 2002). Historically a YF outbreak occurred in Wales in the 19th century following importation of *Ae. aegypti* and infected passengers aboard a boat.

More recently, *Ae. aegypti* has been suggested as a vector of Zika virus (a flavivirus related to YFV, DENV, WNV, and JEV) owing to its isolation from field collections in Malaysia and in West Africa (Marchette *et al*., 1969, CRORA) and virus transmission under laboratory conditions (Boorman & Porterfield, 1956). The first outbreak of Zika virus, a relatively mild disease characterized by rash, arthralgia, and conjunctivitis, was reported in 2007 on Yap Island, Pacific Ocean, where 185 confirmed or suspected cases were reported. This was the first time the virus had been reported outside its usual geographical range, as previous cases had only been reported from Africa and Asia (Hayes, 2009).

The re-establishment of this mosquito in Europe raises concerns about the autochthonous arbovirus transmission of pathogens such as DENV and CHIKV (Almeida *et al*., 2007), re-inforcing the need for surveillance of this mosquito species is Europe.

3.3 *Aedes atropalpus*

Aedes atropalpus is an invasive North American mosquito that has been found in Italy, (Romi *et al*., 1997), France (2003, S. Chouin & F. Schaffner unpublished data), and more recently in the Netherlands (Scholte *et al*., 2009). Although this latter introduction has shown little spread of the mosquito, preliminary modelling shows that climatic conditions in the Netherlands are not a limiting factor for further spread of this species here or in large parts of Europe (Scholte *et al*., 2009). Laboratory competency studies have shown the ability of *Ae. atropalpus* to transmit La Crosse virus (Freier & Beier, 1984), WNV (Turell *et al*., 2001) and other arboviral encephalitides, but its importance as a vector of infectious diseases is still not known (Scholte *et al*., 2009).

3.4 *Aedes japonicus*

Aedes japonicus is native to Korea, Japan, Taiwan, southern China and Russia (Tanaka, 1979) and was first reported in the US in 1998 (Peyton, *et al.,* 1998), New Zealand in 1993 (Laird *et al*., 1994), northern France in 2000 (Schaffner *et al*., 2003), Belgium in 2002 (Versteirt *et al.,* 2009), Switzerland and Germany in 2008 (Schaffner *et al*., 2009). Field-collected *Ae. japonicus* has been found positive for WNV on a number of occasions in the US (Andreadis *et al*., 2001) and laboratory studies show it is a competent vector of WNV (Sardelis & Turell, 2001; Turell *et al.,* 2001). Laboratory studies have also shown *Ae. japonicus* to be a competent carrier of JEV (Takashima & Rosen, 1989), La Crosse virus (Sardelis *et al*., 2002b) and a moderately efficient vector for Eastern equine encephalitis

(Sardelis *et al*., 2002a) and St Louis encephalitis virus (Sardelis *et al*., 2003). However, its role in the transmission of these viruses in natural conditions is unclear (Versteirt *et al*., 2009).

3.5 *Aedes triseriatus*

Aedes triseriatus is not yet known as established in Europe but it has been intercepted in a batch of used tyres imported from Louisiana (USA) to France, in 2004 (S. Chouin & F. Schaffner, unpublished data). Its ability to overwinter as diapausing eggs renders this species at risk for an establishment in Europe if repeated introductions. Found in the eastern half of the US in hardwood forests areas, *Ae. triseriatus* breeds in tree-holes, tyres and other artificial containers (Borucki *et al*., 2002). It is primarily zoophilic but is also known to bite humans (Freier & Grimstad, 1983). *Aedes triseriatus* is a known vector of La Crosse virus, first isolated from a fatal case in Wisconsin in 1960 and subsequently isolated in the field (Pantuwatana *et al*., 1972; Thompson *et al*., 1972; Watts *et al*., 1974). Transovarial transmission and vector competency have been demonstrated for this virus under laboratory conditions (Watts *et al*., 1973). La Crosse virus can cause serious disease in humans and is the most common cause of paediatric arboviral encephalitis in the US with 42-172 cases reported annually (Borucki *et al*., 2002). Case numbers, however, are suspected to be underestimated (McJunkin *et al*., 2001).

Jamestown canyon virus has repeatedly been isolated from field-collected *Ae. triseriatus* in the US (Andreadis *et al*., 2008) and the mosquito has also been suggested to be a possible bridge vector for WNV following isolations of the virus from field collections (CDC, 2009) and vector competence studies under laboratory conditions (Styler *et al*., 2007). Other vector competence studies have shown its ability to transmit Venezuelan equine encephalitis (Davis *et al*., 1966), Eastern equine encephalitis, Western equine encephalitis, Dengue (type I), St Louis encephalitis virus and YFV under laboratory conditions (Freier & Grimstad, 1983).

Key words: mosquito-borne diseases, invasive mosquitoes.

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4. MOSQUITO SURVEILLANCE METHODS IMPLEMENTED IN EUROPE

E.-J. Scholte, National Centre for Monitoring of Vectors (CMV), Ministry of LNV, the Netherlands
M.A.H. Braks, National Centre for Public Health and the Environment (RIVM), the Netherlands

How nice would it be to have just one method for mosquito surveillance! One method that would provide useful answers to all the questions raised as rationale for mosquito surveillance like: 'What is the spatial and temporal distribution of endemic mosquito species in a certain area? What are the relative abundances of nuisance species? When is the best time to start with mosquito control? Is mosquito abatement effective and sufficient? Where do invasive species occur and are they spreading or not? What geographical areas are high risk areas of mosquito-borne disease outbreaks due to high densities of potential mosquito vectors?' Unfortunately, such a 'one method' does not exist. The choice of surveillance tools depends heavily on the information that is needed/wanted.

In areas where mosquito-borne viruses are (or recently were) circulating, such as northern Italy (Chikungunya, West Nile, Usutu), Finland and Sweden (Sindbis), or southern France (West Nile), vector surveillance is carried out with the aim to determine vector abundance and presence (incidence rates)/absence of the virus in the mosquito populations of the affected area. Surveillance is carried out by adult trapping (mostly using CO_2-baited traps and gravid traps) that provide the samples for virus detection tests. Data for determining relative abundances of known and suspected vector species are collected by several methods, depending on the vector(s) and how these species are best collected. This could be either by adult trapping (e.g. *Culex pipiens*), larval dipping (e.g. *Culex pipiens*), or egg counts (oviposition traps, e.g. *Ae. albopictus*), or a combination. This type of mosquito surveillance is mostly restricted to relatively small areas.

Regarding detection of invasive exotic species, most emphasis is placed on *Aedes albopictus, Ae. japonicus*, and (for some Mediterranean areas) *Ae. aegypti*. Important lessons were learnt from the rapid spread of the invasive exotic *Ae. albopictus* in Italy. It prompted countries such as Italy itself, Albania, Belgium, Croatia, Czech Republic, France, Germany, Greece, Montenegro, the Netherlands, Serbia, Spain, Switzerland, and the UK to start mosquito surveillance to detect invasion as early as possible, making use mostly of oviposition traps and passive surveillance as tools for detection. In this case, strategies for trap placements depend on the most likely way of introduction like imported used tires and Lucky Bamboo, and road traffic originating from infested areas. In the case of surveillance activities at used tire companies, collection of larvae is often used. Occasionally, other invasive mosquito species are detected in these surveillance activities, such as *Ae. atropalpus* in Italy, France, and very recently also in the Netherlands. In cases where invasive species have become established in large areas, such as *Ae. japonicus* in Switzerland and *Ae. albopictus* in Italy, surveillance methods are based on known preferred breeding sites that are easily accessible (e.g. cemeteries for *Ae. japonicus* in Switzerland).

In addition to their vector potential, mosquitoes can be a notorious nuisance. Several areas in Europe experience mosquito nuisance for certain periods of the season. In those cases, surveillance is mostly used to determine the locations and timing of mosquito control activities, and to determine control activities efficacy afterwards (validation). Examples of large areas are the rice field areas in Greece and Italy, the wetlands of southern Sweden, the floodplain of the river Rhine (southern Germany), the French Mediterranean coast, some deltas in north-eastern Spain and south-western Portugal, and floodplains in Hungary, Poland and Serbia. In all of these cases surveillance is based on larval densities, measured by standardized 'larval dipping' methods, associated with adult trapping by human landing collection and CO_2-baited traps for assessing the abatement's efficiency.

In the situation where little is known about the spatial and temporal distribution of endemic mosquito species, surveillance should include a combination of both egg, larval and adult collections. This, however, is very labour intensive and thus expensive, so countries often have to choose a single approach to reduce costs. In Belgium for example, mosquito biodiversity is studied using adult traps only (MODIRISK project), placed randomly in the country (cross-sectional). The sampling strategy was specifically designed to prepare for spatial modelling and to test a variety of sampling strategies to contribute to the establishment of cost-effective mosquito surveillance protocols. The Netherlands applies a similar strategy in their nationwide mosquito surveillance.

The VBORNET project will be a unique opportunity to discuss the standardization of mosquito surveillance protocols. In addition VECMAP a recently started ESA funded project aims at providing a set of standardized software tools and user-tailored services for mosquito surveillance and control activities (see further in this newsletter).

Key words: surveillance of mosquito-borne diseases, invasive mosquitoes.

5. MOSQUITO CONTROL METHODS IN EUROPE

M.A.H. Braks, National Centre for Public Health and the Environment (RIVM), the Netherlands
E.-J. Scholte, National Centre for Monitoring of Vectors (CMV), Ministry of LNV, the Netherlands

Most people associate mosquitoes with being annoying. But in addition to nuisance, they pose a serious risk to public health. To combat mosquitoes and the public health hazards they present, many European countries have established mosquito control programs. Professional 'mosquito fighters' and mosquito experts in Europe are gathered in the European Mosquito Control Association, EMCA, with the aim to strengthen cooperation in technical and operational aspects of mosquito control. It is a non-profit association registered in Strasbourg, France. It was founded in March 2000.

Mosquitoes can be controlled both by chemical and non-chemical methods. Depending on the situation, source reduction, biocontrol, larviciding (control of larvae), or adulticiding (control of adults) may be used to manage mosquito populations, within an integrated mosquito/vector management. These techniques are accomplished using habitat modification, pesticide, biological-control agents, and trapping. Depending on the situation, a specific method is chosen. For example in cases of extreme nuisance or when mosquito-borne disease transmission is actually taken place, adults are controlled, whereas in most other circumstances, larvicidal methods are preferred, largely because mosquitoes will then be controlled before they reach the blood feeding adult stage. In addition, in contrast to adults, larvae are confined to water bodies and so, therefore, are the control measures. In most cases where larval breeding sites can be identified and are accessible, larval control is thus the best control strategy.

Chemical methods used and allowed in Europe are based on one of four active ingredients: *Bacillus thuringiensis israelensis,* methoprene, diflubenzuron and pyrethroid derivates.

Recently, two books regarding vector control have been published. In 2009 a bilingual (FR/EN) book entitled *Disease vector control in France* edited by Dr Fontenille (Institut de Recherche pour le Développement, France) was published. Many different important issues, including the legal framework to control tools are described. The book ends with general recommendations with eight priorities for effective disease vector control. The book contains a wealth of information for many European countries.

The other book is entitled *Vector Biology, Ecology and Control* (Springer 2009) edited by Prof. P. Atkinson (University of California Riverside, USA). Of the 16 chapters, only one contribution concerns mosquito control in Europe, which deals with the Rhine larvicidal program and its application to vector control in Germany and States. It demonstrates that the use of insect-specific toxins from *Bacillus thuringiensis israelensis* is forming an increasingly important component of biological control strategies that are either being implemented or planned for use in mosquito control. Nearly all adulticides used are pyrethroid based formulations (permethrin, cypermethrin, deltamethrin).

Key words: control of mosquito-borne diseases, invasive mosquitoes.

6. INVASIVE MOSQUITOES IN THE EUROPEAN ASSOCIATE CONTINENTAL AND OVERSEAS TERRITORIES

J.M. Medlock, Medical Entomology group, Health Protection Agency, UK
F. Schaffner, Avia-GIS, Zoersel, Belgium & University of Zurich, Switzerland
D. Fontenille, Institut de Recherches pour le développement, Montpellier, France

Many European countries have special territories which often have a certain degree of autonomy represented by a local government, but they do not possess full political independence or sovereignty as a state. There are 7 European outermost regions which are members of EU: the 2 groups of Portuguese islands *Azores* and *Madeira*, the group of Spanish *Canary Islands*, and the 4 French overseas departments *French Guiana*, *Guadeloupe* (also *Saint Martin* and *Saint Barth)*, *Martinique* and *Reunion*. Beside these are 32 territories that have a special relationship with one European country: 16 with the United Kingdom, 6 with France, 3 with Norway, 2 with the Netherlands, 2 with Denmark, 1 with Greece, 1 with Finland, and 1 territory is administrated by the United Nations. Most of them are located overseas but a few are on the European mainland; they may have different status and some are still disputed. Here, a geographical approach more suited to the current purpose, will be adopted, with territories being ranked from north to south within each geographical region.

Europe

North. Only one mosquito species, *Aedes nigripes*, is recorded so far from the *Svalbard and Jan Mayen* islands (Kingdom of Norway). The species is not known as a potential vector but it could be locally responsible for nuisance. More southern, several species have been reported from *Åland islands* (Autonomous province of Finland) without any invasive species, No information is so far available on mosquito fauna from the *Faroe Islands* (Kingdom of Denmark).

North-West. Although there are mosquitoes in the northern European British Crown dependencies, there are no reports of invasive species on the *Channel Islands* (comprising Alderney, Jersey, Herm, Guernsey and Sark), or on the *Isle of Man*.

South. Mosquito control does take place in the British sovereign bases (*Akrotiri and Dhekelia*) on Cyprus, but there are no confirmed reports of invasive species, and no information on mosquito fauna from *UN buffer zone* in Cyprus, from *Gibraltar* (British overseas territory-OT) or from *Mount Athos* (Under Greek sovereignty). Three groups of islands are located in the Atlantic Ocean: the Portuguese autonomous regions *Azores* and *Madeira* and the Spanish autonomous community *Canaries*. Mosquito fauna is diverse, including some endemic species or subspecies: *Culiseta atlantica* on Azores, *Ae. eatoni* on Madeira and Canaries, *Cx. hortensis maderensis* on Madeira. The recent introduction of *Ae. aegypti* in Madeira (reported since 2004), is especially significant, particularly since *Ae. aegypti* is known to transmit Dengue in the neighbouring Cape Verde islands.

Atlantic Ocean

High northern latitudes. Considering the local climate, there is very little possibility that any mosquito-borne transmission will occur under these latitudes. However, even if the diversity is generally low for the biting insect fauna, the abundance of these could be very high at certain periods. Some mosquito species are reported from *Greenland* (Kingdom of Denmark), the larger associate territory, but studies are scarce and no information on invasive species is available. Mosquitoes are also numerous on *Saint Pierre and Miquelon* (French community), no but no precise information is available.

Medium and low northern latitudes. The associated territories in that area are, still from north to south: the British OT *Bermuda*, *Turks and Caicos Islands*, and in the Caribbean the *Cayman Islands*, *Anguilla*, *British Virgin Islands*, the French communities *Saint Martin* and *Saint Barth*, *Sint Maarten*, *Saba* and *Sint Eustatius* as a part of the Dutch OT *Netherlands Antilles*, the British OT *Montserrat*, the French departments *Guadeloupe* (including *Marie-Galante*, *La Désirade* and *Les Saintes*) and *Martinique*, and the Dutch OT *Aruba*, *Curaçao* and *Bonaire* another part of the *Netherlands Antilles*. In these territories, the mosquito story is somewhat different. All have had or currently have populations of *Ae. aegypti*, with *Ae. albopictus* confirmed only on Bermuda and the Cayman Islands. In the Cayman Islands, *Ae. aegypti* was eliminated but was re-introduced in 2002. However during the *aegypti*-free period *Ae. albopictus* was introduced but since the return of *Ae. aegypti* the *Ae*. *albopictus* population has plummeted and is now only found rarely on the island.

Across all the territories various activities are in place for surveillance and control of these invasive species. According to PAHO examples of control include fogging in areas of high mosquito abundance and dengue cases in Anguilla, integrated vector control through community engagement in the Turks and Caicos, port disinfection, ovipot surveillance and chemical control of adults and larvae in the Cayman Islands, also larval biocontrol (Bti) on the French Islands, as well as surveillance of introduction pathways (used tyres). Dengue cases (albeit at low levels) have been reported on all of the six British territories, although it is questionable how much of this is due to local transmission and hence true endemicity, as most cases appear to be due to importations from elsewhere in the region. Dengue is also endemic on the French islands and epidemics of several serotypes occur regularly. Imported malaria and chikungunya cases are surveyed, with application of preventive focal insecticiding in the surrounding. Also the Dutch islands have regular outbreaks of dengue fever during the rainy seasons, despite control programmes of its vector *Ae. aegypti*. Further work is ongoing to ascertain the status of invasive species and transmission of dengue in these territories, and VBORNET would welcome further communication with individuals involved in mosquito surveillance and control in the British and Dutch Overseas territories and dependencies.

Low southern latitude. The second larger associate territory is *French Guiana*, located on the South American continent. The mosquito fauna is various and abundant, and comprises many vector species. Malaria is still endemic mainly on inland territories along rivers in the Amazone forest where it has decreased during the last years while because of migratory movements, transmission is becoming more frequent in coastal municipalities and close to the capital Cayenne. The main vector is *Anopheles darlingi* but several secondary vectors are involved in the transmission. Dengue is now considered as hyperendemic, while outbreaks of all four serotypes occur regularly. The vector is *Ae. aegypti*. Other mosquito borne arboviruses have also been recorded. *Aedes albopictus* importation is regularly assessed, and the species has not been recorded so far.

Medium southern latitude. The British OT *St. Helena* and dependencies (*Ascension Island* and *Tristan da Cunha* -see below-) are located more southern in the Atlantic Ocean. *Aedes aegypti* was reported on St Helena, along with *Culex quinquefasciatus,* however according to local sources there have been no recent reports of *Ae. aegypti* on the island.

High southern latitude. For the more southern British OT in the south Atlantic, the human population is small or not fully resident and therefore there is no or little information on invasive mosquito species. The *Falkland Islands* and *Tristan da Cunha* are reportedly free of mosquitoes, including invasive species. This absence and the small human populations inhabiting these isolated territories also means there is no significant surveillance or control of mosquitoes. In the case of *South Georgia*, *South Sandwich Islands* and *British Antarctic Territory*, the climate is also likely to be inimical to the survival of these species. Similar assumptions could be made for *Bouvet Island* (Norway dependant territory), uninhabited and covered by glaciers, as well as for *Queen Maud Land* (Norwegian Antarctic territory).

Indian Ocean

Low southern latitudes. From *British Indian Ocean Territory* (Chagos Archipelago, the largest island being Diego Garcia) there is no available information and VBORNET would welcome contact.

Medium southern latitudes. Some islands of the *French Southern and Antarctic Lands* (French OT) are located in or close to the Mozambique Channel (Eparse Islands): Banc du Geyser, Glorioso Islands, Tromelin Island, Juan de Nova, Bassas da India, and Europa. If inhabited, they are generally only by researchers in scientific stations. Little information on mosquito fauna is available but a very recent survey made in the Eparse islands has reported *Ae. albopictus* introduced in Grande Glorieuse and Juan de Nova, the species having not been observed during a preceding survey from 2000 to 2003. The French community *Mayotte*, part of the Comoros Archipelago, has several vectors among the mosquito fauna (36 species recorded to date), including *Anopheles gambiae*, *An. funestus*, *Ae. aegypti* and *Ae. albopictus*, this last being present for only for a few years. Though Malaria transmission is endemic, it is has been decreasing dramatically in recent years. Chikungunya outbreaks in 2006-2007 have affected about 40 % of the human population. Dengue is also circulating. Recent local transmission of Rift Valley fever virus has been observed in 2000 and 2008. Several potential vectors are present on the island such as *Ae. circumluteolus* and *Cx. quinquefasciatus*. *Aedes albopictus* is reported to have been present in the French department *Reunion* since at least 1913 and *Ae. aegypti* since 1902. Twelve mosquito species have been recorded in all. *Aedes aegypti* is now restricted to small wild populations. Mosquito surveillance and control has been effective for decades, but until 2004, these programmes were aimed almost exclusively at malaria vectors in order to prevent any local transmission. A small dengue outbreak then occurred (the first since the 70's), followed by a huge chikungunya outbreak with 266,000 estimated cases and a incidence of 40%. Since then, an integrated vector control programme is implemented for limiting chikungunya and dengue transmission.

High southern latitudes. The rest of the *French Southern and Antarctic Lands* (French OT) are *Saint-Paul Island*, *Amsterdam Island*, *Crozet Island, Kergelen Islands*, and *Adélie Land* in Antarctica, also generally uninhabited, except by researchers in scientific stations, and probably support no mosquito fauna.

Pacific Ocean

Low northern latitude. The French state private property *Clipperton* has no permanent inhabitants, and no information on mosquito fauna is available.

<u>Medium southern latitudes.</u> The French *Wallis and Futuna* (OT), *French Polynesia* (Overseas country) and *New Caledonia* (OT) have regular dengue outbreaks, with *Ae. aegypti* as main vector. other species that contribute to transmission include *Ae. polyniensis in Wallis and Futuna* and *French Polynesia, and Ae. albopictus* has not been reported. Integrated dengue vector control programmes are implemented. Lymphatic filariasis, transmitted by *Ae. vigilax* in New Caledonia and *Ae. polynesiensis* in the other islands, has been reported in the general population, but current levels are unclear. Malaria does not occur. Two other arboviruses which are active in the Pacific region require attention, the Ross River virus which affected New Caledonia and Wallis and Futuna in 1979-80, and the Japanese encephalitis virus which is currently expanding its distribution range. The British OT *Pitcairn Islands* is an isolated island with a population of fifty. Local sources report that the island has a mosquito biting problem, suggesting that both malaria and dengue vectors occur on the island but with there are no reports of mosquito-borne disease cases. However their closest neighbour, Mangareva (in French Polynesia), does have a problem with mosquito-borne infections, and there is concern of possible spread and a recognised need for mosquito control on Pitcairn.

<u>High southern latitudes.</u> The last territory is *Peter I Island*, Norwegian Antarctic territory, an uninhabited volcanic island, with unfavourable conditions for mosquitoes and mosquito-borne transmission.

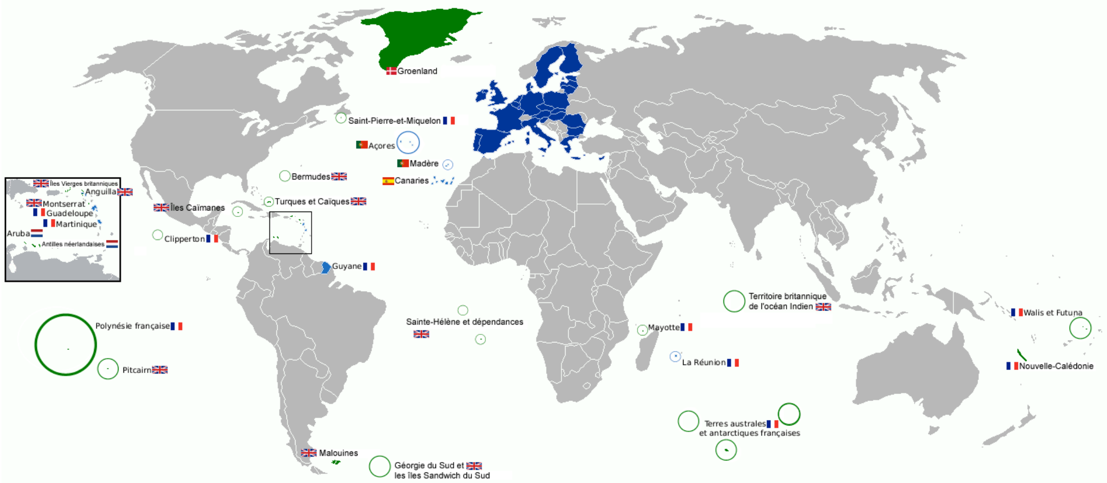

Figure 5. Overseas territories associated to European Union members. The associate territories located within geographical Europe and the ones associated with Norway are not shown.
Source: Alix Guillard, 2006
http://en.wikipedia.org/wiki/Special_Member_State_territories_and_the_European_Union

Key words: mosquito-borne diseases, invasive mosquitoes, Overseas territories.

7. INTERNATIONAL LEGAL INSTRUMENTS THAT COULD HELP IN THE MANAGEMENT OF INVASIVE VECTORS

M.A.H. Braks, National Centre for Public Health and the Environment (RIVM), the Netherlands
E.-J. Scholte, National Centre for Monitoring of Vectors (CMV), Ministry of LNV, the Netherlands

The Convention on Biological Diversity (CBD), an international legally binding treaty to sustain the diversity of life on Earth that was adopted in Rio de Janeiro in June 1992 (http://www.cbd.int/). The CBD was inspired by the world communities' growing commitment to sustainable development. The convention's governing body is the Conference of the Parties (COP), consisting of all governments (and regional economic integration organizations) that have ratified the treaty. According the CBD, invasive alien species (IAS) are one of the most important threats for global biodiversity. In COP 6 several guidelines on how to deal with IAS are described. Signatories voluntarily committed to follow these guidelines (http://www.biodiv.org/decisions). A European Strategy on Invasive Alien Species was developed which aims to facilitate implementation of international commitments and best practice and to support development of realistic policies, measures and targets (http://www.jncc.gov.uk/pdf/BRAG_NNS_Genovesi&Shine-EuropeanStrategyonInvasiveAlienSpecies.pdf). However control and curtailment of invasive alien species is lagging either because economic and ecological effects of IAS are underrated or not tangible in short term, or because too many stakeholders are involved to be effective.

An example of a professional field that has a long history in dealing with invasive species, including legislation, is plant protection; The 'EU plant Quarantine Directive', provides practical tools to prevent IAS that might have impact either for e.g. plant biodiversity and economic damage (http://ec.europa.eu/food/plant/organisms/index_en.htm). Several (inter)national initiatives followed, e.g. the North European and Baltic Network on Invasive Alien Species (NOBANIS; http://www.nobanis.org) that developed a network of common databases on alien and invasive species of the region. By establishing a common portal access to IAS-related data, information and knowledge in the region is facilitated.

Besides biodiversity, other possible legal tools in place that relate arthropod vectors to potential health problems of humans and/or animals is found in the International Health Regulations (IHR 2005; http://www.who.int/ihr/en/), whose objective is to limit international propagation of diseases. It constitutes a constraining instrument of law with binding power, in particular for all World Health Organization member states. Vector-borne diseases are in this framework mainly dealt with by measures geared to limiting the spread of potentially infected vectors whether in means of transport and goods. European Commission decision (2007/875/EC) emphasizes the prominent role mosquitoes play in the transmission of certain diseases. It added vector-borne diseases to the list of transmissible disease categories (decision 2119/98/EC). Also applicable to vector-borne diseases is the Commission's decision (2000/57/EC), which relates to early warning and quick-responses systems for transmissible disease prevention and control (2119/98/EC). However the core reference text within Community law is the biocidal product provision (European Parliament and Council directive 98/8 EC; http://ec.europa.eu/environment/biocides/basic.htm). This community biocide regulation delimits the use of insecticides, repellents and baits in the context of vector control. The objective of its main directive (98/8/EC), which is due for revision from 2009, is to subordinate marketing authorization of such product to unacceptable level of human an environmental risk and to the absence of unacceptable effects and sufficient of efficacy.

However, there is no list of so called 'quarantine vector species related to human and/or animal health' for the EU; i.e. a list of potentially harmful (invasive) arthropod vector species that each country is legally bound to monitor for and, if that organism is found, to control that particular vector species. Such a list should consist of vector species that could significantly increase disease transmission in case of pathogen incursion in that country.In the framework of early warning and disease prevention, and the increase in importance of vector-borne diseases in Europe, it would not be unwise to start thinking in that direction.

Key words: biodiversity, invasive mosquitoes.

8. THE VECMAP PROJECT: Toward developing a cost-efficient tool and service for mosquito mapping and control

G. Hendrickx, Avia-GIS, Zoersel, Belgium

8.1 Introduction

The presence and spread of vector-borne diseases in general and mosquito-borne diseases in particular depend on a series of diverse and interacting factors such as current distribution, climate, weather and wind patterns, proximity to water bodies, land use and vegetation.

Hitchhiking on international trade and travel, foreign species may establish themselves in new environments world-wide if conditions are favourable. Trends such as climate change and land development also contribute to changes in vector distribution. Amongst others, mosquito-borne diseases (Chikungunya, Dengue and West Nile) are an increasing public health concern in many European countries. Pilot research projects have demonstrated that it is possible to assess densities of local mosquito species and the risk of arrival of foreign species through modelling of the dependencies between habitat conditions, seasonal trends and in-situ sampling results. To help bridge the gap between research and routine application, there is a need for standardized cost-efficient protocols and tools to map mosquito distributions, the spread of invasive species and to assist with mosquito control, either as a nuisance or as a potential threat.

8.2 VECMAP feasibility study

ESA promotes through its ARTES 20 Integrated Applications Promotion (IAP) program, the development of new operational services utilizing at least two different space assets. ESA identified mosquito habitat mapping as a suitable topic and after an open call for tender procedure the VECMAP project was selected. As for all its IAP projects, a three step approach is adopted by ESA.

As a first step a feasibility study was awarded. During this stage much attention will be given to user needs and requirements. Long-term sustainability will be assessed through a market and cost-benefit analysis. Though no research activities are funded as part of IAP, topics for further research which may contribute to a better fulfilment of user needs will be identified for funding through other sources.

As a second step, providing the feasibility study results are positive, a shared cost demonstration project will be funded. During this stage the efficiency of the selected tool and service(s) will have to be demonstrated “grandeur nature”. The necessary tools will be developed and the service will be provided by the VECMAP consortium following contracts/ agreements signed with customers. During this stage ESA is prepared to fund up to 50% of the costs of the project.

Finally the VECMAP tool and services will be expected to be operational and self sustainable based on generated income. In addition to technical challenges, finding a fair economic balance between the different interests of public health agencies, research groups and the VECMAP consortium will be one of the main challenges of VECMAP.

8.3 VECMAP Tool

The proposed VECMAP tool is a software package which enables to plan and manage the various steps ranging from field sampling to spatial modelling and needed to map/model/validate the distribution, abundance and spread of mosquito species, and to assist with mosquito control (Fig.1). It is based on combination of inputs from field work (in-situ samplings and measurements), lab work (mosquito identification) and Earth Observation (EO) data (vegetation, land surface temperature, moisture, water bodies etc.). The in-situ data entered into a palm-to-web terminal is geo-referenced by GNSS and transferred to a central database using mobile communication technologies. The raw EO data (e.g. narrow band optical and infra-red imagery) are pre-processed to generate habitat indicators such as the vegetation index. The VECMAP software product’s algorithms correlate and cross-calibrate both sets of results and generate spatial and temporal predictions of presence, spread and density. Depending on the user’s needs a variety of graphical representations and interactive research is made possible through the engine and specifically developed (based on user needs and requirements) functionalities for the Graphical Information System (GIS)-environment.

8.4 VECMAP Services

During VECMAP three main service pathways will be explored:

- ECDC through VBORNET is building up a centralized database with Pan-EU data on vector distribution at various administrative levels (NUTS 1-2-3). Within VECMAP we will explore how a service could be developed to produce vector distribution maps based on these data on a regular basis and at a European scale, using *Aedes albopictus* as an example.
- National Public Health (PH) institutions arguably are the prime users of mosquito distribution related services (e.g. risk assessment studies). Often data related to mosquito distribution are collected by RTD teams based on specific research grants which may originate from a variety of sources and which are limited in time. Therefore VECMAP has selected users from three countries (BE, UK, NL) and representative both from the PH and RTD community who expressed interest in developing mosquito distribution related services at a national scale. With VECMAP we will explore how such sustainable PH-RTD-VECMAP services could be developed in each of these countries with varying levels of integration.
- Mosquito control activities (MC) require a detailed knowledge of the distribution (abundance) of adults and larval sites. It is important to collect such data in the most cost-efficient way. Therefore VECMAP has selected two users who address these issues in two different settings: Entente Inter-Departementale (EID) regarding mosquitoes as a nuisance in Camargue (France), and Centro Agricoltura Ambiente (CAA) regarding *Aedes albopictus* as a potential vector of tropical viruses in Italy (e.g. Chikungunya). With VECMAP we will explore how sustainable MC-VECMAP Services could be developed as an improvement to existing systems and procedures.

8.5 VECMAP current status

VECMAP started on November 1st 2009 and a user workshop which was held at RIVM (Bilthoven, Netherlands) from 5 to 7 January 2010. Three major documents which will form the basis for further work are currently being compiled: the State-of-the-Art, the User Needs and the User Requirements Documents.

8.6 For more information

VECMAP concept note to be obtained from info@avia-gis.be
http://iap.esa.int/vecmap
http://www.esa.int/SPECIALS/Space_for_health/SEMON3CV34G_0.html
http://iap.esa.int/events/VECMAP

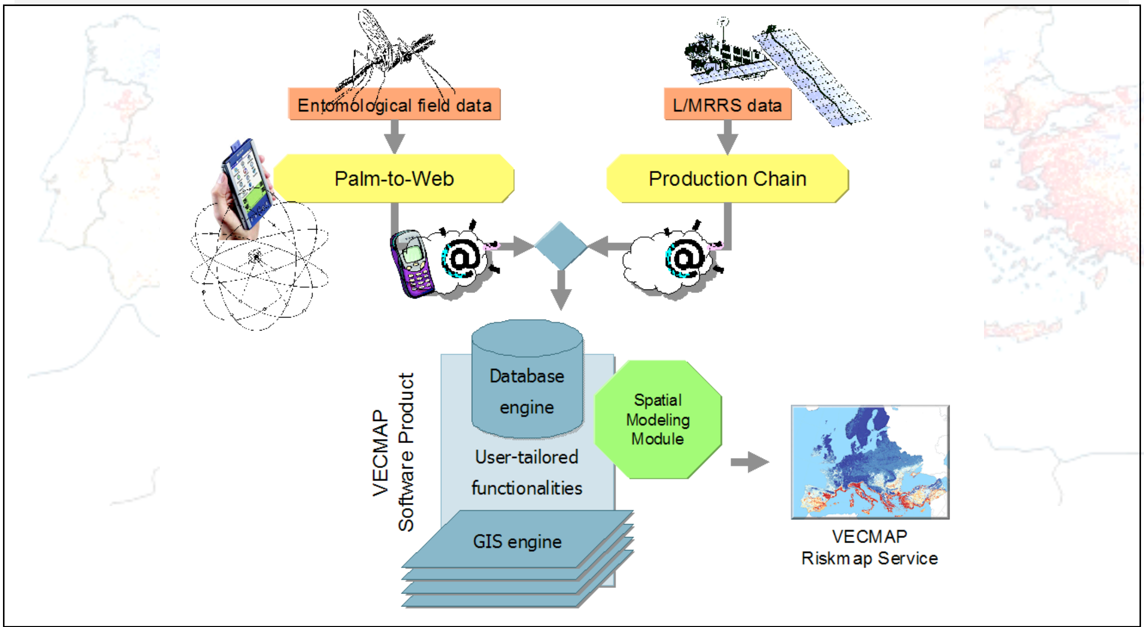

Figure 6. VECMAP system components

Key words: VECMAP, mosquitoes mapping and control.

9. A SELECTION OF WEB SITES DEALING WITH INVASIVE SPECIES

F. Schaffner, Avia-GIS, Zoersel, Belgium & University of Zurich, Switzerland

- **DAISIE, European Invasive Alien Species Gateway**

http://www.europe-aliens.org/index.jsp

This website was developed as part of the Delivering Alien Invasive Species In Europe (DAISIE) project funded by the sixth framework programme of the European Commission (Contract Number: SSPI-CT-2003-511202). It provides a 'one-stop-shop' for information on biological invasions in Europe, delivered via an international team of leading experts in the field of biological invasions, latest technological developments in database design and display, and an extensive network of European collaborators and stakeholders.

The general objectives of DAISIE are:

- to create an inventory of invasive species that threaten European terrestrial, fresh-water and marine environments
- to structure the inventory to provide the basis for prevention and control of biological invasions through the understanding of the environmental, social, economic and other factors involved
- to assess and summarise the ecological, economic and health risks and impacts of the most widespread and/or noxious invasive species
- to use distribution data and the experiences of the individual Member States as a framework for considering indicators for early warning

The site lists 11068 alien species for Europe including several mosquito and tick species that have been found outside their native range are listed. Indeed, the insertion of some of them could be discussed (e.g. *Aedes vexans* and *Aedes (=Ochlerotatus) subdiversus* considered as invasive for UK and Serbia respectively).

- **GISD, a Global Invasive Species Database**

http://www.issg.org/database/welcome/

The Global Invasive Species Database (GISD) aims to increase awareness about invasive alien species and to facilitate effective prevention and management activities. It is managed by the Invasive Species Specialist Group (ISSG) and was developed as part of the global initiative on invasive species led by the Global Invasive Species Programme (GISP).

http://www.issg.org/index.html

The Invasive Species Specialist Group (ISSG) is a global network of scientific and policy experts on invasive species, organized under the auspices of the Species Survival Commission (SSC) of the International Union for Conservation of Nature (IUCN). It was established in 1994. It currently has 196 core members from over 40 countries and a wide informal global network of over 2000 conservation practitioners and experts who contribute to its work. The ISSG promotes and facilitates the exchange of invasive species information and knowledge across the globe and ensures the linkage between knowledge, practice and policy so that decision making is informed.

- **NISIC, a gateway to invasive species information**

http://www.invasivespeciesinfo.gov/index.shtml

The National Invasive Species Information Center (NISIC) from United States Department of Agriculture is a gateway to invasive species information covering Federal, State, local, and international sources.

This site provides:

- Information on the impacts of invasive species and the US Federal government's response
- Select species profiles (animals, aquatic species, microbes, and plants)
- Links to agencies and organizations dealing with invasive species issues
- Information on the National Invasive Species Management Plan
- Terms definition .Invasive Species Definition Clarification and Guidance White Paper (PDF | 104 KB)

- **NOBANIS, a regional portal on invasive alien species**

http://www.nobanis.org/default.asp

The North European and Baltic Network on Invasive Alien Species (NOBANIS) is a gateway to information on alien and invasive species in North and Central Europe.

NOBANIS covers marine, freshwater and terrestrial environments and provides:

- A distributed but integrated database on introduced species in the region
- Fact sheets on many of the most invasive aliens
- A catalogue of the regulation relevant to invasive species in participating countries
- A literature database
- Connects to regional and global networks and projects of invasive aliens species

The participating countries are: Austria, Belgium, Denmark, Estonia, Finland, Faroe Islands, Germany, Greenland, Iceland, Ireland, Latvia, Lithuania, the Netherlands, Norway, Poland, European part of Russia, Slovakia, Sweden.

The site gives very little information on mosquitoes (limited to *Aedes albopictus* cited as suspected to be present in Germany), but information on existing regulations could be very helpful.

Key words: databases, invasive mosquitoes.