WORLD HEALTH ORGANIZATION
REGIONAL OFFICE FOR EUROPE

Guidelines for the Control of Mosquitoes of Public Health Importance in Europe

These guidelines have been initiated by the European Mosquito Control Association (EMCA) in collaboration with the World Health Organization (WHO) Europe.

Editors:
Dr. Peter Lüthy, ETH Zurich Switzerland/EMCA
Dr. Norbert Becker, University of Heidelberg Germany/KABS/EMCA
Dr. Mikhail Edjov, WHO Europe, Copenhagen
Dr. Raman Velayudhan, WHO Geneva, Switzerland

Special acknowledgements:
We thank the German Federal Ministry for the Environment, Nature Conversation, Building and Nuclear Safety (BMUB) for financial support.

For valuable contributions and critical comments:

- Dr. Carola Kuhn, German Federal Environmental Agency, Berlin, Germany
- Dr. Anita Plenge-Bönig, Institute for Hygiene and Environment, Hamburg, Germany
- Dr. Henk van den Berg, Wageningen University, The Netherlands

Cherie Aeberli Millns, EMCA, and Karen Taksøe-Vester, WHO Regional Office for Europe, Copenhagen, for excellent secretarial support.

Edition 2013

Table of Contents

Abbreviations and links

AMCA American Mosquito Control Association
http://www.mosquito.org/

BMUB Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, Germany
http://www.bmu.de/

BPD Biocidal Products Directive

CDC Centers for Disease Control and Prevention
http://www.cdc.gov/

CP Community Participation

ECDC European Centre for Disease Prevention and Control
http://www.ecdc.europa.eu/

EMA European Marketing Area

EMCA European Mosquito Control Association
http://www.emca-online.eu

EU European Union

JHA Juvenile Hormone Analogue

IHR International Health Regulations

IGR Insect Growth Regulator

IVM Integrated Vector Management

SIT Sterile Insect Technology

ULV Ultra Low Volume

VBORNET Network of medical entomologists and public health experts, funded by the European Centre for Disease Prevention and Control (ECDC)
http://www.vbornet.eu/

WHO World Health Organization
http://www.who.int/

Regional Office Europe, Copenhagen
http://www.euro.who.int/

WHOPES WHO Pesticide Evaluation Scheme
http://www.who.int/whopes/1

Executive Summary

Mosquitoes are intimately associated with humans and animals, which provide blood for the development of eggs for mosquito reproduction. The immature stages, larvae and pupae require water for their development, in most cases stagnant water. During their evolution numerous mosquito species have become vectors of infectious diseases, mainly with viruses, protozoa and nematodes as pathogens. In addition, massive mosquito breeding represents a major nuisance for humans and animals. Mosquitoes can reduce human quality of life.

In the course of ongoing globalization, problems with mosquitoes have been intensified. Exotic mosquito species have gained foothold in foreign territories and have spread to new regions of the World. The increased mobility of humans infected with mosquito-borne diseases has been and still is responsible for triggering autochthonous transmission of disease pathogens. An additional factor that may aggravate the problem of mosquito-borne diseases is the ongoing climate change. Globally rising temperatures along with more frequent events of heavy precipitation may create more favourable conditions for the establishment of mosquito populations as well as vector-borne pathogens.

Mosquito control is a key strategy in the fight against mosquito-borne diseases, especially against diseases for which effective drugs or vaccines are lacking. Mosquito control will be needed even if the successful development of vaccines eases the socioeconomic burden. The extent of control must be in line with the risks caused by mosquito species, requiring situation-specific assessments and taking environmental aspects into account. The risk levels imposed by a given mosquito species can be estimated by different indices linked to the population density. The surveillance and removal of aquatic mosquito breeding sites is an essential but neglected part of environmental hygiene, and one that requires renewed emphasis in the European Region. Surveillance of mosquitoes is conducted at two levels: in countries where the targeted mosquitoes have not yet established, and countries or areas where these mosquitoes have become established. Traps designed for eggs and adults are useful tools for gaining at least semi-quantitative data.

The WHO strategic approach based on integrated vector management (IVM) promotes strengthening vector control systems through evidence-based decision making, combinations of vector control methods, multi-disease approaches and inter-sectorial collaboration. In the context of mosquito control, this includes monitoring, tailor-made controls, removal of potential breeding sites, naturally balanced aquatic ecosystems promoting predators (fish, invertebrates), public awareness, personal protection, and the use of biological and chemical control agents.

The IVM approach will improve the efficacy, cost-effectiveness, ecological soundness, and sustainability of mosquito control. IVM must be adjusted to the behaviour and properties of the target mosquito species. IVM involves public authorities at all levels, and should be included in national and regional directives and guidelines. IVM requires long-term

commitment and consistency. National authorities should survey the mosquito situation in their country and if necessary, take action to prevent an impact on public health.

Uniform legislation across the WHO European Region, encompassing 53 nations, on the use of mosquito control agents is an important and highly desirable goal. At present only the 27 EU member states have to follow common directives. Within the European Union (EU), legislation is implemented through the Biocidal Products Directive (BPD) (98/8/EG) and the Biocidal Products Regulation (EU) No 528/2012. Control of European mosquito species of public health importance is of course clearly distinct form those found under tropical conditions. This reflects also on the biocides required for mosquito control. In addition, closer collaboration with manufacturers of mosquito control agents is highly recommended in order to have available enough efficient and safe mosquito control agents.

An IVM-based strategy of mosquito control combines an array of approaches. It comprises community participation, including motivating individual citizens to remove all potential breeding sites from their properties. In townships infested with mosquitoes, mosquito control on public ground should in many instances be organized by communal authorities. Mosquito control agents must be applied by trained personnel. A two-way flow of information between communal, district and national authorities is essential, especially where there is a risk of autochthonous transmission of mosquito-borne infections.

The availability of a number of biocide products for mosquito control is indispensable for adapting emergency control measures which are effective but providing a high degree of biosafety to non-targets. It is likely that within the EU states, fewer mosquito control agents are available than in other countries because many biocides are currently under re-examination. This pertains to most larvicides and adulticides that have been recommended by WHOPES.

The spread of *Aedes* species and their impact on public health is not restricted to Europe but is also a problem in other regions of the World. Therefore, international collaboration, networking and information sharing are required on monitoring and control. WHO's expertise and the global network of experts should be broadly utilized. Initiatives to harmonize the approval of mosquito control agents on a risk-benefit basis are highly desirable.

European medical institutions specializing in tropical diseases are of increasing importance because the rate of imported cases has risen along with the intensity of international travel. More and more people are returning home with mosquito-borne infections acquired abroad. Hence, informing the public about the risks of mosquito-borne diseases can be essential, especially if patients reside in locations where vector mosquitoes are prevalent.

Basic and applied research in microbiology, entomology, vector-competence, and diagnosis and treatment of mosquito-borne diseases should be promoted. Mosquito vectors and mosquito-borne pathogens could be capable of adapting to the new environments of countries where they are introduced, a process that could be facilitated by global warming; this requires further study. Moreover, there is an urgent need to develop novel products, methods and approaches for mosquito control. An example of a promising method is the sterile insect technique (SIT). Promising target-oriented efforts to augment the role of predators in the control of Aedes larvae are under way in Italy with the use of copepods. Last but not least basic and applied studies on the management and prevention of resistance require special attention.

The shortage of insecticide products available for mosquito control in the region highlights the need for the development and evaluation of new insecticides for mosquito control. The development of products with new modes of action might at least temporarily ease the problem of resistance. Increasing the residual effect of biocides, for example larvicides used for controlling container breeders, will help reduce the number of applications. A recent promising development has been reported with a combined formulation of *Bacillus thuringiensis israelensis* and *Lysinibacillus sphaericus,* which has a fast killing action but also residual activity against container breeders for several weeks.

These guidelines are considered to be a 'living document'. In order to cope with the fast-changing landscape of invasive mosquitoes and outbreaks of mosquito-borne diseases in new areas and countries of the European Region, the need for regular (e.g. annual) updating and amendment of the guidelines should be a desirable and achievable objective.

1. Introduction

1.1. Mosquitoes as an increasing threat to public health

The public health importance of mosquitoes in Europe is on the rise. Mosquitoes have long been perceived merely as a cause of nuisance, but they are increasingly becoming a threat to public health. A number of factors have contributed to this pattern.

The worldwide trade of goods facilitates the passive transport of mosquitoes (e.g. by vehicles, trains or aircraft) that allow exotic mosquito species to enter new territory. The increased speed and volume of international trade has raised the chance that mosquito stages survive long-distance transportation. The most invasive mosquitoes spreading across the globe through passive transport are 'container-breeding' species (i.e. mosquitoes that breed in small water containers around human settlements).

Also, the pathogens or parasites linked to mosquito-borne diseases are being imported into Europe at an increasing rate due to human mobility and migration. Infected persons returning from disease-endemic regions can be the starting point for local transmission of diseases such as dengue and chikungunya if suitable mosquito vectors are locally present.

Environmental changes can lead to increased colonization and breeding of invasive and indigenous mosquito. Urbanized areas can provide a range of water-containing breeding sites for mosquitoes, resulting in high mosquito densities. Establishment of human settlements near wetland areas, or the development of new wetlands near residential areas, can result in increased human contact with mosquitoes, thus increasing the risk of pathogen transmission.

Moreover, the ongoing climate change, with shifts in rainfall and temperature patterns, will have an effect on the breeding and survival dynamics of mosquito populations, and could thus influence the distribution and seasonal occurrence of mosquito species in Europe.

1.2. Scope and goal of the European EMCA/WHO guidelines

The initiative to develop these guidelines was taken jointly by the European Mosquito Control Association (EMCA) and the World Health Organization (WHO). The German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) financed a two-day start-up conference in Speyer, Germany, 30-31st May 2011. The conference was attended by 75 participants, representing scientific institutions and international organizations as well as local and national governments. The initiative was driven by the anticipated impact of the colonization of the European Mediterranean basin by the tiger mosquito, *Aedes albopictus,* and by the concurrent threat of this mosquito disseminating dengue and chikungunya.

The goal of the two-day conference was to review the mosquito situation in Europe with a particular emphasis on invasive species. The conference aimed to find common ground between all interested parties, as well as devising a framework for developing strategies for vector control. Also discussed were suitable procedures for timely intervention in the case of autochthonous transmission events. A follow-up meeting, also financially supported by the BMUB, took place in Bonn, Germany on 19-20 February 2013, and was devoted to an in-depth discussion of the draft guidelines. The list of the participants is presented in annex 2 at the end of this document.

The guidelines prioritize the control of mosquitoes for prevention of mosquito-borne diseases. In discussing the mosquito control measures, aspects of surveillance, monitoring, public awareness and the selective use of biocides are covered.

An important consideration for mosquito control is that it must be sustainable and, consequently, an Integrated Vector Management (IVM) approach should be adopted[1]. Another consideration is whether the legislation regulating the use of biocides includes the specific use for mosquito control.

The prevention of mosquito-borne diseases requires capacity strengthening in medical entomology, early detection, epidemiology and related fields of expertise, and should involve expert institutions in all areas concerned. One of the expected outcomes of the regional

[1] WHO (2012) Handbook for integrated vector management.

initiative is that an information network is established to facilitate coordination of mosquito control measures and strategies among the member states of the WHO Region for Europe.

The target audience of these guidelines are national and local health authorities, particularly those involved in mosquito control. These guidelines should assist countries in designing corresponding documents adjusted to their specific needs.

1.3. Related documents

Detailed technical guidelines for the surveillance of invasive mosquitoes in Europe[2] have been published by the European Centre for Disease Prevention and Control (ECDC), an EU agency with the primary mission of strengthening defences against infectious diseases within member states.

The regional European office of WHO has also prepared a document entitled 'Surveillance and Control of Invasive Vectors and Re-Emerging Vector-Borne Diseases[3]'. The document focuses on those *Aedes* mosquitoes of public health importance, and integrates Europe into the global network of mosquito-borne infectious diseases.

In 2012 WHO published the 'Global strategy for dengue prevention and control 2012-2020'[4]. This document is relevant in view of the regional situation on dengue and other diseases transmitted by *Aedes* vectors. The risk of dengue appears to be on the increase, since vectors have invaded the Mediterranean basin, and locally transmitted dengue cases have been confirmed. The 2012 outbreak of dengue in Madeira highlights the urgency of the situation.

The textbook *Mosquitoes and their Control*[5], by N. Becker and co-authors also provides important background information on the bionomics, systematics, ecology and control of mosquitoes.

The large amount of research and documentation available on these topics provides a wealth of information for all European nations necessary to evaluate the risks of mosquito-borne diseases within their own national territories. Where national guidelines for the prevention of mosquito-borne diseases are required, the guidance documents provided by EMCA, WHO Europe and ECDC could be utilized.

---

[2] TER ECDC 2012, http://ecdc.europa.eu/en/publications/Publications/Forms/ECDC_DispForm.aspx?ID=948

[3] www.euro.who.int/...diseases/vector-borne 2014–2020

[4] ISBN 978 92 4 150403 4; http://apps.who.int/iris/bitstream/10665/75303/1/9789241504034_eng.pdf

[5] Springer 2010, ISBN 354092874X

2. Mosquitoes and mosquito-borne diseases of special concern

A number of exotic species, such as *Aedes albopictus*, *Aedes aegypti* and *Aedes japonicus* have become established in Europe, particularly in the Mediterranean basin. In addition, some native mosquitoes are involved in pathogen transmission. Mosquitoes with public-health significance are listed in Table 1a and 1b. An overview of mosquito-borne diseases of public health relevance is given in Table 2.

The Asian tiger mosquito, *Aedes albopictus*, is able to transmit more than 20 arboviruses, and is currently the most prominent invasive mosquito species in the World. *Aedes albopictus* is a very efficient vector of chikungunya, but is somewhat less competent of transmitting dengue. It originates from Asia, with a range that extends as far north as Beijing and North Korea, where it breeds in tree holes and other natural water-holding containers. Northern races have an effective winter diapause mechanism that enables them to survive severe winters in the egg stage. In the past three decades the species has rapidly expanded its range and is now present throughout most of the Americas, more than 20 countries in Europe and the Middle East, and has been reported from several countries in equatorial Africa. It was first reported on the European continent in Albania in 1979, most likely imported from China. In 1990, it was detected in Genoa, Italy, probably introduced by used tires from the United States. In turn, the US infestations are attributed to imports of used tires from northern Asia, probably Japan. Currently the species is present, often abundantly, over a wide range from Spain to Romania. *Aedes albopictus* poses a significant public health risk for Europe. In 2007 it was responsible for an epidemic of chikungunya in northern Italy. Sporadic instances of autochthonous transmission of dengue and chikungunya have occurred since then in France and Croatia.

Aedes aegypti feeds strictly on humans and other primates, and is the principal urban vector of dengue, chikungunya and yellow fever. It was present and widespread in Mediterranean Europe until the first part of the 20th Century. It is not clear why it became extinct, but in recent years it has re-appeared in southern Russia, Abkhazia and Georgia. In 2004 it was detected in Funchal, the capital of Madeira, and subsequently spread to other parts of the island, where in 2012, between October and the end of the year, it was responsible for at least 2200 confirmed cases of dengue, including at least 60 cases in tourists and travelers returning from visits to the island.

Two other exotic species, *Aedes japonicus,* and *Aedes koreicus,* are now well established and spreading across continental Europe. *Aedes atropalpus* has been present for four years after its detection in a small focus in the Netherlands. However, their significance as vectors of human diseases in Europe is unknown.

Mosquito-borne West Nile Virus (WNV) infections of humans have become a major public health concern in Europe. In 2012, the ECDC recorded around 900 human cases of WNV in

Europe. The foci were concentrated along the Mediterranean basin from Italy to Greece, in regions bordering the Black Sea as well as in central Europe (Hungary).

The WNV circulates in bird populations, where it is transmitted by *Culex* mosquitoes. Several *Culex* species feeding on birds as well as on humans play an important role as so-called bridge vectors, by transmitting the virus to humans. Humans are a dead-end host, implying that humans do not contribute to spread of the disease. Nevertheless, WNV infections in humans can cause serious neurological disorders. Horses are also affected by WNV.

Sindbis virus is an enzootic virus prevalent in northern European countries, also transmitted by *Culex pipiens* and indigenous *Aedes* spp.

Seasonal emergence of floodwater mosquitoes, such as *Aedes vexans* and *Aedes caspius*, can cause nuisance, seriously affecting the quality of life, but these species are not considered to be of public health significance. In many regions of Europe the larval breeding sites of these mosquitoes are commonly controlled with microbial products based on *Bacillus thuringiensis*.

Malaria was once endemic as far north as the Arctic Circle, but has now almost been eliminated from the European Region. Recently, however, an increasing number of autochthonous malaria cases have been reported from Greece. Highly effective vectors, such as *An. sacharovi*, *An. labranchiae*, *An. atroparvus* and *An. plumbeus*, are locally present, often abundantly, in many parts of the Region. Diligence for the appearance of human cases is advisable in such areas.

Table1a. Exotic and invasive mosquito relevant for surveillance and control in Europe

Mosquito species	Status in Europe	Impact on Public Health
Aedes albopictus	Has gradually colonized the European Mediterranean basin over the past 20 years; where it is now widely established and still expanding. It is an urban container breeder.	Confirmed high vectorial capacity for chikungunya and dengue viruses, but also competent for more than 20 other arboviruses.
Aedes aegypti	Re-emerging species. Established in Madeira, Georgia, and Russia. Container breeder.	Worldwide the most prominent vector of dengue, yellow fever viruses and other arboviruses.
Aedes japonicus	Widely established in Switzerland, southern Germany, parts of South-Eastern Austria, a small focus in Belgium and expanding in central Europe. Container breeder.	Vector potential in Europe under investigation. Major nuisance problem.
Aedes koreicus	Foci in Belgium and north-east Italy.	Competent vector of arboviruses and of *Dirofilaria.*
Aedes atropalpus	Focus in the Netherlands. Foci in France and Italy eliminated.	Competent vector of arboviruses.
Aedes triseriatus	Introduced into France and eliminated.	Confirmed vector of La Crosse virus in Northern America.

Table1b. Indigenous mosquitoes relevant for surveillance and control in Europe

Aedes vexans	Floodwater mosquito; appears in temporary flooded freshwater sites in high population densities.	Potential vector of Rift Valley fever virus Limited vector potential for West Nile virus. Vector of *Dirofilaria* in dogs.
Aedes caspius	Prevalent at high population densities in temporary flooded brackish marshes and rice fields.	Potential vector of Rift Valley fever virus.
***Culex pipiens* (complex)**	Omnipresent in Europe in both artificial and natural water sites.	The most important vector of WNV. Vector of Sindbis virus.
Culex perexiguus	Present in the Mediterranean basin. Breeds in artificial and natural freshwaters.	Secondary vector of WNV.
Culex modestus	Widespread in Europe. Breeds in clear water marshes.	Secondary vector of WNV.
Anopheles sacharovi	Present in the Mediterranean area and Eastern Europe. Breeds in soft water.	Vector of malaria (*Plasmodium* spp.).
Anopheles labranchiae	Present in Corsica, Italy, and along the Dalmatian coast. Breeds in soft water.	Vector of malaria (*Plasmodium* spp.).
Anopheles atroparvus	Present in most parts of Europe. Breeds in soft and brackish water.	Vector of malaria (*Plasmodium* spp.).
Anopheles plumbeus	Present in most parts of Europe. Tree hole and artificial container breeder.	Minor vector of malaria (*Plasmodium* spp.).

Table 2: Mosquito-borne diseases relevant for Europe[6]

Disease	Main vectors	Disease	Main vectors
Chikungunya	*Aedes albopictus, Aedes aegypti*	La Crosse	*Aedes triseriatus,* *Aedes albopictus*
West Nile Virus[7]	*Culex pipiens* complexe, *Cx. modestus,* *Cx. perexiguus, Aedes cinereus,*	Usutu[8]	*Culex pipiens*
Dengue	*Aedes aegypti, Aedes albopictus*	Malaria	*Anopheles sacharovi, Anopheles labranchiae* *Anopheles atroparvus,* *Anopheles plumbeus*
Sindbis	*Aedes cinereus, Culex pipiens*		

[6] The following mosquito-borne viral pathogens are not relevant for Europe at the moment and will not be given further consideration within this document: Eastern equine encephalitis; Ross River virus; Venezuelan equine encephalitis; Western equine encephalitis; Japanese encephalitis; St. Louis encephalitis.
[7] Migratory and non-migratory birds represent the reservoirs. Mosquitoes serve as amplification and bridge vectors.
[8] The Usutu virus is responsible for heavy enzootic outbreaks in bird population. In rare cases humans can be infected.

3. Legislation

The control of mosquitoes and mosquito-borne diseases is a public matter requiring national and international legislation and regulations. It is a topic of great complexity considering the inter-linkages at global level. Legislation and regulations should primarily be in line with the protection of the human population. Legislation regarding mosquito-borne diseases is still largely in the developmental phase in the European Region. Thus, risk-benefit related harmonization on an international and global basis should ideally be the ultimate goal of successfully handling vector-borne diseases.

3.1. International Health Regulations

The dissemination of mosquito-borne diseases, especially dengue and WNV, depends largely on international trade and travel. Therefore, the International Health Regulations (IHR) [9] produced by the WHO are highly relevant to the subject matter. At the beginning of the IHR document the following statement is made:

"With the support of WHO, the 194 States Parties to the International Health Regulations (IHR) have been implementing these global rules to enhance national, regional and global public health security. Key milestones for the countries include the assessment of their surveillance and response capacities and the development and implementation of plans of action to ensure that these core capacities are functioning by 2012.

In response to the exponential increase in international travel and trade, and emergence and re-emergence of international disease threats and other health risks, 194 countries across the globe have agreed to implement the International Health Regulations (2005) (IHR). This binding instrument of international law entered into force on 15 June 2007."

The IHR, in its fifth annex, include specific measures for vector-borne diseases (see Annex 1 of these guidelines). In the IHR, the WHO is requested to publish, on a regular basis, a list of areas where disinsection or other vector control measures are recommended for conveyances arriving from these areas. The IHR also recommends that aircrafts and ships leaving a point of entry situated in an area where vector control is recommended by WHO should be disinsected and kept free of vectors by the application of insecticides at the beginning of each journey. Ports and airports should also be kept free of possibly infected vectors, up to a distance of 400 meters. Additionally, if an incidence of mosquito-borne disease meets two or more of the four criteria in the decision instrument in the second annex of the IHR, the incidence must be reported under Article 6 of the IHR.

---

[9] http://www.who.int/ihr/IHR_2005_en.pdf, ISBN 978 92 4 158041 0

3.2. EU Regulation on biocides

In EU member states, the marketing and use of biocidal products is regulated by the Biocidal Products Directive (BPD) (98/8/EG), which has been replaced by the Biocidal Products Regulation (EU) No 528/2012 in September 2013. In addition to EU member states, the regulations are implemented by member states of the European Marketing Area (EMA)

Active substances of biocidal products are evaluated in an EU-wide process. Biocidal products can only be authorised if the active substance is included in the list of approved active substances. Biocidal products containing active substances that have been on the market before May 2000 may be distributed and applied until there is a decision in the EU-wide evaluation process. Insecticides that are applied for mosquito control fall under product type 18 (Pt 18-Insecticides, Acaricides). Active substances included for that product type in Annex I of BPD 98/8/EG or the list of approved active substances of BPR 528/2012, respectively, can be retrieved from the website of the European Commission[10] and in the future from the website of the European Chemical Agency (ECHA). Authorization for biocidal products is processed on a national level, and information about authorized products can be retrieved from the competent authorities. Lists of mosquito biocides are included in Chapter 6 of this document and are updated regularly.

A competent authority may authorize, for a period not exceeding 120 days, the placing on the market or the use of a biocide product which does not fulfil the conditions for authorization, if such a measure is necessary because of an unforeseen problem to public health, animal health or the environment which cannot be contained by other means. This is of special interest for nations where no suitable biocide products for mosquito control are authorized.

In the course of the evaluation process of biocides, several adulticides (e. g. Malathion) and larvicides (e. g. Chlorpyrifos, Temephos) have been phased out. With increasingly fewer active substances available for mosquito control, there is a risk that a lack of biocides may lead to emergency situations. Resistance in mosquitoes against pyrethroids that are predominantly applied as adulticides constitutes a severe problem in this context. Against this background, the development of new active ingredients, application of preventive measures and further strategies of IVM (Chapter 6, Section 6.3) is essential.

3.3. National and regional directives

National decision-making on mosquito control strategies and interventions should be supported by clearly defined structures. Each nation potentially exposed to invasive mosquitoes should develop and adopt directives for surveillance and interventions. The documents listed under Chapter 1.3 as well as these guidelines could serve as a basis for the development of such directives.

---

[10] http://ec.europa.eu/environment/chemicals/biocides/active-substances/approved-substances en htm

National authorities should have final responsibility for control and follow-up measures, even if the responsibility is delegated to local administrative levels, where the national directives could be amended according to specific local needs. Where control measures are necessary, attention should be paid to national regulations and permissions, if applicable. WHO (WHOPES) recommendations may be adopted, provided that these are in accordance with European law.

The global and regional strategic framework on integrated vector management (IVM) promote the improvement of vector control systems through evidence-based decision making, combinations of vector control methods, multi-disciplinary approaches and inter-sectorial collaboration. The IVM approach will improve the efficacy, cost-effectiveness, ecological soundness, and sustainability of vector control[11] [12].

4. Principles of Surveillance[13] and Monitoring[14]

4.1. General strategies

Valuable information on the occurrence and distribution of the most important mosquito species can be retrieved from maps prepared and regularly updated by VBORNET[15], but data from some member states are still lacking. Surveillance systems should be tailor-made to cope with risks in individual countries with regard to the vectorial capacities of mosquitoes, especially *Aedes albopictus*. The risk-dependent surveillance should have two components: surveillance of indigenous mosquito species and surveillance of invasive species. It is recommended that each nation should appoint a government authority responsible for the surveillance and control of vector mosquitoes.

Public health authorities need up-to-date information of the situation of invasive mosquitoes in order to judge the risk brought about by imported cases. Northern countries where the climatic conditions would limit the reproduction to a single generation and/or the eggs would have no chance to survive the cold season do not need a routine surveillance system. However, countries with climatic conditions that could allow for the survival of eggs and seasonal proliferation of invasive mosquitoes should plan for surveillance programs. To be cost effective, the selection of sites should include only focal points where the probability of detecting mosquitoes is highest. Examples of such sites are the final destinations of international trade and air traffic, stops along highways leading from the Mediterranean basin, container terminals along the Atlantic coast, international airports, and marinas with intensive

---

[11] WHO, *Global strategic framework for Integrated Vector Management. WHO document WHO/CDS/CPE/PVC/2004.10*. 2004, Geneva: World Health Organization.

[12] WHO, *Handbook for integrated vector management. WHO/HTM/NTD/VEM/2012.3. Available: http://whqlibdoc.who.int/publications/2012/9789241502801_eng.pdf*. 2012, Geneva: World Health Organization

[13] In the context of this document surveillance is defined as a longer-term continuous activity to obtain an overview of the mosquito situation within a defined region as the basis for decision-making processes and prevention. Details of monitoring data are components of surveillance activities.

[14] In the context of this document monitoring is defined as an activity of on-site recording and data collection to determine the presence and prevalence of mosquitoes.

[15] http://www.ecdc.europa.eu

yacht traffic during the holiday season in the Mediterranean and Black Sea. Special attention in surveillance is required for the trade in used tires and the import points of Lucky Bamboo (*Dracaena sanderiana*), with a focus on the Dutch greenhouses where *Aedes albopictus* is known to find suitable breeding conditions.

4.2. Methods and Tools

4.2.1. General

Appropriate tools should be available for monitoring the presence and population density of mosquitoes. Early warning systems are important to detect invasive species in new places and to update risk assessments on mosquito-borne diseases. The adoption of uniform criteria and standard methods of mosquito trapping in the European Region is desirable because it generates comparable data between countries. The establishment of a mosquito risk map is recommended as a Europe-wide early warning system. Such a risk map needs to be continuously updated during the mosquito breeding season.

It is important that the costs for monitoring, evaluation and data processing be planned and budgeted carefully. The monitoring program must be adjusted to the available funds and should be in line with the risk levels.

Population density surveys are long-term, routine activities, and therefore must be sustainable. Annual data recording starts with the onset of the mosquito breeding season and is terminated once falling temperatures inhibit mosquito activity. The selection of sampling sites should be representative, and include locations where population densities are known to be highest. In some instances, pre-existing monitoring sites may be modified by increasing the number of trapping sites based on a grid system.

If the area to be covered is too large, sentinel sites can be selected. Numerous tools for mosquito monitoring are commercially available. A detailed compilation is given in Annex 3 of the ECDC 'Guidelines for the Surveillance of Invasive Mosquitoes in Europe[16]. Once a given system has been adopted for monitoring and found satisfactory, it is advisable to maintain it. Changes may yield different results and may affect the flow of data. However, alterations might be justified in cases of harmonization between countries to adopt uniform standards. Handling and positioning of the surveillance tools is also important for obtaining consistent results.

Standardizing and optimizing trapping techniques is recommended in order to collect reliable data. Special attention must be paid to the selection of sampling sites. The arrangements of traps can be based on grid patterns with regular distances between the traps. This allows sustainability, reliable recording and evaluation of the data, which can then be transformed into risk maps, and finally entered into national and international information systems such as those developed and maintained by ECDC (VBORNET).

---

[16] http://www.ecdc.europa.eu

As a non-static approach, traps may be placed in hot spots following complaints by residents. It should be noted that all the tools to monitor mosquitoes yield only qualitative, or in the best case, semi-quantitative data. The number of mosquitoes caught in a trap is species dependent. Furthermore, traps may be in competition with nearby natural sites, which may be more attractive for blood meals or oviposition sites.

4.2.2. Monitoring of eggs

Ovitraps are used to monitor the presence of a given mosquito species or to estimate the population density based on egg counts. The design of standard traps is simple. They consist of a dark plastic container with a volume of about one litre. Two holes are drilled below the upper rim to allow excess water to flow out in case of rain. The trap is filled with water and a wooden or polystyrene board placed in the container in an angular position. The eggs are deposited by the mosquitoes on the oviposition support above the water surface. In order to prevent the development of larvae, it is advisable to add a larvicide, e.g. granules of *Bacillus thuringiensis israelensis* to the water. The oviposition supports should be retrieved and replaced at regular intervals, at least every two weeks. The traps should be rinsed thoroughly with water, before fresh oviposition supports are added. The boards are taken to the laboratory and checked under the binocular for the presence of eggs. Ovitraps yield only semi-quantitative results since they may compete with the attractiveness of nearby natural breeding sites.

4.2.3 Monitoring of larvae

This is done with commercially available dippers of standard volumes. The white graduated plastic dippers, which are fitted to a wooden or aluminum dowel, have a diameter of 125 mm and a depth of 50 mm. Dippers are used to check breeding sites for the presence of larvae and pupae, and to determine the effect of biocides by taking pre-and post-treatment samples. It is advisable to consider only 4th instar larvae and pupae, where the chance is high that they will develop to the adult stages. The systematic sampling of aquatic mosquito stages is not easy, because the microhabitat preferences of mosquito species should be well known. Sufficient samples of breeding sites should be taken in order to obtain statistically sound values.

4.2.4 Monitoring of adults

CDC traps

The CDC traps are the most frequently used traps for adult mosquitoes, the principle technique of which has not changed over the past 50 years. The traps are used to catch females in search of a blood meal. The attractant is CO_2 released from dry ice. Once the mosquitoes have reached the trap, they are sucked into a bag permeable to air by a battery-driven airstream. CDC traps are also equipped with a weak light as an additional attractant. CDC traps are used to monitor a wide range of mosquito species. The market offers different types and designs of CDC traps.

BG Sentinel traps®[17]

BG Sentinel traps are especially effective for capturing both females and males from *Aedes albopictus* and *Aedes aegypti*. They use a fan to simultaneously draw the mosquitoes into the catch bag and to produce an air current that resembles the plume produced by the mosquito host. Host attractants, e.g. human skin odours (BG-Lure for *Aedes albopictus* and *Aedes aegypti*), octenol or other attractants can be added to the air plume. Carbon dioxide from dry ice or an add-on system for CO_2 bottles will further improve catch rates for *Aedes albopictus* and *Aedes aegypti,* and is necessary for catching most other species.

Gravid traps

Specific traps are available to attract gravid female mosquitoes. Adult females are attracted by baits that release a mixture of odors mimicking natural oviposition sites. When the mosquitoes come within close distance from the trap they are sucked into it by a battery-driven air stream. Trapping of gravid females is important for monitoring the infection rate by arboviruses or other pathogens. Gravid traps are commercially available and are produced by several companies.

Mosquito Magnet®

'Mosquito Magnet' is a commercially available product based on CO_2 produced by the burning of propane. Mosquito Magnets can attract mosquitoes within a radius of 10 m and are preferentially used to protect persons outdoors. The attractiveness of Mosquito Magnets can be enhanced with short-distance lures, for example based on octanol. The Mosquito Magnet runs without interruption for up to one month. It is a useful, though costly, tool for continuous, long-term sampling.

Sticky traps

Sticky traps have been designed to monitor females seeking places for oviposition. After having been attracted by a lure, the mosquitoes stick to boards covered with glue. The traps need to be replaced frequently. The traps are not specific to mosquitoes and other non-target insects may also stick to the glue. Several designs of sticky traps are available on the market.

Human landing catches

Determining the landing rates on legs or arms is quite an efficient and specific method for monitoring anthropophilic mosquitoes. Location and time must be chosen carefully. Compliance with ethnic regulations is required.

4.3. Levels of surveillance

4.3.1. Surveillance in countries where vector populations are absent

In a number of countries, exotic mosquito species have not yet been established, possibly due to unfavorable or sub-optimal climatic conditions. Nevertheless, global warming as well as the possibility of stepwise adaptation of invasive mosquito species to new environments could justify the setup of mosquito surveillance systems in these countries. These surveillance

[17] Biogents AG • Weissenburgstr. 22 • 93055 Regensburg • Germany

systems should focus on the points of entry, and should be developed on a case-by-case basis in close collaboration between neighbouring states.

4.3.2. Surveillance in countries where mosquito vectors are regularly introduced

In countries where individual specimens of mosquito vectors are regularly introduced, but where vector populations have not established, a surveillance system focusing on the most probable points of entry should be set up, thus complying with the directives laid down in the IHR (Section 3.1). The relevant points of entry are harbours and airports. Traffic corridors, such as highways and railroads, originating from countries where exotic mosquitoes with vector competence are already established, should be surveyed for the target mosquitoes.

Ovitraps are the tools of choice for monitoring the introduction of exotic mosquitoes. The goal of monitoring by means of ovitraps is to attract gravid adults escaping at points of entry from cargos or from vehicles. Ovitraps may also catch individual mosquitoes originating from breeding sites in close proximity to points of entry. Due to the seasonality of mosquito breeding, monitoring the presence of target mosquito species is only required during the warm season from late spring to early fall. Ovitraps must be checked for eggs at regular weekly or bi-weekly intervals. As a rule, only a limited number of ovitraps are required, whereby positioning is essential, taking into consideration the flight range of target species.

There are several countries where information on the presence or absence of exotic mosquito species is still missing, for example, in the geographic region stretching from the Black Sea to the western shore of the Caspian Sea. To determine whether monitoring programmes are required, the best reference points are derived from models based on climatic data estimating the chances of proliferation and survival (eggs). These reference points can be compared with data sets from places where monitoring is established. Important meteorological reference values are isotherms during the potential breeding seasons.

4.3.3. Surveillance strategy in countries with established vector population

Surveillance should be adjusted to the mosquito species (Chapter 2, Table 1), whereby population density, the host exposure and vector competence play a key role. The dominance of *Aedes albopictus* in the scene of invasive mosquitoes requires special attention. *Aedes albopictus* has colonized parts of countries in the Mediterranean basin. Once firmly established in an area with favourable climatic conditions, *Aedes albopictus* cannot be eradicated. Surveillance has thus become a tool to follow the seasonal population densities to be used in decision making on mosquito control interventions.

4.3.4. Surveillance in case of autochthonous (indigenous) transmissions

Where autochthonous transmission of dengue or chikungunya have been confirmed, knowledge of the population density of vector mosquitoes is important to determine the risk of the disease spreading within the human population.

Since autochthonous transmissions are expected to increase over the years to come, more evidence of the correlation between the densities of vector populations and incidences of disease should become available. This may require the positioning of additional traps. The use of Geographic Information System (GIS)-supported systems should be emphasized to plot cases of indigenous transmissions on maps, with special reference to the disease, the number of associated cases and the local vector density.

5. Assessments of risks

5.1. General

The assessment and management of the public health risks of invasive mosquitoes is highly demanding. Risk assessment will be illustrated below for *Aedes albopictus*, for which the invasion, establishment and spread represents the most serious threat; the same general principles apply for other mosquito species. Risk assessment prioritizes public health considerations over the nuisance problem caused by the mosquitoes. Nevertheless, in many situations, the reduction of the nuisance caused by mosquitoes goes hand-in-hand with a reduction in public health risks.

The risk for autochthonous transmission increases with the population density of a mosquito vector. Single cases of introduced disease can occur in any human population. Such isolated disease incidences are not expected to lead to local transmission when the vector population density is low. However, once the vector population is above a certain density, the local transmission or occurrence of outbreaks of mosquito-borne diseases can no longer be excluded. Risk assessments are required as basis for decision making for interventions against mosquitoes. Factors such as life span, behaviour, population density and temperature, play an important role in the transmission of pathogens.

5.2. Establishment of risk levels for *Aedes albopictus*

Table 3 presents guidance to countries on the use of risk levels with recommended actions for *Aedes albopictus*. A number of risk levels have been identified for *Aedes albopictus*, ranging from absence to high population densities; for each risk level, recommended actions are given. The risk categories and actions are largely based on the guidelines that has been developed and used in France[18], and could be further adapted to the specific conditions in other countries.

Risk level 0 includes countries and regions where *Aedes albopictus* has not been detected, although the occasional introduction of individual specimens by traffic may occur. The climatic conditions do not allow the overwintering of eggs or the establishment of colonies of *Aedes albopictus*.

[18] http://www.sante.gouv.fr/IMG/pdf/guide_modalite_mise_en_oeuvre_plan_anti_dissemination_chikingunya_et_dengue.pdf

Risk level 1 refers to climatic regions where overwintering of eggs, deposited by invading mosquitoes, is possible and establishment of colonies of *Aedes albopictus* cannot be excluded. Here, the introduction of *Aedes albopictus* should be monitored with ovitraps placed at possible points of entry such as motorway service areas, seaports and airports. Since it is impossible to survey all potential points of entry, a careful selection has to be made. As soon as positive ovitrap catches are detected, the risk level of the site is increased to level 2.

Risk level 2 applies to areas where *Aedes albopictus* has been detected for the first time or is only present in single and well-confined foci. Pre-planned elimination programmes must be implemented. Post-elimination monitoring is important.

Risk levels 3 to 5 refer to increasing levels of established self-propagating and uniformly spread populations of *Aedes albopictus*. Generally speaking, the public health risk of mosquito vectors increases alongside with the nuisance problems caused by the mosquitoes. The critical thresholds for risk level 4 have where an average number of >200 eggs per trap is listed, requires probably more fine tuning taking into account site and environment specific factors such as extension of *Ae. albopictus* infestations and density of urban settlements

Table 3: Description of risk levels relevant for *Aedes albopictus*

Risk level	Criteria, definition	Recommended actions
0	*Ae. albopictus* is absent.	Climatic conditions limit the proliferation to one generation and the overwintering of eggs is exclude No measures required.
1	*Ae. albopictus* has not been detected.	Overwintering of eggs cannot be excluded. Monitoring of potential hot spots of entry with ovitraps and/or BG Sentinel traps at selected sites.
2	Individual specimens of *Ae. albopictus* have been detected	Attempt to eradicate with adulticides and larvicides around the positive ovitraps.
3	*Ae. albopictus* is established. Eggs have successfully overwintered.	Attempt to eradicate, or at least to block the extension and the spread to new sites. Intensification and extension of monitoring.
4	*Ae. albopictus* has reached a critical density: Average number of eggs per trap >200. Complaints by residents.	Large-scale intervention strategies come into force to reduce the population density. Increase in the number of traps per surface area. Initiation of adult trapping. Information of residents and a call to check and eliminate all potential breeding sites. Public health authorities must be informed.
5	Autochthonous cases of dengue and Chikungunya have been confirmed.	Immediate communication with national and international health authorities (ECDC). Immediate information of the local authorities. Prevention of the spread of the vector-borne disease. Intensive use of insecticide within given perimeters.

5.3. Indices for monitoring densities of *Aedes* species

5.3.1 General

A large amount of literature is available covering different indices to determine the presence and the population densities of container breeding *Aedes* spp. and to estimate the risks of outbreaks of mosquito-borne infectious diseases. The majority of studies originated from tropical regions. The studies have demonstrated that the population densities of the immature *Aedes* stages correlated well with the prevalence of dengue. Most studies concentrated on post-epidemic outbreaks to confirm the validity of indices. Fewer field studies have been conducted on prediction or risk assessment of dengue epidemics.

A general overview shows that indices can assist in risk assessments and provide useful warning signals needed to initiate proactive control measures. The indices may be adapted to regional conditions. More than one single index may be considered to obtain sound data on risk situations. The main focus of available indices has been *Aedes aegypti* in connection with the transmission of dengue, but the same indices can also apply for *Aedes albopictus.*

5.3.2. Egg index

- This is the average number of eggs deposited in ovitraps over a given period, as a rule between two to four weeks.

5.3.3. Larval/pupal indices

- House index: The percentage of houses infested with larvae or pupae.
- Container index: The percentage of water-holding containers infested with larvae and pupae.
- Breteau index: The number of positive containers per 100 houses inspected. This is the most commonly used index[19].

  In the case of *Ae. albopictus* the container index is probably the most meaningful since important breeding sites are also found on public ground. Only L_4 and pupa should be considered. Younger larval stages have often high and irregular mortality rates.

5.3.4. Adult indices

- Landing rates on humans over a fixed period of collection time are the most sensitive means of estimating adult population densities. Ethical clearance is required.
- Catches with adult traps of different designs.
- Complaints by residents about biting activity represent an additional risk indicator. The location of complaints can be recorded on a map, and correlated with the number of *Aedes albopictus* eggs found in nearby traps.

---

[19] For example, the threshold of the Breteau index defined by the Ministry of Health of Malaysia is set at 5% (World Academy of Science, Engineering and Technology 58, 2011, p.572.

6. IVM based control strategies with emphasis on exotic species[20]

6.1. General aspects

Every mosquito control programme should adopt locally appropriate control strategies. The implementation of each control strategy must be based on a well-structured surveillance programme (see Chapter 4), which should be adapted to a clearly defined goal (e.g. early detection of an exotic species to avoid its establishment) to enable assessment of the effectiveness of interventions to reduce the risk of pathogen transmission.

The spread and establishment of an exotic species is mainly regulated by biological and ecological variables that determine whether an area is suitable for the mosquitoes. At present two scenarios can be defined for Europe:

- Regions stretching from Mediterranean to the Black Sea provide favourable climatic conditions for the exotic species *Aedes albopictus and Aedes aegypti.* In these areas, the priority is to maintain the existing mosquito populations at manageable levels in order to reduce the risk of transmission and to reduce nuisance caused by the mosquitoes.

- In regions with sub-optimal conditions for the exotic species *Aedes albopictus and Aedes aegypti*, it is known that mosquitoes are being imported on a regular basis. In this context, rapid elimination of the introduced mosquitoes through appropriate surveillance and control strategies is crucial. The surveillance programme should define the newly infested areas for immediate action and evaluate the outcome of the intervention.

Above all, the introduction of alien species should be prevented. Therefore, it is important to understand the pathways of introduction. The goal should be, first, to avoid, and second, to stop further invasions of exotic mosquitoes, especially *Aedes albopictus*. This could be achieved by targeted government regulations in close cooperation with control and regulating agencies, as well as trade companies. Points of entry like harbours, airports, railroads and highway traffic deserve special consideration. The spread of *Aedes albopictus* is particularly associated with the trade of used tires and exotic plants. Containers importing critical goods should be regularly inspected when they arrive in their country of destination and, if exotic species are found, immediate control measures are necessary. Regulation of the trade on used tires is urgently needed at the national level.

The WHO, ECDC and EMCA play an important role in designing mosquito control strategies and developing recommendations for appropriate control techniques. The three organizations have the infrastructure and the capacity to develop regional networks to define hot spots for

[20] IVM: Integrated Vector Management, the common approach to mosquito control.

intervention. Such networks should cover all European countries, not just for EU member states. Countries should consider the use of WHO-recommended control techniques. To facilitate cooperation and data sharing at the European Regional level, it is desirable that regulatory structures should be harmonized and coordinated between countries. A competent group of experts (e.g. members of EMCA) should lead the initiative for containment and control of invasive mosquitoes in close cooperation with WHO, ECDC and the national regulatory authorities.

As a general principle, it is advisable that mosquito control should prioritize the control of immature stages over the adult mosquito stage. Immature stages are confined to specific aquatic breeding sites, particularly in the case of 'container breeders', whereas the adult mosquitoes can spread out within a perimeter of several hundred meters from their breeding grounds. In addition, the control of aquatic stages generally has less negative impacts on the environment as compared to the control of adult mosquitoes. Nevertheless, in situations where transmission of pathogens has taken place, adult mosquitoes as source of infection must be controlled within the recommended distance from the infection sites, considering the average migration perimeter of major container breeding vector species.

A contingency plan should be developed at national levels, and emergency units formed and activated in the case of an epidemic. In this regard, a useful example is provided in the French guidelines[21].

6.2. Proactive measures in case of risk of transmission

Appropriate proactive measures should be initiated once population densities of vector mosquitoes reach a critical level above which the autochthonous transmission of arboviruses can no longer be excluded. This may include the following steps:

- Stepping-up the information exchange between the national and local authorities responsible for public health and mosquito surveillance.
- Information exchange between international and national organizations involved in the surveillance and intervention network.
- Recommendations to the public, travellers and tourists on how to prevent mosquito bites.
- Calling on local residents to eliminate any stagnant water and water-holding containers on private properties.
- Treatment of breeding sites with larvicides, where appropriate.
- Treatment of high-risk public areas with adulticides, where appropriate, at times of high vector mosquito densities.
- General increase in monitoring activities.

[21] http://www.sante.gouv.fr/IMG/pdf/guide_modalite_mise_en_oeuvre_plan_anti_dissemination_chikingunya_et_dengue.pdf

6.3. Mosquito control methods considering principles and components of integrated vector management

A number of methods are available for mosquito control, including physical, biological, environmental and chemical methods. Each method has its strengths and weaknesses. Within the context of Integrated Vector Management, the selection and timing of a method or combination of methods should be based on surveillance data and evidence of cost-effectiveness of the interventions in achieving the expected outcomes. It is recommended that chemicals are used as method of last resort. It has to be noted that many insecticides, among them agents used for mosquito control, are under review by the European Union. Thus the list of authorized biocides will undergo changes over the years to come. Furthermore the safety of biocides used in mosquito control is crucial since they are applied within or in close proximity of human settlements or in ecologically sensitive wetlands.

6.3.1. Physical control

Physical control measures include:

- **Source reduction.** This is the most important measure to prevent breeding opportunities for mosquitoes. Wherever possible, even small spots of stagnant water have to be removed or changed weekly. Water must be stored in mosquito-proof containers to prevent egg deposition.
- **Avoidance of mosquito-human contact**. Personal protection can be achieved with repellents, for example, containing DEET or Picaridin. New products can also be used outdoors as repellent barriers. Insecticide vaporizers or mosquito coils and insecticide-treated materials can prevent mosquitoes entering houses or will kill mosquitoes inside the premises. In special cases, clothing, window screens or curtains may be impregnated with pyrethroids.

6.3.2. Microbial control agents

Microbial control agents widely used against the larval stages of mosquitoes are based on the two spore forming bacteria *Bacillus thuringiensis israelensis* and *Lysinibacillus sphaericus* which produce during the sporulation process mosquitocidal proteins.

6.3.2.1. *Bacillus thuringiensis israelensis*

Bacillus thuringiensis israelensis (Bti) products are the most widely-used biological control agents against mosquito larvae. During the sporulation process, Bti produces an array of mosquitocidal proteins highly toxic to the larval stages of most mosquito species and blackfly larvae. Bti products are highly effective, target specific, easy to handle, and with least negative effects on human health and the environment as compared to other products. They are therefore especially suitable for community participation. Numerous different formulations are available on the market. A selection of Bti-products is listed in Table 4.

Table 4: Overview of important Bti products based on strain AM65-52 and strain SA3A

Trade names	Specifications/Properties	Comments
Vectobac®	Based on strain AM65-52 Formulations: • Aqueous suspensions, • Water dispersible granules, • Tablets, • Icy Pearls used in Germany.	The content of the active ingredient is measured in International Toxic Units (ITUs). Depending on the formulation, the ITUs are adapted for the sites of application.
Teknar®	Teknar SC is a liquid concentrate based on the spore-minus strain SA3A.	The potency is 1200 ITUs against *Ae. aegypti* larvae.
Vectobac® products in Germany	Vectobac WG Icy Pearls (Vectobac WG-IP). Vectobac DT/Culinex tablets.	Does not contain living spores.

6.3.2.2. *Lysinibacillus sphaericus*

Lysinibacillus sphaericus (Lsph) (formerly known as *Bacillus sphaericus*) is also a spore-forming bacterium, producing a so-called binary toxin. Lsph is especially effective against species of the genus *Culex*. Lsph products provide residual activity for several weeks. The risk of the development of resistance is relatively high. A recent product under the trade name Vectomax®, consisting of Bti and Lsph, provides increased persistence also against *Aedes* spp. Commercial products are listed in Table 5 and 6.

Table 5: Microbial Insecticide based on *Lysinibacillus sphaericus*

Vectolex®	Vectolex CG is a granular formulation based on *Lysinibacillus sphaericus* (strain ABTS-1743).	Potency 50 Bs ITUs. Vectolex provides good residual activity up to several weeks. The potency of Vectolex CG is 50 Bs ITUs.

Table 6: Microbial Insecticide based on a combination of *Bacillus thuringiensis* and *Lysinibacillus sphaericus*

Vectomax®	Vectomax-FG is a granular formulation combining *Bacillus thuringiensis subsp. israelensis (strain AM65-52) and Bacillus sphaericus 2362 (strain ABTS 1743.)* Also available as water soluble pouches.	Potency 50 Bs ITUs. Kills mosquito larvae immediately and provides persistence for several weeks. Especially promising for the control of *Ae. albopictus*. Recommended application rates 2.8 to 11.2 kg/ha depending of the water status and the density of the vegetation cover.

6.3.3. Biochemical and chemical control agents

Agents interfering with the development of mosquitoes or having neurotoxic effects should be used as method of last resort, to complement environmental management or biological control, and applied only when there is a risk of disease transmission. Besides biological products such as Bti formulations, insect growth regulators (IGR) such as diflubenzuron, methoprene or pyriproxifen could be used for larval control. Space spraying with adulticides such as pyrethroids (deltamethrin, permethrin or cypermethrin) or carbamates should only be applied in case of emergencies, e.g. when the risk of disease transmission requires immediate intervention.

6.3.3.1. Important biochemical insecticides

Insect growth regulators (IGRs)

IGRs disrupt the growth and development of insects. Since the target site of action for these chemicals is known and susceptible to disruption only in certain species at certain times during their life cycle, these materials are thought to have fewer side effects on non-target species than other chemical insecticides. There are two major groups of IGRs that differ in their modes of action:

- Chitin synthesis inhibitors, such as diflubenzuron, interfere with new cuticle formation, resulting in moult disruption.
- Juvenile hormone analogues, such as methoprene and pyriproxifen, interfere with the metamorphic processes affecting development to the adult stage.

Chitin synthesis inhibitors – diflubenzuron

Products in this category (Table 7), such as diflubenzuron, inhibit the enzyme chitin synthetase and thus the build-up of chitin. After an IGR treatment, symptoms are not immediately observed but become apparent once the moulting process is initiated. The degree of the disruption of shedding of the old cuticle (ecdysis) is related to the dosage used.

The compounds exhibit several unique characteristics. First, they are generally toxic when ingested by the immature target organism. The second characteristic concerns the ‘activity window’ of the compounds. The peak activity occurs during chitin synthesis of the insect. In practical terms, the susceptibility of larvae is greatest prior to each moulting. Treatments should therefore be done either at the time of the greatest susceptibility or alternatively, the treatment should have sufficient residual activity to span to the next ‘activity window’. The third characteristic concerns the prolonged larval life after a toxic dose is acquired. Even after exposure at the susceptible stage, the insect may live in a moribund state for many days before dying. Mortality can be recorded during larval and pupal stages as well as during emergence of adults. It is advisable to conduct treatments during the early larval stages of development. It should be noted that diflubenzuron can also have detrimental effects for non-target insects and should therefore not be used in aquatic systems with a high biodiversity of insects.

Table 7: The use of diflubenzuron for mosquito control

Trade names	Formulations	Comments
Dimilin® Novaluron® Device SC15®	Available as: • Tablets, • Granules, • Wettable powder, • Liquids (soluble concentrates).	To be applied in the following concentrations (active ingredient): • 25 to 100 g/ha, • 0.05 - 0.10 mg/l against container breeders. Diflubenzuron can have an effect over several weeks.

Juvenile Hormone Analogues (JHA)

The natural juvenile hormone, in relation to the moulting hormone ecdyson, regulates the moulting process from the larval to the pupal stage. Upsetting the level of juvenile hormone at certain periods during the life history will adversely affect metamorphosis. The effect of the JHA compounds is primarily seen during the larval-pupal transformation, and may result in various degrees of incomplete metamorphosis. Treating early larval instars will have very little effect on metamorphosis, since the requirement for larval-larval moult is a high concentration of the hormone. However, if the last larval instar is treated with JHA when in the natural process of metamorphosis the juvenile hormone level dramatically decreases, the result is abnormal pupation and/or incomplete adult formation. The eco-toxicological effects of JHA have been extensively investigated. The toxicity to vertebrates is extremely low, e.g. the oral LD50 of methoprene for rats exceeds 34'500mg/kg.

Methoprene, fenoxycarb and pyriproxyfen

Methoprene is a commonly used mosquito control substance outside of Europe. It is available in liquid, pellet and briquette formulations, which allow considerable flexibility at the operational level. The persistence of these methoprene formulations is up to 10 days. The pellet formulation releases an effective level of methoprene for approximately 30 days into artificial water containers, tires, waste treatment ponds, man-made depressions, and tree holes. Depending on the biotic and abiotic factors of the breeding site, the application rate ranges from 3 – 12 kg/ha.

For long-term control, briquettes of methoprene or pyriproxyfen are perhaps the principal choice, especially where access to the breeding sites is difficult. Briquettes should be placed at a rate of 1 briquette per 9m^2 of water surface area. The residual effect depends on water temperature, water quality and water fluctuations but can be expected to persist for approximately four months in continental and Mediterranean climates.

Other JHA are fenoxycarb (a carbamate insect growth regulator), and pyriproxyfen (a pyridine-based biocide), which also suppresses insect embryogenesis, metamorphosis and adult emergence through hormonal imbalance. Products are listed in Table 8.

Table 8: Juvenile Hormone Analogues used for mosquito control

Compound/Selection of trade names	Properties	Selection of Formulations
Methoprene: Altosid®, Apex®, Diacan®, Dianex®, Kabat®, Minex®, Pharorid®, Precor®	Juvenile hormone analogue	briquettes and pellets
Fenoxycarb: Insegar®, Logic®, Pictyl®, Torus® and Varikill®	Carbamate insect growth regulator	liquids, pellets and briquettes
Pyriproxyfen: Admiral®, Nylar®, Biodac®	Suppresses embryogenesis, metamorphosis and adult emergence	granular, emulsifiable concentrates

6.3.3.2. Chemical control agents: Pyrethrins and Pyrethroids (Table 9)

Pyrethrins and pyrethroids are a group of neurotoxic insecticides. Pyrethrins are natural insecticide compounds that are extracted from the flowers of *Chrysanthemum* species. These natural products are unstable to UV light and temperature. However, because of their low mammalian toxicity, pyrethrums are preferably used for the control of mosquitoes and other indoor pests. Pyrethrum extract is also incorporated into mosquito coils. The smoke repels, knocks down or kills mosquitoes.

Table 9: Pyrethrins and Pyrethroids for the control of adult mosquitoes

Pyrethrum/pyrethroids	Properties	Main uses
Pyrethrum	Natural insecticide produced from flowers of Chrysanthemum spp. UV-sensitive	Coils for indoor and outdoor use for personal protection.
Deltamethrin	Synthetic compound with improved UV-stability	Used outdoors and indoors
Permethrin	Synthetic compound with improved UV-stability	Used outdoors and indoors. Impregnation of fabrics to protect from bites.

Pyrethroids are synthetic compounds with higher stability against UV-light, and may show, depending on the molecular structure, an increased mosquitocidal activity. Due to their broad spectrum of activity, pyrethroids have to be used with great care when applied in the outdoor environment. Pyrethroids are also toxic to beneficial insects, including honeybees and natural enemies of common pests. Fish toxicity is of particular concern in view of the potential use of pyrethroids in or close to aquatic habitats. It should be noted that WHO does not recommend pyrethroids for control of mosquito larvae.

Pyrethroids are recommended in special circumstances for:

- Disinfection of aircraft
- Personal protection: pyrethroid-impregnated nets and clothing
- Household formulations: mosquito coils and electric mats containing a pyrethroid.

6.3.4. Control by predators

The developmental stages (egg, larvae, and pupae) of most vectors are vulnerable to attack by predatory insects, spiders, copepods or small fish. These predators are beneficial organisms that should be conserved or augmented, where possible. Chemical larviciding aimed to kill mosquito vectors will also affect the predators. The best-known aquatic predators of mosquitoes are fish, especially the mosquito fish *Gambusia affinis.* In Europe, only the use of native fish with the emphasis on cyprinids is allowed. The introduction of non-indigenous fish species is banned to avoid interference with the ecosystem.

6.4. Mosquito control supported by community participation

6.4.1 General

The management of mosquito populations at the community level requires a multidisciplinary approach, involving entomologists, community representatives, local politicians, civil engineers, civil society organizations, and behavioural scientists.

The majority of breeding sites for *Aedes* spp. in urban environments are human-made. Urban areas provide a wide range of breeding sites, ranging from flower vases in cemeteries, water barrels, buckets, cans, water catch basins, bird baths, tree holes and many more artificial and natural water bodies. Consequently, mosquito control can only be successful when local residents are involved in environmental management.

Programme authorities should plan and evaluate the best strategy to achieve community participation in mosquito control, including a system of local municipal regulations and inspections. Penalties for non-compliance of residents may also be considered. The successful inter-connection between the vertical (regional authorities) and the horizontal (community) organizational structures means that the people become ‘actors’ instead of ‘spectators’. The programme must enable people to contribute to the solution of their mosquito problem related to their own settlement. This can be achieved by a comprehensive campaign of instruction dealing with the biology of mosquitoes, simple sampling methods, and straightforward methods of control such as environmental sanitation, as explained by means of websites, the distribution of information via leaflets to households, television and radio spots, daily newspapers, workshops in schools, practical demonstrations, posters and videos. Thus, ‘help through self-help’ can be achieved. It is important to keep the level of motivation high over a long period.

Cemeteries are of special concern because of the continuous availability of standing water, allowing mosquitoes to proliferate. Water in flower vases and other small containers should be exchanged weekly. Vases can also be filled with sand to prevent oviposition. The checking and handling of water should fall into the responsibility of employees supervising cemeteries.

6.4.2. Specific points for strengthening of public awareness

Capacity building, public awareness and community participation are essential proactive measures for reducing the threat of mosquitoes. Information of the public is extremely challenging. Selection of communication tools, timing, and public address intervals are important. The intensity of information must be carefully adjusted to the risk exposure in order to maintain an appropriate level of public awareness. The communication channels to create public awareness are summarized in Table 10.

The main contribution expected from the public is the removal of breeding sites on private properties to prevent the presence of mosquitoes. The elimination of stagnant water is primarily a measure of self-protection, especially in the case of the container-breeding mosquito species. *Aedes albopictus* has a very limited flight range, not exceeding a few hundred meters at the most. Private properties in urban areas usually have a range of small water bodies that can serve as *Aedes* breeding sites, ranging from flower vases, water barrels, buckets, cans, birdbaths, and other artificial and aquatic biotopes and natural water bodies.

Table 10: Communication channels to create public awareness on mosquitoes with vector potential.

Communication channel	Platform	Remarks
Internet	Links to websites: • Google • Wikipedia • Facebook • YouTube	The information accessible via electronic media must be updated continuously and old information removed.
Print media	News, background articles, interviews, documentaries, scientific background information.	Panic reactions should be avoided. Local information services should explain the measures taken by the authorities.
TV	News, interviews, documentaries, spots.	Panic reactions should be avoided. Spots are expensive.
Tailor-made information	• Flyers displayed in: markets, tourist offices, camping sites, pharmacies. • Cartoons.	Printed information distributed to individual households. They should be simple and easily comprehensible. The text and illustrations should be limited, and not exceed one page.
Schools	• Primary and high school education in entomo-logy and vector biology.	Tailor-made teaching programs appropriate to age and level of education. Questions could be included in exams.

Information leaflets for distribution to the public (including tourists) have been designed in several countries infested by *Ae. albopictus* (e.g. Switzerland, Italy, and Spain). The hardcopy flyers should refer to websites, which are regularly updated. An example of a functioning website is given by the Greater Los Angeles County Vector Control District[22]. The public should also have access to hotlines. Evaluation is needed to assess the impact of the communication tool on public awareness.

6.5. Geographic Information Systems (GIS)

GIS dealing with spatially-related data have become widely used tools by professionals in research, government and industry in a range of disciplines. Modern information technology allows the integration of GIS with database technology, and with mobile field-data collection systems supported by a Global Positioning System (GPS).

GIS and information technology can greatly improve the surveillance, logistics, evaluation and documentation of mosquito control operations. The possible applications range from direct digital site-mapping using GPS-assisted mobile devices, to timely aggregation of operational reports. A spatially referenced database containing all features of interest is the basis for all further data collection and analysis. This spatial element enables thematically related features (e.g. occurrence and population densities of certain species, vegetation type, zones of nuisance or disease) to be organized in separate layers of information, which can then be analysed and displayed in a user-defined context. The following is an outline of possible applications:

- Analysis and query of available digital maps, aerial photos or satellite imagery, and thematic maps (e.g. hydrology, climatic features, plant inventories), in order to determine potential larval habitats.
- GPS-assisted field data collection and breeding site inspection (detailed habitat mapping, larval and pupal survey). The use of handheld systems that synchronize data with the main database allows accurate and timely processing of results and database updates.
- GPS-assisted operations allow the tracking and direct digital documentation of field activities (e.g. application activities).
- Forecasting of time and location of appropriate control activities, based on correlations between the spatial occurrence of triggering events for larval development (e.g. local weather data, the potential of larval development sites, and the results of current survey data).

22

- Preparation of operational maps to improve logistics, to calculate the quantities of control materials and manpower required, and to calculate the duration and costs of treatment.

- Defined database and map queries which give immediate access to information stored in the database. The results of the queries can then be visualized and printed in the form of standardized thematic maps, graphics or tables.

6.6. Insecticide application techniques and tools

The success of an insecticide application depends very much on the quality of the equipment used, and its performance. Manuals on mosquito control refer to a wide range of application equipment for delivering control products to the target site. Here, the more commonly used application equipment in mosquito control is described, according to WHO/CTD/WHOPES.

6.6.1. Hand-operated compression sprayer

These sprayers are designed to apply insecticides to breeding sites or onto surfaces with which the insect will come into contact. The technical product and water are either mixed before filling the tank or mixed within it. The tank is then pressurized by a hand-operated plunger. A trigger on the stem of the sprayer controls the release of the material through a nozzle. Filtering the water while filling the sprayer, routine maintenance by qualified personnel and routine nozzle checks and calibration, are essential in maintaining the equipment's effectiveness.

6.6.2. Mist blowers (power-operated)

This equipment can either be portable or vehicle-mounted. Portable knapsack mist blowers are powered by a two-stroke engine, producing a high velocity air stream in which the insecticide formulation is atomized as a fine mist. The volume discharge can be adjusted through flow restrictors. At high flow-rates, large droplets are produced. Large droplets coat surfaces, whereas the smaller droplets act as an aerosol impacting insects in flight or at rest. Although the formulation is diluted in water, the overall volumes applied with mist blowers are still relatively small. Knapsack mist blowers can cover a large area in a relatively short time, and provide ease of access to areas which vehicle-mounted equipment cannot reach.

6.6.3. Aerosol generators (power-operated)

These are referred to as cold aerosol or cold foggers, and dispense ULV applications of the technical material diluted in oil or water. Only formulations recommended for ULV use by the manufacturer should be applied with this equipment. These machines can be hand-held or truck mounted, depending on their size. The volume of material used per unit area is much lower than with thermal foggers or mist blowers. By using ULV aerosol generators, a larger area can be covered more quickly. With ULV aerosol generators, the calibration and accuracy of the droplet size is particularly important.

6.6.4. Thermal foggers (power-operated)

These machines are either portable or vehicle-mounted, and are preferred by some vector control agencies where the dense fog generated is perceived as 'more effective'. However, the same feature can be construed as quite repulsive, especially by persons who express environmental concerns. The droplet size is far less controlled than with ULV machines, and a wide range of droplet sizes from less than 1-200µm are produced. In such situations, some insecticide will be wasted due to convection currents or early fall out. Moreover, the heat from these thermal foggers can be detrimental to the control product used.

6.6.5. Aerial application equipment

Large-scale and emergency vector control programs often employ aircrafts to apply insecticides. Aircrafts are well suited for rapid treatments of large areas where there is no access to the target-sites, or where the vegetation is dense. Accurate placement of the insecticide formulation is usually more difficult with aircraft than with ground application equipment. However, currently available computerized technology provides very accurate treatment of the target area (GIS-based technology).

6.7. Recapitulation of the requirements for successful mosquito control programmes

6.7.1. Baseline collection of entomological and ecological data

Baseline data are needed to plan for planning of the intervention strategies and to assist in the evaluation of the impacts on mosquito populations. A baseline survey should include surveillance of the occurrence of mosquito species, with special attention to exotic species, and their population dynamics in relation to abiotic (e.g. climatic) factors. Decisions on the type of traps, location and number of traps have to be carefully planned and evaluated.

Knowledge about the biology, ecology and seasonal dynamics of the relevant mosquito species is essential for implementation of cost-effective and ecologically sound control programmes. Thus, a surveillance system should be in place to determine the species composition, abundance and population dynamics in relation to the conditions of a location, as well as the spatial and temporal patterns of mosquito migration or invasion.

Methods for monitoring eggs, larvae and adults have been described in Chapter 4. Samples are preferably taken at regular intervals. Upon collecting the adults from traps, the mosquitoes should be identified and, if exotic mosquitoes are present, the authorities, such as health departments and national environmental agencies, should be informed. Larval collections should be taken at regular intervals from a variety of potential breeding sites within the control area. Usually ten or more dips with a standard dipper are taken per breeding site to obtain comparable data on abundance. The larval instars are recorded and an adequate number of larvae are taken to the laboratory for species identification.

6.7.2. Mapping of breeding sites

Mapping of breeding sites is essential for planning environmental management interventions or larvicide applications. For container breeding *Aedes* species, it is advisable to assess indices, like the Breteau index, house index, or container index or pupal densities in most productive areas. A threshold of mosquitoes should be considered in order to initiate control activities (e.g. regularly more than three exotic mosquitoes per trap or eggs in ovitraps). The use of a Geographic Information System (GIS) (section 6.5) will be helpful to assist in planning surveillance and control activities and evaluation of effects.

6.7.3. Selection of mosquito control methods and insecticide application techniques

The selection of mosquito control methods should be based on a careful appraisal of advantages and disadvantages of each method. The appraisal could include criteria of cost, effectiveness, safety, resistance, community involvement and policy support.

For insecticidal methods, the appropriate dosages should be determined for the selected application method and adjusted for use under local conditions. Optimal use of the product requires homogenous dispersal of the material in the recommended dosage over the target area in a certain period of time. For instance, the volume of water used for a dilution depends on the spray system (size of the nozzles, pressure of the system and speed of application) to obtain the desired dosage per area. The rate of emission in relation to the speed of application must be calibrated before routine treatments, to ensure application of the correct dosage.

The selected equipment must also be correctly adjusted, operated and maintained. Knowledge and training on how to use and maintain the application equipment, and supervision of spraying teams, are important factors for successful mosquito control.

6.7.4. Training of field staff

To generate competencies on mosquito surveillance and control activities, adequate training of field teams is required. Field operations should be thoroughly planned and organized, while the control team should remain flexible enough to respond to each individual situation. The leaders of field teams should be trained in the identification, biology and ecology of the target mosquitoes, appraisal of available mosquito control methods, the mode of action of the control agents, and the application techniques. The teams should be briefed regularly and meet for refresher training. In cooperation with WHO and ECDC, EMCA should take the lead in organizing workshops dealing with the above-mentioned issues and prepare field manuals which have to include guidelines on communication techniques and community participation.

6.7.5. Governmental approval requirements

Governmental approval for control activities or the use of mosquito control agents is a legal requirement. The application documents for approval should contain data on the materials and formulations in use, strategy of control, dosages, application techniques, the threshold for the control operation, assessment of the mosquito density and ecological considerations. Governmental application formalities and the flow of information must be carefully discussed, and each step of action and results should be shared with the respective authorities.

Regular evaluation of the effectiveness of the operation should be performed by external experts.

6.7.6. Public information systems

An intensive public relations network is the basis for transparency and involvement of the public in the programme. Appropriate and timely information will encourage community participation in mosquito control and will increase public acceptance of the treatments. At regular intervals the media should be informed about the progress of operations.

7. The role of medical institutions and public health authorities

7.1. General

The requirements for the notification of mosquito-borne diseases are not the same in all countries in Europe, except for the directives that have been specified under the IHR. A disease may be notifiable in one country but not in another.

To prevent the transmission and spread of human infections, it is vital that the detection and diagnostic reports of mosquito-borne disease cases by medical institutions are promptly communicated, via the responsible public health institutions, to the entomologists involved in the surveillance and control of mosquito populations.

Even where the disease is not notifiable or notification laws allow a certain delay of time concerning the communication of such cases, the communication linkage between medical institutions and the entomologists will be important. A continuous flow of information will allow the timely access to details on the number and location of imported or autochthonous cases needed to prevent spread of the disease. Nevertheless, regulations on the protection of data privacy have to be respected.

It is essential to know whether infected persons reside in areas where vector mosquitoes are prevalent, thus making immediate mosquito control interventions a priority. To execute these rapid measures, it may be necessary to release or adjust the national directives or statutory orders concerning the control of vector-borne diseases. In this context, it would be valuable to establish a pan-European communication network that would administer a central databank. This entity would make available the required information on mosquito prevalence and disease incidence to the key institutions involved in the control of mosquito-borne diseases in individual member states.

7.2. National emergency plans

Ministries of public health in countries at risk of the transmission of mosquito-borne diseases should have national emergency plans at hand that can take effect when autochthonous cases (for example, dengue or chikungunya) have been identified. Impartial statements issued to the media are essential in order to avoid panic reactions and unnecessary financial losses, for example to tourism. Timing of statements and control actions will be a crucial factor in preventing spread of the disease. National emergency plans should include information and guidelines on the following items:

- Location where the case(s) were found, and information on the pathogen
- Number of persons affected and the distance between the affected persons
- Measures to be taken by residents living in the proximity to prevent the spread of infection
- Estimated densities of the vector population at the site were the infections occurred
- Estimated densities of the vector population in the region
- Information on breeding within the affected perimeter
- Treatments with insecticides at and around the sites where the infections began
- Treatments with insecticides in the affected region
- Further diagnostics regarding the pathogenic agent and its possible method of introduction.

8. Strengthening of international collaboration

8.1. General

The public health threat posed by invasive mosquito species, especially *Aedes albopictus* and *Aedes aegypti*, is not confined to national borders, or even the European Region, but North America, Australia, and New Zealand are currently confronted with very similar situations. In South America, Asia and parts of Africa, *Aedes albopictus* is also spreading, but in these regions *Aedes albopictus* will enter into competition with existing populations of *Aedes aegypti*.

Valuable information can be gathered from Australia and New Zealand on strategies to prevent the establishment of *Aedes albopictus*[23] [24]. In North America, *Aedes albopictus* began spreading from the Gulf of Mexico in 1985, and it has since become indigenous to 26 states, where it is under close surveillance. Available information suggests that California is the only US state where *Aedes albopictus* could be successfully eradicated. However, according to recent reports, *Aedes albopictus* has now gained a foothold in Los Angeles.

---

[23] Holder et al. 2010. A biosecurity response to *Aedes albopictus* (Diptera: Culicidae) in Auckland, New Zealand. J Med Entomol. 2010 Jul;47(4):600-9.

[24] Implementation Plan for *Aedes albopictus* Prevention and Control in the Torres Strait. Program. National Partnership Agreement on Health Services. www.federalfinancialrelations.gov.au.

8.2. Role of international organizations

International organizations such as WHO, ECDC, CDC and the international mosquito control associations EMCA and AMCA have an important role to play in coordinating and strengthening public awareness in the European Region about the risks posed by invasive mosquitoes. The international organizations serve as communication platforms, maintaining close ties with national health ministries. WHO is in the leading position to disseminate know-how, and has experts on hand to provide up-to-date health-related information. The ECDC provides an information platform for weekly updates of cases of vector-borne infectious diseases in the region. Information and experience from these international organizations in relation to the prevention of mosquito invasion or disease transmission could be adopted and adapted to European needs. Also, international organizations could provide, where meaningful, support in streamlining and harmonizing public awareness.

8.3. Pan-European network

A mosquito information network should eventually cover and be accessible to all European WHO member states from the Atlantic coast to the western border of the Caspian Sea. The information network could be administered and managed by existing organizations, such as ECDC and WHO. VBORNET has produced region-wide maps and data banks on invasive mosquitoes, and these resources should be more widely used by member states. Also, the wealth of know-how within the EU and affiliated states should be shared with southeastern European member states of the WHO. As the basic network is already available, the costs will be modest.

8.4. Support for countries where vector surveillance has not yet been established

There are a number of European countries, especially in the region stretching from the Black Sea to the western border of Caspian Sea, where information on the establishment of potential mosquito vectors is still missing. However, the expertise and experience on developing mosquito surveillance systems is available from south-western Europe. Hence, pan-European collaboration between these two sub-regions can help fill the existing gaps in surveillance systems.

8.5. Information exchange and collaboration at global level

Outside of Europe, other regions are also increasingly confronted with identical or similar problems of invasive mosquitoes. Therefore, the establishment of a global platform for the exchange of information regarding mosquitoes with vector potential is highly desirable. At the core, such a platform should include an interdisciplinary group of experts in the fields of entomology, epidemiology and public health. Ideally such a platform would be led and coordinated by WHO. The platform would gather and disseminate information at global level and, where necessary, organize expert meetings on priority issues.

The global databanks should incorporate data on incidences of disease caused by invasive vectors, which should include all cases of emerging diseases such as dengue and chikungunya. The data on both vectors and disease cases will provide insight into the role of invasive mosquitoes in disease transmission, thus serving as a tool for implementing proactive measures. The data banks should be continuously updated.

ANNEXES

Annex 1. Specific measures for vector-borne diseases, as stipulated in the ihr, 2005 (annex 5)

1. WHO shall publish, on a regular basis, a list of areas where disinsection or other vector control measures are recommended for conveyances arriving from these areas. Determination of such areas shall be made pursuant to the procedures regarding temporary or standing recommendations, as appropriate.

2. Every conveyance leaving a point of entry situated in an area where vector control is recommended should be disinsected and kept free of vectors. When there are methods and materials advised by the Organization for these procedures, these should be employed. The presence of vectors on board conveyances and the control measures used to eradicate them shall be included:

(a) In the case of aircraft, in the Health Part of the Aircraft General Declaration, unless this part of the Declaration is waived by the competent authority at the airport of arrival;
(b) In the case of ships, on the Ship Sanitation Control Certificates; and
(c) In the case of other conveyances, on a written proof of treatment issued to the consignor, consignee, carrier, the person in charge of the conveyance or their agent, respectively.

3. States Parties should accept disinsecting, deratting and other control measures for conveyances applied by other States if methods and materials advised by the Organization have been applied.

4. States Parties shall establish programmes to control vectors that may transport an infectious agent that constitutes a public health risk to a minimum distance of 400 meters from those areas of point of entry facilities that are used for operations involving travellers, conveyances, containers, cargo and postal parcels, with extension of the minimum distance if vectors with a greater range are present.

5. If a follow-up inspection is required to determine the success of the vector control measures applied, the competent authorities for the next known port or airport of call with a capacity to make such an inspection shall be informed of this requirement in advance by the competent authority advising such follow-up. In the case of ships, this shall be noted on the Ship Sanitation Control Certificate.

6. A conveyance may be regarded as suspect and should be inspected for vectors and reservoirs if:
(a) It has a possible case of vector-borne disease on board;
(b) A possible case of vector-borne disease has occurred on board during an international voyage; or
(c) It has left an affected area within a period of time where on-board vectors could still carry disease.

7. A State Part should not prohibit the landing of an aircraft or berthing of a ship in its territory if the control measures provided for in paragraph 3 of this annex or otherwise recommended by the Organization are applied. However, aircraft or ships coming from an affected area may be required to land at airports or divert to another port specified by the State Party for that purpose.

8. A State Party may apply vector control measures to a conveyance arriving from an area affected by a vector-borne disease if the vectors for the foregoing disease are present in its territory.