COST Action "Investigation and Mathematical Analysis of Avant-garde Disease Control via Mosquito Nano-Tech-Repellents"

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COST Mission

COST aims to enable breakthrough scientific developments leading to new concepts and products. It thereby contributes to strengthening Europe's research and innovation capacities.

www.cost.eu

COST Mission

In order to achieve its mission, COST endeavours to:

- Build capacity by connecting high-quality scientific communities in Europe and worldwide
- Provide networking opportunities for Early Stage Researchers (ESR)
- Increase research impact on policy makers, regulatory bodies and national decision makers as well as on the private sector.

Through its inclusiveness policy, COST supports the integration of research communities, leverages national research investments and addresses issues of global relevance.

International Cooperation

For over 40 years, COST has supported and actively promoted cooperation in science and technology, bringing together researchers from 36 Member States in a truly pan-European networking framework.
COST encourages the involvement of researchers from Near Neighbour Countries and allows participation of researchers from International Partner Countries in COST Actions.

COST Strategy

COST's interdisciplinary bottom-up research and innovation networks are effectively bridging the innovation divide and participation gaps in Europe and are providing a large spectrum of opportunities for young generations of researchers and innovators. Involvement in COST Actions both anticipates and complements the activities of the EU Collaborative Framework Programme (FP), spreading excellence across Europe and beyond.

Excellence and Inclusiveness

This policy is tailored to bring out excellence in science Europe-wide and clear away obstacles by creating cooperation opportunities for researchers, engineers and scholars from all COST Member States.

Features

Through bottom-up, open and excellence-driven COST Actions and activities, the policy nurtures talent and creativity. It is developed around three main elements :

- geographical spread
- career stage: involving early career investigators
- gender balance

Geographical spread includes less research-intensive COST Member States - COST *Inclusiveness Target Countries* (ITCs): BIH, **BG**, CY, CZ, EE, HR, HU, LT, LV, LX, ML, MN, PL, PT, RO, SL, SK, FYROM, SR, TR.

Excellence and Inclusiveness

Objectives

- identifying excellence in science and technology across Europe
- increasing research communities' access to funding and infrastructures
- triggering structural changes in COST Member States' national research systems

To reach these objectives, COST Action activities will focus on:

- leadership: encouraging researchers and institutions in ITCs to set up and lead COST Actions, as well as manage COST Action grants
- increasing researchers' visibility and connection, no matter their location, age or gender, to leading European science hubs

How COST works

COST funds pan-European, bottom-up networks of scientists and researchers across all science and technology fields. These networks, called 'COST Actions', promote international coordination of nationally-funded research.

COST Actions

COST does not fund research itself, but provides support for networking activities carried out within COST Actions.
COST Actions are bottom-up science and technology networks open to researchers and stakeholders, with a 4-year duration and a minimum participation of 7 COST Member States.
COST Actions are active through a range of networking tools, such as meetings, workshops, conferences, training schools, short-term scientific missions (STSMs) and dissemination activities.
COST Actions are open to researchers from universities, public and private research institutions, as well as to NGOs, industry and SMEs.

COST Action CA16227

Investigation and Mathematical Analysis of Avant-garde Disease Control via Mosquito Nano-Tech-Repellents

21.9.2017 - 20.9.2021

www.imaac.eu

IMAAC The Basic Objective

cost
EUROPEAN COOPERATION
IN SCIENCE & TECHNOLOGY

Disease

Vector borne diseases transmitted by daytime active mosquitos put a high health burden on the society

Control

Insecticides and repellents are available but hard to administer in an environmentally sustainable way

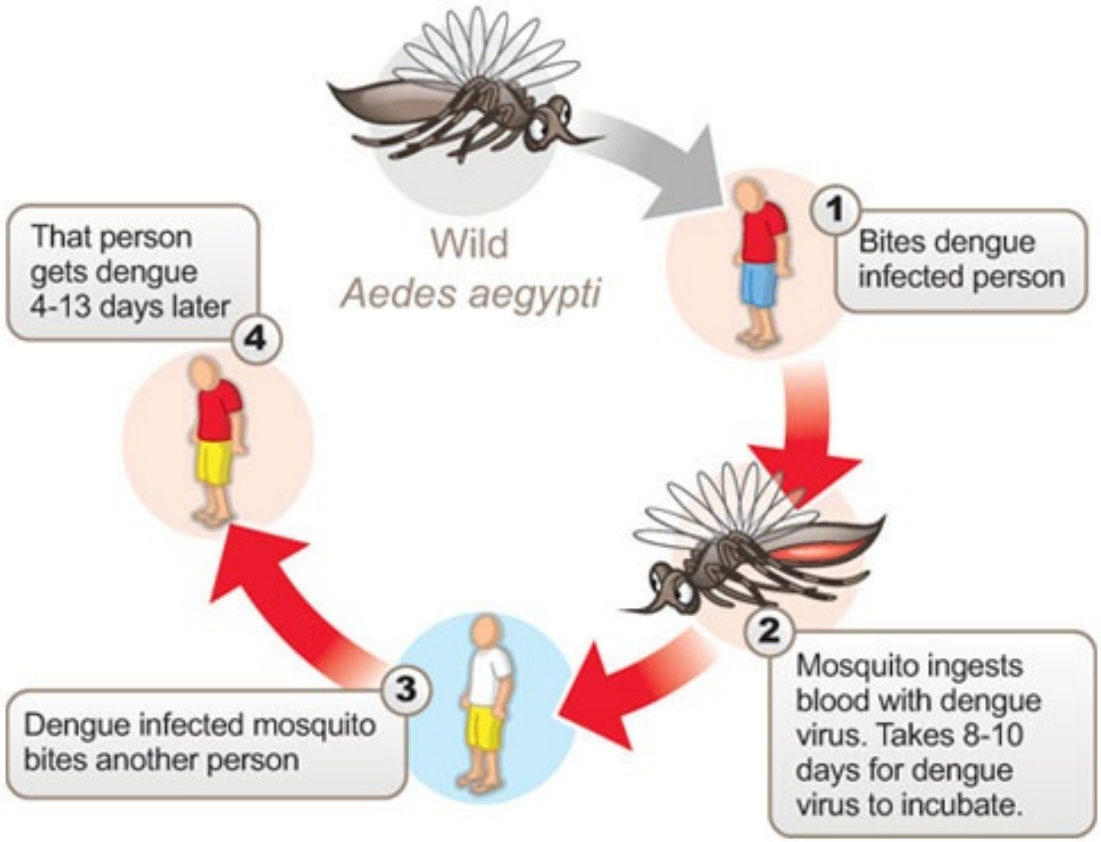
Nanoparticles

Use micro- and nanoparticles to release insecticides and repellents in a well controlled dosage

IMAAC Overview

IMAAC aims at investigation and mathematical analysis of the effect of avant-garde control measures in vector-borne diseases (VBD) involving day-time active mosquitos transmitting diseases like *dengue*, *Zika*, *chikungunya* and *yellow fever*.
The control measures involve new technologies in textile and paint products based on nano- and micro-particles releasing repellents or pesticides in well portioned dosage.
The study will also be expanded to scenarios using vaccines in combination with mentioned control techniques.
The main focus will be on dengue fever transmitted via *Aedes aegypti* and *Aedes albopictus* mosquitoes in synergy with existing EU-projects, but the application will have also positive effects on other vector-borne diseases.

VBD


Wild
Aedes aegypti
1
Bites dengue infected person
2
Mosquito ingests blood with dengue virus. Takes 8-10 days for dengue virus to incubate.
3
Dengue infected mosquito bites another person
4
That person gets dengue 4-13 days later

Aedes

- *Aedes* –daytime mosquito active early in the morning and in the evening before dusk
- In tropical areas, *Aedes* mosquitos cause more than 100 million symptomatic cases/year of viral diseases, such as dengue, yellow fever, chikungunya and Zika, and thousands of deaths.
- With increasing trade and travel, several *Aedes* species have been introduced into Europe and are now spreading spectacularly rapidly becoming a widespread significant public health risk which needs to be effectively addressed, as testified by recent cases of autochthonous chikungunya and dengue transmission.

VBD

- dengue
  - high fever, headache, vomiting, muscle and joint pains, skin rash
  - may develop into dengue hemorrhagic fever, resulting in bleeding, low levels of blood platelets and blood plasma leakage
  - secondary infection - more severe
  - vaccine available, limited efficacy
- zika
  - fever-like syndroms, asymptomatic
  - microcephaly, brain malformations in some babies
  - sexual transmission possible as well
  - no vaccination available
- chikungunya
  - high fever, joint pain, and rash
  - may become chronic, and lead to debilitation of the limb
  - no vaccination available

Dengue Distribution

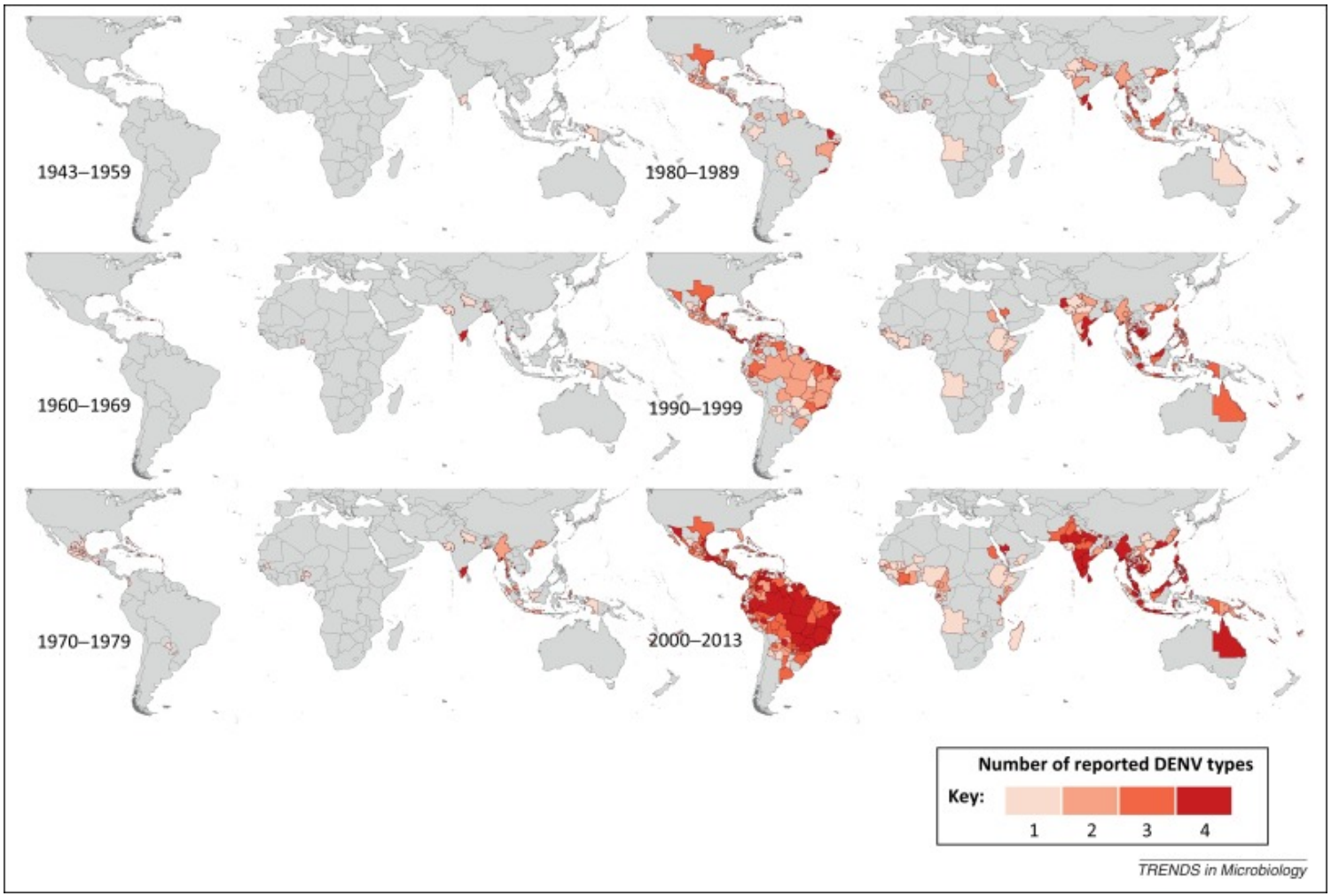


Figure: DENV Co-circulation. Cumulative number of DENV types reported by decade since 1943 (Messina et al. (2014) *Trends Microbiol.*)

Chikungunya Distribution

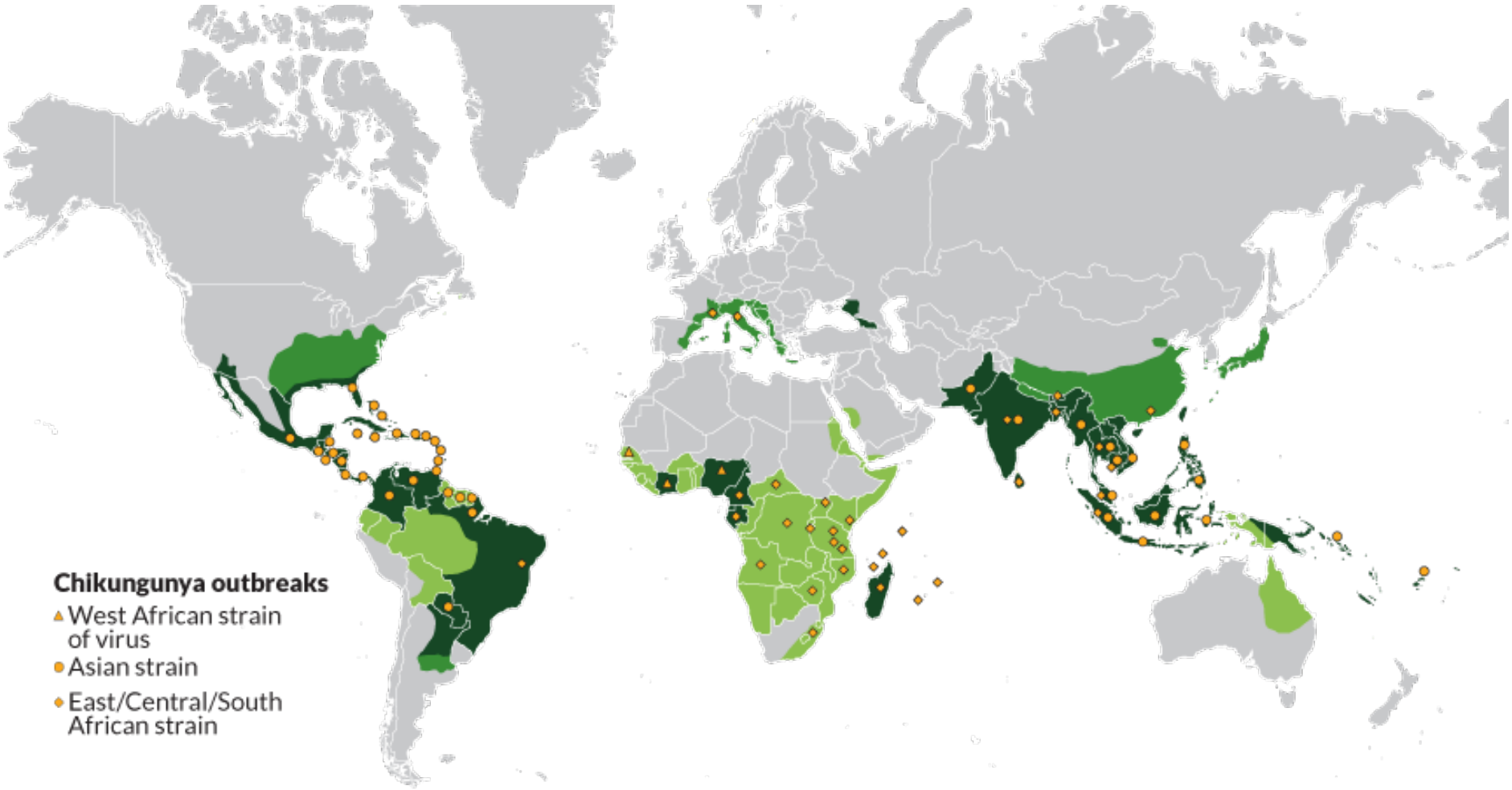


Figure: Chikungunya cases (Seppa (2014) *Science News.*).

Chikungunya Distribution

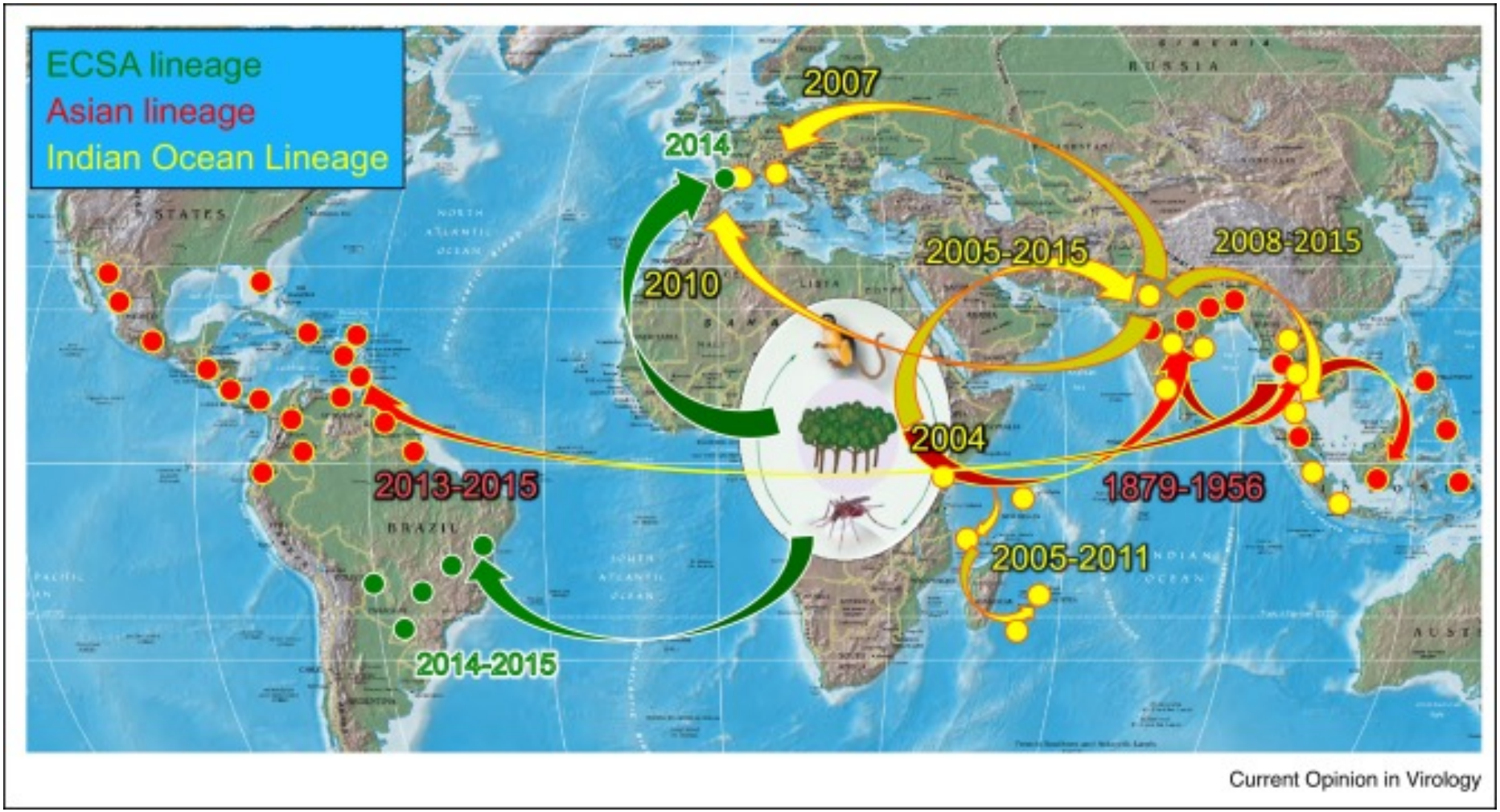


Figure: Chikungunya spread.

IMAAC Overview

Nano- and micro-particles are used in textile production for various purposes, and can be used to release chemicals like repellents and insecticides in a well-controlled rate.
First attempts in this direction have been made, but no efficacy studies could be performed yet. The spectrum of combinations of nano- or micro-particles, repellents, insecticides and types of textiles (or paint) has not been well studied.
Especially, efficacy studies in cases using these control measures in combination with vaccines are unchartered territories and mathematical modelling has to be developed.

IMAAC Overview

Main directions

- Bring together experts from epidemiology, biostatistics, mathematics, biology, nano-technology, chemical and textile engineering to implement new techniques to combat mosquito transmitted vector-borne diseases.
- Analyse how far such avant-garde measures can help to reduce the disease burden, eventually in collaboration with existing vaccines which turned out to have only limited efficacy on their own.

Structure

Chair Dr Peyman Ghaffari (PT)
Vice-chair Prof Ana Marija Grancarić (HR)

	WG Title	WG Leader
WG1	Mathematical analysis, data analysis, statistics	Prof Nico Stollenwerk (PT)
WG2	Structured population models and optimal control	Prof Hasnaa Zidani (FR)
WG3	Biological and epidemiological research on vector borne diseases focusing on avant-garde control measures	Prof Nataša Janev Holcer (HR)
WG4	Avant-garde control measures in combination with textile and paints using industrial applications	Prof Christian Fischer (DE)
WG5	Pilot field studies and their management	Dr Lauren Cator (GB)
WG6	Data-collection, communication and dissemination	Dr Markus Schwehm (DE)

WG1 & WG2

- Data analysis of mobility patterns is a core research area.
- Define theoretical tools to measure the efficacy gained from the real data related to disease cases, in case of discussed application of avant-garde mosquito repellents combating diseases using nano-micro-particles on textiles, paints and other materials. Action participants from other WGs perform pilot studies.
- Crossing between applied mathematics, statistical physics and epidemiology in relation to spreading of mosquito transmitted infectious diseases on large geographical areas including the complexity and stochastic effects in disease dynamics.
- Optimal control theory.
- Analysis of solutions to structured nonlinear population dynamics model with emphasis on existence, uniqueness, positivity, comparison results and large-time behaviour of the solution.
- Controllability of age-structured population dynamics.

Problems and challenges

1. Establish a clear understanding of the present status in mathematical modelings mimicking the effects of control measures combating mosquito- transmitted diseases in human populations.
2. Translate the information gained during the past GP1 to define the actual and future aims of each WG for the this and next GPs.
3. Translation of test results of samples with different repellents and insecticides in Mosquito Labs (performed by WG3, WG4 and WG5) into useful mathematical parameters for WG1 and WG2.
4. Attracting new members including instituations, companies and research-groups through networking and dissimination tools.
5. Development of new stochastical and epidemiological mathematical models including parameters mimicking the new generation of mosquito control measures within the framework of this Action.

Model of mass transfer in textiles

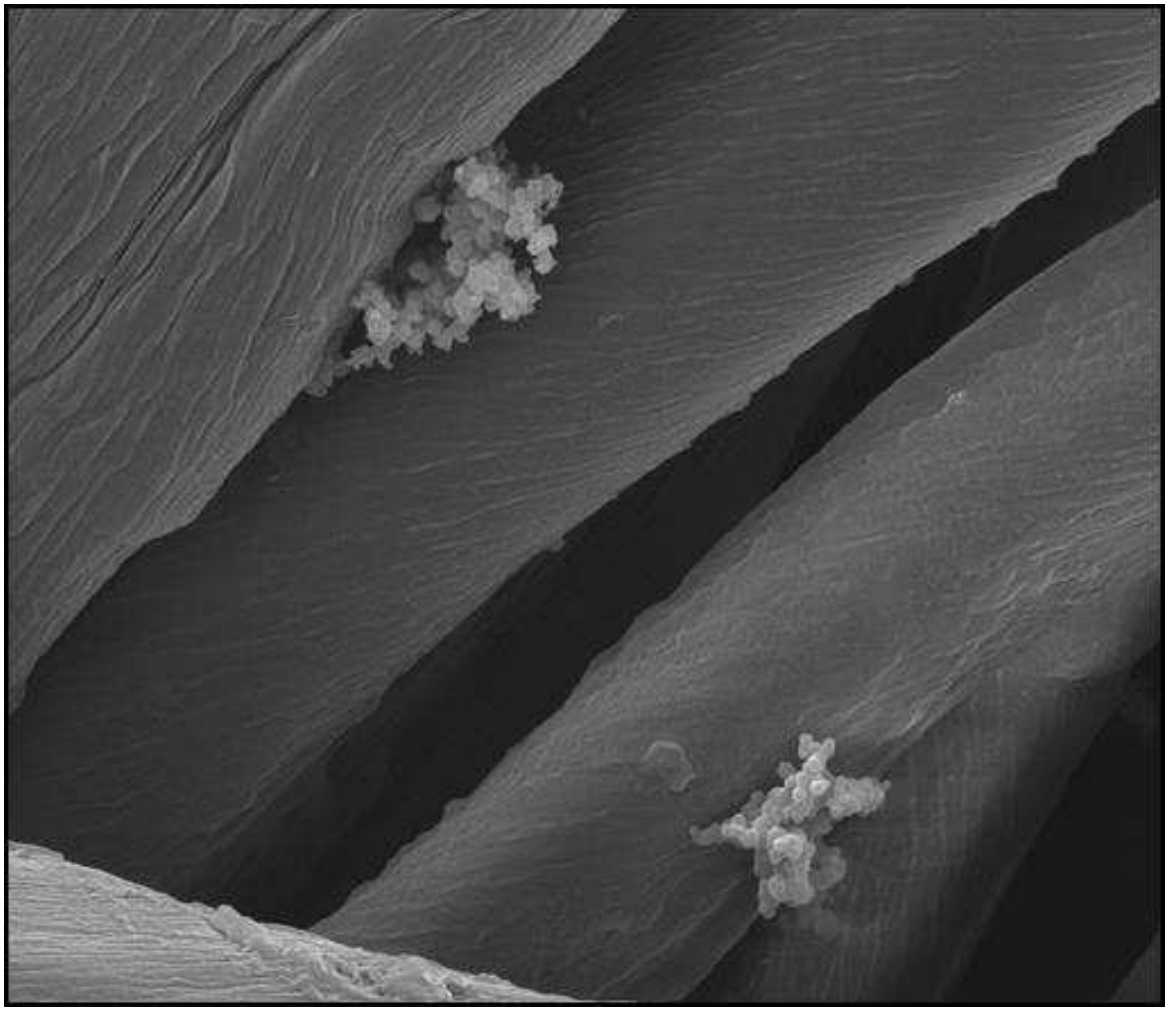


Figure: Nano particle particles on a textile substrate.

Model of mass transfer in textiles

- develop a model using the publication of Goessens et al. (2015) as a stepping stone for the IMAAC setting
- diffusion to the outer boundary of the textile polymer-coated with a volatile active ingredient (insecticide, DEET, perfume)
- compute changes in the concentration of the active ingredient
- three step multi-scale approach
  1. fibre (micro-scale, 1-dimensional)
  2. yarn (meso-scale, porous medium)
  3. fabric (macro-scale)
- minimise concentrations of ingredient used to achieve a lasting effect (repellency, odour strength)

Literature

1. Goessens et al. (2015) A volume averaging and overlapping domain decomposition technique to model mass transfer in textiles. *J. Comput. Appl. Math.* 275: 456-464.

Age-structured dengue model

- use two-strain SIR model of Aguiar, Stollenwerk and colleagues as a basis
- introduce continuous age dynamics
- remove assumption of seasonality forcing
- study the effect of varying ranges of vaccination (above X years of age)

Literature

1. Kooi, Aguiar, Stollenwerk (2013) Bifurcation analysis of a family of multi-strain epidemiology models. *J. Comput. Appl. Math.* 252: 148-158.
2. Kooi, Aguiar, Stollenwerk (2014) Analysis of an asymmetric two-strain dengue model. *Math. Biosci.* 248: 128-139.
3. Capasso (1993) *Mathematical Structures of Epidemic Systems*. Springer.

Mobility effects

- develop a model for a SIR epidemic based on mobility patterns
- use work of Castillo-Chavez and colleagues as a stepping stone
- extend framework of high-frequency mobility (daily commute) to seasonal mobility (migrant workers)
- validate model using multi-year data on DENV infections from Thailand

Literature

1. Bichara et al. (2015) SIS and SIR Epidemic Models Under Virtual Dispersal. *Bull. Math. Biol.* 77: 2004-2034
2. Bichara, Castillo-Chavez (2016) Vector-borne diseases models with residence times - A Lagrangian perspective. *Math. Biosci.* 281: 128-138

Opportunities for students and early career investigators

- 10 STSMs
- ITC Conference Grant
- Training School on Optimal Control Theory, Epidemiological Mathematical Modelling and Mosquito Control Strategies (5-7.3.2019, Finland)

STSMs

Short-term scientific missions (STSM) are exchange visits between researchers involved in a COST Action, allowing scientists to visit an institution or laboratory in another COST country.
They are aimed at fostering collaboration, sharing new techniques and infrastructure that may not be available in other participants' institutions or laboratories.
STSM are intended especially for young researchers.
IMAAC STSM Coordinator: Prof Tatjana Atanasova-Pachemska (MK)

ITC Conference Grants

Conference grants help PhD students and early-career investigators from participating Inclusiveness Target Countries attend international science and technology related conferences that are not specifically organised by a COST Action.

Въпроси?

Благодаря за вниманието!

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