SEVENTH WORKSHOP DYNAMICAL SYSTEMS
APPLIED TO BIOLOGY AND NATURAL SCIENCES

# BOOK OF ABSTRACTS

ESCOLA DE CIÊNCIAS E TECNOLOGIA,
UNIVERSIDADE DE ÉVORA, PORTUGAL


ISBN: 978-989-98750-2-9

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The Seventh Workshop DSABNS was held at Escola de Ciências e Tecnologia of Évora University in Portugal, from February 2 to 5, 2016.
The workshop has both theoretical methods and practical applications and the abstracts included in the program cover research topics in population dynamics, eco-epidemiology, epidemiology of infectious diseases, molecular and antigenic evolution and methodical topics in the natural sciences and mathematics.

Workshop Organizers:
Maíra Aguiar, UL; Russell Alpízar-Jara, UE; Carlos Braumann, UE; Fabio Chalub, UNL; Peyman Ghaffari, UL; Bob Kooi, VU; Luis Mateus, UL; Paula Rodrigues, UNL; Nico Stollenwerk, UL; Ezio Venturino, TU
UL: Universidade de Lisboa, Lisboa, Portugal; UE: Universidade de Évora, Évora, Portugal; VU: Vrije Universiteit Amsterdam, The Netherlands; TU: Turin University, Turin, Italy

Sponsors:
The organizers are grateful for the sponsorship and support of the Universidade de Évora and its Escola de Ciências e Tecnologia, who have hosted the Workshop, to the participant research centers CMAF-CIO (Universidade de Lisboa), CIMA (Universidade de Évora), CMA (Universidade Nova de Lisboa, NovaID) and to CIM (Centro Internacional de Matemática). They also gratefully acknowledge Fundação para a Ciência e a Tecnologia (FCT, under the FACC program), European Union FP7 program (under the DENFREE project) and Câmara Municipal de Évora and its Tourist Office for their support.

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# SCIENTIFIC PROGRAM

ESCOLA DE CIÊNCIAS E TECNOLOGIA,
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# SEVENTH WORKSHOP

## "DYNAMICAL SYSTEMS APPLIED TO BIOLOGY AND NATURAL SCIENCES"

**2-5 FEBRUARY 2016**

**CIMA | ÉVORA UNIVERSITY**

**PROGRAM**

# DSABNS2016

**CMAF-CIO|LISBON UNIVERSITY**
**CIMA|ÉVORA UNIVERSITY**
**CMA|NOVA UNIVERSITY**

| FEBRUARY 2nd 2016 | | | | | | |
|---|---|---|---|---|---|---|
| 09:00 - 09:30 | Registration | | | | | |
| | Amphitheater 1 | | Room 131 | | Room 133 | |
| 09:30 – 09:50 | Opening | | | | | |
| | Chair: Maíra Aguiar | | -- | | -- | |
| 09:50 – 10:40 | Carlos-Castillo-Chavez | Ebola, Influenza, SARS and TB: Lessons learned for mitigating the impact to future outbreaks and pandemics | -- | -- | -- | -- |
| 10:40 – 11:00 | Coffee Break | | | | | |
| | Chair: Carlos Braumann | | Chair: Ezio Venturino | | Chair: Fabio Chalub | |
| 11:00 – 11:50 | Odo Diekmann | Dangerous connections : On binding site models of infectious disease dynamics | -- | | -- | -- |
| 11:50 – 12:20 | Russell Alpizar-Jara | An overview on integrated population dynamics models | Natalia Petrovskaya | Patchy invasion of alien species in the presence of long-distance dispersal | Paula Rodrigues | Modelling tuberculosis transmission: the role of heterogeneity in susceptibility to infection |
| 12:20 – 12:50 | David Greenhalgh | Backward bifurcation, equilibrium and stability phenomena in a three stage extended brsv epidemic model | Sara Bernardi | A mathematical model for viral infections in *Apis Mellifera* beehives transmitted by the *Varroa Destructor* mite | Cristiana Silva | The effect of migration on tuberculosis epidemic |
| 12:50 – 13:20 | Pablo Sommer | Hopf and torus bifurcations in stochastic systems in mathematical population biology | Valentina Clamer | Dynamics of Host-Parasitoid Interactions and Coexistence of Different Hosts | Anuradha Yadav | Study of treatment strategies on infectious disease model in presence of information |
| 13:20 – 15:00 | Lunch | | | | | |
| | Chair: Nico Stollenwerk | | -- | | -- | |
| 15:00 – 15:50 | Teresa Faria | Persistence and stability for some cooperative population models with delays | -- | | -- | |
| 15:50 – 16:40 | Malay Banerjee | Spatio-temporal pattern formation: effect of nonlocal interactions | -- | | -- | |
| 16:40 – 17:10 | Coffee Break | | | | | |
| | Chair: Luís Mateus | | -- | | -- | |
| 17:10 – 18:00 | Bob W. Kooi | Sensitivity analysis and bifurcation analysis | -- | | | |
| 18:00 – 20:00 | Poster Session & Happy Hour | | | | | |

| FEBRUARY 3rd 2016 | | | | | | |
|---|---|---|---|---|---|---|
| | Amphitheater 1 | | Room 131 | | Room 133 | |
| | Chair: Russell Alpizar-Jara | | -- | | -- | |
| 09:00 -9:50 | Manoel Molina | Two-sex branching populations | -- | | -- | |
| 09:50 - 10:40 | Carlos Braumann | Population growth in a random environment: How wrong are approximate models? | -- | | -- | |
| 10:40 - 11:00 | Coffee Break | | | | | |
| | Chair: Luís Mateus | | Chair: Paula Rodrigues | | Chair: Peyman Ghaffari | |
| 11:00 - 11:50 | Carlos Ramos | Ontogenesis and phylogenesis of discrete dynamical systems: developments in cellular automata | Raquel Barreira | Cross-diffusion-induced patterns for reaction diffusion systems | Alessandra Ragusa | An index monitoring the sensitivity to Desertification: ESPI |
| 11:50 - 12:20 | Telmo Peixe | Polymatrix Games and Replicators | Jean-Baptiste Burie | Asymptotic behaviour of an age and infection age structured model | Mahruy Saidalieva | The nonlinear functional-differential equations of living system regulatorika |
| 12:20 - 12:50 | Filipe Martins | A Bifurcation Theorem for Evolutionary Matrix Models | Antonio F. Miguel | Pulmonary Transport and Deposition of Inhaled particles | Mahmoud El-Borai | On some stochastic singular integro-partial differential equations and the parabolic transform |
| 12:50 | LUNCH | | | | | |
| 14:50 | SOCIAL PROGRAM: GUIDED VISIT TO ÉVORA (meeting point: Tourist Office) | | | | | |

| FEBRUARY 4TH 2016 | | | | | | |
|---|---|---|---|---|---|---|
| | Amphitheater 1 | | Room 131 | | Room 133 | |
| | Chair: Bob W. Kooi | | -- | | -- | |
| 09:00 -09:50 | Bobby Reiner | Estimating serotype-specific dengue virus force of infection and temporary cross immunity using longitudinal serological data | -- | | -- | |
| 09:50 - 10:40 | Nico Stollenwerk | Power law jumps and power law waiting times, fractional calculus and human mobility in epidemiological systems | -- | | -- | |
| 10:40 - 11:10 | Coffee Break | | | | | |
| | Chair: Maíra Aguiar | | Chair: Paula Rodrigues | | Chair: Ezio Venturino | |
| 11:10 - 11:40 | Sofia Rodrigues | Optimal control for a dengue scenario with two serotypes: | Erida Gjini | How classical and adaptive regimes interact with host immunity in antibiotic treatment of resistant infections | Yadigar Sekerci Firat | Mathematical Modelling of Spatiotemporal Plankton-Oxygen Dynamics under the Climate Change |
| 11:40 - 12:10 | Luís Mateus | Estimating the efficacy of a candidate dengue vaccine | Alberto Pinto | A dynamical model of immune response by t cells | Urszula Skwara | Modelling epidemiological spreading via spatio-temporal fractional systems |
| 12:10 - 12:40 | Hyun Mo Yang | Quiescence eggs and vertical transmission – are they important in dengue transmission? | Thomas Wester | Mathematical Modeling: Immune System Dynamics in the Presence of Cancer and Immunodeficiency in vivo | Andrea Parisi | Reconstructon of human population densities for simulations of geographical spread of historical infectious diseases |
| 12:40 - 13:10 | José Martins | The existence of multiple decisions for vaccination in the reinfection siri model | Yuliya Kyrychko | Dynamics of neural networks with discrete and distributed time delays | Ishtiaq Ali | An efficient numerical scheme for carcinogenesis mutations models based on reaction-diffusion equations with time delay |
| 13:10 - 14:40 | Lunch | | | | | |
| | Chair: Fabio Chalub | | -- | | -- | |
| 14:40 - 15:30 | Konstantin Blyuss | Mathematical insights into RNA interference | -- | | -- | |
| 15:30 - 16:20 | Ezio Venturino | A mathematical model for goat farms affected by two strains of caprine arthritis encephalitis | -- | | -- | |
| 16:20 - 16:50 | Coffee Break | | | | | |
| | Chair: Nico Stollenwerk | | -- | | -- | |
| 16:50 - 17:40 | Alberto D'Onofrio | A random walk in the effects of bounded-randomness in cellular biochemistry | -- | -- | | |
| 20:00 | Workshop Dinner: (meeting point: ex-Celeiros da EPAC, Rua de Eborim) | | | | | |

| FEBRUARY 5TH 2016 | | | | | | |
|---|---|---|---|---|---|---|
| | Amphitheater 1 | | Room 131 | | Room 133 | |
| | Chair: Bob W. Kooi | | -- | | -- | |
| 09:00 -09:50 | Gustavo Olivera | The role of indirect protection in the assessment of dengue vaccination impact | -- | | -- | |
| 09:50 - 10:40 | Maíra Aguiar | Feels right, but it's so wrong: The impact of empirical data analysis on public health practical intervention | -- | | -- | |
| 10:40 - 11:10 | Coffee Break | | | | | |
| | Chair: Russell Alpizar-Jara | | -- | | -- | |
| 11:10 - 12:00 | Fábio Chalub | Optimal Vaccination Strategies and Rational Behavior in Seasonal Epidemics | -- | | -- | |
| 12:00 - 12:50 | Fernando Fontanari | When more of the same is better | -- | | -- | |
| 12:50 - 14:30 | Lunch | | | | | |
| | Chair: Nico Stollenwerk | | | | | |
| 14:30 - 15:20 | Thomas Gotz | Optimal control and applications in Biomath | -- | -- | -- | -- |
| | Chair: Nico Stollenwerk | | Chair: Carlos Braumann | | Chair: Ezio Venturino | |
| 15:20 - 15:50 | Max Souza | Evolution of insecticide resistance | Fernando Carapau | A one-dimensional model for blood flow based on cosserat theory | Elena Almaraz | On the time to reach a critical number of infections in recurrent epidemic models |
| 15:50 - 16:20 | Karola Shaefer | Insect-Proofing of Textiles to Prevent Vector-borne Diseases | Joaquim Correia | Modelling, Analysis and Simulations of Coagulant Fluids | Schehrazad Selmane | Dynamic Transmission of Cutaneous Leishmaniasis |
| 16:20 - 16:50 | Peyman Ghaffari | Avant-garde mosquito repellent Technologies based on nano-technology and micro capsules in combating vector-borne diseases | Peter Mpasho Mwamtobe | Mathematical analysis of a lymphatic filariasis model with quarantine and treatment | Anuj Kumar | Role of optimal screening and treatment on infectious diseases |
| 16:50 - 17:20 | Coffee Break | | | | | |
| | Chair: Maíra Aguiar | | -- | | -- | |
| 17:20 - 18:10 | Sergei Petrovskii | Statistical mechanics of individual animal movement | -- | | | |
| 18:10 - 18:20 | Closing | | | | | |

*Seventh Workshop Dynamical Systems Applied*
*to Biology and Natural Sciences DSABNS 2016*
*Évora, Portugal, February 2-5, 2016*

# PULMONARY TRANSPORT AND DEPOSITION OF INHALED PARTICLES

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## ABSTRACT

Breathing is the way that the respiratory tree interacts with the outside environment. The large surface area of tree available for gas exchange is also exposed to particles suspended in the inhaled air. A two-fold justification exists for studying particle transport and deposition in the respiratory tree [1,2]: *(i)* Assessment of the health hazards of particles (some viral infections such as influenza, pneumonia, involve the upper airways; inhalation anthrax (spores of the bacteria *Bacillus anthracis*) is considered to be the deadliest form of anthrax); *(ii)* Improvement of drug delivery (Pharmaceutical inhalation particles play a vital role in the health and well-being because are the best first-line therapy for asthma and chronic obstructive diseases. Inhalation route drug delivery for the treatment of systemic diseases, such as diabetes mellitus, is also a good option).

Knowledge of particle transport and deposition in the respiratory tree and the sites, where particles of different sizes deposit, is essential to understanding subsequent biological response [3]. Here a 3D computational simulation is used to examine particle transport and deposition in the bronchial tree. A four-generation bifurcation (Weibel model [1]) is considered. At each generation, the branching is dichotomous, and obey to the relationship known in physiology as the Hess-Murray law [4]. This study offers a spatial accurate

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analysis that gives us insight into the particle dynamics under steady and pulsatile flow fields. Among the results obtained in this study, Figure 1 highlights the dependence of particle deposition with respect to the Stokes number and to the Reynolds number (breathing frequency 14/min).

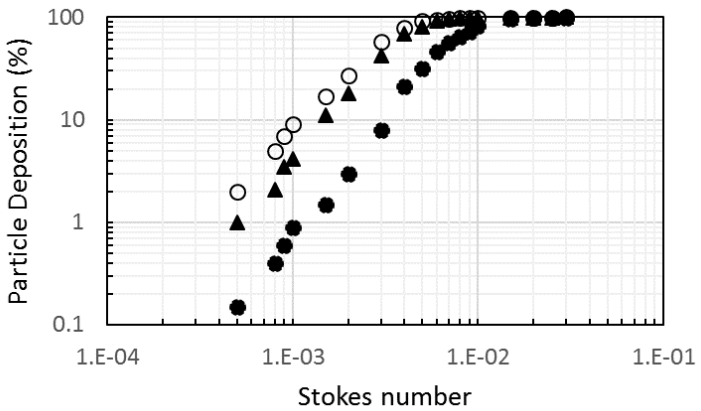


Figure 1. Particle deposition versus the Stokes number and to the Reynolds number (● Re=2000 ▲Re=750 o Re=550)

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## References

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[2] N. R. Labiris, M. B. Dolovich (2013) *Pulmonary drug delivery. Part I: Physiological factors affecting therapeutic effectiveness of aerosolized medications*. Br. J. Clin. Pharmacol. 56(6): 588–599.

[3] A. Tsuda, F. S. Henry, J. P. Butler (2013) *Particle transport and deposition: basic physics of particle kinetics*. Comp. Physiol. 3(4): 1437–1471.

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