



Report on the Maupertuis grant 2021 awarded for organising a workshop on Entomovectoring

Grant administered by:

the Department of Environmental and Biological Sciences, University of Eastern Finland, Kuopio, Finland

PI in charge: Dr. Ingeborg Menzler-Hokkanen

Summary of the outcome of the workshop

- Twenty-three experts from 11 different countries participated in this virtual workshop
- Twenty review presentations were given with associated discussions over the workshop period of three days, covering fundamental, applied, and forward-looking aspects concerning entomovectoring
- Numerous new and exciting ideas were presented to enhance using insects to deliver beneficial organisms, substances or devices (e.g., electrostatic enhancement, advances in formulation, multiagent applications, robotics and cyborg insects)
- A case concerning ecological dangers when exotic insects have been used either for pollination or for entomovectoring was highlighted: spread of devastating pollinator diseases following commercial use of exotic pollinators. Best known case from South-America was reviewed based on popularizing (<https://www.theguardian.com/environment/2019/may/04/the-battle-to-save-the-worlds-biggest-bumblebee-from-european-invaders>) and scientific sources (e.g. Schmid-Hempel et al. 2013: The invasion of southern South America by imported bumblebees and their parasites <https://doi.org/10.1111/1365-2656.12185>)
- As an outcome from the workshop, we have commissioned a review article concerning biological invasions by pollinators, their parasites, and mechanisms by leading world experts on the topic. The article will be open access.
- Further outcomes include the signing of a book contract with CABI, to publish the reviews presented at our workshop, with some additional chapters, as a book within about one year after the workshop (2022)
- In addition, a contract to publish a book series on “Ecostacking” by CABI was also signed. The Entomovectoring -book will be part of that series (second book in the series).
- Limitations to successful use were presented and discussed including hive health, environmental contaminants such as pesticides, difficulties to steer insects to the desired targets, and possible environmental impacts
- It was presented that the Virtual Special Issue (VSI) in the Springer Journal Arthropod-Plant-Interactions was a necessary step in preparing the forming of the present workshop. In the acknowledgement to the VSI the Maupertuis programme and its sponsors have been named. See link: <https://www.springer.com/journal/11829/updates/18584618>
- The support of the Maupertuis programme and its sponsors will be acknowledged in the publications arising from this workshop
- The "entomovectoring podcast" by 4 students from Otaniemen Lukio could not be included, because of delayed preparation and editing of the final version of the podcast. The podcast is now available, and can be accessed under this link: beepodcast.valmis.mp3 - [Google Drive](#)

Budgetary details: to be added

Annexes:

Annex 1: List of workshop participants

Annex 2: Background to the International Workshop on Entomovectoring

Annex 3: Workshop Programme

List of workshop participants

Name	Country	Affiliation
Thierry Brevault	France	CIRAD
Beatrice Muriithi	Kenya	International Center of Insect Physiology and Ecology
Paul Egan	Sweden	Swedish University of Agricultural Sciences (SLU)
Ingeborg Menzler-Hokkanen	Finland	University of Eastern Finland
Heikki Hokkanen	Finland	University of Eastern Finland
Isabel Alves dos Santos	Brazil	University of Sao Paulo
Katja Hogendoorn	Australia	University of Adelaide
Jay Iwasaki	Australia	University of Adelaide
Bente Berg	Norway	Norwegian University of Science and Technology
Xi Chu	Norway	Norwegian University of Science and Technology
Clara Montgomery	UK	Harper Adams University, Newport
Maodo Cisse	Senegal	Université Cheikh Anta Diop de Dakar
Esther Diouf	Senegal	CIRAD
Samba Diop	Senegal	CIRAD
Minni Tapola	Finland	University of Helsinki
Minna J Manninen	Finland	University of Helsinki
Joonas Mäkinen	Finland	University of Eastern Finland
Tove Ortman	Sweden	Swedish University of Agricultural Sciences
Mohamed Luseni	Sweden/Benin	SLU, International Institute of Tropical Agriculture
Ivan de La Cruz Arguello	Sweden/Mexico	Swedish University of Agricultural Sciences
Johannes Fagbohoun	Norway/Benin	Norwegian University of Life Sciences, IITA
Linn Vassvik	Norway	Norwegian University of Life Sciences
Kossiba Jeannette Winsou	Norway/Benin	Norwegian University of Life Sciences, IITA

International Workshop on Entomovectoring

Virtual workshop on 3-4-5 November 2021, using Microsoft Teams.

In this Virtual workshop, curated by Heikki Hokkanen and Ingeborg Menzler-Hokkanen, we wish to highlight advances in the study of insect-plant interactions as basis for entomovectoring. The term “entomovectoring” was created by us in 2006, and used for the first time in a publication in 2007 (see reference¹ below). We introduced it to specify the technique of using insects to vector beneficial organisms or substances (usually biocontrol agents for crop protection) to specific targets^{1,2}. These include flowers, other plant parts such as leaves, or other organisms (e.g., mosquitoes to vector myxomatosis virus to rabbits). As presented in this workshop on 3 November by the Pest Free Fruit consortium, entomovectoring can be used to disseminate biocontrol organisms between insects as well (fruit flies as an example).

Using insects as vectors has great potential to help develop sustainable, pesticide free production systems, but is grossly underutilised and poorly understood. This workshop explores the scientific foundation and insights necessary for exploiting the potential of insects as vectors of beneficial organisms or substances. We discuss some of the latest knowledge required for understanding how potential entomovectors can be managed, deployed, and enhanced to optimally perform their beneficial functions. Novel approaches will be presented that will stimulate the development and uptake of entomovectoring as a tool in pest management, such as fruit fly control, to substitute for chemical pesticide use, to complement ecostacking techniques, to help in engineering sustainable ecosystem management schemes, and to boost the quality and quantity of agricultural production. We further present the current situation of utilizing entomovectoring in leading countries and discuss obstacles to the uptake of this technology and possible solutions to overcome any hurdles. Basic research on entomovectoring is scattered. We wish to encourage underlying research for this area as a basis to engage in exploiting this powerful technology for the purpose of safe, targeted biological crop protection, and improved pollination. Some key developments in the area, unfortunately, could not be included in the workshop, but have been promised as chapters for our forthcoming book “Entomovectoring - using insects as vectors of beneficial organisms and substances”. The complexity of the area is well reflected in the presentations in this workshop. Fundamental research such as on olfaction and taste are crucial pillars in constructing functioning entomovectoring systems. Spill-over effects of the present climate change with weather extremes, and their effects on entomovectoring systems have to be included. The contributions in the Arthropod-Plant Interactions virtual special issue “Pollinator-plant interactions as basis for entomovectoring” are an attempt to compile research results reflecting some of the bottlenecks and challenges in this area. See link: <https://www.springer.com/journal/11829/updates/18584618>

Acknowledgement: The support provided by the Institut Francais de Finlande, the Embassy of France in Finland, the French Ministry of Higher Education, Research and Innovation, the Finnish Academy of Science and Letters, and the Finnish Society of Science and Letters is acknowledged in organising and co-financing this international workshop on entomovectoring. Our thanks to the Maupertuis Program. Financial support by the Pest Free Fruit project, funded by the EU-ERA-Net program LEAP-AGRI, and the intellectual support by Pest Free Fruit consortium led by prof. Thierry Brevault, is gratefully appreciated. Further support has been provided by the NOVA University Network and the NOVA PhD course in Alnarp, Sweden, 8-11 November 2021, see link [Integrated Pest and Pollinator Management, 3 ECTS | Externwebben \(slu.se\)](#). Our thanks to prof. Paul Egan. We wish to thank also the NOVA Network coordinator Geir Loe.



¹ Hokkanen HMT & Menzler-Hokkanen I. (2007). Use of honeybees in the biological control of plant diseases. Entomol Res 37 (Suppl. 1), A62-A63.

² Menzler-Hokkanen I, Hokkanen HMT (2017). Entomovectoring: an agroecological practice of using bees for biocontrol. In: Wezel, A. (Ed.), Agroecological Practices for Sustainable Agriculture. World Scientific Publishing Europe, London. pp. 183-199.

International Workshop on Entomovectoring

Virtual workshop on 3-4-5 November 2021, using Microsoft Teams. Invitation links will be sent to participants.

Introductory page to the workshop: see attachment

Confirmed list of presenters, and topics to be presented (status 23.10.2021):

3rd November 2021. Starting time at 11:00 Central European Time [corresponds to 10:00 am UTC-time, 10:00 in Dakar and in Newport, 13:00 in Nairobi, and 8:00 in Sao Paulo --- please check to make sure by yourself!]

Time: 11:00 – 11.10 Central European Time Chair: Heikki Hokkanen, Introduction.

Time: 11:10-11:40 CET (Central European Time)

1. **Thierry Brevault and Esther Diouf**, CIRAD, Dakar, Senegal (confirmed)
Testing the boosted SIT technique for fruit fly management with a multi-agent model

Time: 11:45-12:15 CET

2. **Thierry Brevault and Samba Diop**, CIRAD, Dakar, Senegal (confirmed)
Males as entomovectors of entomopathogenic fungal spores for fruit fly control

Time: 12:20-12:50 CET

3. **Beatrice Muriithi**, ICIPE, Nairobi, Kenya (confirmed)
Impact of integrating Autodissemination technique with Male Annihilation Technique on fruit fly infestation rate and magnitude of mango losses

Time: 12:55-13:15 CET

4. Discussion with prof. Thierry Brevault and Pest Free Fruit consortium members: During the international Conference: CID Dakar, 24-26 November 2021; meeting during the CID and discussion of further actions (including the CABI book proposal).

Time: 13:20 – 13:50 CET

5. **Clara Montgomery**, Harper Adams University, Newport, UK (confirmed)
Electrostatic enhancement of entomovectoring

Time: 13:55-14:30 CET

6. **Isabel Alves dos Santos**, University of Sao Paulo, Brazil (confirmed)
Understanding bee biology for successful entomovectoring

Time: 14:35-14:50 CET

7. Heikki Hokkanen: summary

4th November 2021 – Starting time at 09:00 Central European Time [corresponds to 18:30 Adelaide time, and 08:00 UTC time --- please check to make sure by yourself!]

Time: 9:00-9:10 Central European Time

Chair: Heikki Hokkanen, opening words

Time: 9:15-9:45 CET (Central European Time)

8. **Katja Hogendoorn**, University of Adelaide, Australia (confirmed)
Entomovectoring situation in Australia

Time: 9:50-10.10 CET (Central European Time)

9. **Katja Hogendoorn**, University of Adelaide, Australia (confirmed)
Hive health aspects

Time: 10:15-10:45 CET

10. Jay Iwasaki & Katja Hogendoorn, University of Adelaide, Australia (confirmed)
Non-insecticide pesticide impacts on bees

Time : 10:50-11:30 CET

11. Bente Berg, Xi Chu and Jonas Kymre, NTNU, Norway (confirmed)
Insect olfaction.

Time : 11:35-11:55 CET

12. Ingeborg Menzler-Hokkanen, University of Eastern Finland (confirmed)
presentation of APIS Virtual Special Issue "Pollinator-plant interactions as basis for entomovectoring"
<https://www.springer.com/journal/11829/updates/18584618>

Time: 11:55-12:05 CET

13. Heikki Hokkanen, closing words
-

5th November 2021 – starting time **10:00 CET** [corresponds to 19:30 Adelaide time, and 09:00 UTC time --- please check to make sure by yourself!]

Chair: Paul Egan and Ingeborg Menzler-Hokkanen

Time: 10:00-10:10 Central European Time

14. Paul Egan, SLU: opening words

10:15-10:45 CET (Central European Time)

15. Heikki Hokkanen, Aasatek Oy, Finland (confirmed)
Development of the entomovectoring concept

Time: 10:50-11:10 CET

16. Jonas Kristian Mäkinen U. of Eastern Finland, Mohamed Mambu Luseni SLU / IITA and Ivan de La Cruz Arguello SLU (confirmed)
Competition between pest natural enemies and pollinators
Comments: Heikki Hokkanen

Time: 11:15-11:35 CET

17. Minni Tapola U. of Helsinki and Linn Vassvik Norwegian Univ of Life Sciences NMBU + NIBIO (confirmed)
Pollinator facilitation of weeds as an ecosystem disservice
Comments: Paul Egan

Time: 11:40-12:00 CET

18. Kossiba Jeannette Winsou NMBU and Minna J Manninen U. of Helsinki (confirmed)
Feasibility of using bees to vector entomopathogenic fungi
Comments: Ingeborg Menzler-Hokkanen

Time: 12:05-12:25 CET

19. Johannes Fagbohoun NMBU and Tove Ortman SLU (confirmed)
Impacts of multiple pesticides on pollinator foraging

Comments: Paul Egan

Time: 12:30-12:50 CET

20. **Ingeborg Menzler-Hokkanen** UEF (confirmed)

Circular farming approaches for a sustainable intensification of production systems

Time: 12:55-13:05 CET

21. **Paul Egan**: summary
-

Selected supporting literature:

Chailleux, A, Thiao, DS, Diop, S, et al. (2021). Understanding *Bactrocera dorsalis* trapping to calibrate area-wide management. J Appl Entomol. <https://doi.org/10.1111/jen.12897>

Egan PA, Adler LS, Irwin RE, Farrell IW et al. (2018). Crop domestication alters floral reward chemistry with potential consequences for pollinator health. Frontiers in plant science 9. <https://doi.org/10.3389/fpls.2018.01357>

Gao Y, Hokkanen HMT, Menzler-Hokkanen I (eds) (2020). Integrative Biological Control: Ecostacking for Enhanced Ecosystem Services. Progress in Biological Control Volume 20, Springer-Nature. https://doi.org/10.1007/978-3-030-44838-7_1

Ian, Elena; Kirkerud, Nicholas Hagen; Galizia, C. Giovanni; Berg, Bente Gunnveig (2017). Coincidence of pheromone and plant odor leads to sensory plasticity in the heliothine olfactory system. PLOS ONE. vol. 12 (5). <https://doi.org/10.1371/journal.pone.0175513>

Iwasaki, J.M, Hogendoorn, K. (2021). Non-insecticide pesticide impacts on bees: A review of methods and reported outcomes. Agriculture, Ecosystems & Environment 314, 107423, <https://doi.org/10.1016/j.agee.2021.107423>

Kymre, Jonas Hansen (2021). Connection patterns in the central olfactory pathway of the male moth. PhD-Thesis, Norwegian University of Science and Technology NTNU 2021: 260.

Liporoni R, Cordeiro GD, Prado PI, Schlindwein C, Warrant EJ & Alves-dos-Santos I (2020). Light intensity regulates flower visitation in Neotropical nocturnal bees. Sci Rep 10, 15333. <https://doi.org/10.1038/s41598-020-72047-x>

Menzler-Hokkanen I (2020). APIS Virtual Special Issue "Pollinator-plant interactions as basis for entomovectoring" <https://www.springer.com/journal/11829/updates/18584618>

Rauw, W.M., Rydhmer, L., Kyriazakis, I., Øverland, M., Gilbert, H., Dekkers, J.C., Hermes, S., Bouquet, A., Gómez Izquierdo, E., Louveau, I. and Gomez-Raya, L. (2020). Prospects for sustainability of pig production in relation to climate change and novel feed resources. J Sci Food Agric, 100: 3575-3586. <https://doi.org/10.1002/jsfa.10338>

Sow, A., Brévault, T., Benoit, L. et al. (2019). Deciphering host-parasitoid interactions and parasitism rates of crop pests using DNA metabarcoding. Sci Rep 9, 3646. <https://doi.org/10.1038/s41598-019-40243-z>

Tichit Pierre, Alves-dos-Santos Isabel, Dacke Marie and Baird Emily (2020). Accelerated landings in stingless bees are triggered by visual threshold cues. Biol. Lett. 16: 20200437. <http://doi.org/10.1098/rsbl.2020.0437>

Wangithi, C.M.; Muriithi, B.W.; Belmin, R. (2021). Adoption and Dis-Adoption of Sustainable Agriculture: A Case of Farmers' Innovations and Integrated Fruit Fly Management in Kenya. Agriculture 11: 338. <https://doi.org/10.3390/agriculture11040338>