Research lines at the laboratory of Entomology, Wageningen University

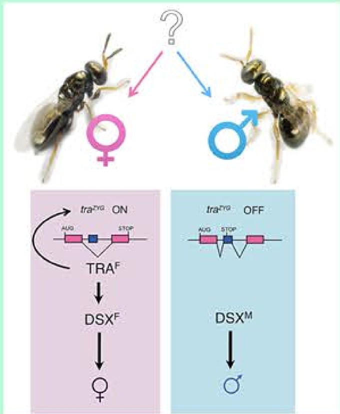
Evolutionary developmental biology and reproduction

Researcher: Eveline Verhulst
email: eveline.verhulst@wur.nl www.evelineverhulst.nl

? *How do genes drive the development of insects towards male or female?*

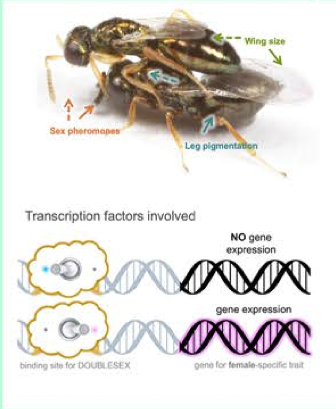
Theme 1: Molecular basis of sex determination.

In my group we study the genetic pathway leading to male and female development. Important genes in this pathway are *Doublesex (DSX)* and *Transformer (TRA)*. How these genes exactly make the switch between the male or female developmental pathway is one of our focal points. In most projects the focus is to understand what is happening at the transcript level in terms of splicing events and differential expression.



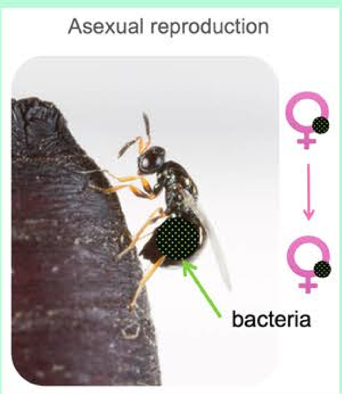
Theme 2: Molecular pathways involved in sexual differentiation.

Doublesex is the last gene in the sex determination pathway and as transcription factor it regulates sexual differentiation by switching genes on or off. We are studying exactly which male or female specific traits are regulated by *DSX* per species, how this is done, and how this diversifies in closely related species.



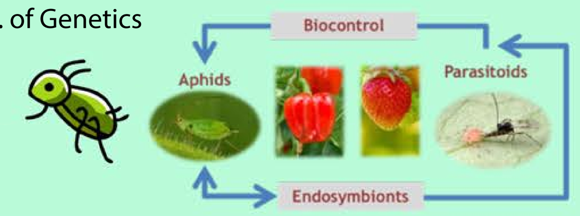
Theme 3: Endosymbionts manipulating sex determination

Bacteria living in insect tissues (endosymbionts) are transmitted by the mother to her offspring. To improve transmission, endosymbiont manipulate sex determination and reproduction. One way is by inducing asexual reproduction in which females can produce females without the need for males. We study the mechanisms by which these endosymbionts can induce this asexual reproduction in their host.



Theme 4: Manipulation sex rations for biocontrol

Many parasitoid wasps can adjust the number of sons and daughters they produce. Parasitoid wasps are used a lot for biocontrol of aphids, flies and caterpillars. For biocontrol purposes having a lot of females is advantageous, so we study how we can steer the parasitoids to produce as many female offspring as possible. Also the role of endosymbionts is taken into account. This research is in collaboration with Bart Pannebakker from the Lab. of Genetics



Insect species and main techniques

Species: parasitoid wasps that parasitize on flesh and blow flies (Hymenoptera:Pteromalinae), such as *Nasonia, Muscidifurax, Trichomalopsis.*

Techniques: basic genetics crossings, behavioural observations, CRISPR-Cas9 mutagenesis, RNA interference using microinjections, RNA sequencing and bioinformatics analyses, (quantitative) RT-PCR, plasmid work and cloning, protein production.

Insect-plant-microbiome interactions

Researcher: Karen Kloth
email: karen.kloth@wur.nl
www.wur.nl/en/persons/karen-kloth-1.htm

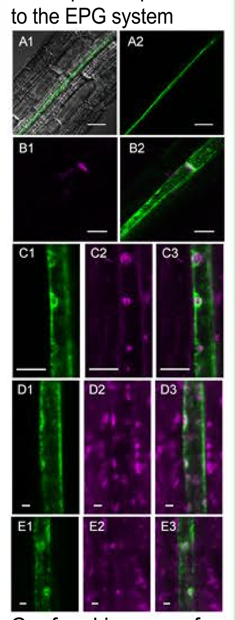
? *How do plants defend themselves against herbivorous insects? & What role does the microbiome play herein?*

Theme 1: Plant resistance to aphids

Aphids are sap-feeding insects that probe into their host plant with flexible stylet mouthparts. They are major vectors of plant viruses and cause economic damage to crops on a worldwide scale. In our group, we study aphid probing behaviour and track plant defense responses in space and time to understand how aphids and plants interact at molecular and organismal level.

Cryofixed *M. persicae* aphid stylets (red tubular structure) in an *Arabidopsis* leaf.

Green peach aphid wired to the EPG system



Confocal images of pSLI1:EYFP:SLI1 (green) in seedling roots

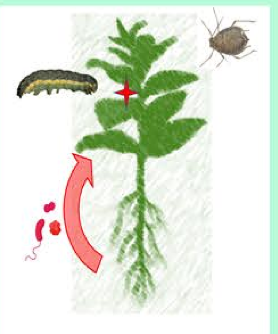
Theme 2: Host plant manipulation by aphids

Aphids are masters in manipulation. They do not only avoid the induction of plant defenses with their flexible mouthparts, but they also secrete saliva into their host plant to suppress defense responses. The composition of their saliva is highly plastic and changes during host switches, microbial infections and environmental changes. We study how aphids use their salivary toolbox to manipulate host plant defenses.

Green peach aphids on host plant

Theme 3: The role of the microbiome in insect-plant interactions

The microbiome plays an important role in insect-plant interactions. The soil is the richest reservoir of microbial diversity. When plants are under attack of herbivores, they change root-associated assembly of bacteria, fungi and other microorganisms. These microbes can play beneficial roles via systemic priming of plant defenses, activation of plant resistance mechanisms in the phyllosphere, and direct interaction with herbivorous insects. We study these 'hidden' players and explore their potential for insect pest management.



Insect species and main techniques

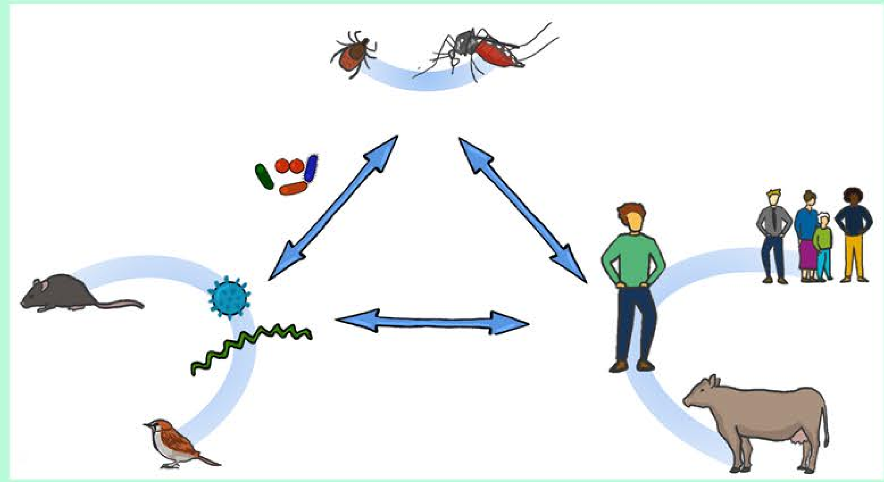
Species: *Myzus persicae, Lipaphis erysimi, Brevicoryne brassicae, Mamestra brassicae, Delia radicum.*
Techniques: Electrical Penetration Graph (EPG) recording, spatio-temporal transcriptomics, metagenomics, proteomics, metabolomics, microscopy, genetic engineering

Ecology and control of vectors and vector-borne diseases

Researcher: Sander Koenraadt
email: sander.koenraadt@wur.nl www.onehealthentomologygroup.nl

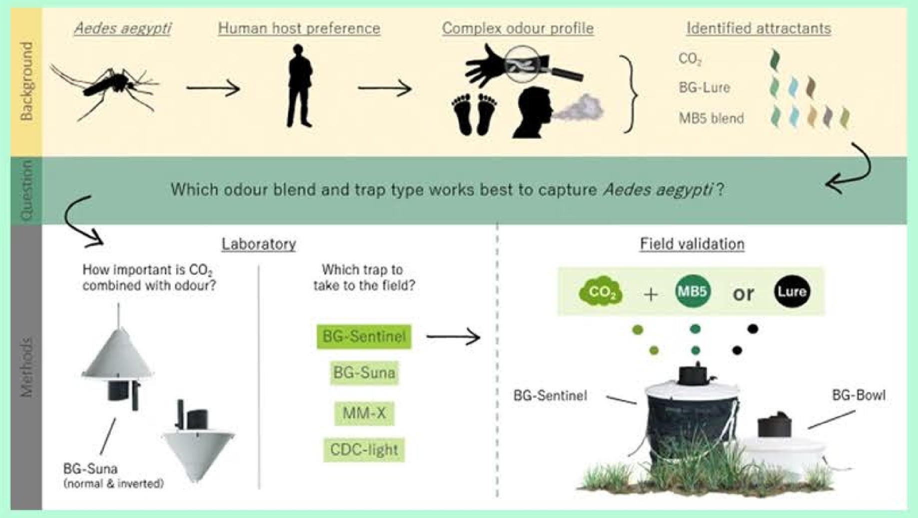
? *Why are some insects such efficient vectors of viruses and parasites, and others not? & How do climate and environmental change affect the ecology of blood-feeding insects?*

Theme 1: fundamental aspects of arthropod-pathogen-host interactions



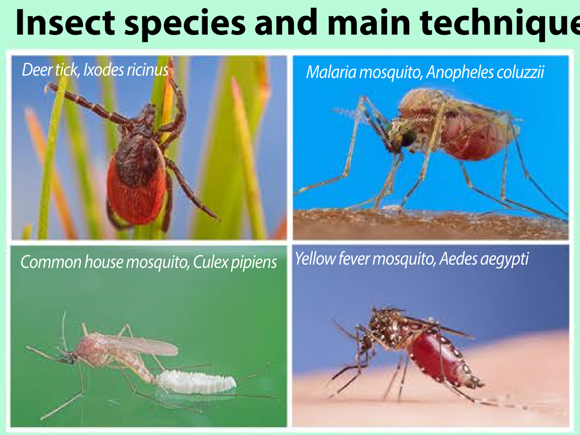
In our group, we are interested in why some mosquitoes, midges or ticks are such good vectors of certain pathogens, and others not. For this purpose, we study pathogen-vector interactions in our secured Bio-Safety Level 3 laboratory in collaboration with the Laboratory of Virology. to study transmission of flaviviruses (West Nile virus, Zika) and alphaviruses (chikungunya and Mayaro). We specifically investigate how vector competence, i.e. the insects ability to transmit a pathogen, is shaped by its immune system, microbiome and environmental factors such as temperature and larval stress

Theme 2: development of novel (biological) tools for surveillance and control.



Vector-borne disease control relies heavily on insecticides and little attention is paid to the opportunities of biological (non-chemical) alternatives. Our research focuses on the use of bacteria and entomopathogenic fungi for integrated management of mosquitoes and ticks. Our biological control are investigated in multidisciplinary projects and include the social sciences perspective. Ultimately, we aim to create a world in which we can quickly respond to the threat of vector-borne diseases with means that are affordable, safe for human and animal use and, most notably, sustainable in the context of our changing environment.

Insect species and main techniques



Vector competence experiments in BSL-3 laboratory conditions, microbiome sequencing and metabarcoding, windtunnel and olfactometer bio-assays, camera-equipped observation rooms, (experimental) field work in the Netherlands,

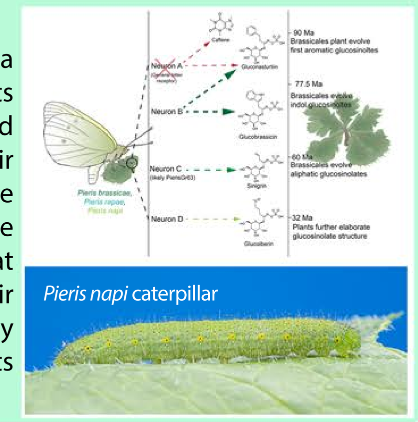
Neuro-ethology of host-plant selection

Researcher: Alexander Haverkamp
email: Alexander.haverkamp@wur.nl
www.wur.nl/en/persons/alexander-haverkamp-1.htm

? *How do herbivorous insects find the right host plant?*

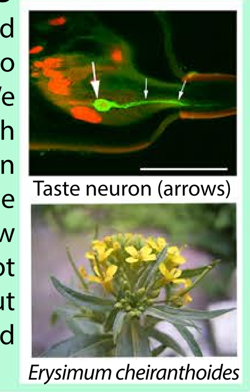
Theme 1: The evolution of host-choice behaviour in insect herbivores.

Insect and plants are entangled in a coevolutionary arms-race; with plants evolving novel chemical defences, and insect herbivores adapting their detoxification machinery and to specialize on certain host plants. We investigate the evolution of sensory mechanisms that allow insect herbivores to identify their host-plant and what role the sensory system plays in the coevolution of insects and plants.



Theme 2: Balancing the good and the bad: How herbivores assess their host-plants

Insect herbivores use their chemical senses (taste and smell) to detect feeding or egg laying stimuli, and to recognise toxins and other harmful compounds. We investigate how insect herbivores evaluate both attractive and deterrend stimuli and how adaptations in these neuronal mechanisms might lead to the colonisation of new host-plants. Identifying how deterrent compounds are perceived by insects is not only crucial for understanding host-plant choice, but these compounds also have a great potential to be used in environmentally friendly crop protection strategies.



Taste neuron (arrows)

Erysimum cheiranthoides

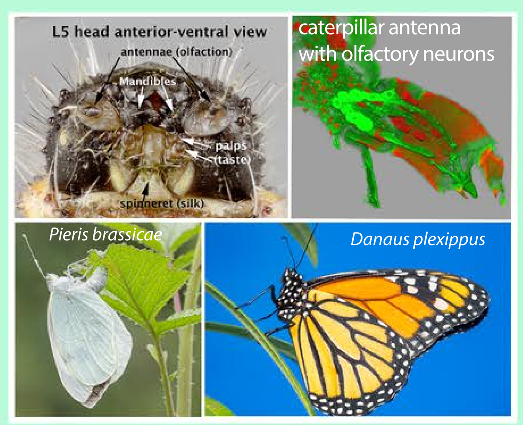
Theme 3: Pick your poison – Can insect herbivores select toxic compounds for there own defence?

Some insect herbivores not only disarm the chemical defences of their host-plants, but even use these chemicals for their own protection. Monarch butterflies sequester the toxic cardenolide compounds from their milkweed host-plants, which makes them deterrent to most vertebrate and invertebrate predators. We investigate whether monarch caterpillars and butterflies can actively select plants rich in those cardenolides which they can most easily sequester without intoxicating themselves.

Theme 4: Friends and foes – How plants attract pollinators but hide from herbivores

Butterflies are important flower visitors yet their caterpillars are often voracious herbivores on the same plants that the adult insects pollinate. Many plants lace their floral nectar with secondary metabolites that are perceived as deterrents by many flower visiting insects. We investigate wether these floral defences also work against specialist herbivores and whether female butterflies might even be able to use these secondary metabolites in the flower nectar to find the best plants to oviposit on.

Insect species and main techniques



Species: *Pieris brassicae, Pieris rapae, Pieris napi* and *Danous plexippus* caterpillars and butterflies.

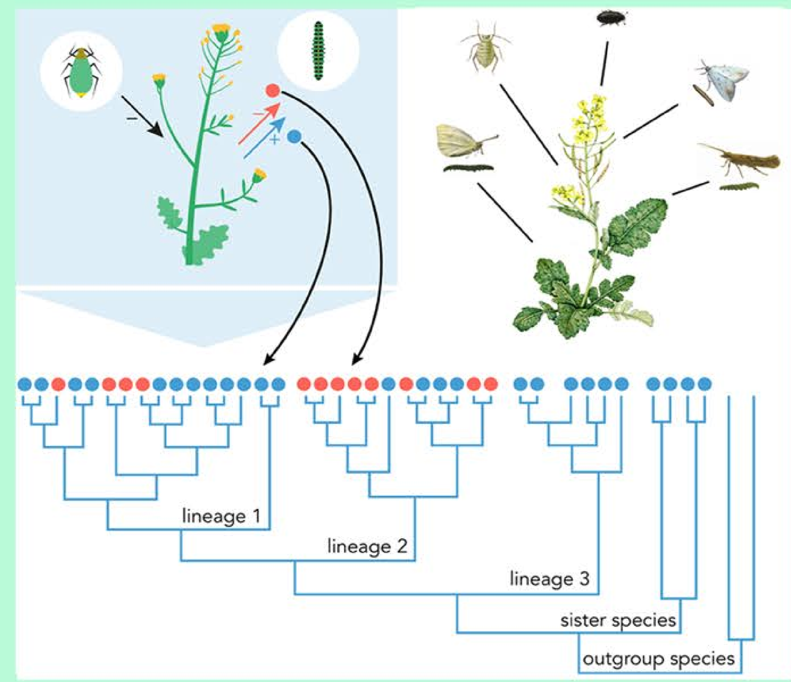
Techniques: behavioural assays in semi field and lab conditions; Crispr/Cas9 knockout mutants, receptomics, quantitative PCR; HPLC and GC, taste neuron recordings, immuno histochemistry and confocal laserscanning microscopy.

Community ecology of plant-insect interactions

Researcher: Erik Poelman
email: Erik Poelman@wur.nl http://erikpoelman.com

? *What strategies do plants play to deal with unpredictable interactions of a multitrophic insect web of antagonists and mutualists?*

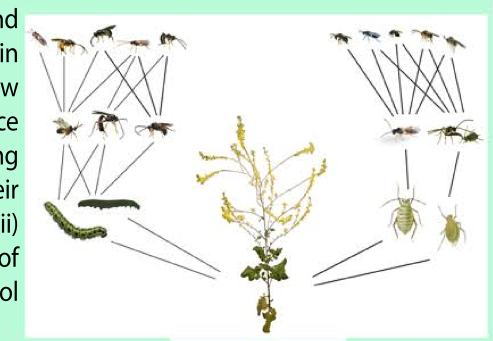
Theme 1: Evolution of plant defence plasticity to attack by multiple herbivores



Individual plants harbour species rich communities of insects, structured by direct and indirect interactions. We investigate the evolution of plant defence to deal with attack by multiple insect herbivores. We focus on: i) Plant physiological adaptations in response to attack by multiple herbivores; ii) Plant mediated interactions among herbivores and pollinators; iii) Community organisation and predictability of attack across plant species in the Brassicaceae family.

Theme 2: Parasitoids, hyperparasitoids and predators in biological control

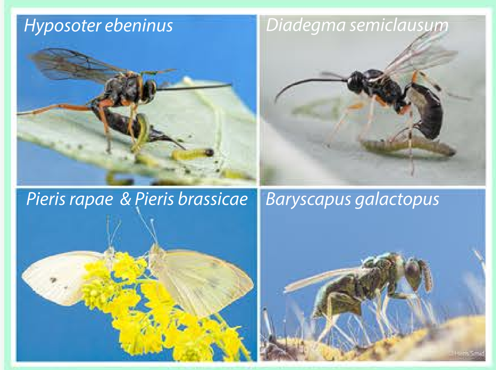
Natural enemies such as parasitoids and predators are often combined in biological control. We address: i) How combinations of natural enemies reduce pest pressure in open field cropping systems; ii) How parasitoids locate their hosts in complex environments; iii) Whether the hyperparasitoid enemies of parasitoids suppress biological control and how they locate their host.



Theme 3: Sustainable agriculture: ecology-based production using crop diversity that stimulates insect biodiversity

In collaboration with the agricultural sector we unravel how crop diversity in strip intercropping can be a stepping stone towards sustainable crop production. We assess natural pest suppression, crop performance, functional and general biodiversity across farms in the Netherlands that use strip cropping.

Insect species and main techniques



We study trait evolution in flowers and leaves of the Brassicaceae plant family, interactions in their insect community of herbivores, parasitoids, hyperparasitoids, predators and pollinators by field ecology and greenhouse experiments, plant physiology in response to insect herbivory as measured by growth morphology, gene expression and chemical analyses. We take an applied perspective in open field and greenhouse biological control and measure the effect of sustainable nature inclusive crop production on insect biodiversity.