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ERL ENVIRONMENTAL ROBOTICS LABORATORY

# Use of miniature drones for biodiversity survey

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Environmental Robotics Lab

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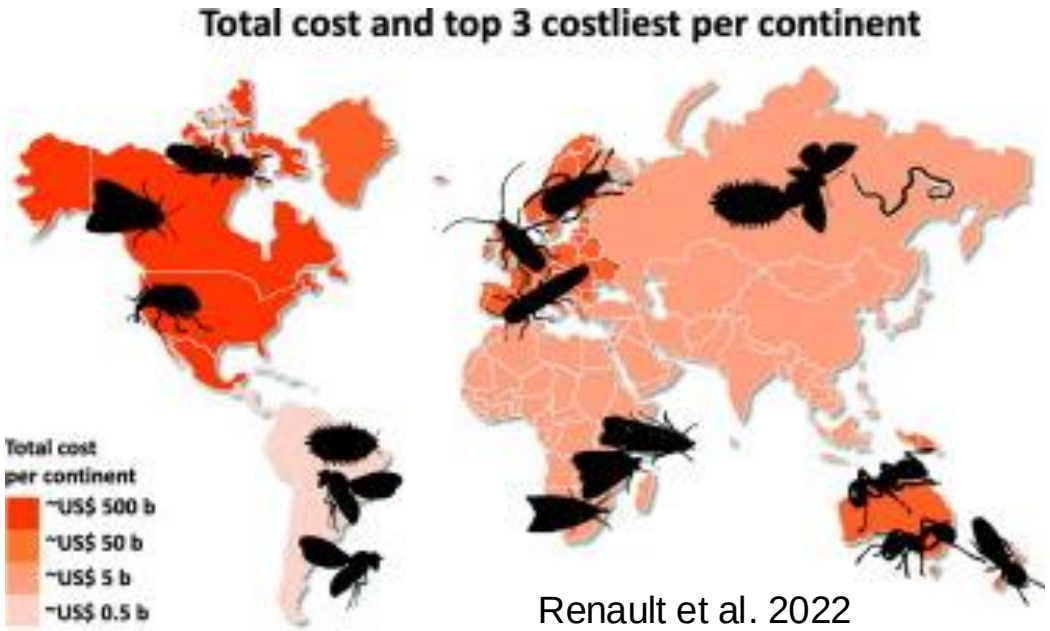
# Motivation

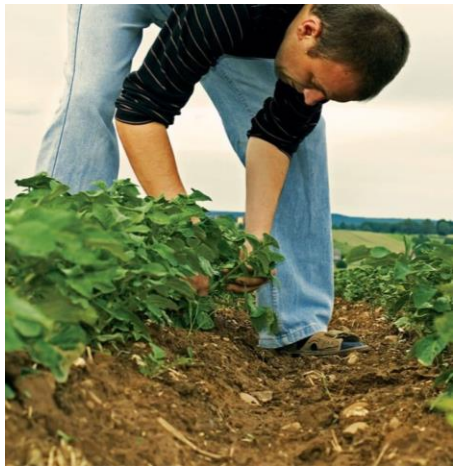
Globalisation and climate change have led to an **increase in pest invasions** and outbreaks worldwide, causing significant crop losses and economic damages.

- These costs are rising and were mostly due to invasive insects (88%)
- These costs mainly resulted from direct resource damages and losses (75%)



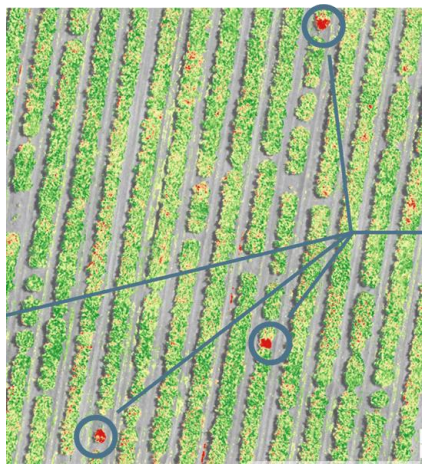

Renault et al. 2022

Traditional **monitoring approaches are inadequate** in detecting invasions or outbreaks during their **early stages**, when management protocols are most effective and sustainable.



Visual survey

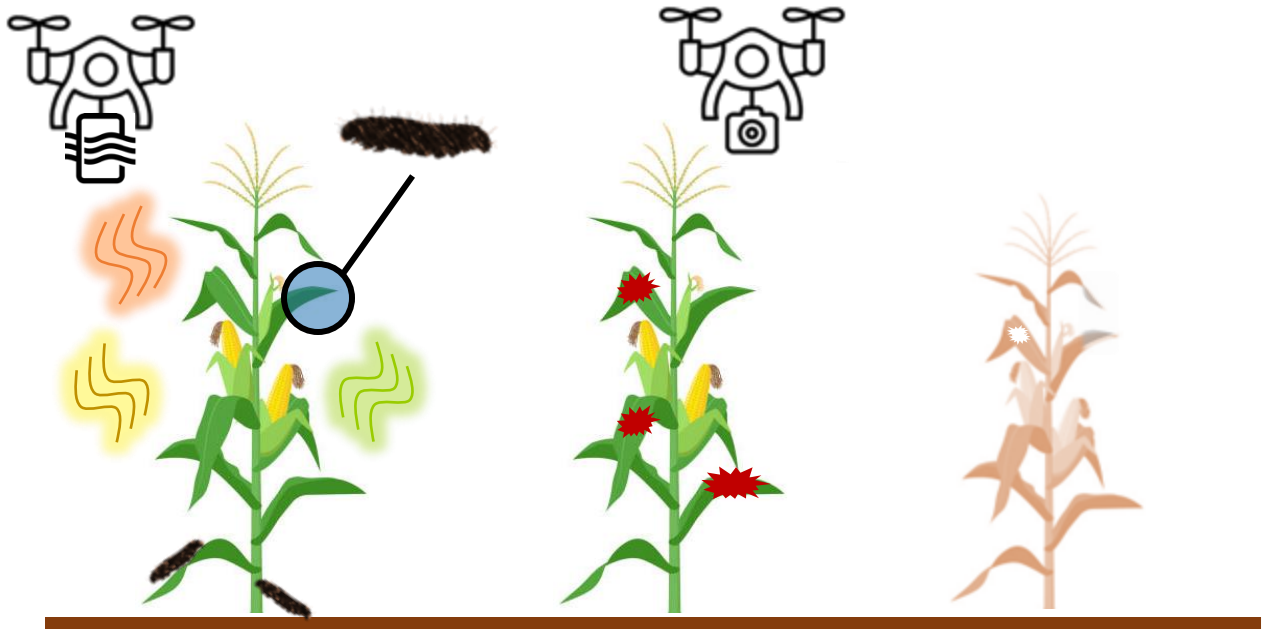
Camera / pheromone traps

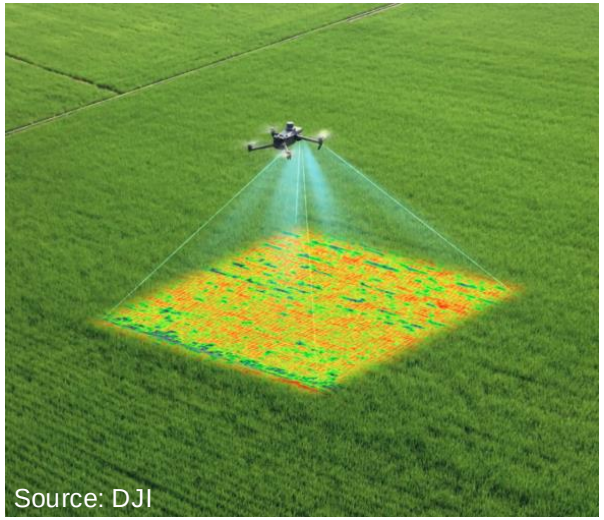


Remote sensing

# Early pest detection for sustainable agriculture

**Plant volatiles** **Imageable symptoms**






Seconds-Hours Days-Weeks Weeks-Months

**Minor damage** **Bulk damage** **Severe damage**

**Early intervention**

**Crop loss**

***Plant EcoAir***

In collaboration with:

- Prof. Meredith Schuman
- Dr. Sergio Ramos

University of Zurich[UZH]

syngenta

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# Plant volatiles for remote sensing of insect pests

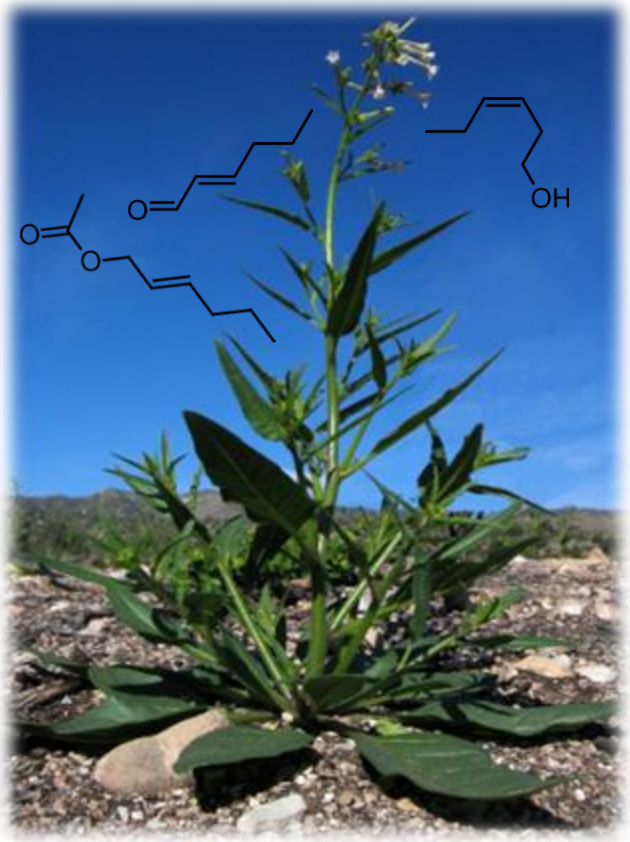
Attract predators and parasitoids
(Kessler & Baldwin 2001, Brodman et al. 2008)

Repel adult herbivores
(Allmann et al. 2013)

What make volatiles an excellent early warning system?

- *Rapid* (released withing seconds / hours)
- *Predictable* (provide info about the physiological and phenological status of the plant)
- *Tailored* (mixture and ratio depends on the herbivore)

Plant volatiles …




Schuman and Baldwin, 2012, Ch. 15 in The Ecology of Plant Secondary Metabolites

… collection

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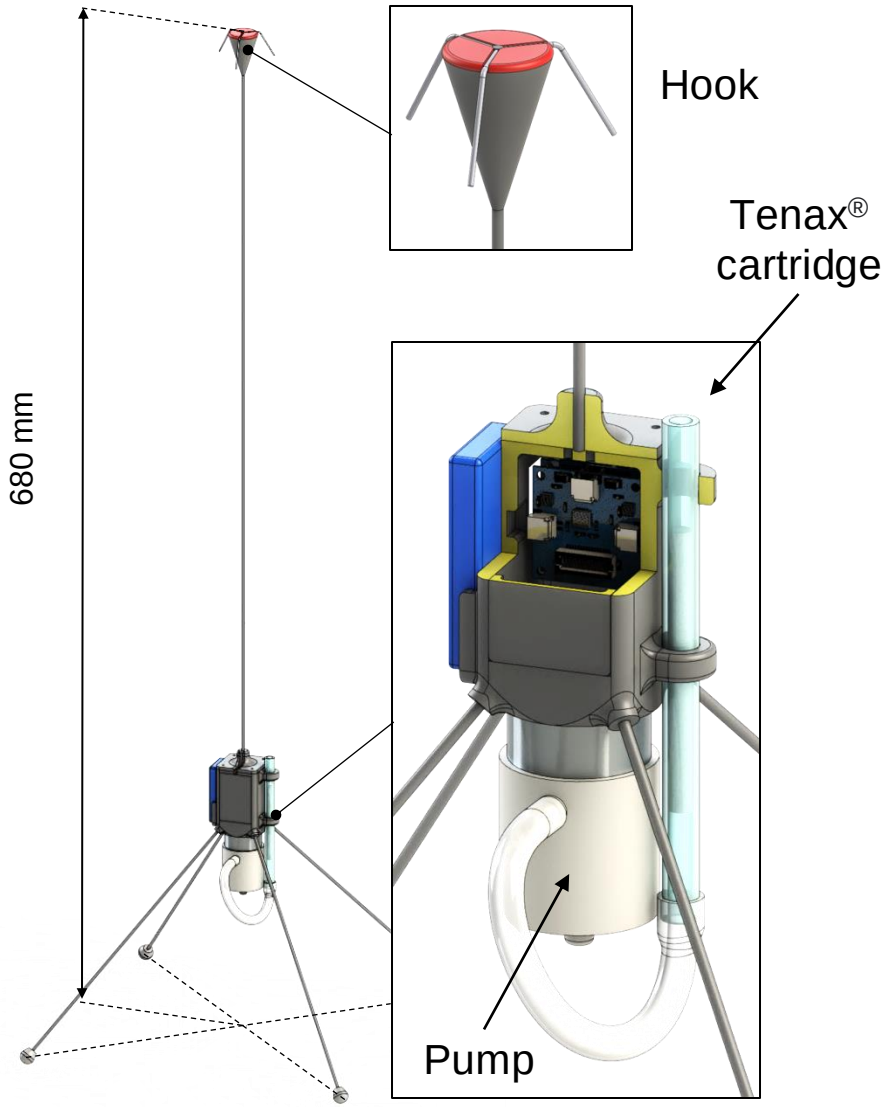
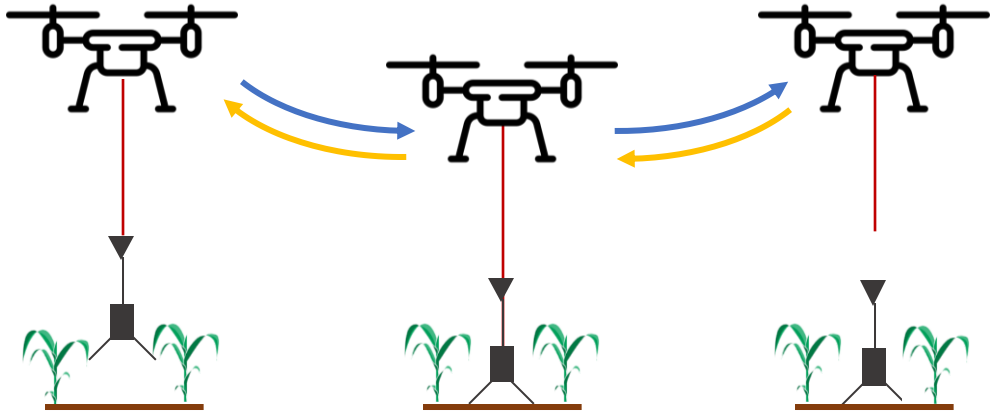
Slide taken from M. Schuman (BIO339, Co-Evolution with Herbivores)

# Drone-base collection of plant volatiles

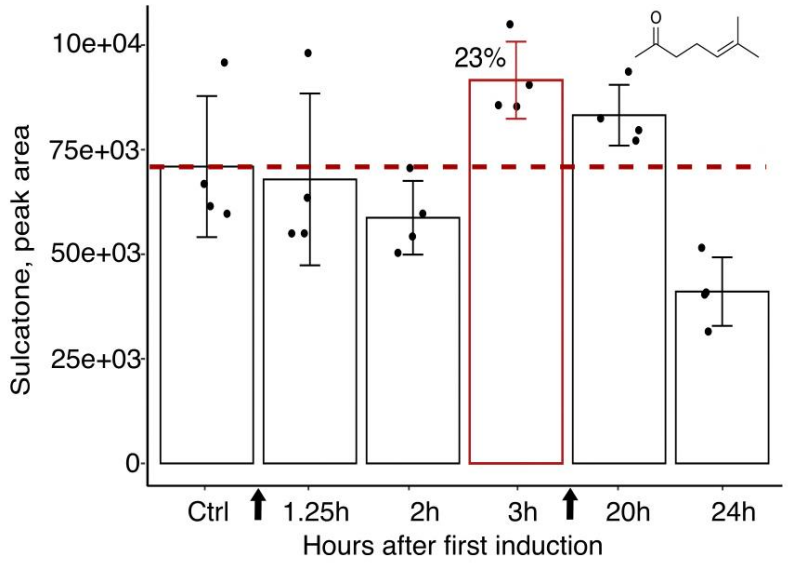


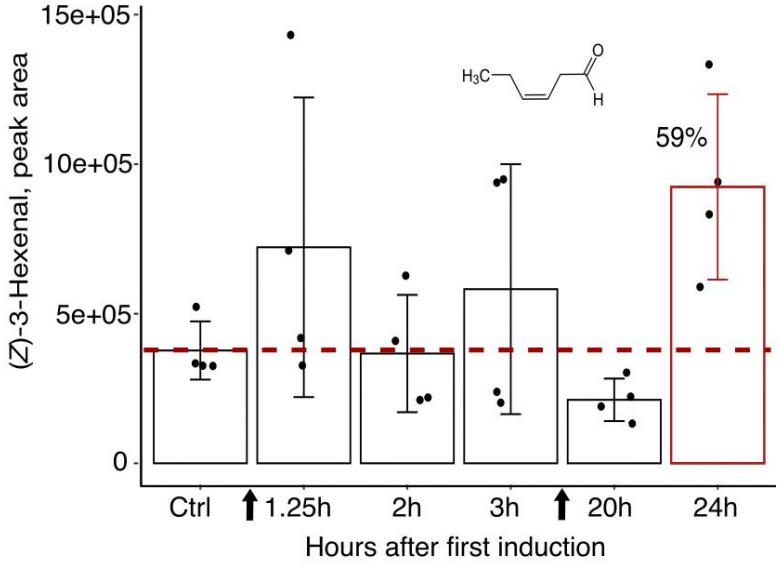



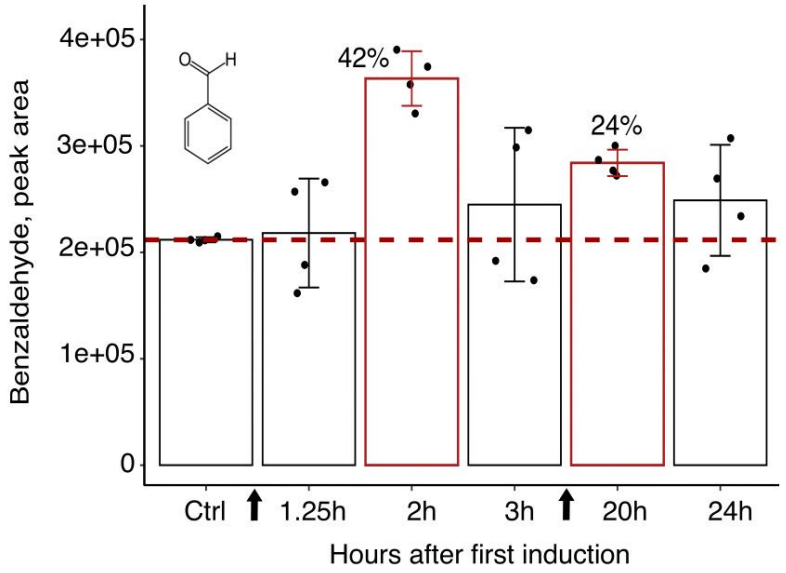
Outdoor Deployment

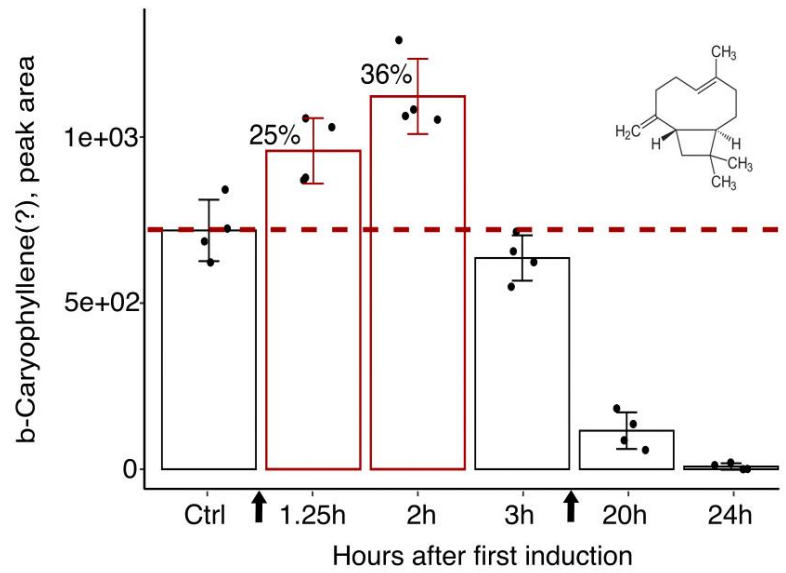
C. Geckeler, S. E. Ramos, M. C. Schuman and S. Mintchev, "Robotic Volatile Sampling for Early Detection of Plant Stress: Precision Agriculture Beyond Visual Remote Sensing," in *IEEE Robotics & Automation Magazine,* vol. 30, no. 4, pp. 41-51, Dec. 2023.

# Proof-of-concept outdoor sampling

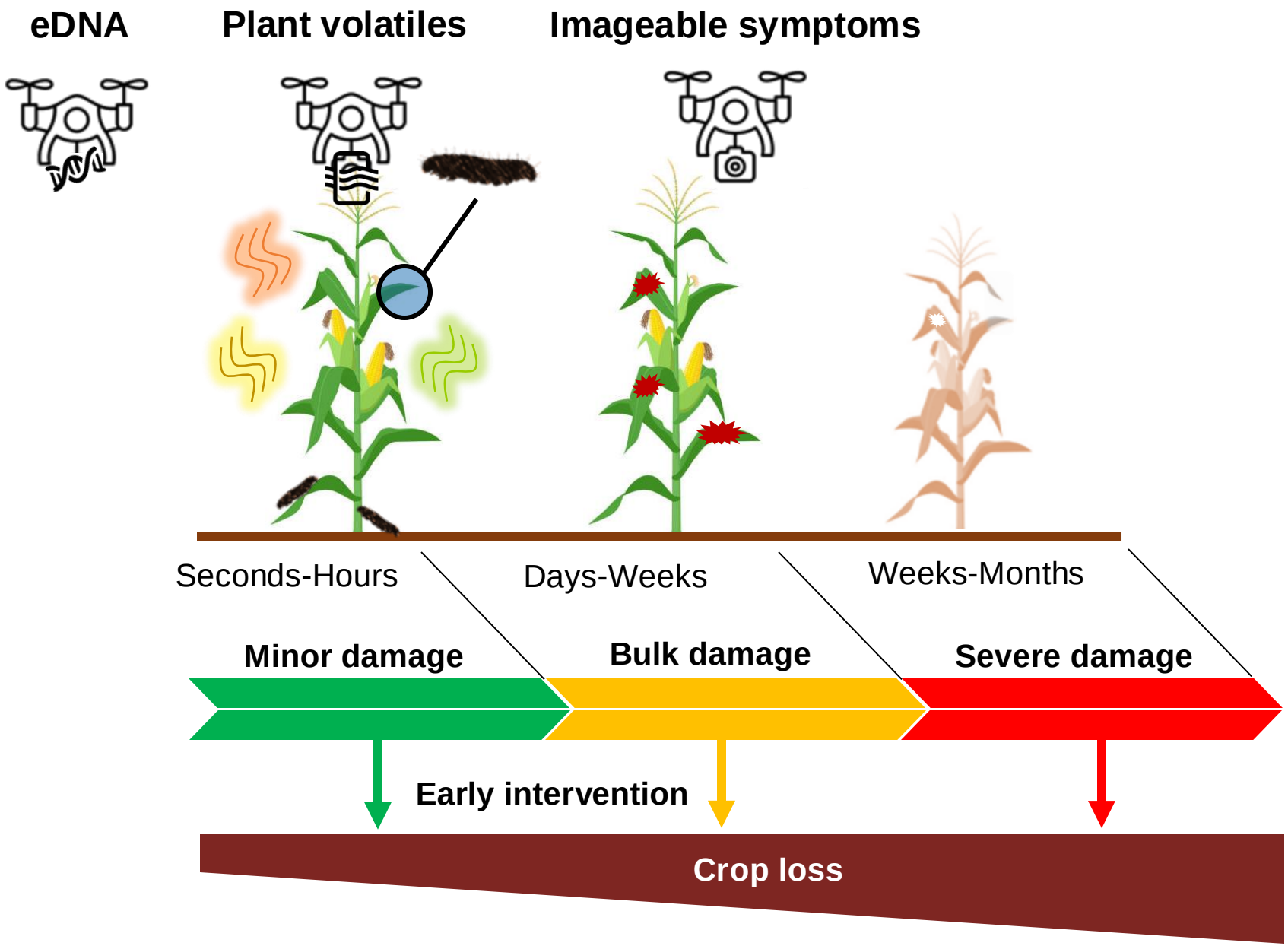


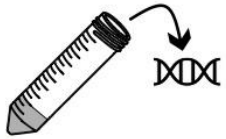
# Early pest detection for sustainable agriculture



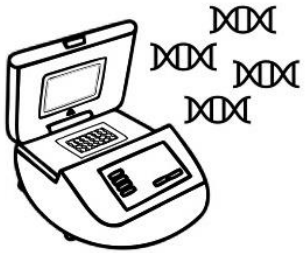
# Environmental DNA

**eDNA collection**

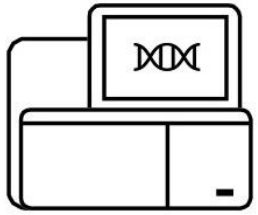
**DNA extraction**



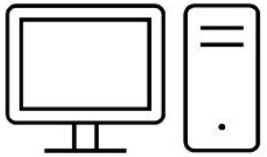
**DNA amplification**



**Sequencing**



**Bioinformatics**



**Results**

Valentin et al. 2019, Allen et al. 2020

# State-of-the art and limitations

Survey tools based on eDNA have proven especially useful for detecting rare or elusive species due to their high sensitivity to detect minute traces left behind by organisms.

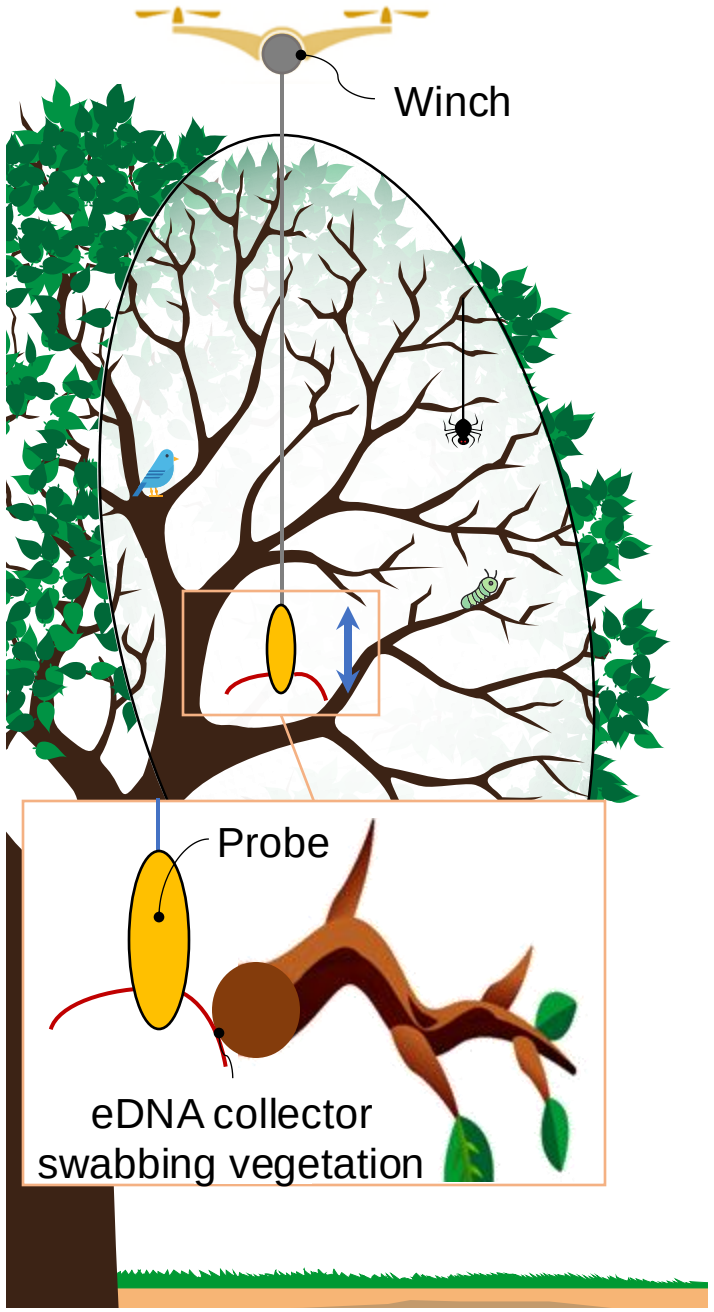
Valentin et al. 2019, Allen et al. 2020

The probability of detecting spotted lanternflies given presence in a plot was over two times higher for eDNA (84%) versus visual surveys (36%).

**Limitations**

1) Manual eDNA collection is labor intensive, time-consuming (2 m/min) and not repeatable.
2) Processing samples can be expensive and time-consuming.

# eProbe - Surface eDNA Sampling

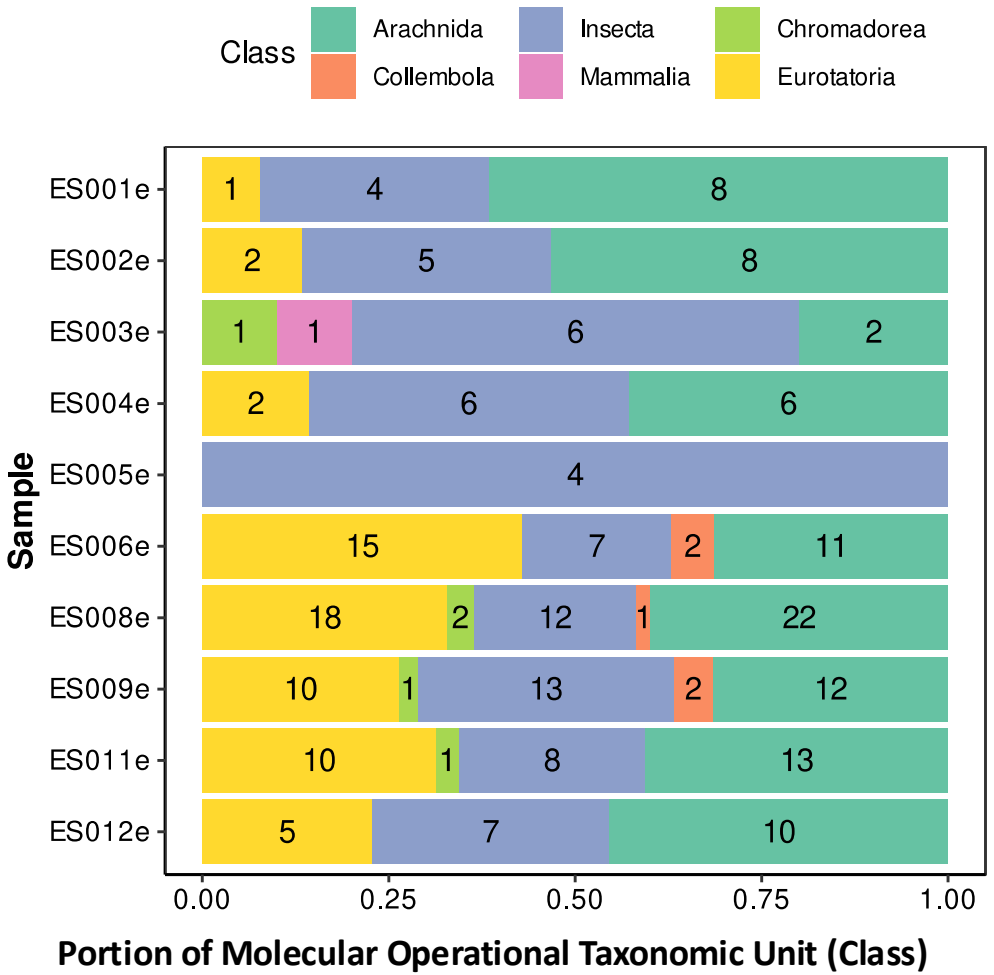


S. Kirchgeorg, et al., “eProbe: Sampling of Environmental DNA within Tree Canopies with Drones”, Environmental Science and Technology, 2024.

# Results - eDNA Survey in Singapore

# of probes = 10

# of metazoan detections = 152



*Macaca fascicularis*

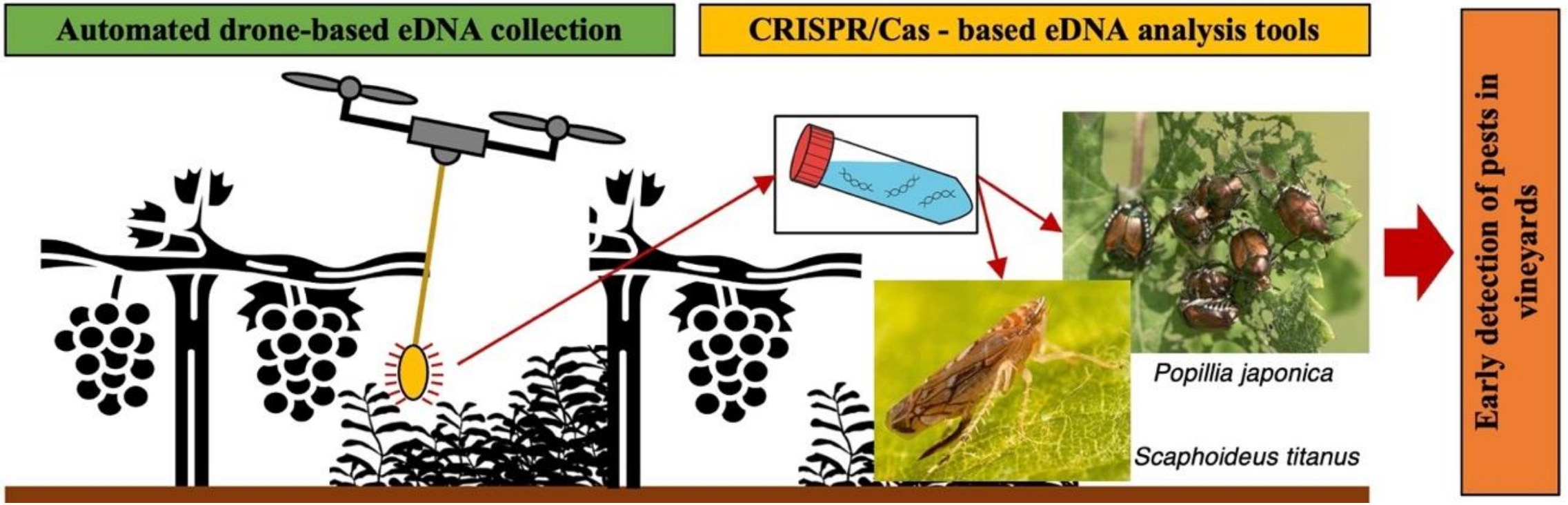
*Hospitalitermes sp*

*Cecidomyiidae* sp.

*Entomobrya marginata*

# The GRiP Project

This interdisciplinary research project aims to **improve the sensitivity and timeliness** of pest detection and surveillance in Swiss vineyards through the integration of **robotics and genetic technologies.**




In collaboration with:
- Prof. Loïc Pellissier
- Dr. Martina Lüthi

# Filed tests in vineyards

Successfully developed and tested:

- Drone-based eDNA sampling
- CRISPR_cas detection of *P. japonica*

Collection of dataset to compare eDNA sampling (drone and manual) with visual survey

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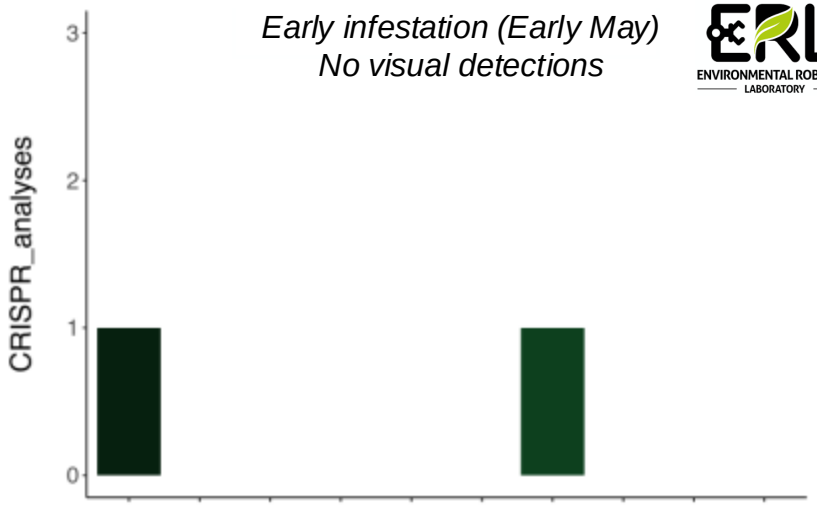
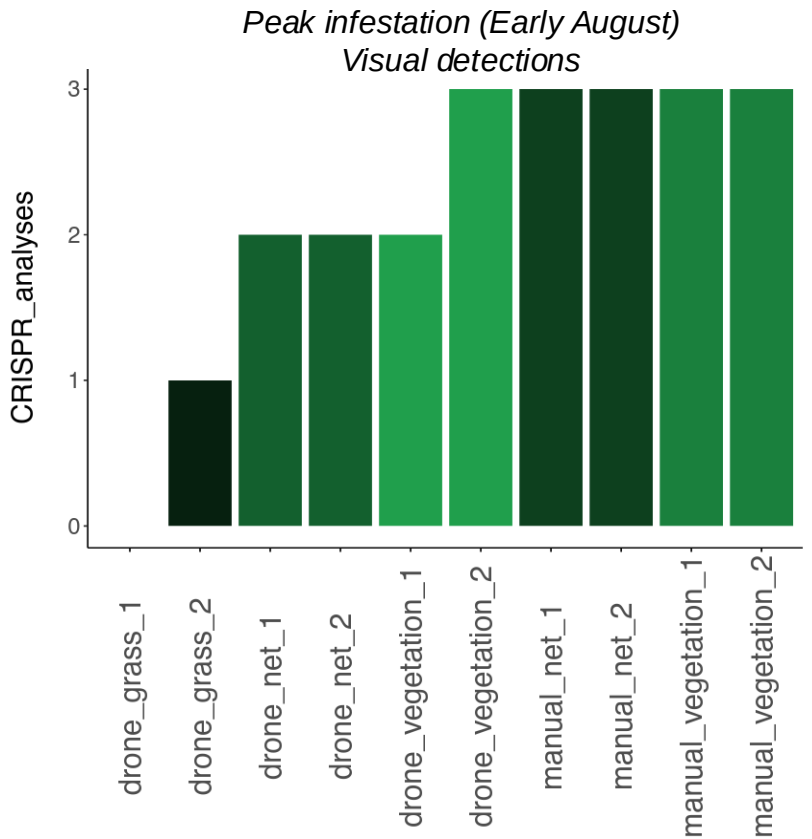
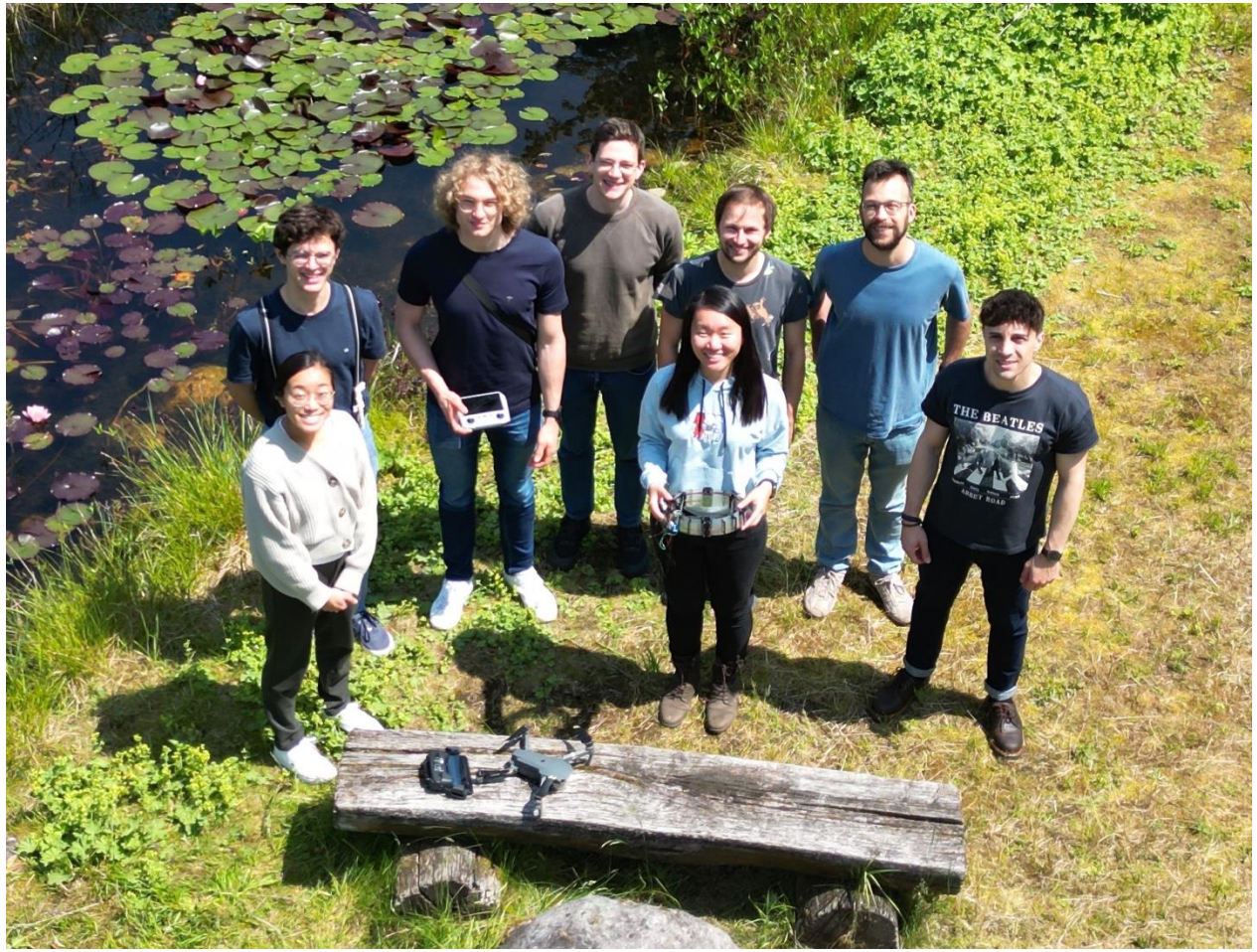


**ERL Members :**

- Christian Geckeler
- Luca Girardi
- Steffen Kirchgeorg
- Gabriel Maquignaz
- Ilya Semenov
- Dr. Adam Seewald
- Dr. Rui Wu

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**Research Partners:**

ETH zürich, zooh! Zürich, World Food System Center, WSL, University of Zurich[UZH], Agroscope, plant science center, Weinbauzentrum Wädenswil

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# Thank you!

# Questions?