



UCA Complex days

07/02/2023, Crowne Plaza Hôtel (Grand Arénas - Nice)

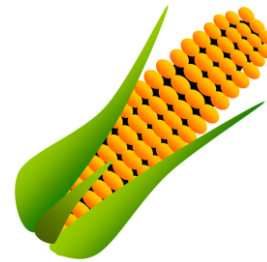
 Bridging behavior and spatial propagation: a new double-spiral maze and image analysis pipeline to study dispersal in groups of minute insects 

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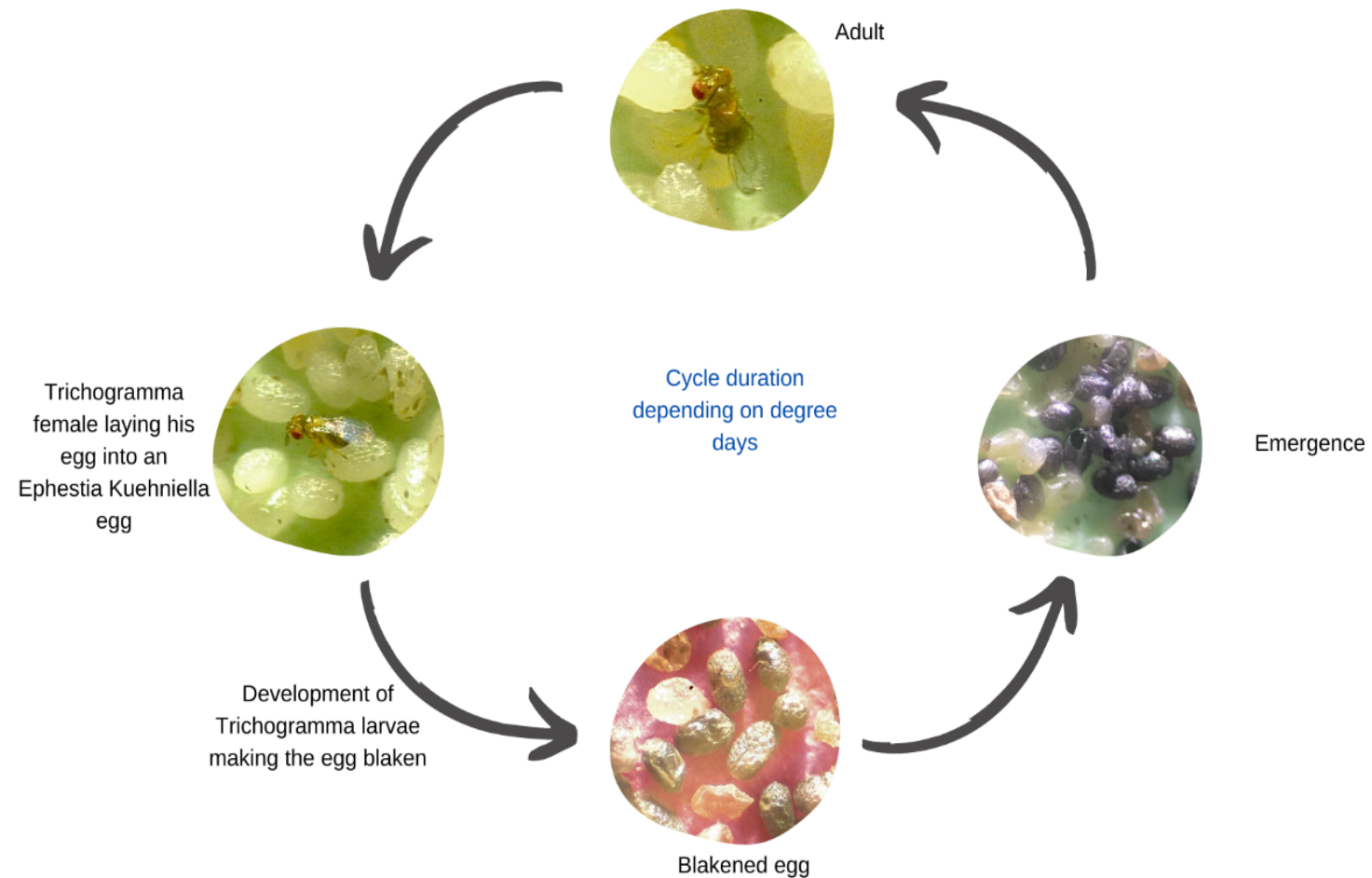
- You've probably all eaten popcorn before, right?
- Before being a sweet treat, it is a corn kernel that clings to its cob.



- A crop that can be threatened by pest attacks! Like the European Corn Borer *O. nubilalis*
- A clean, sustainable, environmentally and human friendly protection: biocontrol! → the use of natural enemies (whether introduced or otherwise manipulated) to control insect pests (Smith 1996)
- Famous natural enemy, one of the most used: Trichogramma sp.!

Presentation of *Trichogramma* sp.

- Oophagous parasitoids
- Hymenoptera less than 0.5mm.
- Ease of rearing on alternative hosts, wide geographical distribution interesting biocontrol agents.
- Walking insects
- Species studied: *Trichogramma cacoeciae* with 17 asexual strains from the CRB "Egg Parasitoids Collection" (CRB EP-Coll).



Biological Control



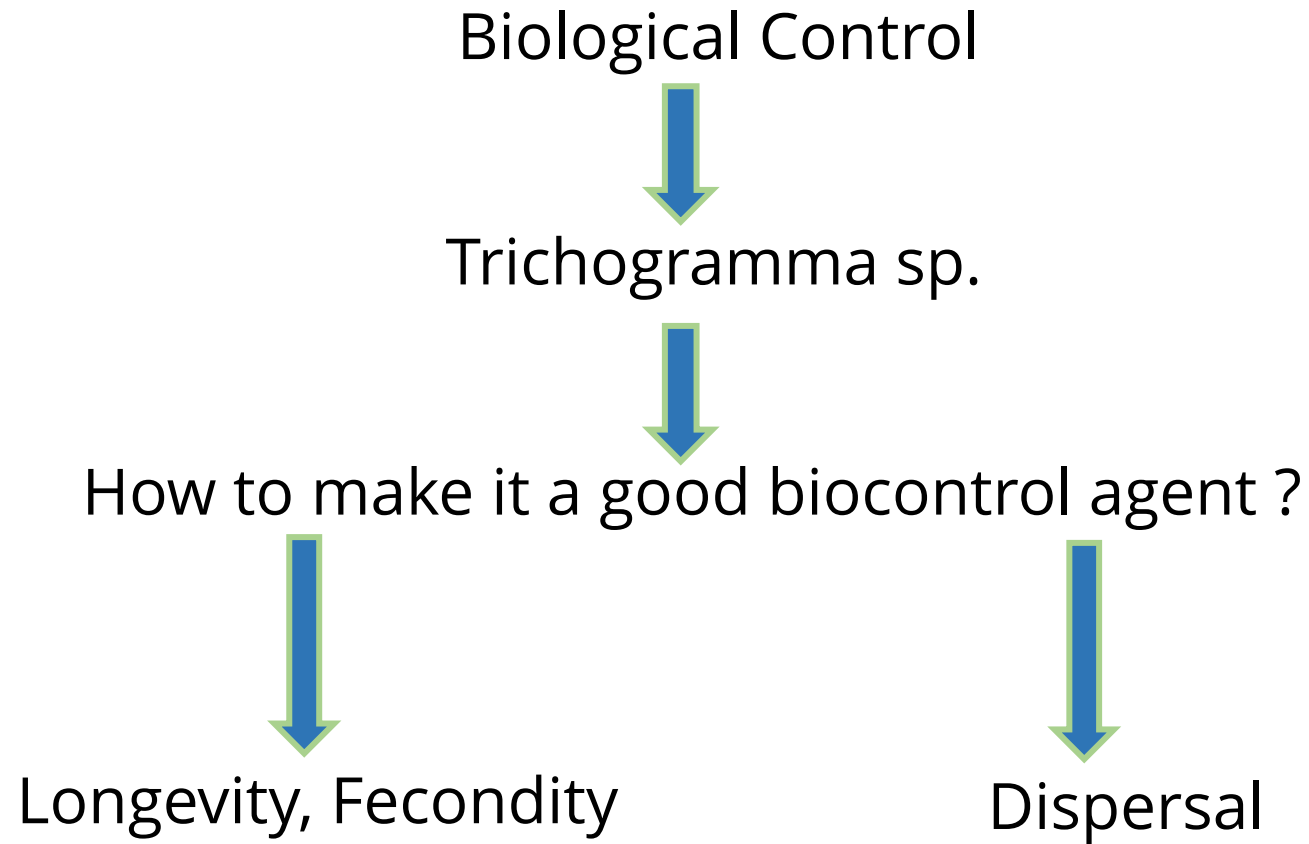
Trichogramma sp.



How to make it a good biocontrol agent ?



Longevity, Fecondity



Why be interested in dispersal?

A key element of life history and fitness, affecting not only individual fitness, but also genetics and population dynamics, and ultimately species distribution.

For biocontrol:

- Good distribution of the insects in the appropriate crops.
- Reducing the workload by reducing the number of release points per unit area.

We address here the following **definition of dispersal**

The spatial spread of individuals (dispersal sensu lato), which can potentially have consequences on reproduction, and gene flow (dispersal sensu stricto).

Biological Control



Trichogramma sp.



How to make it a good biocontrol agent ?



Longevity, Fecondity



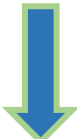
Dispersal

Field releases

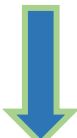
- Close to real-life conditions
- Time consuming
- Expensive
- High variability of results
- Impossible to monitor, indirect measures

Change of scale: a double spiral maze

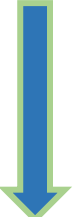
Biological Control



Trichogramma sp.



How to make it a good biocontrol agent ?



Longevity, Fecondity

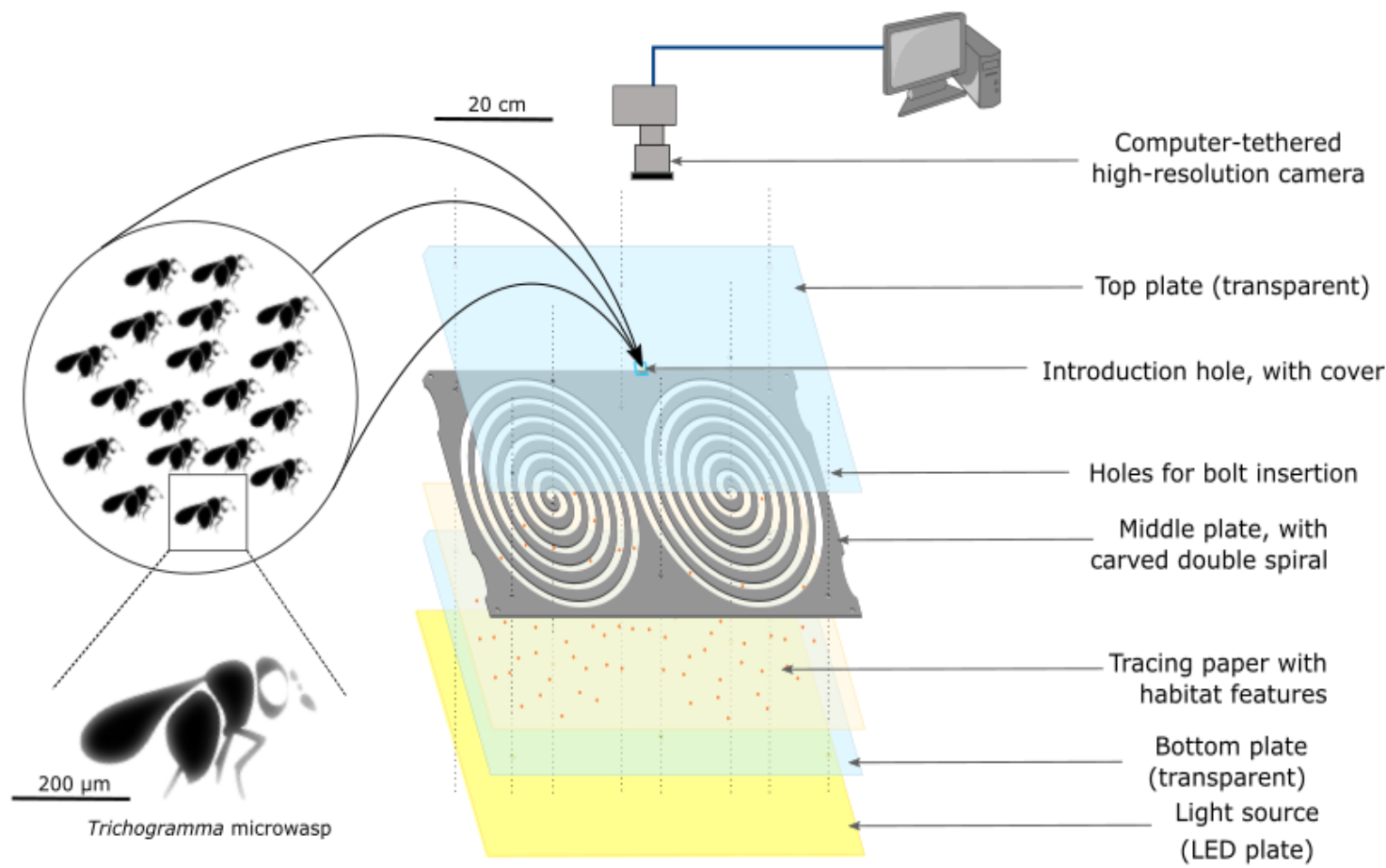


Dispersal

Change of scale: a double spiral maze

Combining experimental ease and dimensions approaching reality

Presentation of the double spiral maze arena



The double spiral offers a path of almost 6m in a small-- rectangular area.



The entire surface can be filmed efficiently with standard camera sensors.

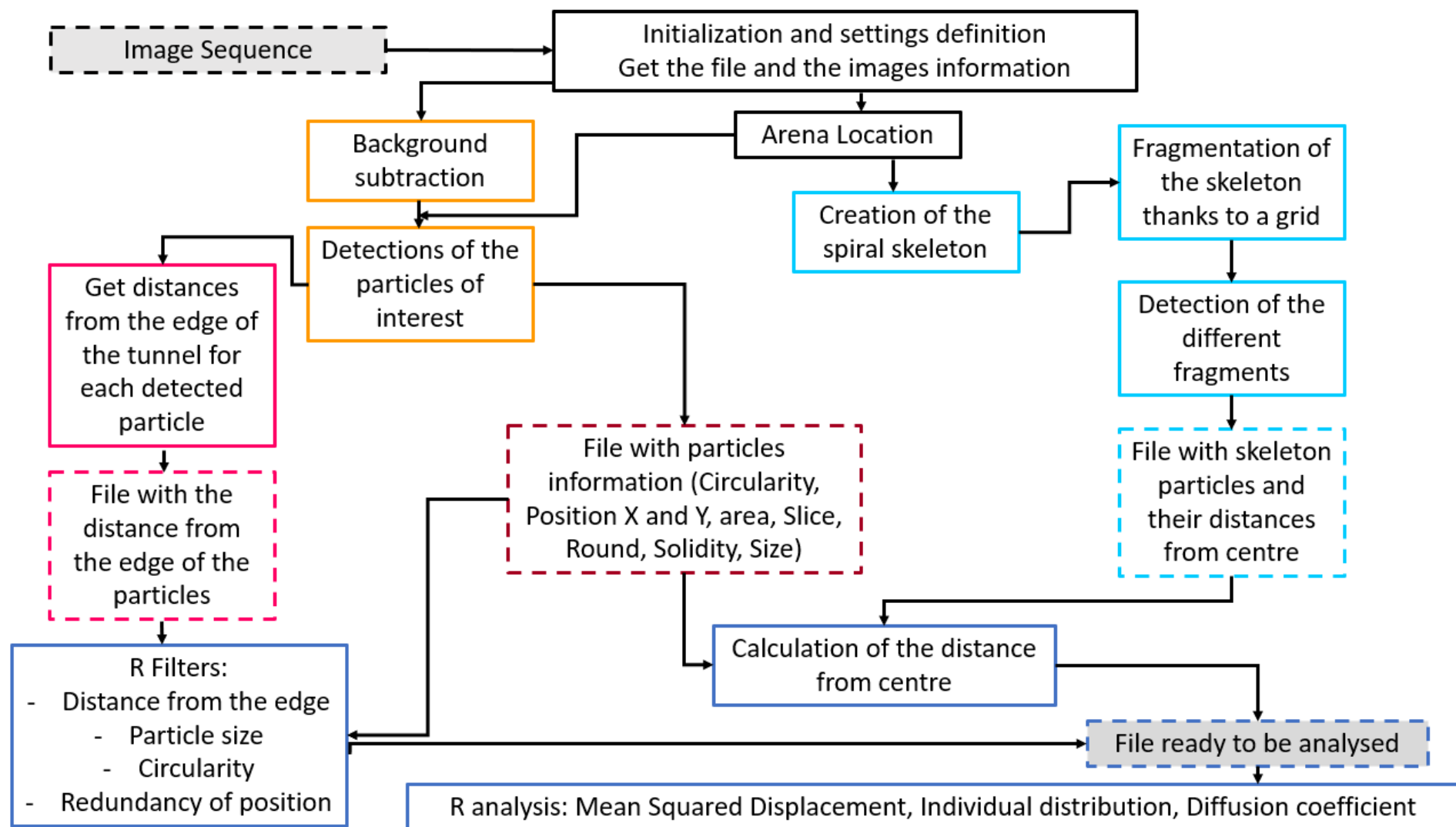


High resolution images (36 Mpx) of the entire arena are taken every minute for 6 hours.

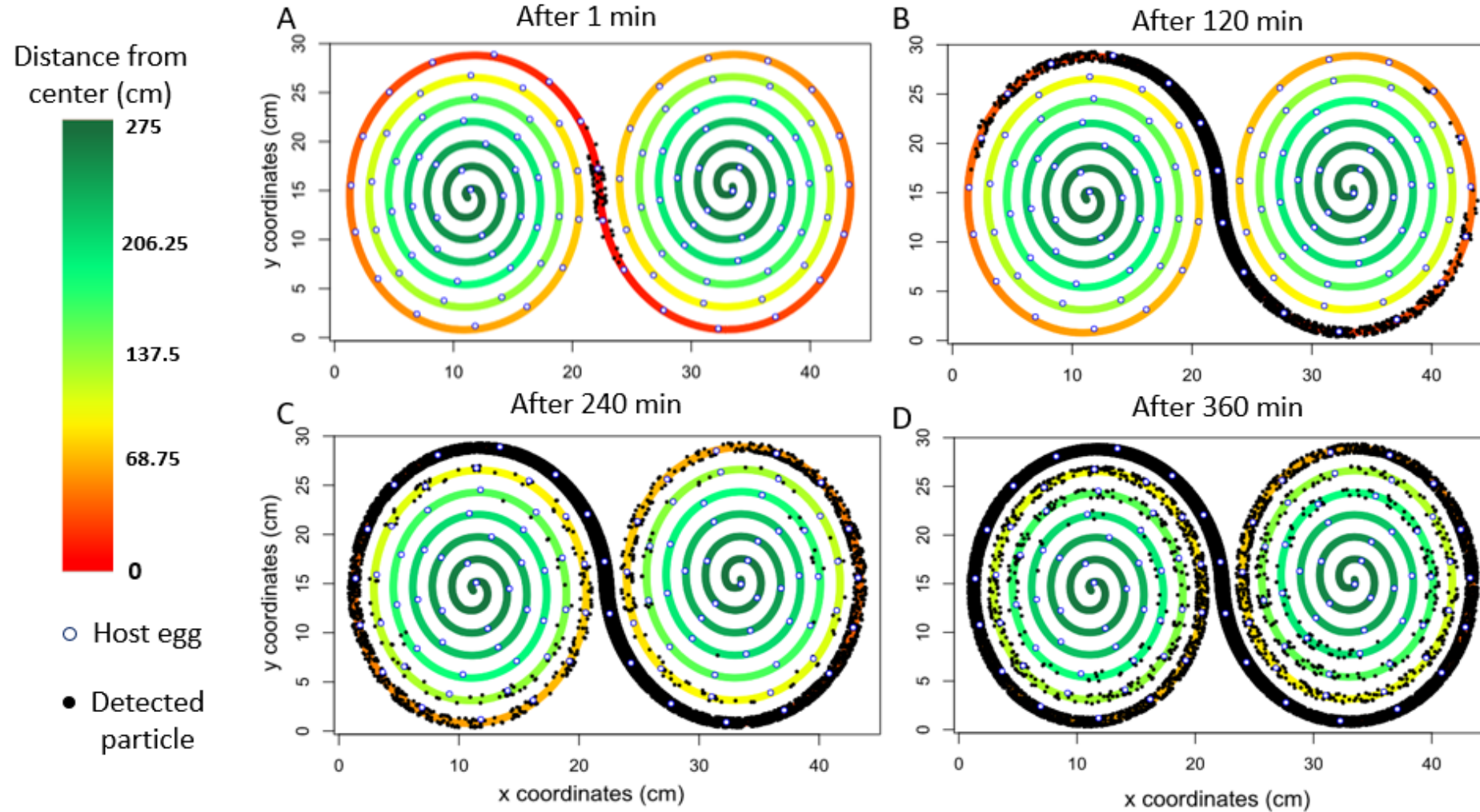


The image analysis pipeline provided detects the location of each individual at each time

Overview of how the automatic image analysis pipeline works



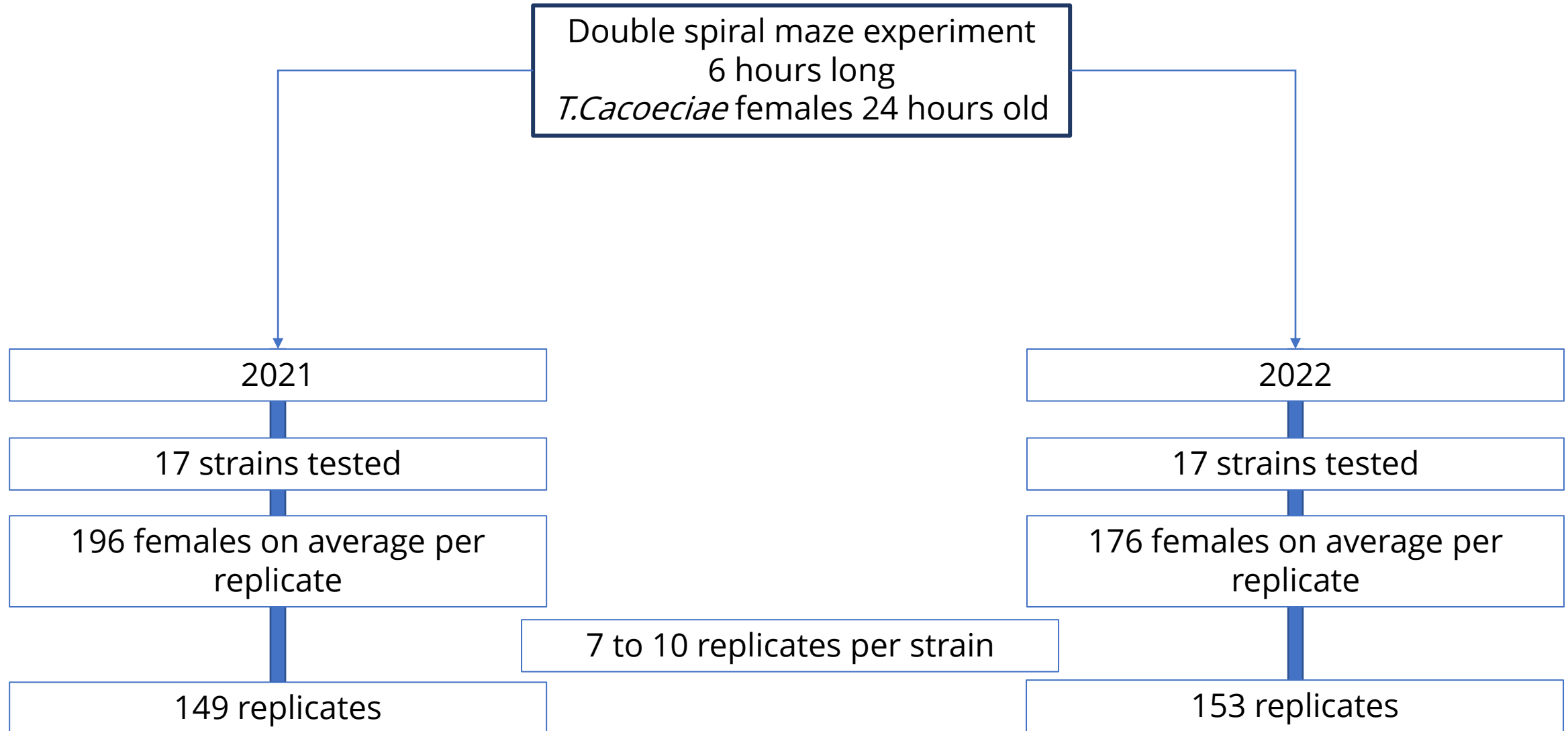
Detection of Trichogramma individuals at different times by the automatic pipeline



Technical verification

- **Verification of the symmetry and the effect of the direction of rotation.** The direction of rotation has no effect on the individual dispersion within the double spiral and the distributions are well symmetrical with respect to the release point.
- **Quality of sealing.** A variation of the labyrinth was designed with solid walls, or septa, along the double spiral tunnel, delimiting 39 zones. No leakage.
- **Lighting.** No systematic variation according to distance from the center, fluctuations around the average of more or less 14%.
- **Overall detection rate of 72%.** Somewhat variable between replicates, ranging from 68% to 78%, but stable over time and shows little variability along the double spiral path.

Method



With the position data over time of the detected individuals



Calculation of the **Mean Square Displacement** over time



Then, **piecewise linear regressions** on these data points



The slopes of the lines obtained correspond to **diffusion coefficients**

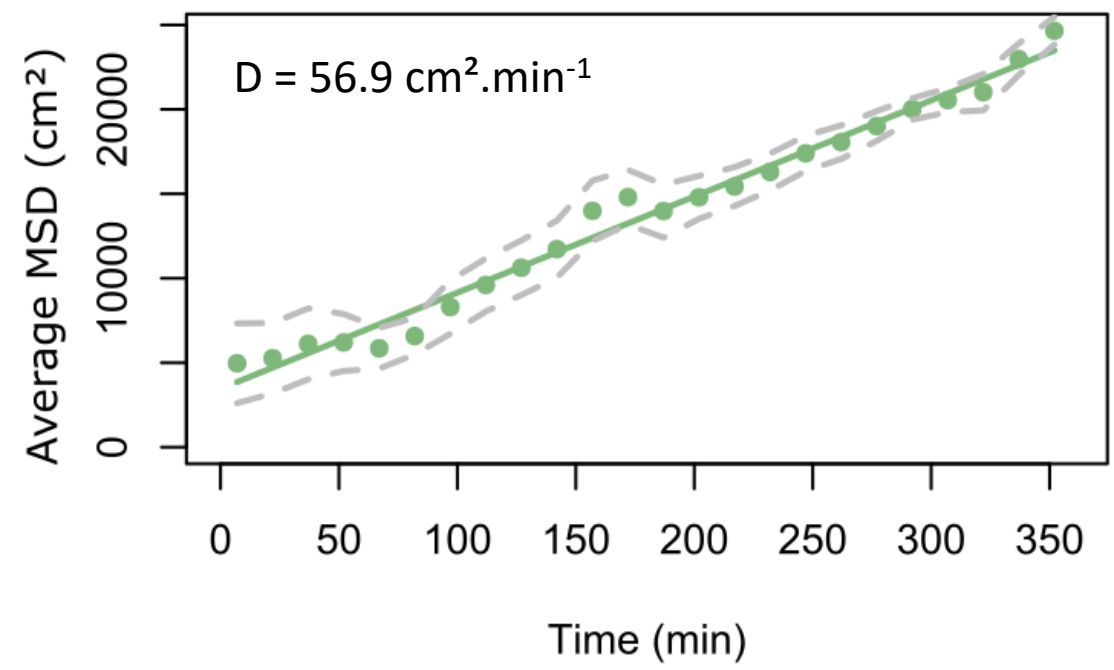
The variance of the distribution of individuals at a given time. It should increase linearly with time in the case of a simple diffusion process for a random walk

An area covered in a given time

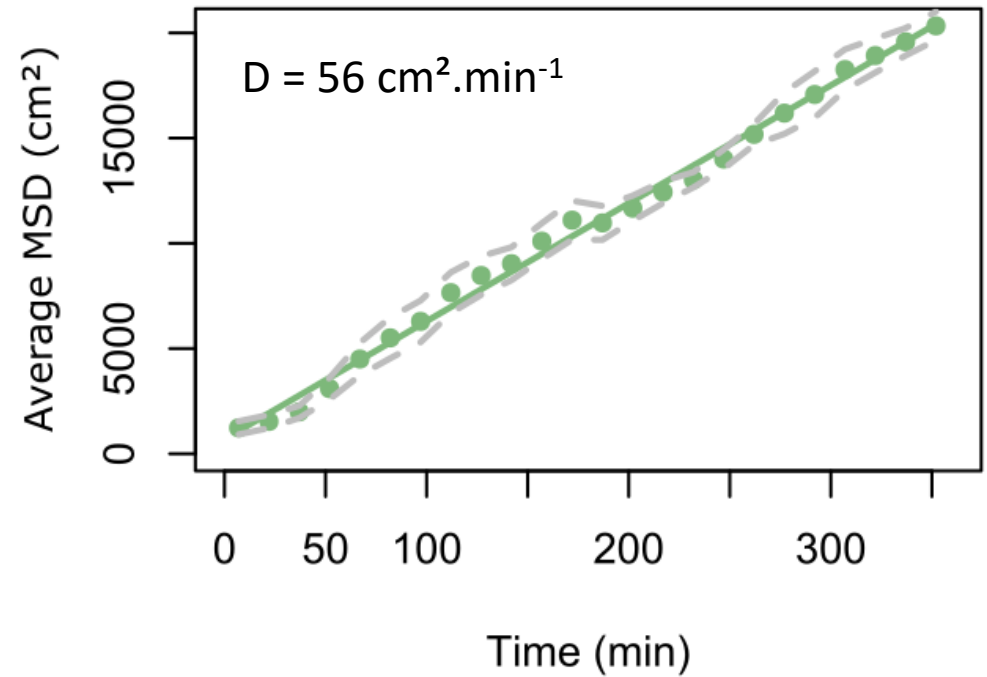
Results

Type1 = Linear 2021/2022

ISA1067



Strain_9

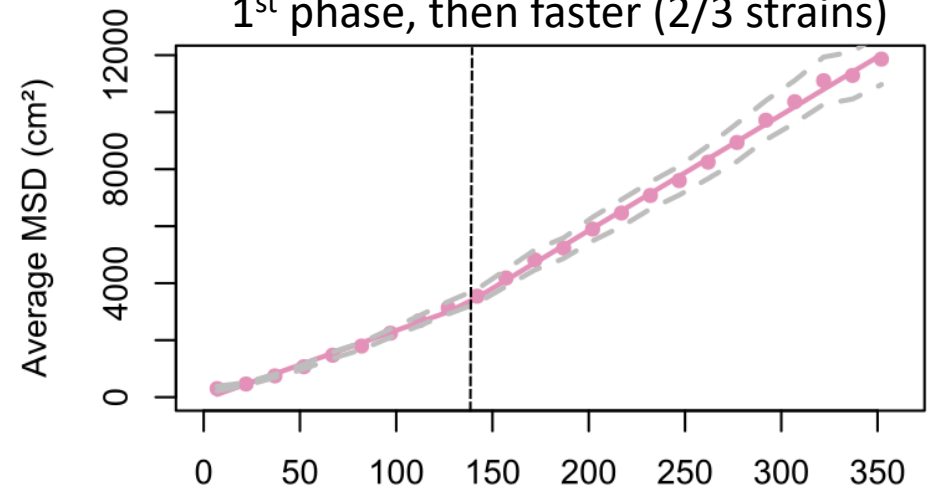


Results

Type2: 2021

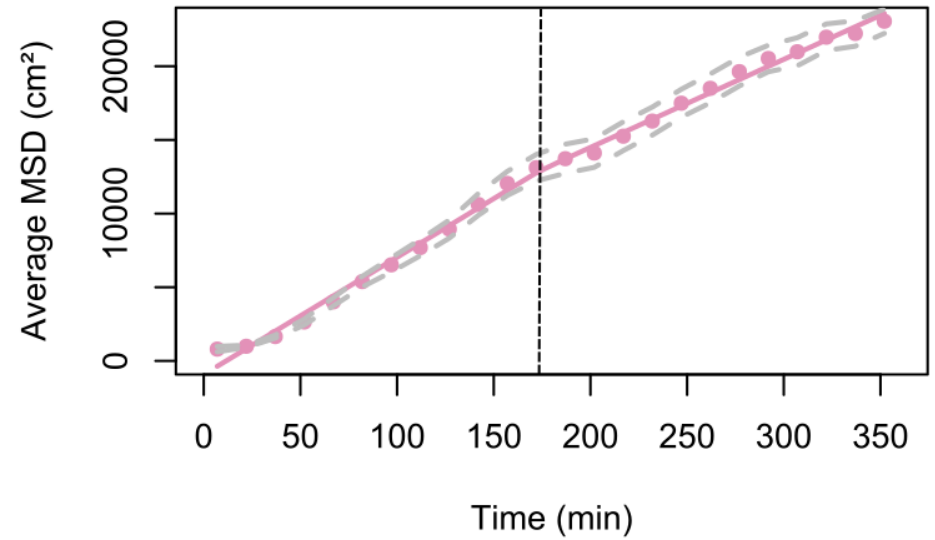
ACJY144

1st phase, then faster (2/3 strains)



TSM008

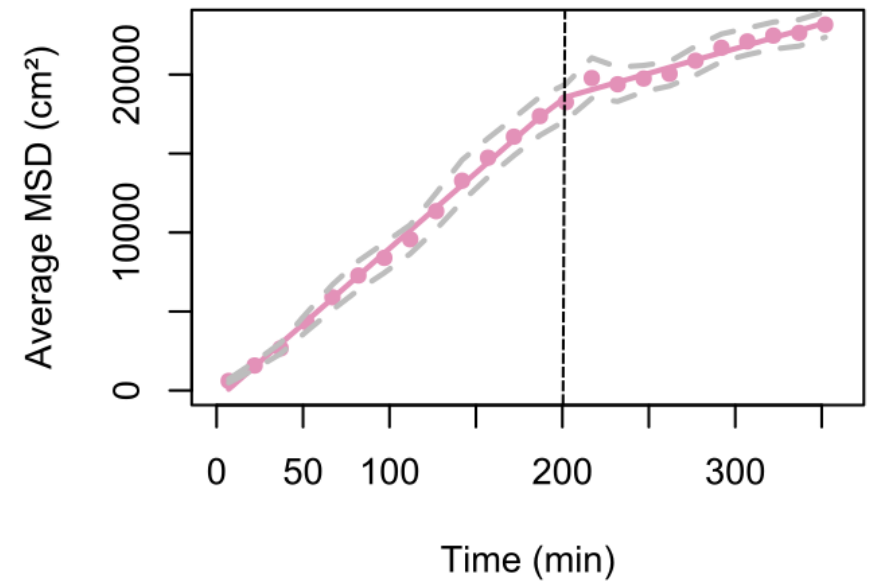
1st phase, then slower (1/3 strains)



Type2: 2022

Strain_16

1st phase, then slower (2/2 strains)

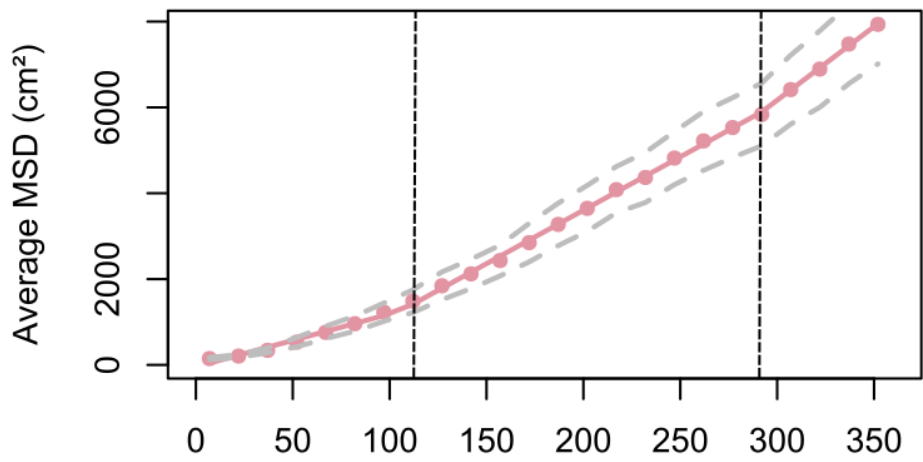


Results

Type3: 2021

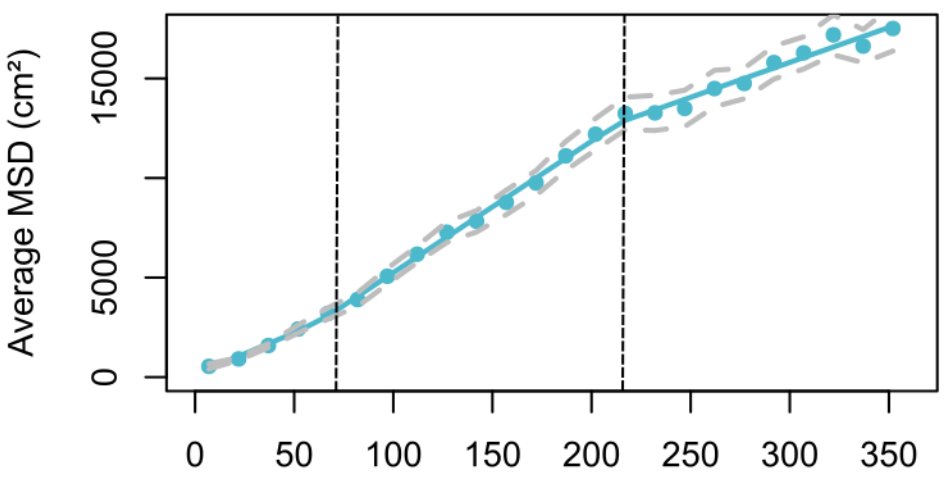
PJ

1st phase, then faster and faster (1/13 strains)



PUG233

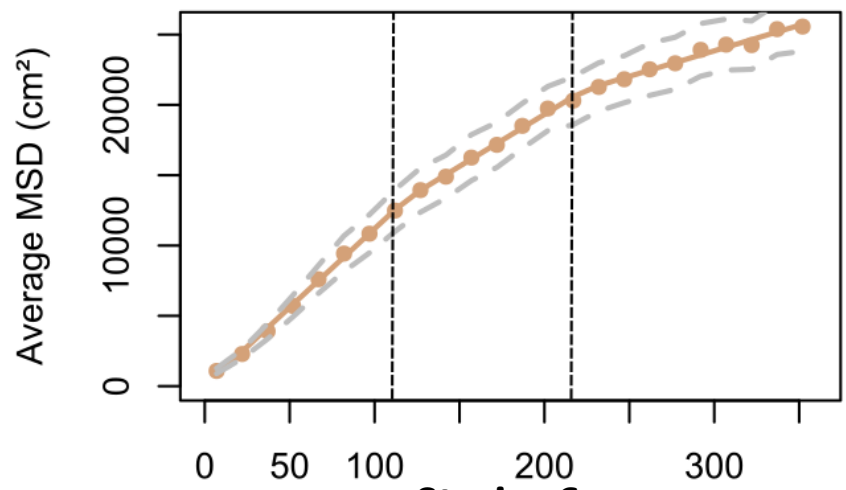
1st phase, then faster, then slower (12/13 strains)



Type3: 2022

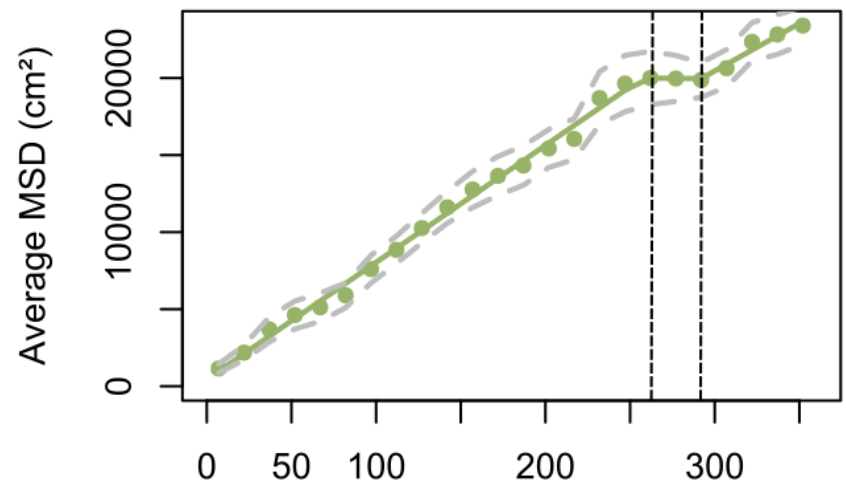
Strain_5

1st phase, then slower and slower (1/14)



Strain_6

1st phase, then slower and faster (1/14)



Results

For both years, **3 types of dispersal** behaviour were identified, differentiated first by the number of phases that constitute them, then by the nature of these phases.

Type 1 = Linear

2021
1st phase, then faster (2/3 strains)
Or
1st phase, then slower (1/3 strains)

2022
1st phase, then slower (2/2 strains)

Type 2 = Two phases

2021
1st phase, then faster, then slower (12/13 strains)
Or
1st phase, then faster and faster (1/13 strains)

2022
1st phase, then faster, then slower (8/14 strains)
Or
1st phase, then faster and faster (1/14 strains)
Or
1st phase, then slower and slower (4/14)
Or
1st phase, then slower and faster (1/14)

Type 3 = Three phases

- It is for now difficult to relate these dispersal patterns to what is already known about the dispersal of *Trichogramma* sp., owing both to the novelty of our method, and the relative scarcity of quantitative data on *Trichogramma* dispersal.
- Ongoing work is seeking to correlate these dispersal patterns with (i) more traditional smaller-scale behavioral studies of dispersal, and (ii) larger scale field experiments.
- Ideal objective: highlight which dispersal profiles are most effective for biocontrol in realistic field conditions → the time-consuming and costly field evaluations of candidate biological control agents could benefit from a pre-screening using the double-spiral maze and/or small-scale studies.

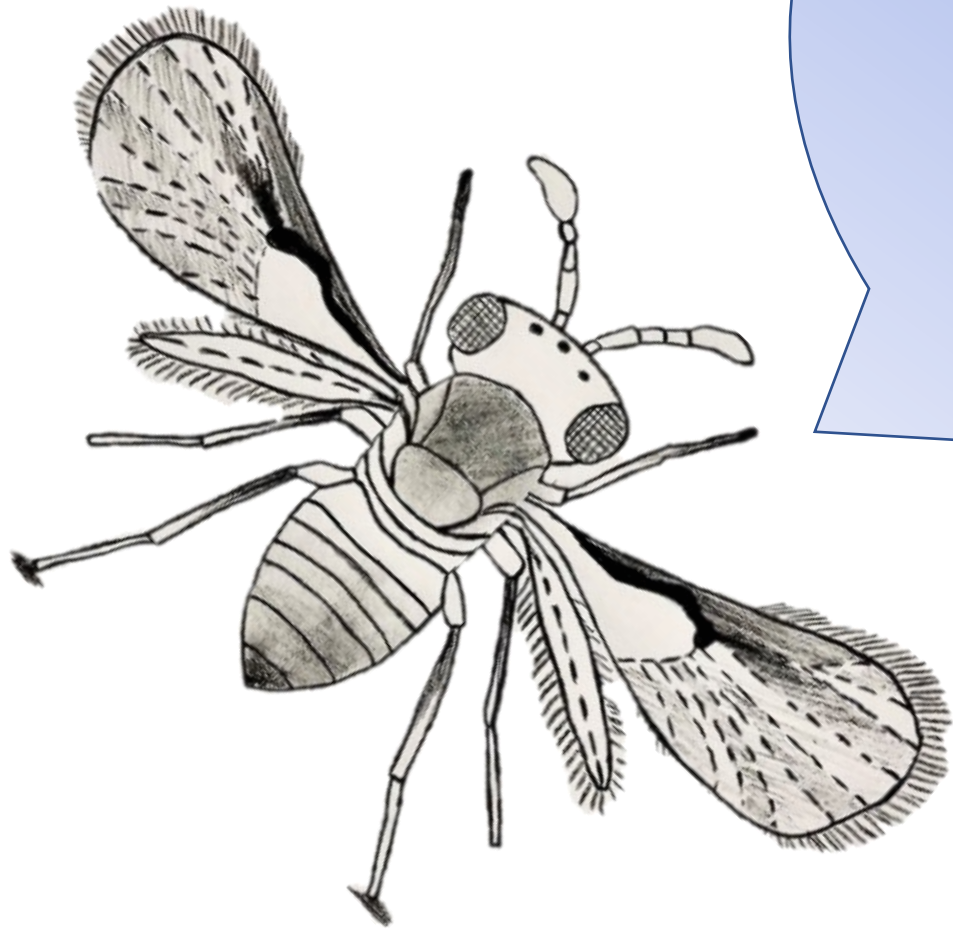
Acknowledgements



Thanks to our financial partners: **Université Côte d'Azur**, **INRAE** Department of Plant Health and Environment, **Bioline AgroSciences**.

Thanks to all the people who helped us in this project: Mathias Launay (Master 2 internship) and Morgane Lheureux (Master 2 internship) for the experimental work, Xavier from the FabLab of Sophia Antipolis for the cutting of the double spiral mazes.

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Thank you
for your
attention !

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Context - Dispersal in double spiral maze - Conclusions - Perspectives

Strains 2021	Replicates_2021	Strains 2022	Replicates_2022
ACJY144	10	Strain_1	10
PMBIO1	10	Strain_2	9
PJ	10	Strain_3	9
Citron	10	Strain_4	8
TCVigne	8	Strain_5	8
TSM008	7	Strain_6	9
GOT0130	7	Strain_7	10
ISA1067	9	Strain_8	10
ISA1075	9	Strain_9	10
MES008	8	Strain_10	8
PPI073	8	Strain_11	9
PUG233	9	Strain_12	7
TCMz	9	Strain_13	10
CAS052	9	Strain_14	10
BL103b	9	Strain_15	7
FLO064	8	Strain_16	9
FLO239	9	Strain_17	10
Totaux	149		153

