CESAB - GDR TheoMoDiv

Mutual benefits of joint species distribution models and laboratory data for the understanding of community dynamics #FruitFliesForEver…

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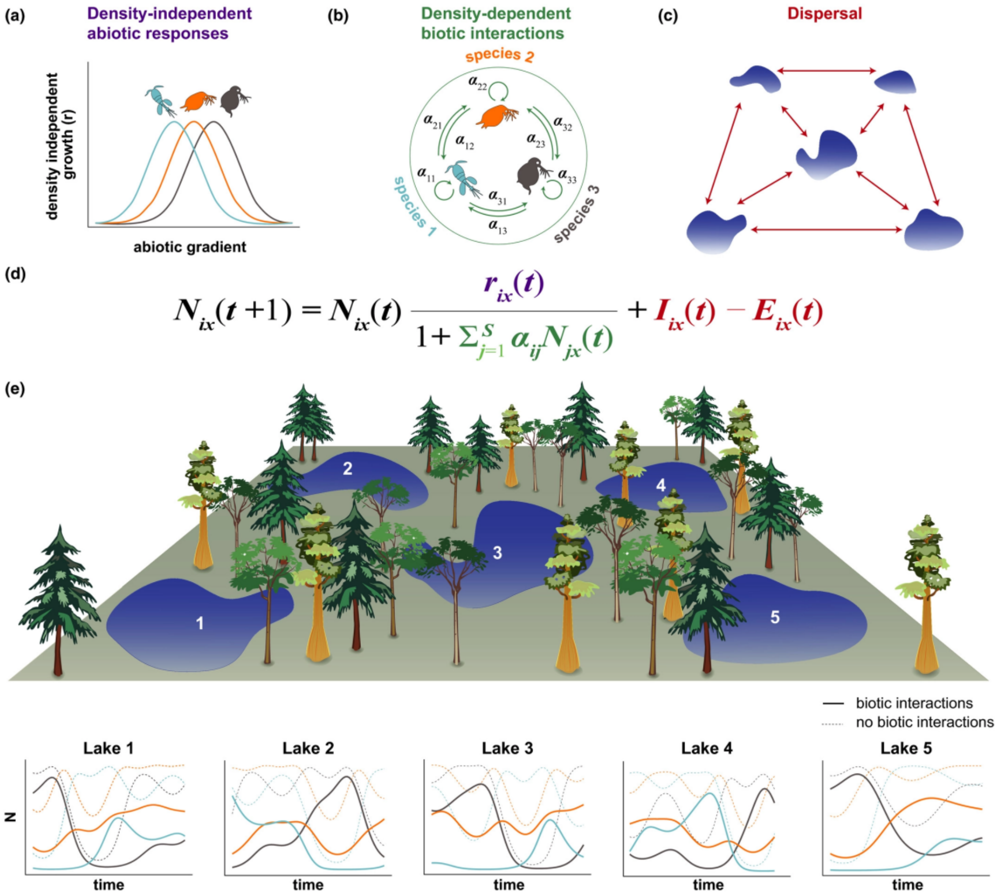
Projet ANR *Next Generation Biomonitoring* - D. Bohan

Community ecology



Thompson et al. 2020 Eco Lett

Regional species pool

↓

Ecological drift under species loss and immigration processes

Niche

Species interactions

?

↓

Observed communities

Phytophagous insects

… are among the most abundant and diversified group on the planet
… are often key species in the ecosystem due to their multiple effects on plants




Niche has at least two classes of dimensions
- abiotic (e.g., climate, environment)
- biotic = host plants

Does competition shape abundances?
- Many laboratory competition experiments suggest YES (ex : Denno et al. 1995, Kaplan & Denno 2007)
- BUT no pattern of negative coocurrence in natural communities (ex: Tack et al. 2009, Brazeau & Schamp 2019)

Fruit flies in Réunion

A community with 8 Tephritidae fruit flies in true sympatry in Réunion

C. catoirii

C. capitata

C. quilicii

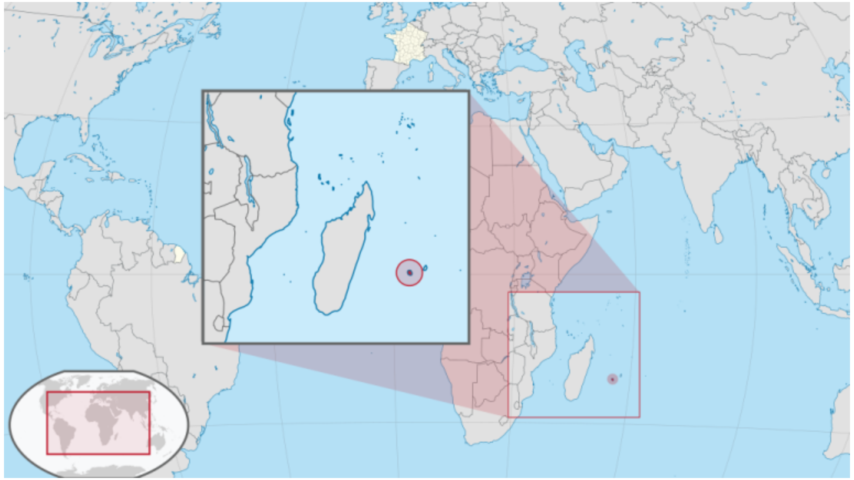
B. zonata

D. demmerezi

Z. cucurbitae

D. ciliatus

N. cyanescens



Photos : Antoine Franck

Fruit flies in Réunion

A community with 8 Tephritidae fruit flies in true sympatry in Réunion

Ceratitinae

C. catoirii

C. capitata

C. quilicii

Dacinae

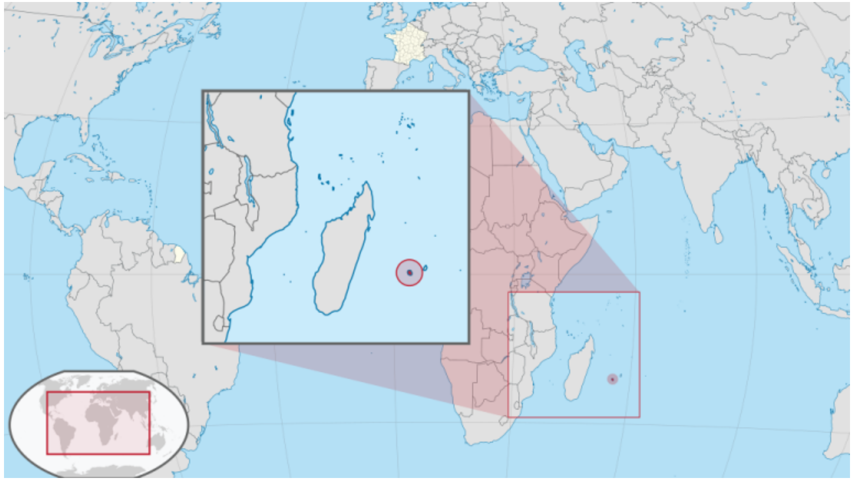
B. zonata

D. demmerezi

Z. cucurbitae

D. ciliatus

N. cyanescens



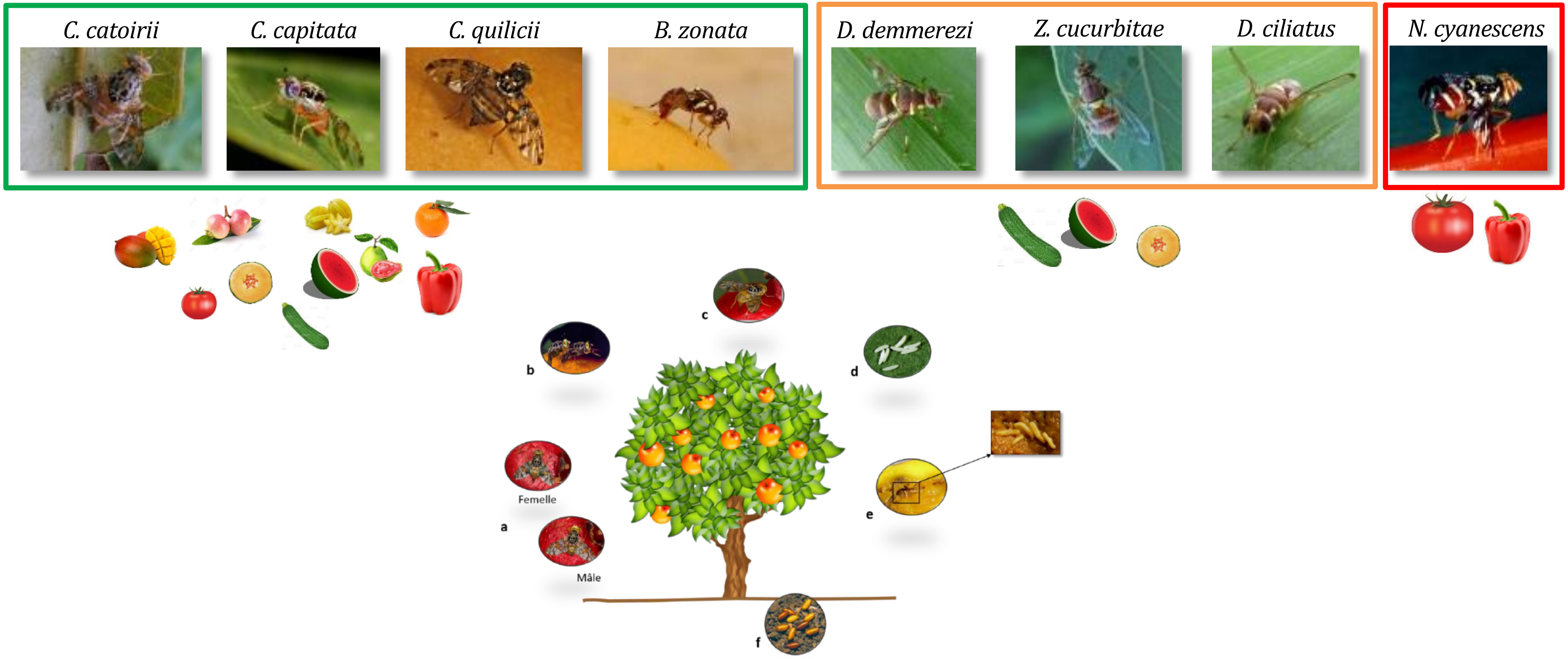
Photos : Antoine Franck

Fruit flies in Réunion

> 100 host plant species

Generalists

Specialists



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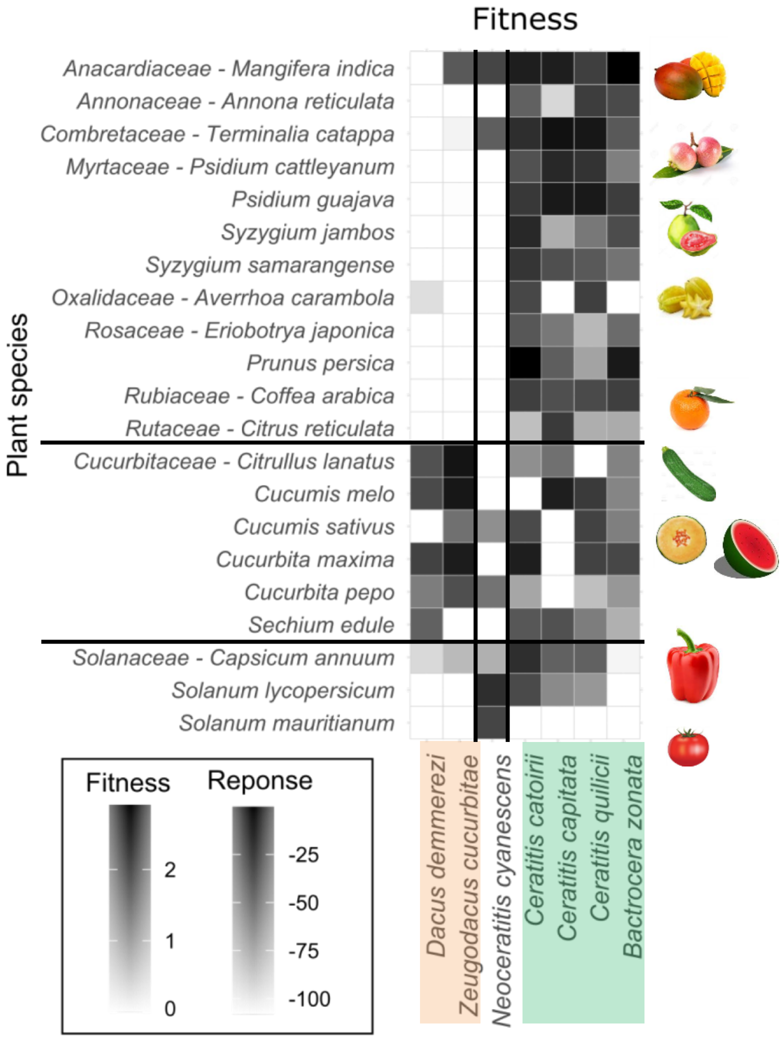
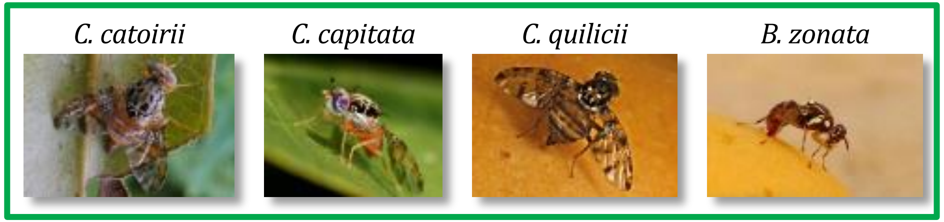
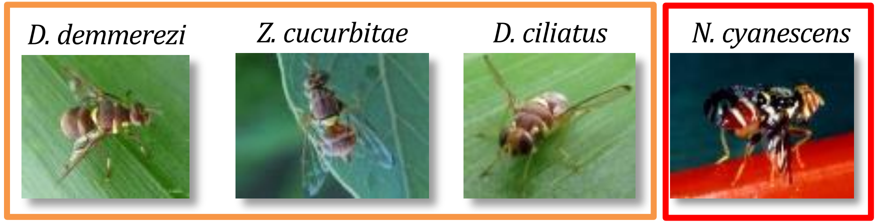


Generalists



Specialists



- Laboratory measures of female preference and larval performance (hatching rate + development time + survival rate) on 21 plants hôtes (Abir Hafsi & Maud Charlery de la Masselière)

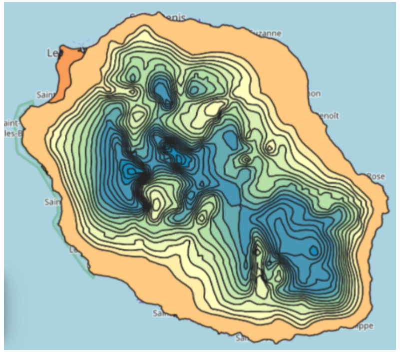
→ **Fundamental** host plant range

Photos : Antoine Franck

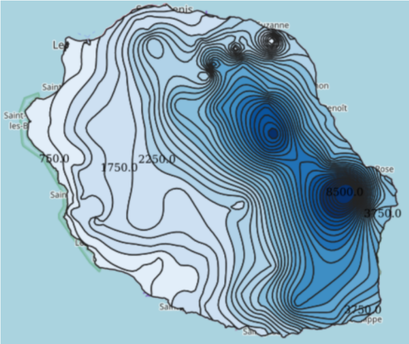
Ecological data

Elevation

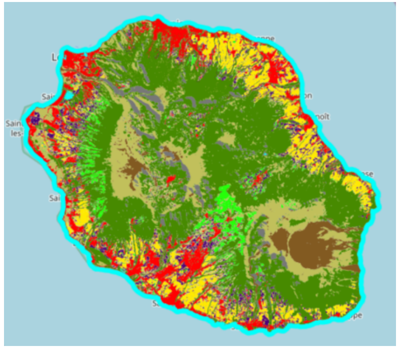
Temperature



Rainfall

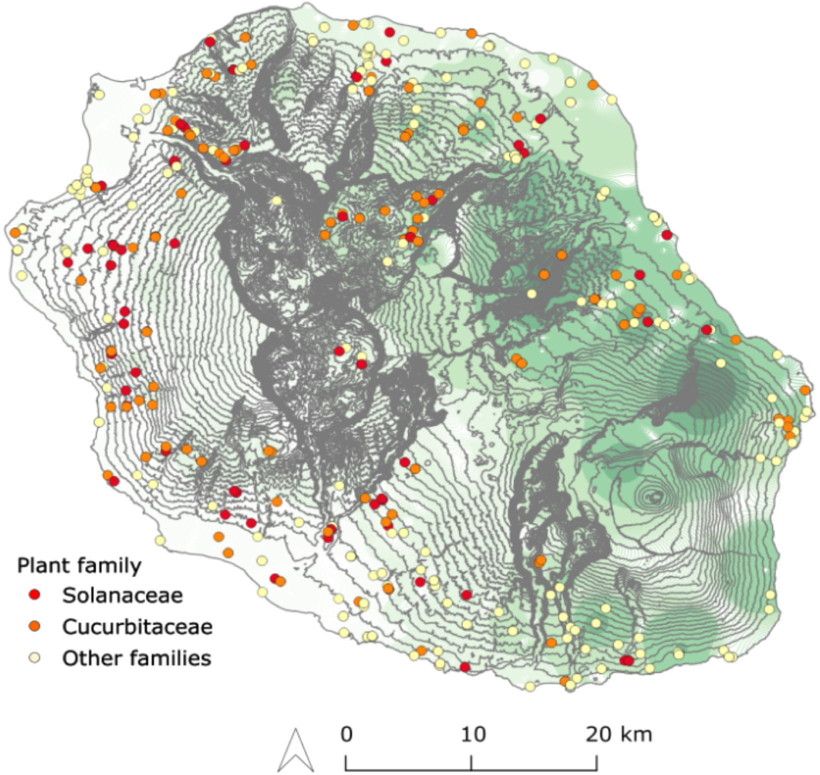


Land use



AWARE Cirad, Dupuy & Gaetano 2019

Abundances



12872 fruit samples
(> 40 host plant species)

GPS coordinates + Host species sampled at least 10 times + At least one fly alive + One of the 21 host plants studied in the lab

4918 observations of 8 fly species
soit > 95 000 individual flies
On 21 host plants
= 104 field sessions on 380 sites
between 1991 and 2009

Modelling joint species distributions with PLNmodels

! Phenomenological !

Abundance matrix

~

Poisson(exp(intercept + covariates + log(offset) + residual matrix))

Residual covariations
not explained by
confounding factors

« « « Significant » » » residual associations ← Sparsification

Chiquet et al. 2018,2019

Get insights into the relative importance of niche factors vs species interactions for abundances

1. **Are niche factors sufficient to explain abundances?**

- Compare PLN models

Eco-climatic factors × Full residual matrix

Host plants Diagonal matrix

2. **Does the residual matrix contains traces of potential interactions?**

- Have a look at the residual matrix of the best du meilleur model PLN (after sparsification)

3. **Do fly species distribute as expected from their fundamental niche?**

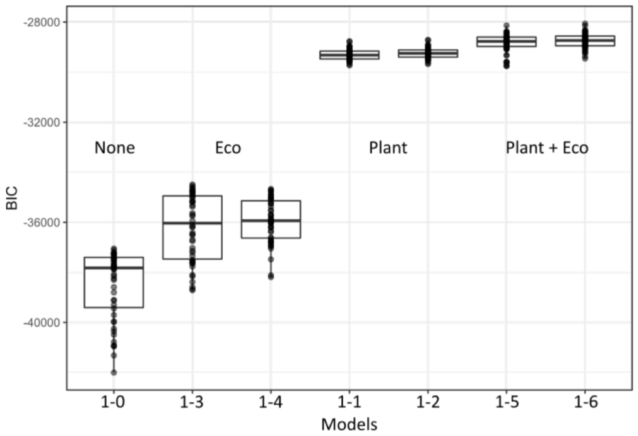
- Compare realised vs. fundamental niches

Abundances → Regression coefficients = responses of abundances to host plants ⟺ Laboratory fitness measures

1. **Are niche factors sufficient to explain abundances?**
Model selection

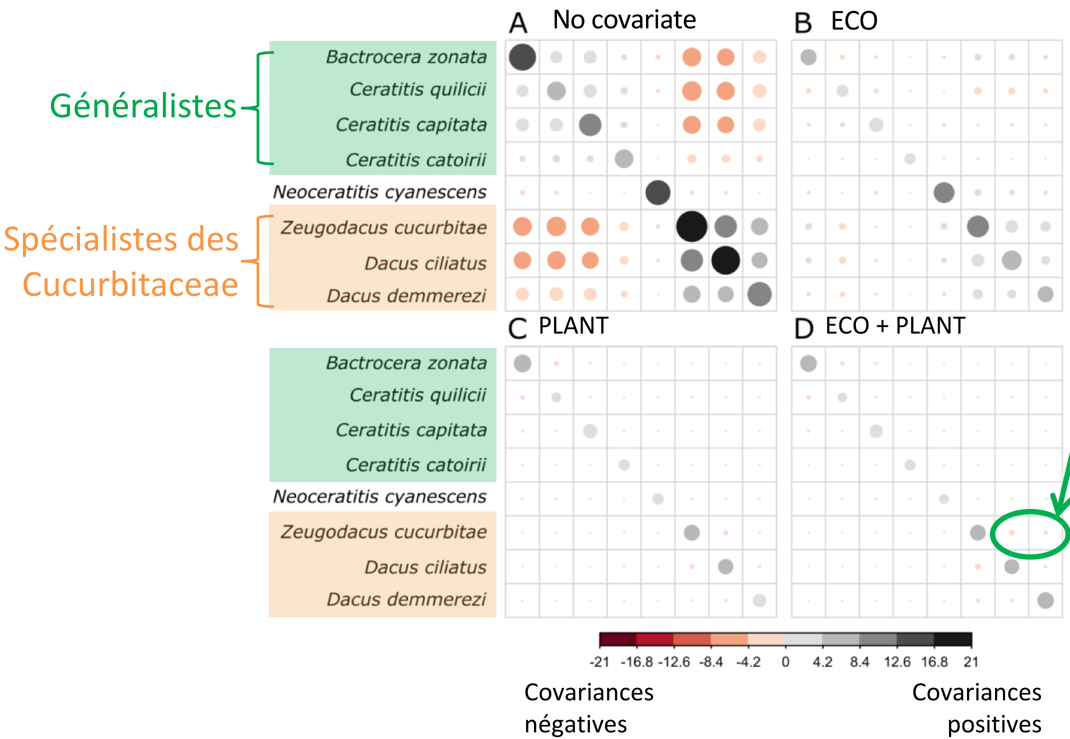
Models	Covariates	Residual matrix	*K*	*L*	BIC	Δ_{BIC}
A) Model set 1 (21 plants x 8 flies)						
Model 1-5	Plant + Eco	Full	284	-27664.3	57742.8	0.0
Model 1-6	Plant + Eco	Diagonal	256	-27997.8	58171.7	428.9
Model 1-2	Plant	Diagonal	176	-28608.9	58713.9	971.1
Model 1-1	Plant	Full	204	-28784.0	59302.1	1559.2
Model 1-3	Eco	Full	124	-35888.8	72831.6	15088.8
Model 1-4	Eco	Diagonal	96	-36598.4	74012.9	16270.1
Model 1-0	None	Full	44	-37228.1	74830.3	17087.4

BIC distributions for 50 bootstraped datasets



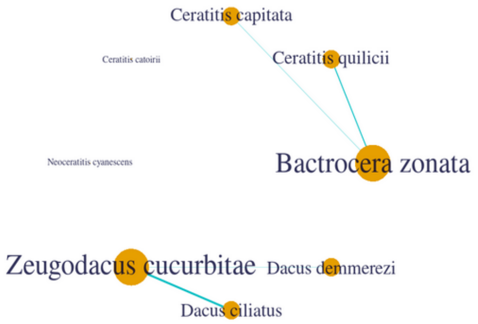
- The best model takes plant + eco
- Full residual matrix is slightly better than diagonal matrix but this does not hold on bootstraped datasets (= non significant)

2. Does the residual matrix contains traces of potential interactions?

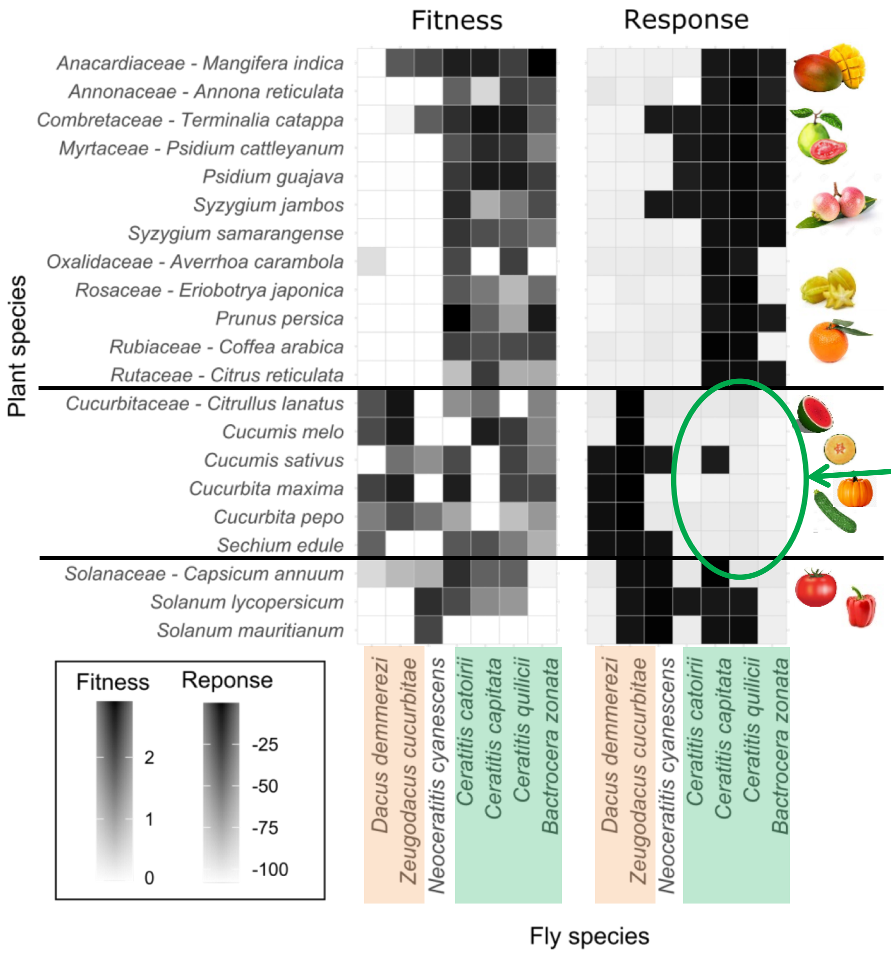


Very small residual covariations once host plants are accounted for

Weak but significant negative residual covariations between specialists of Cucurbitaceae and between the most abundant generalists



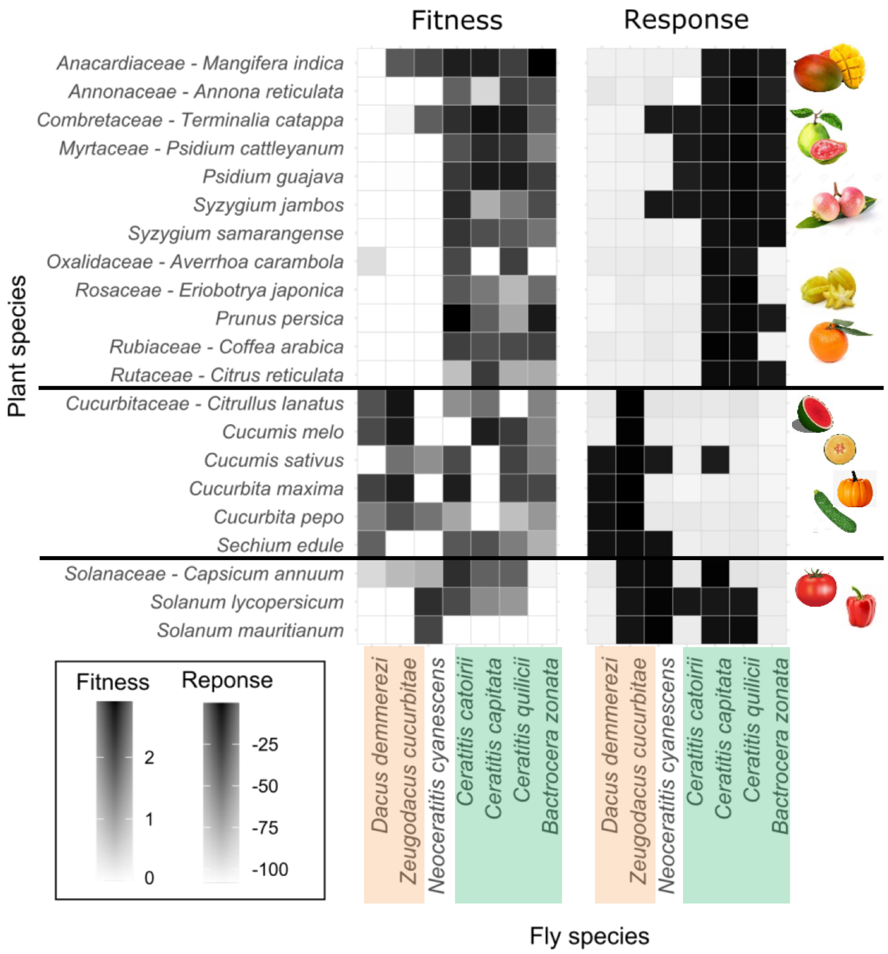
3. **Do fly species distribute as expected from their fundamental niche?**

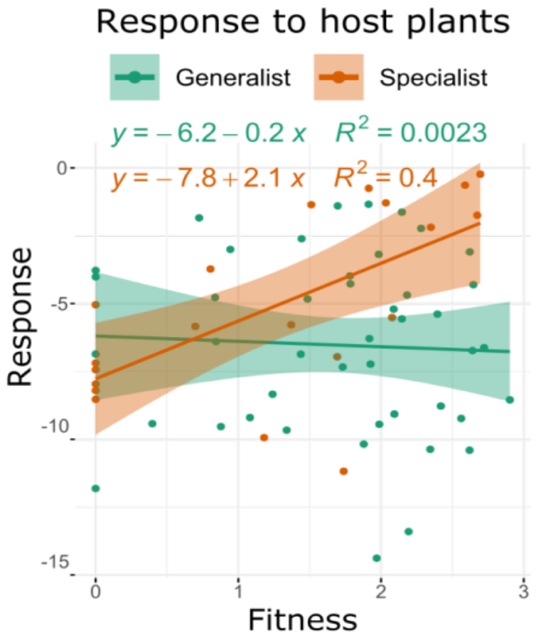


Mostly yes, but…

Looks like competitive exclusion of generalists by specialists on Cucurbitaceae

3. Les mouches se distribuent-elles conformément à leur niche fondamentale ?





« species sorting » vs. « mass effect » ??

Leibold et al. 2004

Get insights into the relative importance of niche factors vs species interactions for abundances

… still very complex!

From JSDM only:

- The residual covariance matrix also contains associations stemming from omitted factors, local extinctions…
- Competitive exclusion is a black hole for JSDM analysis

Leads:

- Systematically confront with laboratory data/ integrate laboratory data as priors in the analysis
- Invest on time series

Thanks

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Stéphane Dupuy

cirad | AWARE

Kalideos

Projet ANR *Next Generation Biomonitoring* - D. Bohan

Dave Bohan, Corinne Vacher

Peer Community In Ecology
Free and transparent preprint and postprint recommendations in ecology

Facon B., Hafsi A., Charlery de la Masselière M., Robin S., Massol F., Dubart M., Chiquet J., Frago E., Chiroleu F., Duyck P.-F., & **V. Ravigné** (2021) Joint species distributions reveal the combined effects of host plants, abiotic factors and species competition as drivers of community structure in fruit flies. bioRxiv, 2020.12.07.414326. ver. 4 peer-reviewed and recommended by ***Peer community in Ecology***. Also published in ***Ecology Letters.***