

Emergence de nouvelles maladies et évolution des pathogènes



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- Parasites et pathogènes
- Coévolution
- Evolution de la virulence
- Emergence de nouveaux parasites de plantes
- Mécanismes d'adaptation génomique

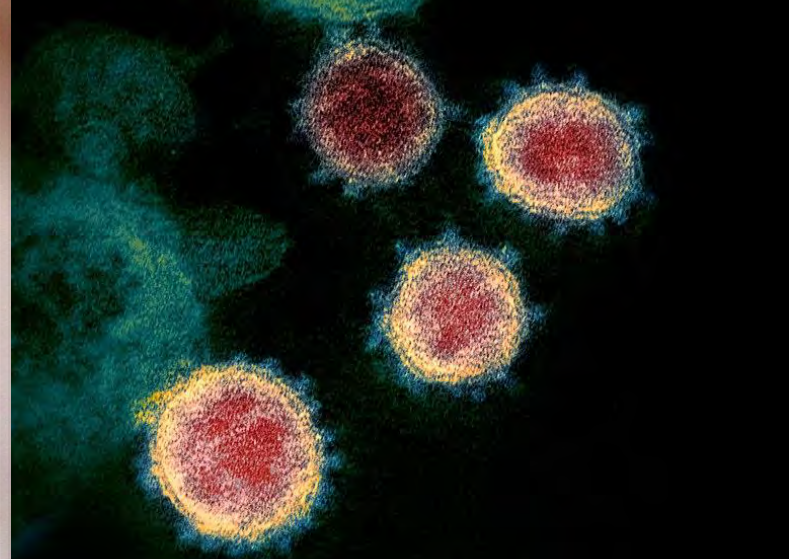


Alex Wild

Relations hôtes-parasites



Parasites et pathogènes





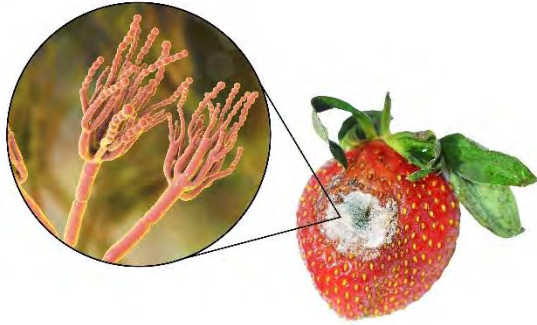
<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0007725>



Parasites et pathogènes



Parasites et pathogènes



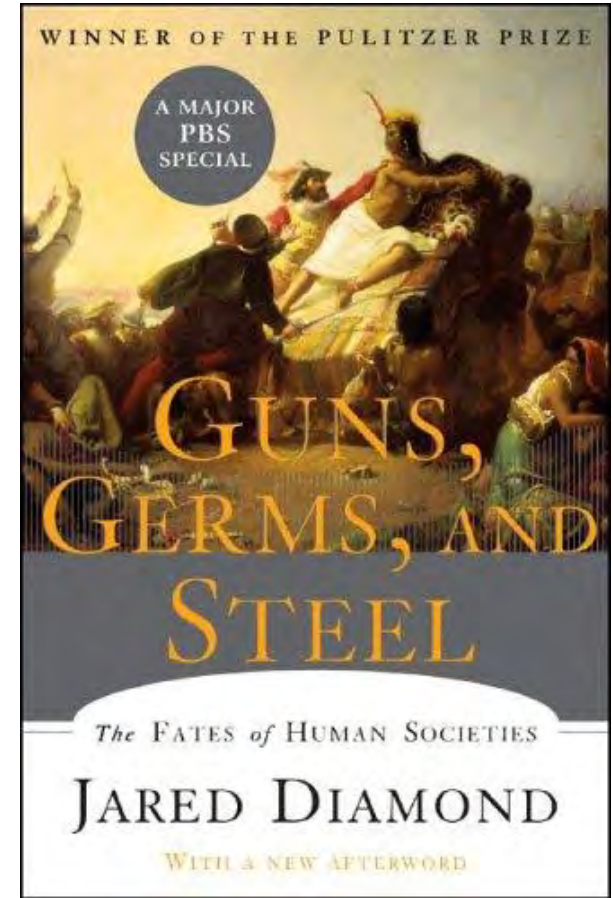
Parasites et pathogènes



Parasites et pathogènes: importance écologique



Parasites et pathogènes: importance historique



Composés des plantes pour se défendre contre l'herbivorie



Glucosinolates dans la moutarde

Acide salicylique dans le saule

Caoutchouc



Caféine



Capsicine



Cannabinol

Coévolution dans les relations hôtes-pathogènes



Coévolution

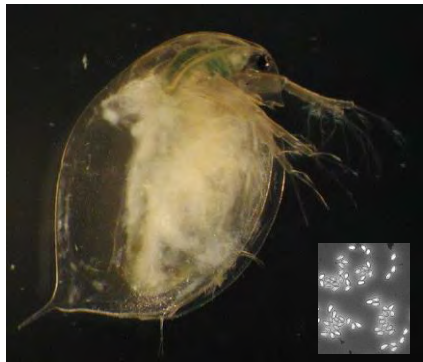


Coévolution

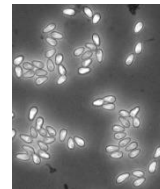
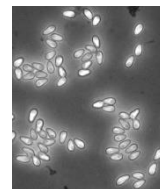
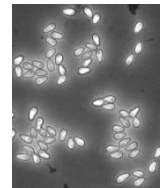
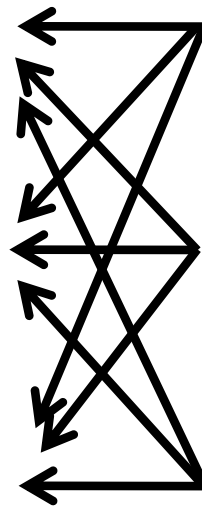
Daphnie saine



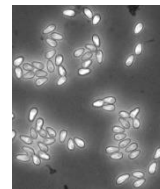
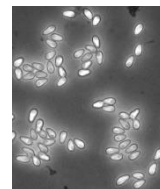
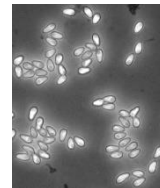
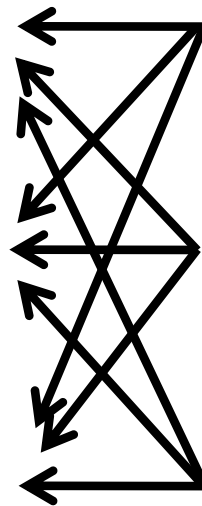
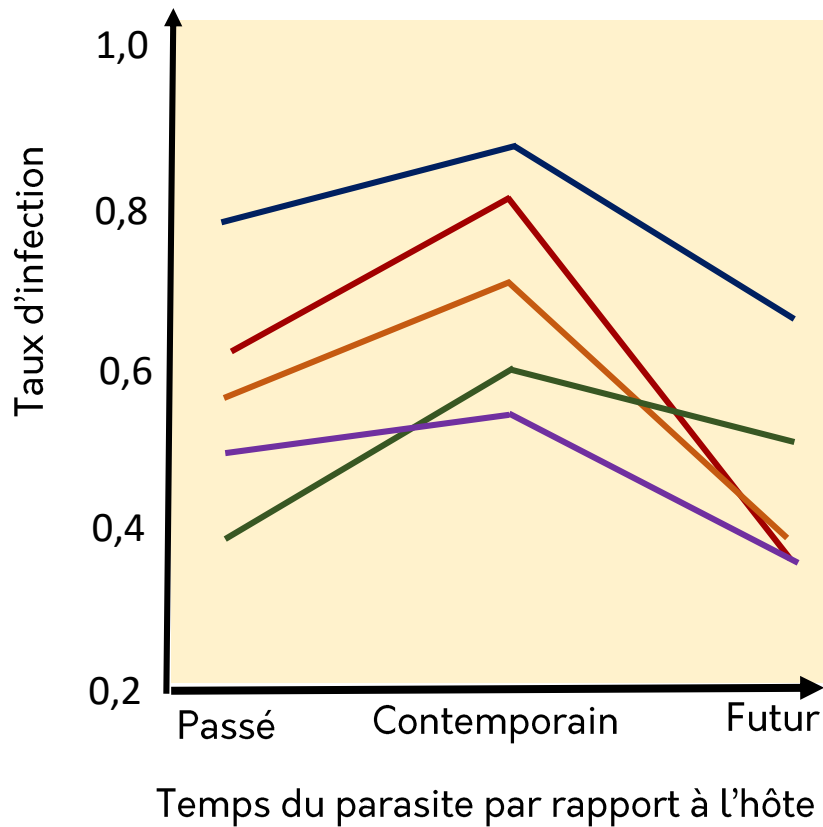
Daphnie parasitée
(microsporidies)



Extraction de carottes de
sédiments jusque ~ 39 ans



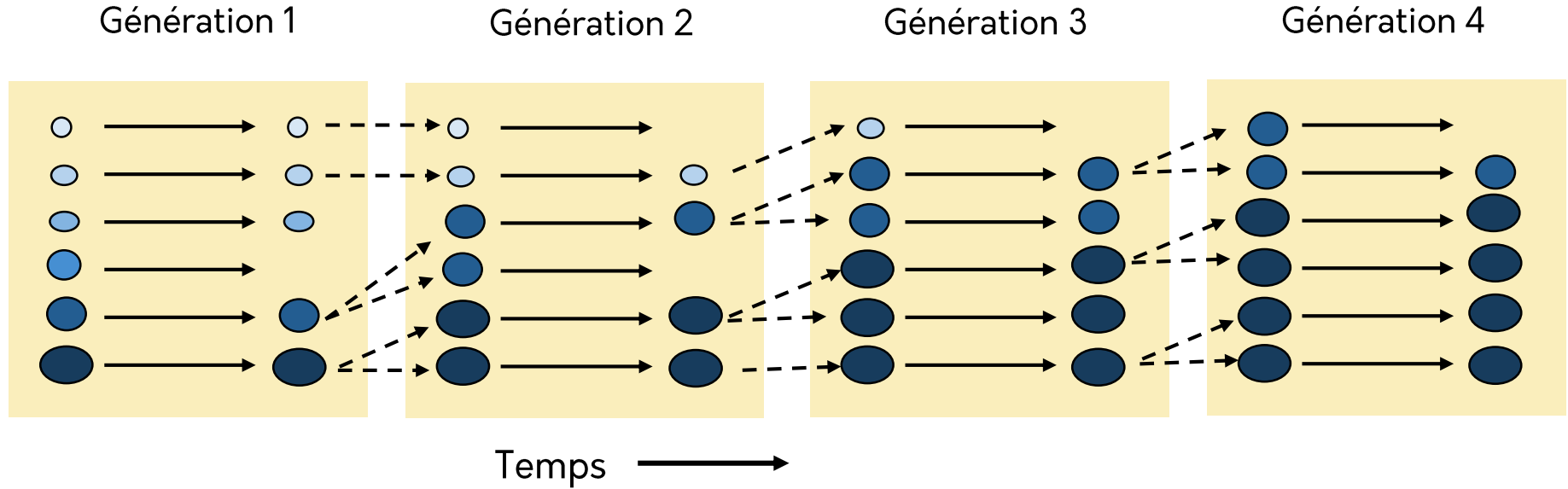
Coévolution



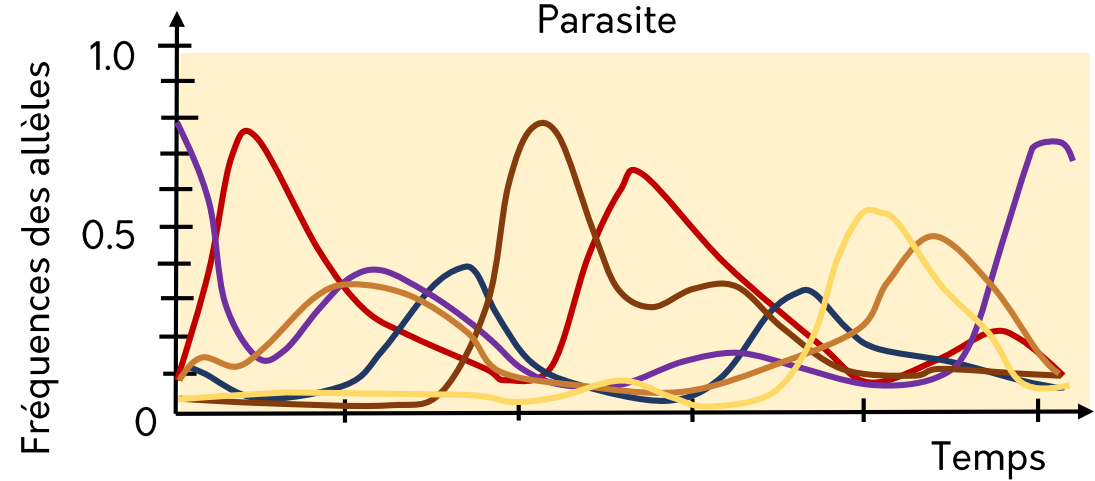
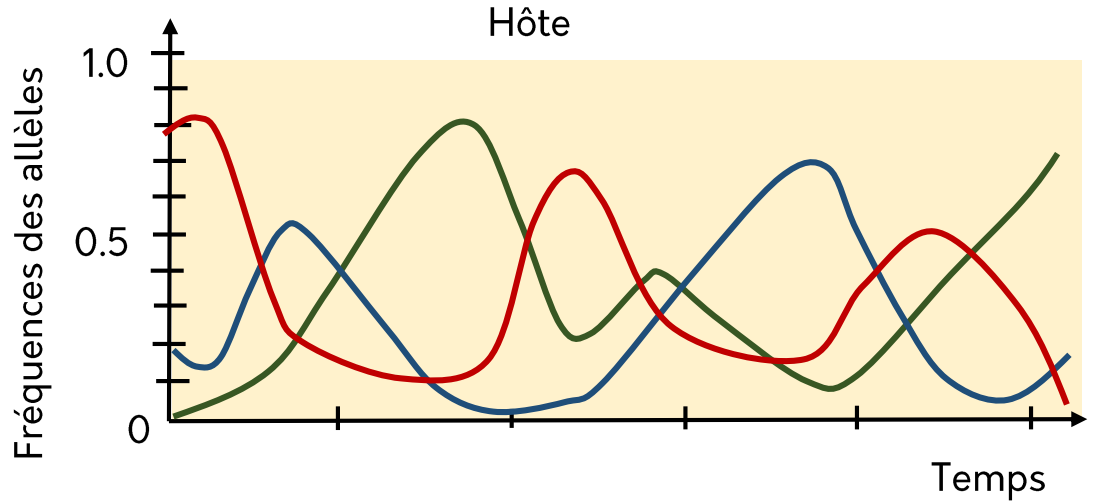
Coévolution



Sélection naturelle



Evolution des fréquences alléliques aux gènes impliqués dans les relations hôtes-parasites





Ce qui ne tue pas...



Ce qui ne tue pas...
..mute et essaie encore

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Evolution de la virulence

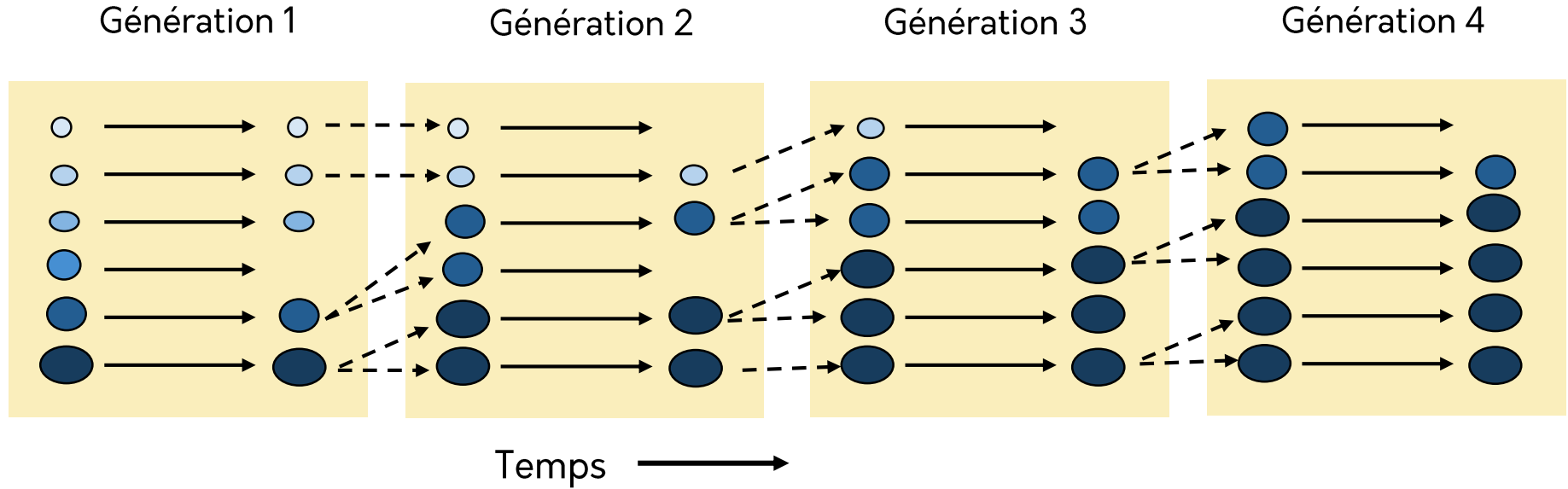
Un parasite n'a pas intérêt à tuer son hôte?



« Tout est pour le mieux dans le
meilleur des mondes »
répète Pangloss,
précepteur de Candide



Sélection naturelle



Evolution de la virulence

Comment maximiser sa transmission pour un parasite?



Evolution de la virulence

De quoi dépend le niveau de virulence optimal?



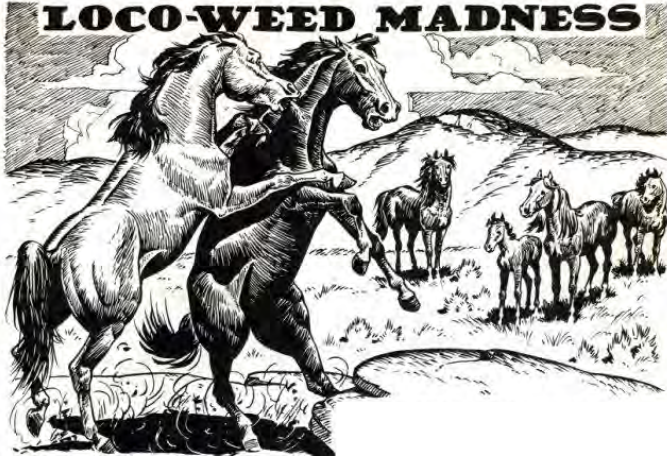
Le niveau de virulence optimal dépend :
-du mode de transmission
horizontal versus vertical



Le niveau de virulence optimal dépend :
- du mode de transmission
horizontal versus vertical



Champignons endophytes mutualistes transmis dans les graines (production d'alkaloïdes contre les herbivores)



Feu de Saint Antoine



Ergotamine contre la
migraine

Ergot du seigle: toxique

drogue utilisée par les
mayas



LSD
acide lysergique

Stratégies d'un parasite à transmission verticale pour augmenter sa transmission

- Biais de sex-ratio
- Induction de la parthénogenèse
(bactéries *Wolbachia* chez des Hyménoptères)
- Féminisation des mâles
(*Wolbachia* chez les cloportes, microsporidies chez les gammarès)



Manipulation du comportement de l'hôte par les parasites pour augmenter sa transmission

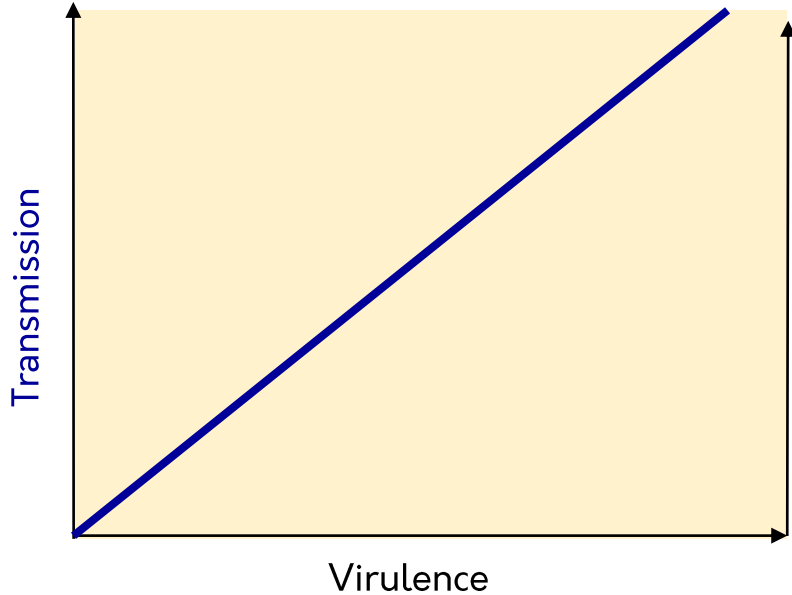


Maximiser sa transmission pour un parasite à transmission horizontale

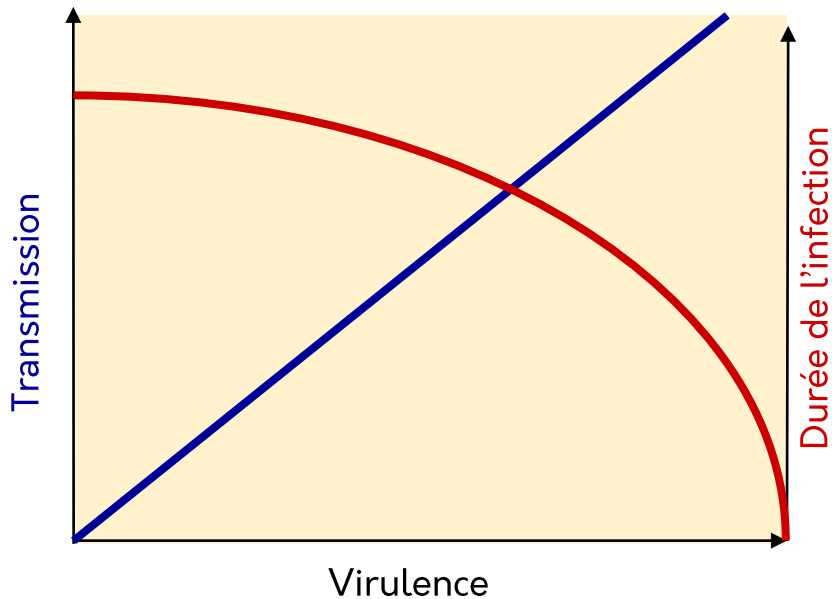
Quel niveau de virulence optimal pour
transmettre le maximum de descendants?



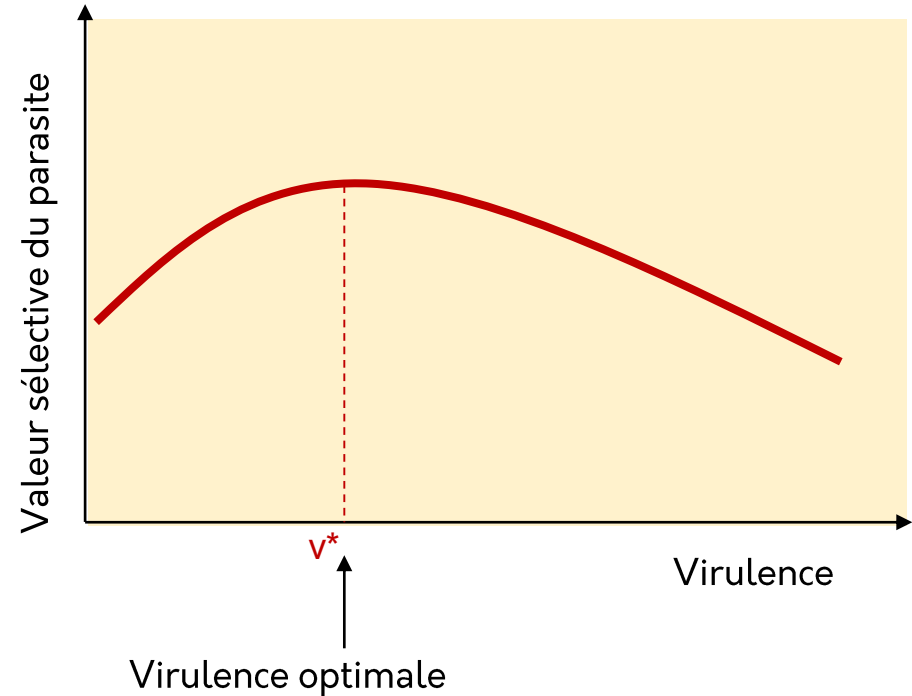
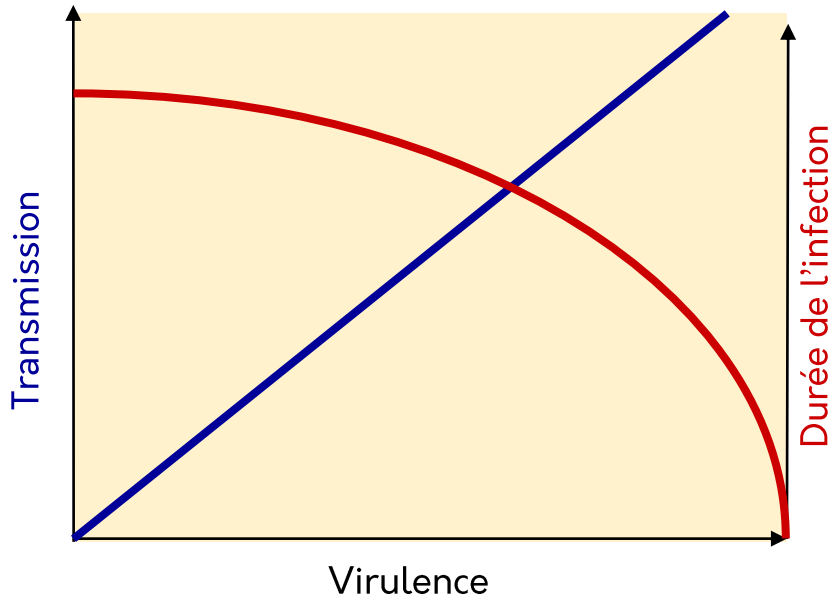
La virulence est corrélée à la transmission,
par exemple liées à la charge virale
(ex: VIH)



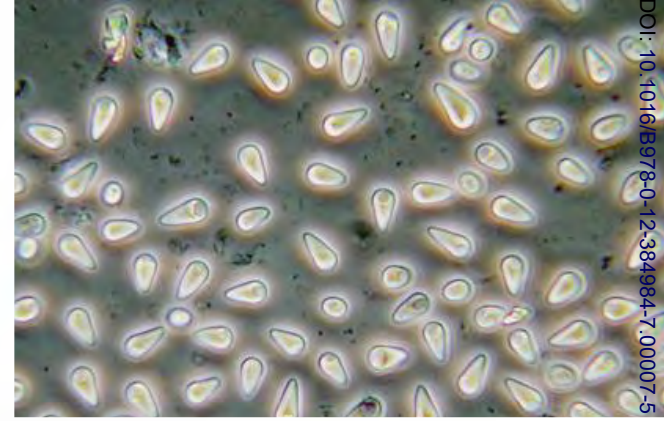
Mais la virulence diminue la durée de transmission
(mort de l'hôte plus rapide)



Il existe une virulence optimale pour le parasite



Relation entre transmission et virulence



DOI: 10.1016/B978-0-12-384984-7.00007-5

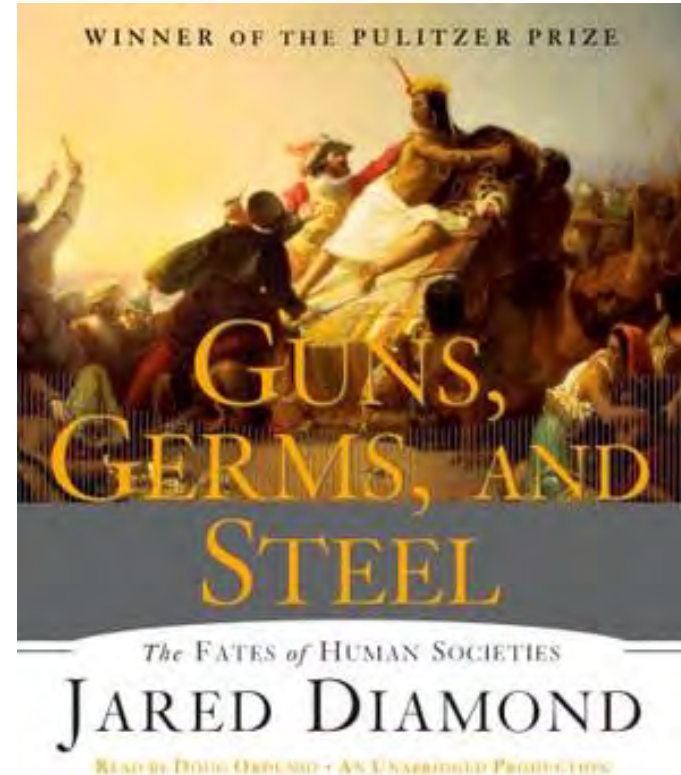
Relation entre transmission et virulence



Relation entre transmission et virulence



Taille des populations hôtes

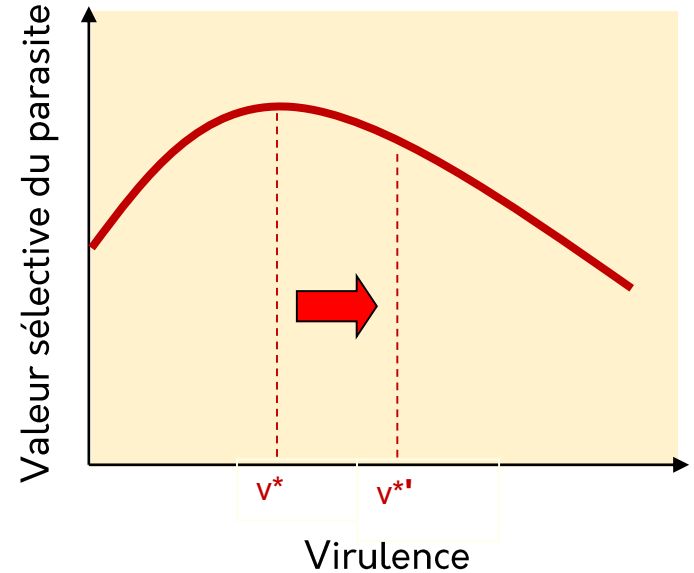
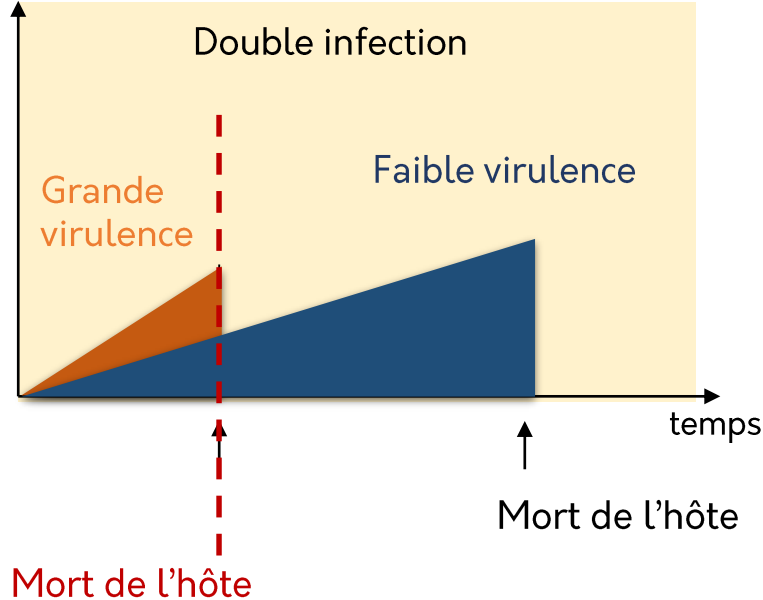


Relation entre capacité de dormance et virulence



Infections multiples

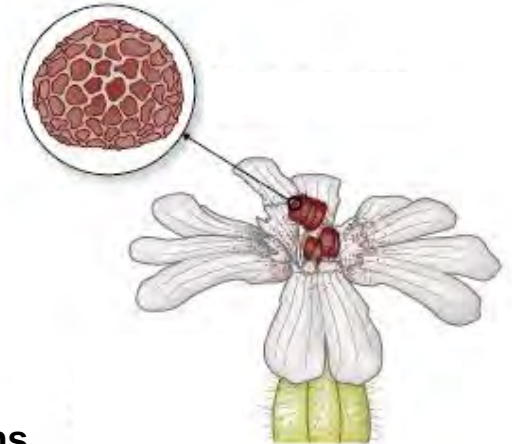
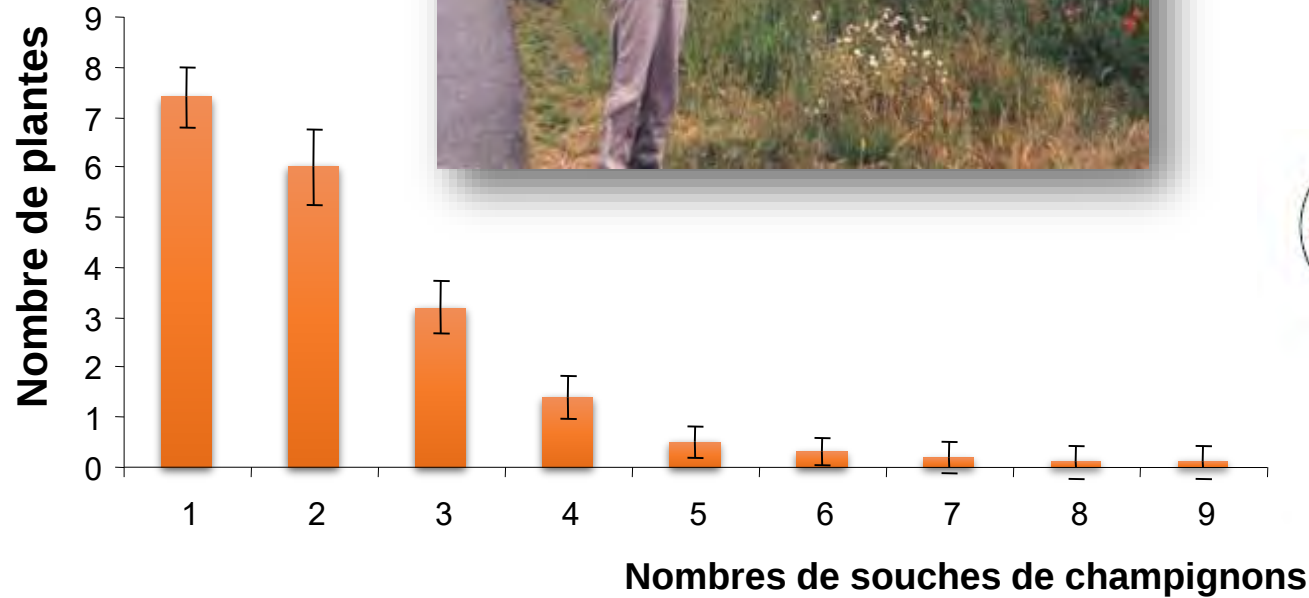
Reproduction du parasite dans l'hôte





Infections multiples par les
champignons

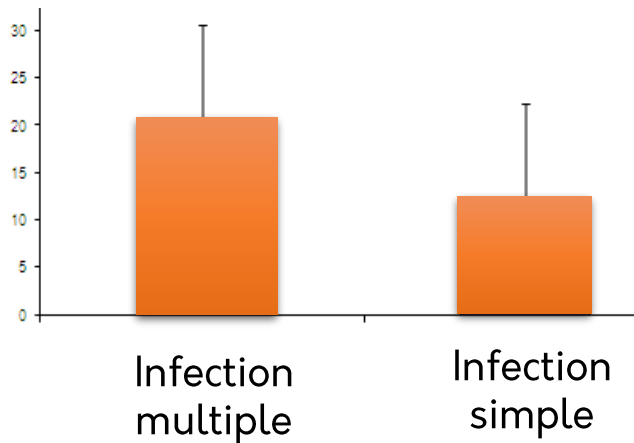
Infections multiples au sein d'une même plante



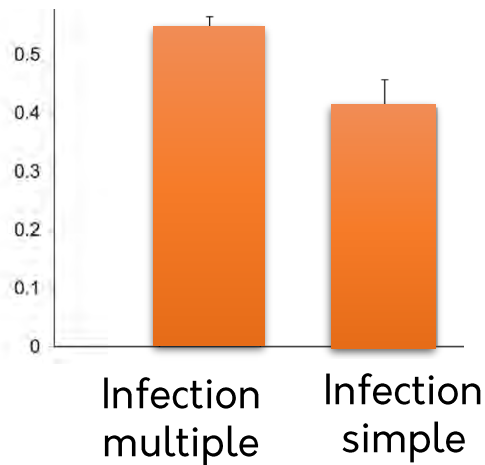
Plus grande virulence en infections multiples



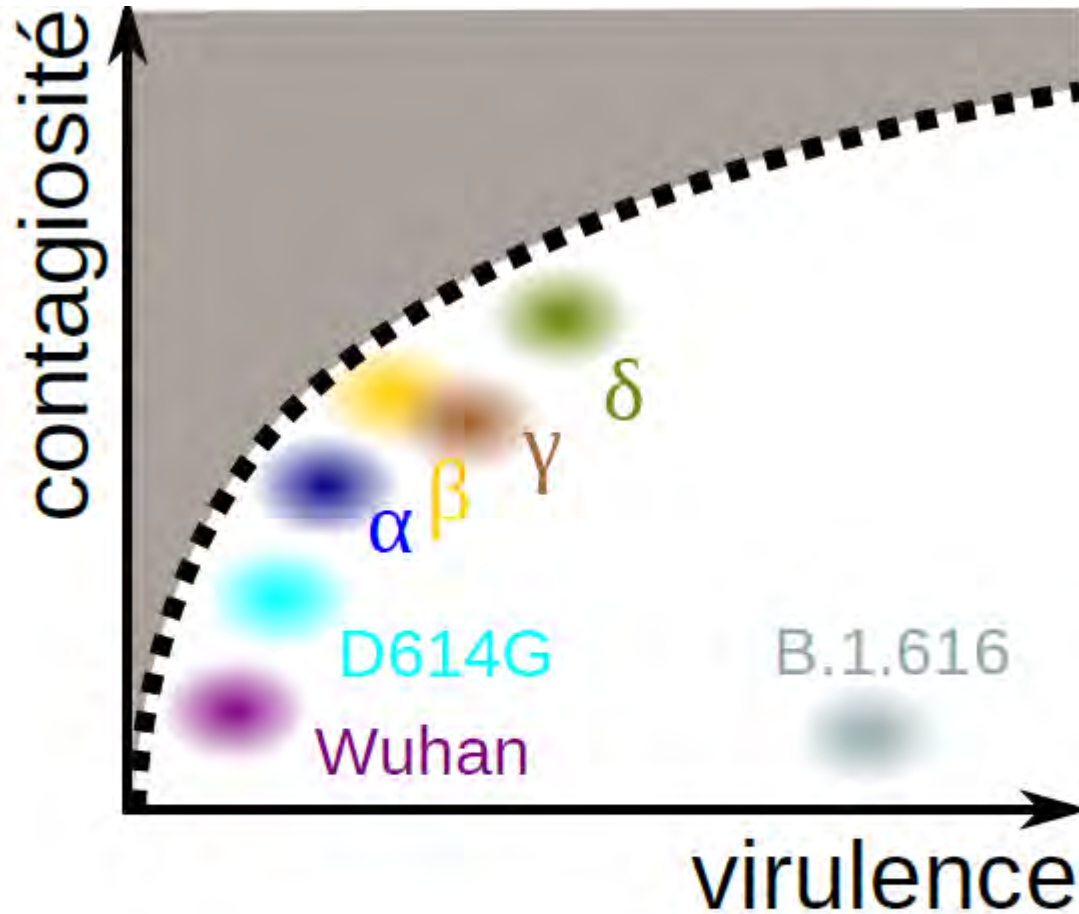
Nombre de spores par fleur



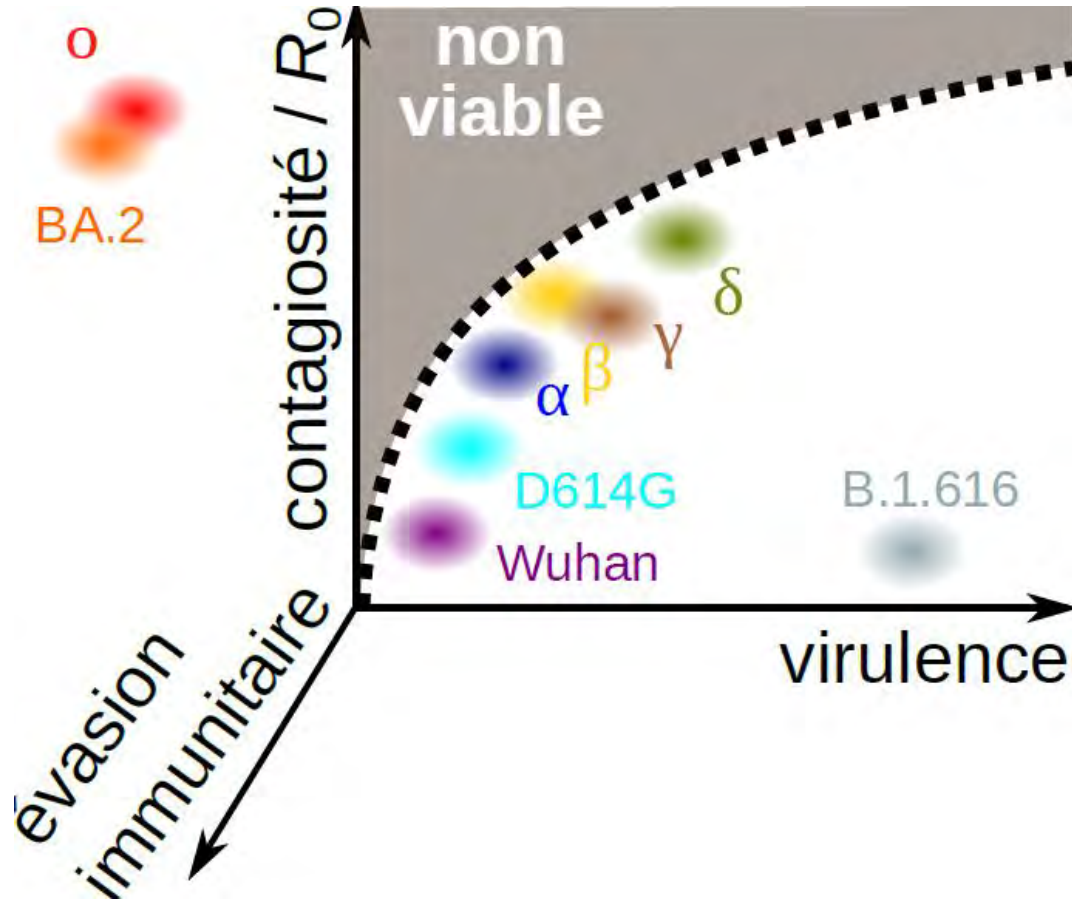
Pourcentage de branches stérilisées



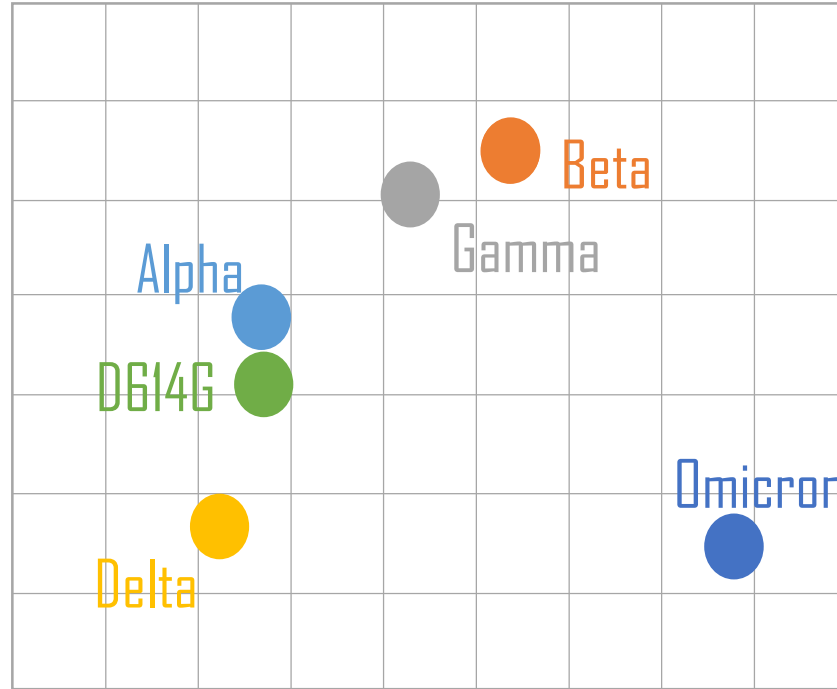
Relation transmission – virulence chez SARSCoV2



Relation transmission – virulence chez SARSCoV2

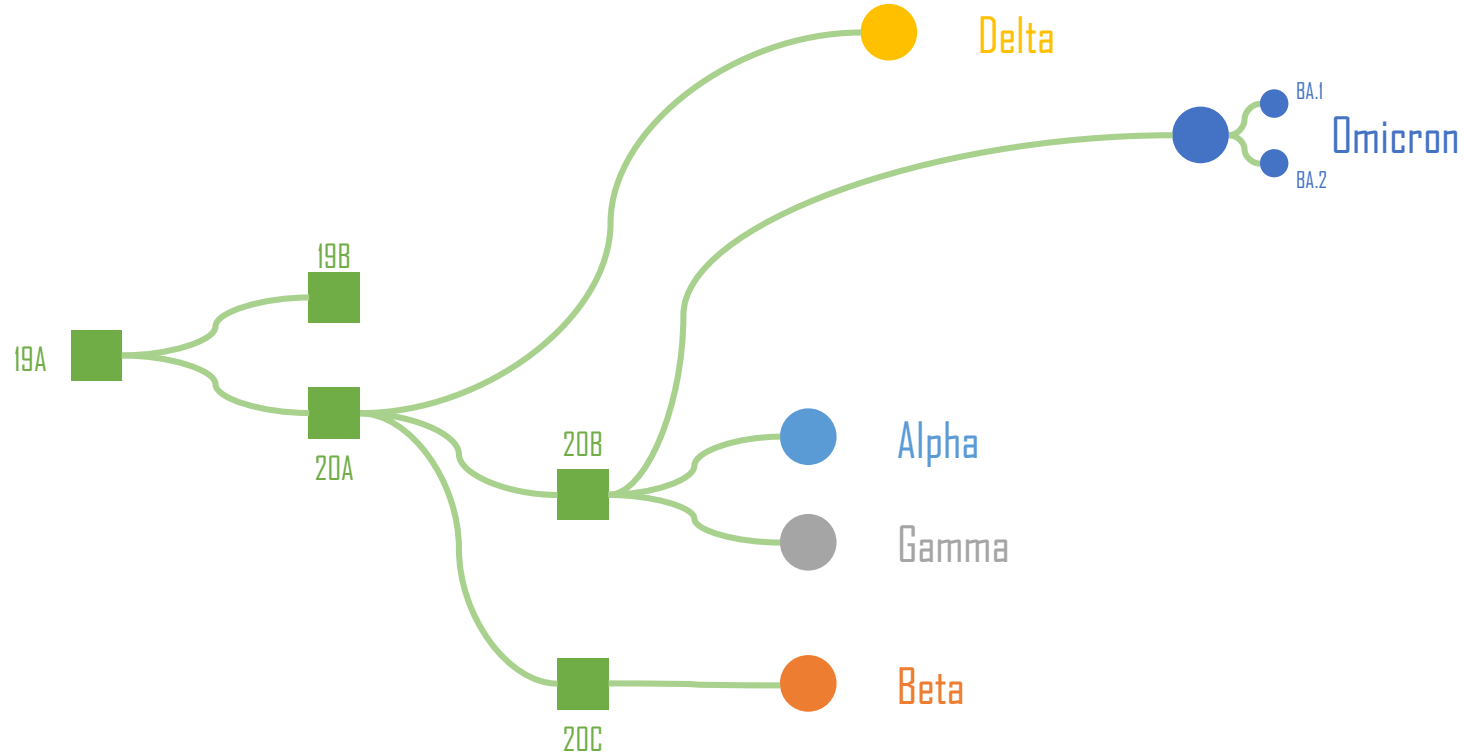


Evasion immunitaire



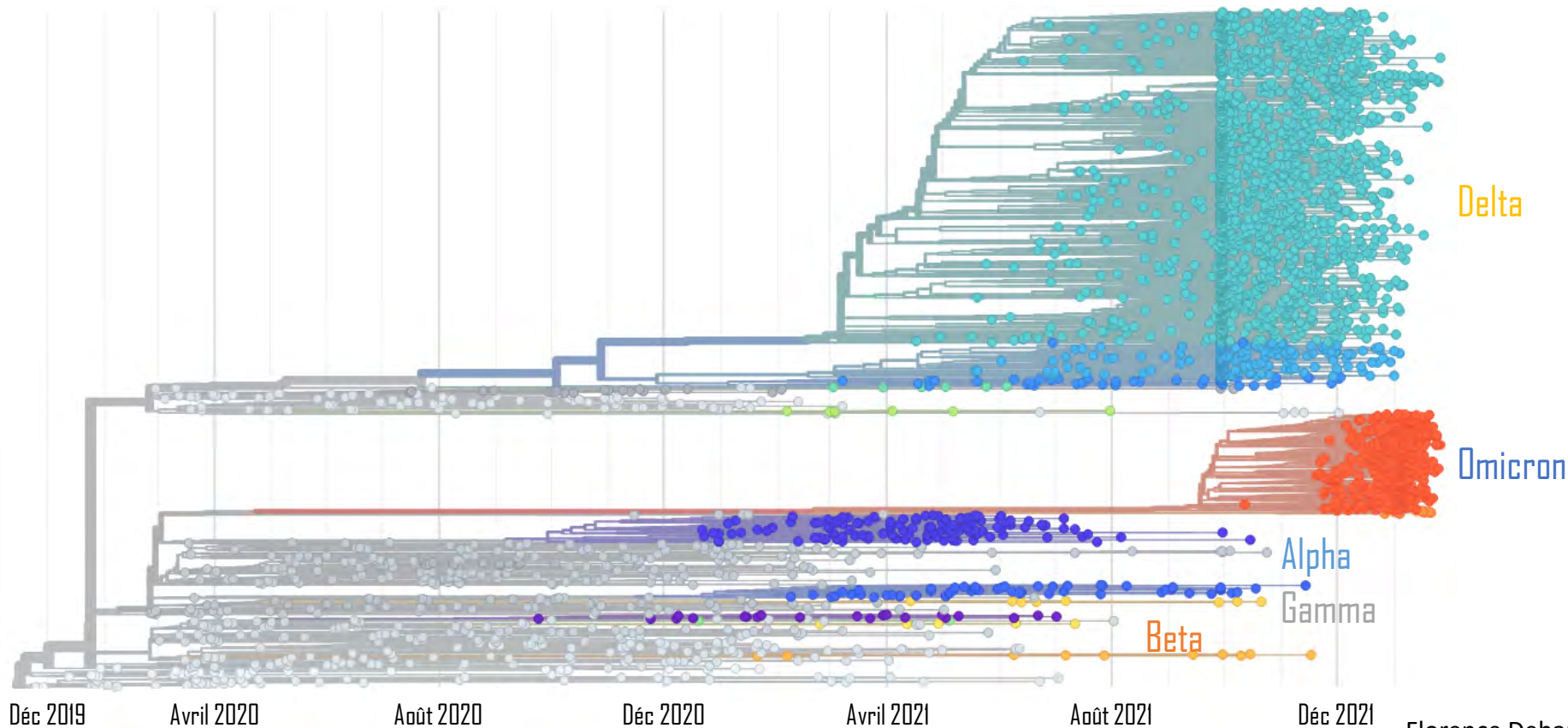
Carte antigénique

Aucun des variants préoccupants ne descend d'un précédent variant préoccupant



Florence Debarre

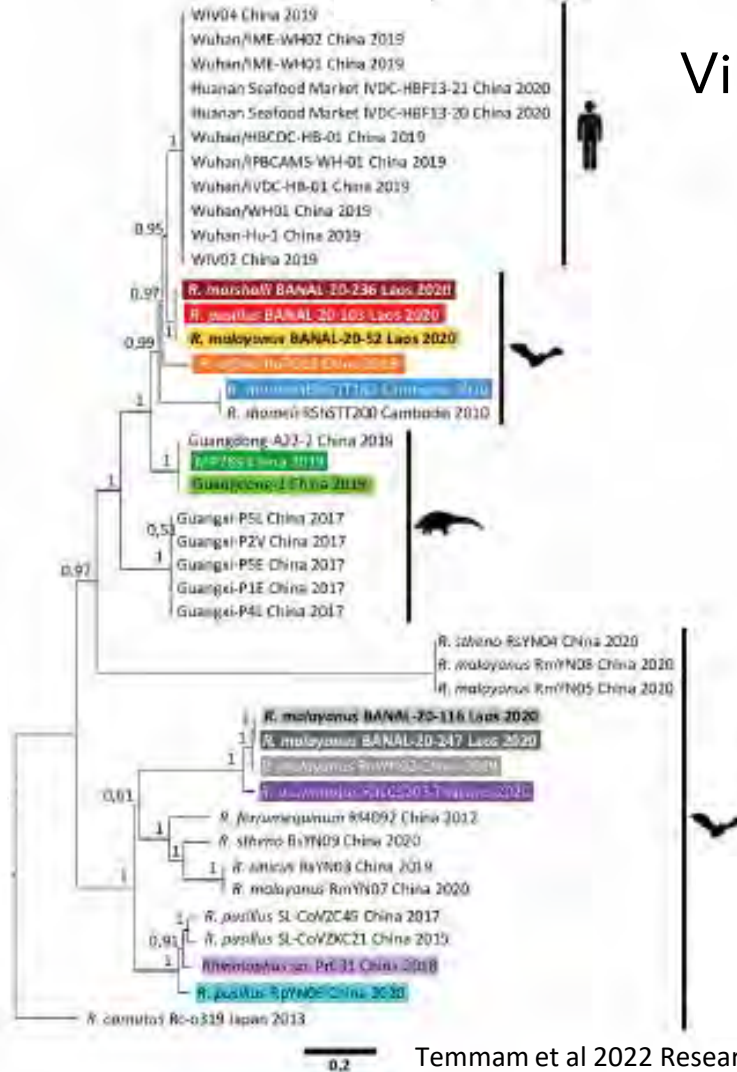
Les branchements ayant mené aux variants préoccupants actuels sont anciens



Florence Debarre

Virus connus les plus proches du SARS-CoV-2 : dans des chauves souris du Laos

Seulement 1 ou 2 différences dans le
domaine de la protéine spike
se liant au récepteur humain



Emergences de nouvelles maladies de plantes

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- Maladies émergentes
 - Invasions biologiques
 - Changements d'hôtes
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Invasions biologiques

Phytophthora

Oregon Department of Forestry



Chancre du châtaignier



Control and Eradication of Forest Diseases
Forest Management Regulations

NO UNAUTHORISED ENTRY



All vehicles and machines must
be free of soil before passing
this point.

Enquiries to the Manager,
Donnelly District on 9776 1207.



Department of
Environment and Conservation

Control and Eradication of Forest Diseases
Forest Management Regulations



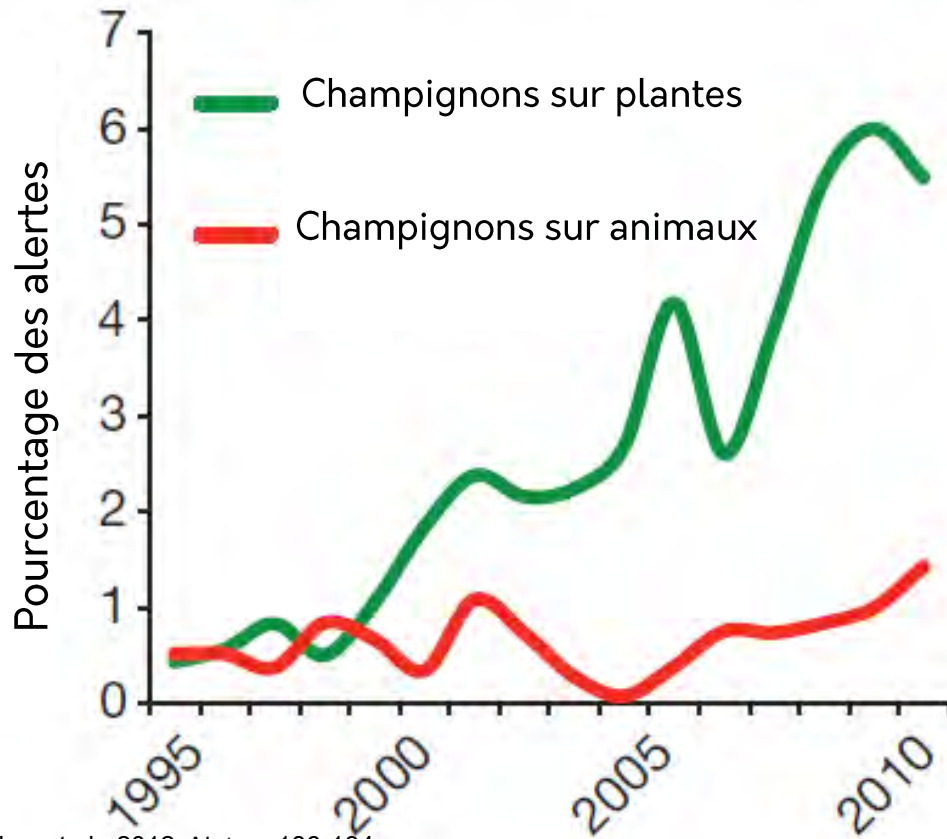
DISEASE RISK AREA

**NO ENTRY WITHOUT A
WRITTEN AUTHORITY**

Emergences de nouvelles maladies de plantes



Emergences de nouvelles maladies de plantes



Fisher et al., 2012, *Nature* 186-194



Ryan Hodnett



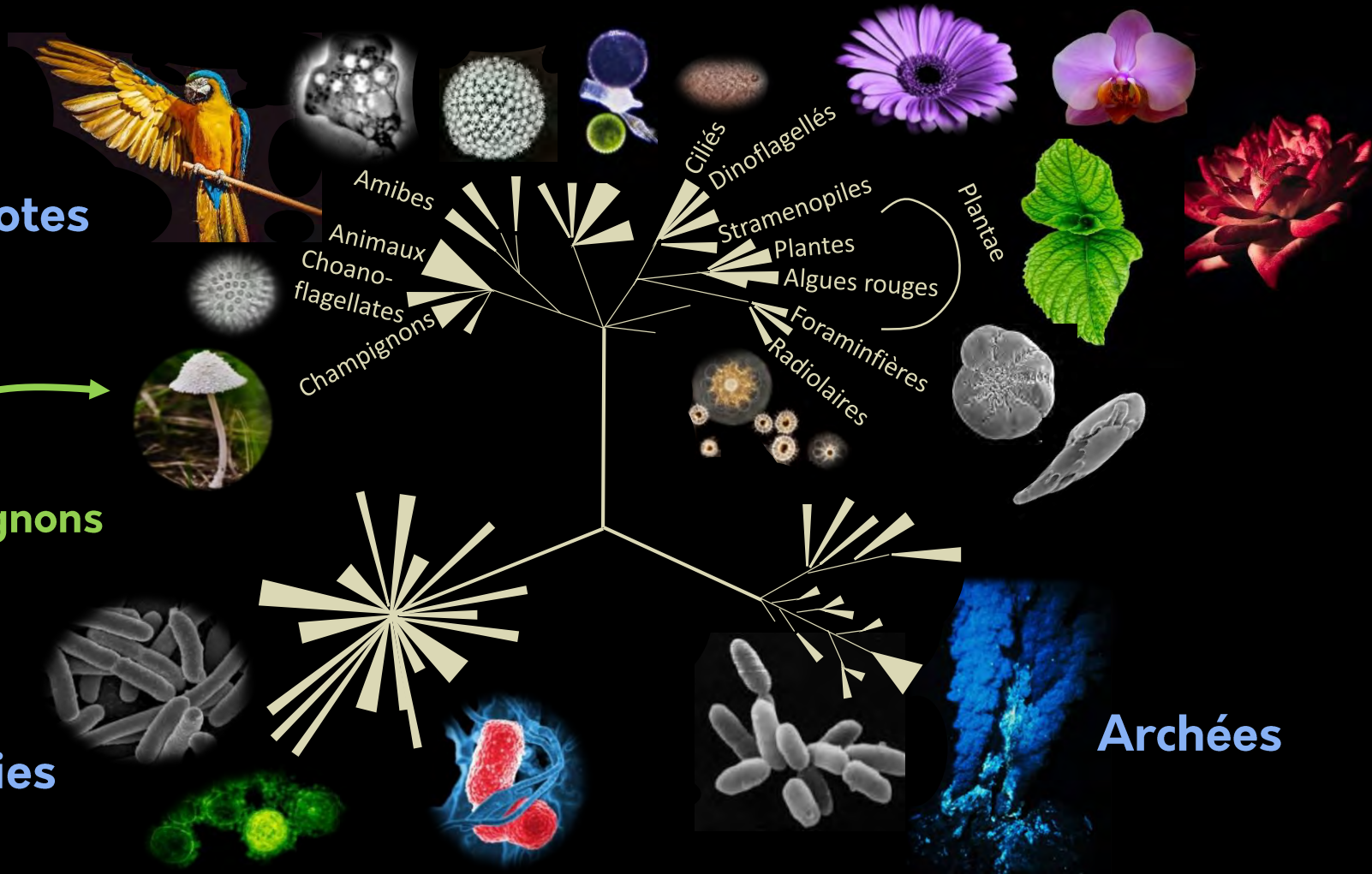
Ryan von Linden/New York Department of Environmental Conservation

Eucaryotes

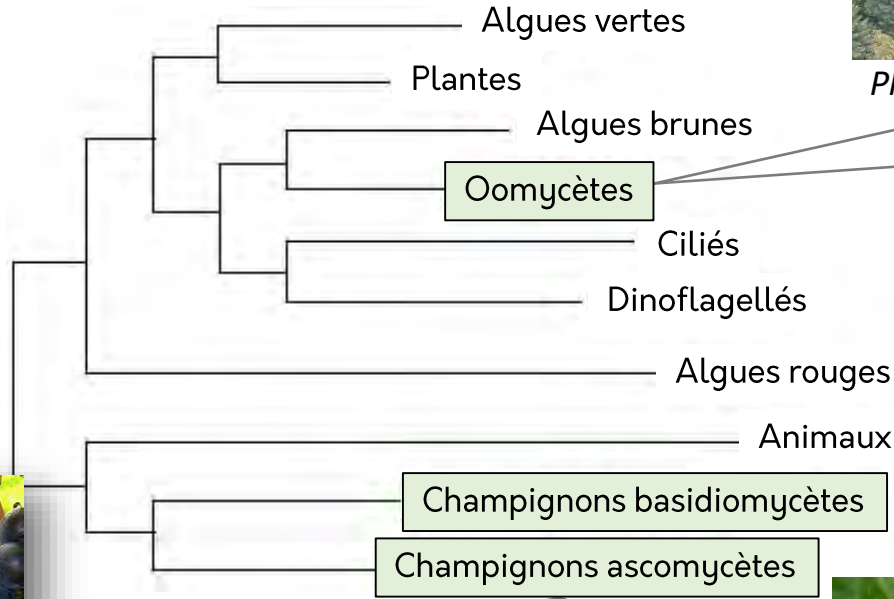
Champignons

Bactéries

Archées



Champignons et oomycètes



Oregon Department of Forestry

Phytophthora



François Delmotte

Plasmopara

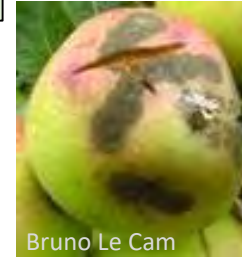


Microbotryum



Ryan Hodnett

Melampsora



Bruno Le Cam

Venturia



Armillaria



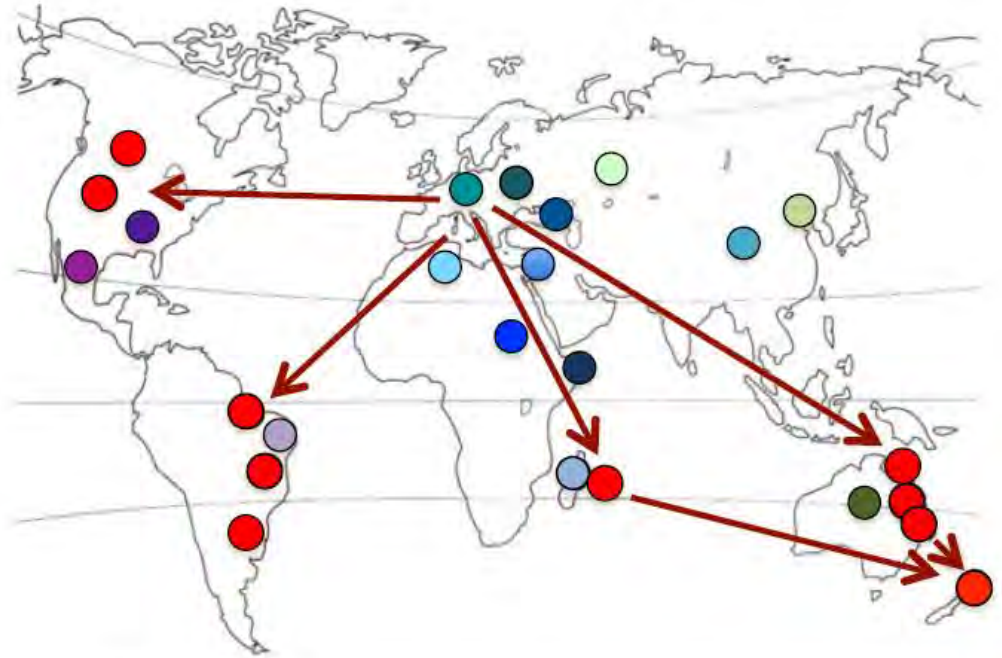
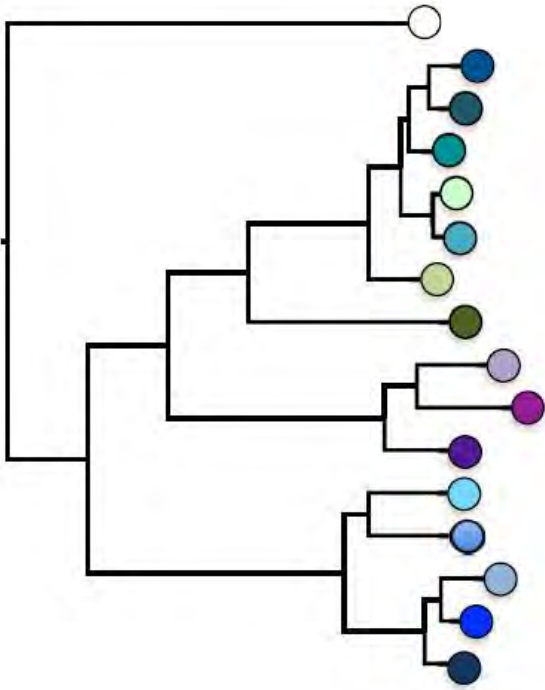
T. Peever

Ascochyta



Botrytis

Invasions biologiques



Histoire de l'invasion du mildiou de la vigne?



Histoire de l'invasion du mildiou?



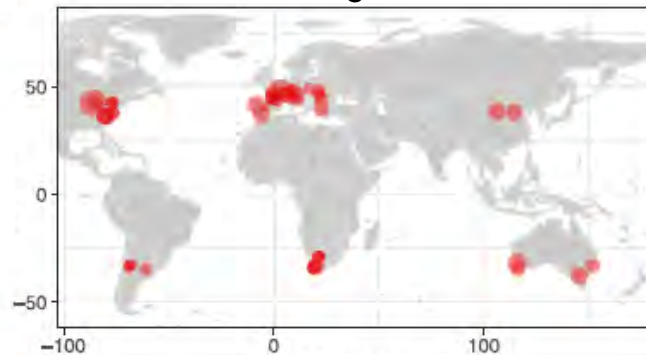
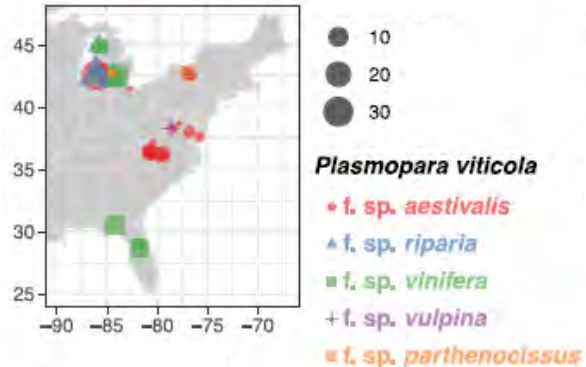
Vignes sauvages



Plasmopara viticola
Oomycète



François Delmotte



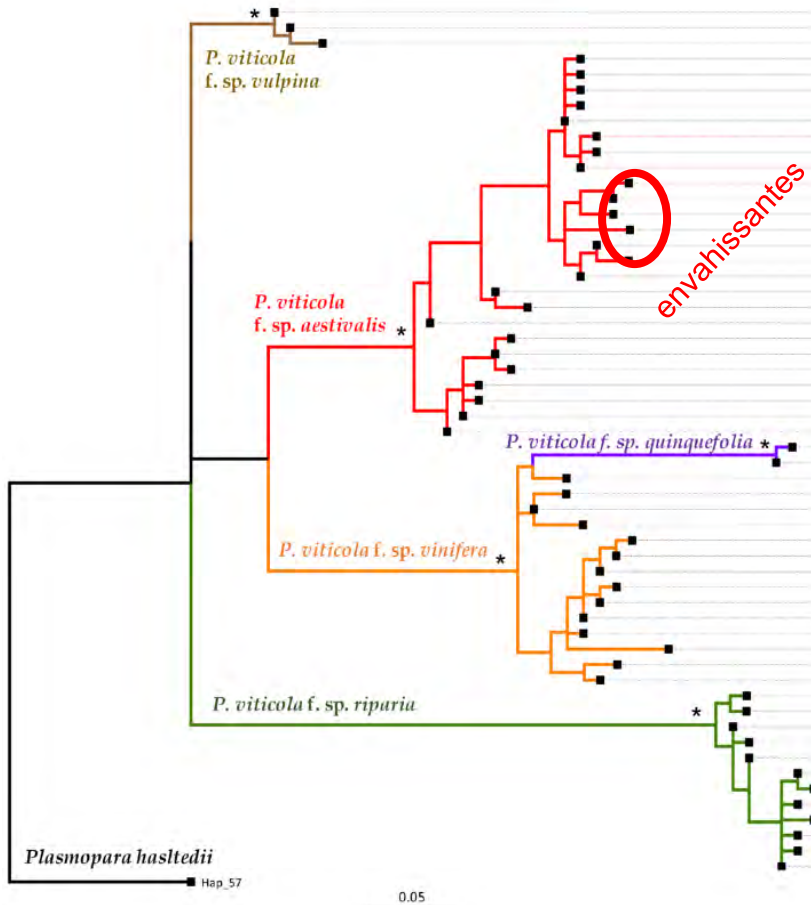
Vignobles



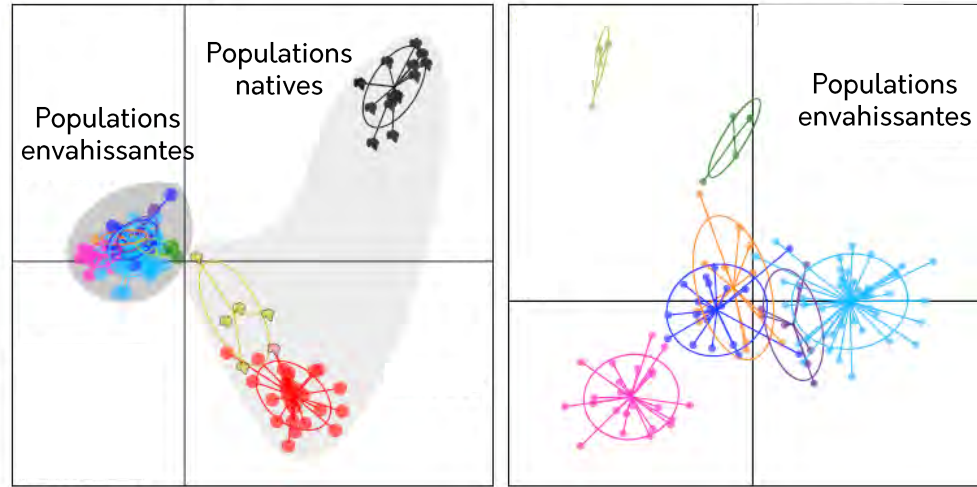
Phylloxera

Fontaine et al 2021 Current Biology

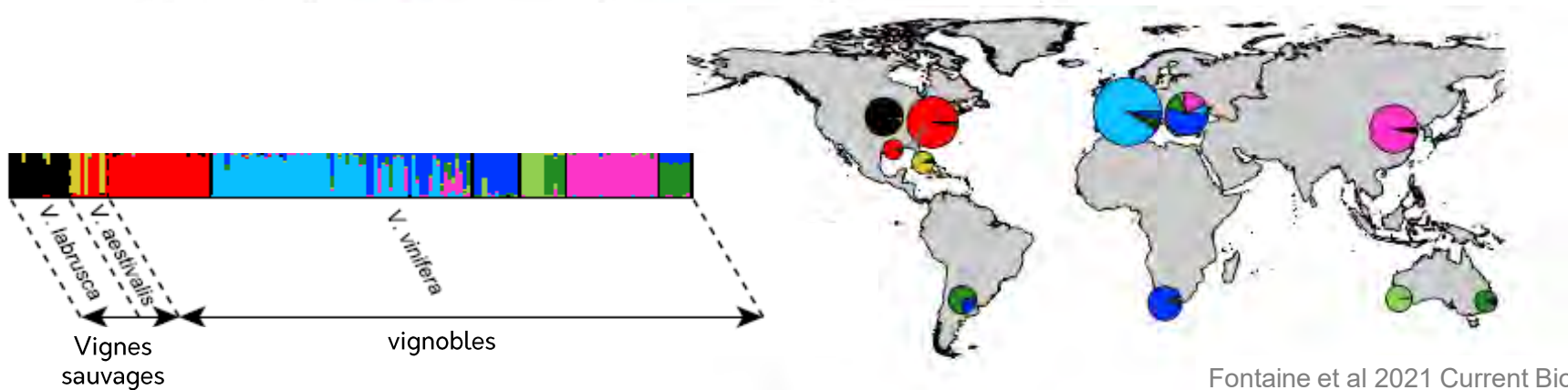
Invasion depuis une seule des espèces



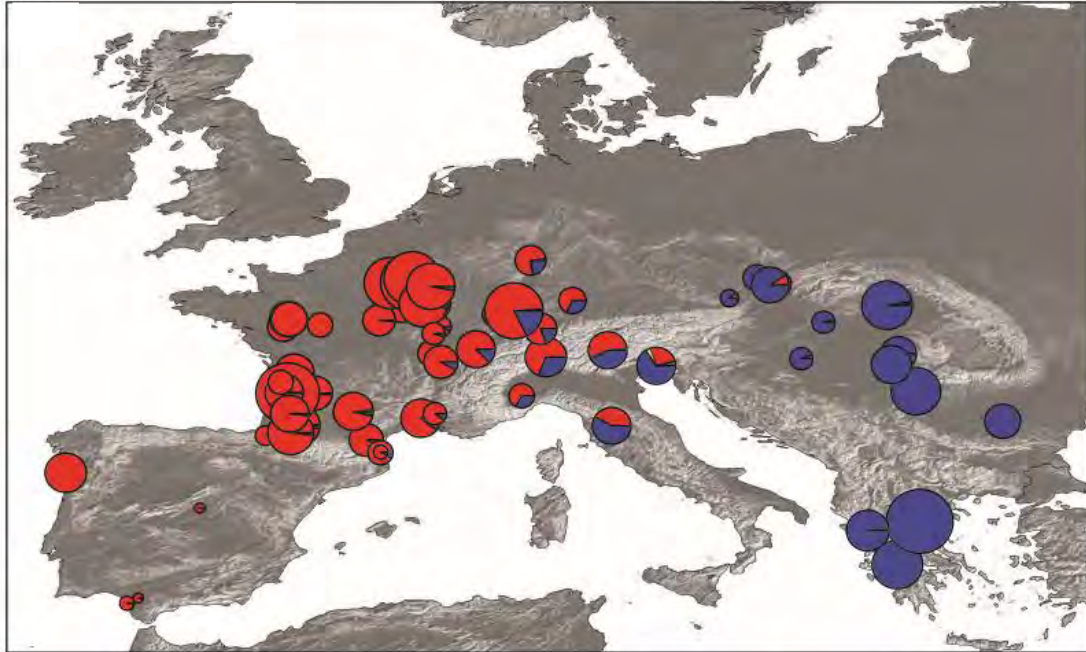
Structure des populations mondiales



François Delmotte

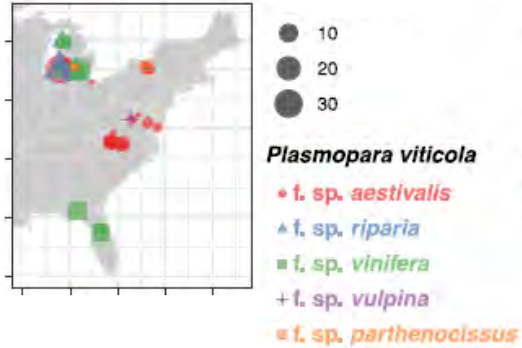


Structure des populations européennes

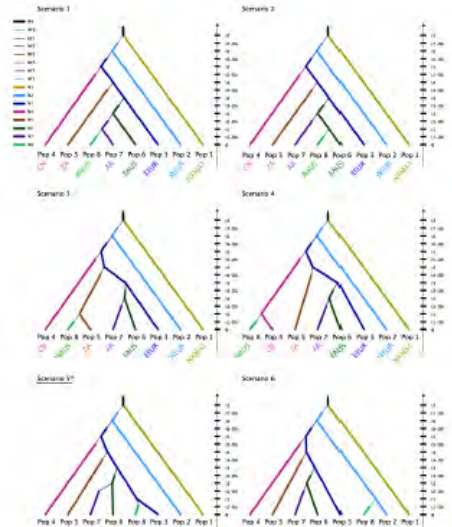


François Delmotte

Histoire de l'invasion du mildiou?



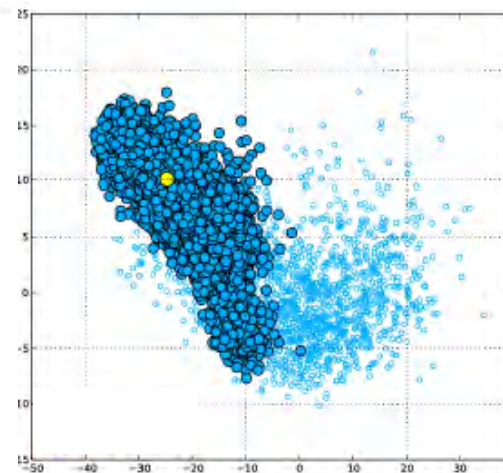
François Delmotte



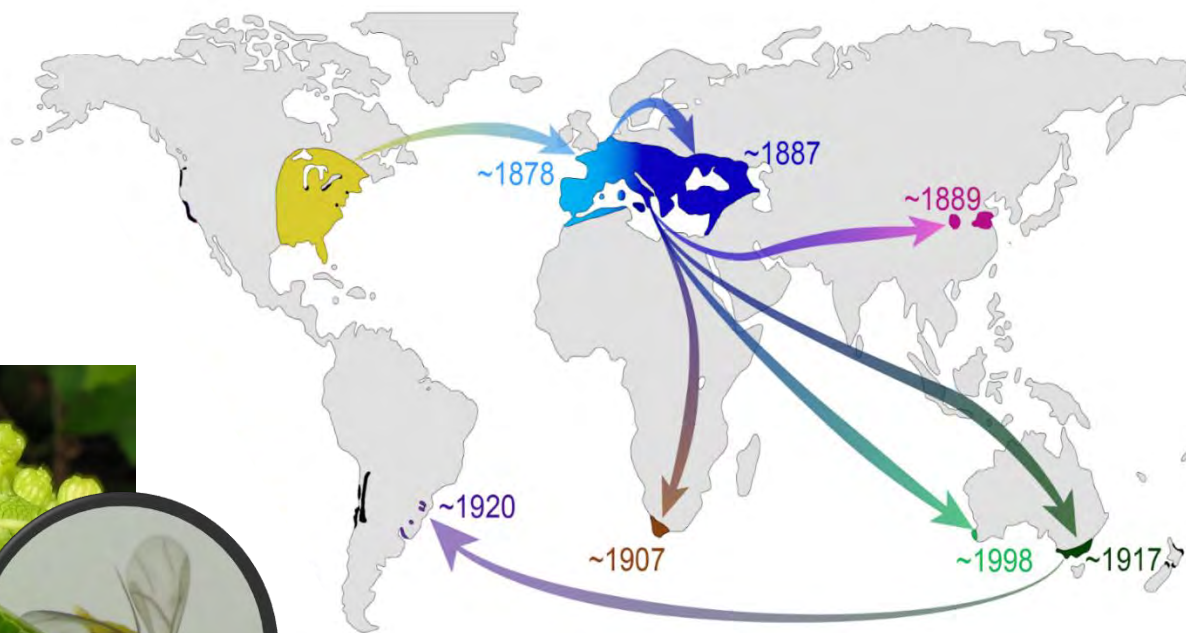
Tests de
scenarios:

ABC

256 statistiques
résumées



Histoire de l'invasion du mildiou

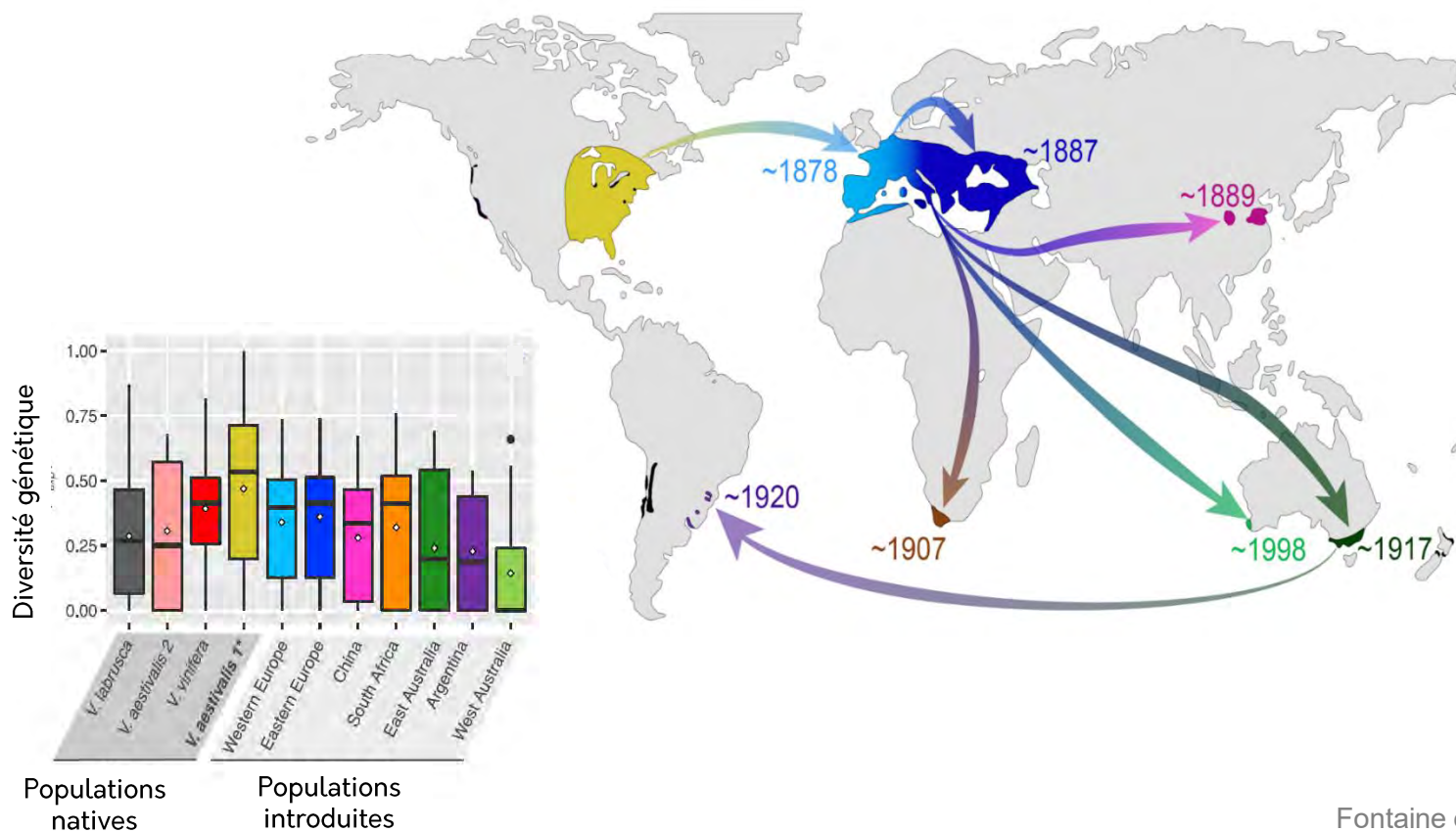


François Delmotte

Phylloxera



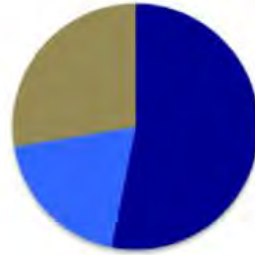
Histoire de l'invasion du mildiou



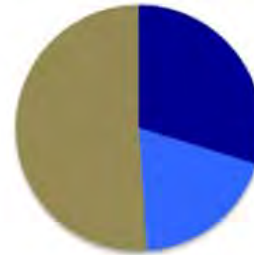
François Delmotte

Invasions de champignons pathogènes

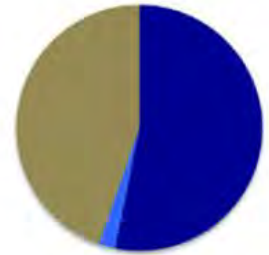
Changement d'hôte



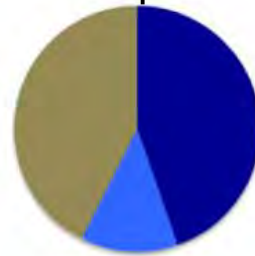
Changement de mode de reproduction



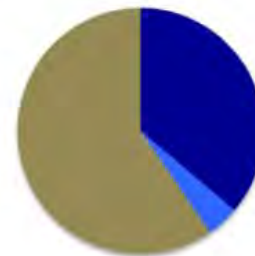
Perte de diversité génétique



Introductions multiples

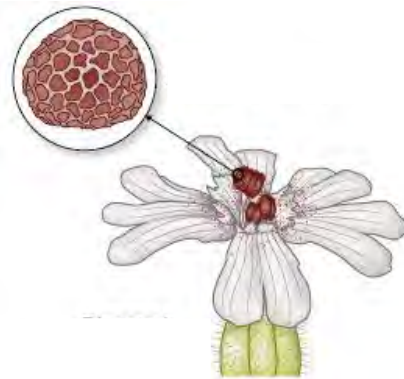
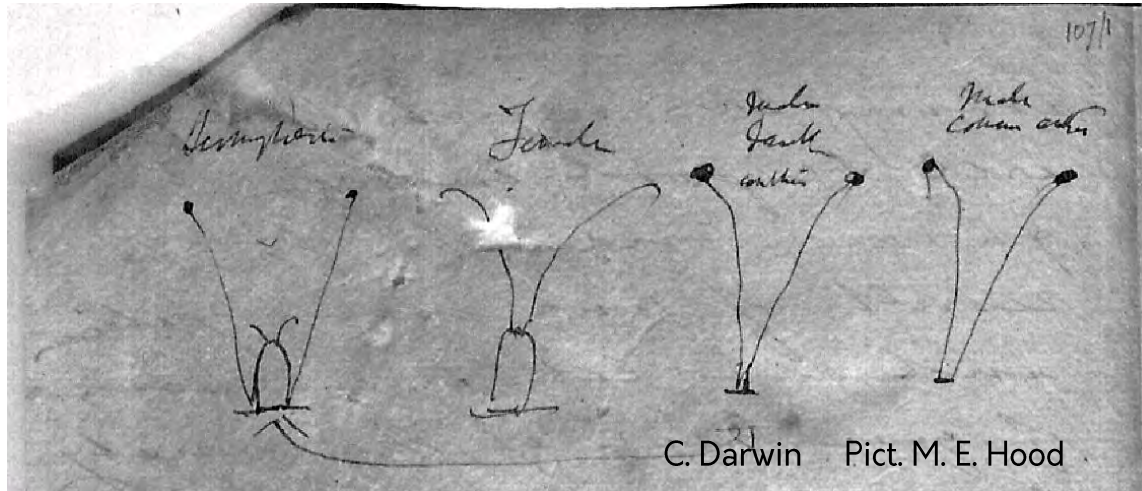


Hybridations



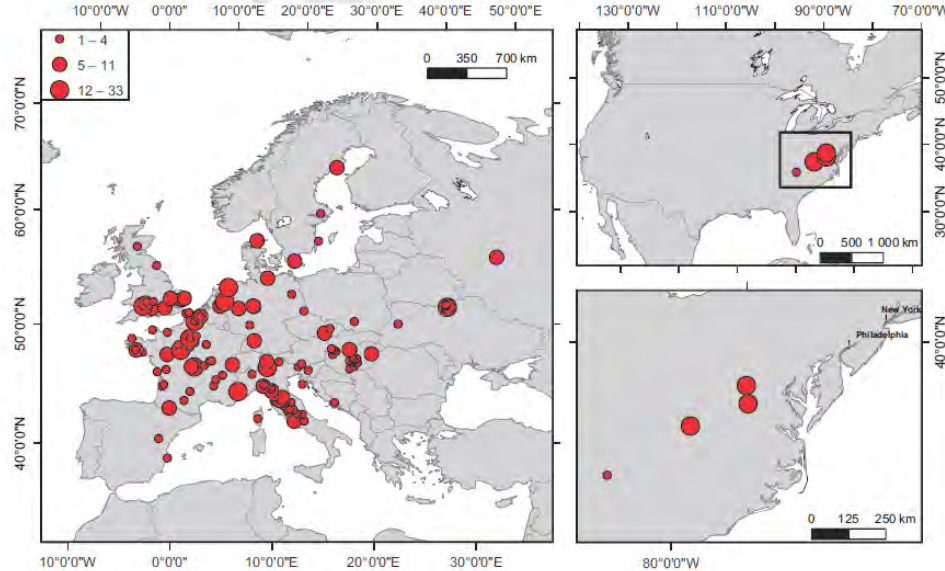
- Oui
- Non
- Pas de données

Microbotryum: charbon des anthères



Histoire des invasions biologiques?

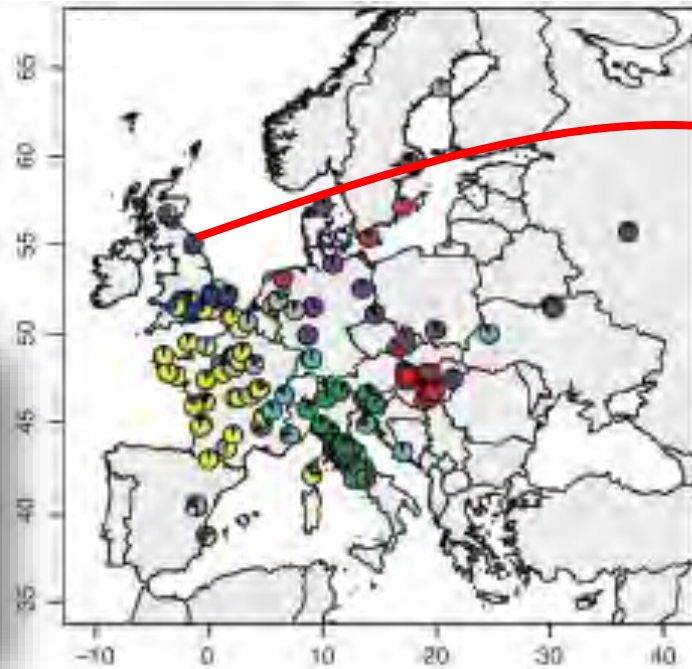
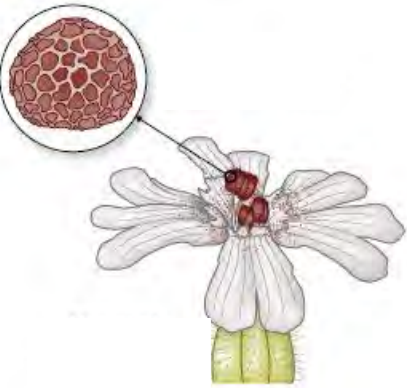
Invasion aux E.-U., 19^{ème} siècle



Michael E Hood



Invasions biologiques



Gladieux et al 2015 Mol Ecol



Fontaine et al 2013 New Phytologist

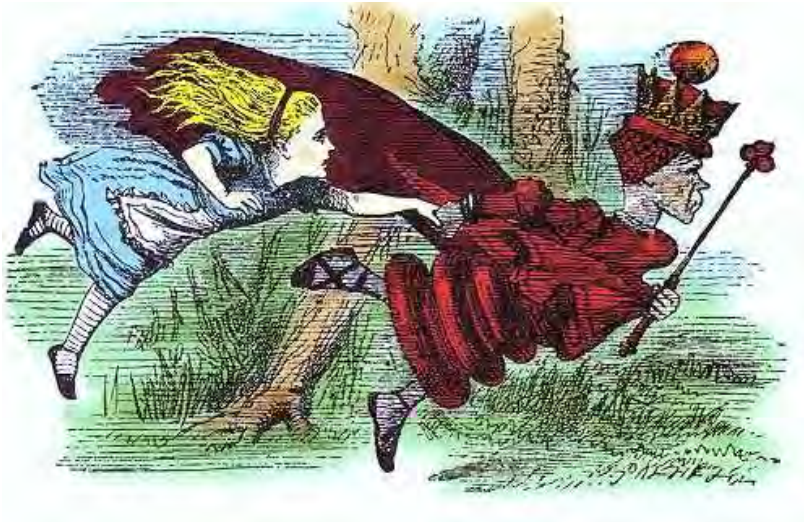
An aerial photograph of a forest. A large, irregularly shaped area in the center of the image is filled with dead, brown, and skeletal trees, standing out against the surrounding dense forest of healthy green conifers. A narrow, light-colored path or clearing runs diagonally through the lower part of the dead zone. The overall scene suggests a forest undergoing a significant die-off event, likely due to a disease or pest outbreak.

Emergences de nouvelles maladies de plantes

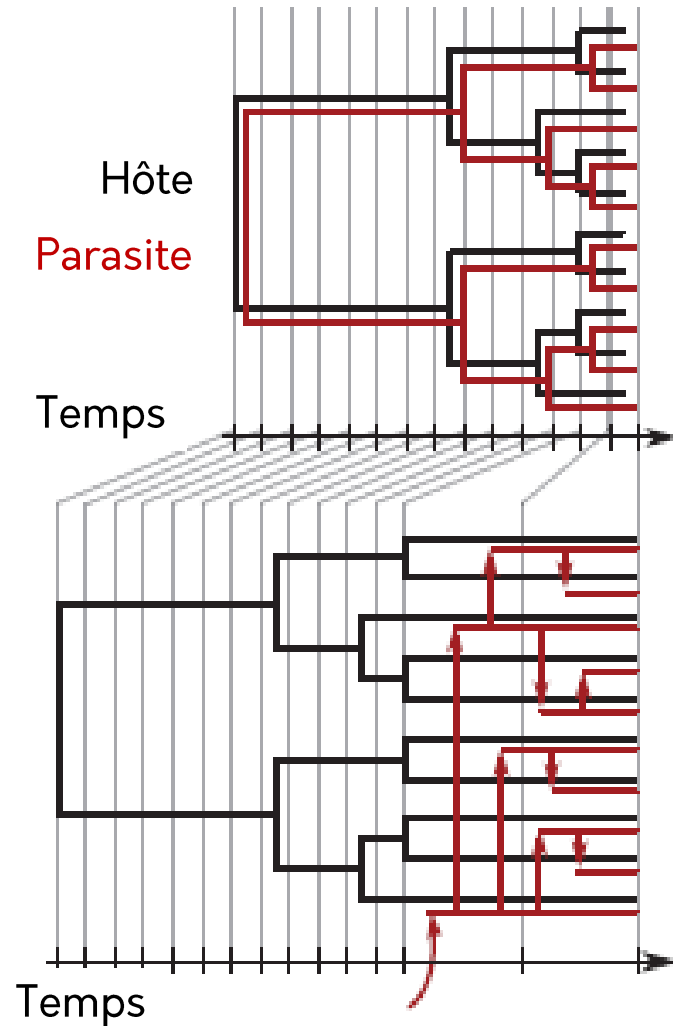
- Parasites et pathogènes
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 - Changements d'hôtes
 - Costructure
- Mécanismes d'adaptation génomique

Spéciation des parasites: Cospéciation ou sauts d'hôtes?

Différent de la question de la
coévolution



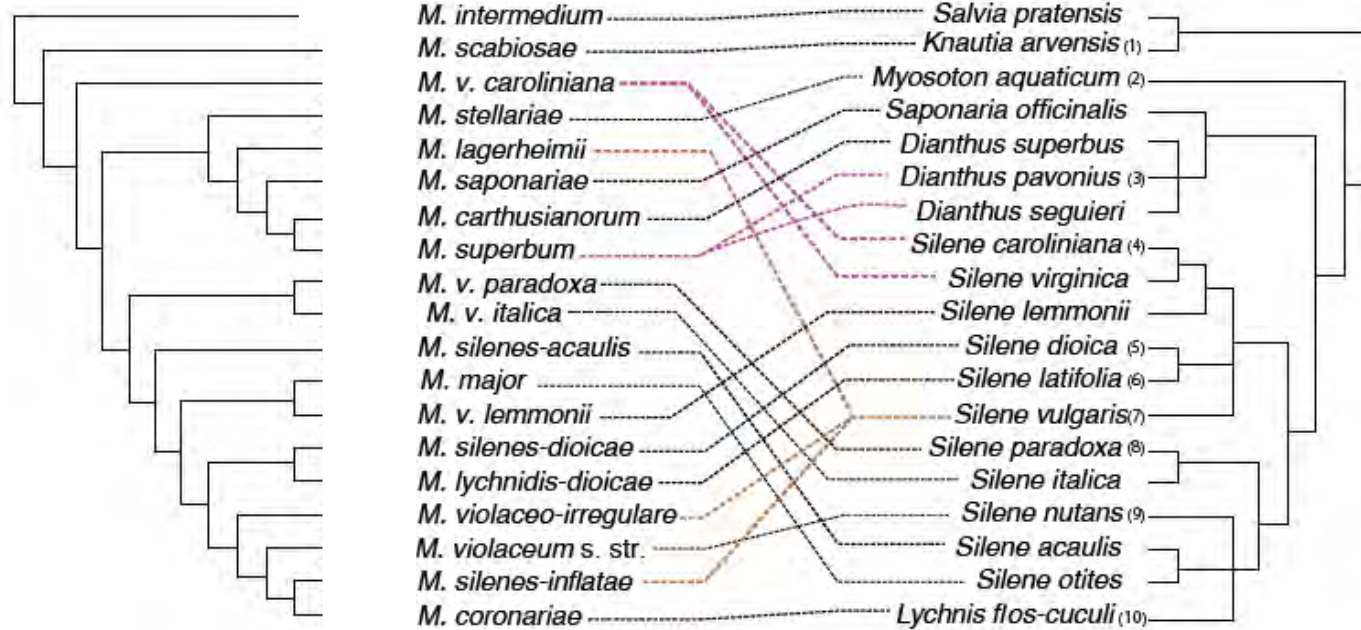
de Vienne et al. 2013 New Phytol



Changements d'hôtes fréquents

Microbotryum

Hosts



Refrégier et al. 2009 BMC Evol Biol

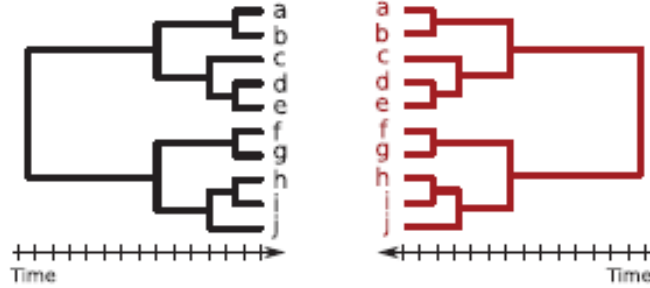
Hartmann et al. 2019 Ann. Rev. Phytopathology

de Vienne et al. 2013 New Phytologist

La coévolution n'implique pas la cospéciation

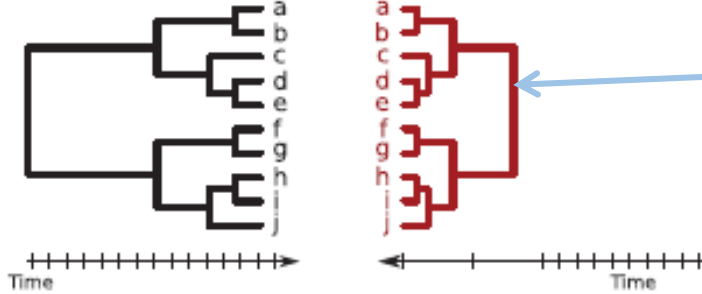
Congruence

Incongruence

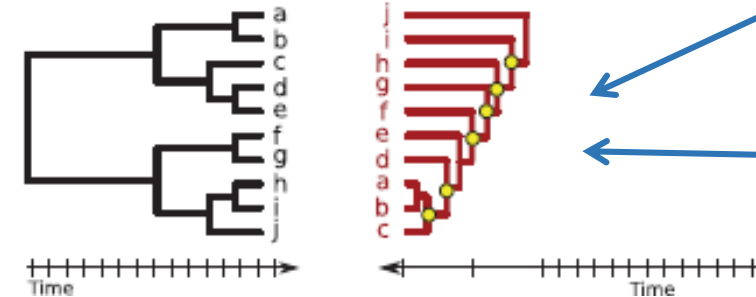


Cospéciation
Uniquement des
mutualistes

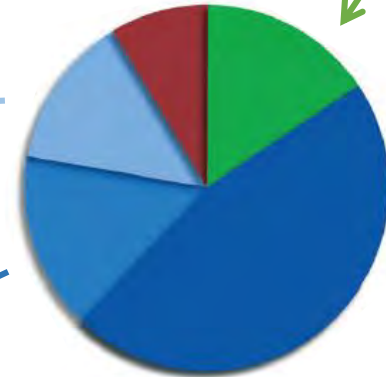
Pas clair



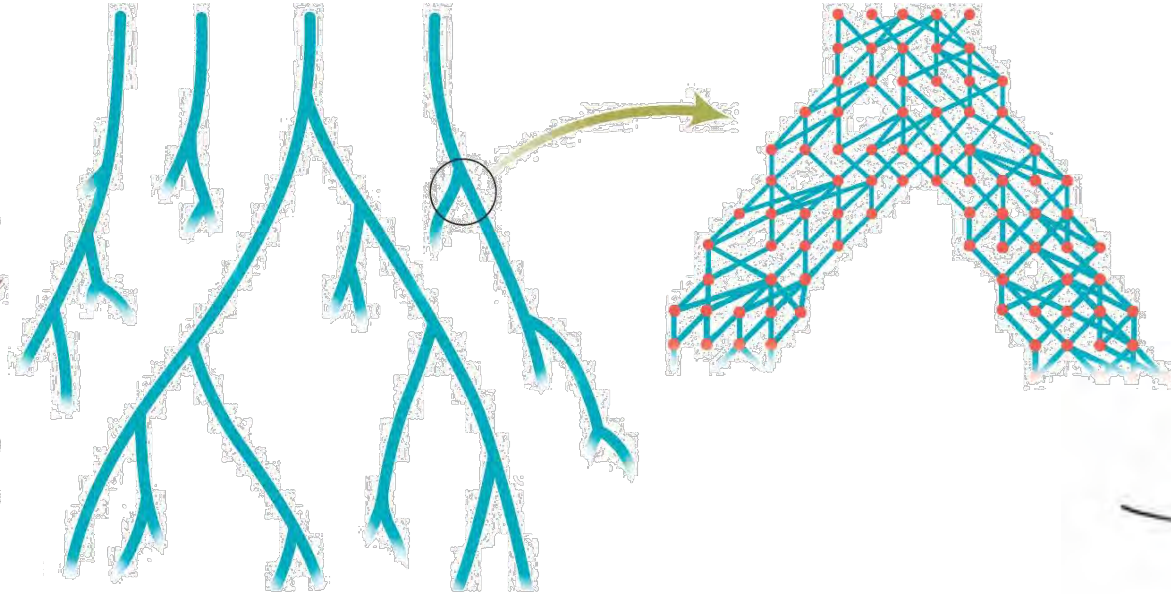
Incongruence
temporelle
Sauts d'hôtes



Incongruence
topologique
Sauts d'hôtes



Mécanismes de speciation et spécialisation?



Andreas Kay



Luca Livraghi, Michel Cast

Une adaptation optimale à tous les hôtes ne doit pas être possible

Spécialistes versus généralistes

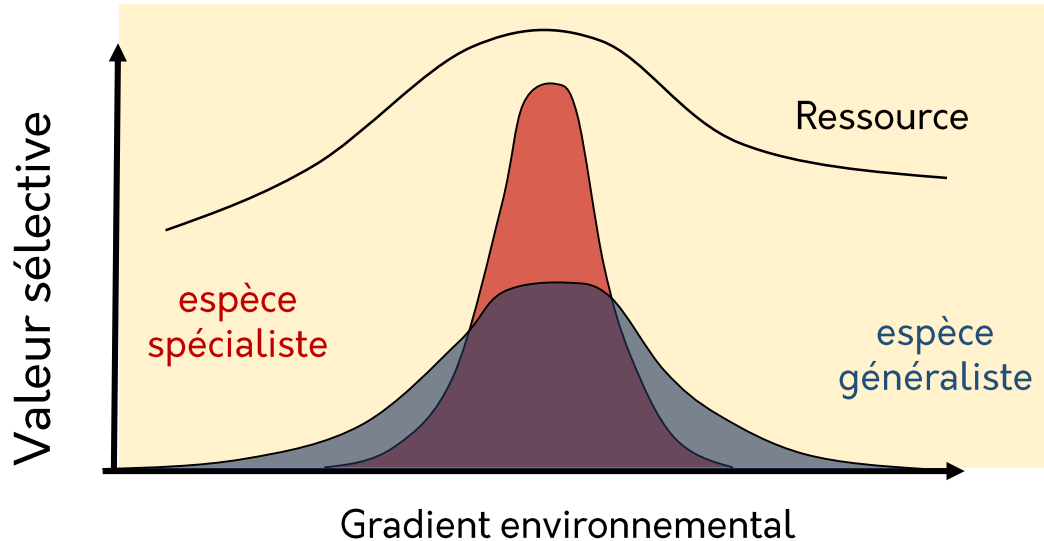


Zoran Veselinović



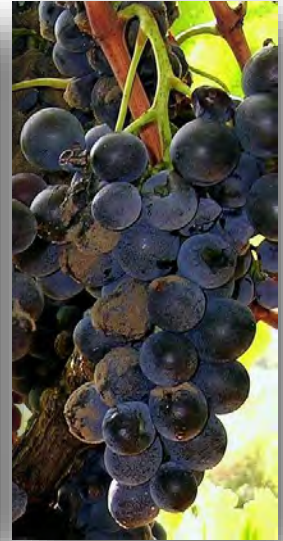
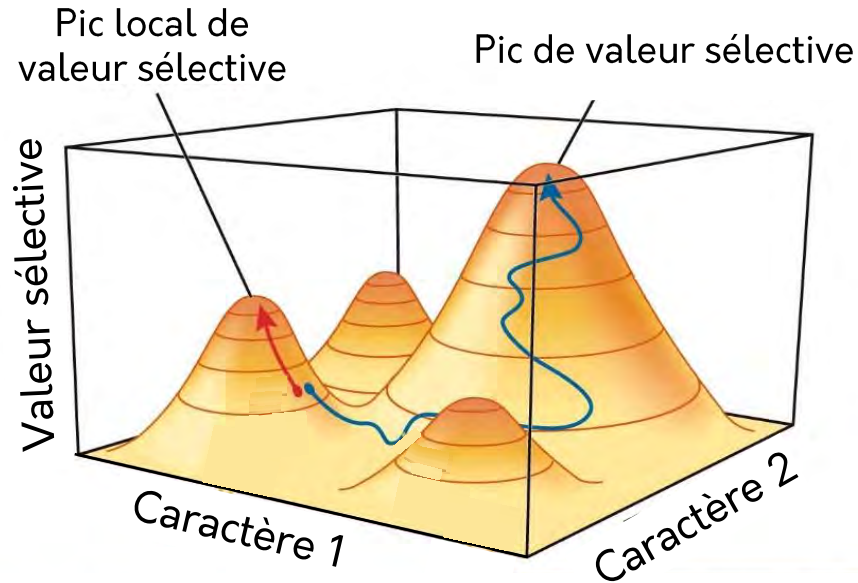
Artaxerxes

Spécialistes versus généralistes



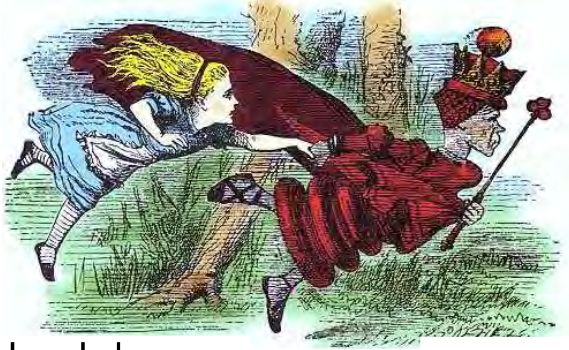
Spécialistes versus généralistes

Compromis?



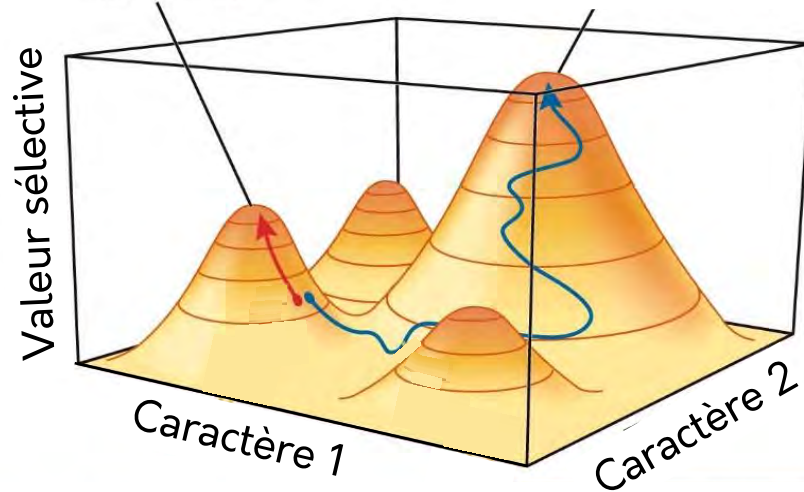
Botrytis

Spécialistes versus généralistes

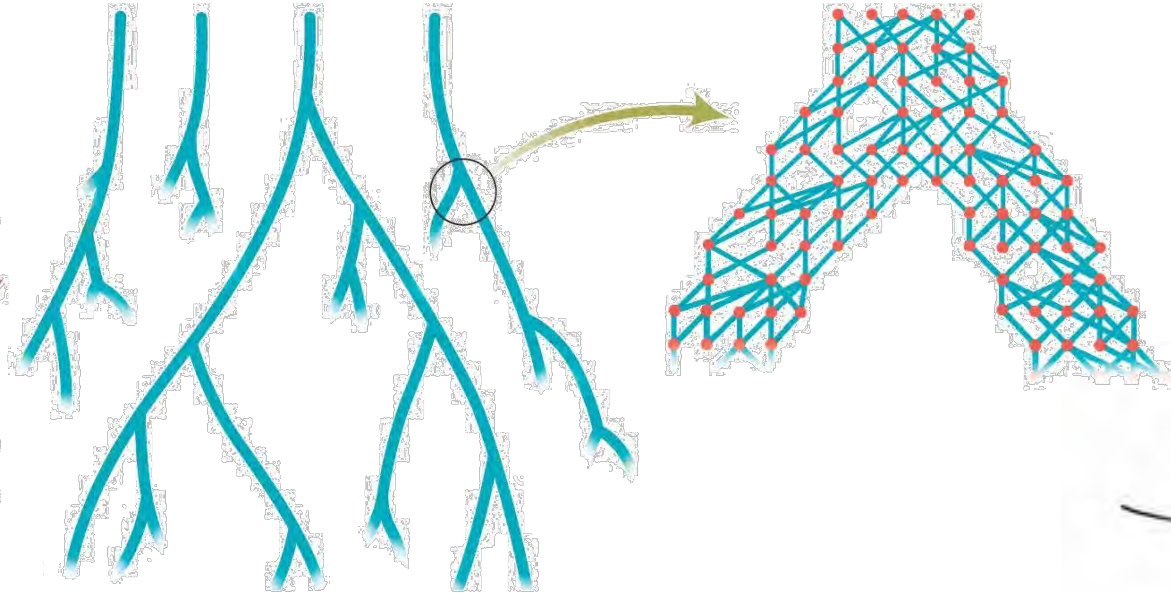


Pic local de
valeur sélective

Pic de valeur sélective



Mécanismes de speciation et spécialisation?



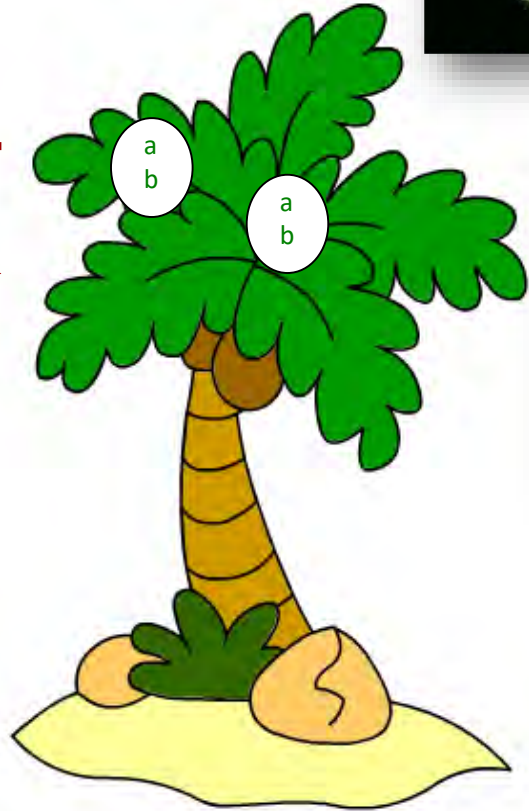
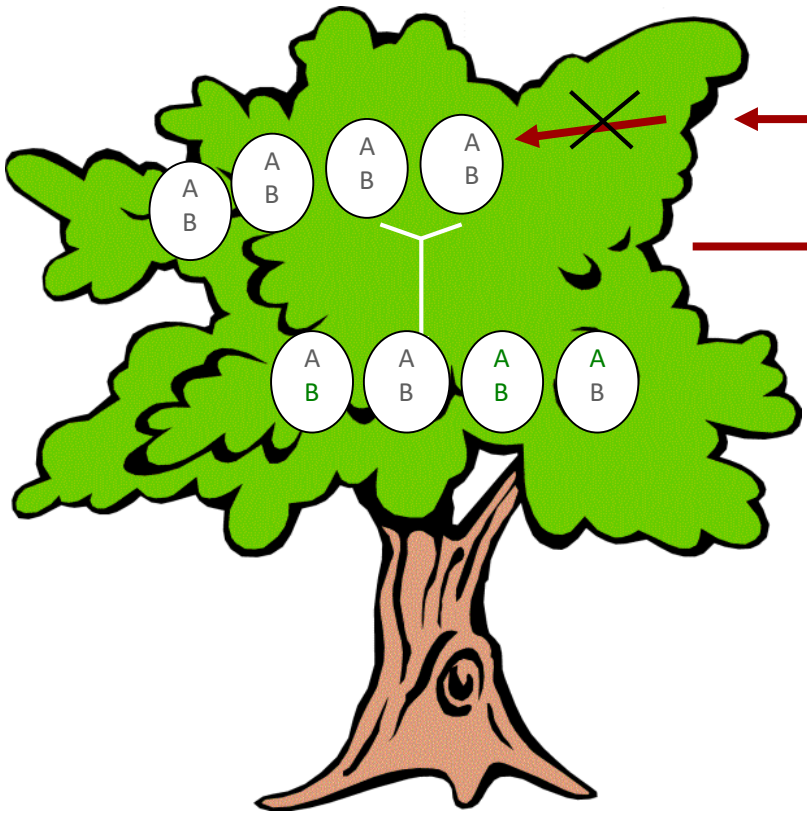
Andreas Kay



Luca Livraghi, Michel Cast

Une adaptation optimale à tous les hôtes ne doit pas être possible

Spécialisation facilitée chez les pathogènes



T. Peever



Le Cam

Spécialisation facilitée chez les champignons pathogènes

- Croisements au sein des hôtes
- Forte sélection sur peu de gènes (système gène pour gène)



- Milliards de spores:
 - Mutations plus nombreuses
 - Fardeau plus supportable



Dolors Villegas, IRTA, Spain

Isolement reproducteur en
sympatrie facilité chez les
pathogènes



Venturia inaequalis
sur arbres sensibles



Venturia inaequalis
sur arbres résistants



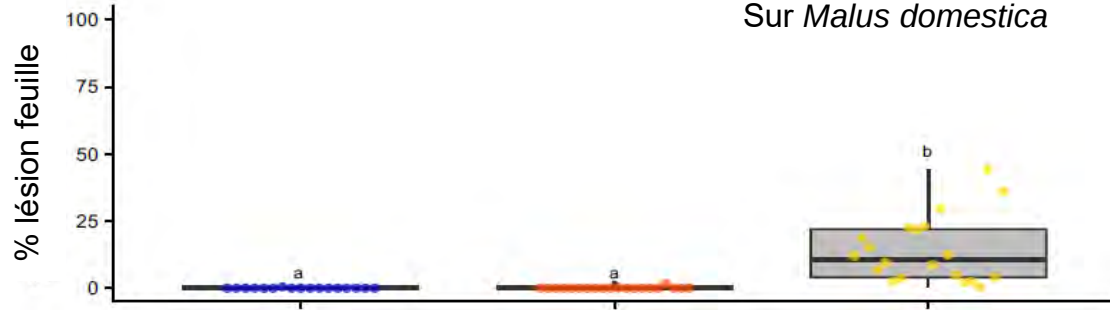
Venturia inaequalis

Spécialisation facilitée chez les champignons pathogènes

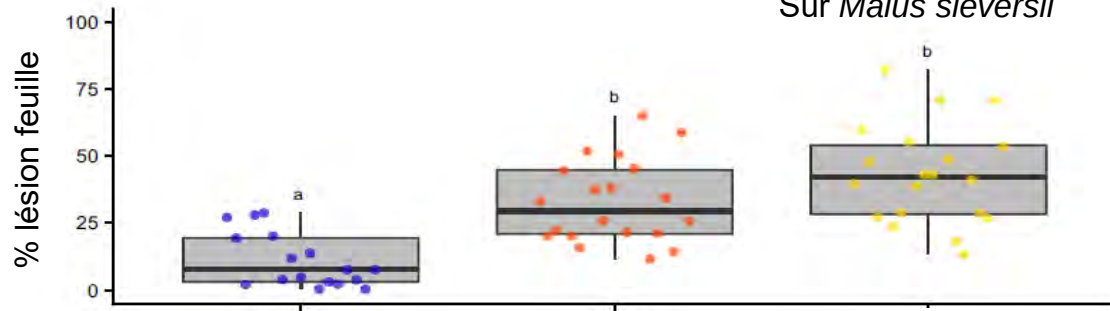
Gladieux et al. Mol Ecol 2011

Pathogènes pestifiés menaçant les populations de pommiers sauvages: augmentation de la virulence

Sur *Malus domestica*



Sur *Malus sieversii*



champignon:

sauvage

hybrides

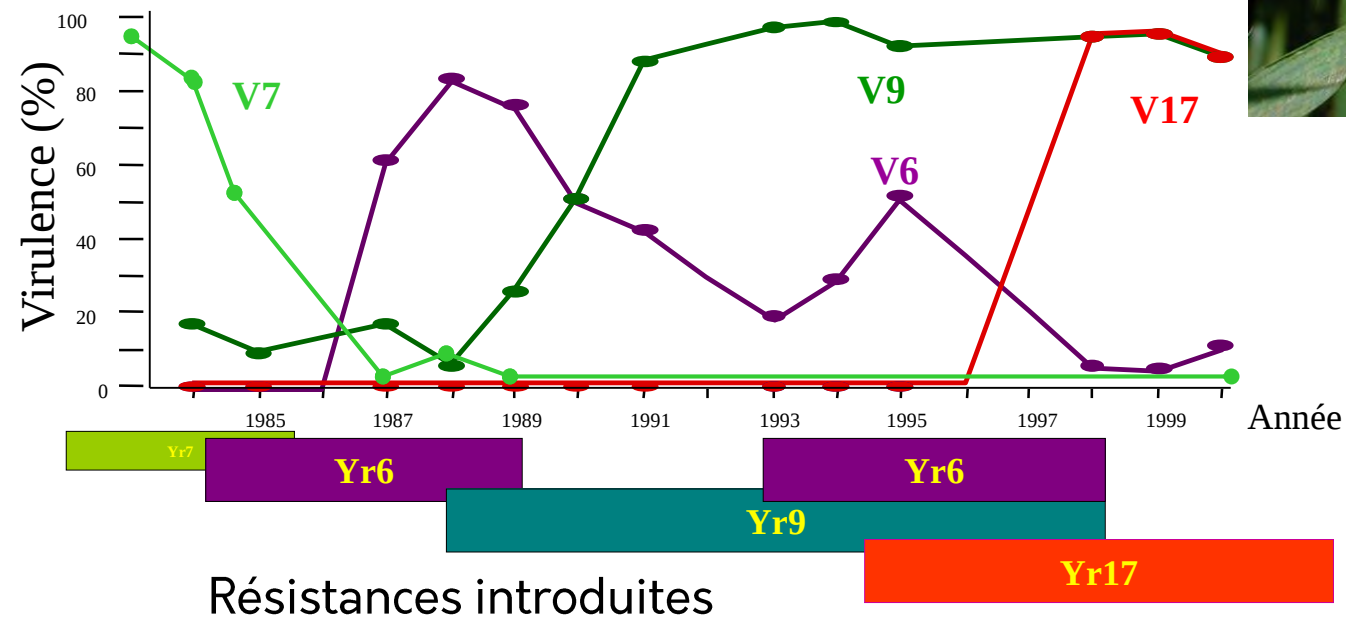
anthropique



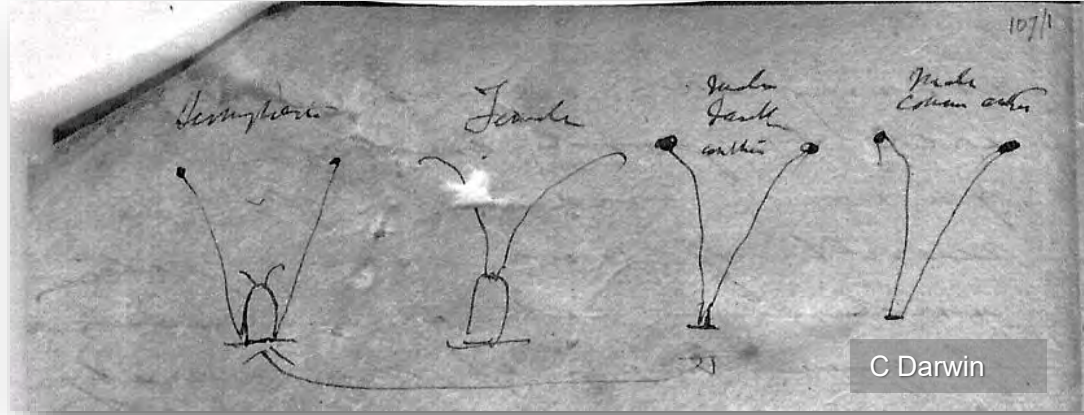
Contournement par les pathogènes des résistances introduites

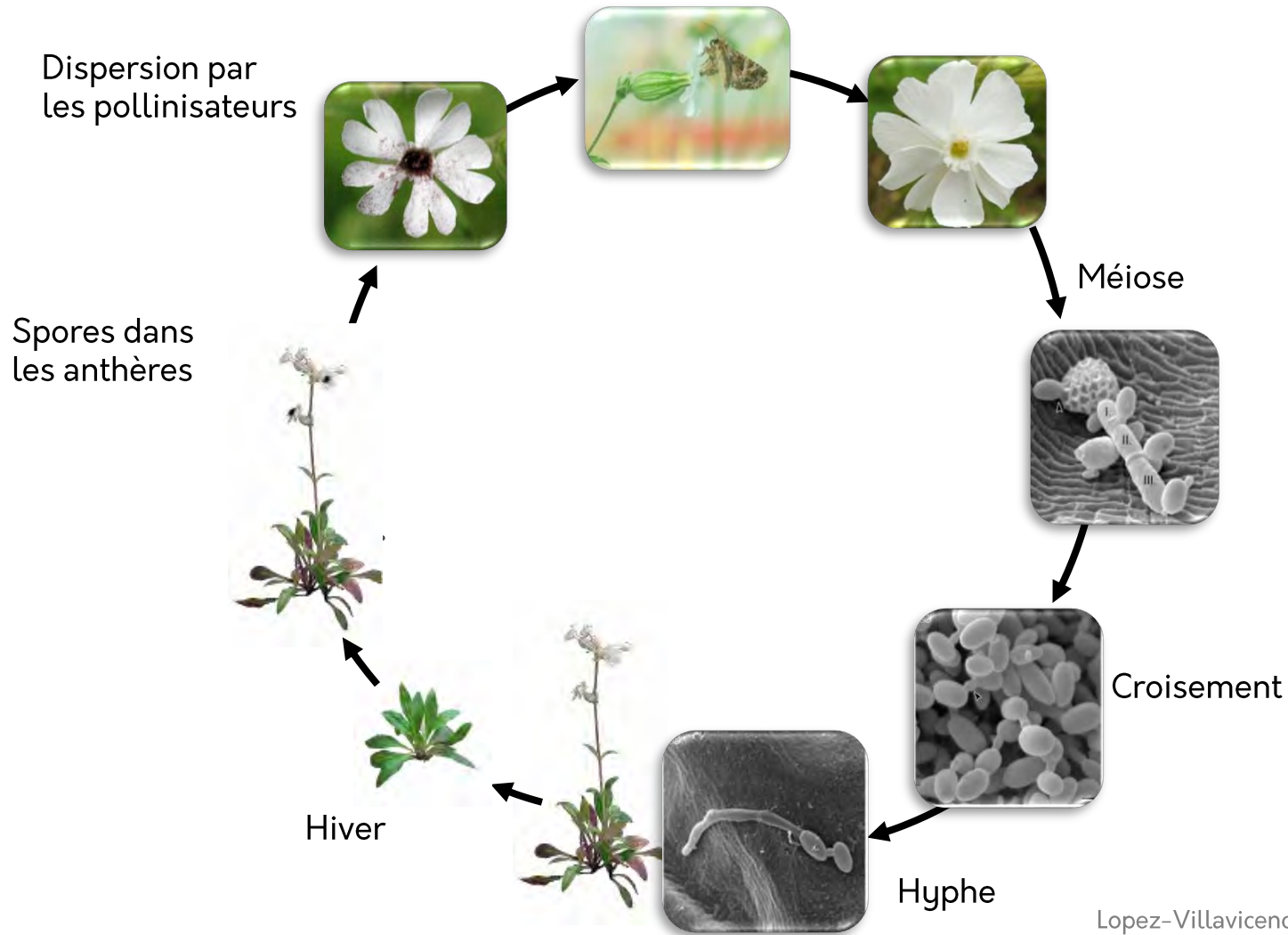


Rouille du blé

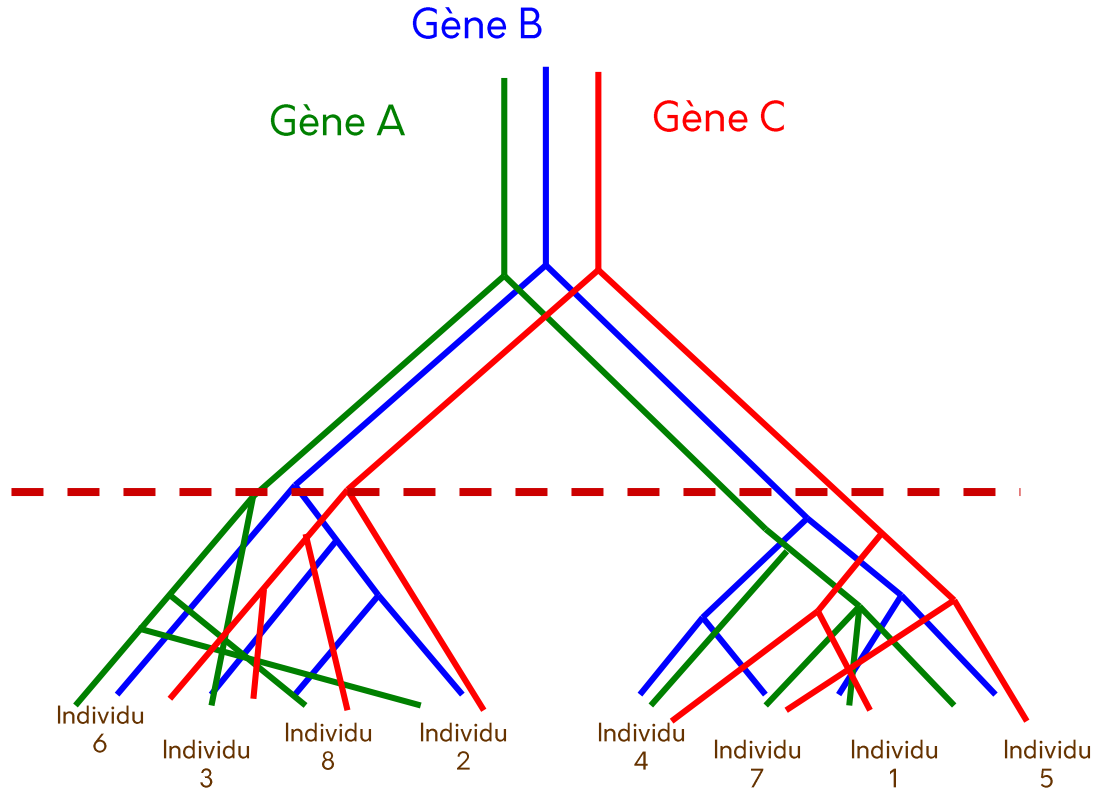


Spécialisation chez les champignons *Microbotryum*?

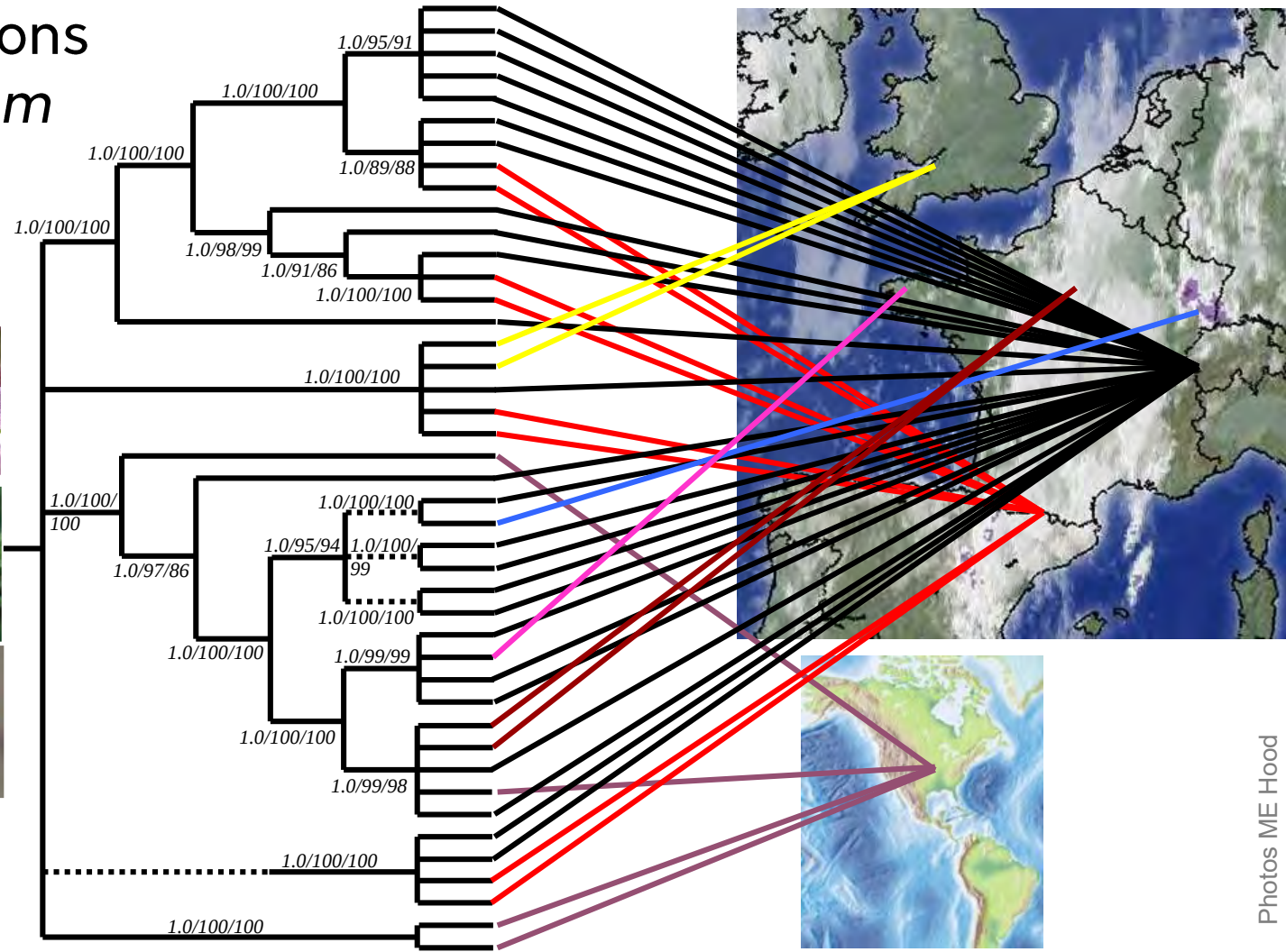




Critères d'espèces : congruence entre phylogénies multiples



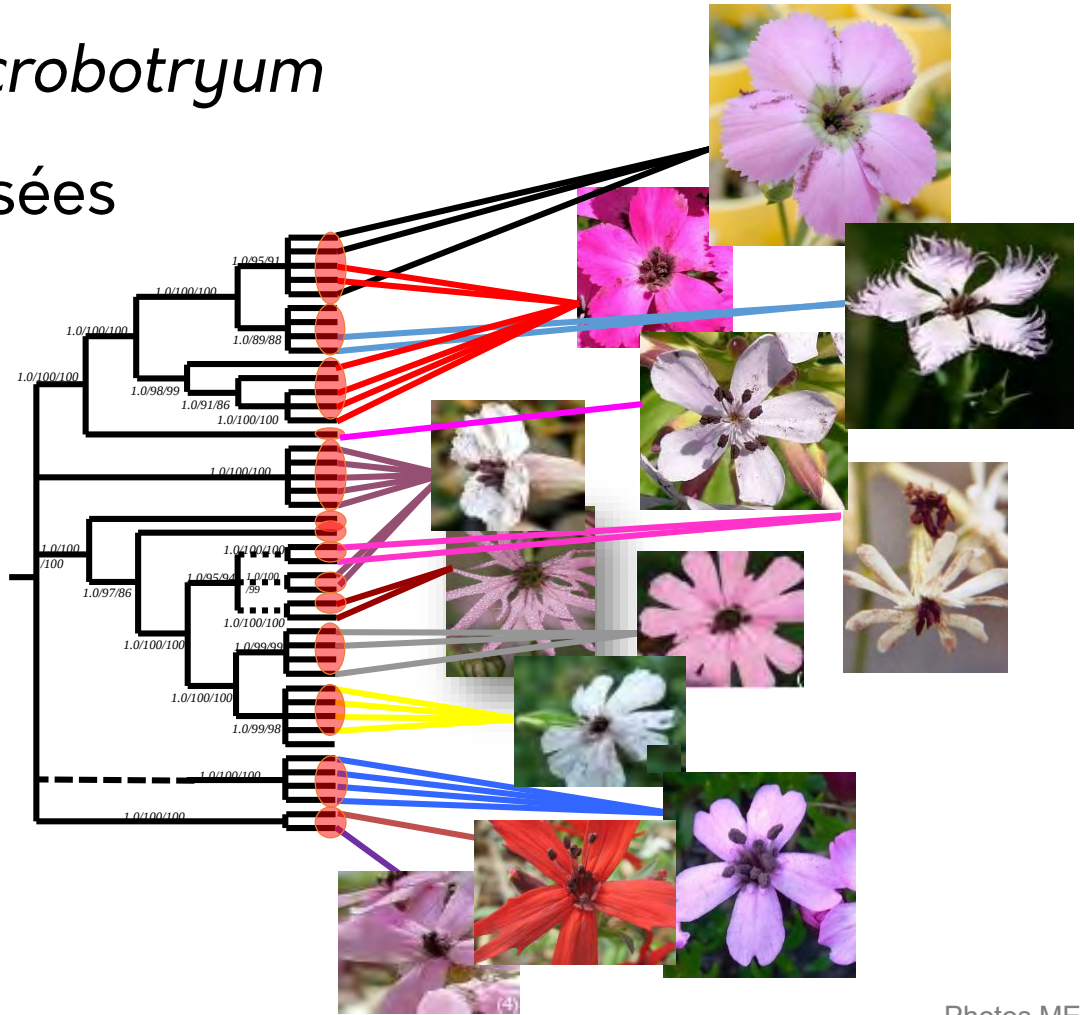
Les champignons *Microbotryum*



Le Gac et al, Evolution 2007
Refrégier et al. 2008
Picts ME Hood

Les champignons *Microbotryum*

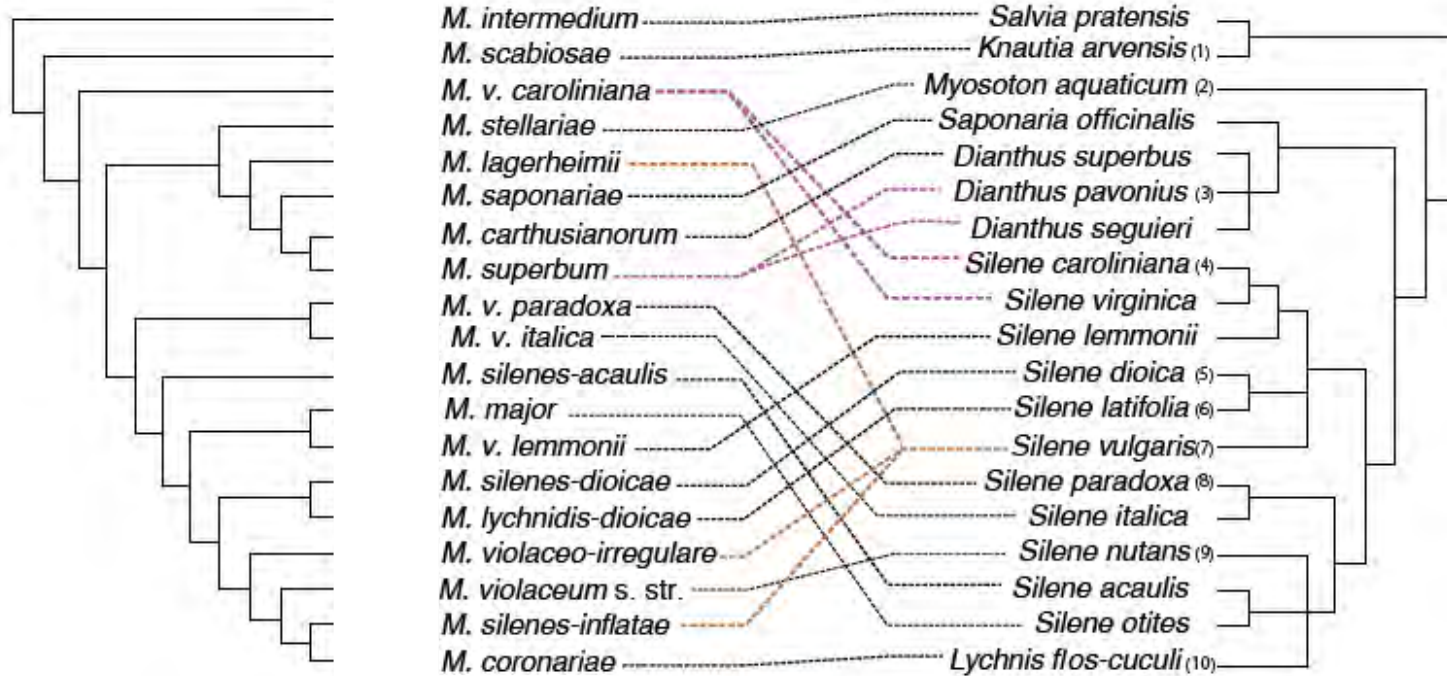
Espèces spécialisées



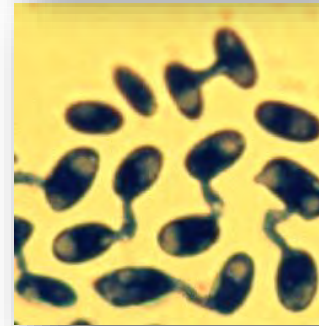
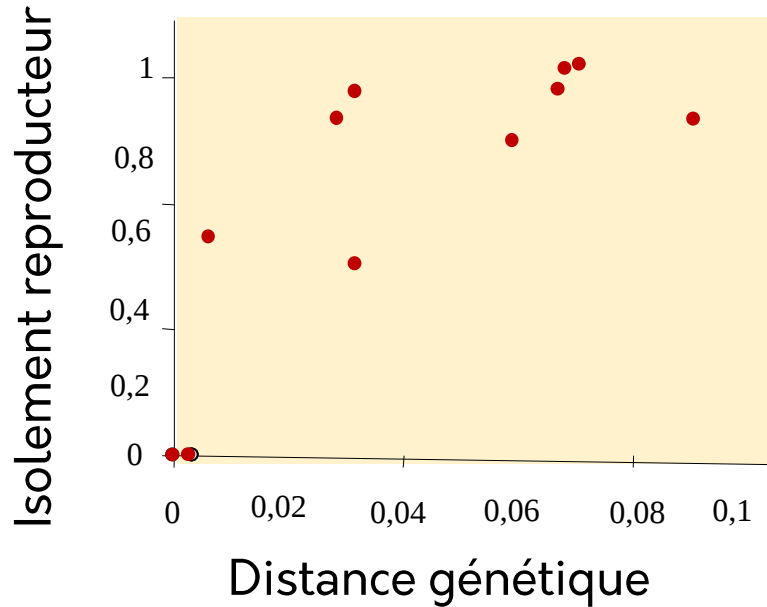
Le Gac et al, Evolution 2007
Refrégier et al. 2008
Picts ME Hood

Photos ME Hood

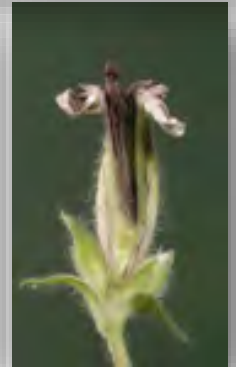
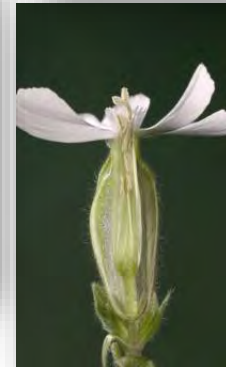
Spéciation par sauts d'hôtes, pas de cospéciation



Augmentation de l'isolement reproducteur avec la distance génétique en sympatrie

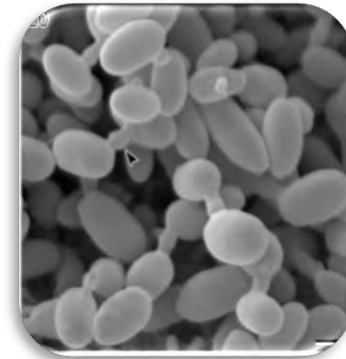
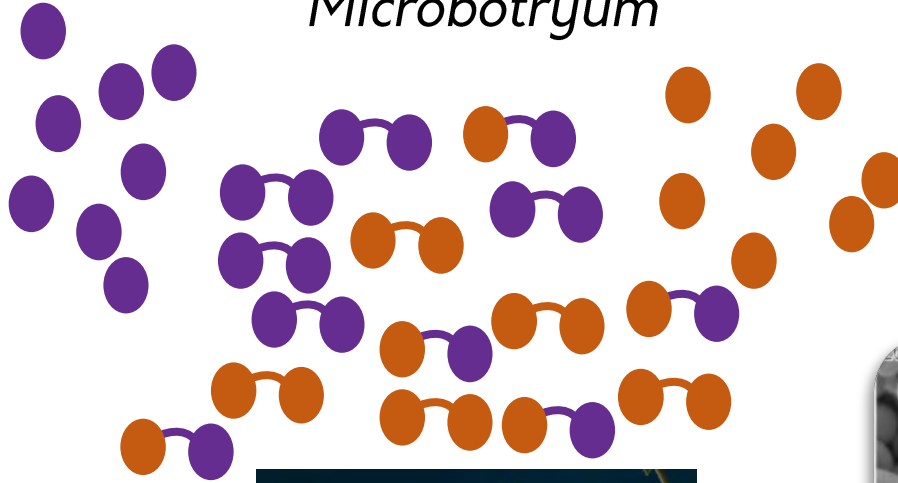
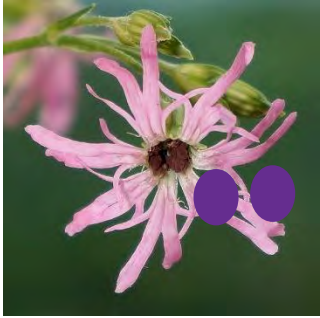


M.E. Hood



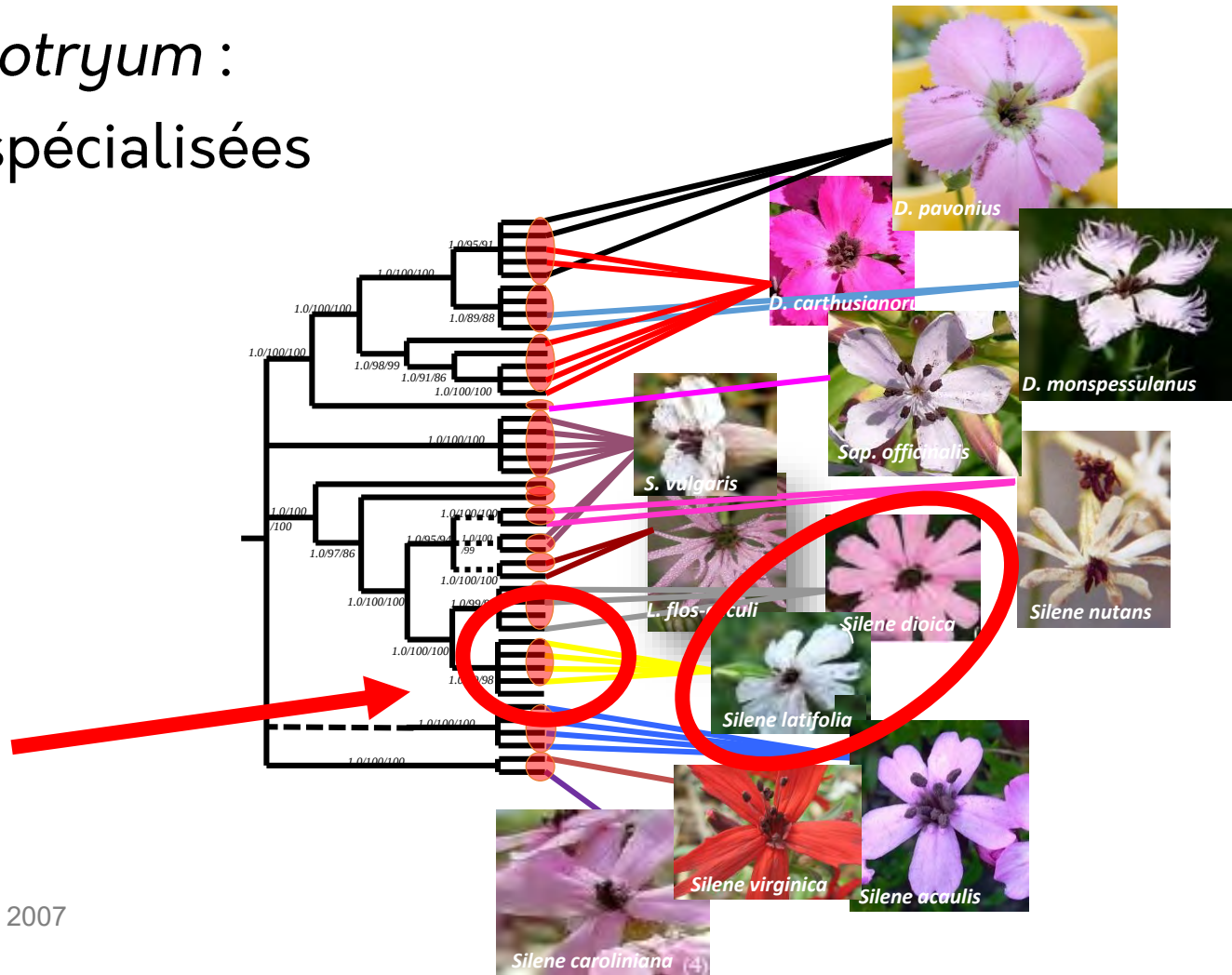
Spécialisation facilitée chez les pathogènes

Autofécondation chez *Microbotryum*



Schäfer et al. 2010 Botany

Microbotryum : espèces spécialisées



Biodiversité et évolution

Tatiana Giraud



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DE FRANCE
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Fondation
Jean-François et Marie-Laure
de Clermont-Tonnerre

