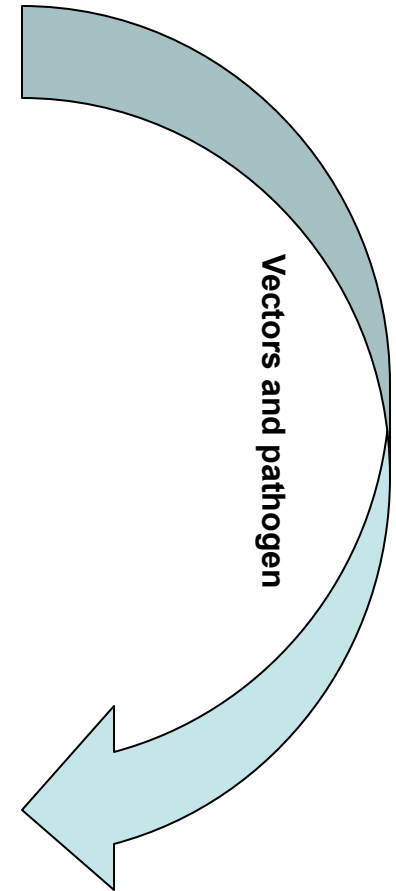
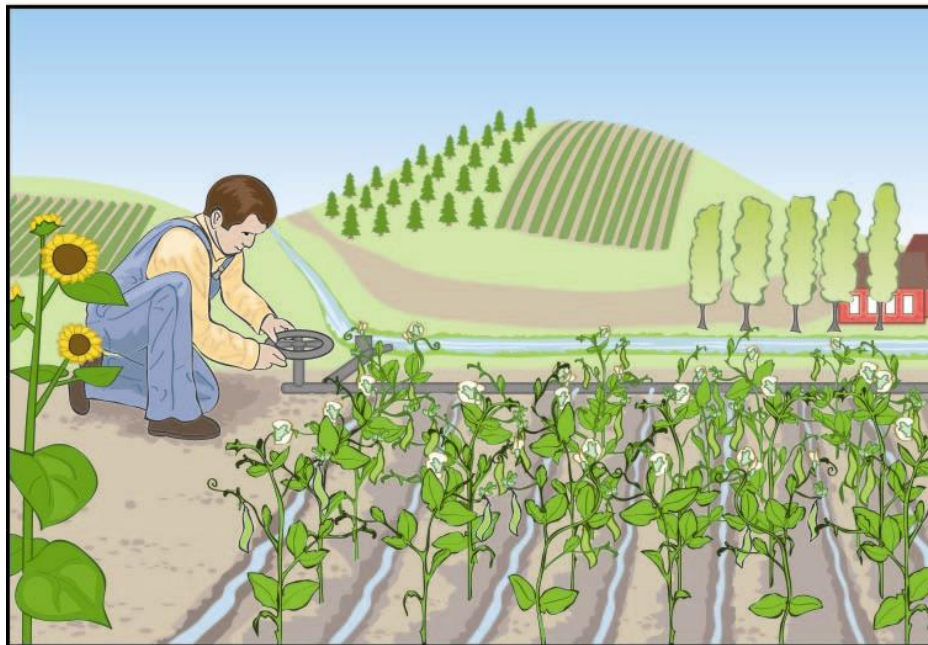
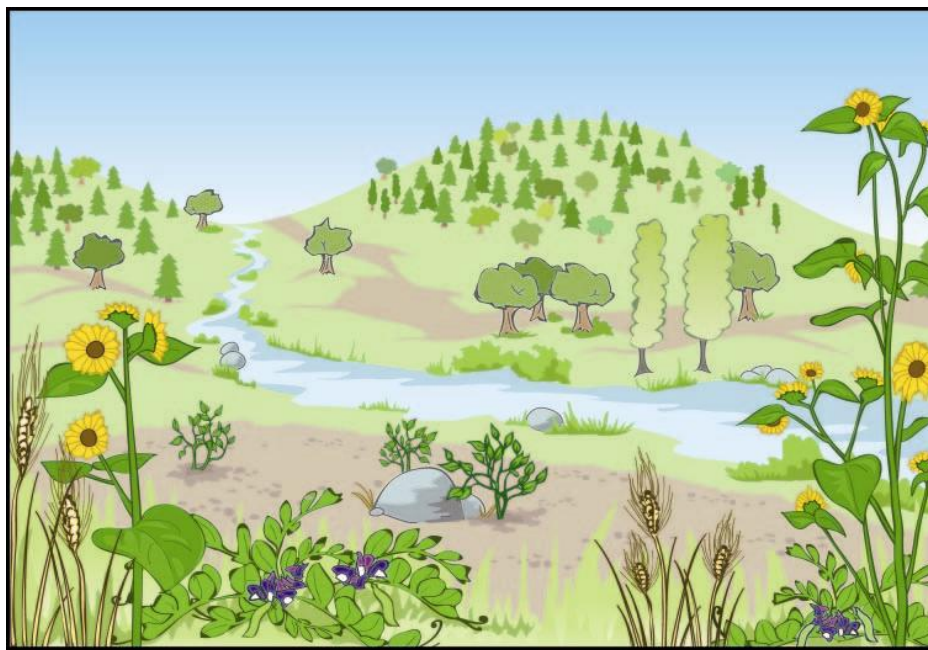
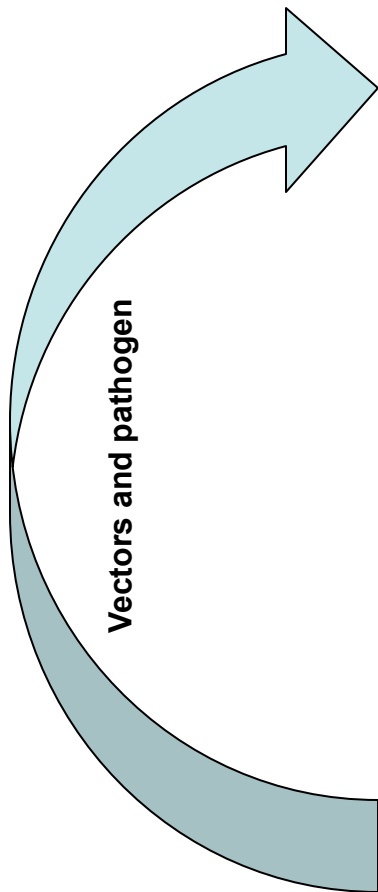


Layers of ecological complexity:

- ✓ **environment (e.g. temperature)**
- ✓ **vector ecology**
- ✓ **pathogen ecology**
- ✓ **host plant ecology**
- ✓ **outcome of various interactions**
- ✓ **disease management**

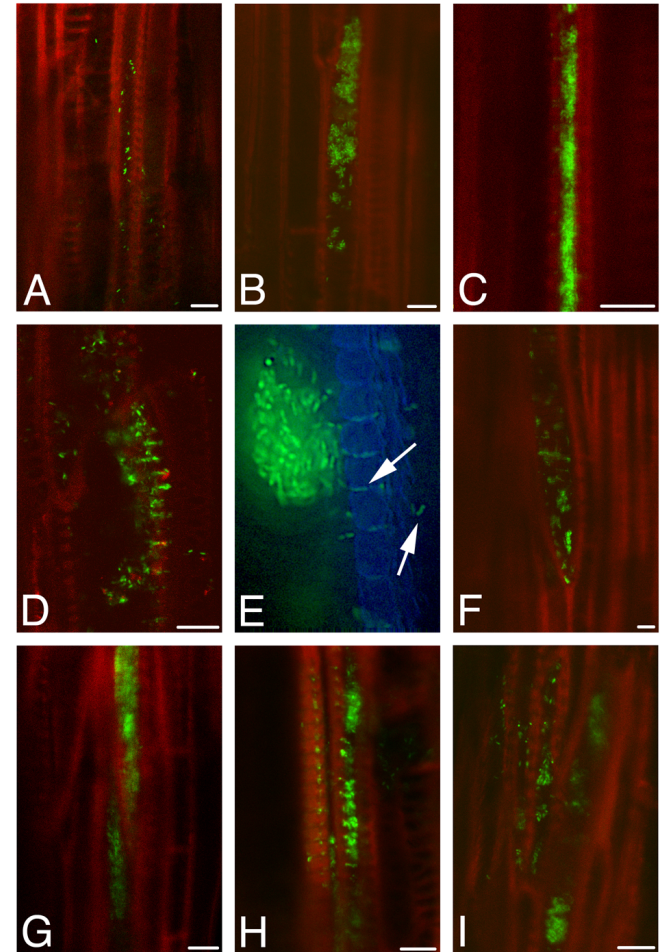
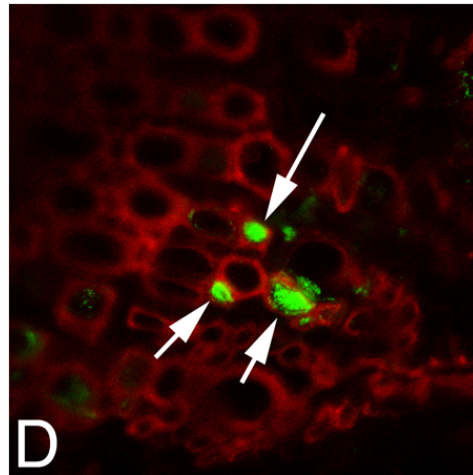
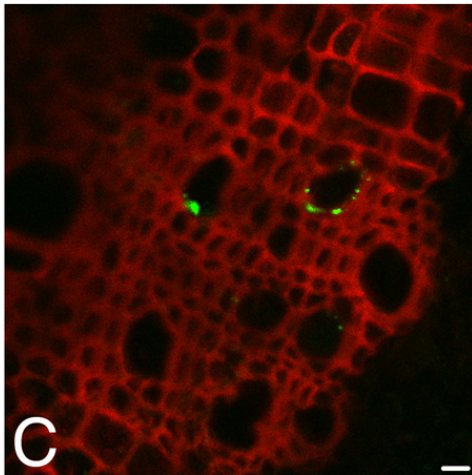
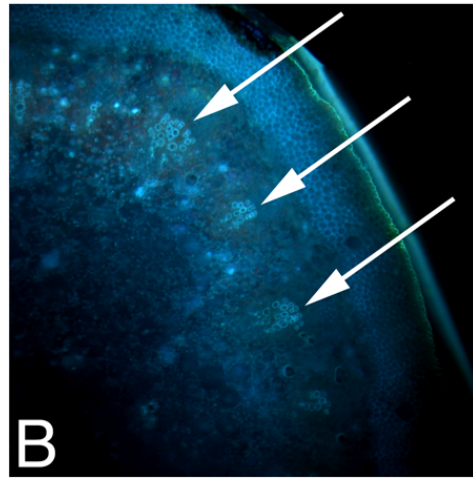
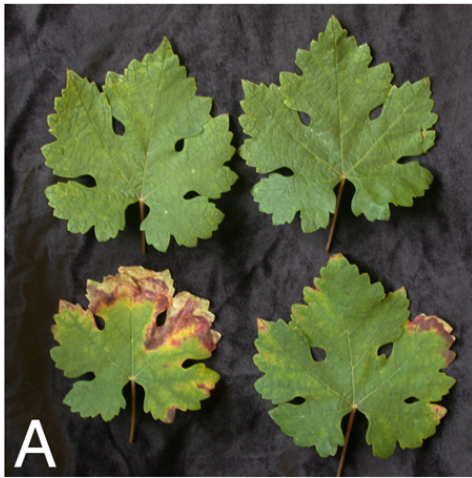


A scanning electron micrograph (SEM) showing numerous rod-shaped bacteria, identified as Xylella fastidiosa, against a dark background. The bacteria are elongated and appear to be arranged in some degree of parallelism, though some are slightly curved or overlapping. The image is in grayscale, highlighting the texture and form of the microbial structures.

Xylella fastidiosa

- Gammaproteobacteria, Xanthomonadaceae
- Xylem-limited bacterium
- Colonizes >350 host plant spp., usually without causing disease
- Present throughout the Americas, more recently reported in Taiwan, Italy, France, Iran, Spain...
 - Major crops affected include grape, citrus, coffee, almond, peach, plum, pecan, olive, various ornamentals and shade trees
- Xylem sap-feeding insects are only vectors
 - Cicadellinae (sharpshooter leafhoppers), Cercopoidea (spittlebugs)

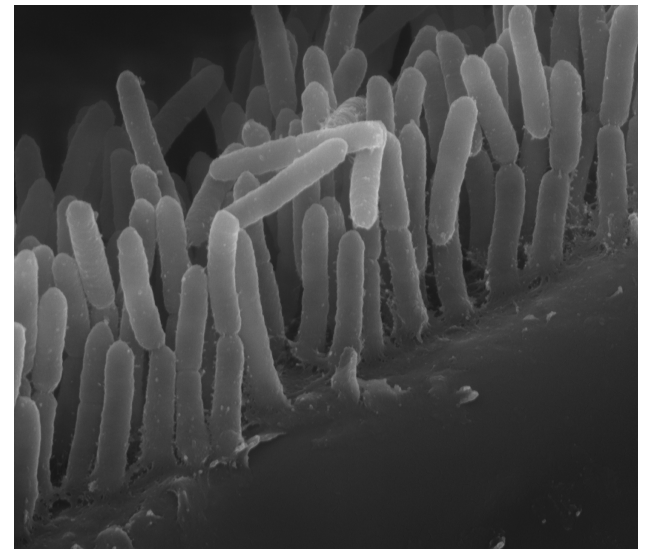
Plant colonization



Vector transmission of *X. fastidiosa*

- the basics -

- ✓ No vector species – pathogen strain specificity
- ✓ Nymphs and adults transmit *X. fastidiosa*
- ✓ No latent period
- ✓ No transmission after molting
- ✓ No transovarial transmission
- ✓ Persistent



Brief introduction

Why are we here?

Drivers of disease emergence

X. fastidiosa – what does it mean?

X. fastidiosa detected in Italy in October 2013



Donato Boscia

The previous 'absence' of *Xylella fastidiosa* from Europe is not a recent interest to those working with this bacterium

The characteristics of vector transmission of *X. fastidiosa* suggest that a lack of potential insect vectors should be no obstacle to sustaining introductions of the bacterium in new regions. There is broad group speci-

Journal of Plant Pathology (1997), 79 (2), 99-105 Edizioni ETS Pisa, 1997

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INVITED REVIEW

XYLELLA FASTIDIOSA, A REGIONAL PROBLEM OR GLOBAL THREAT?

A.H. Purcell

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SUMMARY

Until now, the xylem-limited bacterium *Xylella fastidiosa* has been recorded only from the Americas, with the exception of a pear disease in Taiwan. Is this bacterium a potential threat to other continents and islands? Climate appears to play a major role in the geographic distribution of diseases caused by *X. fastidiosa*, but this differs with strain and host plant. Mild winters may be necessary for the long term persistence of *X. fastidiosa* within a climatic region, but the possible limiting effects of summer temperatures have not been explored. Potential vectors are widespread and often common in most parts of the world not currently affected by *X. fastidiosa*. An important feature to maintain endemic infections of the bacterium in temperate regions may be the occurrence of potential vectors that overwinter as adults. Previously unrecorded plant diseases in citrus and oleander, caused by *X. fastidiosa*, have rapidly spread, suggesting that vigilant phytosanitary measures outside the Americas should be maintained against the introduction of *X. fastidiosa*. Molecular detection methods such as the polymerase chain reaction for a wide spectrum of strains of *X. fastidiosa* are preferable to serological methods because of their sensitivity and reliability.

RIASSUNTO

XYLELLA FASTIDIOSA, UN PROBLEMA REGIONALE O UNA MINACCIA MONDIALE? Il batterio xilematico *Xylella fastidiosa* è stato finora riscontrato, con l'eccezione di una malattia del pero a Taiwan, solamente nel continente americano. Il batterio costituisce una minaccia potenziale per altri paesi? Le condizioni climatiche sembrano giocare un ruolo importante nella distribuzione geografica della malattia causata da *X. fastidiosa*, ma vi sono anche differenze a livello di ceppo e di pianta ospite. Nell'ambito di una determinata re-

gione climatica possono essere necessari inverni miti per assicurare la persistenza a lungo termine di *X. fastidiosa*, tuttavia i possibili effetti limitanti delle temperature estive non sono stati ancora analizzati. I vettori potenziali sono diffusi e frequenti in gran parte delle regioni del globo non ancora interessate da *X. fastidiosa*. Un elemento importante, capace di mantenere le infezioni endemiche del batterio in regioni temperate, potrebbe essere rappresentato dalla presenza di vettori potenziali svernanti come adulti. Malattie, non riscontrate in precedenza su agrumi e su oleandro e causate da *X. fastidiosa*, si sono diffuse rapidamente, suggerendo come, al di fuori del continente americano, debbano essere mantenute misure fitosanitarie rigide al fine di impedire l'introduzione di *X. fastidiosa*. Metodi di determinazione molecolare, come la PCR nei confronti di un'ampia gamma di ceppi di *X. fastidiosa*, sono preferibili a quelli serologici in quanto più sensibili e affidabili.

Key words: epidemiology, vectors, *Xylella fastidiosa*.

INTRODUCTION

The xylem-limited bacterium *Xylella fastidiosa* (Wells *et al.*, 1987) causes diseases in many plant species in the Americas, mostly in woody perennials such as grape, peach, almond, citrus and oak (Hopkins, 1989; Purcell and Hopkins, 1996). Outside of North or South America, the bacterium has been reported to have been isolated only from Taiwan, where it causes leaf scald in pear (Leu and Su, 1993). Table 1 reviews the plant diseases proven or suspected to be caused by *X. fastidiosa*. Grape or alfalfa strains of the bacterium have a very wide plant host range (Freitag, 1951); essentially 3 of every 4 species were classified as symptomless hosts, based on the vector transmission of the causal agent of Pierce's disease. With such a large vector and host range, the continued restriction of these diseases to the Americas is puzzling (Purcell, 1989; Purcell and Hopkins, 1996). Does *Xylella fastidiosa* pose a threat to Europe, Asia, Africa, Australia, and other continents or islands where now it is unknown?

vectors are not a limiting factor anywhere in Europe

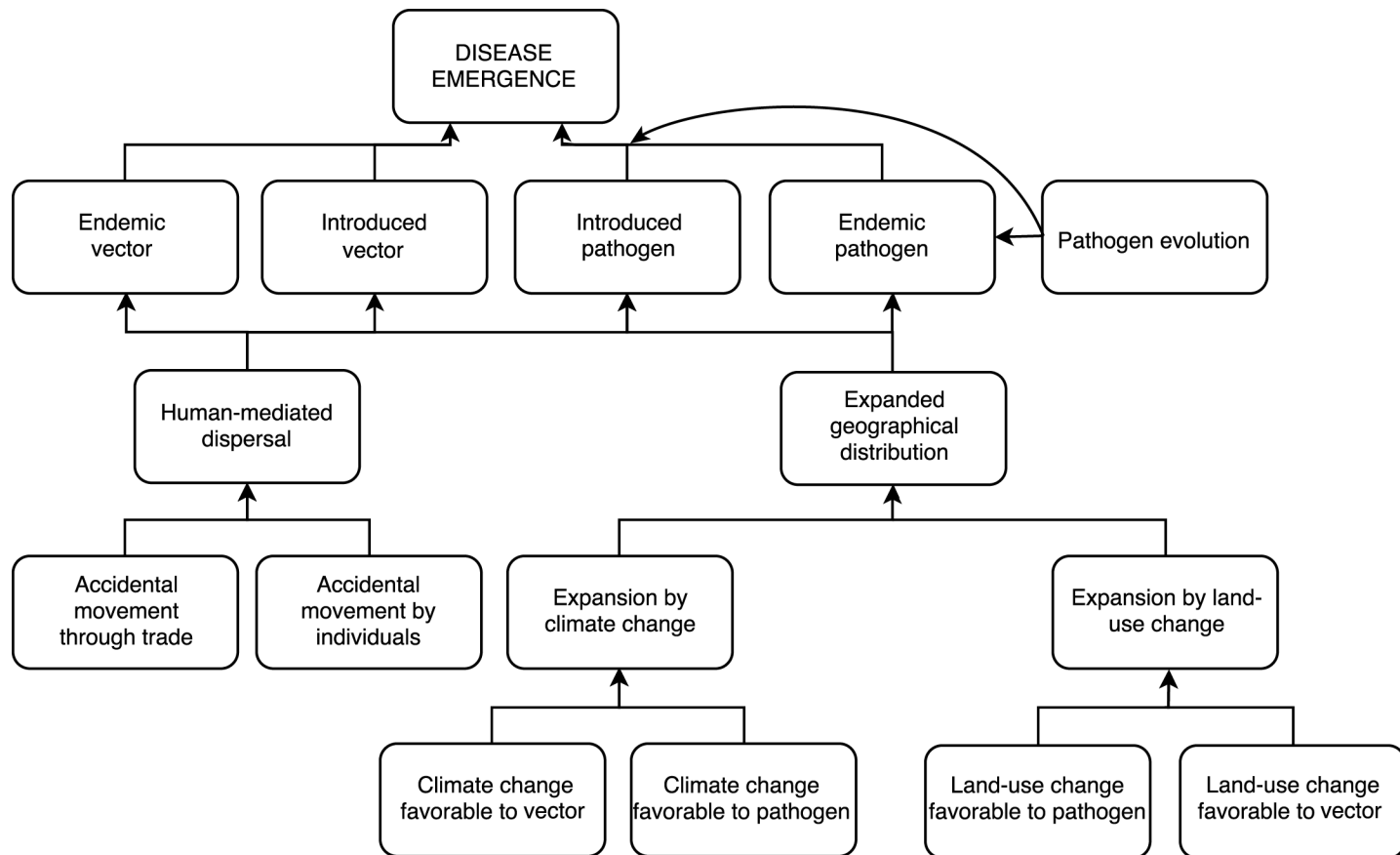
plants with lower or non-systemic populations. However the symptomless condition of most hosts is a threat because the lack of symptoms may contribute to illegal importation of seemingly healthy plants. In addition the lower populations of *X. fastidiosa* in symptomless plants may make detection of the bacterium more difficult.

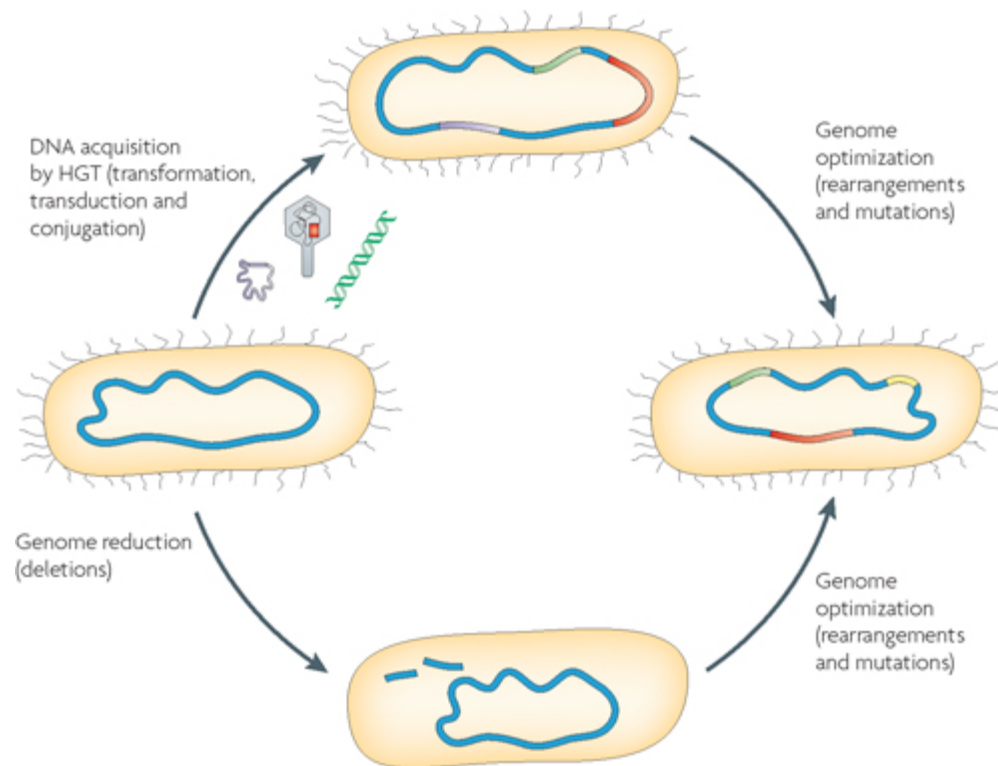
the fact one cannot 'see' disease or detect the pathogen does not mean it is not present

introductions should be prevented, efforts to limit dispersal should be implemented

These indicate that the most logical emphasis of phytosanitary measures to prevent the introduction of *X. fastidiosa* to new regions now free of this pathogen should be to monitor the movements of live plants from regions where *X. fastidiosa* occurs.

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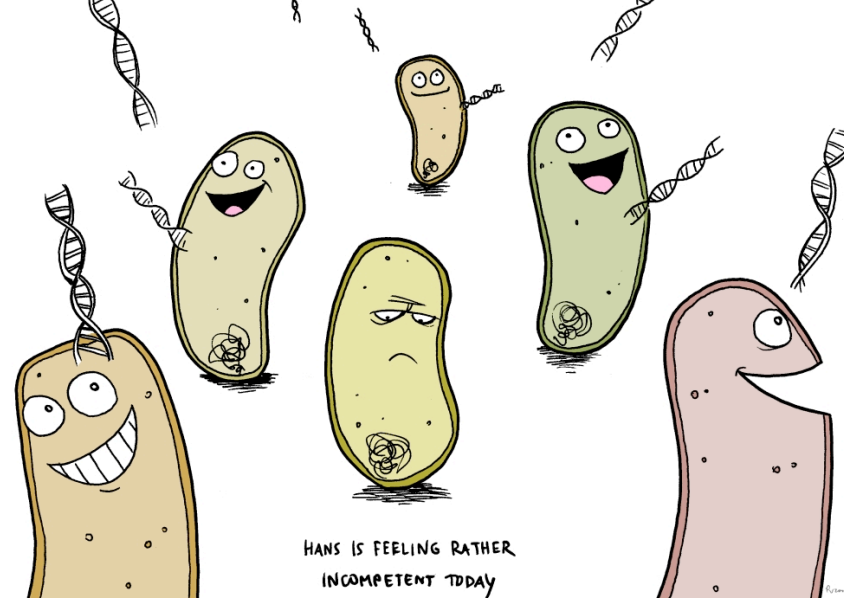


Recombination more common than mutations -using 'field' MLST data-

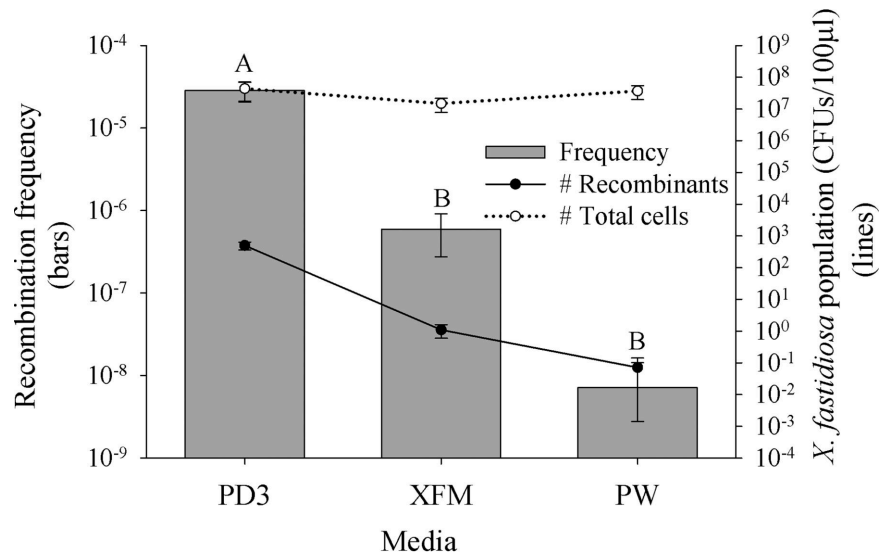
Relative rate of recombination to mutation 1.66

Mean divergence of imported DNA 1.5%

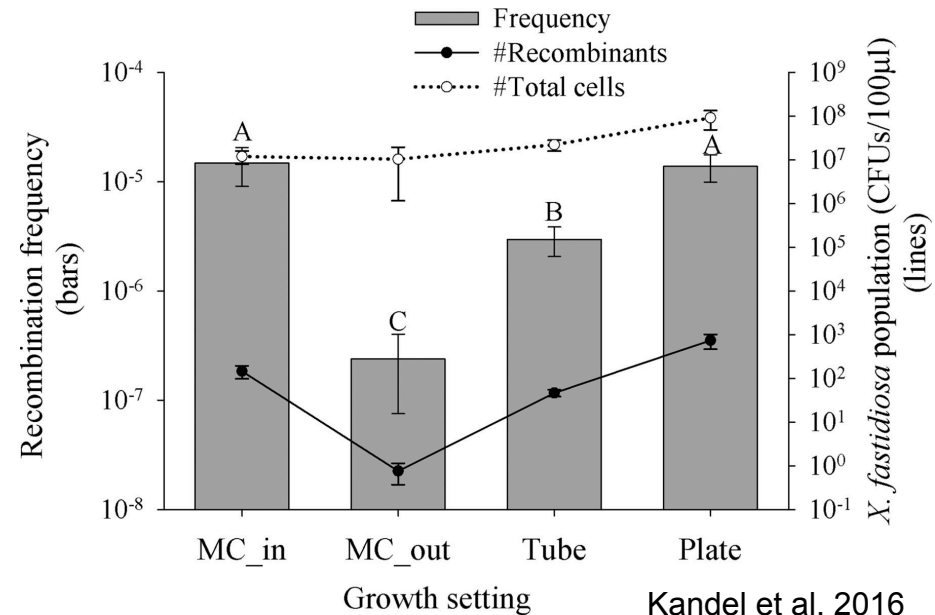
Data: all MLST data available in November 2017.
Analysis done with ClonalFrameML using default settings.



High rates of recombination in vitro



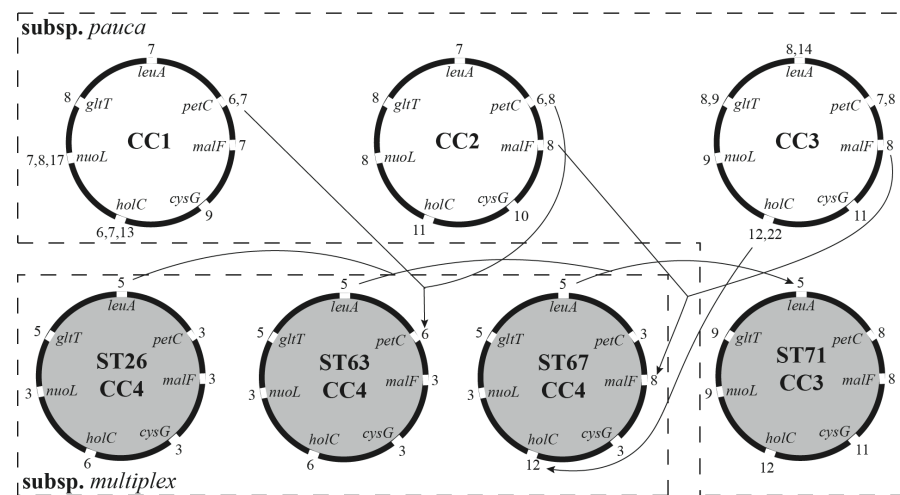
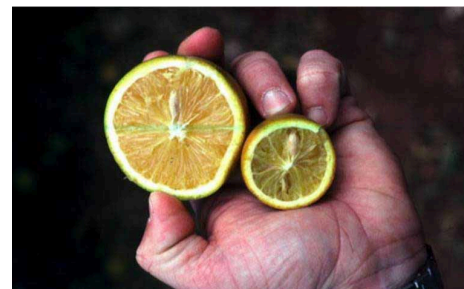
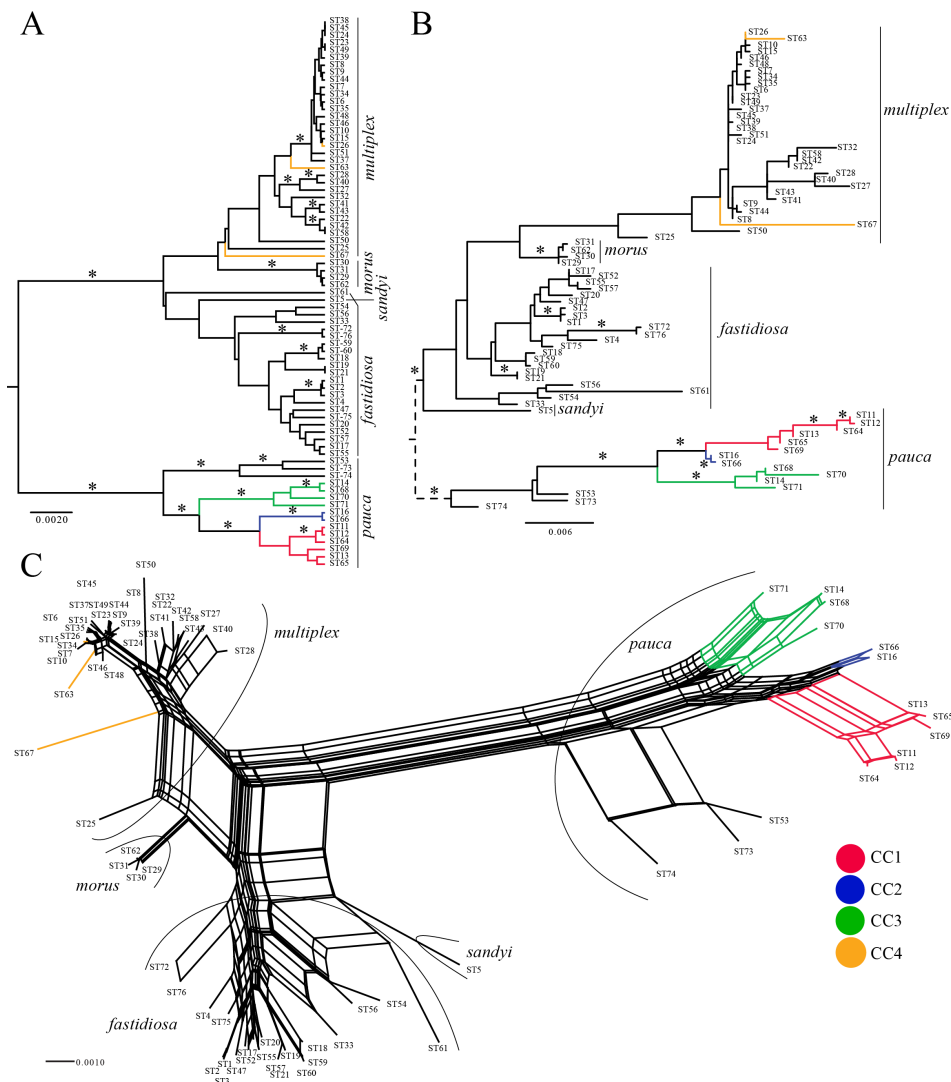
High rates of recombination with co-cultures



Kandel et al. 2016

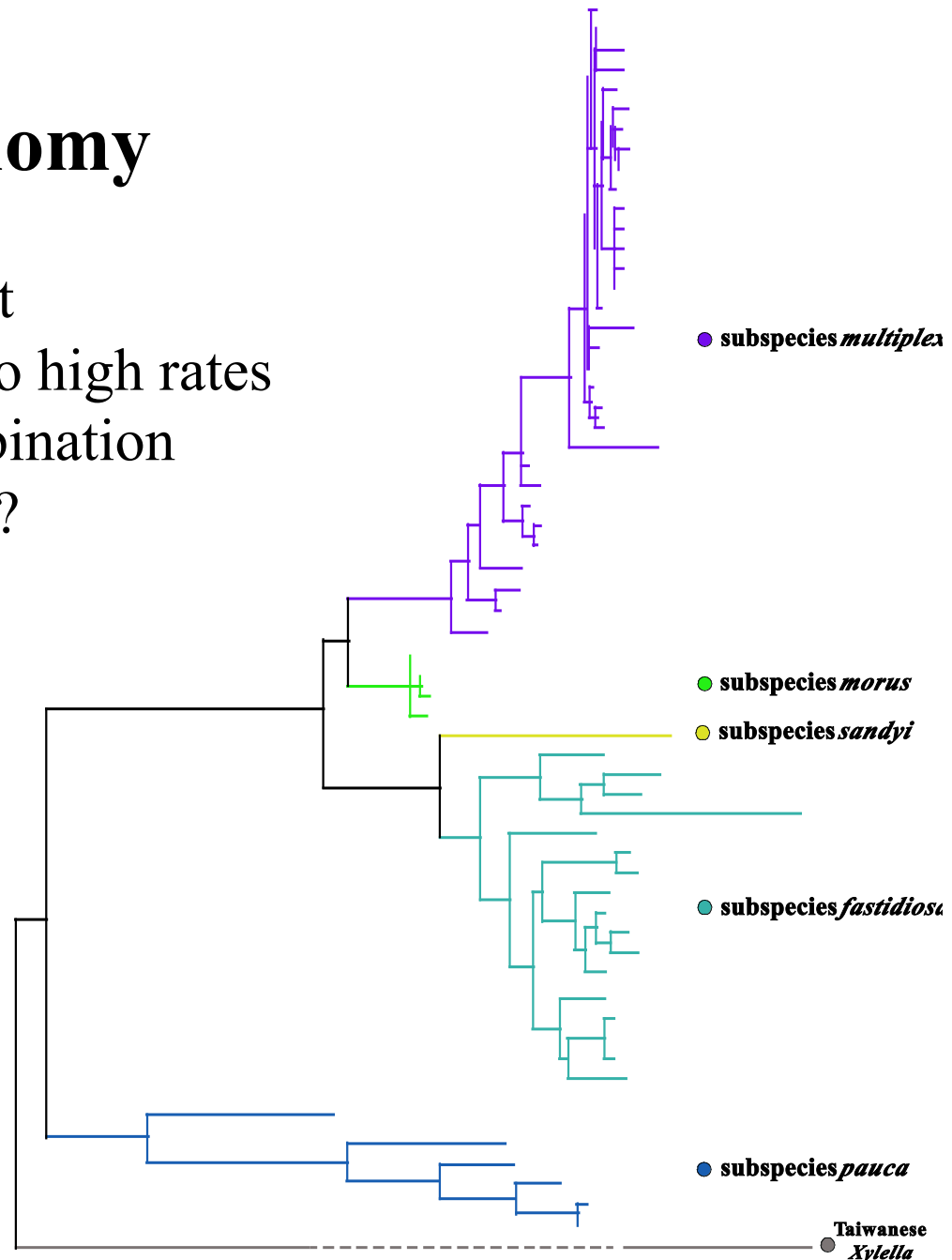
Does recombination matter?

-a detection/inference example-



X. fastidiosa taxonomy

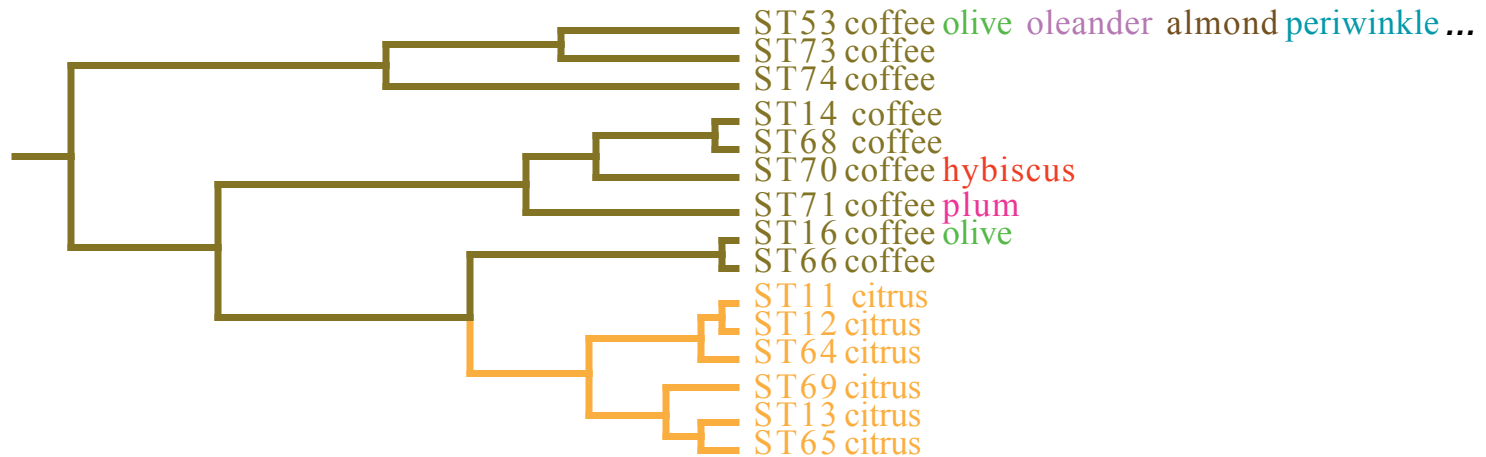
- based on MLST, robust
- MLST important due to high rates of homologous recombination
- but what does it tell us?



What does subspecies mean biologically?

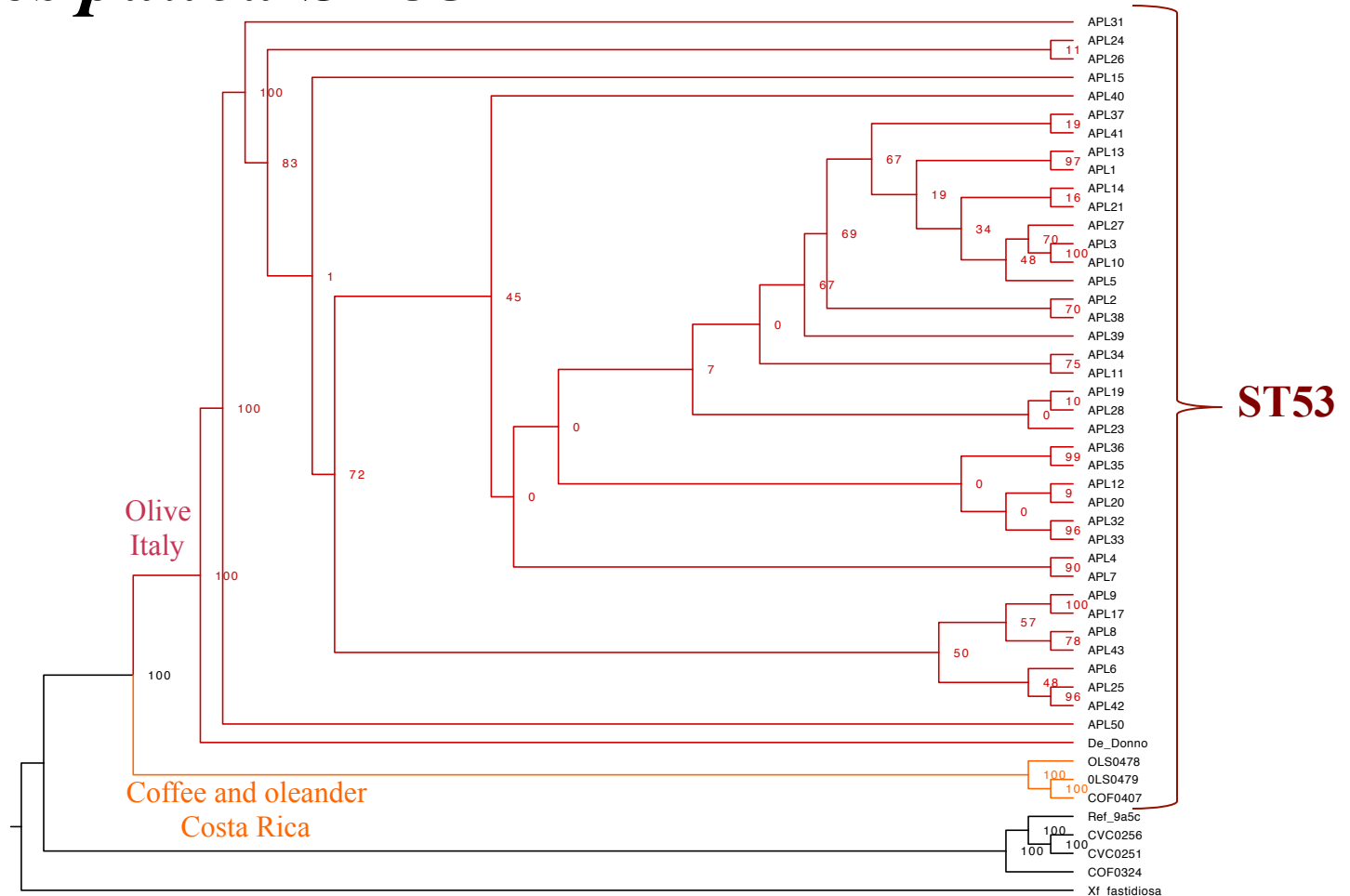
-an example with *pauca*-

pauca - based on current data...



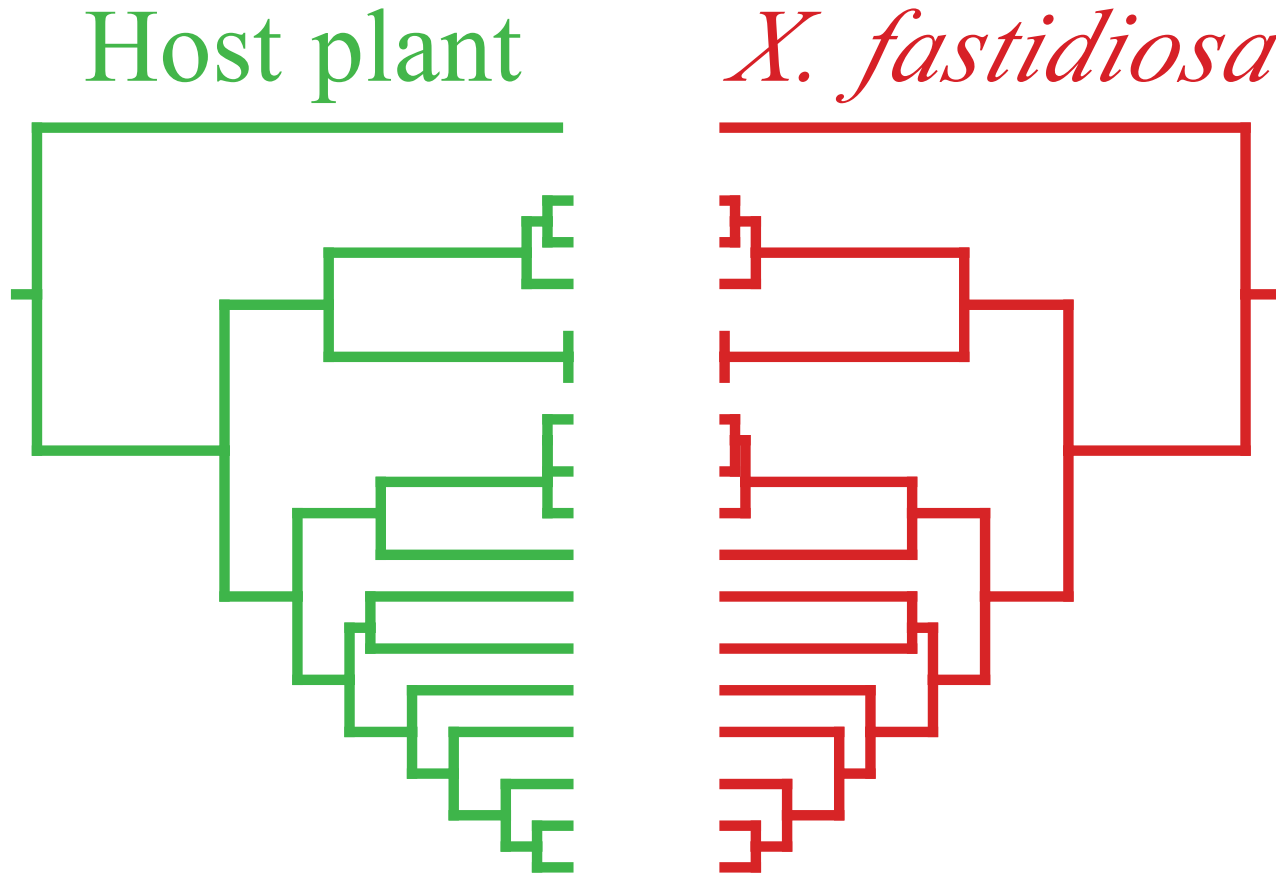
What does ST mean?

- an example with subspecies *pauca* ST53-

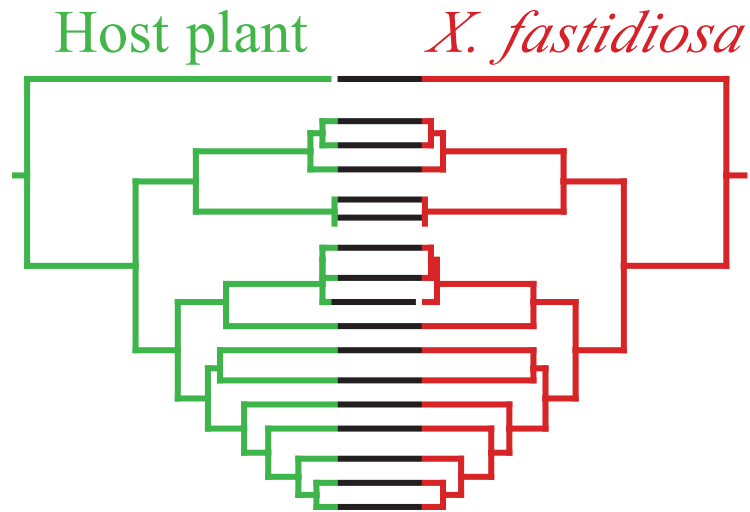


Sicard et al.

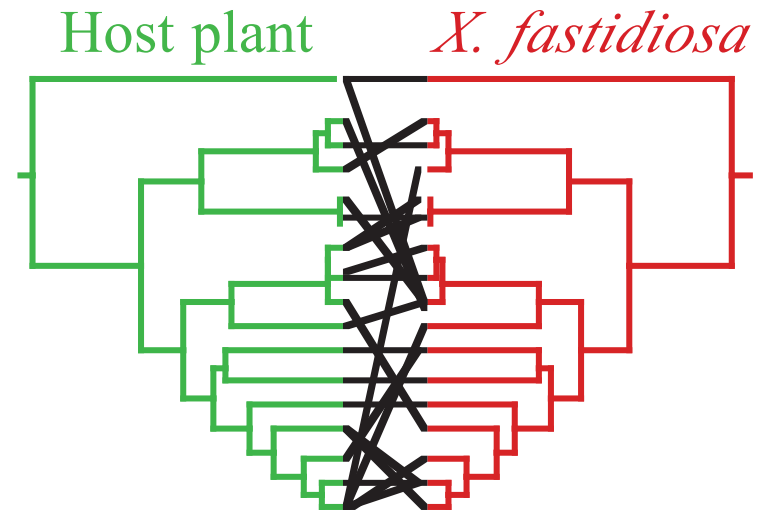
Host jump predictions



tree congruence, host jump prediction feasible

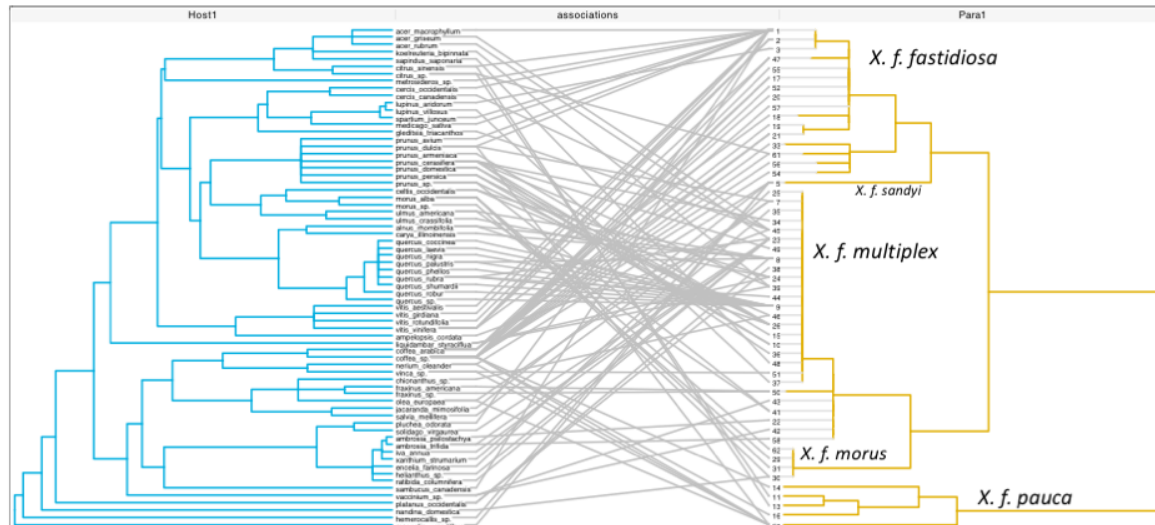


no tree congruence, host jump prediction not feasible



Host plant

X. fastidiosa



Test is statistically significant
-i.e. no congruence of trees-

A historical perspective as Europe embarks on *X. fastidiosa* research

U.S. DEPARTMENT OF AGRICULTURE.

DIVISION OF VEGETABLE PATHOLOGY.

BULLETIN No. 2.

THE

CALIFORNIA VINE DISEASE.



A PRELIMINARY REPORT OF INVESTIGATIONS

BY

NEWTON B. PIERCE,
SPECIAL AGENT.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE,
1892.



Newton B. Pierce

Bul. 2, Div. Veg. Path., U. S. Department of Agriculture.

PLATE XXI.



M.F. Brading

DISEASED JACQUES LEAVES FROM CALIFORNIA.

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PLATE XXII.



M.F. Brading

DISEASED FLAMING TOKAY LEAVES FROM CALIFORNIA.

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PLATE XXIII.



R. Cowing

DISEASED LEAVES OF WILD VINE FROM CALIFORNIA.

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PLATE XXIV.



M.F. Brading

DISEASED MUSCAT OF ALEXANDRIA LEAVES FROM CALIFORNIA.

Bul. 2, Div. Veg. Path., U. S. Department of Agriculture.

PLATE XXV.



M.F. Brading

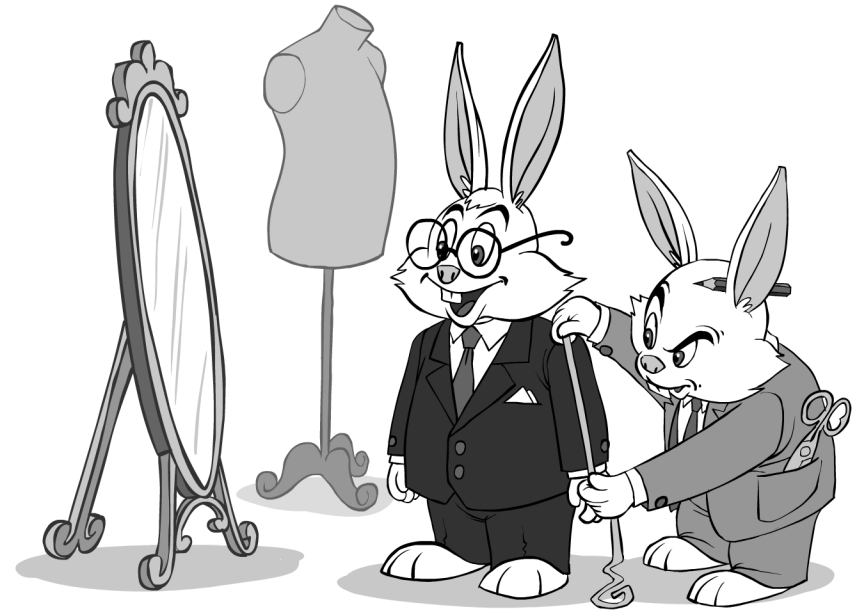
DISEASED CANES FROM MUSCAT OF ALEXANDRIA VINES, CALIFORNIA.

X. fastidiosa diseases are complex, multi-factorial,
and management requires holistic approaches.

There is no ‘one-size fits all’ solution for *X. fastidiosa*
diseases, or any solution available that does not require
vector control and inoculum removal.



ONE SIZE
FITS ALL



MADE TO
MEASURE