Emergent diseases threatening California ecosystems

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Disease: injurious physiological activity caused by the <u>continuous</u> irritation by a primary causal factor and expressed in characteristic pathological conditions called <u>symptoms</u>

Disease: any disturbance of a plant that interferes with its normal, structure, function or economic value

Primary causal factor = <u>agent</u>

ABIOTIC

BIOTIC (incl. VIRUSES)

Multiple factors, often biotic + abiotic = <u>syndrome</u>

Note that determining causality is much more complex than simple association. In Plant Pathology we use "Koch's postulate" to prove causality.



ABIOTIC DISEASES

Maple scorch





Premature needle yellowing and loss on ponderosa pine

Ozone mottle





Loss of vigor in ponderosa pine exposed to ozone





Smog symptoms on ponderosa pine in southern California

Advanced smog symptoms on ponderosa pine



Acute SO₂ injury



Ash

Persimmon

BIOTIC DISEASES caused by:

Parasitic plants Bacteria Fungi Oomycetes Viruses

Nematodes

Tree of Life, from Patterson & Sogin, 1992



CHROMISTA now referred to as STRAMINIPILA



PARASITIC PLANTS:

True Mistletoe Dwarf Mistletoe Dodder Orchids Ericaceous plants (Indian pipe)



Phorodenron villosum on oak

Leafy or true mistletoe





Sticky seed adhere to birds, they also can be ingested and spread in feces





Phoradendron pauciflorum on white fir





Phorodendron libocedri on incence cedar







Figure 5.1 – World distribution of *Arceuthobium*. The distribution is primarily in the Northern Hemisphere, crossing the Equator only in Kenya.

Dwarf Mistletoe



Large number of species because of high host specificity



Arceuthobium campylopodum on Jeffrey pine





Arceuthobium douglasii on Douglas-fir

Male flowers



Mature female shoots - seeds



Explosive seed dispersal of Arceuthobium





Management issues associated with dwarf mistletoe

- Multi layered forest increases infection
- Group selection also
- You can have up to 30% reduction in growth
- Larger clearcuts is the only way to mitigate problem

Parasitic orchid and ericaceous plants



Coralroot orchids



BACTERIA

Prokaryotes Unicellular Variously shaped Do not produce spores Reproduce by binary fission



Richiami sulle entità biotiche



Genetic elements

Chromosome (single one, circular)

Plasmids

Primary mechanisms of variation

Mutations

Loss/acquisition of plasmids and transposons

Recombination through: **transformation** (incorporation in Chromosome of plasmid DNA; **conjugation** (incorporation of DNA from another bacterium); **transduction** (incorporation through bacterial viruses called bacteriophages)



Bacterial Leaf Scorch Xylella fastidiosa




Hosts

Q. shumardii

Q. falcata

Q. bicolor

Q. laevis

Q. nigra

Q. alba

Q. phellos

Scientific Scientific Common Common Quercus sp. Acer sp. Q. velutina Black oak **Red maple** A. Rubrum O. incana Bluejack oak A. negundo Boxelder Bur oak Q. macrocarpa A. saccharum Sugar maple Q. prinus Chestnut oak Flowering dogwood Q. laurifolia Laurel oak C. florida Q. virginiana Live oak C. occidentalis Hackberry Q. rubra Sweet gum L. stryraciflua Q. palustris Pin oak Morus alba Whitemulberry Q. stellata Post oak Platanus sp. Scarlet oak Q. coccinea Shingle oak Q. imbricaria P. occidentalis American sycamore

P. x acerifoliaLondon planeUlmus americanaAmerican elm

Northern red oak Shumard oak Southern red oak Swamp white oak Turkey oak Water oak White oak Willow oak

TABLE 1 | Partial list of the main plant hosts of Xilala fasticlosa and their X. fasticlosa subspecies.

Host scientific name	Type of infection	EPPOCode	Subspecies
Acaola saligna	Incidental	ACASA	режа
Acar rubrum	incidental	ACRIRE	multiplax
Carya Alhoihansis	Minor	CYAL	multiplax
Citrolontuneila microcarpa	Minor	CJEMI	nd
Citronoitus	Minor	1CJCB	nd
Citrus	Minor	1CIDG	pauca, Australia
Citrus sinonsis	Major	CIDSI	pauca
Dofficial sp.	Major	COFSS	pauca (BRM)
Doffice sp.	Major	COFSS	tasticiosa (C.Rica)
Cyperaceae	WedWeed	1CYPF	nd
Fortunalla	Minor	1FOLG	nd
. kpuklambar styracilkus	Incidental	LIQST	multiplax
Wedkago sativa	Minor	MEDSA	Restkilkisa
Morus alba	incidental	MORAL	morus, (former multiplex, sandyl)
Morus rubra	Incidental	MORRU	teshtilosa
Vertum olaandar	Major	NEROL	sandyl
Dilat auropapa	Major	OLVEU	pauca (ITA, ARG, BRA)
Dias auropasa	Major	OLVEU	multiplax (USA, FRA)
Porsee americana	Incidental	PEBAM	nd
Platanus ocoldentails	Minor	PLTOC	multiplax
Posocala	WedWood	1GRAF	nd
Polygala myrtifolia	Major	POGMY	pauca (TTA)
Polygala myntifolia	Major	POGMY	multiplax FRA)
Poncinus infloitata	Minor	PMITR	nd
Prunus angustilloite	Incidental	PENAN	nd
Prunus armoníaca	Minor	PRIMAR	multiplan
Prunus avlum	Minor	PERNAW	pasucia (TEA)
Prunus avlum	Minor	PERMAN	Ass/Allosa (USA)
Prunus cerasillera	incidental	PENCE	multplax
Prunus domestica	Minor	PFINDO	multiplax
Prunus dulais	Minor	PRNDU	multiplax-tasticilosa (USA)
Phunus dulais	Minor	PENDU	pauca (TTA)
Prunus parsida	Major	PENPS	multiplax, fasticilosa
Prunus saliciha	Minor	PRNSC	multiplan
Duerous pakustris	Minor	QUEPA	multiplax
Duerous rubra	Minor	QUERU	multiplax
Sorghum hallaponso	WildWood	SORHA	nd
Sparthum Junceum	incidental	SPUJU	Resticiosa (USA)
Spartium Juncoum	Incidental	SPUJU	multiplax (FRA), pauca (ITA)
Ulmus amerikana	Minor	ULMAM	multiplax
Vaccinium corymbosum	Minor	VACOD	multiplay
Vaccinium virgatum	Minor	VACVIS	nd
Vinca minor	Incidental	VINM	papos (TTA)
//05	Minor	IVITG	fastkilosa
Vite labrusca	Minor	VITLA	fasticilosa
Vite whitera	Major	VIIV	Restkillosa
Westringta ituticosa	Incidental	WESRO	pasuca (TTA)
accepte plante	VARIa Manual	24000	multiplay

Source: EPPO Global Database (https://gd.appo.ini/faxon/MLEFA/hosts), and EFSA Journal database (EFSA, 2016). Major Inflations are indicated in boid.

Symptoms

- First appear in late summer / early fall
- Leaf scorching
- Limb death









Vector

- Not determined for each tree species yet
- Most likely Graphocephala, Oncometopia and Homalodisca species.



Graphocephala atropunctata

Oncometopia orbona Homalodisca vitripennis

Distribution Maps of Plant Diseases

Compiled by CABI in association with EPPO

Map No. 262

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Xylella fastidiosa Wells et al. Bacteria

Hosts: Grapevine (Vitis vinifera and others), peach (Prunus persica), Citrus, almond (Prunus dulcis), lucerne (Medicago sativa), some wild trees (incl. Acer rubrum, Platanus occidentalis, Quercus rubra, Ulmus americana), other wild plants and weeds.



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Phytoplasmas

Prokaryotes lacking a cell wall (MLOs - Mollicutes)

Usually vascular pathogens

Generally vectored by piercing insects

VIRUSES and VIROIDS

Submicroscopic parricles always intracellular when in the host, infectious and pathogenic

They comprise

Nucleic Acids (RNA or DNA) and a capsid protein

Viroids instead are simply constituted by a single RNA molecule, they do not code for or possess proteins

<u>Nucleic acid</u>: ssRNA, dsRNA, ssDNA, dsDNA <u>Protein capsid</u>: protects virus during transport



VIRAL REPLICATION

The genome of the virus codes for:

- 1- capsid protein;
- 2- polymerase;
- 3- protein for intracellular movement;
- 4- proteins involved in transmission and relationship with vectors

How does a virus code for all of the necessary proteins in such a small structure?

- 1- One virus may require multiple particles to successfully infect a host. Each particle codes for different genes
- 2- Same DNA or RNA strand, but coding is staggered, i.e. transcription starts at differnt points, thus one strand can code for multiple genes



Some examples of bacteria, phytoplasmas and viruses present in forests

- Bacterial leaf scorch: Xylella fastidiosa
- Crown Gall: Agrobacterium tumefaciens
- Ash and elm yellows: Ca. *Phytoplasma* alni and *P. ulmi*
- Bacterial wetwood (Enterobacter, Klebsiella, Erwinia and Pseudomonas)
- Poplar mosaic virus, poplar potyvirus
- Cherry leaf roll virus (elms, dogwood)
- Tobacco Mosaic Virus (tanoak, oaks alders)







A. tumefaciens

Elm yellows

Ash yellows





Bacterial wetwood

Cherry Leaf Roll virus







NEMATODES

*

Fungi

 Eukaryotic organisms, heterotrophs, characterized by chitin and B-glucans in the cell wall, feeding through absorption, reproducing by spores and producing a vegetative structure made up of tubular structures, branched, irregular, and indefinite in growth (modified from B. Kendric 1992)

Fungal hyphae and mycelium



There are no differentiated structures in fungi, but hyphae can generate...



mycelia

stroma

rhizomorphs

There are no differentiated structures in fungi, but hyphae can generate...

Asco- or basidio-spores



Sexually generated spores (meiospores) Conidia



Asexually or clonally generated spores (mitospores)



Infection structures





FRUITING BODIES



Ascomycetes (predominance of n in life cycle)



Ascus

Sexual spores (ascospores) are generated within "sacks" called asci











*

pseudothecium









Basidiomycetes (Div. Basidiomycota) n+n or rarely 2n is predominant in life cycle



Sexual spores, basidiospores, are carried naked on surface of "clubs" called basidia



Richiami sulle entità biotiche

Basidiomycota



















anamorphic fungi no sexual stage



picnidio



Fitness of Fungi as Plant Pathogens

1- HYPHAE CAN DIFFERENTIATE INTO MANY SRUCTURES

2-HYPHAE CAN HAVE INDEFINITE GROWTH (LIMITED BY OTHER FUNGI, BY AVAILABILITY OF RESOURCES, AND BY ENVIRONMENTO

3-SEXUALLY REPRODUCING FUNGI CAN ADAPT FAST

4-HOWEVER THANKS TO CLONAL REPRODUCTION THROUGH CONIDIA, AN AGGRESSIVE STRAIN CAN BE REPLICATED IN TRILLIONS OF COPIES. IF SUPER SUCCESSFUL MAYBE SEX WILL BE LOST

5- SOME SPORES CAN BE SURVIVAL STRUCTURES WHEN CONDITIONS ARE UNFAVORABLE

SCLEROTIA WITH MELANIZED PUTER CELL WALL



Oomycetes (Div. Oomycota) Kingdom: straminopila (prev. Chromista)







Important group of forest pathogens, includes the genera

Pithyum and Phytophthora

Although apparently similar to the fungi, oomycetes are an example of convergence, basically the same morphology was selected because of their lifestyle similar to that of the fungi. they all have a water dependent phase, they have cellulose in the cell wall, and are mostly 2n

Types of disease: biotic vs. abiotic or..

- Infectious: a disease that is caused by a pathogen which can spread from a diseased to a healthy host.
- Non-infectious: a disease that is caused by an environmental or host factor. It is not spread between a diseased and healthy individual.

Types of diseases

- Foliar diseases and blights
- Stem diseases: cankers, wilts
- Trunk rots
- Root diseases
- Seedling diseases
- Fruit and flower disease