Eutypa lata (Eutypa dieback)

- 80 woody host species (Carter 1991)

- Different inoculum sources for grape infection (Trouillas & Gubler 2010)

Development of perithecial stromata: mean annual rainfall > 350 mm (Carter 1988)
Life cycle of *Eutypa lata*

**Ascospores:**
- Dissemination: each rainfall > 0.5 - 1 mm (Moller & Carter 1965)
- Dissemination by wind
- Liberation: within 2 hr or 3 hr of the onset of rainfall throughout the whole year (Pearson 1980, Trese *et al.* 1980)
- Stopped 24 hr or even 36 hr after the end of the rainfall (Pearson 1980, Dubos 1987).
- Penetration into the plant by pruning wounds during winter dormancy
- Migration in the subjacent tissues to the pruning wound (until at least 2 cm under the influence of water (Larignon 2006))
Life cycle of *Eutypa lata*

Susceptibility of pruning wounds affected by date of pruning


+ high when vines pruned early in dormant season
+ low when vines pruned later in the dormant season

- Other ways of penetration: Wounds due to desuckering and removal of buds (Lecomte & Bailey 2011)
- No detection in canes
- No propagation by material propagation
Life cycle of *Eutypa lata*

**Inoculum sources**

Pycnidia (role ?) (*Libertella blepharis*)

Their function?

No germination *in vitro*

**Genetic variability:** propagation in its sexual form (Peros *et al.* 1997).
Esca

Phaeomoniella chlamydospora

Phaeoacremonium aleophilum

Fomitiporia mediterranea
Sexual stage: unknown


Genetic variability:
No important genetic biodiversity suggesting its clonal propagation (Mostert *et al.*, 2006; Smetham *et al.*, 2010; Comont *et al.*, 2010; Péros *et al.*, 2000)

Airborne fungus during a period of life cycle
Life cycle of *Phaeomoniella chlamydospora*

**Sources of inoculum**


- **Conidia**

**Pruning wounds**

- In vessels

**Production of free conidiophores** inside deep cracks and crevices of the wood which provide a protected humid environment favorable for sporulation (Edwards *et al.* 2001).

- **Pycniospores**

Its presence at the surface of different organs (tendrils, spurs, cordons, trunks, berry surfaces) suggesting its epiphytic character (Eskalen *et al.* 2003).
Life cycle of *Phaeomoniella chlamydospora*
Dissemination, ways of penetration

**Spore dispersion** (Larignon & Dubos 2000, Eskalen and Gubler 2001):
- All the year
- During rainfall

**Penetration** by pruning wounds during winter (Larignon & Dubos 2000; Eskalen & Gubler 2001)

**Susceptibility of pruning wounds**
France, Italy: for a long time for early pruning (Larignon & Dubos 2000, Serra *et al.* 2008).
California: until 4 months (Eskalen *et al.* 2007).
Life cycle of *Phaeomoniella chlamydospora*

- **Dissemination by arthropodes**
  (South Africa, Moyo 2013)

  Portuguese millipedes
  (*Ommatoiulus moreleti*)

  Moyo 2013

- Cocktail ants (*Crematogaster pyrengueyi*)

  Moyo 2013
Life cycle of *Phaeomoniella chlamydospora*

**Considered as a soilborne pathogen** due to its capacity to produce chlamydospore like structures in culture (Crous & Gams 2000).

**Detected by molecular methods in vineyard soils** in New-Zealand (Whiteman *et al.* 2002) and in South Africa (Damn & Fourié, Retief *et al.* 2006).

**Isolated from roots of vine cuttings** sampled 6 months after planting in the nurseries but these authors suggest they are not primary soilborne pathogens (Halleen *et al.* 2003).

**In the vineyard from old vines,** no study has been made to detect its presence in the roots.
Life cycle of *Phaeomoniella chlamydospora*

**Propagation by vegetative material**

+ Isolation from scion canes, rootstock canes, nursery cuttings (*surface and wood tissues*) (Larignon & Dubos, 2000; Fourie & Halleen 2002; Halleen et al., 2003; Whiteman *et al.* 2007, …)

+ In nurseries, *Pch* DNA detected by PCR in the hydration tanks, grafting tools, substrates used for the callusing (Ridgway *et al.* 2002; Retief *et al.* 2006; Edwards *et al.* 2007; Aroca *et al.* 2009, …).

**Two steps for contamination:** callusing, nursery field (Larignon *et al.* 2006)
Togninia minima (Esca disease)

- Hosts: *Salix* sp., *Prunus pennsylvanica*, *Actinidia sinensis*, *Pyrus* sp., *Malus* sp, *Olea europaea*


Detection of genetically identical isolates within and among subpopulations: asexual reproductive component no excluded (Gramaje *et al.* 2013).
Life cycle of *Phaeoacremonium aleophilum*

**Dissemination:**
France: vegetative period (Larignon & Dubos 2000), sometimes in late winter

**Contamination of pruning wounds:**
France: after the bleeding, t>10°C, rain (Larignon 2012), sometimes in late winter (mild winter)

**Type of spores:** unknown in France

**California:**
**Type of spores:** ascospores
**Dissemination:** during winter and spring (Feb until July) (Eskalen & Gubler 2001), even in absence of rain (Rooney-Latham *et al.* 2005)

**Propagation by arthropods** (Moyo 2013) (South-Africa)
Life cycle of *Phaeoacremonium aleophilum*

**Susceptibility of pruning wounds**

**California:** until 4 months even through infection incidence decreased after the second month (Eskalen *et al.* 2007) (in artificial condition)

**France:** at least 8 weeks in natural conditions (Larignon 2012)

**Other ways of penetration:** possibility to contaminate the wounds due to practices used in vegetative growth period (shown in artificial conditions). In natural conditions???
Life cycle of *Phaeoacremonium aleophilum*

- Isolated from soil (Gubler *et al.* 2004)
- Reisolated from plants grown in artificially inoculated soils which were infested by drenching them with spore suspensions.
- Its ability to infect grapevines through the root system in naturally infested soils (Agusti-Brisach *et al.* 2013)
- Isolated from roots of vine cuttings sampled 2 months after planting in the nurseries but these authors suggest they are not primary soilborne pathogens (Halleen *et al.* 2003)
- But the importance of this way of penetration in the vineyard is not known. In the literature, its presence in the root from vine has been not shown.
Life cycle of *Phaeoacremonium aleophilum*

Propagation by vegetative material

Isolation from scion canes, rootstock canes, nursery cuttings (surface and wood tissues) (Larignon & Dubos 2000; Fourie & Halleen 2002; Halleen *et al.* 2003; Whiteman *et al.* 2007,…)

In nurseries, *Pch* DNA detected by PCR in the hydration tanks, grafting tools, substrates used for the callusing (Aroca *et al.* 2010)

**One step for contamination:** nursery field (Larignon *et al.* 2006)
Botryosphaeriaceae
(Botryosphaeria dieback)

- Distribution: probably all the european countries

D. seriata

- Hosts: apparently plurivorous (Slippers & Wingfield 2007)

N. parvum

Shoot dieback

Canker, black dots, brown stripe (under bark)
Life cycle of *Botryosphaeriaceae*

**Sources of inoculum**

- **Pycnidia**
- **Trunk**
- **Pruning wounds**
- **Bleached canes**

Predominantly asexual in the field (Phillips 2002).

Only rare reports of sexual reproduction (van Niekerk *et al.* 2006)

Present also at the surface of different organs like canes (Larignon *et al.* 2009)
Life cycle of *Botryosphaeriaceae*

**Dissemination**

- **Spore dispersion:**
  During rainfall (van Niekerk *et al.* 2010, Urbez-Torres *et al.* 2010), Overhead sprinkler irrigations (Urbez-Torres *et al.* 2010)

- **Seasonal spore dispersion patterns:** variable
  - California: winter months (Urbez-Torres *et al.* 2010)
  - South-Africa: winter months during rainy period (van Niekerk *et al.* 2010), vegetative period no studied
  - France: all the year, but more important during vegetative period (Larignon & Dubos 2001, Kuntzmann *et al.* 2009) (Mean temperature > 9-10°C).
Life cycle of *Botryosphaeriaceae*

Ways of penetration

Probably pruning wounds (Urbez-Torres et al. 2009, Bester et al. 2006, …)

Example of *N. parvum* in California

Susceptibility of pruning wounds: during dormant season

Wound susceptibility (Urbez-Torres et al. 2009):

- high when vines pruned in dormant season
- low when vines pruned in early March
- greatest when inoculations were done on fresh wounds
Life cycle of *Botryosphaeriaceae*

Ways of penetration

Example of *D. seriata* in France (Larignon 2012) and in Italy (Serra *et al.* 2008)

Susceptibility of pruning wounds: after the bleeding (mean temperature > 10°C).

Wound susceptibility:

+ at least 8 weeks (France), until 4 months (Italy)

+ greatest when inoculations were done in March than in winter

Contamination: Yes  

Infection: ???
Life cycle of *Botryosphaeriaceae*

Ways of penetration

Wounds due to the breakage of the shoot by strong winds (*D. seriata*)

Removal of lateral shoots (*N. luteum*) (Molot *et al.* 2006)

Buds (*Diplodia mutila*)
Life cycle of *Botryosphaeriaceae*

**Other ways of penetration**

Diplodia seriata (G/H stage)

Grey necrosis

Diplodia seriata (stage between flowering and véraison)

Spagnolo, Fontaine, Larignon (in preparation)

**Susceptibility of the plant to infection: flowering until véraison**
Life cycle of *Botryosphaeriaceae*

Propagation by vegetative material


In nurseries, *Botryosphaeria* DNA detected in rain-water run-off from the vine canopy (Billones-Baaijens *et al.* 2013)  
*Neofusicoccum parvum* DNA detected by PCR from wash and hydration tanks, on grafting tools and in callusing media.

Two steps for contamination: callusing, nursery field  (Larignon 2012)
Life cycle of *Cylindrocarpon* spp.

Two main species: *C. liriodendri* & *C. macrodidymum*

Hosts: various plant families.

Isolated from roots, wood of rootstock, mainly at the base and from the graft union (Rego *et al.* 2000, Halleen *et al.* 2004, Aroca *et al.* 2006, …)

**Main inoculum sources:** vineyard and nursery soils (Agusti-Brisach *et al.* 2013)
Conclusions

Questions remain about their life cycle.

Advanced knowledge different according to the fungus

To control them, it is essential to know:

+ the sources of inoculum in order to limit them in the vineyard,

+ the periods of spore dissemination in phase with the plant susceptibility against these fungi to know the periods of intervention,

+ the ways of penetration to know the intervention periods to identify the targets,

+ ...