Mycoflora of Stone Fruit Mummies in California Orchards

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ABSTRACT

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Stone fruit mummies infected by *Monilinia fructicola* were periodically collected in winter from trees and from the ground in eight orchards in 1995-96 and from five orchards in 1996-97. Mycoflora were determined by spreading mummy washings and plating inner tissues onto petri dishes containing acidified potato dextrose agar, then counting colonies of individual fungi after incubation at 23°C for 4 days. Twenty genera, representing 29 fungal species, were isolated from both mummy washings and inner tissues. *Aspergillus japonicus*, *A. terreus*, and species of *Harknesia*, *Paecilomyces*, and *Trichoderma* are the first recorded from species of *Prunus* in the United States, and *Aureobasidium pullulans* and *Epicoccum purpurascens* are the first reported for California. The principal mycoflora recovered from mummy washings were species of non-filamentous yeasts (32.1%), *Penicillium* (28.8%), *Cladosporium* (11.4%), and *Mucor* (10.8%). Major mycoflora of mummy inner tissues were species of *Penicillium* (23.7%), *Mucor* (19.6%), *Cladosporium* (17.3%), and *Rhizopus* (11.1%). The relative recoveries of individual fungi from mummy inner tissues differed with location, *Prunus* species, and sampling position (tree or ground), and changed as the season progressed. The relative recovery of *M. fructicola* from mummy inner tissues was negatively correlated with *Botrytis* ($R = -0.53$, $P = 0.0052$), *Penicillium* ($R = -0.58$, $P = 0.0681$), and *Rhizopus* ($R = -0.50$, $P = 0.0696$). These results could help obtain naturally occurring antagonists and maximize their use in biocontrol systems aimed at reducing primary inoculum for blossom blight of stone fruits in California orchards.

Additional keywords: antagonism, carpo-stromasphere, nectarine, peach, plum, prune

Mummies of stone fruit (*Prunus* spp.) infected by *Monilinia fructicola* (G. Wint.) Honey can serve as a source of primary inoculum for initiating brown rot epidemics in California (12,23) and other growing areas worldwide (1,2,18). These mummies can either produce conidia (23) or develop apothecia, which release ascospores (12). The importance of mummies in the epidemiology of brown rot, however, varies among different geographic locations and between seasons within the same regions, as in California (15).

Two requirements must be met for mummies to function as a source of primary inoculum: (i) *M. fructicola* must survive the winter, and (ii) environmental conditions must be conducive for the fungus to sporulate during stone fruit bloom. In California, *M. fructicola* can survive some winters in mummy tissues (13,23).

Determining the factors that affect the survival of this fungus may help in understanding the epidemiology of brown rot and the development of disease management strategies.

Plant pathogens are vulnerable to antagonism from associated microflora during their saprophytic existence in plant residue. A minor change in the inhabitants of plant residues may have a great influence on the survival or activity of pathogens, but knowledge of the microflora inhabiting plant residue is scanty (4). During spring survey of stone fruit infected by *M. fructicola*, we frequently observed mummies overgrown with various fungi, which include species of *Cladosporium*, *Penicillium*, *Trichothecium*, or *Trichoderma* (14), from which we were unable to recover *M. fructicola*. The role that these colonizing fungi may play in relation to the survival of *M. fructicola* in mummies is unknown.

Research on plant microflora has increased tremendously in the last 20 years, and our knowledge of epiphytic (9,19) and endophytic (29) microflora in the rhizosphere (25,26) and phyllosphere has increased accordingly (3), but our knowledge of the microflora in the carpo-stromasphere is very limited. Knowledge of plant microflora has greatly facilitated naturally occurring biological control (17,28) and the introduction of microorganisms for the biological control of plant pathogens (4).

For example, *Penicillium frequentans* and *Epicoccum purpurascens* were identified and developed as biological agents to control peach twig blight in Spain, following investigations on the mycoflora of peach twigs and flowers (5,22). An isolate of *Trichoderma atroviride* was also identified in our laboratory for control of postharvest brown rot of stone fruits (16). In this research, we used stone fruit mummies as a model system and investigated the mycoflora in the carpo-stromasphere. The objective of this study was to determine mycoflora of mummies of nectarine, peach, plum, and prune infected by *M. fructicola* in California orchards.

MATERIALS AND METHODS

Sampling of mummies. Mummies infected by *M. fructicola*, with few if any visible contaminants on their surfaces, were collected from eight orchards at four locations in California monthly from November 1995 to March 1996. These orchards consisted of one peach (*P. persica*), five nectarine (*P. persica* var. *nectarina*), and two plum (*P. salicina*). Mummies hanging from trees and lying on the ground were sampled separately and are referred to as tree mummies and ground mummies, respectively. Three replications of 30 tree mummies and 30 ground mummies were arbitrarily collected from each orchard, each placed separately in a clean plastic bag, kept in an ice box, and transported to the laboratory. During the winter of 1996-97, mummy sampling was repeated monthly in five orchards, including one peach, three nectarine, and one prune (*P. domestica* cv. French), using the same procedure. Mummies were collected at the beginning of each month.

A total of 42 samples were taken from trees and 44 from the ground in the 1995-96 winter. During the winter of 1996-97, 25 samples of tree mummies and 25 samples of ground mummies were collected. The orchards sampled represented four major stone fruits growing in California: peach, nectarine, plum, and prune. These orchards were located in Fresno and Madera counties, in the center of the San Joaquin Valley, where most fresh market stone fruit are produced. The commercial orchards sampled were 8 to 10 years old, with late-season varieties, while the orchards at the Kearney Agricultural Center (KAC) were 18 to 22 years old, with middle-season varieties. Most orchards sampled received two to four bloom sprays and one to three preharvest sprays with either

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iprodione or benomyl (Table 1). The peach and plum orchards at the KAC were removed in the 1996-97 winter, so in their place we sampled a peach and a prune orchard in Madera County. The details of irrigation schedule and pesticide application were provided by growers.

Isolation from mummy washings. In 1995-96, five mummies per replicate were placed in a 500-ml clean plastic bottle containing 300 ml of deionized water and shaken on an Eberbach shaker (Eberbach Corporation, Ann Arbor, MI) at 180 osc/min for 2 h. According to preliminary studies, 100 µl of the diluted mummy washings (1:100) was spread onto each of three petri dishes containing 20 ml of acidified (2.5 ml of 25% lactic acid per liter) potato dextrose agar (APDA) using a turntable with a sterile L-shaped glass rod. Dishes were incubated at 23°C for 4 days, then examined microscopically for fungal colonies. A fungus that was frequently recovered from plant tissue was referred to as a colonizer of that tissue. A fungus was recorded as a major colonizer when it had ≥30 colonies in a dish and as a minor colonizer when it had <30 colonies. The absolute predominance of a colonizer was represented by the number of dishes in which the species was recorded as a major colonizer. The absolute predominances of individual colonizers were added together to give a total predominance of all colonizers. For example, a dish with three major colonizers was counted as three predominant dishes in the total predominance. The relative predominance of individual colonizers was then calculated by dividing their predominance by the total predominance.

Isolation from mummy inner tissues.

Five mummies were arbitrarily selected from each of three replicate bags. Each mummy was split with a flamed knife, and five small (approximately 2 × 2 × 2 mm) pieces of the inner tissues were removed with a pair of fine forceps and placed at the center and across two perpendicular diameters of a dish containing 10 ml of APDA. Dishes were incubated at 23°C for 4 days, then examined microscopically for fungal colonies. Using relevant taxonomic keys, fungal colonies were identified to species whenever possible. The number of colonies of each fungus per dish was recorded. Relative recovery was calculated by dividing the number of colonies of indi-

vidual fungi by the total number of all fungal colonies recovered from mummies of each replicate and expressed as a percentage. Data of the relative recovery of individual fungi were examined for normality using the SAS UNIVARIATE procedure (SAS Institute, Cary, NC, 1999). Nonparametric analyses were subsequently performed using the SAS NPARIWAY procedure for determining the differences in relative recovery of individual fungi between locations, species of stone fruits, sampling positions (tree versus ground), and using the SAS FREQ procedure for determining the difference among the sampling months. The data of mean relative recovery at different locations, species of

Table 2. Populations of colonizing fungi isolated from inner tissues and surface of stone fruit mummies in California orchards

Fungus	Relative recovery (%) ^y		Relative predominance (%) ^z
	1995-96	1996-97	
<i>Alternaria</i>	2.0	0.4	0.2
<i>Aspergillus</i>	1.9	8.8	2.4
<i>Aureobasidium</i>	6.1	1.2	8.0
<i>Botrytis</i>	8.0	1.5	0.2
<i>Cladosporium</i>	17.3	6.4	11.4
<i>Fusarium</i>	1.4	0.6	0.5
<i>Gilbertella</i>	2.0	0.2	0.5
<i>Monilinia</i>	1.5	13.5	0
<i>Mucor</i>	19.6	5.8	10.8
<i>Penicillium</i>	23.7	32.7	28.8
<i>Rhizopus</i>	11.1	8.0	4.7
<i>Trichoderma</i>	1.4	3.5	0.0
Yeast	2.0	14.6	32.1
Other fungi	2.1	2.8	0.5

^y The relative recovery was calculated by dividing colony number of individual fungi by total colony number of all fungi recovered from inner tissue of mummies.

^z Relative predominance of a fungus recovered from mummy washing.

Table 1. Cultural practices and fungicides applied in stone fruit orchards sampled for mummies infected by *Monilinia fructicola* in 1995-96 and 1996-97 winters

Orchard	Site, county	Age (year)	First harvest	Irrigation ^w	Herbicide ^x	Fungicide ^y		
						A	B	C
1995-96								
Nectarine								
Fantasia	KAC, Fresno	21	7/1	7-14	B	2	2	2
Summer Red	Parlier, Fresno	8	8/15	10-14	C	2	2	2
August Red	Reedley, Fresno	10	8/15	10-14	C	— ^z	—	—
September Red	Reedley, Fresno	10	9/1	10-14	C	—	—	—
Flaming Red	Madera, Madera	9	8/20	12	C	3	4	3
Peach								
Multiple	KAC, Fresno	18	—	7-14	B	2	2	2
Plum								
July Santa Rosa	KAC, Fresno	18	7/15	7-14	B	2	2	1
Rosemary	Madera, Madera	10	7/20	12	C	4	2	0
1996-97								
Nectarine								
Fantasia	KAC, Fresno	22	7/1	7-14	B	2	1	1
Summer Red	Parlier, Fresno	9	8/15	10-14	C	2	0	1
Flaming Red	Madera, Madera	10	8/20	12	C	4	2	1
Peach								
Fairtime	Madera, Madera	—	8/20	12	C	4	2	1
Prune								
French	Madera, Madera	—	9/10	10-14	B	—	—	—

^w Number of days between two irrigations throughout the growing season.

^x Orchard floor management: B denotes herbicides applied only on irrigation berms (tree rows), and C denotes herbicides sprayed on entire orchard floor.

^y Number of fungicide applications during periods: A = bloom, B = postbloom, and C = preharvest.

^z No data available.

stone fruits, sampling positions, and sampling months were further analyzed with the SAS CORR procedure.

RESULTS

Overall, 20 genera represented by 29 species of filamentous fungi and nonfilamentous yeasts were isolated from mummy washings and inner tissues. The principal species recovered were *Alternaria alternata*, *Aspergillus niger*, *Aspergillus japonicus*, *Aspergillus oryzae*, *Aspergillus terreus*, *Aureobasidium pullulans*, *Cladosporium herbarum*, *Botrytis cinerea*, a *Fusarium* species, *Gilbertella persicaria*, *Mucor racemosus*, *Penicillium* spp., *Rhizopus stolonifer*, *Trichoderma atroviride*, and various nonfilamentous yeasts. Minor species included *Epicoccum purpurascens*, *Trichothecium roseum*, and species of *Geotrichum*, *Harknessia*, *Nigrospora*, *Stemphylium*, and *Verticillium*.

Mycoflora from mummy surface. The fungi most frequently recovered from mummy washings in the 1995-96 winter (Table 2) were species of nonfilamentous yeasts (32.1%), *Penicillium* (28.8%), *Cladosporium* (11.4%), and *Mucor* (10.8%). *M. fructicola* was not recovered from any mummy washings. Similar data were obtained in 1996-97.

Mycoflora from mummy inner tissues.

Fungi most frequently recovered from mummy inner tissues in the 1995-96 winter were species of *Penicillium* (23.7%), *Mucor* (19.6%), *Cladosporium* (17.3%), and *Rhizopus* (11.1%) (Table 2). In the 1996-97 winter, *Penicillium* spp. remained the most frequently isolated fungi from inner tissues of mummies sampled, but *M. fructicola*, *Aspergillus* spp., and nonfilamentous yeasts increased, and species of *Botrytis*, *Cladosporium*, and *Mucor* decreased dramatically from those in 1995-96 (Table 2). Significant differences were observed in the relative recovery of individual fungi among locations, *Prunus* species, and sampling dates. Differences in the relative recovery also were observed between sampling positions (tree versus ground) and seasons.

Ten genera of fungi had different relative recovery among locations in the 1995-96 winter, whereas only four genera had different recovery in the 1996-97 winter (Table 3). Lower recoveries of *M. fructicola* were made from mummies collected from the KAC orchards than from those from any other orchards (Table 3).

The relative recoveries of *Aureobasidium*, *Fusarium*, *Gilbertella*, *Trichoderma*, and yeasts did not differ among nectarine,

peach, and plum in the 1995-96 winter and among nectarine, peach, and prune in the 1996-97 winter (Table 4); however, higher recoveries of *Aspergillus* were made from peach mummies than from nectarines (Table 4). Lower recoveries of *M. fructicola* were made from prune mummies than from nectarine and peach mummies in the 1996-97 winter, although no difference was observed among nectarine, peach, and plum mummies in the 1995-96 winter (Table 4).

The relative recoveries of most fungi were associated consistently with sampling position in both 1995-96 and 1996-97 winters (Table 5). *Aureobasidium*, *Cladosporium*, and *M. fructicola* were isolated more frequently from tree mummies than from ground mummies. In contrast, *Mucor*, *Rhizopus*, and yeasts were isolated more frequently from ground mummies than from tree mummies (Table 5). No differences were observed in the relative recoveries of *Botrytis* and *Fusarium* between tree and ground mummies (Table 5).

Relative recovery of some colonizing fungi changed consistently throughout the winter (Tables 6 and 7). For example, *Penicillium* increased, while *Aspergillus* spp. and *M. fructicola* decreased as the winter progressed. However, recovery of other species changed dramatically. A con-

Table 3. Relative recovery (%) of colonizing fungi isolated from inner tissues of stone fruit mummies in California orchards of different locations

Fungus	1995-96 winter					1996-97 winter			
	Parlier	KAC	Madera	Reedley	P ^y	Parlier	KAC	Madera	P ^y
<i>Alternaria</i>	2.6 ^z	2.6	0.7	2.1	0.0034	0.1	0	0.7	0.2480
<i>Aspergillus</i>	1.0	2.8	1.9	1.1	0.2194	7.6	13.1	7.7	0.6949
<i>Aureobasidium</i>	5.8	8.3	3.3	6.3	0.0816	0.4	1.8	1.3	0.9523
<i>Botrytis</i>	5.1	15.3	5.2	2.0	<0.0001	0.5	3.4	1.2	0.2667
<i>Cladosporium</i>	21.4	21.7	9.7	17.1	0.0013	3.5	12.2	5.3	0.0189
<i>Fusarium</i>	4.3	0.9	1.2	0.6	0.0007	0	0.3	0.9	0.2519
<i>Gilbertella</i>	2.5	2.4	1.0	2.2	0.0006	0	0.1	0.2	0.2520
<i>Monilinia</i>	4.4	0.7	1.2	1.3	0.0007	20.3	0.2	16.0	<0.0001
<i>Mucor</i>	17.2	7.4	20.6	37.8	<0.0001	4.9	5.2	6.4	0.8999
<i>Penicillium</i>	15.5	27.8	34.8	9.7	<0.0001	39.5	40.0	27.6	0.0075
<i>Rhizopus</i>	8.5	5.2	16.7	14.7	<0.0001	5.7	10.6	7.9	0.8090
<i>Trichoderma</i>	0.7	0.9	1.1	3.1	0.8032	2.3	1.7	4.6	0.0974
Yeast	5.7	1.7	1.6	1.0	<0.0001	12.9	7.1	17.7	0.0304

^y Significance of Kruskal-Wallis test.

^z Relative recovery was calculated by dividing colony number of a genus by total colony number of all fungi.

Table 4. Relative recovery (%) of colonizing fungi isolated from the inner tissue of different stone fruit mummies in California orchards

Fungus	1995-96 winter				1996-97 winter			
	Nectarine	Peach	Plum	P ^y	Nectarine	Peach	Prune	P ^y
<i>Alternaria</i>	1.8 ^z	1.6	2.3	0.2016	0.0	0.4	2.1	<0.0001
<i>Aspergillus</i>	1.0	2.5	3.1	0.0085	9.2	13.3	0.8	0.0255
<i>Aureobasidium</i>	5.3	7.2	6.9	0.1132	0.9	2.8	0.5	0.3485
<i>Botrytis</i>	7.2	17.2	5.9	<0.0001	1.7	1.6	0.4	0.3917
<i>Cladosporium</i>	17.9	16.8	16.5	0.8746	6.2	1.6	14.1	0.0025
<i>Fusarium</i>	1.6	0.7	1.3	0.7350	0.6	0.5	0.6	0.8089
<i>Gilbertella</i>	0.7	1.8	3.9	0.6891	0.1	0	0.6	0.1123
<i>Monilinia</i>	2.0	0.9	1.0	0.1806	17.2	11.6	0.2	<0.0001
<i>Mucor</i>	21.8	6.9	20.7	0.0025	5.1	5.9	8.9	0.2621
<i>Penicillium</i>	21.4	33.2	23.8	0.0001	33.3	30.9	33.3	0.8610
<i>Rhizopus</i>	13.1	4.3	10.4	0.0149	6.6	13.4	6.7	0.0162
<i>Trichoderma</i>	1.5	0.4	1.7	0.7595	2.5	4.7	5.9	0.2304
Yeast	2.3	2.4	1.6	0.6663	14.0	11.4	20.3	0.4761

^y Significance of Kruskal-Wallis test.

^z Relative recovery was calculated by dividing colony number of individual fungi by total of colonies of all fungi.

sistent decrease of *Cladosporium* and an increase of *Mucor* were observed in 1995-96 (Table 6), but these trends were not observed in 1996-97 (Table 7). The relative recovery of *Fusarium*, *Rhizopus*, *Trichoderma*, and other fungi and nonfilamentous yeasts were low and showed no consistent seasonal pattern (Tables 6 and 7).

The correlation coefficients between *M. fructicola* and the principal colonizing

fungi were species of *Alternaria* 0.71 ($P = 0.0043$), *Aureobasidium* 0.75 ($P = 0.0021$), *Botrytis* -0.53 ($P = 0.052$), *Penicillium* -0.58 ($P = 0.0681$), *Rhizopus* -0.50 ($P = 0.0696$), and nonfilamentous yeasts 0.87 ($P < 0.0001$), respectively (Table 8).

DISCUSSION

This study is the first attempt to determine the mycoflora of the surface and

inner tissues of the carpo-stromasphere using *Prunus* mummies. The mycofloral communities of stone fruit mummies are more complex than those reported for peach twigs (22,24). Among 29 species recovered, *A. japonicus*, *A. terreus*, and species of *Harknesia*, *Paecilomyces*, and *T. atroviride* were first recorded on *Prunus* crops in the United States, and *A. pullulans*, and *E. purpurascens* had not been

Table 5. Relative recovery (%) of colonizing fungi isolated from inner tissues of stone fruit mummies collected from trees and the ground in California orchards

Fungus	1995-96 winter			1996-97 winter		
	Tree	Ground	P^y	Tree	Ground	P^y
<i>Alternaria</i>	2.9 ^z	1.1	<0.0001	0.7	0.2	0.6336
<i>Aspergillus</i>	1.9	2.0	0.5066	13.3	4.5	0.0125
<i>Aureobasidium</i>	9.4	3.1	<0.0001	1.9	0.6	0.0407
<i>Botrytis</i>	8.4	7.6	0.4254	1.3	1.8	0.4887
<i>Cladosporium</i>	29.0	6.6	<0.0001	11.2	1.8	<0.0001
<i>Fusarium</i>	0.8	1.9	0.2135	0.1	1.0	0.1647
<i>Gilbertella</i>	1.0	2.8	<0.0001	0.1	0.2	0.3367
<i>Monilinia</i>	2.4	0.6	0.0003	21.7	5.7	<0.0001
<i>Mucor</i>	5.1	32.9	<0.0001	0.6	10.8	<0.0001
<i>Penicillium</i>	28.5	19.4	0.0023	33.1	32.4	0.7553
<i>Rhizopus</i>	6.2	15.5	<0.0001	4.6	11.2	0.0039
<i>Trichoderma</i>	1.3	1.5	0.3347	0.6	6.3	<0.0001
Yeast	1.6	2.5	0.0460	8.0	20.6	<0.0001

^y Significance of Kruskal-Wallis test.

^z Relative recovery was calculated by dividing colony number of individual fungi by total colony number of all fungi.

Table 6. Seasonal populations of colonizing fungi isolated from inner tissues of stone fruit mummies in California orchards, 1995-96 winter

Fungus	Relative recovery (%) ^y					P^z
	Nov.	Dec.	Jan.	Feb.	Mar.	
<i>Alternaria</i>	5.9	6.5	1.0	2.7	0.1	<0.0001
<i>Aspergillus</i>	7.8	2.0	1.1	2.5	0.3	0.0178
<i>Aureobasidium</i>	10.9	15.6	9.6	4.9	1.7	<0.0001
<i>Botrytis</i>	0	0	7.7	8.6	10.4	0.1808
<i>Cladosporium</i>	51.8	34.4	22.4	11.1	10.7	<0.0001
<i>Fusarium</i>	0	1.3	0.1	2.9	0	<0.0001
<i>Gilbertella</i>	8.2	0.9	0.3	1.7	4.9	0.0009
<i>Monilinia</i>	4.6	14.1	2.1	0	0	<0.0001
<i>Mucor</i>	1.8	11.1	17.9	21.1	25.7	0.0866
<i>Penicillium</i>	1.8	3.0	24.7	21.2	38.8	0.0004
<i>Rhizopus</i>	5.4	1.7	8.6	15.1	7.7	<0.0001
<i>Trichoderma</i>	0.3	0	1.1	2.4	0	0.0106
Yeast	0	9.7	1.2	3.2	0	<0.0001

^y Relative recovery was calculated by dividing colony number of individual fungi by total colony number of all fungi.

^z Significance of Friedman's test.

Table 7. Seasonal populations of colonizing fungi isolated from the inner tissues of stone fruit mummies in California orchards, 1996-97 winter

Fungus	Relative recovery (%) ^y					P^z
	Nov.	Dec.	Jan.	Feb.	Mar.	
<i>Alternaria</i>	0	0.1	0.5	0.8	0.7	0.7334
<i>Aspergillus</i>	35.9	6.3	0.1	2.1	4.6	<0.0001
<i>Aureobasidium</i>	1.6	2.81	0.4	1.3	0	0.0704
<i>Botrytis</i>	0.1	3.8	2.2	0.8	0.3	0.0103
<i>Cladosporium</i>	4.1	8.1	5.6	5.6	7.9	0.5564
<i>Fusarium</i>	0	0	0.9	0	2.0	0.0142
<i>Gilbertella</i>	0	0.3	0	0.4	0	0.3839
<i>Monilinia</i>	22.0	18.0	8.3	12.8	7.7	0.0225
<i>Mucor</i>	7.0	4.1	5.5	4.1	9.1	0.2654
<i>Penicillium</i>	8.1	15.4	44.5	43.9	48.6	<0.0001
<i>Rhizopus</i>	4.4	9.6	6.7	6.3	12.8	0.1240
<i>Trichoderma</i>	0	2.1	5.9	5.2	3.7	0.0396
Yeast	15.7	27.3	15.6	11.9	0.4	<0.0001

^y Relative recovery was calculated by dividing colony number of individual fungi by total colony number of all fungi.

^z Significance of Friedman's test.

reported in California before (10). This study provides initial ecological data on the colonization of the carpo-stromosphere, which may help in understanding the survival of *M. fructicola* overwintering in California stone fruit orchards.

Most colonizing fungi such as *Penicillium* spp. were present consistently on mummy surfaces and inner tissues throughout both winters. Lower recoveries of *M. fructicola* were associated with higher recoveries of species of *Botrytis*, *Penicillium*, *Mucor*, *Rhizopus*, and *Trichoderma*. *M. fructicola* was not recovered from mummies, which were overgrown with species of *B. cinerea*, *C. herbarum*, *M. racemosus*, *Penicillium* spp., *R. stolonifer*, *T. atroviride*, or by *T. roseum* in commercial orchards. Some of these commonly recovered fungi may have contributed to the decline in the recovery of *M. fructicola* from mummies during the winter, and thus contributed to the reduction of primary inoculum in California orchards. The mechanisms by which these fungi suppress *M. fructicola* might be through substrate competition and niche exclusion (23), antibiosis (2), or both. An in vitro antagonism study indicated that these commonly isolated fungi and yeasts reduced the mycelial growth of *M. fructicola* on APDA dishes, even when the pathogen was seeded 2 days earlier than the colonizing fungi (data not shown). It must be noted that both *B. cinerea* and *R. stolonifer* are weak pathogens of stone fruits of early season varieties, and of minor importance when compared with brown rot in California. It may be possible to promote naturally occurring colonizing fungi by modifying cultural practices to favor biological control of brown rot, particularly in orchards of late-season varieties. The best strategies and methods for maximal use of these naturally occurring colonizer antagonists for control of brown rot need further investigation.

An antagonist sought for use in soil, on a plant surface, or within a plant tissue is most likely to develop in that niche if it was originally obtained from a similar niche (4). For example, *E. purpurascens* and *A. pullulans* were isolated from blossoms and developed as control agents of brown rot blossom blight and latent infection of cherry by *M. fructicola* in the United States (30). *P. frequentans* and *E. purpurascens* were obtained from peach twigs and were shown to be effective for controlling infections of blossoms and twigs by *Monilinia laxa* in Spain (6,20). A wide range of antagonists such as *A. pullulans*, *E. purpurascens* (20,21), *Trichoderma* spp. (7,8,11,16), and *T. roseum* (4) were obtained in the present study. These fungi have potential and warrant further investigation for the reduction of primary inoculum and brown rot blossom blight in stone fruits.

Similar mycoflora were associated with peach, nectarine, plum, and prune mummies. Variations in relative recovery of some filamentous fungi and nonfilamentous yeasts between the two winters were expected because of different weather conditions. It was very dry and warm in the second half of 1995, but it was much wetter and cooler in the same period of 1996. The relative recovery of some filamentous fungi and nonfilamentous yeasts from mummies at the KAC orchards differed from those in other orchards. The trees sampled at the KAC orchards were about 10 years older, and fruit harvest date was 1.5 months earlier than for those in the other orchards. The association of mycoflora in stone fruit mummies with tree age and fruit harvest date has not been studied. The application of fungicides may affect the recovery of *M. fructicola* (27) and some other species, but the orchards we sampled in this research received similar fungicide sprays. The higher recoveries of *Mucor* and *Rhizopus* spp. from the ground

mummies than from tree mummies can be explained by the common occurrence of these fungi in soil (7).

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Table 8. Correlation analysis of colonizing fungi isolated from inner tissues of stone fruit mummies infected by *Monilinia fructicola* in California orchards^x

Fungus	Pearson correlation coefficient (upper right) / $P > R $ (lower left) ^y													
	Alt	Asp	Aur	Bot	Cla	Fus	Gil	Mon	Muc	Pen	Rhi	Tri	Yea	Oth
<i>Alternaria</i> ^z		0.62	0.81	-0.56	0.83	0.02	0.29	0.71	-0.54	-0.79	-0.54	-0.25	0.51	-0.16
<i>Aspergillus</i>	0170		0.37	-0.26	0.70	-0.24	0.69	0.00	-0.55	-0.45	-0.26	-0.21	-0.21	-0.02
<i>Aureobasidium</i>	0004	1874		-0.35	0.82	-0.25	-0.05	0.75	-0.62	-0.58	-0.72	-0.32	0.48	-0.18
<i>Botrytis</i>	0380	3769	2191		-0.46	-0.06	-0.23	-0.53	0.18	0.76	-0.13	-0.11	-0.28	0.41
<i>Cladosporium</i>	0002	0057	0005	0957		-0.28	0.43	0.49	-0.70	-0.64	-0.65	-0.41	0.13	-0.11
<i>Fusarium</i>	9334	4130	3794	8375	3257		-0.25	0.13	0.17	-0.15	0.30	0.19	0.53	0.64
<i>Gilbertella</i>	3169	0054	8668	4308	1270	3846		-0.21	-0.16	-0.26	-0.18	-0.29	-0.40	-0.13
<i>Monilinia</i>	0043	9992	0021	0502	0787	6524	4635		-0.27	-0.58	-0.50	-0.39	0.87	-0.23
<i>Mucor</i>	0457	0401	0189	5430	0056	5655	5915	3419		0.04	0.76	0.61	-0.12	-0.17
<i>Penicillium</i>	0008	1042	0287	0014	0146	6037	3642	0681	8995		0.14	-0.09	-0.44	0.05
<i>Rhizopus</i>	0481	3727	0034	6461	0114	3050	5400	0696	0016	6271		0.73	-0.30	0.00
<i>Trichoderma</i>	3835	4773	2573	7074	1502	5075	3088	1688	0201	7636	0032		-0.24	0.11
<i>Yeast</i>	0610	4774	0856	3235	6500	0512	1509	0001	6827	1150	2909	4084		0.01
Others	5889	9397	5343	1474	7059	0143	6522	4319	5560	8558	9998	9062	7093	

^x Data of colonizer fungi analyzed were the means of relative recovery of each of four locations, three *Prunus* spp., two sampling positions (tree versus ground), and 5 months, so that N = 14.

^y Pearson correlation coefficients are listed in the upper right corner, and statistical significance is presented in the lower left corner of the table.

^z Bold letters indicate abbreviation of each genus used in horizontal subtitle of table.

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