# Wood Decay, Lignicolous Fungi, and Decline of Peach Trees in South Carolina

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**ABSTRACT**

Adaskaveg, J. E., Miller, R. W., and Gilbertson, R. L. 1993. Wood decay, lignicolous fungi, and decline of peach trees in South Carolina. Plant Dis. 77:707-711.

In the fall of 1990, a survey of lignicolous fungi and wood decay was conducted in 24 peach (*Prunus persica*) orchards in the Coastal, Ridge, and Piedmont regions (eight orchards per region) of South Carolina. A total of 2,400 trees, averaging 12.5 yr old, were evaluated for decay fungi; and 480 trees were evaluated for incidence, severity, and type of decay. Thirty-nine species in 30 genera were collected; 18 are new reports on peach in South Carolina, while 16 species are new reports on peach in the United States. Including the fungi in this study, the total number of wood rotting fungi reported on peach or nectarine in the United States and Canada is 67. White rot fungi were most commonly collected and included species in the following genera: *Armillaria, Ganoderma, Laeticorticium, Oxyporus, Schizophyllum, Schizopora, Stereum, Trametes,* and *Trichaptum.* Species of brown rot fungi collected were *Antrodia albida, Fomitopsis meliae, F. nivosa, F. palustris,* and *Gloeophyllum mexicanum.* The incidence of trees with decay was generally high, with orchard averages ranging from 20 to 100%. Incidences of decay were 63.7, 80.6, and 84.3% in the Ridge, Piedmont, and Coastal regions, respectively. Disease-severity ratings indicated that trees were affected mostly by decays of scaffold branches that were associated with improper stub-cut, pruning wounds. Based on tree age and health, wood decay is recognized as a distinct disease and is associated with declining peach trees in commercial production in South Carolina.

Wood rot diseases of peach trees occur throughout the temperate zone, fruit tree growing areas of the world (1,15). Despite the common occurrence of these diseases, the incidence of decay, the fungi responsible, and the role of wood rot diseases in fruit tree decline are poorly understood. In North America, Seymour (21) listed 21 wood decay fungi on peach, and Weiss and O'Brien (28) listed 16 species and annotated them with geographical distribution and type of decay or tissue affected. In South Carolina and Georgia, Rhoads (18) found seven species that cause trunk and limb decay of peach. In 1960 and 1961, Petersen (16,17) made the first extensive surveys of hymenomycetous fungi of peach wood in South Carolina and identified 35 species associated with decay. Currently, Farr et al (9) lists 44 species of wood decay fungi in the Basidiomycotina on peach (*Prunus persica* (L.) Batsch). Petersen (16,17) included *Trametes versicolor* (L.:Fr.) Pilát and *Armillaria tabescens* (Scop.:Fr.) Dennis, Orton & Hora. Adaskaveg and Ogawa (1) list 16 in California, including five species not previously reported on peach, making a total of 51 species on peach in the United States. In Canada, Conners (5) lists three wood rotting fungi (previously reported), whereas Ginns (12) lists no wood decay fungi on peach trees. No additional surveys have been conducted recently in the Southeast.

Accepted for publication 10 March 1993.



Peach trees in the southeastern United States may live only 5–7 yr (4). Many biotic (bacteria, fungi, and nematodes) and abiotic factors (cold and frost damage) contribute to diseases such as peach tree short life and peach tree replant problems of commercial peach trees (19,29). In South Carolina, Petersen (16,17) and Alconero et al (2) recognized wood decay and other diseases as causes of limb losses and trunk deterioration, and identified these problems as contributing to early decline of peach trees. Similarly, wood decay fungi were associated with the decline of peach trees in Western Australia (7). Few studies, however, have documented the incidence and severity of decay, as well as provided a detailed identification of the fungi responsible. The objectives of this study were to conduct a detailed survey of fungi associated with wood decay and to evaluate the incidence and severity of wood decay in commercial peach orchards in three regions of South Carolina.

## MATERIALS AND METHODS

**Survey of orchards.** In the fall of 1990, 24 commercial orchards more than 7 yr old (eight each in the Coastal, Ridge, and Piedmont regions of South Carolina) were selected randomly and surveyed for lignicolous fungi. In most orchards surveyed, sprinkler irrigation was used during periods of fruit production or water stress; drip irrigation was used in one orchard. Tree age was determined from planting date records kept by growers. Trees ranged in age from 8 to 12, 7 to 20, and 10 to 20 yr old in the Coastal, Ridge, and Piedmont regions, respectively. Cultivars surveyed in the Coastal region were Camden, Fay Elberta, Harvestor, June Gold, Raycrest, and Rubired; cultivars surveyed in the Ridge region were Blake, Camden, Cornett, June Gold, Jefferson, Monroe, and Rubired; and cultivars surveyed in the Piedmont region were Camden, Redglobe, June Gold, Lovell, and two unidentified cultivars.

**Incidence and identification of lignicolous fungi.** In each orchard, approximately 100 trees were selected arbitrarily and were observed for decay fungi. The incidence of fungal genera and species was recorded. Fruiting bodies of fungi found on peach were collected and identified based on macro- and microscopic morphological characteristics (10,11). When decay was observed and fruiting bodies were not present, cultures of wood decay fungi were obtained by placing decayed wood on 2% malt extract agar (MEA) amended with 10 μg/ml benomyl (Benlate, 50 WG) and 100 μg/ml streptomycin. Cultures were transferred to MEA and identified based on cultural characteristics (14,24).

**Evaluation of decay.** In each orchard, 20 trees were arbitrarily selected and evaluated for incidence of decay and severity of either brown or white rots. Trees were inspected and evaluated for decay by examining exposed wood in wounds of scaffold branches, trunks, or exposed roots. To facilitate evaluations, wood was additionally exposed with a hatchet. Decay was visually characterized as either a white rot or a brown rot. Fruiting bodies on trees also were used as indicators of decay: where fruiting bodies were attached, wood was exposed as indicated above and examined for decay. Decay severity in trees was based on a rating index of 0–3 where 0 = no decay observed, 1 = stub branch decay appearing compartmentalized, 2 = scaffold branch decay, and 3 = scaffold and trunk decay with limb breakage.

## RESULTS

**Lignicolous fungi and their incidence.** A total of 39 species representing 30 genera of lignicolous fungi were collected (Table 1). Eighteen of the species

**Table 1.** Lignicolous fungi collected from surveyed peach trees in South Carolina

| Genus-species[a] | New report[b] | New for SC[b] | Type of decay[c] | Tissue decayed[d] |
|---|---|---|---|---|
| *Abortiporus biennis* (Bull.:Fr.) Singer | * | * | W | R |
| *Antrodia albida* (Fr.:Fr.) Donk | * | * | B | S |
| *Armillaria* sp. | | | W | RT |
| *Auricularia* sp. | * | * | W | S |
| *Calocera cornea* (Batsch:Fr.) Fr. | * | * | B | S |
| *Calosphaeria pulchella* (Pers.:Fr.) J. Schröt. in Cohn | | * | ND | S |
| *Ceriporiopsis subvermispora* (Pilát) Gilb. & Ryvarden | * | * | W | S |
| *Dacryopinax spathularia* (Schwein.) G.W. Martin | | * | B | S |
| *Dendrophora albobadia* (Schwein.:Fr.) Chamuris | | | W | S |
| *Fomitopsis meliae* (Underw.) Gilb. & Ryvarden | | | B | ST |
| *Fomitopsis nivosa* (Berk.) Gilb. & Ryvarden | * | * | B | ST |
| *Fomitopsis palustris* (Berk. & M.A. Curtis) Gilb. & Ryvarden | | | B | ST |
| *Ganoderma lobatum* (Schwein.) G.F. Atk. | | | W | RT |
| *Ganoderma lucidum* (Curtis:Fr.) P. Karst. | | | W | RT |
| *Gloeophyllum mexicanum* (Mont.) Ryvarden | * | * | B | S |
| *Gloeoporus dichrous* (Fr.) Bres. | | | W | ST |
| *Hyphoderma praetermissum* (P. Karst.) J. Erikss. & Å. Strid in J. Erikss. & Ryvarden | * | * | W | S |
| *Hyphodontia lanata* Burds. & Nakasone | * | * | W | S |
| *Hypoxylon* sp. | | | W | S |
| *Irpex lacteus* (Fr.:Fr.) Fr. | | | W | ST |
| *Laeticorticium roseum* (Fr.) Donk | * | * | W | S |
| *Lenzites betulina* (L.:Fr.) Fr. | | | W | RST |
| *Meruliopsis ambiguus* (Berk.) Ginns | * | * | ND | S |
| *Oxyporus corticola* (Fr.) Ryvarden | | | W | RST |
| *Oxyporus latemarginatus* (Durieu & Mont. in Mont.) Donk | | | W | RST |
| *Phellinus gilvus* (Schwein.:Fr.) Pat. | | | W | RST |
| *Phlebia* sp. | * | * | W | S |
| *Pulcherricium caeruleum* (Schrad.:Fr.) Parmasto | * | * | W | S |
| *Pycnoporus cinnabarinus* (Jacq.:Fr.) P. Karst. | | | W | ST |
| *Schizophyllum commune* Fr.:Fr. | | | W | ST |
| *Schizopora flavipora* (Cooke) Ryvarden | * | * | W | S |
| *Schizopora paradoxa* (Schrad.:Fr.) Donk | * | * | W | S |
| *Stereum complicatum* (Fr.) Fr. | | | W | S |
| *Stereum hirsutum* (Willd.:Fr.) Gray | | | W | S |
| *Stereum ochraceo-flavum* (Schwein.) Ellis | | | W | S |
| *Trametes hirsuta* (Wulfen:Fr.) Pilát | | | W | ST |
| *Trametes pubescens* (Schumach.:Fr.) Pilát | * | * | W | ST |
| *Trametes versicolor* (L.:Fr.) Pilát | | | W | ST |
| *Trichaptum biforme* (Fr. in Klotzsch) Ryvarden | | | W | S |

[a]Authors names follow Kirk and Ansell 1992 (13).
[b]New reports on peach for the United States and Canada or South Carolina (SC).
[c]Type of decay: W = white rot, B = brown rot, and ND = not determined.
[d]Tissue decayed: R = roots, T = trunk, and S = scaffold branches.

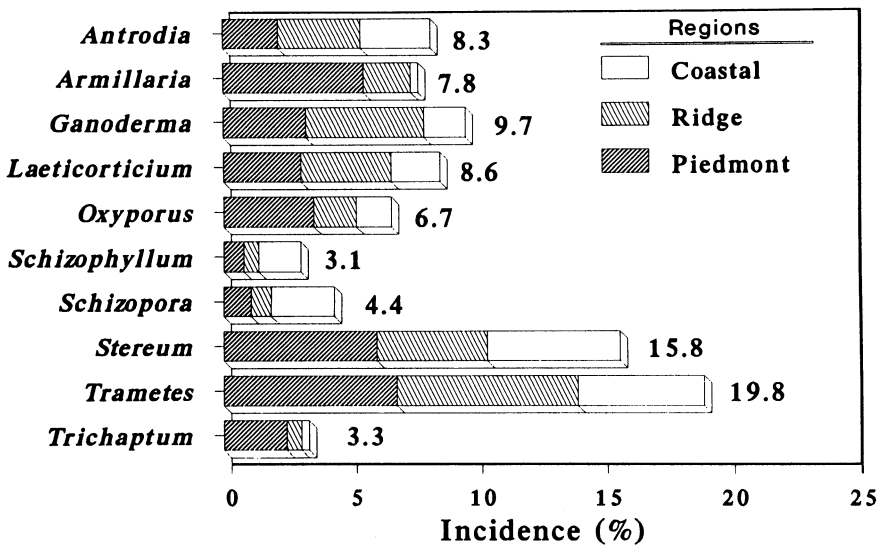


**Fig. 1.** Incidence of the 10 most common genera of wood decay fungi collected on peach, based on field identifications, as well as basidiocarps and cultures obtained from trees with decay in a survey of 2,400 trees in 24 orchards in three regions (Coastal, Ridge, and Piedmont) of South Carolina.

collected are new reports on peach in South Carolina, and 16 are new reports on peach in North America (Table 1). Most fungi were basidiomycetes; however, two species were ascomycetes: *Calosphaeria pulchella* (Pers.:Fr.) J. Schröt. in Cohn and an unidentified *Hypoxylon* species. White rot fungi were most commonly collected and included species in the following genera: *Armillaria, Ganoderma, Laeticorticium, Oxyporus, Schizophyllum, Schizopora, Stereum, Trametes,* and *Trichaptum.* Species of brown rot fungi collected were *Antrodia albida* (Fr.:Fr.) Donk, *Fomitopsis meliae* (Underw.) Gilb. & Ryvarden, *F. nivosa* (Berk.) Gilb. & Ryvarden, *F. palustris* (Berk. & M.A. Curtis) Gilb. & Ryvarden, and *Gloeophyllum mexicanum* (Mont.) Ryvarden. Incidence of the 10 most common genera of wood decay fungi collected on the peach trees surveyed in three regions of South Carolina are shown in Figure 1. The five most common genera were *Trametes, Stereum, Ganoderma, Laeticorticium,* and *Antrodia* (Fig. 1).

Most of the fungi collected were associated with scaffold branch decays (Tables 1 and 2). Fruiting bodies of decay fungi were commonly associated with improper stub-cut, pruning wounds, or other scaffold injuries such as sunburn or mechanical damage (Fig. 2). Most of the basidiocarps of *Antrodia albida* and species of *Oxyporus* and *Stereum* were found fruiting on stub-cut pruning wounds. *Irpex lacteus* (Fr.:Fr.) Fr., *Schizophyllum commune* Fr.:Fr., *Trichaptum biforme* (Fr. in Klotzsch) Ryvarden, and species of *Fomitopsis, Trametes,* and *Schizopora* were commonly found fruiting on large pruning wounds, injuries from sunburn, or directly on the bark surface. Basidiocarps of *Phellinus* species were commonly found on large pruning and mechanical injuries on the trunk, and those of *Ganoderma* were found attached to roots. *Laeticorticium roseum* (Fr.) Donk was always found fruiting on the cut surface of wood of improper pruning wounds, as well as on proper, well-healed pruning wounds.

**Incidence, severity, and type of decay.** Orchard age, incidence and severity of decay, and types of decay in 24 orchards from three regions of South Carolina are indicated in Table 2. The average tree ages of the surveyed orchards in the Coastal, Ridge, and Piedmont regions were 9.6, 13.25, and 14.37 yr old, respectively; and average tree age for all orchards was 12.41 yr old. The incidence of decay ranged from 20 to 100% for the orchards surveyed. The average incidence of decay was highest in the coastal region (84.3%) and lowest in the ridge region (63.7%). White rots were more common than brown rots, with their incidence ranging from 20 to 100%, while incidence of brown rots ranged

from 0 to 40% (Table 2). The highest average incidence of brown rots (13.7%) was in the ridge region. For the composite of three regions, the average incidences of white and brown rots were 65.4% and 12.5%, respectively.

Decay severity ranged from 0.25 to 2.17 (Table 2). The average decay severities for the Coastal, Ridge, and Piedmont regions were 1.38, 1.10, and 1.34, respectively. For the composite of trees in all three regions, average decay severity was 1.27 (Table 2).

## DISCUSSION

Many of the species of decay fungi observed and collected in this study were also reported by Rhoades (18), Petersen (16,17), and Farr et al (9); however, 18 species collected in our study are new reports on peach in South Carolina, and 16 are new in the United States and Canada (Table 1). Surveys made by Petersen (16,17) were done from 1955 to 1960. Our study was done in October (1990), because most wood decay fungi form reproductive structures in the fall. In the 30 yr between these surveys, many factors including changes in climate, cultural practices, and cultivars grown may account for the additional species found in our study that were not previously reported on peach. Detailed records of tree age, cultivars (Table 2), region (Fig. 1), and cultural practices such as irrigation and pruning methods (Fig. 2) are provided in the current study. Similar information, however, was not reported in earlier studies (16–18,21,28). Furthermore, many of the fungi found on peach in South Carolina were different from the ones found in California (1). Fungi found in South Carolina but not in California were mainly white rot species *I. lacteus* and *Trichaptum biforme*; corticioid fungi *L. roseum, Pulcherricium caeruleum* (Schrad.:Fr.) Parmasto, and *Meruliopsis ambiguus* (Berk.) Ginns; brown rot species in the genera *Antrodia* and *Gloeophyllum*; species in the *F. meliae* complex (Aphyllophorales); and the species *Calocera cornea* (Batsch.:Fr.) Fr. and *Dacryopinax spathularia* (Schwein.) G.W. Martin of the Dacrymycetales. The most common species in both areas were those in the genera *Ganoderma, Phellinus, Oxyporus, Schizophyllum, Stereum,* and *Trametes*. Based on the 46 total species listed by Farr et al (9) and Petersen (16,17), five additional species reported by Adaskaveg and Ogawa (1), and the 16 additional species reported by us, the total number of wood rotting fungi in the Basidiomycotina reported on peach or nectarine in the United States and Canada is 67.

Petersen (16,17) listed nine species, found over 100 times during his surveys, that he considered to contribute to early decline of peach trees in South Carolina. These were *Armillaria mellea* (Vahl:Fr.) P. Kummer, *Armillaria tabescens* (= *Clitocybe tabescens* (Scop.:Fr.) Bres.), *F. palustris* (= *Polyporus palustris* Berk. and M.A. Curtis), *Ganoderma lucidum* (Curtis:Fr.) P. Karst. (= *Polyporus curtisii* Berk.), *I. lacteus* (= *Polyporus tulipiferea* (Schwein.) Overh.), *Phellinus gilvus* (Schwein.) Pat. (= *Polyporus gilvus* (Schwein.) Fr.), *Stereum complicatum* (Fr.) Fr., *Trametes hirsuta* (Wulfen:Fr.) Pilát. (= *Polyporus hirsutus* Wulfen:Fr.), and *T. versicolor* (= *Polyporus versicolor* L.:Fr.). Our observations would also include *Antrodia albida,* species in the *F. meliae* complex (*F. meliae, F. palustris,* and *F. nivosa*), and species of *Oxyporus*. Additionally, we consider Armillaria root and crown rots distinct problems in orchard management; thus, these diseases should be separated when defining wood rot decline of peach trees in South Carolina and other fruit tree growing areas.

A higher incidence of decay (77.9%) was observed in South Carolina in peach orchards where annual precipitation generally exceeds 110 cm than in orchards in the western United States (26). In the arid San Joaquin Valley of California, annual precipitation is less than 50 cm (25), and the incidence of decay observed in peach and nectarine orchards averaging 15 yr old was 36% (1). In California, cherry orchards with sprinkler irrigation had greater decay than those with furrow irrigation (1). In South Carolina, the high rainfall and the use of sprinkler irrigation possibly provide extended periods of wetness for the establishment of wood decay fungi on peach.

Other factors possibly contributing to the establishment of wood decay include management practices and diseases that lead to wood-exposing injuries. Viral diseases, such as Prunus necrotic ringspot (PNR) and prune dwarf (PD), or excessive fertilization can cause excessive shoot formation (water sprouts) that may require additional pruning. Limb and scaffold branch dieback commonly

**Table 2.** Incidence, severity, and type of decay in 24 orchards from three regions in South Carolina

| Region | Orchard code[a] | Tree age[b] | Rots (%)[c] | | Incidence of decay (%)[d] | Decay severity[e] |
|---|---|---|---|---|---|---|
| | | | White | Brown | | |
| Coastal | MP | 11 | 70 | 25 | 95 | 2.00 |
| | MP-B | 8 | 80 | 5 | 85 | 1.10 |
| | MS | 8 | 60 | 15 | 75 | 1.15 |
| | MS-C | 8 | 70 | 5 | 75 | 1.35 |
| | MS-H | 10 | 65 | 0 | 65 | 0.95 |
| | MS-R | 10 | 80 | 5 | 85 | 1.15 |
| | JH | 10 | 95 | 5 | 100 | 1.90 |
| | BC | 12 | 65 | 30 | 95 | 1.45 |
| | Mean | 9.6 | 73.1 | 11.3 | 84.3 | 1.38 |
| Ridge | TW | 12 | 40 | 0 | 40 | 0.71 |
| | TW-II | 12 | 40 | 0 | 40 | 0.41 |
| | TW-III | 15 | 70 | 40 | 100 | 1.65 |
| | MV | 20 | 100 | 20 | 100 | 2.17 |
| | PW | 15 | 45 | 15 | 60 | 1.00 |
| | PW-II | 15 | 70 | 35 | 100 | 2.00 |
| | JS | 10 | 55 | 0 | 50 | 0.64 |
| | JS-II | 7 | 20 | 0 | 20 | 0.25 |
| | Mean | 13.25 | 55.0 | 13.7 | 63.7 | 1.10 |
| Piedmont | DA | 12 | 65 | 5 | 70 | 1.10 |
| | CC | 15 | 75 | 0 | 71 | 1.14 |
| | HC | 20 | 80 | 20 | 100 | 1.98 |
| | JB | 14 | 75 | 20 | 83 | 1.56 |
| | MS | 19 | 75 | 15 | 82 | 1.90 |
| | JG | 15 | 75 | 25 | 95 | 2.10 |
| | MB | 10 | 45 | 5 | 45 | 0.50 |
| | GB | 10 | 55 | 10 | 50 | 0.42 |
| | Mean | 14.37 | 68.1 | 12.5 | 80.6 | 1.34 |
| Average of three regions | | 12.41 | 65.4 | 12.5 | 77.9 | 1.27 |

[a] Cultivars in regions (1 = Coastal, 2 = Ridge, 3 = Piedmont) surveyed were: Blake (2), Camden (1,2,3), Redglobe (3), Cornett (2), Fay Elberta (1), Harvestor (1), Jefferson (2), June Gold (1,2,3), Lovell (3), Monroe (2), Raycrest (1), and Rubired (1,2).

[b] Determined by planting date.

[c] Incidence based on decay in 20 trees per orchard surveyed. Summation of percent rots may not equal the incidence of decay because some trees may have both types of decay.

[d] Based on the presence of decay in 20 trees per orchard surveyed.

[e] Decay severity based on a rating index: 0 = no decay observed, 1 = stub decay/compartmentalized, 2 = scaffold decay, and 3 = scaffold and trunk decay with limb breakage.

observed on peach trees with peach tree short life often leads to large pruning cuts, thus providing additional wood-exposing wounds for the establishment of decay fungi. Peach tree short life, PNR, or PD can also cause splits and cankers to limbs and trunks that may provide entry sites for wood rotting fungi. Weir (27) associated wood decay fungi with other pathogenic fungi.

Reports of peach trees with wood rotting fungi from the United States (1,2,16,17) and Australia (7), as well as reports of apple or other fruit trees with these organisms from California (1), Minnesota (3,8), Washington (6), and Wisconsin (20), indicate that wood decay fungi may contribute to the decline of trees. Other problems afflicting peach trees in the southeastern United States, such as peach tree short life and peach tree replant problem (19,29), are distinct from wood rot diseases that are associated with the decline of older trees. Petersen (16,17), Alconero et al (2), and Adaskaveg and Ogawa (1) associated wood decay fungi with the decline of fruit trees including peach and recognized these diseases as orchard management problems. Bergdahl and French (3) also associated wood decay fungi with the decline and mortality of apple trees on less optimal sites for apple production in Minnesota. Of the regions surveyed in our study, orchards in the Coastal region of South Carolina were in the most severe state of decline. The incidence (84.3%) and severity (1.38) of decay was highest, and average tree age was lowest (9.6) of the three regions surveyed. We associated extensive wood decay with improper pruning practices in the coastal region. Stub-cut and large pruning wounds were common in this region and possibly contributed to the higher incidence and severity of decay (Table 1). These types of wounds should be avoided, because peach trees respond to wood-exposing injuries following the model compartmentalization of decay in trees, or CODIT (23), and such wounds are poorly compartmentalized (22). Although average tree age was higher, the incidence and severity of decay were lower in the Ridge and Piedmont regions, where pruning wounds were made correctly and cuts were often well-healed and compartmentalized.

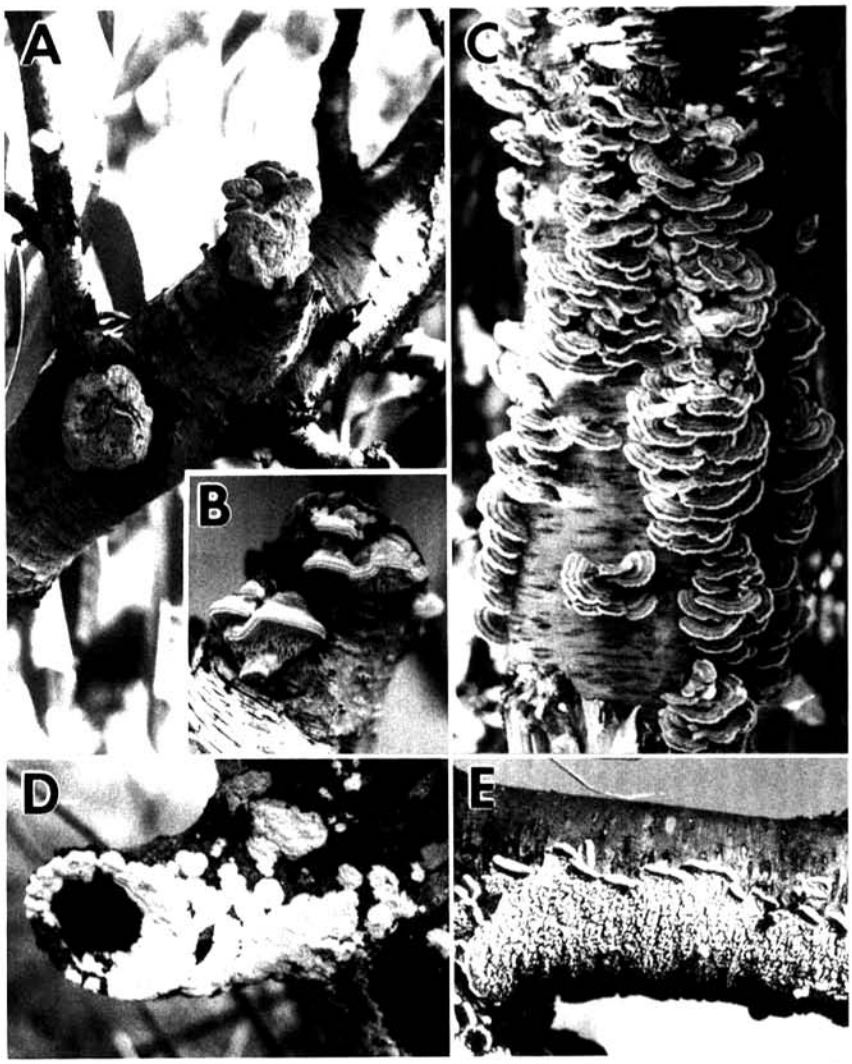


**Fig. 2.** Decay fungi associated with wounds of peach. **(A)** *Antrodia albida* on stub-cut pruning wound. **(B)** Close-up of *A. albida*. **(C)** *Trametes versicolor* associated with trunk injury. **(D)** *Oxyporus corticola* on stub-cut pruning wound. **(E)** *Irpex lacteus* on a branch with a sunburn injury.

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