THE RELATION OF VALSA KUNZEI TO CANKERS ON CONIFERS

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[3]The variety designated as Valsa kunzei var. kunzei (typical) agrees closely with the Latin description of V. kunzei Fr. in Saccardo's Syll. Fung. 1: 139, 1882; also, the variety Cytospora kunzei var. kunzei (typical) corresponds with the Latin description of C. kunzei Sacc. in Syll. Fung. 3: 270, 1884.

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Summary.--The species of Cytospora that is found commonly on cankers on various species of spruce, and its related Valsa stage, were studied in comparison with species of Cytospora and Valsa associated with cankers on other coniferous hosts. Pycnidia and perithecia from cankers on Abies balsamea, Pseudotsuga menziesii, Larix decidua, Tsuga canadensis, Picea abies, P. pungens, P. glauca, P. orientalis, P. rubens, Pinus strobus, and P. wallichiana and from cultures on artificial media and sterilized twigs were studied microscopically. Pycnidial stromata were extremely variable on any one host. Characteristics of perithecial stromata were more constant and were used for diagnostic purposes.

The fungus, on all coniferous hosts, corresponded with Valsa kunzei, and, on the basis of stromatal variations, three varieties and their corresponding pycnidial stages are described: Valsa kunzei var. kunzei var nov., typical, on Abies balsamea, Pseudotsuga menziesii, Larix decidua, and Tsuga canadensis; V. kunzei var. piceae var. nov. on Picea abies, P. glauca, P. pungens, P. orientalis, and P. rubens; V. kunzei var. superficialis comb. nov. on Pinus strobus and P. wallichiana. Cultural characteristics also indicated varietal differences.

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Inoculations with isolates of Valsa kunzei representing each of the varieties were made on nursery trees of Picea pungens, P. abies, P. glauca, Pseudotsuga menziesii, Abies fraseri, Larix decidua, Tsuga canadensis, and Pinus strobus. Positive results were obtained only with V. kunzei var, piceae on Picea species and in 3 inoculations on Pseudotsuga menziesii.

Experiments in spraying ornamental spruce trees affected with the canker and in cutting out infected bark indicated that the latter method was effective, but not practical for controlling large cankers. Spraying with Bordeaux failed to give sufficient coverage to prevent infection of twigs and branches. Unfavorable environment seems to predispose the various coniferous hosts to infection. Therefore, the selection of site and of the species best adapted to the site is important in establishing plantations of the more susceptible conifers.

Inoculations with isolates of *Valsa kunzei* representing each of the varieties were made on nursery trees of *Picea pungens*, *P. abies*, *P. glauca*, *Pseudotsuga menziesii*, *Abies fraseri*, *Larix decidua*, *Tsuga canadensis*, and *Pinus strobus*. Positive results were obtained only with *V. kunzei* var. *picaea* on *Picea* species and in 3 inoculations on *Pseudotsuga menziesii*.

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Among the fungi most commonly reported on trunks and branches of conifers are species of Cytospora and associated perfect forms in the genus Valsa. These species are variously listed as occurring on cankers, dead branches or trunks, or following dieback by some other cause. Cytospora cankers are common on species of spruce in the eastern United States and the disease has been under observation by the writer for some years. A brief comparative study of isolates of this Cytospora on spruce and of an associated species of Valsa, with isolates of Cytospora and Valsa from other conifers has been made, to determine whether cross infection among the conifers may occur. Cultural characteristics and the results of cross inoculations have indicated that the isolates studied can be divided into three groups which differ only slightly from one another. These results, including a discussion of the identity of the species, and experiments on control, are described briefly in this paper.

Hosts and distribution.--Gilgut (5, 6) reported Cytospora kunzei Sacc. as the cause of canker on Colorado blue spruce (Picea pungens Engelm.) and Norway spruce (P. abies (L.) Karst.) in Massachusetts. It was also reported by the writer in 1937 (15) on P. pungens from Vermont, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, and Minnesota; on P. abies from Rhode Island, New York, Pennsylvania, and Illinois; on P. glauca (Moench.) Voss from Massachusetts; P. rubens Sarg. from Maine; and P. orientalis (L.) Link from New York and Pennsylvania.

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On other conifers, various species of Cytospora have been reported as associated with cankers, but their parasitism has been tested on only a few hosts. Zentmyer (19) described a new form of Cytospora cenisia Sacc. (C. cenisia littorialis) as a pathogen on branches and trunks of Cupressus sempervirens stricta Ait. in California, causing serious injury and death of trees weakened by unfavorable environment. Wright (18) reported Cytospora abietis Sacc. as the cause of cankers on forest trees of Abies concolor (Gord. & Glend.) Lindl. and A. magnifica A. Murr. in the northern Sierra Nevada, when the trees were weakened by environmental factors. Baxter (2) found cankers on plantation trees of Himalayan pine (Pinus wallichiana A. B. Jackson) in the Saginaw Forest, Michigan, on which fruiting bodies of a fungus identified as Valsa superficialis Nits. and its Cytospora stage were abundant. Girdling cankers at the nodes caused dieback and death of the trees.

In 1930 a canker was described (1) on European larch (Larix decidua Mill.) growing in a poor site in a forest reservation in Saratoga County, New York. From cankers on these trees collected by the writer in 1936, and from European larches in other localities in New York, Massachusetts, and Pennsylvania, a species of Cytospora and an associated Valsa were isolated and studied.

On other conifers, various species of *Cytospora* have been reported as associated with cankers, but their parasitism has been tested on only a few hosts. Bentmyer (19) described a new form of *Cytospora centrale* Sacc. (*C. centrula littoralis*) as a pathogen on branches and trunks of *Cupressus sempervirens* atriotes Ait. In California, causing serious injury and death of these [illegible]

Cytospora abietis Sacc. as the cause of cankers on inoculated trees of *Abies concolor* (Gord. & Glend.) Lindl. and *A. magnifica* A. Murr. in the northern Sierra Nevada, when the trees were weakened by environmental factors. Baxter (2) found cankers on plantation trees of Himalayan pine (*Pinus wallichiana* A. B. deckson) in the Saginaw Forest, Michigan, on which fruiting bodies of a fungus identified as *Valsa superficialis* Nits. and its *Cytospora* stage were abundant. Girdling cankers at the nodes caused dieback and death of the trees.

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From cankers, or branches killed by girdling cankers, on ornamental, plantation, or forest trees, species of Valsa and Cytospora were isolated and studied from Pseudotsuga menziesii (Mirb.) Franco in New Hampshire, Vermont, Massachusetts, Pennsylvania, and Washington; Abies balsamea (L.) Mill. in Maine and Vermont; Tsuga canadensis (L.) Carr. in New Hampshire and Connecticut; Pinus strobus L. in Maine, Connecticut, New York, and Virginia; P. wallichiana in Maryland; Picea abies in Massachusetts and Connecticut; P. glauca in Connecticut; P. orientalis in Connecticut and Pennsylvania; P. pungens in Connecticut, New York, and New Jersey; and P. rubens in Maine and New Hampshire.

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Symptoms.--The disease symptoms on the several hosts included in the study varied slightly as follows:

Spruce.--On blue, white, and oriental spruces, the cankers occur principally on the lower branches, frequently starting around the base of a small twig. If a branch becomes girdled by a canker, dieback causes brown "flags." The disease progresses slowly and trees are rarely killed, though seriously disfigured. On red and Norway spruces, trunk cankers are more common than branch cankers, and the death of entire trees may result. Excessive resin flow is characteristic of infection on all spruces, and indicates the locus of infection. Superficially, the fruiting bodies of the fungus and the limits of the cankered areas are not evident. When the resin and outer bark are peeled off, the brown discoloration of the infected inner bark and cambium is noticeable and the small black Cytospora pycnidia are visible with a hand lens, particularly at the outer margins of the resinous area. In moist summer weather amber or orange colored spore tendrils may exude. Small black erumpent fruiting bodies of the Valsa are found on branches that have been killed recently by girdling cankers, or on old cankers associated with the Cytospora, as reported by Marsden (11).

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[illegible] around the base of a small twig. If a branch becomes girdled by [illegible] slowly and trees are rarely killed, though seriously disfigured. On red and Norway spruces, trunk cankers are more common than branch cankers, and the death of entire trees may result. Resin flow is characteristic of infection on all spruces, and indicates the locus of infection. Superficially, the fruiting bodies of the fungus and the limits of the cankered areas are not evident. When the resin and outer bark are peeled off, the brown discoloration of the infected inner bark and cambium is noticeable and the small black *Cytospora* pycnidia are visible with a hand lens, particularly at the outer margins of the resinous area. In moist summer weather amber or orange colored spore tendrils may exude. Small black erumpent fruiting bodies of the *Valsa* are found on branches that have been killed recently by girdling cankers, or on old cankers associated with the *Cytospora*, as reported by Waterman (11).

European larch.--Both branch and stem cankers are found on European larch, and serious injury or death of young trees may result. The area of infection is more clearly defined than on spruce. The bark of young branch or trunk cankers is slightly depressed and is smoother than that of healthy portions. The margins of the cankers gradually become raised, the bark cracks, and callus is formed. Older branch cankers have heavily callused margins and may become hypertrophied by excessive callus growth. Resin flow is not as excessive as on spruce, but is conspicuous, particularly on the smooth bark near the margins of the canker.

Douglas fir.--Young branch and trunk cankers develop slowly and are more or less depressed with smooth bark, gradually becoming cracked and callused at the margins. Cytospora fruiting bodies form as small erumpent pustules scattered over the infected areas. Infected trees are disfigured, but usually are not killed, unless infection is accompanied by unfavorable growing conditions. Resin flow is not excessive, but on older cankers a thin deposit of resin may cover most of the bark. A species of Valsa is found on dead branches that have been killed by girdling cankers.

European larch.—Both branch and stem cankers are found on European larch, and serious injury or death of young trees may result. The area of infection is more clearly defined than on spruce. The bark of young branch or trunk cankers is slightly depressed and is smoother than that of healthy portions. The margins of the cankers gradually become raised, the bark cracks, and callus is formed. Older branch cankers have heavily callused, deeply cracked margins, and the callus is often overgrown by healthy bark. Resin flow is not as excessive as on spruce, but is sometimes particularly on the smooth bark near the margins of the canker.

Douglas fir.—Young branch and trunk cankers develop slowly and are more or less depressed with smooth bark, gradually becoming [illegible]. Cankered areas are small enough to be scattered over the diseased crown. Infected trees are distressed, but usually are not killed, unless the infection is accompanied by unfavorable growing conditions. Resin flow is not excessive, but an older canker has a thin deposit of resin on most of the bark. A spruce or [illegible] is found on very

Balsam fir.--Branch or trunk cankers are slightly depressed with callused margins and thin scattered spots of resin. Fruiting bodies of Cytospora are commonly noticeable as erumpent pustules, with spore tendrils exuding in moist weather. A species of Valsa may be found on small twigs killed by developing cankers or in the bark of dead branches. Trees weakened by unfavorable site or other environmental factors seem to be particularly subject to infection and the death of infected trees may result from injury by a combination of such factors.

Eastern hemlock.--Both branch and trunk cankers resemble those on Douglas fir, but resin flow is usually more excessive. On large cankers resin may cover the bark and drip onto the lower branches or flow down the trunk. The bark of the cankers is smooth, depressed, cracked at the margins with callus. Cankers with numerous Cytospora fruiting bodies frequently develop around branch stubs left from pruning. A species of Valsa is found on dead branches. The disease is rarely extensive or serious except on pruned trees in hedge rows.

Balsam fir.--Trees, or trunk sections one slightly decayed with callused margins and thin scattered scale of resin. Pockets of *Trichoderma* are commonly noticeable as cinnamon mottling with scant tenuifila mycelium in moist weather. A species of *Phlebia* may be found on small twigs killed by devitalizing conditions or in the sapwood of dead branches. These weakened by unfavorable site or other environmental factors seem to be particularly subject to infection and the death or infected areas may result from injury by a combination of such factors.

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Eastern white pine.--Branch or trunk cankers are relatively inconspicuous, with little or no resin flow. The bark of the infected area is smooth, reddish-brown, slightly raised at the margin, sometimes with callus. Cytospora fruiting bodies are moderately abundant on the cankers, and also may be found among the conspicuous pustules of the Valsa stage on dead lateral twigs and branches. Infection seems to occur only on trees weakened by other factors, and the fungus itself rarely causes extensive injury.

Himalayan pine.--Branch cankers are small and inconspicuous with smooth bark, cracked and callused at the margin. Trunk cankers usually occur at a node, at first with smooth slightly depressed bark; in older cankers the bark becomes cracked and flaky, with some callus at the margins. Dieback or death of young trees may result from trunk infection. Small erumpent Cytospora fruiting bodies are moderately abundant on the young cankers and conspicuous pustules of the Valsa stage occur on older cankers and dead branches.

Identity of the species of Valsa and Cytospora.--In attempting to identify the fungi isolated from the various conifers, and to determine their possible relation to one another, it was found that the morphological characters of the Cytospora stage were not sufficiently distinctive to indicate that more than one species was involved. The size of the stromata and the size and number of the pycnidial locules in a stroma varied over a wide range on any one host. When compared with similar ranges on other hosts, the differences were too slight to be considered as species distinctions.

Western white pine.--Branch or trunk cankers are relatively inconspicuous, with little or no resin flow. The bark of the infected area is smooth, reddish-brown, slightly raised at the margin, sometimes with callus. Cytospora fruiting bodies are moderately abundant on the cankers, and also may be found among the conspicuous pustules of the Valsa stage on dead lateral twigs and dead branches. Infection seems to occur only on trees weakened by other factors, and the fungus itself rarely causes extensive injury.

Himalayan pine.--Branch cankers are small and inconspicuous with smooth bark, cracked and callused at the margin. Trunk cankers usually occur at a node, at first with smooth slightly depressed bark; in older cankers the bark becomes cracked and flaky, with some callus at the margins. Dieback or death of young trees may [illegible]. Cytospora fruiting bodies are moderately abundant on the young cankers and conspicuous pustules of the Valsa stage occur on older cankers and dead branches.

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Moreover, the size and the shape of the conidia were similar in the pycnidia on all hosts. On certain hosts, particularly balsam fir and white pine, pycnidial stromata that had formed near perithecial stromata were outlined in the cortex by a dark marginal line which delimited the perithecial stromata. This marginal line, however, was usually indistinct or lacking when the pycnidial stromata occurred alone. The perithecial stromata on the coniferous hosts showed certain distinctive and more constant characters and were used in a comparative morphological study.

Marsden (11) reported the isolation of a Valsa, from cankers on Picea abies and P. pungens, which was identified by Wehmeyer as Valsa kunzei (Fr.) Fr. The perithecial stromata in the collections from the various coniferous hosts in this study were compared closely with this fungus.

Four other species of Valsa have been reported in the United States on one or more of these hosts: V. abietis Fr., V. curreyi Nits., V. pini Alb. & Schw. ex Fr., and V. superficialis Nits. Of these, only V. superficialis, reported on Pinus strubus and P. wallichiana, seemed to correspond with any of the isolates studied. Sections of the perithecial stromata from all the hosts showed that the perithecia were surrounded by stromatic tissues and that a more or less pronounced dark marginal zone of tissue delimited the size of the stroma.

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This development of stroma and marginal zone is characteristic of the Valsa subgenus Leucostoma Nits. (12) which includes V. kunzei and V. superficialis. Von Hohnel (7) described Leucostoma as a genus separate from Valsa, on the basis of stromal development. Wehmeyer (17) also considered Leucostoma as a genus with perithecia surrounded by stromatic tissue which has a delimiting zone line. However, the writer has retained the genus name Valsa, until such time as the relation between it and Leucostoma is more definitely established.

The asci and ascospores on all hosts studied were similar and corresponded in form and size range from those described for Valsa kunzei and V. superficialis. The number of perithecia in a stroma, and the shape and size of the perithecia and stromata also were comparatively uniform, but showed slight variations among the different hosts as well as among various collections from the same host.

This development of stroma and marginal zone is observed in the *Valsa* subgenus *Leucostoma* Nitz. (12) which includes *V. kunzei* and *V. auperficialis*. Von Hohnel (7) described *Leucostoma* as a genus separate from *Valsa*, on the basis of stromal development. Wehmeyer (17) also considered *Leucostoma* as a genus with perithecia surrounded by stromatic tissue which has a delimiting zone line. However, the writer has retained the genus name *Valsa*, until such time as the relation between it and *Leucostoma* is more definitely established.

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In Abies balsamea, Pseudotsuga menziesii, Larix decidua, and Tsuga canadensis, the marginal zone line develops before the perithecia become mature, and arises in the innermost layers of the periderm. In a vertical section through the perithecial stromata, this black line is visible with a hand lens, and is conspicuous in a microtome section (Fig. 1). The periderm is split by the developing stroma, and the innermost periderm cells become a part of the zone line which curves closely around the bases of the perithecia. The zone line may extend through the periderm for some distance between the separate stromata, curving inward to border a series of several perithecial or pycnidial stromata.

Around the perithecia, the stromatic tissue includes portions of the decomposing bark cells, but develops outward into a compact cushion-like stroma that soon becomes penetrated by the necks and the ostioles of the perithecia. Superficially this stromatic tissue may be noticeable as a greyish-white disc. This form of perithecial stroma corresponds with that of Valsa kunzei described by Wehmeyer (16) on Thuja plicata Don.

In *Abies balsamea*, *Pseudotsuga menziesii*, *Larix decidua*, and *Picea canadensis*, the marginal zone line develops before the peritheria become mature, and arises in the innermost layers of the peridium. In a vertical section through the peritheacial stroma, this black line is visible with a hand lens, and is conspicuous in a microtome section (Fig. 1). The peridium is split by the developing stroma, and the innermost peridium cells become a part of the zone line which curves closely around the bases of the peritheria. The zone line may extend through the peridium for some distance between the separate stromata, curving inward to border a series of several peritheacial or pyramidal stromata.

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This fungus was originally described by Fries (9) as Sphaeria kunzei "in cortice Abietis frequens." He referred to a specimen of it, number 153 in the exsiccati of Schmidt and Kunze (13), designated as Sphaeria pini Alb. and Schw. pini, on bark of Pinus picea, which is now known as Abies alba Mill. In another reference (3), he stated that the fungus occurred "in cortice Pini piceae; etiam in Abiete," indicating that he had found it on both A. alba and Picea abies. In 1849 Fries (4) transferred S. kunzei to his genus Valsa, as V. kunzei. In the present study, the fungus on Abies balsamea seemed to correspond with the description of the type specimen of V. kunzei. Therefore, the fungus in the collections from A. balsamea, Pseudotsuga menziesii, Larix decidua, and Tsuga canadensis, from New England, is designated as typical of V. kunzei.

This fungus was originally described by Price (9) as *Sphaeria kumaei* "in cortice Abietis frequens." He referred to a specimen of it, number 153 in the exsiccati of Schmidt and Kunze (13), designated as *Sphaeria pini* Alb. and Schw. *pini*, on bark of *Pinus picea*, which is now known as *Abies alba* Mill. In another reference (3), he stated that the fungus occurred 'in cortice Pini piceae; etiam in Abiete," indicating that he had found it on both *A. alba* and *Picea abies*. In 1929 Fries (4) transferred *S. kumaei* to his genus *Valsa*, as *V. kumaei*. In the present study, the fungus on *Abies balsamea* seemed to correspond with the description of the type specimen of *V. kumaei*. Therefore, the fungus in the collections from *A. balsamea*, *Pseudotsuga menziesii*, *Picea rubens*, and large *Picea mariana*, from New England, is designated as typical of *V. kumaei*.

On species of Picea (P. abies, P. glauca, P. pungens) the delimiting zone line is relatively indefinite and inconspicuous, and frequently forms as an irregular broken band of tissue in the cortex slightly below the perithecia when they are fully mature (Fig. 2). Because of its variability, the zone line sometimes is not noticeable except by microscopic examination of microtome sections. The area between the zone line and the bases of the perithecia is filled with decomposed cells of the innermost layer of the periderm and closely matted mycelium in and around the cortex cells. Stromatic tissue surrounds the upper portion of the perithecia, and through it the long perithecial necks penetrate to the bark surface. The cushion-like stromata rarely protrude conspicuously above the flaky bark, but sometimes they form a superficial greyish disc with numerous ostioles. Although this form of stroma varies slightly from that on Abies balsamea and other hosts, the differences do not seem to be sufficient for designating the fungus as a separate species of Valsa. The fungus is therefore considered to be a variety of Valsa kunzei on Picea abies, P. pungens, P. glauca, P. orientalis, and P. rubens, in the collections studied from New England, New York, New Jersey, Pennsylvania, Maryland, and Illinois.

On Pinus strobus and P. wallichiana, the marginal zone is conspicuous but is usually located irregularly in the cortex some distance below the bases of the perithecia (Fig. 3). Although it is first formed in the periderm, it curves deeply into the cortex as an unbroken line, and the perithecia are formed in the outer cortex. The zone line may extend through the cortex for some distance, bordering the stromata of several clusters of perithecia. A dense stromatic tissue develops around the perithecia and the long curving necks. It is usually erumpent with a superficial yellowish-grey disc which becomes inconspicuous when penetrated by the slender protruding necks of the numerous perithecia. A comparison with the perithecia on the other coniferous hosts failed to show any characters of specific significance. The descriptions of Valsa superficialis (8, 16) indicate that the fungus in the collections on Pinus strobus and P. wallichiana in this study corresponds with that species. However, the location of the marginal line in the cortex is the characteristic by which the stromata in these collections differ from those on the other coniferous hosts studied. Therefore, this fungus also is similar to Valsa kunzei and has been considered as a variety of the species in collections from New England, New York, Maryland, and Virginia.

On Pinus strobus and P. wallichiana, the marginal zone is conspicuous but is usually located irregularly in the cortex some distance below the bases of the perithecia (Fig. 8). Although it is first formed in the periderm, it curves deeply into the cortex as an unbroken line, and the perithecia are formed in the outer cortex. The zone line may extend through the cortex for some distance, bordering the stromata of several clusters of perithecia. A dense stromatic tissue develops around the perithecia and the long curving necks. It is usually ornament with a superficial yellowish-grey disc which becomes inconspicuous when penetrated by the slender protruding necks of the numerous perithecia. A comparison with the other coniferous hosts failed to show any characters of specific significance. The descriptions of Valsa superficialis (8, 15) indicate that the fungus in the collections on Pinus strobus and P. wallichiana in this study corresponds with that species. However, the location of the marginal line in the cortex is the characteristic by which the stromata in these collections differ from those on the other coniferous hosts studied. Therefore, this fungus also is similar to Valsa kunzei and has been considered as a variety of the species in collections from New England, New York, Maryland, and Virginia.

It is evident, therefore, that there is considerable similarity in the development of the stromata on the various hosts. However, slight differences indicate the three types of stromal development are involved which are used as the basis for distinguishing three varieties of the species Valsa kunzei as follows:

1) Valsa kunzei var. kunzei var. nov. (typical)[3].--Syn: Sphaeria pini ? pini Schm. & Kunz. Deuts. Schwamme 7:1-6. No. 153. 1817.

Sphaeria kunzei Fr. In Kunz. & Schm., Myk. Hefte 2: 45, 1823; also Syst. Myc. 2: 389. 1823.

Valsa kunzei Fr. Summa Veg. Scand., p. 411. 1849.

Stromata medium to large, scattered, pustulate, with circular greyish disc sometimes inconspicuous, penetrated by small black ostioles; perithecia numerous, oval, with long converging necks, surrounded by stromatic tissue, sometimes with decomposed bark cells in the stroma; wide dark marginal band of tissue limiting the size of the stroma, and separating it from the cortex, curving closely around the bases of the perithecia, sometimes bordering several clusters of perithecia; asci narrow, clavate, sessile, 8-spored, 24-30 x 4-5 μ; ascosproes cylindric, curved, hyaline, continuous, 5-9 x 1.5 μ.

It is evident, therefore, that there is considerable similarity in the development of the stromata on the various hosts. However, slight differences indicate the three types of stromal development are involved which are used as the basis for distinguishing three varieties of the species Valsa kunzei as follows:

1) Valsa kunzei var. kunzei var. nov. (typicus).--Syn:

[illegible]

Cytospora kunzei Fr. In Kunz. & Schm., Myk. Hefte 2: 48. 1823; also Nat. Myc. 2: 589. 1832.

[illegible]

Stromata medium to large, scattered, punctate, with circular areolan disc sometimes inconspicuous, penetrated by small discs surrounded by stromatic tissue, sometimes with decomposed bark cells in the stroma; wide dark marginal band of tissue limiting the size of the stroma, and separating it from the cortex, curving closely around the bases of the perithecia, sometimes bordering [illegible]

24-30 x 4-5 ; ascospores cylindric, curved, hyaline, contiguous, 5-9 x 1.[illegible].

Pycnidial stage: Cytospora kunzei var. kunzei var. nov. (typical).[3] Syn.: Cytospora kunzei Sacc., Syll. Fung. 3: 270. 1884.: Stromata conoid, solitary or grouped, 1-3 mm. at the base, yellowish grey or dark grey disc at the top usually conspicuous, with one central opening; multilocular, pycnidial locules irregular in size and shape, more or less radially arranged; dense hymenial layer of filamentous conidiophores; conidia continuous, hyaline, curved, 4-6 x 1μ; narrow dark marginal band of tissue delimiting pycnidial stromata that are scattered among perithecial stromata; indistinct or lacking when pycnidial stromata occur alone.

On Abies balsamea, Pseudotsuga menziessi, Larix decidua, Tsuga canadensis, from collections in New England.

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2) Valsa kunzei var. piceae var. nov. Stromata magna, solitaria vel aggregata, disco circulari fusco-griseo rare prominenti, ostiolis magnis atris caespitosis perforato praedita; perithecia numerosa, ovalia vel compressa, collis longis convergentibus munita, stromate subevoluto plerumque mycelio laxe intertexto et cellulis corticis disintegrantibus composito, circum colla peritheciorum densiori, cincta; taenia marginali fusca angusta infra bases peritheciorum, interdum intermittens et indefinita, irregulariter in cortice evoluta; asci angusti clavati sessiles octospori 24-30μ x 4-5μ; ascosporae cylindracae curvatae hyalinae continuae 5-9μ x 1.5μ; asci ascosporaeque varietatae typicae similes.

Status pycnidicus: Cytospora kunzei var, piceae var. nov.: Stromata late conoidea, basi 3-4 mm. lata, disco fusco-griseo apice ore uno centrali aperienti praedita; multilocularii loculi pycnidici magnitudine formaque variabiles labyrinthiformes plus minusve radiatim dispositi; strato hymeniali denso conidiophororum filamentosorum vestiti; conidia continua, hyaline, curvata, 4-6μ x 1μ; taenia texturae marginali angusta fusca stromatem limitanti in cortice infra loculos pycnidicos intimos interdum evoluta, plerumque intermittenti et indefinita. A varietate typica stromatibus latioribus et taenia marginali irregulari indefinite differt.

Stromata large, solitary or grouped, circular greyish disc rarely prominent, ostioles large, black clustered; perithecia numerous, oval, or flattened by crowding, with long converging necks; surrounded by poorly developed stroma, usually composed of loosely matted mycelium and decomposing bark cells; merging into denser stromal tissue around perithecial necks; narrow dark marginal band of stromatic tissue developed irregularly in the cortex slightly below the bases of the perithecia, sometimes intermittent and poorly defined; asci narrow, clavate, sessile, 8-spored, 24-30μ x 4-5μ; ascospores cylindric, curved, hyaline, continuous, 5-9μ x 1.5μ; asci and ascospores resembling those of the type variety.

resembling those of the type variety.

Pycnidial stage: Cytospora kunzei var. piceae var. nov.: Stromata broadly conoid, 3-4 mm. at the base, dark grey disc at the top with one central opening; multilocular, pycnidial locules irregular in size and shape, labyrinthiform, more or less radially arranged; dense hymenial layer of filamentous conidiophores; conidia continuous, hyaline, curved, 4-6 x 1 ; narrow dark marginal band of tissue delimiting stroma occasionally developing irregularly in the cortex slightly below the innermost pycnidial locules, usually intermittent and poorly defined. Variety differs from the type variety in the broader stromata and the poorly defined irregular marginal band of tissue.

On Picea abies, P. glauca, P. pungens, P. orientalis, P. rubens, from collections in New England, New York, New Jersey, and Pennsylvania.

Specimens of perithecial and pycnidial stages on Picea glauca, Morris, Conn., have been deposited in the National Fungus Collections, Beltsville, Maryland.

Pycnidial stage: *Cytospora kunzei* var. *piceae* var. nov.: Stromata broadly conoid, 3-4 mm. at the base, dark grey disc at the top with one central opening; multilocular, pycnidial locules irregular in size and shape, labyrinthiform, more or less radially arranged; dense hymenial layer of filamentous conidiophores; conidia continuous, hyaline, curved, 4-6 x 1 µ; narrow dark marginal band of tissue delimiting stroma occasionally developing irregularly in the cortex slightly below the innermost pycnidial locules, usually intermittent and poorly defined. Variety differs from the type variety in the broader stromata and the poorly defined irregular marginal band of tissue.

On *Picea abies*, *P. glauca*, *P. pungens*, *P. orientalis*, *P. rubens*, from collections in New England, New York, New Jersey, and Pennsylvania.

Specimens of perithecial and pycnidial stages on *Picea glauca*, Morris, Conn., have been deposited in the National Fungus Collections, Beltsville, Maryland.

3) Valsa kunzei var. superficialis comb. nov., Syn.: Valsa superficialis Nits. Pyren, Germ. p. 232. 1870.

Stromata large, solitary or confluent, circular yellowish-grey disc around erumpent ostioles which are large, black, and clustered; perithecia numerous, oval or flattened by crowding, with long necks surrounded by dense stromatic tissue; narrow dark continuous irregular marginal band of tissue forming at first in the periderm, but curving deeply into the cortex below the perithecia, frequently bordering the stromata of several clusters of perithecia; tissue between marginal line and bases of perithecia composed of mycelium and decomposing bark cells; asci and ascospores as in type variety.

Pycnidial stage: Cytospora kunzei var. superficialis comb. nov. Syn.: Cytospora superficialis Höhn. Mitt. Bot Tech. Hochsch. Wien 3: 5-15. 1928.

Stromata broadly conoid, 4-6 mm. at the base, yellowish-grey disc at the top usually conspicuous, with one central opening; multilocular, pycnidial locules irregular in size and shape, labyrinthiform; dense hymenial layer of filamentous conidiophores; conidia continuous, hyaline, curved, 4-6 x 1 ; narrow black marginal band of tissue in the cortex delimiting the pycnidial stromata frequently present, particularly when perithecial and pycnidial stromata occur in proximity.

On Pinus strobus and P. wallichiana from collections in New England, New York, Maryland, Virginia, and Michigan.

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grey discs around erumpent ostioles when are large, black, and

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marginal line and bases of peritheeia composed of myxelium and decomposing

pure cells; sacci and sacospores as in type variety.

Stromata broadly conoid, 4-6 mm. at the base, yellowish-grey

disc at the top usually conphcuous, with one central opening;

multiloculer, pyramidal locules irregular in size and shape,

lapyrinthiform; dense hymenial layer of filamentous conidiophores;

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band of tissue in the cortex delimiting the pyramidal stromata frequently

present, particularly when peritheeial and pyramidal stromata occur in

proximity.

On Pinus strobus and P. wallichiana from collections in

New England, New York, Maryland, Virginia, and elsewhere.

Cultural study.--Isolates for the study of the cultural characteristics of the Valsa and Cytospora stages on the hosts given in table 1 were grown on agar medium and on sterilized twigs of the host species or a closely related species. In certain collections of the Valsa stage, the ascospores could not be readily separated from one another for monospore cultures. Therefore, from all Valsa collections, asci in a water suspension were cultured on agar plates and monoasci containing germinating ascospores were then isolated.

From the Cytospora stage in the various collections, isolations were from monospores. All isolates produced mature pycnidia of the Cytospora stage on agar medium, but no perithecia. When grown on Leonian's nutrient medium (10) the mycelium and pycnidia showed distinct and constant characters according to the hosts of the original isolates. These distinctions were not so clearly defined or constant on malt or potato dextrose media. The cultures from the monoascu Valsa isolates resembled closely the monospore Cytospora cultures from the same collection. When only the Valsa or the Cytospora stage was present in a collection, the isolates were carefully studied to determine whether all isolates from a host were identical in growth characters.

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Small blocks of mycelium and pycnidia of selected isolates were transferred to sterilized twigs in flasks. The fruiting bodies that were developed on the twigs were much more stromatic and more variable than those produced in nature. Frequently a dense growth of superficial mycelium or a superficial stromatic mass formed around the ostioles. From a comparative series of agar cultures and of twig cultures, the isolates were grouped into three types, representing the three varieties of Valsa kunzei.

1) Valsa kunzei var kunzei. All isolates from Abies balsamea, Larix decidua, Pseudotsuga menziesii, and Tsuga canadensis. On Leonian's nutrient medium: mycelium white or cream colored, appressed to slightly fluffy, pycnidial stromata white to grey or black with white hyphae at the top; relatively small and fairly numerous, cream or yellowish spore tendrils exuding. No perithecia formed in cultures. On sterilized twigs of the respective hosts: white superficial mycelium; small erumpent pycnidial stromata and numerous stromatic perithecia; black marginal zone line formed closely below both pycnidial and perithecial stromata.

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2) Valsa kunzei var. piceae.--All isolates from species of Picea. On Leonian's nutrient medium: mycelium at first white or cream colored, darkening to tawny or brown, appressed forming a dense mat; pycnidial stromata at first olivaceous darkening to brownish black; rare but very large and stromatic; cream or amber colored spore tendrils exuding. No perithecia formed in cultures. On sterilized twigs of Picea abies: surface mycelium scanty or lacking on bark of twigs; large erumpent stromatic pycnidia with dense brown mycelium around ostioles. No perithecial stromata formed. A dark brown or black marginal zone line was formed occasionally slightly below the pycnidial stroma.

3) Valsa kunzei var. superficialis.--All isolates from Pinus strobus and Pinus wallichiana. On Leonian's nutrient medium: mycelium white but appressed closely to the surface of the medium, sometimes darkening to cream or tan; pycnidial stromata white at first, becoming grey or black but white at the top; small and numerous; exuding spore tendrils amber colored. No perithecia formed. On sterilized twigs of Pinus strobus and Larix decidua: surface mycelium scanty or lacking on bark of twigs inoculated with isolates from P. strobus; with small or medium-sized scattered pycnidial and perithecial stromata; dark marginal zone line in the cortex below the perithecial stromata identical with that produced in nature, and also present below pycnidial stromata. The one isolate from Pinus wallichiana produced a slight amount of brownish mycelium with large pycnidial stromata and black marginal zone line in the cortex, but no perithecia.

Valsa kunzei var. picena.--All isolates from needles of Picea. On beerman's nutrient medium: mycelium at first white or cream colored, darkening to tawny or brown, appressed forming a dense mat; pycnidial stromata at first oliveaceous darkening to brownish black; rare but very large and aromatic; cream or amber colored spore tendrils exuding. No perithecia formed in culture. On eterilized twigs of Picea abies: surface mycelium scanty or lacking on bark of twig; large erumpent stromatic pycnidia with dense brown mycelium around ostioles. No perithecial stromata formed. A dark brown or black marginal zone line was formed occasionally slightly below the pycnidial stroma.

3) Valsa kunzei var. superficialis.--All isolates from Pinus mycelium white but appressed closely to the surface of the medium, sometimes darkening to cream or tan; pycnidial stromata white at first, becoming grey or black but white at the top; small and numerous; exuding spore tendrils amber colored. No perithecia formed. On eterilized twiga of Pinus strobus and larix decidua: surface mycelium scanty or lacking on bark of twig; inoculated with isolates from P. strobus; with small or medium-sized scattered pycnidial and perithecial stromata; dark marginal zone line in the cortex below the perithecial stromata identical with that produced in nature, and also present below pycnidial stromata. The one isolate from Pinus multicaule produced a slight amount of brownish mycelium with large pycnidial stromata and black marginal zone line in the cortex, but no perithecia.

Inoculations.--The relation of the Cytospora isolates from spruce with those from other conifers was tested by inoculations on nursery trees of eight species of conifers, including Picea pungens, P. abies, P. glauca, Pseudotsuga menziesii, Larix decidua, Pinus strobus, Tsuga canadensis, and Abies fraseri Poir.

The inoculum consisted of mycelium and mature Cytospora pycnidia from agar cultures obtained by isolations from Picea abies, P. pungens, P. rubens, Abies balsamea, Larix decidua, Pseudotsuga menziesii, Pinus strobus, and Tsuga canadensis. All inoculations were made by cutting with a sterilized scalpel a small triangular section of bark and cambium on a branch. This section was turned back from the wood sufficiently to allow the insertion of a small piece of inoculum. The bark was then pressed back against the inoculum and the part inoculated was wrapped with wet cotton and waxed paper. A total of 288 inoculations were made on the various conifers. Check inoculations were made in the same manner but with the insertion of sterile agar without mycelium. The wrappings were removed after 2 weeks. During the growing season all check inoculations healed with callus and showed no indication of infection.

An inoculation was considered to be positive only if a canker was formed and an organism resembling that of the original inoculum was reisolated. In a few inoculations considerable callus was produced around the wound and the fungus could not be reisolated. Therefore, these results were rated as negative.

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Positive results were obtained only from inoculations with isolates from Picea abies, P. orientalis, and P. glauca on Picea species and on Pseudotsuga menziesii (table 2). Characteristic cankers with excessive resin exudate and Cytospora fruiting bodies were obtained on the species of spruce and from three inoculations on Douglas fir with the isolate from Picea pungens. In seven other similar inoculations on Douglas fir, small cankers developed with resin exudate, but soon became callused and healed over in a year's time. The fungus could not be reisolated from these inoculations. No perithecia were formed in association with the pycnidia on any of the cankers and therefore no determination of the variety of Valsa kunzei could be made from the host. Cultures of the isolated organism, however, resembled those of V. kunzei var. piceae, rather than of V. kunzei var. kunzei.

Infection of conifers by species of Cytospora has been generally considered to occur only on trees weakened by some other factor, such as unfavorable site, drouth, frost, or fire injury. Many of the trees from which the collections were made had been subjected to these or similar adverse conditions. In contrast, the trees used for the inoculations were young healthy trees, most of them growing in a favorable site. Therefore, the vigor of the trees might explain the failure of most of the inoculations. The Cytospora from spruce, however, seems to be a more active wound parasite on its specific hosts, and also may infect Douglas fir.

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Control of Cytospora on spruce.--The prevalence of Cytospora cankers on ornamental blue spruces and the unsightliness of affected trees has caused considerable demand for an efficient method of control (14). Several methods were tried experimentally to determine whether satisfactory results might be obtained.

Diseased trees of white and blue spruce in a large planting were selected for the experiments. All dead branches were pruned out and destroyed. In April 1938, Cytospora cankers on living branches were treated by four methods: 1) Thirteen large cankers on 6 trees were painted with a thick coat of a mixture of Bordeaux and linseed oil; 2) Two cankers on another tree were scraped, removing the outer bark in which the fruiting bodies were imbedded, and no Bordeaux was applied; 3) Three cankers on 2 trees were treated by carefully cutting out all bark and cambium in the cankered area and scraping off the margins of the cankers, and no Bordeaux was applied; 4) One canker was treated as in method 3 and painted with the Bordeaux paste.

In the spring of 1939, the results of these treatments were as follows: 1) Seven of the treated branches painted with Bordeaux had died, with fruiting bodies of Cytospora and Valsa abundant below the Bordeaux and beyond the treated areas; 2) One canker from which the bark was scraped had girdled the branch, causing its death; 3) and 4) Branches with cankers from which the diseased bark was removed were healthy with no evidence of spread of the fungus, and callus was rapidly covering the exposed wood. The callus on the two cankers without Bordeaux eventually completely covered the treated areas and the branches remained healthy. All branches treated by methods 1 and 2 died during the summer of 1940.

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Diseased trees of white and blue spruce in a large planting were selected for the experiments. All dead branches were pruned out and destroyed. In April 1938, Cytospora cankers on living branches were treated by four methods: 1) Thirteen large cankers on 8 trees were painted with a thick coat of a mixture of Bordeaux and linseed oil; 2) Two cankers on another tree were scraped, removing the outer bark in which the fruiting bodies were imbedded, and no Bordeaux was applied; 3) Three cankers on 2 trees were treated by carefully cutting out all bark and cambium in the cankered area and scraping off the margins of the cankers, and no Bordeaux was applied; 4) One canker was treated as in method 3 and painted with the bordeaux paste.

In the spring of 1939, the results of these treatments were as follows: 1) Seven of the treated branches painted with Bordeaux had died, with fruiting bodies of Cytospora and Valsa abundant below the Bordeaux and beyond the treated area; 2) One canker from which the bark was scraped had girdled the branch, causing its death; 3) and 4) Branches with cankers from which the diseased bark was removed were healthy with no evidence of spread of the fungus, and callus was readily covering the exposed wood. The callus on the two cankers without Bordeaux eventually completely covered the treated areas and the branches remained perfectly healthy. All branches treated by methods 1 and 2 died during the summer of 1940.

A second series of cankers on 6 additional trees were treated in June 1941 by cutting out the bark and cambium of the affected areas. One canker per tree was selected. The lengths of the cuts required to remove infected bark were 19, 10-1/2, 6-1/2, 6, 5-1/2 and 3-1/2 inches. The widths of the cuts at the widest part were 2, 1-1/2, 1-1/4, 2-1/4, 1-1/2 inches and 1 inch, respectively. Rapid callus formation occurred in all cases and the branches remained alive into the following growing season. No further observations were made until the spring of 1946 at which time only the branch with the smallest treated canker was still healthy; the remaining branches had died, apparently from new infections and girdling cankers that had occurred between the treated areas and the branch tips.

In May 1941, four slightly infected trees were selected for spray experiments. After the dead or noticeably infected branches were pruned out, all remaining small twig cankers were tagged. One tree was left untreated and the others were sprayed thoroughly with a 4-4-50 Bordeaux mixture, to which casein had been added as a spreader. The spray was applied particularly to the branches, from the trunk outward. Two additional applications were made at 2-week intervals. The following spring it was found that the small cankers had increased in size and new infections were present, on the treated trees as well as on the untreated.

A second series of cankers on 6 additional trees were treated in June 1941 by cutting out the bark and cambium of the affected areas. One canker per tree was selected. The lengths of the cuts required to remove infected bark were 15, 10-1/2, 6-1/2, 6, 5-1/2 and 3-1/2 inches. The widths of the cuts at the widest part were 2, 1-1/2, 1-1/4, 2-1/4, 1-1/2 inches and 1 inch, respectively. Rapid callus formation occurred in all cases and the bramches remained alive into the following growing season. No further observations were made until the spring of 1942 at which time only the branch with the smallest treated canker was still healthy; the remaining branches had died, apparently from new infections and girdling cankers that had occurred between the treated areas and the branch tips.

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It is evident that none of the above methods are satisfactory or practical for the control of the disease. The infection in small individual branch cankers may be controlled by cutting out the affected bark, but in most cases this method would be difficult and impractical on ornamental or plantation trees.

Discussion.--A total of 53 collections of cankers and dead branches with fruiting bodies of Valsa and Cytospora from ornamental trees of the various coniferous hosts and from forest trees, both planted and naturally reproduced, were examined and compared microscopically. Each of the collections in which the Valsa stage was present was classified in the corresponding variety of V. kunzei.

Those having only the Ctyospora stage were closely compared with similar collections in which both Valsa and Cytospora were present and similarly classified. Although each of these collections was listed in one of the three varieties of V. kunzei as described, this does not indicate that this species only is present on the coniferous hosts in the eastern United States. Other species, such as V. abietis, V. cenisia De Not., V. pini, and V. curreyi have been reported in the eastern United States on these same hosts, but their parasitism is not definitely known. Nitschke (12) assigned these species to Euvalsa, a subgenus of Valsa, which is distinguished from V. kunzei by a different type of stromal development and the lack of a delimiting zone line. A study of a larger number of collections from conifers in many localities would be necessary to determine definitely the interrelation of these Valsa species.

It is evident that none of the above methods are satisfactory or practical for the control of the disease. The infection in small individual pinetum gardens may be controlled by cutting out the affected bark, but in most cases this method would be difficult and impractical on ornamental or plantation trees.

Discussion.--A total of 58 collections of gardens and dead branches with fruiting bodies of *Valsa* and *Cytosopora* from ornamental trees of the various coniferous hosts and from forest trees, both planted and naturally reproduced, were examined and compared microscopically. Each of the collections in which the *Valsa* stage was present was classified in the corresponding variety of *V. kunzei*.

Those having only the *Cytosopora* stage were closely compared with similar collections in which both *Valsa* and *Cytosopora* were present and similarly classified. Although each of these collections was listed in one of the three varieties of *V. kunzei* as described, this does not indicate that this species only is present on the coniferous hosts in the eastern United States. Other species, such as *V. abietis*, *V. centata* De Not., *V. pini*, and *V. ourpurea* have been reported in the eastern United States on these same hosts, but their parasitism is not definitely known. Mitsuba (12) assigned these species to *Nivalae*, a subgenus of *Valsa*, which is distinguished from *V. kunzei* by a different type of stroma development and the lack of a delimiting zone line. A study of a larger number of collections from conifers in many localities would be necessary to determine definitely the interrelation of these *Valsa* species.

The results of the inoculations indicated that the variety of Valsa kunzei on species of spruce is an active wound parasite causing canker and dieback. Although it may infect Douglas fir, it does not seem to be serious on that host. Young healthy trees of fir, pine, larch, and hemlock were not susceptible, and also failed to become infected by isolates of the varieties of V. kunzei from these hosts.

Close planting, exposure to frost or other unfavorable climatic conditions, poor soil, and drought, seem to be predisposing factors for susceptibility in ornamental blue spruce plantings. Forest plantation trees of Norway, white, and red spruce, and of European larch, under similar unfavorable conditions are frequently susceptible. The formation of trunk cankers results in serious injury and slow death of the trees. Infection on balsam fir, Douglas fir, hemlock, and pine rarely causes serious injury. Therefore the presence of V, kunzei on any of these coniferous hosts may be indicative of unfavorable growing conditions.

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Spraying of entire trees, treatment of cankers with fungicides or by the removal of all infected tissue, proved ineffective or impractical in controlling infection by Valsa kunzei var. picsae on plantation trees of white and blue spruce. The only effective method of arresting the spread of the disease in ornamental trees is the prompt removal of all infected twigs or branches as soon as possible after infection is detected. Infected plantation trees of the more susceptible species should be removed and destroyed. In the establishment of plantings of susceptible conifers, careful selection of site and of the species best adapted to the site is important to insure the most favorable growing conditions, and thus lessen the possibility of infection.

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Table 1.--Origin of the isolations used in the cultural study of Valsa kunzei on coniferous hosts

Host	Stage of fungus isolated from each collection		
	Both Valsa and Cytospora	Valsa only	Cytospora only
Abies balsamea	Me. - 1[a]	Me.-2, Vt.-1	
Larix decidua	Mass.-1, N.Y.-1		
Pseudotsuga menziesii	N.H.-1	Mass.-1	Vt.-1
Tsuga canadensis		N.H.-1	Conn.-1
Picea pungens	Conn.-1		N.Y.-1, N.J.-1
Picea abies		Mass.-1	Conn.-2, Mass.-1
Picea glauca			Conn.-1
Picea orientalis			Conn.-1, Pa.-2
Picea rubens			Me.-2, N.H.-2
Pinus strobus	N.Y.-1	Me.-2, Conn.-1	Va.-1
Pinus wallichiana			Md.-1

[a]Numerals indicate number of collections studied from each state.

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Abies balsamea	Ma. - I_a	Ma.-2, Va.-1	
Larix decidua	Masa.-1, M.Y.-1		
Pseudotsuga mensiesii	M.M.-1	Masa.-1	Va.-1
Tsuga canadensis		M.M.-1	Conn.-1
Picea pungens	Conn.-1		M.Y.-1, M.d.-1
Picea abies	Masa.-1		Conn.-2, Masa.-1
Picea glauca			Conn.-1
[illegible]			[illegible]
[illegible]			[illegible]
[illegible]	[illegible]		[illegible]
[illegible]			[illegible]

[illegible] indicate number of collections studied from each state.

Table 2.--Results of inoculations on species of Picea and on Pseudotsuga menziesii with isolates of Valsa kunzei from Picea species

Species inoculated	Source of inoculum					
	Picea abies		Picea orientalis		Picea pungens	
	Inoculations	Infections	Inoculations	Infections	Inoculations	Infections
	No.	No.	No.	No.	No.	No.
Picea abies	3	1	9	5	14	9
Picea glauca	2	2	0	0	13	10
Picea pungens	2	2	0	0	13	13
Pseudotsuga menziesii	2	0	1	0	13	3

Table 2.--Results of inoculations on species of Ploca and on Pseudotsuga menziesii with isolates of Yalsa kunzei from Ploca species

Species inoculated	Source of inoculum					
	Ploca abies		Ploca orientalis		Ploca pungens	
	Lesions	Cankers	Lesions	Cankers	Lesions	Cankers
	No.	No.	No.	No.	No.	No.
Ploca abies	3	1	9	5	14	9
Ploca glauca	2	2	0	0	12	10
Ploca pungens	2	2	0	0	13	12
Pseudotsuga menziesii	2	0	1	0	12	8

Fig. 1. Valsa kunzei var. kunzei on Abies balsamea. Young stroma showing black zone line of tissue below perithecia delimiting the size of the stroma.

Fig. 2. Valsa kunzei var. piceae on Picea glauca. Old well-developed stroma, delimited by wide dark irregular band of tissue.

Fig. 3. Valsa kunzei var. superficialis on Pinus strobus. Large cushion-like stroma, with narrow black delimiting line of tissue in the cortex.

Magnifications x 75

Fig. 1. *Valsa kunzei* var. *kunzei* on *Abies balsamea*. Young stroma showing black zone line or tissue below perithecia defining the size of the stroma.

Fig. 2. *Valsa kunzei* var. *pinea* on *Pinus pinea*. Old well-developed stroma, delimited by wide dark irregular band of tissue.

Fig. 3. *Valsa kunzei* var. *pinea* on *Pinus pinea*. Young convolution-like stroma, with narrow black defining line of tissue in the cortex.

Magnifications x 75

Figure. 1. Valsa kunzei var. kunzei on Abies balsamea. Young stroma showing black zone line of tissue below perithecia delimiting the size of the stroma.

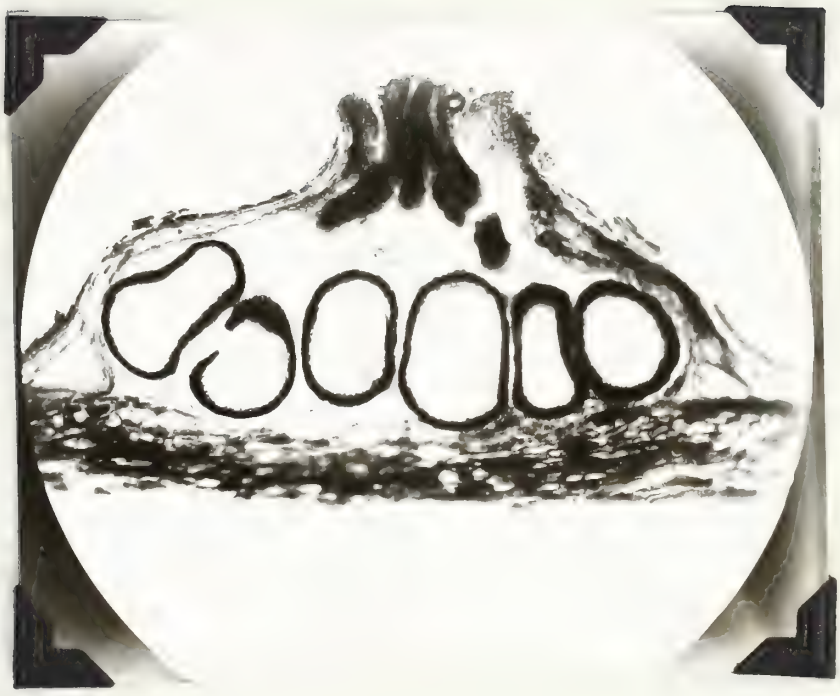

Figure 2. Valsa kunzei var. piceae on Picea glauca. Old well-developed stroma, delimited by wide dark irregular band of tissue.

Yglea kunzei var. picaea on Picea glauca. Old well-
developed stroma, delimited by wide dark irregular
band of tissue.

Figure 3. Valsa kunzei var. superficialis on Pinus strobus. Large cushion-like stroma, with narrow black delimiting line of tissue in cortex.

cushion-like stroma, with narrow black defining line of tissue in cortex.

Summary

Hosts and distribution

Symptoms

Spruce

European larch

Douglas fir

Balsam fir

Eastern hemlock

Eastern white pine

Himalayan pine

Identity of the species of Valsa and Cytospora

Valsa kunzei var. kunzei.

Valsa kunzei var. picea.

Valsa kunzei var. superficialis.

Cultural study

Inoculations

Control of Cytospora on spruce

Discussion

Literature cited