Bursaphelenchus xylophilus **System:** Terrestrial

Kingdom	Phylum	Class	Order	Family
Animalia	Nemata	Secernentea	Aphelenchida	Aphelenchidae

Common name pinewood nematode (English)

Synonym *Aphelenchoides xylophilus* ,
Bursaphelenchus lignicolus

Similar species *Bursaphelenchus*

Summary The pinewood nematode, *Bursaphelenchus xylophilus* is the causative agent of pine wilt disease. Vectors of this nematode are long-horned beetles especially those belonging to the genus *Monochamus*. The introduction of this nematode into Japan had devastating effects on the native pines in that country. Most species of conifers endemic to North America are resistant to the wilt disease, but many exotic species are highly susceptible.

view this species on IUCN Red List

Species Description
The University of Illinois Department of Crop Sciences (1998) states that, \"Accurate *B. xylophilus* identification requires microscopic examination because other species of nematodes frequently inhabit dead or diseased wood.\" The authors go on to state that, \"The most prominent symptom of *B. xylophilus* is the sudden decline and death of the entire tree within a few weeks or months after the first sign of disease. Symptom development is most rapid and uniform over the tree during the warmest months of the year, when the needles seemingly die all at once and in young to middle-aged trees. The foliage of the infected tree passes from the normal, healthy green through four stages of discolouration. The needles first turn light grayish green. By this time, resin no longer flows from the wood and the tree is already dead. The overall colour of the tree then proceeds to a yellowish green as chlorophyll begins to disappear from needles, then to a yellowish brown as the remaining chlorophyll is lost, and finally to a total brown. Longer and softer-needled species of pines show an obvious wilt of needles over the entire tree, as if its source of moisture has been suddenly cut off. Because death is so rapid, the tree retains its brown needles for a long period of time, often up to a year. Thus, wilt-killed pines stand out prominently among healthy neighboring pines.\"
Ichihara *et al.* (2002) state that, \"Fukuda (1997) divided the symptom development into an early stage and an advanced stage. In the early stage, *B. xylophilus* invasion induces cytological changes in pine stems as a defense reaction, resulting in partial cavitations within tracheids. In the advanced stage, a complete cessation of water conduction within the xylem occurs, resulting in physiological changes in needles such as a marked decrease in leaf water potential, and in both photosynthetic and transpiration rates. Sakuta *et al.* (1994) reported that roots stopped growing on the sixth day after *B. xylophilus* inoculation in *Pinus thunbergii* seedlings.\"
Please see PaDIL (Pests and Diseases Image Library) Species Content Page *Non-insects Pine Wilt Nematode* for high quality diagnostic and overview images.

Lifecycle Stages
The following life cycle information has been summarised from the University of Illinois Department of Crop Sciences report on *B. xylophilus* (1998). The *B. xylophilus* disease cycle is highly complex, involving at least four different organisms. Infection of healthy pines results from a unique relationship between *B. xylophilus* and a sawyer beetle in the genus *Monochamus*. The dispersal-stage *B. xylophilus* accumulate around the pupation chamber (of the sawyer beetle) and molt to more specialised, non-feeding fourth-stage juveniles, called dauer larvae. *B. xylophilus* enter the beetle through its spiracles, or breathing pores, and mass within its tracheae, or breathing tubes. The beetle then chews its way out of the wood, carrying large numbers of *B. xylophilus* in a quiescent state in its respiratory system. Soon after emergence from the dead wood, the beetle flies to a live pine and feeds on the branches. *B. xylophilus* emerge from the beetle spiracles and enter the tree through the feeding wounds in the branches. *B. xylophilus* migrate to the resin canals of the pine and molt to adults. The adults begin to feed on the thin-walled cells lining the canals. The adults mate and females begin laying eggs in the resin canals. The juvenile nematode molts once within the eggs, hatches as a second-stage juvenile, and passes through two additional feeding stages before a final molt to the adult stage. This normal life cycle without production of dispersal and dauer larva stages then continues, building up the nematode population in the tree (University of Illinois Department of Crop Sciences, 1998). (Dauer or dauer larva refers to a special larval stage of nematodes at which the animal changes its structure to adapt to an unfavourable environment such as lack of food or high population density. Dauer larvae do not feed but can survive a much longer period of time than non-dauer nematodes do).
As the wood of the dead pine dries, begins to decay, and generally becomes inhospitable to the nematode, reproduction ceases and the second stage juvenile molts to the dispersal stage, rather than to the normal third-stage juvenile (Kosaka, Hajime., pers.comm., 2005).

Habitat Description
Dwinnel (1986) states that, adult pine sawyers (*Monochamus* spp.), which are woodborers, are vectors of *B. xylophilus* and other species of *Bursaphelenchus*. The borers colonise pine logs held in storage or pines weakened or killed by natural or manmade stresses.\" The University of Illinois Department of Crop Sciences (1998) states that, \"Virtually all species of pine grown east of the Rocky Mountains are known hosts of the *B. xylophilus*. The species differs widely, however, in their susceptibility to *B. xylophilus*. Fortunately, native American pines are relatively resistant. Thus, *B. xylophilus* does not appear to be as serious a threat to pine forests in this country as it is to those in Japan, where the native pines are highly susceptible. The disease does not occur in conifers other than pines, although the nematode has been found occasionally in white and blue spruce, balsam fir, eastern and European larch, and Atlas and deodar cedar.\"
Sousa *et al.* (2002) state that, \"Several other insects have also been described worldwide to carry *B. xylophilus*: 21 species of Cerambycidae, two species of Curculionidae and one genus of Buprestidae (Linit, 1988, in Sousa *et al.* 2002).\" Sousa *et al.* (2002) state that their results, \"Showed that *M. galloprovincialis* is the only vector of *B. xylophilus* in Portugal.\"

Reproduction
The University of Illinois Department of Crop Sciences (1998) states that, \"*B. xylophilus* has the shortest life cycle of any plant-parasitic nematode, resulting in a population explosion within highly susceptible pines. One generation is completed in four days when the nematode is cultured on fungi in its optimum. During the warm summer months, *B. xylophilus* reproduce rapidly to very high numbers. They spread throughout the resin canal system of susceptible pines, into the trunk and virtually all branches, and even into the roots. When live tree cells are no longer available,*B. xylophilus* continue to feed and reproduce on the fungal hyphae that grow through the resin canals. *B. xylophilus* become inactive in late fall and over winter in the wood of both live and dead trees. Activity resumes in the spring.\"

Nutrition
Asai & Futai (2001) conducted a study that suggests that, \"The exposure to air pollutants including acid rain might reduce the resistance of pine trees and might lead to their death. In the present study, exposure to sulfur acid rain over 1 year accelerated the disease development in Japanese black pine, whereas exposure to sulfur acid rain over 2 years did not break the tolerance of Japanese red pine trees to pinewood nematode. These results suggest that acid rain is a weak promoting factor of the pine wilt disease.\" The University of Illinois Department of Crop Sciences (1998) states that, \"The adults (of *B. xylophilus*) feed on the thin-walled cells lining the resin canals.\"

General Impacts
APHIS (1999) states that, \"*B. xylophilus* harms pine trees and other conifer plants. Upon infection by *B. xylophilus*, the transmission of water within the plant is hindered, the leaves turn yellow and soon the whole plant wilts and dies. It takes only two to three months from the infection to the death of the plant. Therefore, the wilt disease is internationally recognised to be the most harmful disease of the forestry industry. Up to now the infection has caused death of over 16 million plants. There is about 850 million mu of conifer forest in China. The total area of pine trees, the largest forest resource of China is about 500 million mu. At present *B. xylophilus* has not arrived in the main forest area of China, but due to existence of *Monochamus alternatus*, the highly efficient media of *B. xylophilus*, the suitable climate and lack of natural enemy, *B. xylophilus* can very easily spread in China and cause disastrous damage to the forestry industry as well as the ecological system and tourism in China.\"
Kosaka *et al.* (2001) states that, \"Some well-managed pine forests such as those used for producing Matsutake mushrooms or those growing in tourist areas are suffering from the disease which has spread from surrounding infected forests.\"

Management Info
Skarmoutsos and Skarmoutsos (2000) state that, \"*B. xylophilus* is a quarantine pest for the European Union under Directive 77/93/EEC (Anonymous 1993).\" The EPPO Bulletin (2003) reports that, \"*B. xylophilus* is an EPPO A1 pest.\" The bulletin sets out pest-specific phytosanitary requirements for and its vectors, this covers plants for planting, cut\r\nbranches, isolated bark and various types of wood (squared wood, round wood, packaging wood, particle wood and waste wood) of coniferous species generally.
Samples from 3416 batches of wooden packaging material were inspected for the presence of nematodes in the Ningbo Entry–Exit Inspection and Quarantine Bureau, China between January 2003 to June 2005. *Bursaphelenchus* spp. were detected in 202 batches from 25 different countries, species detected include *B. xylophilus*, *B. fungivorus*, *B. rainulfi*, *B. hylobianum*, *B. thailandae*, *B. mucronatus*, *B. aberrans*, *B. lini*, *B. singaporensis*, *B. doui*, *B. conicaudatus*, *B. vallesianus*, *B. pinasteri*, *B. hofmanni* and *B. arthuri*. The most frequently found species were *B. mucronatus*, *B. xylophilus*, *B. fungivorus*, *B. rainulfi* and *B. thailandae*.
B. xylophilus was not only found in packaging wood imported from areas where it is known to occur (i.e. The United States of America, Japan, Korea, Hong Kong and Taiwan), but also from countries considered to be free of this dangerous pest (i.e. Brazil, Thailand, Belgium, The Netherlands, Italy and Spain).
The authors state that, \" The occurrence of *B. xylophilus* in packaging wood from countries regarded as being free of the nematode can most likely be explained by the global circulation of wooden packaging material among infested and non-infested countries. Our findings emphasise the need to fully implement international standards on phytosanitary treatment of packaging wood, in order to prevent further spread of the pine wood nematode, and the need for careful re-examination of the current heat treatment measures\". (Abstract: Gu *et al.* 2006)
In 2002, United Nation FAO's (Food and Agriculture Organisation) Interim Commission on Phytosanitary Measures imposed a global standard for treating wood packaging International Standard for Phytosanitary Measures No. 15 to stop the spread of invasives, that are now being adopted by individual countries.
For details on management of this species including physical, biological and chemical control please *management information*.
The American Phytopathological Society (APS) offers on its website illustrated lessons to introduce the symptoms and signs, pathogen biology, disease cycle, epidemiology, disease management, and scientific, economic and social significance of major plant diseases. Please follow this link *\r\nPine wilt disease* for details.

Principal source: European and Mediterranean Plant Protection Organisation (EPPO). 2002. *Bursaphelenchus xylophilus* and its vectors: procedures for official control. Bulletin OEPP/EPPO Bulletin
Pine Wilt Disease University of Illinois Department of Crop Sciences, 1998

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ALIEN RANGE

[1] CHINA
[1] JAPAN
[1] MEXICO
[1] TAIWAN
[1] HONG KONG
[1] KOREA, REPUBLIC OF
[1] PORTUGAL

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Summary: The American Phytopathological Society (APS) offers on its website illustrated lessons to introduce the symptoms and signs, pathogen biology, disease cycle, epidemiology, disease management, and scientific, economic and social significance of major plant diseases. The website will also offer basic information on the history, biology, survival, dissemination, host-parasite interactions, epidemiology and management of the major groups of plant pathogens. This section is in development.
APS Introductory Plant Pathology Resources is available from http://www.apsnet.org/education/IntroPlantPath/top.html. This page is available from: http://www.apsnet.org/education/LessonsPlantPath/PineWilt/default.htm [Accessed 7 November 2006]

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Walker, K. 2006. Pine Wilt Nematode (*Bursaphelenchus xylophilus*) Pest and Diseases Image Library. Updated on 24/09/2006 8:10:56 AM.
Summary: PaDIL (Pests and Diseases Image Library) is a Commonwealth Government initiative, developed and built by Museum Victoria s Online Publishing Team, with support provided by DAFF (Department of Agriculture, Fisheries and Forestry) and PHA (Plant Health Australia), a non-profit public company. Project partners also include Museum Victoria, the Western Australian Department of Agriculture and the Queensland University of Technology. The aim of the project is: 1) Production of high quality images showing primarily exotic targeted organisms of plant health concern to Australia. 2) Assist with plant health diagnostics in all areas, from initial to high level. 3) Capacity building for diagnostics in plant health, including linkage developments between training and research organisations. 4) Create and use educational tools for training undergraduates/postgraduates. 5) Engender public awareness about plant health concerns in Australia. PaDIL is available from : http://www.padil.gov.au/aboutOverview.aspx, this page is available from: http://www.padil.gov.au/viewPestDiagnosticImages.aspx?id=574 [Accessed 6 October 2006]

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