EPPO Datasheet: *Pissodes strobi*

Last updated: 2023-03-30

IDENTITY

Preferred name: *Pissodes strobi*
Authority: (Peck)
Taxonomic position: Animalia: Arthropoda: Hexapoda: Insecta: Coleoptera: Curculionidae: Molytinae
Other scientific names: *Pissodes engelmanni* Hopkins, *Pissodes sitchensis* Hopkins
Common names: Engelmann-spruce weevil, Sitka-spruce weevil, white-pine weevil
view more common names online...
EPPO Categorization: A1 list
view more categorizations online...
EU Categorization: Quarantine pest ((EU) 2019/2072 Annex II A)
EPPO Code: PISOST



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Notes on taxonomy and nomenclature

Much information about this species is published under the junior synonyms *P. engelmanni* and *P. sitchensis*. *Pissodes strobi* is known to naturally hybridize with *P. nemorensis* in eastern North America and produce viable offspring (Boyce *et al*., 1994), but it is not known how commonly this happens.

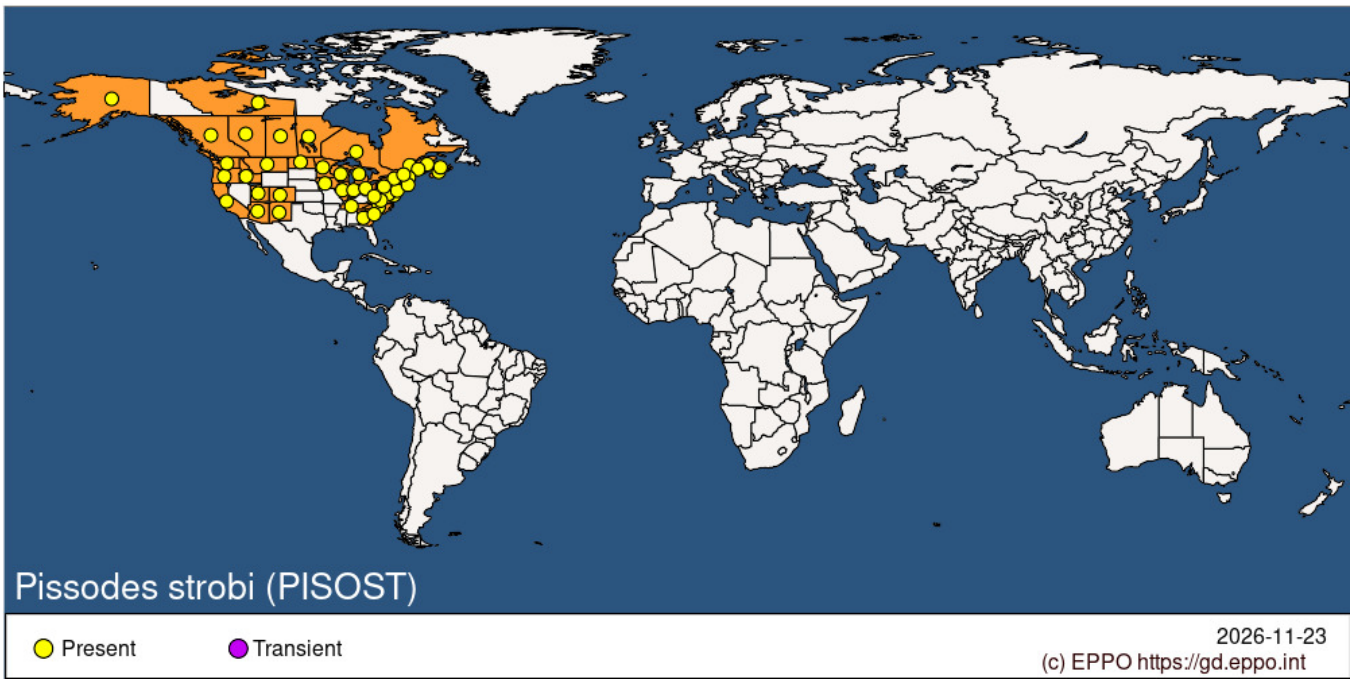
HOSTS

Pissodes strobi is confined to coniferous trees and almost exclusively infests *Pinus* and *Picea* throughout its range. It attacks mainly Sitka spruce (*Picea sitchensis*) along the Pacific coast of North America, Engelmann spruce (*Picea engelmannii*), white spruce (*Picea glauca*) and their hybrids in British Columbia and Pacific Northwest states, white spruce in the Canadian Prairie Provinces and US Great Plains, jack pine (*Pinus banksiana*) in the eastern half of Canada, and eastern white pine (*Pinus strobus*) in Eastern Canada and North-Eastern USA.Many other native pines and spruces also serve as hosts. *Pissodes strobi* also readily attacks and successfully breeds in several tree species native to the EPPO region that are planted in North America. Norway spruce (*Picea abies*) is commonly infested in Eastern Canada and is even preferred for oviposition over the native *P. glauca* and *Pinus strobus* (Hamel *et al.*, 1994). On Vancouver Island, the European *Picea omorika* proved as susceptible to *P. strobi* as the native Sitka spruce (Hulme & Dawson, 1992). Scots pine (*Pinus sylvestris)* is also readily colonized in North American plantations (Khalil, 1969; Klein, 1971). A comprehensive list of host plants of *P. strobi* is found in Smith & Sugden (1969).

Host list: *Picea abies, Picea engelmannii, Picea glauca, Picea mariana, Picea omorika, Picea pungens, Picea rubens, Picea sitchensis, Pinus balfouriana, Pinus banksiana, Pinus cembra, Pinus contorta, Pinus densiflora, Pinus flexilis, Pinus monticola, Pinus mugo, Pinus nigra, Pinus pungens, Pinus resinosa, Pinus rigida, Pinus strobus, Pinus sylvestris, Pinus wallichiana, Pseudotsuga menziesii*

GEOGRAPHICAL DISTRIBUTION

Pissodes strobi has a large distribution in North America ranging from Alaska and the southern part of Northwest Territories south to California, Arizona and New Mexico, across the entirety of Canada (except for Newfoundland and Labrador) and adjacent states, and throughout the North-Eastern USA as far south as Georgia and Tennessee. Old records from Mexico and Newfoundland are incorrect.



North America: Canada (Alberta, British Columbia, Manitoba, New Brunswick, Northwest Territories, Nova Scotia, Ontario, Prince Edward Island, Québec, Saskatchewan), United States of America (Alaska, Arizona, California, Colorado, Connecticut, Delaware, Georgia, Idaho, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, Montana, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin)

BIOLOGY

The biology of *P. strobi* is well documented (e.g., Alfaro, 1994; Hamid *et al.*, 1995; Hiratsuka *et al.*, 1995), and these publications are the main sources utilized for this summary. Adults overwinter in the leaf litter. They leave their hibernation sites in March to late April and walk or fly to host trees where they feed on the previous year's terminal leader (referred to as 'terminal' from here on). There can be more than one terminal on a tree and 1-3 of these can be attacked in the same year. It is not known how far adults can disperse in a season, but they probably travel only far enough to find suitable hosts, which is typically tens to hundreds of metres in forests where there has been harvesting activity and thus where there are plentiful young, regenerating trees. Adults tend to select host trees with the longest and thickest terminal leaders, and these are usually open growing individuals. Adults feed on the inner bark and cambium, chewing a hole of about 1.0-1.5 mm in diameter through the bark to reach these tissues. Feeding is usually concentrated in the apical half of the previous year's terminal, but can extend over its entirety when weevil populations are high. Adult feeding activity is influenced by chemical stimulants in the bark (Alfaro & Borden, 1985). During feeding, males produce an aggregation pheromone consisting of grandisol and grandisal (Booth *et al.*, 1983). Mating occurs on the terminal. A few days after the start of adult feeding, oviposition commences whereby eggs are laid in some of the feeding punctures, which are then termed oviposition punctures. Oviposition punctures are capped with a dark brown plug of excrement but punctures made only for feeding are not. In areas where there are very high weevil populations, oviposition can occur on the stem just below the emergence holes of the previous year, and larval feeding continues down the stem destroying additional years of growth.

Typically one egg, but occasionally as many as four, are laid in each oviposition puncture. Adults usually remain on trees between late March and July. Air temperatures of at least 8°C are required for adult activity, and activity stops above 35°C (Hulme *et al.*, 1986). On eastern white pine, females lay an average of 132 eggs (range 40-344) in the laboratory when supplied with unlimited host material (Trudel *et al.*, 2001). Most females oviposit in more than one terminal and most terminals contain eggs from more than one female. Many eggs and newly hatched larvae can be inundated with resin and killed. When eggs hatch, young larvae commence feeding in the phloem, moving downward in the terminal. Eventually feeding galleries coalesce forming feeding groups, and groups eventually join together to form a feeding ring that spans the circumference of the terminal, effectively girdling it. Larvae that hatch

first and become part of the feeding ring tend to be most successful. Late hatching larvae and those that lag behind the feeding ring find little to eat and die of starvation, or are killed by insect predators under the bark. Larvae first feed in the phloem and as they grow they can also feed on the cambium and even outer wood. There are four larval instars, and third and fourth instars are attacked by hymenopterous parasitoids. Feeding continues for 5-6 weeks, and by late May pupae start to appear. Mature larvae excavate chambers in the outer wood, which can even reach the pith in thin terminals. Larvae chew off small shreds of wood which they use to line the walls of the so called 'chip cocoon', and pupate within.

Pupation lasts 2-3 weeks and new callow adults remain in their chip cocoons for two weeks as their cuticle hardens. The adult emergence period extends from mid-July to late August or even to September in some cooler environments. Hardened adults chew round holes of 3-4 mm diameter through the bark to emerge. They then feed on buds and phloem of side branches and the stem for a few weeks. During this period mating can occur but there is a reproductive diapause. As temperatures decline in early autumn, new adults (and presumably surviving adults from the previous generation) move to the leaf litter to overwinter. Adults typically live only until autumn or winter, but a few can survive winter and live for an additional 1-3 years.

There is variation in phenology. In areas with cooler climates (e.g., higher latitudes and altitudes), some individuals may overwinter in the terminals as large larvae, pupae or callow adults.

Pissodes strobi occurs in relatively small numbers in natural, undisturbed mature conifer forests where they breed in young trees in open areas around edges of stands and in forest gaps caused by blowdown or disease. Populations may build up somewhat in young regenerating stands resulting from wildfire; however, the typical high stem density and presence of overtopping vegetation (e.g., hardwood trees) prevents devastating outbreaks. Industrial forest activities resulting in the creation of large expanses of young and open conifer plantations, many of them managed to eliminate competing vegetation, has been an advantage for this weevil species.

In coastal Sitka spruce stands of British Columbia and Oregon, plantations start being attacked by *P. strobi* by the time they are only five years old (Alfaro & Omule, 1990; Mitchell *et al.*, 1990). Initially only a few trees are attacked but then populations can grow exponentially for 8-10 years. After this period of increase the rate of attack stabilizes at a high level (30-40%), with interannual fluctuations, for 10-20 years. This phase of stability represents an equilibrium between the weevil population level and food supply (i.e., number of leaders available for colonization). This phase of stability eventually gives way to a population decline phase when the plantation is 35-40 years old, when annual rate of attack declines, eventually to about 5%. At this point the growth rate of trees has declined, affecting quality of food supply, and the canopy has started to close, probably adversely affecting environmental conditions for the weevil. A similar epidemiological pattern has been observed for *P. strobi* populations in white spruce in the boreal forest of Alberta.

DETECTION AND IDENTIFICATION

Symptoms

Symptoms are summarised in Hiratsuka *et al.* (1995). Adult *P. strobi* attack trees 0.5–9.0 m tall, but typically 1.5–8.0 m tall. The first signs of attack are visible in early spring on the previous year's terminal growth of spruces and pines, often before all snow has melted from the ground. Beads of resin ooze from feeding punctures and the glistening resin is visible from up to 15 m away on sunny days. Upon close examination of terminal leaders, feeding punctures (1.0-1.5 mm diameter) are visible, particularly on the apical half of the previous year's growth. The feeding of larvae eventually girdles the 2-year-old stem, killing it and the current year's growth above it, causing the affected foliage to wilt, forming a shepherd's crook, and fade to yellow or yellow-brown (in spruces) and yellow to rusty-red (in pines) by June. Dissection of discoloured terminals will reveal the presence of larvae, pupae, adults and/or empty chip cocoons in the bark or outer sapwood of the previous year's terminal; however, as the larvae feed downward in the terminal, it is not uncommon for more than one and up to four years of terminal growth to be infested in one season. After adults emerge, they create circular emergence holes of 3-4 mm diameter in the bark. Dead terminals can remain on trees for many years (even decades) after beetles have emerged, and the presence on these of old adult feeding and oviposition punctures, larval feeding damage to phloem, chip cocoons in the outer wood and adult emergence holes can be used to identify old attacks. When the terminal leader dies, the main stem usually develops a major crook or fork, but these usually straighten out after 2-3 years if the stem is not attacked

again. It is common for the same tree to be attacked in successive years with adults feeding and laying eggs in the stem just below the adult emergence holes of the previous generation. Trees attacked in successive years have a bushy appearance and deformed stems.

Symptoms caused by *P. strobi* may be confused with those caused by the lodgepole terminal weevil, *Pissodes terminalis*, as both species attack the tops of trees and cause the terminal to become discoloured and sometimes form a shepherd's crook. The distributions of both weevil species overlap throughout most of the range of *P. terminalis* (i.e., the western half of North America from southern parts of both Yukon and Northwest Territories south to Colorado and California (Langor *et al.*, 1991)). However, it is possible to distinguish these two species even as early as during feeding and oviposition as: 1) *P. terminalis* feeds and oviposits on the current year's terminal with punctures largely limited to the lower third of the terminal, whereas *P. strobi* feeds and oviposits on the previous year's terminal with most punctures on the upper half and punctures can occur along the entire length of the previous year's growth; 2) larvae of *P. terminalis* feed mainly upward in the leader, at least after the first two weeks following hatching, and individual larval galleries rarely coalesce, whereas the larvae of *P. strobi* feed predominantly downwards in the stem and individual galleries eventually coalesce so that there is an agglomeration of larvae around most or all of the circumference of the stem forming a so-called 'feeding ring'; and 3) *P. terminalis* pupates in the pith of current year's leader and does not form chip cocoons, whereas *P. strobi* pupates mainly in the phloem and outer wood of the previous year's terminal (or even further down the stem) and chip cocoons are formed (Hiratsuka *et al.*, 1995). The only other predominantly terminal-infesting *Pissodes* in the world are *P. nitidus* from North-Eastern China, adjacent parts of Russia, the Korean Peninsula and Japan (Hokkaido) and *P. yunnanensis* from the Yunnan Province of China. Symptoms caused by these species are similar to those caused by *P. strobi* and examination of mature larvae or adults is necessary for identification.

Morphology

Eggs

Eggs are translucent, pearly white, ovoid, 0.7-0.9 mm long and 0.4-0.5 mm wide (Plummer & Pillsbury, 1929), and look like the eggs of many species of *Pissodes*.

Larva

Larvae are legless, have milk-white bodies and light brown heads, the abdomen is slightly curved downwards, and are about 10-12 mm long at maturity (Hiratsuka *et al.*, 1995). Superficially, larvae of this species look like larvae of other species of *Pissodes*. Detailed descriptions of mature larvae of *P. strobi* and *P. terminalis*, as well as those of the closely related *P. nemorensis* and *P. schwarzi*, accompanied by illustrations, are provided by Williams & Langor (2002a). Detailed descriptions mature larvae of the two other known terminal-infesting *Pissodes* in the world, *P. nitidus* and *P. yunnanensis*, are provided by Lee (1992) and Williams & Langor (2011), respectively.

Pupa

Pupae are about 6-8 mm in length and are milk-white, but the mandibles, eyes, rostrum, prothorax and legs become medium brown before adult emergence (Plummer & Pillsbury, 1929). Pupae of different *Pissodes* species cannot currently be distinguished.

Adult

Adults have a long snout, are mottled brown with variable white and yellow patches on the elytra, and 5-8 mm long (Hiratsuka *et al.*, 1995). There is no easy way to discriminate between *P. strobi* and *P. terminalis* without using a morphometric approach (Williams & Langor, 2002b). Adults of *P. strobi* are distinct from native species in the EPPO region and from the terminal-infesting *P. nitidus* and *P. yunnanensis*.

The adult morphology of *P. strobi* is also similar to that of another Nearctic species, *P. nemorensis*, a predominantly bole-inhabiting species (Phillips & Lanier, 1983) that also poses a risk to the EPPO region. The two species are not easily separated except using DNA barcodes. These two species overlap in range in eastern North America. There are forms that are intermediate between the two species and may represent hybrids.

Detection and inspection methods

This species typically attacks spruce and pine saplings ranging from 0.5-9.0 m tall and is most common on trees growing in plantations with an open canopy. More uncommonly, trees less than 0.5 m or greater than 9.0 m tall may be infested. Young saplings with copious resin droplets on the previous year's stem growth should be investigated for signs of weevil attack such as feeding and oviposition punctures and presence of adults on the bark. Drooping of the terminal leader and eventual wilting and discoloration of foliage is also a sign of infestation. Removal of bark on previous year's leader growth on trees suspected of being infested may reveal larval galleries in the phloem, sapwood and pith, pupae, callow adults, chip cocoons and round adult emergence holes in the bark. The presence of chip cocoons is certain evidence of *Pissodes* damage. There are no native species of *Pissodes* in the EPPO region that specifically target the terminal leaders of spruces and pines, so detection of young spruces and pines with such damage and clear evidence of the presence of *Pissodes* is likely to signal the presence of one of four non-native terminal-infesting *Pissodes*, one of which is *P. strobi* (others are *P. terminalis*, *P. nitidus*, and *P. yunnanensis*). DNA barcodes are available for most species of *Pissodes* native to the EPPO region, as well as for all terminal-infesting species except *P. nitidus* (Langor & Sperling, 1997; Zhang *et al.*, 2007).

PATHWAYS FOR MOVEMENT

The natural spread of *Pissodes* spp. is determined by the flight performance of the species which is probably not more than 10 km per year based on what is known about flight capabilities of other species of *Pissodes*. International spread would most probably occur via the shipment of living pines and spruces for planting and Christmas trees. As *P. strobi* attacks only the previous year's leader (and sometimes an additional 1-3 years of stem growth), it is unlikely to be carried by wood commodities, isolated bark or wood packaging material (incl. dunnage).

PEST SIGNIFICANCE

Economic impact

The larvae of *P. strobi* feed downward in the previous year's leader growth and therefore kill at least two year's height growth during the year of attack (previous and current), and sometimes an additional 1-3 years growth depending how far down the stem the larvae tunnel (Hiratsuka *et al.*, 1995). After a leader dies, one or more of the side branches of the first live node below the dead terminal assumes leadership, resulting in a crooked or forked stem with a bushy top. Secondary organisms, especially heartwood rot fungi, may enter through the infested terminals (Ostrander & Foster, 1957). Commonly, trees may be attacked in two or more successive years, with the new attacks (egg laying) commencing on the stem just below the emergence holes of adults of the previous generation (Hiratsuka *et al*., 1995). The more cumulative attacks a tree sustains, the more severe the impact on stem quality and growth, which reduces the tree's value for lumber production. Stem deformities can result in reduction of merchantable volume, and lumber can be degraded due to grain aberrations and bark encased knots at the site of the crooks (Ostrander, 1971; Brace, 1972). Small trees <0.5 m tall may be infested down to the root collar in a single year, resulting in tree death (Hiratsuka *et al.*, 1995). Stand development may also be affected by *P. strobi.* Sitka spruce in mixed plantations were virtually eliminated resulting in development into pure stands of Douglas-fir (*Pseudotsuga menziesii*) in British Columbia (Alfaro & Wegwitz, 1994) and western hemlock (*Tsuga heterophylla*) in Oregon and Washington (Wright & Baisinger, 1955). The high susceptibility of Sitka spruce to *P. strobi* has virtually eliminated this species from reforestation programs in most of coastal British Columbia, Washington and Oregon (King & Alfaro, 2004).

Throughout its range in Canada and the northern and eastern parts of the USA, this weevil is one of the most destructive pests of young spruce and pine plantations, especially of the native *Picea glauca*, *Picea sitchensis* and *Pinus strobus*, as well as of the European *Picea abies* planted in North America. The losses to Sitka spruce in British Columbia as well as the relative benefits of pest management have been modelled (McMullen *et al.*, 1987). In Ontario (Canada), *P. strobi* attacks on *P. strobus* reduced height growth by over 3 m and merchantable volume by 3-20%, resulting in a reduction in timber value by 25% (Brace, 1972). Also, in Ontario from 1980-1983, growth losses in plantations were estimated at 8000 m^3 and annual losses due to culling were estimated at 10 400 m^3 in plantations

and 5000 m^3 in natural stands (Gross, 1985). In New Hampshire, weevil-caused volume loss to *P. strobus* was about 40% in the saw-log portion of trees (Godwin & Reeks, 1967).

Control

Traps baited with ethanol and turpentine have been used to monitor *P. strobi* populations in a *P. sylvestris* Christmas tree plantation in Wisconsin (Rieske & Raffa, 1993). *Pissodes strobi* is especially prevalent in open growing plantations of several conifer species. Once established, weevil populations increase quickly and remain high for many years. Control by pruning or application of pesticides is possible but typically annual interventions are required to keep weevil populations low. Such investment in pest management is economically feasible in only high value plantations (e.g., genetics trials, Christmas tree nurseries). Pruning infested leaders showing signs of wilting and discolouration of current year's terminals can be effective if the entirety of the infested top is removed and the pruned material is destroyed before adults emerge by burning, burying or chipping. A new leader can be encouraged by clipping all but the strongest branch of the uppermost whorl, resulting in an improvement of stem form (Dirks, 1964). The effectiveness of pruning is dependent upon the percent of infested leaders discovered and removed. Not all leaders show symptoms simultaneously, so it is ideal for plantations to be surveyed and pruned twice each summer before adults begin emerging. Two or more years of pruning may be required to reduce the population to acceptable levels, and regular pruning thereafter will likely be necessary to keep populations from building up again.

Many pesticides have been tested for control of *P. strobi*. Approved pesticides mixed with a commercial spreader/sticker to improve persistence on the tree may be applied to the previous year's terminal growth in the spring before adult emergence from overwintering sites, thereby targeting feeding and ovipositing adults. Neem application to leaders containing *P. strobi* eggs and young larvae achieved 68-82% protection of leaders (Helson *et al* ., 1998). Success is affected by the amount of precipitation following pesticide application. Stem implants containing the systemic insecticides oxydemeton-methyl or acephate have been used successfully against *P. strobi* on Sitka spruce in British Columbia (Fraser & Heppner, 1993). Insect growth regulators such as Dimilin and precocene applied to leaders may be effective ovicides or sterilants under certain conditions (Retnakaran & Smith, 1982).

There are potential biological control options for *P. strobi* management. As there are several species of parasitoids that attack *P. strobi*, it may be possible to augment parasitoid populations in plantations by caging pruned infested terminals in meshed cages whereby the mesh size is sufficiently fine to trap the robust weevils but coarse enough to allow escape of the slender parasitoids (Hulme *et al.*, 1987). Some parasitoids of European species of *Pissodes* were identified as having good potential for introduction into North America for classical biological control of *P. strobi* (Hulme, 1994; Kenis & Mills, 1994). Adults, larvae and pupae of *P. strobi* were highly susceptible to several entomopathogenic fungi in laboratory tests (Timonin & Morris, 1974; Kope *et al.*, 2006; Trudel *et al.*, 2007).

In mixed plantations, shading of conifer hosts creates suboptimal environmental (cooler) conditions for *P. strobi*, and may also interfere with host detection; however, shading also slows conifer growth. When crop trees are weevil-susceptible species, faster growing overstory trees (usually hardwoods) should not be all removed to increase conifer growth but rather a portion can be removed to maintain some shade while increasing conifer growth somewhat (Ledig & Smith, 1981; Taylor *et al.*, 1996). Reduced spacing between trees in plantations can also reduce weevil damage (Alfaro & Omule, 1990), although this was not the case for Norway spruce in Quebec (Archambault *et al.*, 1993).

Several native and introduced species of *Pinus* and *Picea* susceptible to *P. strobi* have variants that appear to exhibit resistance to weevil attack or reproduction. Most work on genetic resistance to *P. strobi* has occurred in Sitka spruce and eastern white pine. Resistance is related to relative amounts of different foliar and cortical chemicals (Harris *et al.*, 1983; Brooks *et al.*, 1987), intensity of the induced resin response during injury (Alfaro *et al*., 1996b), density of outer resin ducts (Tomlin & Borden, 1997), crystallization of resin (Santamour & Zinkel, 1977), and chemical-induced reduction of reproduction and progeny development and survival (Sahota *et al.*, 1994). Breeding for genetic resistance to weevil attack could be utilized to complement silvicultural tactics in the management of *P. strobi* (Alfaro *et al*., 1996a). Varieties of trees resistant to *P. strobi* can be mass-propagated using somatic embryogenesis (Roberts, 1994). While there was some evidence for resistance to *P. strobi* in Norway spruce, this species may not possess the defence mechanisms to fight off weevil attack (Poulin *et al*., 2006). It is possible to breed for high?quality, *P. strobi*-resistant Norway spruce reforestation stock with high accuracy achieved from single?trait or multi?trait genomic selection (Lenz *et al.*, 2020).

Alfaro *et al.* (1995) describe an integrated pest management (IPM) system relying on accurate hazard rating of plantation sites and continuous monitoring of attack levels.

Phytosanitary risk

As a serious pest of the non-native *Picea sitchensis* planted in the EPPO region, and of the native *Picea abies* and *Pinus sylvestris*, three very important timber species in Europe, and with an obvious potential to establish in the conditions of Northern Europe which resemble those of Canada, *P. strobi* clearly presents a serious risk for the EPPO region. Lodgepole pine is planted in the EPPO region, particularly in Northern Europe (Vacek *et al.*, 2022), and it is an occasional host of *P. strobi* in Canada (Humble *et al.*, 1994). Finally, other species that are native and widespread in the EPPO region have been recorded as hosts, such as *Pinus nigra*, *P. cembra*, *P. mugo* or *Picea omorika*.

PHYTOSANITARY MEASURES

To prevent the introduction of life stages of *P. strobi* to Europe, EPPO recommends that host plants for planting (except seeds) and cut branches (including Christmas trees) should originate in a pest free area (EPPO, 2018). Pest free place of production is the specific requirement mentioned in the EU regulation (EU, 2022).

As wood commodities and isolated bark are unlikely pathways (see Pathways for movement), phytosanitary measures are not detailed here. Measures for such commodities in relation to *P. strobi* are mentioned in EPPO (2018) and EU (2022).

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