EPPO Datasheet: *Arceuthobium abietinum*

Last updated: 2020-11-06

IDENTITY

Preferred name: *Arceuthobium abietinum*
Authority: (Engelmann) Engelmann ex Munz
Taxonomic position: Plantae: Magnoliophyta: Angiospermae: Basal core eudicots: Santalales: Santalaceae
Common names: fir dwarf mistletoe
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EPPO Categorization: A1 list
view more categorizations online...
EPPO Code: AREAB

Notes on taxonomy and nomenclature

Mathiasen and Kenaley (2019) have recombined the species *Arceuthobium abietinum*. The species consists of three subspecies, which are morphologically distinct and exhibit a high degree of host specificity: (1) *Arceuthobium abietinum* subsp. *abietinum* (formerly f.sp. *concoloris*) (white fir dwarf mistletoe), (2) *Arceuthobium abietinum* subsp. *magnificae* (formerly f.sp. *magnificae*) (red fir dwarf mistletoe), (3) *Arceuthobium abietinum* subsp. *wiensii* (Wiens' dwarf mistletoe). The new designations from Mathiasen and Kenaley (2019) are used in the datasheet. Recently, Kenaley (2020) proposed two further subspecies, namely *Arceuthobium abietinum* subsp. *mathiasenii* (Mathiasen's dwarf mistletoe), and *Arceuthobium abietinum* subsp. *grandae* (grand fir dwarf mistletoe).

HOSTS

Arceuthobium abietinum subsp. *abietinum* is a common plant parasite of *Abies grandis* (Douglas ex D. Don) Lindl. (grand fir), *Abies lowiana* (Gordon) A. Murray bis (Sierra white fir), *Abies concolor* (Gord. et Glend.) Lindl. ex Hildebr. (Rocky Mountain white fir), and the hybrid populations of *Abies concolor x Abies grandis* in the Pacific Northwest and California, USA (Hawksworth *et al*., 2002; Mathiasen, 2019; Mathiasen and Kenaley, 2019). It also parasitizes *Abies durangensis* Martínez (Durango fir) in Durango and Chihuahua, Mexico (Mathiasen, 2010; Quiñonez Barraza *et al*., 2013) and produces heavy infections on *Picea breweriana* Watson (Brewer spruce) (Hawksworth *et al*., 2002)

Arceuthobium abietinum subsp. *abietinum* was also reported on *Tsuga mertensiana* (Bong.) Carrière in Oregon, USA. These trees were growing among severely infected *Abies grandis* (Mathiasen, 2002). The white fir dwarf mistletoe was found to be parasitizing *Pinus mexicana* Martínez in Southern Chihuahua, Mexico (Mathiasen, 2010). Infected *Picea engelmannii* Parry ex Engelm. has been observed in Oregon, USA by Oblinger (2015). Hawksworth *et al.* (2002) reported that *Abies lasiocarpa* (Hook.) Nutt. is occasionally parasitized where this tree grows in association with infected *Abies lowiana* (Arizona, USA). Moreover, the authors stated that *Abies amabilis* (Douglas ex Loudon) J. Forbes is a rare host (Oregon, USA) as well as different *Pinus* spp. (*Pinus ayacahuite* Ehrenb. ex Schltdl., *Pinus contorta* var. *murayama* (Balf.) S.Watson, *Pinus lambertiana* Douglas, and *Pinus monticola* Douglas ex D. Don).

The principal host of *Arceuthobium abietinum* subsp. *magnificae* is *Abies magnifica* (red fir) and its varieties *crutchfieldii* and *shastensis* (Hawksworth *et al*., 2002; Mathiasen, 2019).

Arceuthobium abietinum subsp. *wiensii* is a severe parasite on *Picea breweriana* as well as *Abies magnifica* and occasionally *Abies concolor* and *Abies lasiocarpa*. It is rarely parasitic on *Pinus monticola* (Mathiasen and Daugherty, 2009).

Table: Susceptibility of hosts of *Arceuthobium abietinum.* Note: for the mistletoes there is a classification system of susceptibility (= rare, occasionally, secondary and principal host) and this is adopted for the three subspecies.

	Principal hosts	**Secondary [s], Occasional [o], Rare [r] hosts**
A. abietinum subsp. *abietinum*	*Abies lowiana* *Abies grandis* *Abies durangensis* *Abies concolor* *Abies concolor x A. grandis*	*Picea breweriana* (s) *Picea engelmannii* (r) *Picea mexicana* (o) *Tsuga mertensiana* (r?) *Abies lasiocarpa* (o) *Abies amabilis* (r) *Pinus ayacahuite* (r) *Pinus contorta* var. *murrayana* (r) *Pinus lambertiana* (r) *Pinus monticola* (r)
A. abietinum subsp. *magnificae*	*Abies magnifica*	-
A. abietinum subsp. *wiensii*	*Picea breweriana* *Abies magnifica*	*Abies concolor* (o) *Abies lasiocarpa* (o) *Pinus monticola* (r)

Host list: *Abies amabilis, Abies concolor var. lowiana, Abies concolor, Abies durangensis, Abies grandis, Abies hybrids, Abies lasiocarpa, Abies magnifica, Abies, Picea breweriana, Picea engelmannii subsp. mexicana, Picea engelmannii, Pinus ayacahuite, Pinus contorta var. murrayana, Pinus lambertiana, Pinus monticola, Tsuga mertensiana*

GEOGRAPHICAL DISTRIBUTION

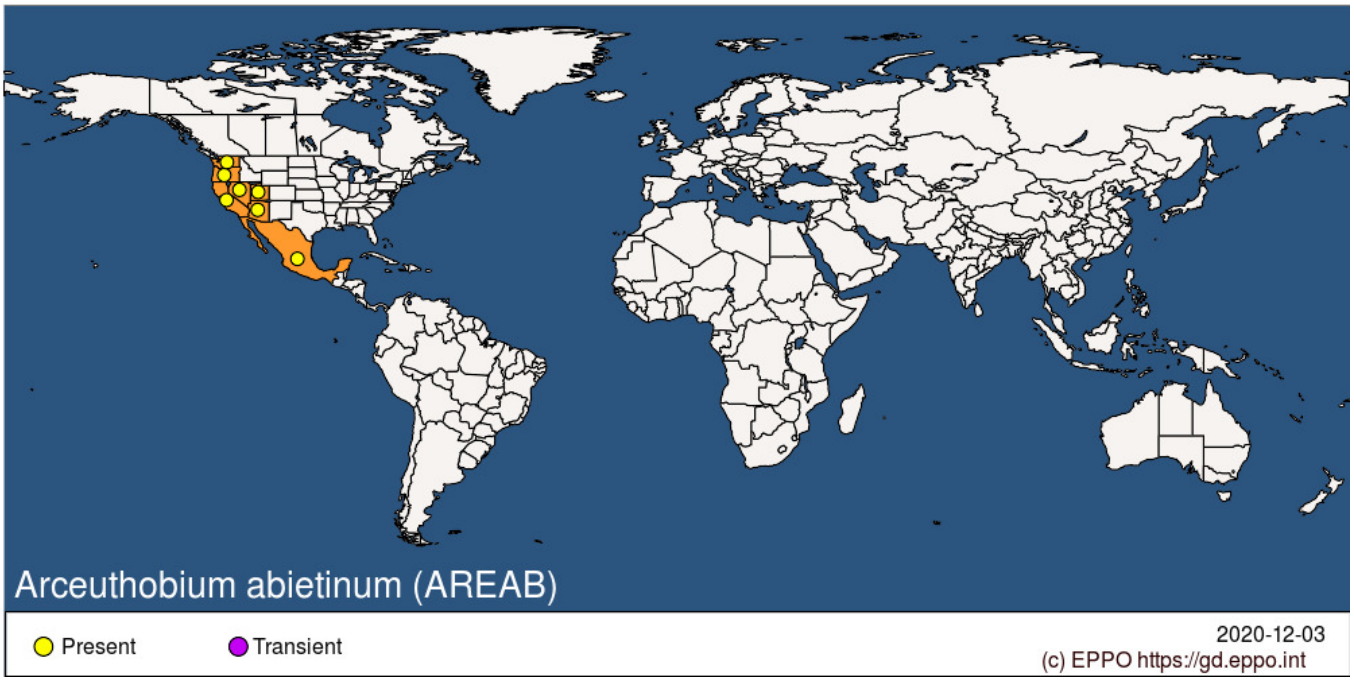
Arceuthobium abietinum occurs in the Western United States and Mexico. A detailed description of its distribution and maps can be found in Mathiasen and Daugherty (2009) and Mathiasen and Kenaley, respectively (2019).

The distribution of *Arceuthobium abietinum* subsp. *abietinum* encompasses Southern Washington southward to Southern California. Isolated populations are present in Nevada, Utah and Arizona (Hawksworth *et al*., 2002). The species has also been found in Mexico (Southern Chihuahua, Durango) (Mathiasen, 2010; Quiñonez Barraza *et al*., 2013). It occurs from near sea level along the coast to over 2 650 m ASL (Southern Nevada).

Arceuthobium abietinum subsp. *magnificae* occurs in Southwestern Oregon to the Southern Sierra Nevada in

California (close to the border of Nevada) (Hawksworth and Wiens, 1996; Hawksworth *et al.*, 2002). Its elevational range is from 1 500 to 2 400 m ASL.

Arceuthobium abietinum subsp. *wiensii* has been found in the Klamath–Siskiyou Mountains in Northwestern California and Southwestern Oregon (Mathiasen, 2010).



North America: Mexico, United States of America (Arizona, California, Nevada, Oregon, Utah, Washington)

BIOLOGY AND ECOLOGY

Information on the biology of *Arceuthobium* spp. can be found in Hawksworth and Wiens (1996) and Hawksworth *et al.* (2002). The life cycle of *Arceuthobium* spp. is distinctive because of two features: (1) obligate parasitism (i.e. an endophytic 'root' system ramifies within the host branch) and (2) hydrostatically controlled, explosive seed dispersal. General aspects of the biology of *Arceuthobium* spp. (with a focus on *Arceuthobium abietinum*) are summarized below.

In *Arceuthobium abietinum*, peak anthesis usually occurs from early-July to mid-September peaking in late-July to late August. Seed dispersal is from late August to late October peaking in late September to early October (Mathiasen and Daugherty, 2009; Mathiasen and Kenaley, 2019). *Arceuthobium abietinum* is dioecious with populations usually exhibiting a 50/50 pistillate/staminate plant ratio. Pollination appears to be predominantly by generalist insects (especially ants and flies), but may also occur by wind. However, no true seeds are formed. The “seed” is an embryo that is embedded in chlorophyllous endosperm, surrounded by viscin (referred to seed hereafter). Dispersal of the seed is involves an explosive process, which expulses the seed with a force that could carry it for up to 10 m. Most seeds of *Arceuthobium* spp. however, are intercepted within 2 to 4 m by host needles by means of its viscin coating. Seed interception rates, however, are highly variable depending on variation in crown density, position of the dwarf mistletoe on the host, and needle characteristics. Many intercepted seeds are lost to disease, predation, or removal by rain. Less than 5% of intercepted seed establish new infections. The number of seeds produced on trees is variable and controlled by variation in the size of the endophytic system, host–parasite physiology, activity by pathogens and insects, and environmental conditions. Once an infection is established, the dwarf mistletoe develops a system of haustoria. After a period of a few years (approx. 2 to 5) from infection, initial shoots develop, and flowering occurs 1 to 2 years after shoot development.

DETECTION AND IDENTIFICATION

Symptoms

The first external symptom is usually a swelling of the host tissues at the infection site, which eventually becomes fusiform (tapered at the ends). Shoots are the best indication that a tree is infected by *Arceuthobium abietinum*. In the absence of shoots, examination with a hand lens of the affected bark, or of a cross section of it, will reveal yellowish, wedge-shaped sinkers, which were the small basal cups in which *Arceuthobium abietinum* shoots were inserted. Other obvious field symptoms of an infection are dying branches (flagging), crown thinning and forming of distorted host branches (witches' brooms). Once the crown is heavily parasitized, growth rate declines rapidly and the height and diameter of trees is reduced, foliage yellows and becomes sparse, with a subsequent top dieback and eventual death (illustrative images of symptoms can be found in Worrall and Geils, 2006). Particularly in early stages of infection, however, symptoms may be subtle or absent.

Morphology

Arceuthobium abietinum is a dioecious and obligate parasite with an endophytic 'root' system ramifying within the host branch. Plants are quite small (max. 25 cm), glabrous, and 'the staminate buds [have the] same color as the subtending bracts' (Hawksworth and Wiens 1996). The detailed description of the subspecies *abietinum*, *magnificae* and *wiensii* follows Mathiasen and Daugherty (2009) and Mathiasen and Kenaley (2019).

Arceuthobium abietinum subsp. *abietinum* can be 3.1 to 24.5 cm in height, with a mean of 11 cm. The basal diameter of dominate plants is 1.7 to 6.8 mm (mean 3.1 mm). The staminate plants are yellow-green, while pistillate plants are primarily yellow-green to green-brown. Staminate flowers are 3- or 4-partite and 2.9 mm and 3.8 mm in diameter (mean), respectively. Fruits are 3.2 to 6.2 mm (4.7 mm) long and 2.2 to 4.1 mm (3.0 mm) wide. Seed are 1.3 to 3.4 mm (2.5 mm) long and 0.8 to 1.6 mm (1.2 mm) wide.

Arceuthobium abietinum subsp. *magnificae* can reach 6.0 to 25.1 cm in height, with a mean of 12 cm. The basal diameter of dominate plants is 1.9 to 7.6 mm (mean 3.5 mm). The staminate plants are yellow-green, while pistillate plants are primarily yellow-green to brown-green. Staminate flowers are 3- or 4-partite and 2.6 mm and 3.8 mm in diameter (mean), respectively. Fruits are 3.4 to 5.9 mm (4.7 mm) long and 2.2 to 3.9 mm (3.0 mm) wide. Seed are 1.8 to 3.3 mm (2.5 mm) long and 0.8 to 1.6 mm (1.2 mm) wide.

Arceuthobium abietinum subsp. *wiensii* can reach 3.8 to 16.1 cm in height, with a mean of 9 cm. The basal diameter of dominate plants is 1.8 to 5.8 mm (mean 3.1 mm). The staminate plants are green-brown to red-brown, while pistillate plants are primarily green-brown to red-brown to yellow-brown. Staminate flowers are 3- or 4-partite and 2.8 mm in diameter (mean). Fruits are 3.1 to 5.0 mm (4.2 mm) long and 2.2 to 3.5 mm (3.0 mm) wide. Seed are 1.9 to 2.9 mm (2.4 mm) long and 0.9 to 1.5 mm (1.1 mm) wide.

The subspecies exhibit extreme host specificity often together with an occurrence only in certain geographical regions. They can be further separated by a few, but significantly different, morphological characters (e.g. shoot colour, plant height, basal diameter of male plants). Another difference between the subspecies is that they have slightly different flowering and seed dispersal periods (Mathiasen and Kenaley, 2019, Kenaley 2020).

Detection and inspection methods

At the initial stage of infection, *Arceuthobium abietinum* grows within the host tissue and cannot be detected by visual inspection. Mature *Arceuthobium abietinum* on infected host tress are conspicuous and can be easily noticed. Identification keys to distinguish the different *Arceuthobium* spp. are accessible (Hawksworth and Wiens, 1996). Molecular detection techniques for *Arceuthobium abietinum* are not available yet, although polymerase chain reaction (PCR) techniques for detecting other *Arceuthobium* spp. in tissues of their hosts have been developed (Marler *et al*., 1999).

PATHWAYS FOR MOVEMENT

Natural dispersal is the main mean of dispersal over a short distance. Birds and mammals may be important for the

rare long-distance dispersal of seeds to new infection centres. Movement of timber, which has not been completely de-barked, can result in movement of complete plants of *Arceuthobium abietinum* and possible transfer of seeds to new sites (Hawksworth and Wiens, 1996; CABI, 2020).

Infected host plants are the most likely pathway of accidental international spread. Plants for planting and cut-branches could carry living plants, especially in the prolonged endophytic stage before the external plant develops (Hawksworth and Wiens, 1996; CABI, 2020).

IMPACTS

Economic impact

Arceuthobium abietinum reduces growth (diameter, height, volume) of the host trees, increases susceptibility to drought stress, attack by other pathogens (decay fungi, such as *Cytospora abietis*), insects, and direct or indirect mortality (Hawksworth and Wiens, 1996; Mehl *et al*., 2013; Mathiasen, 2019). The effects of infections are dependent on multiple interacting factors, such as, physiological status and developmental stage of the host, occurrence of pathogens, stand density and water availability (Hawksworth and Wiens, 1996). Infection rates of the hosts could be very high. In the Sierra Nevada Mountains (USA), Mathiasen (2019) reported that almost 99% of *Abies magnifica* and 98% of *Abies lowiana* were infected in stands infested with subspecies *magnificae* and *abietinum*, respectively. Mortensen *et al*. (2015) showed annual mortality rates in the Sierra Nevada Mountains for *Abies magnifica* and *Abies lowiana* of 1.8% and 3.0%, respectively. The authors stated that the most significant of multiple factors (i.e. drought, pathogens) involved in the mortality *Abies magnifica* was the presence of the respective dwarf mistletoe.

General figures reveal that *Arceuthobium* spp. are very damaging in North American forests. Losses in terms of timber production have been estimated at 11.3 million m^3 of wood in Western USA and 3.8 million m^3 in Western Canada (Worrall and Geils, 2006).

Control

Management strategies for the control of *Arceuthobium* spp. have been developed (e.g. Muir and Geils, 2003; Worrall and Geils, 2006; Hofmann, 2010).

In general, *Arceuthobium* spp. has a few characteristics that can enhance the success of silvicultural treatments (Muir and Geils, 2002). *Arceuthobium* spp. are obligate parasites and need a living host in order to survive and reproduce, they have a limited seed dispersal, slow intensification within tree crowns, and an extended life cycle. Infections in both individual trees and stands are generally easy to detect (stem swellings, presence of yellowish shoots of the dwarf mistletoe, witches' brooms).

Thus, basic management strategies include (Muir and Geils, 2003; Hofmann, 2010):

- Roguing infested tress or pruning brooms and infected branches.

- Replacing affected stands with mistletoe-free regeneration.

- Precommercial thinning: promoting overall tree vigor, stimulating host height.

- Commercial thinning: select trees for removal in a stand that have a dwarf mistletoe rating (DMR) > 3. DMR is a scale for determining the relative population status of a dwarf mistletoe infestation in a stand. Trees with DMR of 3 and less, especially those with infections limited to the lower third of the crown, will most likely not suffer from significant growth losses.

- Controlled use of fire: it can reduce the abundance of dwarf mistletoes, as heavily affected trees are less likely to survive ground fire than less affected trees.

Chemical and biological control options appear to be inadequate (Shamoun and DeWald, 2002). A chemical option

is the application of ethephon (2-chloroethyl phosphoric acid). It works like a natural growth-regulator causing early abscission of flowers, fruits, and shoots of *Arceuthobium* spp. It has been evaluated for numerous mistletoe–host combinations, but not for any *Arceuthobium abietinum*-host species, yet. Moreover, ethephon does not affect the endophytic system, thus new shoots and fruits develop soon after application. A variety of insects and pathogens attack *Arceuthobium* spp., but none has been yet developed sufficiently for practical application.

Phytosanitary risk

EFSA PLH Panel (2018) concluded that impacts on coniferous woodlands, plantations, ornamental trees and nurseries can be expected, if *Arceuthobium* spp. are introduced into the European Union.

Hosts of *Arceuthobium abietinum* include species of the genera *Abies*, *Picea*, *Pinus* and *Tsuga*. Though the principal hosts of the species presented in this data sheet are indigenous to North America, they are cultivated in the EPPO region to some extent (e.g. *Abies concolor*, *Abies grandis*, *Abies magnifica*, *Picea breweriana* in horticulture and landscaping). Once accidentally introduced, there is a risk that *Arceuthobium abietinum* would find hosts on which to multiply, and cause damage in central, eastern and northern European conifer forests.

REGULATORY STATUS

According to EPPO (2018) the specific phytosanitary measures include that plants for planting (except seeds) and cut branches (including cut Christmas trees without roots or soil) of the genera *Abies* and *Picea* should originate from pest-free areas.

REFERENCES

EFSA PLH Panel, Bragard C, Di Serio F, Gonthier P, Jacques M-A, Jaques Miret JA, Justesen AF, MacLeod A, Magnusson CS, Milonas P, Navas-Cortes JA, Parnell S, Potting R, Reignault PL, Thulke H-H, Van der Werf W, Vicent A, Yuen J, Zappala L, Boberg J, Pautasso M and Dehnen-Schmutz K (2018) Scientific Opinion on the pest categorisation of *Arceuthobium* spp. (non-EU). *EFSA Journal* **16**, 5384, 23 pp.

EPPO (2018) PM 8/2(3) Coniferae. *EPPO Bulletin* **48**, 463-494.

Hawksworth FG, Wiens D (1996) *Dwarf mistletoes: Biology, pathology, and systematics*. Agriculture Handbook 709, USDA Forest Service, Washington, DC, USA.

Hawksworth FG, Wiens D, Geils BW (2002) *Arceuthobium* in North America. In: Mistletoes of North American conifers, eds. BW Geils, J Cibrian-Tovar, B Moody, Chapter 4, pp. 29–56, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Hofmann JT (2010) *Management Guide for Dwarf Mistletoe*. US Forest Service. Accessed September 2020, https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5187427.pdf

Kenaley SC (2020) New subspecies of fir dwarf mistletoe (*Arceuthobium abietinum*: Viscaceae) from the western United States and northern Mexico. *Journal of the Botanical Research Institute of Texas* **14**, 27–45.

Marler M, Pedersen D, Mitchell-Olds T, Callaway RM (1999) A polymerase chain reaction method for detecting dwarf mistletoe infection in Douglas-fir and western larch. *Canadian Journal of Forest Research* **29**, 1317–1321.

Mathiasen R (2002) First report of white fir dwarf mistletoe on mountain hemlock. *Plant Disease* **86**, 1274.

Mathiasen RL (2010) First report of white fir dwarf mistletoe (*Arceuthobium abietinum* f. sp. *concoloris*) on Mexican Spruce (*Picea mexicana*) in Northern Mexico. *Plant Disease* **95**, 635.

Mathiasen RL (2019) Susceptibility of red fir and white fir to fir dwarf mistletoe (*Arceuthobium abietinum*) in California. *Forest Pathology* **49**, e12516.

Mathiasen RL, Daugherty CM (2009) *Arceuthobium abietinum* subspecies *wiensii*, a new subspecies of fir dwarf mistletoe (Viscaceae) from northern California and southern Oregon. *Madroño* **56**, 118–126.

Mathiasen RL, Kenaley SC (2019) A morphological comparison of *Arceuthobium abietinum* and *A. campylopodum* (Viscaceae) and nomenclatural changes for *A. abietinum*. *Journal of the Botanical Research Institute of Texas* **13**, 83–101.

Mehl HK, Mori S R, Frankel SJ, Rizzo DM (2013) Mortality and growth of dwarf mistletoe?infected red and white fir and the efficacy of thinning for reducing associated losses. *Forest Pathology* **43**, 193–203.

Mortenson LA, Gray AN, Shaw DC (2015) A forest health inventory assessment of red fir (*Abies magnifica*) in upper montane California. *Écoscience* **22**, 47–58.

Muir JA and Geils BW (2002) Management strategies for dwarf mistletoe: Silviculture. In: Mistletoes of North American conifers, eds. BW Geils, J Cibrian-Tovar, B Moody, Chapter 8, pp. 83–94, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Oblinger BW (2015) First report of white fir dwarf mistletoe (*Arceuthobium abietinum* f. sp. *concoloris*) on Engelmann spruce (*Picea engelmannii*) from Oregon. *Plant Disease* **99**, 1041.

Quiñonez Barraza S, Mathiasen R, Gonzalez-Elizondo S (2013) First report of white fir dwarf mistletoe (*Arceuthobium abietinum* f. sp. *concoloris*) on Durango fir (*Abies durangensis*) from Durango, Mexico. *Plant Disease* **97**, 431–432.

Shamoun SF, DeWald LE (2002) Management strategies for dwarf mistletoes: Biological, chemical, and genetic approaches. In: Mistletoes of North American conifers, eds. BW Geils, J Cibrian-Tovar, B Moody, Chapter 7, pp. 75–82, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Worrall J, Geils B (2006). Dwarf mistletoes. The Plant Health Instructor. Accessed September 2020. https://www.apsnet.org/edcenter/disandpath/parasiticplants/pdlessons/Pages/Dwarfmistletoes.aspx

CABI resources used when preparing this datasheet

CABI (2020) Datasheet *Arceuthobium abietinum* (fir dwarf mistletoe). Accessed September 2020, https://www.cabi.org/isc/datasheet/6823#1793906A-A18F-4B19-AB5E-F68B7962DA63

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Datasheet history

This datasheet was first published in the EPPO Bulletin in 1980 and revised in the two editions of 'Quarantine Pests for Europe' in 1992 and 1997, as well as in 2020. It is now maintained in an electronic format in the EPPO Global Database. The sections on 'Identity', ‘Hosts’, and 'Geographical distribution' are automatically updated from the database. For other sections, the date of last revision is indicated on the right.

CABI/EPPO (1992/1997) *Quarantine Pests for Europe (1st and 2nd edition).* CABI, Wallingford (GB).

EPPO (1980) Data sheets on quarantine organisms No. 40, *Arceuthobium* spp. (non-European). *EPPO Bulletin* **10** (1), 33-39. https://doi.org/10.1111/j.1365-2338.1980.tb02691.x