EPPO Datasheet: *Choristoneura fumiferana*

Last updated: 2022-12-09

IDENTITY

Preferred name: *Choristoneura fumiferana*
Authority: (Clemens)
Taxonomic position: Animalia: Arthropoda: Hexapoda: Insecta: Lepidoptera: Tortricidae
Other scientific names: *Archips fumiferana* (Clemens), *Cacoecia fumiferana* (Clemens), *Harmologa fumiferana* (Clemens), *Tortrix fumiferana* Clemens
Common names: spruce budworm
view more common names online...
EPPO Categorization: A1 list
view more categorizations online...
EU Categorization: A1 Quarantine pest (Annex II A)
EPPO Code: CHONFU

more photos...

Notes on taxonomy and nomenclature

Choristoneura fumiferana (Clemens, 1865) is a member of a larger species complex (=spruce budworm complex) that includes eight or nine species delimited by combinations of morphological, ecological and geographic traits (Freeman, 1967; Volney & Fleming, 2007; Lumley & Sperling, 2011). Overlapping morphological trait variation and genetic similarities between species complicate species delimitation among members of this complex (Freeman, 1967; Lumley & Sperling, 2011; Dupuis *et al*., 2017). However, recent examination of ecological and molecular evidence show that *C. fumiferana* is a distinct species (Brunet *et al*., 2016; Dupuis, 2017; Nelson *et al*., 2022), although there is limited gene flow between *C. fumiferana* and *C. occidentalis biennis* (Blackburn *et al*., 2017).

HOSTS

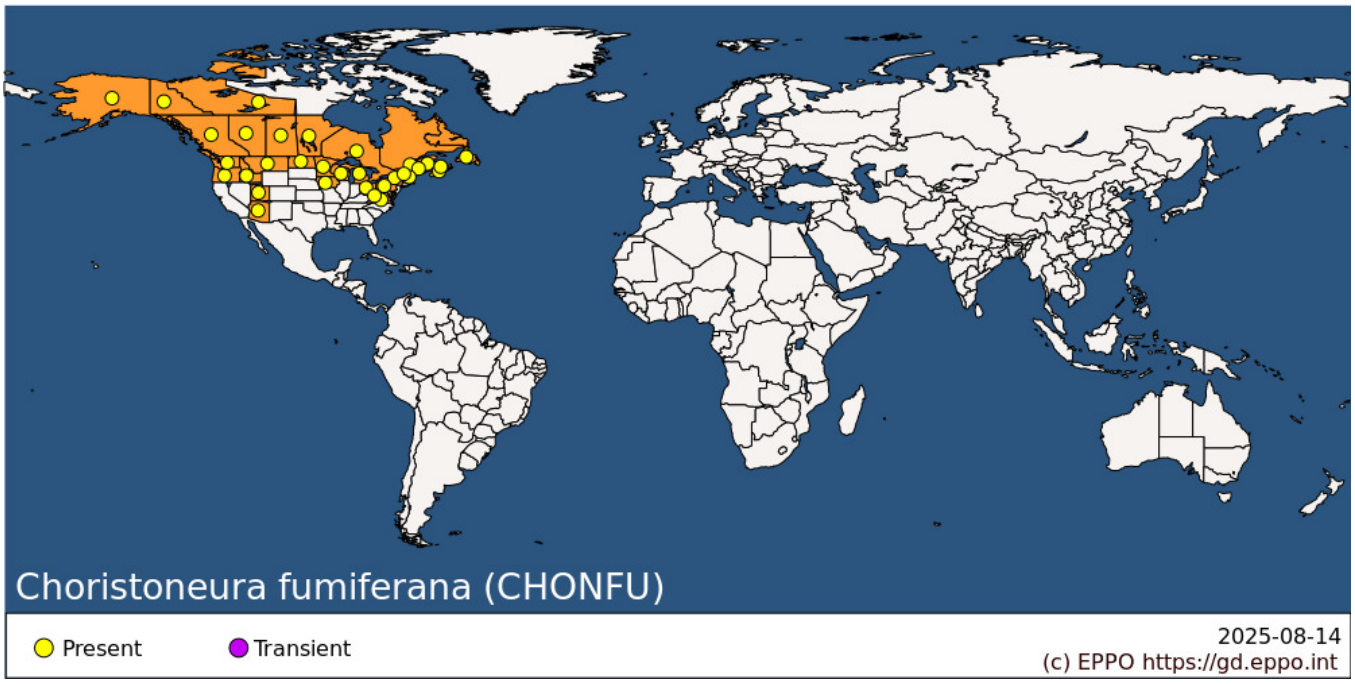
In North America *C. fumiferana* is a major defoliator of coniferous trees. This pest primarily occurs on *Picea* and *Abies*, but has also been recorded on *Pseudotsuga*, *Pinus* and occasionally on *Tsuga* and *Larix* (Brown *et al*., 2008). Stand-level defoliation is well described on *Abies balsamea*, white spruce (*Picea glauca*) and *P. rubens* in Eastern North America and *A. lasiocarpa*, *Picea engelmannii*, *P. glauca* and *Pseudotsuga menziesii* in the West.

Several primary host plants of *C. fumiferana* are widely grown in European forests and plantations (e.g. *Pseudotsuga menziesii*, and for Northern Europe *Abies lasiocarpa*, *Picea engelmannii* and *P. glauca*). In addition, growth and development of spruce budworm on Norway spruce (*Picea abies*) in North American plantations was equivalent to that on white spruce (Berthiaume *et al.*, 2020), highlighting the risks posed to this Norway spruce.

Host list: *Abies balsamea, Abies grandis, Abies lasiocarpa, Abies, Juniperus, Larix laricina, Larix, Picea abies, Picea engelmannii, Picea glauca, Picea mariana, Picea rubens, Picea sitchensis, Picea, Pinus contorta, Pinus, Pseudotsuga menziesii, Tsuga heterophylla, Tsuga*

GEOGRAPHICAL DISTRIBUTION

C. fumiferana is found throughout coniferous forests in Eastern North America and its distribution extends west through the boreal forest, and as far north as Alaska, Yukon, and the Northwest Territories. Host plant availability and seasonal temperatures determine northern and southern limits of the pest (Régnière *et al*. 2012, Gray 2008; Marshall & Sinclair 2015; Butterson *et al*., 2021). Climate change is expected to alter these range limits (Régnière *et al.*, 2012, Candau & Fleming, 2011; Pureswaran *et al*., 2015), changing the defoliation risk in northern forests that have not historically experienced *C. fumiferana* outbreaks (Bognounou *et al.*, 2017).



North America: Canada (Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland, Northwest Territories, Nova Scotia, Ontario, Prince Edward Island, Québec, Saskatchewan, Yukon Territory), United States of America (Alaska, Arizona, Idaho, Iowa, Maine, Michigan, Minnesota, Montana, New Hampshire, New York, North Dakota, Ohio, Oregon, Pennsylvania, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin)

BIOLOGY

C. fumiferana is typically univoltine, with a single generation per year. Adults appear in July or August and mate soon after eclosion. Females lay egg masses on the undersides of needles on their host trees, with up to 20 eggs per mass (Nealis, 2016). Eggs hatch in 8-12 days, and the larvae forgo feeding to seek overwintering locations in bark crevices, under bark scales, lichen mats, or old staminate flower scars (Nealis and Régnière, 2016). Larvae spin silken structures (=hibernacula) in these sites, molt, and enter diapause (Marshall and Roe, 2020). Larvae remain in diapause until late winter and then enter a period of quiescence and resume development in the spring (Han and Bauce, 1996; Marshall and Roe, 2020).

Spring temperatures cue larval emergence, and this occurs prior to budburst in its host plants (Nealis and Régnière, 2016; Régnière and Nealis, 2018). Larvae disperse to branch tips to initially mine old needles, unopened buds, or feed upon the early-opening staminate flowers in advance of host budburst. Once vegetative buds begin opening, larvae move to these new buds and begin feeding within a protective silken cover. Larvae typically have six instars and pupate in their feeding webs or within nearby branches. While one generation per year is typical for *Choristoneura* species, *C. fumiferana* can have a life cycle which takes two-years to complete or one year (if diapause does not occur) (Harvey 1957, 1961).

For more information on the biology of *C. fumiferana* refer also to Furniss and Carolin (2002).

DETECTION AND IDENTIFICATION

Symptoms

In low to moderate population densities, defoliation is restricted to new buds and foliage, especially in the upper crown. Partially consumed needles on the webbed branch tips turn bright reddish-brown by midsummer. At high population densities, host plants can experience severe defoliation, growth reductions and mortality, particularly over successive years (MacLean and Ostaff, 1989).

Morphology

Eggs

The light-green eggs are oval and laid in overlapping shingles along the underside of needles. Egg masses typically contain 20 eggs (Nealis and Régnière, 2004).

Larva

Newly hatched larvae are 1-2 mm in length, pale yellow with a dark head capsule. As they feed and moult, larvae become dark-brown with a black head and light dots along their back.

Pupae

Pupae are dark green and brown, and the sexes can be discriminated by their abdominal morphology (Jennings and Houseweart, 1978). Larvae will pupate in branches near their final feeding structures.

Adult

Adults are predominantly grey with mottled dark-brown markings; their wingspan is approximately 20 mm. A rare brown female morph has also been described (Stehr, 1955).

Detection and inspection methods

Visual detection

Eggs are laid on the underside of needles and can be difficult to detect visually.

Second instar larvae form silken overwintering structures within crevices within branches and the trunk of host plants. While difficult to observe, this stage can be effectively extracted from foliage using a 2% sodium hydroxide wash and counted following separation from plant material with hexane flotation and filtration (Allen *et al*., 1984).

Developing larvae of *C. fumiferana* are found on buds and foliage of coniferous host trees, however they will vacate feeding structures on silken threads when disturbed. Larvae can be identified using available keys and morphological descriptions (Harvey and Stehr, 1967; Lindquist, 1982).

Pheromone traps

Pheromone chemistry is well described for male spruce budworm (Silk *et al*., 1980) and is commercially available. Pheromone trapping is an important management tool to monitor populations within North America (e.g. Carleton *et al*., 2020).

Molecular detection

Molecular identification of specimens from all life stages can be performed using Sanger Sequencing of mitochondrial genes (Lumley and Sperling, 2011). Separation of *C. fumiferana* is predominantly successful, however some complexity arises where *C. fumiferana* populations are genetically very close to other members of the budworm complex (see notes on taxonomy and nomenclature). The EPPO-Q-bank database (https://qbank.eppo.int/arthropods/) notes issues in separating *C. fumiferana* from related North American species. The non-European *Choristoneura*, as a group, can be reliably detected with the standard DNA barcoding region of mitochondrial DNA. Extensive molecular resources are available for *C. fumiferana* and related North American species on Genbank and the DNA Barcoding of Life database (www.boldsystems.org).

PATHWAYS FOR MOVEMENT

Extensive dispersal occurs during population outbreaks of *C. fumiferana*. Adults are strong fliers and can fly 20 km (Greenbank *et al*., 1980), with mated females showing greater dispersal capacity than virgin females (Elliott and Evenden, 2009). When combined with strong winds, *C. fumiferana* can disperse over 450 km (Anderson & Sturtevant, 2011). Wind dispersal also occurs in first instar larvae in late summer and second instar larvae during spring emergence, aided by their habit of ballooning on silken threads (Nealis, 2016).

However, international movement is most likely to occur with diapausing second instar larvae that occur on plants or cut foliage of hosts.

PEST SIGNIFICANCE

Economic impact

C. fumiferana is one of the most widely distributed forest insects in North America and is a highly destructive pest of spruce-fir forests in the USA and Canada. This species undergoes regionally synchronized population outbreaks (Boulanger *et al.*, 2012) that cause widespread defoliation and tree loss. Outbreaks persist for 10 years or more and recur about every 30 to 40 years (Jardon *et al*., 2003). At the peak of an outbreak, spruce budworm repeatedly defoliates *Abies* and *Picea*, leading to growth reduction and mortality, which negatively impacts the forest industry and forest-dependent communities. During the last major outbreak in the 1970s, spruce budworm damaged more than 50 million hectares of forest.

Control

Spruce budworm populations have been typically managed using approaches aimed at protecting high-value stands (= foliage protection). Foliage protection can be achieved via aerial spraying of *Bacillus thuringiensis* var. *kurstaki* (*Btk*) and tebufenozide, which are ingested control products that target larval Lepidoptera (Fleming and Van Frankenhuyzen, 1992; Cadogan *et al.*, 1998). Recently, proactive 'early intervention' strategies are being tested as a means of stopping spruce budworm populations from reaching epidemic levels by focusing aerial spraying on expanding population hotspots (Johns *et al*., 2019).

Mating disruption using sex pheromones has been explored extensively for this species (Rhainds *et al.*, 2012). The success of this tool may be limited to low-density populations at the start of an outbreak (Rhainds *et al.*, 2012), however the impact of disruption can be reduced by adult dispersal into the forest stands that are being treated using mating disruption (Régnière *et al*., 2019).

Spruce budworm populations also have a large range of natural enemies (Fernández-Triana and Huber, 2010) which are considered to be an important source of mortality during development (Royama *et al.*, 2017). Inundative releases of *Trichogramma minutum* successfully reduce regional larval populations (Smith *et al.*, 1990). The relative role of natural enemies (parasitoids and diseases) and bottom-up effects of host plant and weather on population dynamics is not clear and all likely combine to generate the irruptive, cyclical population behaviour observed in *C. fumiferana* (Royama *et al*., 2017).

Silvicultural methods such as thinning can increase stand resistance to spruce budworm outbreaks (Bauce and Fuentealba, 2013).

Phytosanitary risk

C. fumiferana has been added to the EPPO A1 List, but is not regarded as a quarantine pest by any other regional plant protection organization. Of the North American *Choristoneura* species, spruce budworm presents the greatest risk to European forests as it attacks a large number of conifer species and high population densities can lead to tree mortality.

PHYTOSANITARY MEASURES

Requiring that plants for planting or cut branches of hosts (including Christmas trees) originate from a pest free area is an appropriate phytosanitary measure (EPPO, 2018). Other risk management options may be relevant, as recommended for similar Lepidoptera, but whether they are appropriate and feasible for the specific host and commodity should be determined (EPPO, 2021). Such measures include growing the plants under complete physical isolation (EPPO, 2016, 2021, 2022). Measures should be combined with requirements to avoid infestation of the consignments during storage and transport (EPPO, 2022). It is noted that plants for planting of some host species from North America are currently prohibited in the EU (EU, 2022).

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CABI and EFSA resources used when preparing this datasheet

CABI Datasheet on *Choristoneura fumiferana*: https://www.cabi.org/isc/datasheet/13074

EFSA Pest survey card on non-European *Choristoneura*: https://efsa.onlinelibrary.wiley.com/doi/10.2903/j.efsa.2019.5671

ACKNOWLEDGEMENTS

This datasheet was extensively revised in 2022 by Amanda Roe, Research Scientist with the Canadian Forest Service, Natural Resources Canada. Her valuable contribution is gratefully acknowledged.

How to cite this datasheet?

EPPO (2025) *Choristoneura fumiferana*. EPPO datasheets on pests recommended for regulation. Available online. https://gd.eppo.int

Datasheet history

This datasheet was first published in 1997 in the second edition of 'Quarantine Pests for Europe', and revised in 2022. 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 (1997) *Quarantine Pests for Europe (2nd edition)*. CABI, Wallingford (GB).

Co-funded by the European Union