EPPO Datasheet: *Monochamus carolinensis*

Last updated: 2023-09-18

IDENTITY

Preferred name: *Monochamus carolinensis*
Authority: Olivier
Taxonomic position: Animalia: Arthropoda: Hexapoda: Insecta: Coleoptera: Cerambycidae
Common names: carolina sawyer
view more common names online...
EPPO Categorization: A1 list
view more categorizations online...
EPPO Code: MONCCA

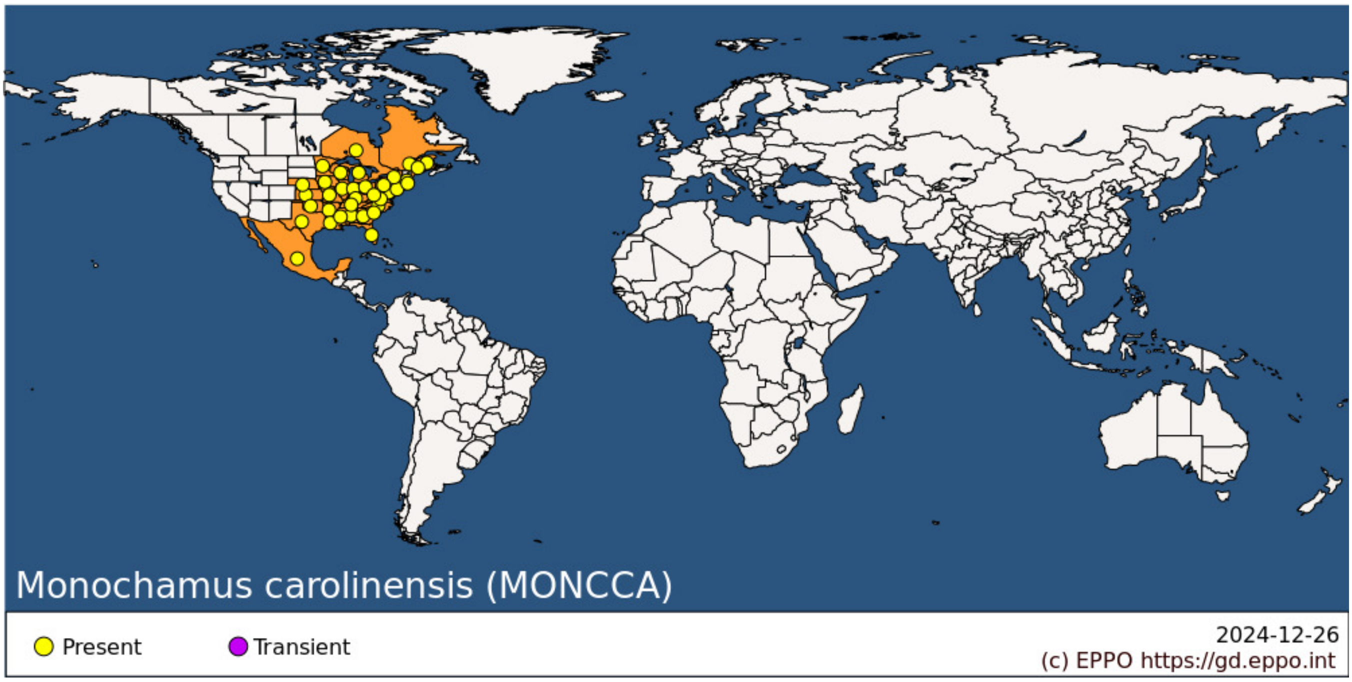
HOSTS

Monochamus carolinensis only attacks and colonizes the members of genus *Pinus*, including jack pine (*P. banksiana*), red pine (*P. resinosa*), eastern white pine (*P. strobus*) (Linsley & Chemsak, 1997), Scots pine (*P. sylvestris*) (MacRae, 1993, Pershing & Linit, 1986b) shortleaf pine (*P. echinata*) (Walsh & Linit, 1984; MacRae, 1993), loblolly pine (*Pinus taeda*) (Alya & Hain, 1985). During experiments, adults of *M. carolinensis* were trapped by flight traps placed at the mid-bole of stressed Virginia pines (*Pinus virginiana*) (Hines & Heikkenen, 1977) showing that they were attracted by these trees, but no adult beetles emerged from the trees.

Host list: *Pinus banksiana*, *Pinus echinata*, *Pinus resinosa*, *Pinus strobus*, *Pinus sylvestris*, *Pinus taeda*

GEOGRAPHICAL DISTRIBUTION

Monochamus carolinensis is native to North America and occurs from South-Eastern Canada (Ontario, Quebec, and New Brunswick) through the eastern half of the USA, from Texas to Minnesota. There is only one record from Mexico (Durango) by Dillon & Dillon (1941).



North America: Canada (New Brunswick, Ontario, Québec), Mexico, United States of America (Alabama, Arkansas, Connecticut, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Virginia, West Virginia, Wisconsin)

BIOLOGY

The development of species in the genus *Monochamus* takes several months to two years (Webb, 1909, Rose, 1957; Akbulut *et al*., 2017). The life cycle of *M. carolinensis* appears to be temperature dependent. In the USA, two-year generations are common in the northern range and two generations per year in the southern range of *M. carolinensis* (Pershing & Linit, 1986a). Adult beetles emerge through circular holes cut in the bark and fly to healthy pine trees, feed on the bark and phloem of twigs and branches prior to mating and oviposition (maturation feeding) for 10-14 days (Akbulut & Stamps, 2012). It is at this point that pine wood nematodes (*Bursaphelenchus xylophilus*), if present on the beetle, exit the beetle's trachea and enter through feeding wounds in the bark. During the night, beetles fly to dead or stressed pines to mate and oviposit in response to volatile chemicals released by trees. After mating, the female deposits an egg below the bark (Walsh & Linit, 1985). If the pine wood nematodes are present in the bodies of female beetles, they may enter oviposition wounds at this time and feed on fungus present in the stressed or dying pine. The number of eggs deposited in an oviposition wound differs both within and among *Monochamus* species (Akbulut *et al*., 2017). The oviposition wounds can be slit like on thin bark or pit like on thick bark, and contain one egg in most cases (Walsh & Linit, 1985), eggless, or multiple eggs can be laid in a single wound. The egg incubation period ranges from 6 to 9 days under natural conditions but can vary from 10 to 12 days according to temperature (Kobayashi *et al*., 1984). The egg hatches and the early instars develop entirely in the subcortical zone of the host trees (Pershing & Linit, 1986b). Larvae can feed on inner bark, cambium, and outer sapwood (Linit, 1988). Late instar larvae construct galleries in the sapwood. Each larva constructs its own gallery. *M. carolinensis* has three to eight larval instars prior to pupation (Pershing & Linit, 1986a). The insect pupates in a chamber in the woody tissue near the cambium layer (Linit, 1988). The adult ecloses within the pupal chamber and remains there for several days until cuticular tanning is complete before exiting the tree. At this point, if present, the dispersal form of the pinewood nematode exits the surrounding wood tissue, crawls onto the body of the insect, and enters the spiracles and trachea for transportation to new host trees. The beetle overwinters most commonly as a larva, but eggs and pupae overwinter as well (Pershing & Linit, 1986a). Adult emergence, which occurs by chewing a round exit hole in the wood and bark, starts in the spring and continues until the late summer. The total development time from oviposition to emergence averages 8-12 weeks (Pershing & Linit, 1986b). In the laboratory, when reared with *Pinus sylvestris* logs, the within-wood developmental period of *M. carolinensis* ranges from 83 to 108 days under constant conditions

(Akbulut & Linit 1999a, 1999b). Linsley (1961) reported that duration of the larval stages of cerambycids can be shorter when they feed on a freshly killed host and longer when they feed on wood that has been dead for some time.

Several studies have examined the life history traits of *M. carolinensis*. Previous laboratory studies (Linit, 1985; Akbulut *et al*., 2004) reported that within-log generation survival of *M. carolinensis* ranged from 6 % to 15 %. Alya & Hain (1985) found within-log generation survival of *M. carolinensis* and *M. titillator* to be 15 % in logs maintained in outdoor cages in North Carolina. The high mortality of beetles within the logs suggested that either intraspecific competition among *M. carolinensis* larvae and/or interspecific competition among *M. carolinensis* and other beetle species occurred within the logs. Akbulut *et al*. (2004) examined the relationships between initial oviposition density and log volume, bark area, and adult survival. They found that the number of adults emerged per log was not related to the number of eggs laid. Late larval and adult numbers were significantly correlated with log size, and only 12% of the initial cohort completed development and emerged as adults. Akbulut *et al*. (2004) attributed the high within-log mortality of beetles to intraspecific competition and cannibalism.

There is a great variation in the longevity of *Monochamus* beetles (Akbulut *et al*., 2017). *M. carolinensis* adults that emerge from *P. sylvestris* logs cut in autumn and spring live for 38 and 59 days, respectively, under laboratory conditions (Akbulut & Linit, 1999b). Togashi *et al*. (2009) reported that the mean longevity of males and females in *M. carolinensis* is 51 and 56 days respectively in the field cages. Similar variations were reported for *M. galloprovincialis* (Naves *et al*., 2006; Akbulut, 2009) and *M. alternatus* (Togashi & Magira 1981; Togashi, 1997). Variations in adult longevity can be attributed to the nutritional quality of the phloem and cambium of pine logs consumed at the larval stage, and also to the quality of the twig subcortical tissues consumed at the adult stage (Akbulut & Linit, 1999b).

The total number of eggs laid by a female (fecundity) varies among species and within species. For example, it ranges from 0 to 384 for *M. carolinensis* (Walsh & Linit, 1985; Akbulut, 1998), and from 0 to 343 for *M. alternatus* (Kobayashi *et al*., 1984; Kobayashi, 1988; Togashi, 1997). *M. galloprovincialis* laid an average of 67 eggs in *P. pinaster* in Portugal (Naves *et al*., 2006), 138 in *P. sylvestris* in France (Koutroumpa *et al*., 2008), 57 eggs in *P. nigra* in Türkiye (Akbulut, 2009).

Monochamus spp. beetles are highly attracted to dead or stressed pine trees. Pheromones for sex attraction may not exist because adult beetles of both sexes are brought together by attraction to volatiles released by the physiological breakdown of pine trees. *M. carolinensis* males search for females (Edwards & Linit, 1991). No sex pheromone is known to exist, and antennal contact between sexes is sufficient for mate recognition in *M. carolinensis*. However, several studies have suggested the existence of sex or aggregation pheromones for other *Monochamus* species (Akbulut *et al*., 2017). Two types of pheromones have been reported for *M. alternatus*: 1) a male sex pheromone that attracts the female and 2) a contact pheromone on the body surface of the female that elicits mate recognition and initiation of courtship (Fauziah *et al*., 1987; Kim *et al*., 1992). Ibeas *et al*. (2008) reported that mature female *M. galloprovincialis* under laboratory conditions were attracted to volatile compounds produced by mature male beetles; however, the males did not respond to female-produced volatiles. A chemical substance of 2-undecyloxy-1-ethanol (monochamol) has been proven to be a male produced aggregation pheromone for *M. galloprovincialis* (Pajares *et al*., 2010), *M. alternatus* (Teale *et al*., 2011), *M. carolinensis* and *M. titillator* (Allison *et al*., 2012, Rasatti *et al*., 2012), *M. scutellatus scutellatus* (Fierke *et al*., 2012) and *M. sutor* (Pajares *et al*., 2013). Macias-Samano *et al* ., (2012) suggest that monochamol is a likely pheromone component for *M. clamator* and *M. obtusus* and attractant for *M. notatus* (Fierke *et al*., 2012). Ryall *et al*. (2015) proved that monochamol is attractive to 12 *Monochamus* species including *M. carolinensis* and has a good potential for surveys of the genus *Monochamus*.

Monochamus beetles are generally poor fliers, even though in flight mill experiments, a *M. carolinensis* beetle has flown a maximum distance of 10 km with a duration of 115 minutes (Akbulut & Linit, 1999c). In the same study, the mean flight distance was reported to be 2.2 km for 1-day-old *M. carolinensis* adult beetles. In mark and recapture studies of the closely related beetle, *M. alternatus*, Ogawa & Hagiwara, (1980) found that most of the beetles were recaptured within 100 m of the release site, whereas Kobayashi *et al*. (1984) reported that beetles mostly moved 800 m from their origin and some flew up to 3.3 km. However, there are no flight performance studies under field conditions for *M. carolinensis*. Mas *et al*. (2013) carried out mark-release-recapture trials with *M. galloprovincialis* and marked adults flew a maximum distance of 22.1 km and about 2% of released beetles travelled more than 3.0 km. Another mark-recapture study carried on *M. galloprovincialis* found that the lifetime adult dispersal distance was 107-122 m on average with a maximum of 464 m (Torres-Villa *et al*., 2015). Several studies were carried out to analyze the spread of pine wilt disease in different countries. The yearly spread of pine wilt disease (due to vector movements) was an average of 7.5 km/year in China (Robinet *et al*., 2009), an average of 6.609km/year in Japan

(Osada *et al*., 2018) and an average of 5.3 km with a maximum of 8.3 km in Portugal (de la Fuente *et al*., 2018). The spread capacities of different *Monochamus* species seem to allow a few kilometres in a single flight and cumulatively reach over several tens of kilometres during the life span of a beetle (EFSA, 2018).

DETECTION AND IDENTIFICATION

Symptoms

The following symptoms and signs may be related to the presence of *Monochamus* spp. (Wilson, 1975, Akbulut & Stamps, 2012):

1. The presence of slit like or pit like oviposition scars chewed into the bark of pine trees.
2. The presence of feeding tracks and oval shaped larval entrance holes in the sapwood caused by larval feeding when the bark is removed.
3. Excelsior-like frass around cut logs from holes in the bark or at the base of trees colonized by the beetle.
4. A round exit hole in the wood and bark created by adults.

Morphology

Egg

Eggs are white, elongate, cylindrical, and slightly flattened with rounded ends. The average size is 2.5 - 3.0 mm long by 0.9 mm wide (CABI, 2019).

Larva

Larvae are soft-bodied, elongate, dirty white in colour, with a light-yellow thorax and amber-brown head. Larvae have ten abdominal segments, are legless, and have a pair of short, stout mandibles. The head is longer than it is wide. Mature larvae may be 25 - 50 mm in length (CABI, 2019).

Pupa

Pupae are initially white and resemble adults in body form. They are 20 -25 mm in length, with antennae tightly curled in spirals flat against the sides of the body. The legs, antennae and wings project from but are closely held to the body. As the pupa matures, it darkens and the limbs become more distinct (CABI, 2019).

Adult

Adult beetles are fairly large, dark reddish-brown insects, 13 - 25 mm in length and 5 -7 mm in width. Male antennae are two times the length of the body, and female antennae are approximately equal to or slightly longer than the length of the body. The antennae are high on the head, close together, and separated by a deep hollow. Males may be slightly smaller and more slender in body shape than females. Both sexes possess a stout pair of mandibles and long, thin legs. The elytra are dark reddish brown with three indistinct bands of white pubescence, giving the elytra a mottled, spotted dirty-white and brown appearance. Each side of the pronotum has a large lateral submedian conical protuberance. The elytra are wider than the pronotum at the base (CABI, 2019).

Detection and inspection methods

Monochamus spp. are attracted to weakened, dying, dead, or freshly cut trees. Therefore, such trees, which often have partly or completely discoloured needles, should be the focus of surveillance for *Monochamus* spp. Close inspection of these trees may allow the detection of oviposition scars in the bark, oval shaped larval entrance holes in the sapwood under the bark or round adult emergence holes in the sapwood. Other cerambycids make similar oviposition scars and emergence holes, so their presence is not a certain confirmation of *M. carolinensis*. Excelsior-like frass may be present around cut logs, from holes in the bark, or at the base of trees infested with the beetle. The cryptic nature of the beetle and its camouflage coloration make it difficult to observe on trees in a natural setting. However, adults can be seen walking or resting on cut and dead wood (EFSA, 2018).

PATHWAYS FOR MOVEMENT

Monochamus beetles are considered to be poor fliers, although there is evidence in the literature (details given in the biology section) that they can perform both short-distance and long-distance dispersals (Akbulut *et al.*, 2017).

According to flight mill, field experiments and models developed *Monochamus* species can naturally disperse by flight a few kilometres to tens of kilometres during their life span. The human assisted spread of *Monochamus* spp. may cover hundreds or thousands of kilometres. Larvae of *Monochamus* spp. develop entirely within the wood, and they are difficult to detect. Therefore, they can be easily transported as untreated conifer wood products in trade. *Monochamus* spp. can be spread by coniferous wood (round or sawn) and wood packaging materials, dunnage from conifers, particle and waste wood of host trees, coniferous wood products and as hitchhikers in containers (EFSA, 2018, 2020). Plants for planting are not likely to be the pathway for the spread of *M. carolinensis*, as they attack dead or stressed pine trees.

PEST SIGNIFICANCE

Economic importance

Monochamus spp. beetles are highly attracted to dead, stressed or recently cut coniferous trees. Therefore, many of them are considered secondary pests, and typically they do not cause the death of trees. *M. carolinensis* may do little damage to healthy trees in the absence of the pine wood nematode (Akbulut & Stamps, 2012). Pine wilt disease is rarely the cause of mortality in native conifers in North America because of the coevolution of the native *Monochamus* species and tree species (Akbulut & Stamps, 2012). The pine wood nematode is widely distributed in the USA, and the disease is most serious in pine trees that are exotic to North America, such as Scots, Austrian, Japanese red and Japanese black pines. Beetles transmit nematodes from dead trees to healthy trees through feeding wounds of newly emerged beetles (during maturation feeding) and weakened, dying, or recently cut trees through oviposition wounds (during egg oviposition). Infection of trees with nematodes under favourable conditions leads to the mass mortality of susceptible pine stands. The disease has a devastating impact on native pine forests in Japan, China, Korea, Taiwan, and Portugal. In the USA, the disease affects exotic pines planted on private properties and natural areas planted with susceptible, non-native, and poorly adapted pine species. Scots pine used in windbreaks, landscape plantings, and Christmas tree farms and nurseries can be affected by pine wilt disease. For lumber producers, timber quality and value can be lessened by beetle’s presence due to larval galleries and the blue stain fungi that are often associated with the beetle's presence in wood (CABI, 2019). Pine wilt disease has a substantial impact on the international wood trade from countries where the nematode and its vector are present to the European Union and other countries. Economic loss as a result of trade restrictions on softwood products is difficult to measure due to environmental, regulatory and supply issues (CABI, 2019), but has been discussed in several publications (Dwinell, 1997; Anon., 1991; Bergdahl, 1988, Miller *et al*., 2013).

Control

In North America, *M. carolinensis* and the pine wood nematode are native and widely distributed. Therefore, control of *M. carolinensis* is usually limited to the removal and burning of infested trees and the timely spraying of insecticides on susceptible exotic pines such as *Pinus sylvestris* (i.e., on Christmas tree plantations). Prevention is the best method for controlling beetles. Adult beetles are attracted to recently dead, dying, or freshly cut trees, so dead and dying trees must be cut down and bark removed from felled trees as quickly as possible to eliminate breeding habitat for the beetles and to prevent nematode transmission to healthy trees (Donald *et al*., 2016). The stumps of logged trees should also be removed or buried as they are also attractive to *M. carolinensis*. *Monochamus* damage can also be prevented by not exposing wood during the egg-laying period of beetles (Dwinell, 1997; Gibson, 2010). Persons in North America who have infected exotic pines on their properties have to remove the infected trees, burn them (CABI, 2019), and are encouraged to plant resistant native conifer species instead of susceptible tree species as ornamentals. Existing valuable trees can be protected from pine wilt disease with preventive injections of nematicide (Donald *et al*., 2016).

Pheromones and traps play an important role in monitoring and controlling *M. carolinensis*. A recent study proved that monochamol (male aggregation pheromone) has good potential for surveying the genus *Monochamus* including *M. carolinensis* (Ryall *et al*., 2015). The blend of monochamol, ipsenol methyl-butenol and ?-pinene used with black Teflon-coated cross-vane traps proved to be an efficient attractant to several *Monochamus* species (Boone *et al*., 2018).

The use of biological control agents against *M. carolinensis* has not been studied (CABI, 2019). The fungus *Beauveria bassiana* has been found to be effective against the closely related *M. alternatus* (Shimazu *et al*., 1995; Shimazu, 2009).

Phytosanitary risk

Accidental introduction of *M. carolinensis* together with the pine wood nematode to new locations increases the rate of spread of the pine wood nematode. The risk of introduction of both pests into the EPPO region is high (Evans *et al* ., 2009; EPPO, 2022). *M. carolinensis* is known to be the main vector of *B. xylophilus* in North America (Akbulut & Stamps, 2012). The egg, larval, and pupal stages of the beetle can be transported via unprocessed softwood logs. Introduction of pine wood nematode-infected *Monochamus* species can be limited by import requirements specified for host plants of the pine wood nematode and coniferous woods by National or Regional Plant Protection Organizations. *Monochamus* species are regularly intercepted in the European Union (EFSA, 2018). For example, according to the EUROPHYT database between 1999 and 2019, there have been 21 interception records of *M. alternatus*, non-European *Monochamus* species, on wood packaging material or dunnage (EFSA, 2020).

PHYTOSANITARY MEASURES

Accidental introduction of *M. carolinensis* and the pine wood nematode to the EPPO region can be limited by specific import requirements for host plants of the pine wood nematode and its vectors. Due to the cryptic life stages of *M. carolinensis*, visual inspection of timber does not always reveal the presence of eggs, larvae, or pupae under the bark or in the wood of imported products. Therefore, international standards have been developed to prevent the importation of infested wood products (FAO, 2017, EPPO 2018a, b). The phytosanitary measures recommended by the EPPO commodity standard for Coniferae, PM 8/2 (3) (EPPO, 2018b) are considered to be effective to prevent the introduction and spread of non-European *Monochamus* spp. and the pine wood nematode. There are recommendations for wood from *Pinus*, originating in countries where *M. carolinensis* is present: it should originate from a pest free area and be transported outside of *M. carolinensis* flight period, or the wood should be covered during the transportation (EPPO, 2018b). Following quarantine treatments for conifer wood are recommended: wood should be bark-free, and either heat treated according to EPPO Standard PM 10/6 or treated with ionizing radiation according to EPPO Standard PM 10/8 or appropriate fumigation and details specified on the Phytosanitary Certificate (EPPO, 2018b). The treatment of wood packaging material, including dunnage, should meet the requirements of ISPM no. 15 (FAO, 2019) to prevent the introduction of *B. xylophilus* and *Monochamus* spp. via international trade into uninfested areas.

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